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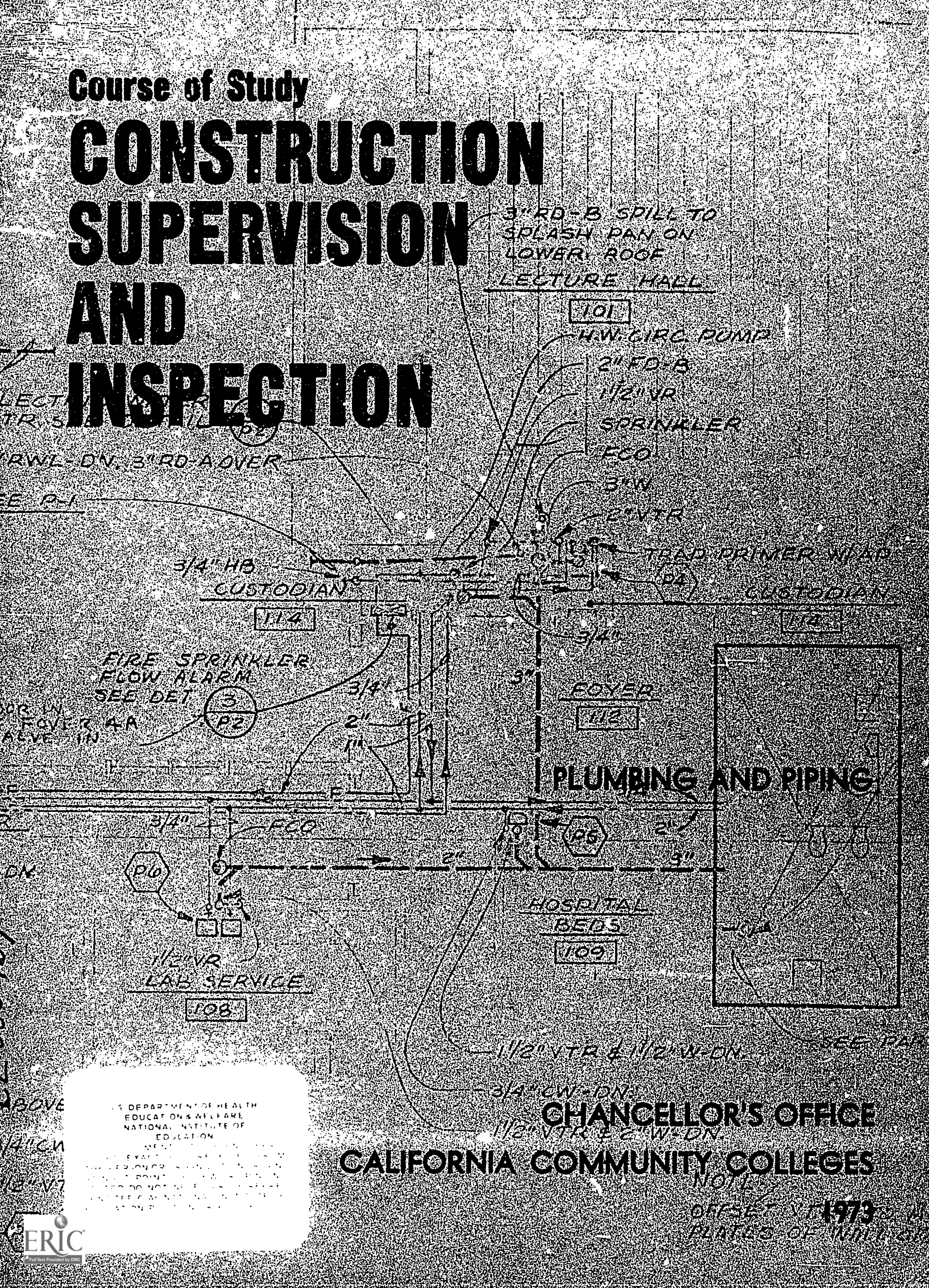
ABSTRACT

This course of study on plumbing and piping is part of a construction, supervision, and inspection series, which provides instructional materials for community or junior college technical courses in the inspection program. Material covered in this volume pertains to: uniform plumbing code; pipes, fittings, supports, and connections; sewer and water systems; drainage vent systems; water distribution systems; fixtures and appliances; fuel systems; fire protection systems; stormwater and special waste systems; landscape piping; corrosion and insulation. In many chapters, sections of the uniform plumbing code are reproduced and related to the chapter material; charts and diagrams also are included to assist the reader. The course of study may contain more material than can be covered in one semester. (EA)

Course of Study

CONSTRUCTION SUPERVISION AND INSPECTION

PLUMBING AND PIPING



CHANCELLOR'S OFFICE

CALIFORNIA COMMUNITY COLLEGES

1973

Course of Study

CONSTRUCTION SUPERVISION AND INSPECTION

PLUMBING AND PIPING

by
Lester O'Meara, P.E.
and
John Turley, P.E.

CHANCELLOR'S OFFICE
CALIFORNIA COMMUNITY COLLEGES
SACRAMENTO
1973

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CONSTRUCTION SUPERVISION AND INSPECTION SERIES

Structural Series No. 1	1966
Structural Series No. 2	1967
Electrical Series No. 1	1972
Air Conditioning, Heating and Ventilating	1973
Architectural	1973
Plumbing and Piping	1973

FOREWORD

The construction industry of today uses a great variety of materials, machines, and processes as well as professional, technical, skilled craftsmen, and building trades to accomplish desired results. A significant role in the construction process required to assure the highest degree of conformity to plans is that of the construction inspector.

As construction practice becomes more complex, the inspector must possess a higher level of competency. Community College construction inspection programs are assisting industry by providing necessary educational programs.

This publication is another in the Construction Supervision and Inspection series. This series was undertaken to provide instructional materials for all technical courses in the inspection program. Each publication is developed by a Community College in cooperation with the Chancellor's Office. Valuable assistance is provided by advisory committees representing architects, engineers, inspectors, contractors, material and equipment manufacturers and suppliers, building trades, and college staff. This series should provide the basis for a comprehensive program.

Sidney W. Brossman, Chancellor
California Community Colleges

PREFACE

This publication provides a comprehensive treatment of materials usually covered in a plumbing and piping inspection course. As with other publications in the Construction Supervision and Inspection series, it is in draft form and will be refined after it has been used and evaluated by instructors, students, and practitioners. The publication may contain more material than can be covered in one semester. Students may find portions useful beyond the classroom since it contains reference information. We welcome your comments and suggestions.

I wish to express my appreciation to the authors, Lester O'Meara and John Turley, and to the advisory committee that assisted them.

Leland P. Baldwin, Assistant Chancellor
Occupational Education
California Community Colleges

ACKNOWLEDGMENTS

The Advisory Committee contributed greatly to the choice of material and composition for this manual during its preparation. The authors are indebted to them for their keen interest and timely suggestions.

CONSTRUCTION SUPERVISION AND INSPECTION
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CHAPTER I

PLUMBING AND PIPING INSPECTION

General: Inspection includes the examination and evaluation of construction work in progress, comparing or contrasting it with recognized norms or standards, and accepting or rejecting it in the light of conformity or nonconformity to the standards.

An Inspector is engaged by the Owner or Architect/Engineer to represent him at the construction site. Public works and engineering departments of communities and special service agencies have inspection staffs to evaluate construction for which they are responsible. In all local communities an Inspector is a law-enforcement employee of the city or county, and seeks compliance with the Building Code in the interests of health, safety, and general welfare of all citizens of the community.

Inspections, in some form or another and under a variety of nomenclatures, have been carried on through all ages of history.

The complexities of government, use of greater varieties of materials, and creation of guilds (ultimately unions) of various trades have steadily increased the need for intelligent and responsible inspection of all types of construction.

Within the past few years, in California, the Construction Inspectors' Association has created a statewide Association with the aim to extend their knowledge and abilities toward bett r inspection service. It is due to the motivation of this group that the course of study on Construction Supervision and Inspection has been prepared.

Qualification: The major qualification of a good Inspector is his years of experience in construction work of a type similar to that for which he is being assigned.

There are several thousand persons employed in Construction Inspection in California. There is every indication that there will be a 5% to 10% increase per year in job opportunities. A greater increase may be anticipated based on population and construction activity projections. Also, inspection staffs will be increased as local communities continue to pursue comprehensive housing inspection programs.

It is becoming more and more--on large projects--a practice to assign Inspectors on the basis of specialized knowledge, such as mechanical, electrical, concrete and steel work; however, large portions of construction projects still require the services of an Inspector with a good general knowledge of all phases of construction.

The need for inspection service is steadily increasing to such an extent that it is becoming more and more difficult to draw men of experience from the ranks of their previous occupations.

As a consequence, young people, without a great amount of job experience, are becoming interested in this field of work.

It is increasingly evident that the qualifications of an Inspector definitely require the inclusion of a basic and current knowledge of building materials and construction procedure.

More contractors and communities are insisting upon and recognizing additional collegiate training for Construction Supervisors and Inspectors. This tends to elevate entrance standards, promotion standards, and salary. Hence, the current presentation of a course of study on Construction Supervision and Inspection as presented by a few of the Community Colleges.

<u>Duties</u>: The prime duty of a Construction Inspector is to assure that construction is performed in accordance with the drawings and specifications. An Inspector has no authority to deviate from them; an Inspector shall avoid assuming an unreasonable attitude concerning his own interpretation when reasonable doubt exists as to intent, especially concerning minor details.

At all times, the Inspector shall bear in mind that the principal objective is the successful completion of the intent of the contract documents. All directions by the Inspector shall be based upon obtaining the best possible final result in accordance with the documents.

Accepted and proven construction practices and the use of common sense and good judgment shall be the basis of the Inspector's attitude.

The above results can only be successfully obtained by the Inspector through a dignified, quiet, tactful, and firm attitude on his part.

Copies of such Codes as Uniform Plumbing, Electrical and Safety Codes, Uniform Building Code, and local ordinances, must be maintained on the project at all times for the use of the Inspector, the Owner, and the Architect/Engineer.

The Inspector shall set up and maintain files, including a daily diary, Inspector's copies of correspondence, daily reports, the contract form, an approved set of plans, specifications addenda, and change orders, approved shop drawings, approved samples, concrete placing records, welding records, pile driving records, water, gas, sewer tests, concrete tests, steel tests, progress reports, and other correspondnece or data pertaining to his portion of the contract.

Contract documents usually call for (and if not, the Inspector shall require) a schedule of the work showing the estimated starting and completion dates of major sub-contracts, all within limits of the time for completion of the contract. As the work progresses, he shall plot on this chart the weekly progress of the work. More sophisticated methods of scheduling are explained in detail under the Architectural Section of this Series.

Diary: It is imperative for the good of the project that the Inspector keep a daily diary. The prime value of the diary is to cover current actions, attitudes, and conditions while the work is in progress. It is potentially extremely valuable.

It may be used to advise Supervisors of the progress of the work, of any difficulties being encountered, of any noncompliance with the drawings and specifications, and matters of similar nature. It will be of use in the event a Contractor requests an extension of time or an increase in contract price, and for audits of work progress.

It is therefore important that the diary be completely filled out in a legible manner and that all pertinent facts be stated precisely. Statements should be so worded that persons reading and evaluating the diary at some future date will be aware of exactly what happened and what information the Inspector intended to convey.

The greatest value of this diary is its information over and above current weather conditions, amounts of material received, lists of material in use, or data on the contractor's labor force.

Items to incorporate in a diary:

Any oral statement or order given to Contractor's supervisory personnel on behalf of the Architect/Engineer concerning additional work or concerning a controversial item.

Warnings given to the Contractor's personnel concerning improper, inadequate, or unsafe methods which are likely to result in injury to personnel or in damage to the Owner.

Conditions encountered in excavation, such as change of material from that indicated on the plans, the presence of rock, boulders, or other hard material, location of utility lines not shown on the drawings or found in a different location.

Any claim the Contractor may make to the Inspector regarding interpretations of drawings and specifications with respect to the inclusion of work or material which he feels is not covered nor required.

Any materials or equipment rejected because of non-compliance with the specifications. This should include any material or equipment that is found to be defective as the result of tests or analysis.

Delays caused by non-delivery of material, equipment breakdown, weather conditions, or insufficient supply of labor; also remarks concerning general progress of the job.

Work accomplished by the Contractor, and its location.

Any and all other reports required on the project can be lifted from this diary on the basis of weekly, semi-monthly, or monthly reports.

The Inspector shall notify the Contractor and Architect/Engineer of any deviation from the approved plans and specifications. Care shall be taken that the Inspector does not issue instructions to the Contractor which will result in a claim for extra compensation or extension of contract time.

Such orders will be issued only as contract change orders from the Architect/Engineer's office after proper approvals have been obtained, and any changes in contract price or time have been determined.

The Inspector shall verify that shop drawings and samples, as required by the plans and specifications, are submitted to the Architect/Engineer's office; they shall be approved before the materials are incorporated in the work.

Contract documents usually require that the bidder shall submit a list of Subcontractors. Any change in the listed Subcontractors shall be approved by the Owner and the Architect/Engineer. Work on the job by any Subcontractor not listed in the contract documents or properly approved is a violation of the contract and the Architect/Engineer should be advised immediately.

Payments: The contract documents usually provide for monthly payments to be made on the basis of percentages of work completed, on a form prepared by the Architect/Engineer or by the Contractor and approved by the Architect/Engineer. This monthly estimate and request for payment must be checked for percentage of work completed and approved by the Inspector before it is submitted to the Architect/Engineer's office for certification.

Change Orders: Changes in the plans and/or specifications are a possibility in any contract.

No deviations from the approved plans and specifications shall be permitted until the Inspector receives notification from the Architect/Engineer that the change meets with the approval of all parties concerned. The Owner is the only party legally authorized to approve any changes in the work under the contract.

A formal change in plans and specifications and, if a change in price or time is involved, a change in contract - termed a Change Order - will be prepared and issued by the Architect/Engineer's office. Occasionally the Architect/Engineer may notify the Contractor to proceed with the change after necessary informal approvals have been obtained, pending approval of the formal Change Order. This information will also be given to the Inspector and will be the Inspector's authority to allow the Contractor to proceed with the change.

The Inspector has no authority to order a change in plans, specifications or contract. Any conditions necessitating a deviation from the requirements of the contract documents must be registered as a Change Order.

Each Change Order, upon approval, becomes a complete, supplemental contract document; therefore, must be complete in every respect, including the following:

Name of the party requesting the change and reason.

A detailed description of the proposed change, listing the exact location and nature of the work, or a supplemental drawing attached to the Change Order.

Change in Contract amount and time.

Record Drawings: Record drawings or as-built drawings shall be maintained by marking up a set of prints indicating items which may comply with the approved plans and specifications but are not located or indicated in detail. The exact locations and depths of underground and underslab conduits and piping, and the location of conduits embedded in concrete or otherwise inaccessible shall be noted. These record or as-built prints shall be turned over to the Architect/Engineer upon completion of the project, or as requested.

If the project is not completed within the time prescribed in the contract, the Inspector shall make a complete report listing all missing items and work not completed, and this shall be forwarded to the Architect/Engineer. When the project is complete, the Inspector will review with the Architect/Engineer all guarantees that are called for in the Contract Documents.

The Inspector must confirm that the above are received by the Owner before the Architect/Engineer can certify the completion of work.

All questions, interpretations, suggestions and criticisms posed by the Contractor or Inspector shall be directed to the Owner or Architect/Engineer, or his field representative.

Criteria for Good Inspection: The Inspector must keep in mind that the Owner is the only party legally authorized to make any change in the work under the contract. The Architect/Engineer, as part of his service and duties under his contract with the Owner, is completely responsible for all phases of the work to and including the completion of the construction contract.

The Inspector, while an employee of the Owner, must keep the Architect/Engineer completely current with all phases of the progress of construction. He serves as the "eyes" for the Architect/Engineer to assure that the design is carried out as contemplated. He must be alert not only in inspecting his phase of the job but must also give careful attention to all phases of the finished work. In this way the Inspector can perform a real service to the Owner, to the Architect/Engineer, and to the Contractor. He should remember that there is a common rule of law that says "in every contract there exists an implied covenant of good faith and fair dealing."

Relationships

Personal Conduct: The following rules shall be observed. The Inspector shall:

Not talk about administrative problems connected with the project in public. Such discussion by the Inspector should only be held with appropriate personnel officially connected with the project. (Loose talk makes for poor relationships with all concerned.)

Be swift and decisive in his actions against violence, negligence, or evidence of bad faith. He should be just as quick to recognize and commend good work.

Have no personal connection with and should not accept a loan, gift, nor gratuity from anyone that is in any way responsible for compliance with the terms and conditions of the Contract.

Not use narcotics nor intoxicating liquors while on duty, nor appear on duty under their influence.

Not suggest nor recommend for employment any particular person or persons or Subcontractor nor should he suggest nor recommend the purchase of any specific material nor product except insofar as the specifications may require.

Not give orders nor instructions to the Contractor nor any Subcontractor involving any change in the work not covered by the contract, except upon instruction from the Architect/Engineer with approval of the Owner.

Not give orders and instructions to the Contractor nor any Subcontractor that in any way involves responsibility for or gives cause for claim against the Owner. He shall not assume the duties of any superintendent nor foreman of the General Contractor nor any Subcontractor.

Contractors: The Inspector shall not interfere with the Contractor's method of performing work. Such interference could, to some extent, release the Contractor from his responsibility under the contract.

His action ordinarily is limited to the rejection or acceptance of various parts of the work as they are completed. If the Contractor's methods are obviously unsafe, inadequate, or do not comply with established construction practices, the Inspector should warn the Contractor against continuing such methods. Following such warning, if the Contractor continues to use such methods, the matter should be promptly brought to the attention of the Architect/Engineer or his designated representative for further action.

He should always do business with the responsible superintendent or foreman on the job, and should carefully avoid the issuance of any directions to the Contractor's workmen. At no time should an Inspector take any action which could be interpreted as supervision or direction of the Contractor's operations.

He should be alert to cooperate with the Contractor in expediting progress of the work; to catch errors in questionable practices in time to avoid future rejection or slowdown of work or material; to observe the Contractor's equipment and operations from a safety standpoint, assisting him in correcting safety hazards. An Inspector's relationship with the Contractor should be cooperative and friendly at all times without compromising the Owner's objective of obtaining high quality construction in accordance with the drawings and specifications, and within the limits of allowable contract time.

The Inspector must realize that the Contractor has agreed to perform his contractual obligation; he is licensed and has been prequalified before his bid was accepted.

There must be mutual respect between the Contractor and Inspector; this will come about when each is qualified and thoroughly familiar with his assignment.

The terms of every contract sets forth adequate procedures and standards necessary to resolve conflicts of interpretation or standards of performance. No action is to be taken that will relieve the Contractor of his obligations.

Smooth relations between the Inspector and the Contractor results in a satisfactory relationship among all parties involved in the particular project.

The General Conditions generally stipulate that the Architect/Engineer will not entertain any request to arbitrate disputes among Subcontractors nor between the Contractor and one or more of his Subcontractors concerning responsibility for performing any part of the work. It is the single prime, or general contractor who has this responsibility where all work is performed under one contract.

Where the contracts are segregated, and each is a "prime" Contractor, i.e. Mechanical, Electrical, and others, the respective Contractor is governed by the General Conditions of his respective contract. In this case the Inspector has an added responsibility of job management and coordination by the authority vested in him.

The Inspector must understand the principles of leadership and exercise them. If the Inspector cannot or will not provide prompt answers to questions raised by Contractors, they will go elsewhere. If proper leadership is shown, the Contractor will respect him.

The atmosphere of responsible authority must be created at the job inception. The Inspector conducts the starting meeting and other coordinating meetings in a businesslike way.

It is necessary to keep in close touch with each of the prime Contractors; each must be dealt with impartially and fairly; do not discriminate nor show disdain, as it will alienate the Contractor.

The Inspector is justified in criticising if it is based on facts and appropriate; by doing so it may keep him from developing further trouble.

Give a Contractor a chance to use his ability and resources; do not close the door to him, as it is frustrating and does not contribute to job progress nor efficiency.

Keep the Contractor informed. Anything that affects the operations of one Contractor needs to be told to the others.

Good record keeping is a must; keep abreast of all problems and decisions; be on top of the job.

Prospective Bidders: Inspectors are prohibited from discussing any matter with prospective bidders that may influence their bid one way or another. No interpretation of the proposed contract plans nor specifications shall be made.

Each bidder shall evaluate the work and rely on the proposed contract specifications for the method of clarification.

Subcontractors: Interpretation of Subcontracts must be left entirely to the discretion of the prime Contractor. Subcontractors are agents of the prime Contractors and have no contractual relationship with the Architect/Engineer.

Owners: In almost every case the Inspector is directly an employee of the Owner and as such is fully responsible to the Owner.

By the same token, the Architect/Engineer, in his services to the Owner is completely responsible for the project from its inception to its completion, which puts the Inspector in a position of being responsible to the Architect/Engineer as well.

The Inspector should, as a consequence, at any time that he receives direct orders from the Owner in any phase of the work, such as reports, changes in work or material, be very careful to contact the Architect/Engineer before proceeding with any such issued orders.

Architect/Engineer: The Inspector shall work under the direction of the Architect/Engineer. In his review of plans and specifications, any inconsistencies or seeming errors must be reported promptly to the Architect/Engineer for interpretation and instructions. Should he feel that such interpretations and instructions are not in conformity with the approved plans and specifications, he shall request further clarification.

Field Representatives: Certain Federal, State, Local, and Building Trade representatives periodically visit most projects. These people are in the nature of Inspectors for such organizations as Health, Education and Welfare, Department of Housing and Urban Development, Office of Architecture and Construction, Department of Local Assistance, Fire Marshal, Industrial Safety, County Health Department, Electrical and Plumbing Codes, Trade Unions and others.

These people should contact the Inspector. If not, the Inspector should be alert to the visits, make himself known and record in general all conversations and specifically any indicated violation or recommendation of Code, or agency requirement indicated, for prompt report to the Architect/ Engineer.

Legal Obligations: Aside from the legal obligations imposed on the Inspector by the terms of the construction contract between the Owner and the Contractor, he has the legal obligations to make truthful reports on the forms furnished, and to comply with the conditions imposed on his employment as an Inspector by local building departments and/or State agencies.

There is no State licensing law governing Inspectors at the present time. Should such be enacted, the Inspector will have legal obligations as enumerated in the law.

CHAPTER 2

UNIFORM PLUMBING CODE

History: The first plumbing code of significant value was the Hoover Code, published in 1928 and revised in 1932. In 1933 the National Association of Master Plumbers published its Standard Plumbing Code and revised it in 1942. In 1936 the Hoover Code was revised, and in 1940 this revision was published by the government in BMS66, plumbing manual primarily designed for housing.

In 1938 the Western Plumbing Officials started their first draft of the Uniform Plumbing Code.

In 1941, due to involvement in World War II, the government initiated a program to conserve critical materials and labor. This resulted in the publishing of the Emergency Plumbing Standards. This was the first code to work successfully on a nationwide basis.

The peacetime forerunner of this code was published in 1949 as the Uniform Plumbing Code, and applied to dwelling units. The code was subsequently expanded through the efforts of the various committees, to apply to all types of structures. In 1955, after extensive research and investigation, it was published as the American Standard National Plumbing Code, ASA A40. 8-1955. This is still the standard used by the Federal Government on their agency projects, with the latest revisions.

Concurrent with this effort, the Western Plumbing Officials' Association (now International Association of Plumbing and Mechanical Officials) endeavored to compile a standard to replace the multitude of conflicting codes in existence.

The committee, composed of Plumbing Inspectors, Master and Journeyman Plumbers, Sanitary and Mechanical Engineers, assisted by the Public Utility Companies, and the Western Plumbing Industry, published the first edition of the "Uniform Plumbing Code" which was adopted in 1945.

General: The Uniform Plumbing Code, if it is to be useful, must be kept up to date; for this reason amendments adopted by the membership are published in a revised code every three years, and reflect the latest tested technological developments. It is now widely used by cities, counties and states. The latest revision was published in 1973.

The Uniform Plumbing Code, like most codes, is considered a minimum with respect to materials, and sizing of pipes, or equipment; many projects, for reasons best known to the Engineer, may require larger sizes or different materials. If the plans and specifications indicate this, the Inspector should require that the plans and specifications be followed, but the standards of the code must be followed as a minimum. A copy of the Code should be available on every construction project where it is the adopted standard.

The State of California also has a Housing Code, Title 25, which may be used for dwelling units, where the Uniform Code has not been adopted, or where local deviations from the Uniform Code has made it less restrictive than the Housing Code.

Administrative Authority: The Code allows the Plumbing Inspector, as a representative of the Authority, to use his judgment in some cases. This is particularly true when listing or labeling of a product by a listing agency is not available. He must first satisfy himself as to its adequacy.

Code Expansion: Each revision of the Code indicates the growing complexity of plumbing systems and the need to augment the Code. Recent additions have been Rainwater Systems, Trailer Park Plumbing Standards, Medium Pressure Gas Systems, Swimming Pools, and Battery Drainage Systems.

Other Codes: There are many other codes and orders which must be kept in mind while administering the Uniform Plumbing Code. These include:

1. National Electric Code
2. State Safety Orders
3. National Board of Fire Underwriters - various pamphlets
4. Federal Standards on Safety and Health - which take precedence over State Standards (OSHA)

Principles: The preamble to the National Plumbing Code lists basic principles which spell out the results desired and necessary to protect the health of the people. They also serve to define the intent of the Code. It can be assumed that they are also the principles which underlie the basic philosophy expressed in the Uniform Plumbing Code, 1973 Edition. They are listed here:

Principle No. 1: All premises intended for human habitation, occupancy, or use shall be provided with a supply of pure and wholesome water, neither connected with unsafe water supplies nor subject to the hazards of backflow or back siphonage.

Principle No. 2: Plumbing fixtures, devices, and appurtenances shall be supplied with water in sufficient volume and at pressures adequate to enable them to function satisfactorily and without undue noise under all normal conditions of use.

Principle No. 3: Plumbing shall be designed and adjusted to use the minimum quantity of water consistent with proper performance and cleaning.

Principle No. 4: Devices for heating and storing water shall be so designed and installed as to prevent dangers from explosion through overheating.

Principle No. 5: Every building having plumbing fixtures installed and intended for human habitation, occupancy, or use on premises abutting on a street, alley, or easement in which there is a public sewer shall have a connection with the sewer.

Principle No. 6: Each family dwelling unit on premises abutting on a sewer or with a private sewage-disposal system shall have, at least, one water closet and one kitchen-type sink. It is further recommended that a lavatory and bathtub or shower shall be installed to meet the basic requirements of sanitation and personal hygiene.

All other structures for human occupancy or use on premises abutting on a sewer or with a private sewage-disposal system shall have adequate sanitary facilities but in no case less than one water closet and one other fixture for cleaning purposes.

Principle No. 7: Plumbing fixtures shall be made of smooth non-absorbent material, shall be free from concealed fouling surfaces, and shall be located in ventilated enclosures.

Principle No. 8: The drainage system shall be designed, constructed, and maintained so as to guard against fouling, deposit of solids, and clogging, and with adequate cleanouts so arranged that the pipes be readily cleaned.

Principle No. 9: The piping of the plumbing system shall be of durable material, free from defective workmanship, and so designed and constructed as to give satisfactory service for its reasonable expected life.

Principle No. 10: Each fixture directly connected to the drainage system shall be equipped with a water-seal trap.

Principle No. 11: The drainage system shall be designed to provide an adequate circulation of air in all pipes with no danger of siphonage, aspiration, or forcing of trap seals under conditions of ordinary use.

Principle No. 12: Each vent terminal shall extend to the outer air and be so installed as to minimize the possibilities of clogging and the return of foul air to the building.

Principle No. 13: The plumbing system shall be subjected to such tests as will effectively disclose all leaks and defects in the work.

Principle No. 14: No substance which will clog the pipes, produce explosive mixtures, destroy the pipes or their joints, or interfere unduly with the sewage-disposal process shall be allowed to enter the building drainage system.

Principle No. 15: Proper protection shall be provided to prevent contamination of food, water, sterile goods, and similar materials by backflow of sewage. When necessary, the fixture, device, or appliance shall be connected indirectly with the building drainage system.

Principle No. 16: No water closet shall be located in a room or compartment which is not properly lighted and ventilated.

Principle No. 17: If water closets or other plumbing fixtures are installed in buildings where there is no sewer within a reasonable distance, suitable provision shall be made for disposing of the building sewage by some accepted method of sewage treatment and disposal.

Principle No. 18: Where a plumbing drainage system may be subjected to backflow of sewage, suitable provision shall be made to prevent its overflow in the building.

Principle No. 19: Plumbing systems shall be maintained in a sanitary and serviceable condition. See definition "Plumbing."

Principle No. 20: All plumbing fixtures shall be so installed with regard to spacing as to be reasonably accessible for their intended use.

Principle No. 21: Plumbing shall be installed with due regard to preservation of the strength of structural members and prevention of damage to walls and other surfaces through fixture usage.

Principle No. 22: Sewage or other waste from a plumbing system which may be deleterious to surface or subsurface waters shall not be discharged into the ground or into any waterway unless it has first been rendered innocuous through subjection to some acceptable form of treatment.

The Plumbing Inspector who understands the principles enumerated will have no difficulty in properly interpreting the Uniform Plumbing Code.

In subsequent chapters exact reproductions are made from sections of the Uniform Plumbing Code, 1973 Edition. The entire Code is not reproduced; those sections shown are complete. The Inspector will find much that is valuable in the sections of the Uniform Code which are included.

Where a vertical line is shown alongside a paragraph or a sentence, it indicates a change, or addition from the 1970 Edition. Technological advances, new materials, better methods of construction, and more accurate and extensive testing methods, along with economic considerations, have contributed to quicker acceptance of change in the Plumbing industry than formerly, so that a revision every three years is a necessity.

Space is provided on the right side of each reproduced section so that appropriate notes can be made by the user.

CHAPTER 3

PLUMBING THEORY

The Plumbing Inspector is primarily concerned with the evaluation of the utility and plumbing and piping systems while the construction work is in progress; he may accept or reject it based on conformity with the standards generally acceptable.

A competent Inspector must be thoroughly familiar with the interpretation of plans and the symbols used. He must also be able to comprehend precisely what the specifications mean. If there are any questions regarding interpretation or meaning that need clarification, they shall be referred to the proper Authority as designated in the documents.

As discussed previously, the combination of job experience and technical and non-technical courses relating to Inspection will in the end benefit the person who wishes to make a career in this field.

A working knowledge of the principles that affect all plumbing and piping systems in some degree is desirable. Mainly these are the laws of hydraulics and pneumatics, plus some knowledge of the properties of the materials used in plumbing systems.

A plumbing and piping system may be simple, as in a small residence, or highly complex, as in a modern large hospital. As the number of fixtures is increased, the branching of supply and drainage pipes is increased, and the protective devices are increased. The complications of the piping is increased as the kinds of fluids are increased.

Safeguards of various kinds are provided because unsafe systems result in dangers to health, due to polluted water supplies from cross connections; the escape of odors and vapors into the enclosed space; rodents or insects in the drainage pipes; and troublesome noises due to improper pipe sizes or poor isolation from the structure. Water heaters may explode when excess pressure builds up due to improper or no protective devices.

Sewer gas is a mixture of several gases, some of which are combustible and explosive in the presence of oxygen. Others are poisonous, such as hydrogen sulfide and carbon monoxide. The sewer gas is sealed from the building by plumbing traps placed in the drain lines; the traps contain water for the seal; the maintenance of the water seal is vital. Vent pipes are provided to keep water in the traps, except that lost by evaporation. The vent pipe, when properly installed, prevents variations of pressure in the drainage pipes that can cause the seal to be broken because of blowing or sucking the water from the trap. Vent stacks also aid in the ventilation of the common sewers.

Water: Water is the substance with which the Plumber must be familiar, as it is carried in the various piping systems; it may be mixed with solids and air, which may or may not be potable. Care must be exercised to maintain the polluted water or wastes within separate systems from the pure water sources.

Water may exist in three states at familiar temperatures; ice (solid); water (liquid); steam or water vapor (gas); in its liquid state it must be contained as it conforms to the shape of vessel or pipe; it is affected by gravity, so seeks the lowest point. When in a gaseous state, the weight and volume are dependent on the pressure exerted and by variations in temperature; water will exist in any one of the three states, dependent on the temperature. Since expansion takes place in the solid state, freezing of pipes must be prevented and the care necessary is a function of the climatic conditions in the area in which the work is performed. Hot water and steam will cause expansion of the metal pipes; allowance must be made for this. Water expands when heated so that the warmer water will rise to the top, for instance, in a hot water tank. The boiling point of water will vary, depending on the pressure exerted on it. At zero gauge pressure it will boil at 212 degrees F.; at 100 pounds per square inch, the boiling point is 338 degrees F.

The phenomenon of expansion and contraction, based on heating or cooling makes it necessary to provide protective devices on hot water heaters, for example. Temperature and pressure relief valves are a common method used, and are required by the Uniform Plumbing Code. Water expands when either heated or cooled from 39 degrees F. It is the cause of broken water pipes under freezing conditions, or the rupture of overheated water heaters.

When particles of a substance are mixed, but not dissolved in a liquid it is known as suspension. When two or more substances are thoroughly mixed it is called a solution; an example is salt water.

Water in its pure state is considered a solvent, because the hydrogen atoms attract the oxygen atoms in other substances; distilled (pure) water will attack most other substances. The PH scale is used for measuring the acidity or alkalinity of water. When acid (PH of 5.0 or lower) it is quite corrosive, and will attack the galvanizing on water pipes. A PH of 7.0 is neutral, and above 7.0 up to 10.6 is considered safe for home use. The PH scale is calibrated from 0 to 14 for general use. Kits for most uses are readily available, particularly since swimming pools have become more popular.

Hard water contains carbonates of calcium, or magnesium, and no lather can be formed. Calcium will cause deposits within pipe lines. All are familiar with the deposits which form in a teakettle after a period of use with hard water.

Water which is "hard" can be treated to lower its PH value. Water softeners, are a familiar way to treat hardness.

The discussion so far has been concerned mainly with water. There are other fluids which have characteristics that require means of measuring them.

The rate at which a liquid flows is affected by its viscosity, which is its relative thickness. The higher the viscosity, the thicker it is, and the greater will be its resistance to flow. The viscosity is increased during cold weather, and decreased during hot weather.

Adhesion is the property that causes dissimilar metals to be attracted to each other. Solder, for example, causes the joining together of two pieces of copper, as in a joint.

Cohesion is the property by which similar materials are attracted to each other. This is what makes a fully tinned joint possible.

Capillary action, or the rising of a liquid in a small space, is the result of both adhesion and cohesion. Solder rises vertically in a soldered joint by capillary action.

Specific gravity is another term associated with substances and is the ratio of the density of a substance to the density of air and water, each of which has been assigned a specific gravity of 1; it is the ratio of the weight of a solid or liquid with the weight of an equal volume of water.

The Plumbing Inspector will find this ratio useful in a manometer instrument which uses mercury as the substance. Since mercury has a specific gravity of 13.6, it can measure the same amount of test pressure with a column one foot in height as a water column 13.6 feet high. Since the height determines the pressure, a small column one inch diameter or less, will exert the same pressure as a four inch diameter column of water. It exerts a pressure of .434 psi for each foot of height regardless of the diameter.

The weight at the bottom of a stack is equal to the area times the pressure. If additional pressure is added by outside means, as a pressure pump, it is added to the pressure if applied at the top of a column; but if applied at the bottom the existing pressure at the bottom of the column is deducted from the applied pressure.

The two laws of physics governing pressure are Pascal's Law which states that any pressure in a fluid acts with equal intensity in all directions throughout the fluid; Boyle's Law states that the volume of a confined gas is inversely proportional to the pressure exerted on it, assuming the temperature remains the same.

The above laws have a practical application in plumbing work with hydraulic pumps, sizing of kick blocks for underground water mains; sizing of air chambers to prevent water hammer; siphonage problems due to the creation of a vacuum and in most testing procedures.

An understanding of simple plumbing theory will enable the Plumbing Inspector to detect trouble of poor design or installation before it becomes serious.

CHAPTER 4

PIPE, FITTINGS AND VALVES

General: The use of the proper pipe materials is important for the safety of building inhabitants and the protection of the investment of the Owner.

Project specifications will usually delineate the materials for all the services for an individual building or group of buildings. Pipe is usually specified by material, strength designation, and in some instances an ASTM specification number. Fittings are most often specified by material, type, strength designation, manufacturer, and USASI specification. Valves are normally specified by manufacturer, model number and type. Specifying a valve in this manner defines the pressure rating, material, and other characteristics necessary for proper performance. The Inspector must have the specified catalog of the manufacturer in order to make an evaluation of a substituted item should this occur.

In 1935 the ASA, under the sponsorship of the ASME, issued the first American standard "Code for Pressure Piping," ASA, B31.1 covering steam, gas and air, oil, refrigeration and district heating piping systems. The standard also contains fabrication details of pipe supports, bends, joints, valves, and fittings. It is recommended the Inspector obtain a copy of this publication along with ASA, B9.1, "Safety Code for Mechanical Refrigeration," for his reference library. There are many other useful ASA publications available. A request for a current index list will make the student aware of what is available. The address is American Society of Mechanical Engineers, 29 West 39th Street, New York, N.Y.

Pipe:

Cast-Iron Pipe: Cast-iron pipe is extensively used for water, gas, sewage, culverts, and drains, in a wide range of sizes and for varying pressures; it is particularly adapted to underground and submerged service because of its comparatively high corrosion-resisting qualities. It is more durable than wrought-iron, or steel pipe, but its first cost is greater for the ordinary sizes required in a pressure pipe line or in a distributing system. The tensile strength of commercial cast-iron pipe is uncertain and, because of its low elasticity, it is not suitable for lines subject to the strains of expansion, contraction, and vibration, unless it is of very heavy weight. This pipe is manufactured in various thicknesses and weights with either flanged, threaded, bell-and-spigot, or plain ends. The latter is generally used for underground work. For exposed piping, flanged ends are used, the joints being made up with gaskets. Flanged pipe has superior strength and tightness of the joint and is used where pipe lines can be well supported. The bell-and-spigot joint possesses greater flexibility, provides for expansion and contraction, and is therefore especially suitable for water pipe; it is largely used for that purpose.

Cast-iron water pipe is manufactured in accordance with a number of standard specifications and in a number of different weights and lengths. Pit-cast pipe is less generally used because of its greater weight and cost compared with centrifugally cast pipe, but fittings that are pit-cast according to the AWWA specifications of 1908 are used almost exclusively with cast-iron water pipe. When cast-iron water pipe is selected for any particular service, the internal pressures and other stresses to which it may be exposed should be compared with the characteristics given to the different classes of pipes and fittings in standard specifications. Three types of end are standard on cast-iron water pipe and fittings: bell-and-spigot, flanged, and screwed.

Cast-iron pipe that is manufactured primarily for use as drainage pipe in plumbing is lighter than cast-iron water pipe. It is generally known as soil pipe.

Three weights of soil pipe are recognized as standard: standard, medium, and extra heavy. Extra-heavy pipe is normally used, when a first-class, permanent job is desired; this may be where the building is subject to vibration or settling, or where corrosive attack may be expected.

At present, cast iron soil pipe is used in tall buildings for drainage, waste and vent purposes without concern for building height and is, in fact, the preferred material. This is in contrast to the early 1940's when it was the consensus that cast iron soil pipe should be used in buildings limited to about 25 stories in height.

Cast-iron fittings with either bell-and-spigot or threaded ends or plain ends are manufactured for soil pipe. The threaded ends are tapped with a standard thread to fit wrought pipe. The use of bell and spigot and no-hub ends on soil pipe is common in plumbing. Cutting of cast-iron soil pipe with hammer and chisel requires training and skill. A special wheel cutting tool is available which simplifies the work.

Threaded cast-iron fittings, kno' n as drainage fittings are made with a shoulder and recess and are tapped so that the pipe screws up tightly to this shoulder, making a continuous interior surface of the same diameter as the pipe. These fittings are known also as Durham fittings.

<u>Vitrified-Clay Pipe</u>: Vitrified clay pipe is used principally for building sewer lines and other drains outside the building. The use of vitrified-clay pipe within a building is prohibited because of the uncertainty that the joint will remain watertight and gastight. The brittleness and inflexibility of the pipe throw the strain of any movement into the joints when the joints are made of cement. These are subject to cracking and the joint is no longer tight.

Double-strength pipe and pipes with extra-wide and deep bells are also used. Extra-heavy pipes are used where unusually heavy stresses are anticipated but the stresses are insufficiently heavy to demand the use of cast-iron pipe. Deep and wide sockets are used for cement joints in wet trenches.

Advantages in the use of vitrified-clay pipe are its durability, its relatively low cost as compared with metal pipes, and the simplicity of its installation. Clay pipe is unaffected by ordinary corrosive substances and many highly corrosive compounds that may be found in sewage. Clay is not affected by most acids or alkalies. It is the cheapest material available, except possibly some cement products and bituminized-fiber pipe. It can be installed satisfactorily by unskilled workmen.

Cement Asbestos Pipe: The first cement-asbestos pipe was manufactured in 1913 in Genoa, Italy. It has since become available in this country under the trade names of Transite, and Certain-Teed in sizes from 3 in. to 36 in. and in pressure classes of 50, 100, 150, and 200 psi. Test pressures range from 2-1/2 to 4 times the rated working pressure, depending on the practice of different manufacturers. This is said to be 40 to 50 per cent of the actual bursting pressure. Standard lengths are 13 ft. with shorter lengths available for radius laying. There is no generally accepted standard for wall thickness and each manufacturer uses his own schedule which is based on the strength of his material. Since the nominal inside diameters are uniform, the products of different manufacturers have somewhat different outside diameters and the couplings are not necessarily interchangeable.

Cement-asbestos pipe is made with machined ends but it can be cut to any desired length and machined on the job site. Pipe walls may be drilled and tapped for threaded service connections.

Pressure type pipe must comply with ASTM Spec. C-296 and pressureless with ASTM C-428. Each length of pipe is required to bare the trade name, size and class designation on the pipe barrel. Coupling and gaskets must be similarly marked.

Asbestos-cement pipe of one well known manufacturer is composed of 15 to 20% asbestos fiber, 32 to 34% silica and bound together with 48 to 51% cement. The pipe, after being formed on a steel mandrel is then cured with high pressure steam.

Cement Pipe and Concrete Pipe: Cement pipe and concrete pipe are used under conditions similar to those for vitrified-clay pipe, except that cement and concrete pipe may be more subject to corrosion by acids. They have also been badly affected by the decomposition of stale sewage where the concrete has been subjected to gases and vapors. The use of concrete pipe for the small sizes that are needed for ordinary building sewers is no more economical than vitrified-clay under most conditions; because of its susceptibility to corrosion, the use of cement and of concrete is usually restricted to storm water collection.

Reinforced-concrete pipe to carry water under pressure is manufactured under ASTM Specifications C75 and C76.

Both pressure and non-pressure type are equipped with rubber gaskets which slip over the pipe end and inside the coupling.

Casting of concrete conduits and storm sewers in the ditch has become common practice in the last few years with the advent of the machinery necessary for this application.

Wrought Iron Pipe: Wrought-iron pipe may be used for drainage, soil, waste, and vent pipes and for the conveyance of water and other fluids that are not corrosive to it, all above ground. It is no longer in common use, however.

The method of manufacture and the materials in wrought-iron and steel are similar. Good quality puddled steel has better lasting qualities than inferior wrought iron, however; good quality wrought iron is superior in resistance to corrosion. Standard dimensions of pipes made from each material are the same, so that fittings for wrought-iron and steel pipes are interchangeable. Wrought-iron pipe is covered under ASA Specification B36.10.

Wrought-iron is made from pig iron which is melted in contact with iron oxide slag, then rolled into sheets called skelp.

Wrought-iron and steel pipe are known by inside diameter but are actually made with varying inside diameters and a fixed outside diameter. Pipes over 12 inch diameter are identified by their outside diameter.

Wrought-iron pipe may be supplied in standard weight, extra heavy or double extra heavy. In all cases the O.D. of the pipe is constant.

Bituminized-Fiber Pipe: Bituminized-fiber pipe is known by many names, the most common of which are Orangeburg and "paper pipe." The pipe is a compound of bituminized impregnated fibers pressed into a hard, smooth bare material.

This pipe is used primarily for residential work, outside the building foundation, for the building sewer line. It is a very inexpensive material that lays rapidly. A heavy duty perforated pipe is made for foundation, road way, and other subsoil drainage.

Orangeburg is not widely accepted for commercial work since failure can occur if the pipe fibers take on moisture. Depth of bury is also an important factor since vertical loads are critical. The UPC and local codes and ordinances should be checked for acceptability.

Corrugated Metal Pipe: Corrugated metal pipe was first developed and used for culverts in 1896. As experience was gained in the use of this thin-wall, lightweight, shop-fabricated pipe, the diameters gradually increased to 96 in. and larger. Fill heights became greater, even exceeding 100 ft. A further development, in 1931, was structural plate pipe with larger corrugations, for field assembly. Diameters and arch spans beyond 25 ft. have been successfully installed.

Specifications for corrugated steel conduits have been prepared by various national engineering authorities in collaboration with steel producers and pipe manufacturers. These are periodically reviewed and brought up to date in the light of research and new product developments. A list of those in common use is found in the table at the end of this chapter.

These specifications cover: general description, material, fabrication, testing, and in some cases, design and construction. In part, the material specification includes chemical composition of the base metal, and the kind and amount of coatings. The fabrication specification includes shape, dimensions and weights, corrugation configurations, seams, end finish and couplings.

Design specifications and tables should include maximum and minimum heights of earth cover from surface to top of structure for the various combinations of diameter or span and gage.

Construction specifications generally include foundation and bedding preparation, how the backfill should be made and other installation information.

Corrugated steel drainage conduits are made in sizes from 6 in. through 24 ft. in round, vertically elongated, pipe arch, horseshoe and arch. Corrugated pipe, when necessary may be lined with a bituminous coating. This can be applied in a heavy pour so as to fill in the spaces between the corrugations for a smooth bore.

Fittings for pipes up to 10 inch diameter are usually available prefabricated. Larger fittings require shop fabrication techniques.

Pipe section length varies with diameter and may be special ordered to suit job or transportation conditions.

Steel Pipe: Steel pipe, ASTM Specification A-120 and A-53 is the most commonly used material for general pressure piping in building construction. This piping is normally supplied either black or hot-dip galvanized.

The material used for steel pipe is made from steel produced in the open-hearth, basic oxygen furnace, Bessemer converter, or electric arc furnace.

It is usually made either by piercing or extruding from steel billets or by cupping from circular discs. Seamless steel pipe is frequently used for high pressure work or where pipe is desired for close coiling, cold bending, or other severe forming operations. It is available in pipe sizes up to 24 in. O.D.

Welded steel pipe is available in several types although the smaller sizes most frequently used in heating and air conditioning work are made by the lap-weld, electric resistance weld or butt weld process. Furnace welded pipe, usually low cost, is used for low pressure service. It is available in pipe sizes 4 in. diameter and smaller. Other types are available in sizes through 24 in. diameter.

Pipe lengths in standard lengths may be from 16 to 22 feet but are normally 20 or 21 feet. Extra heavy and double extra heavy pipe are normally supplied in 12 to 22 foot lengths.

Pipe markings should appear on each length identifying the name brand or manufacturer, length and the ASTM number. ASTM A-120 pipe is normally used for threaded connection and in straight sections. ASTM A-53 pipe is normally used for applications where bending is necessary and welding is employed in joining.

The physical properties are shown in the tables at the end of this chapter.

Plastic Pipe: The plastic pipe industry has produced many materials in recent years which can be formed into pipe and fittings. Some of these are practical for use in plumbing installations that offer flexibility in handling, lower labor costs, and resistance to corrosive fluids. Pressure and temperature are basic limitations to be considered. Voluntary industry codes have been written outlining these limitations with appropriate specifications.

Basically there are two kinds of plastics:

1. Thermoplastic, which melts under heat and hardens when cooled and can be melted and reworked again and again.

2. Thermoset, which hardens and fuses under heat and pressure into a permanent shape and cannot be re-melted.

Some thermoplastics have properties of flexibility and moderate strength for water service where temperatures and pressures are moderate. Thermoplastics may be joined by solvent welding and hot-gas welding. Both pipe and fittings are generally available in IPS sizes.

Epoxy or polyester resins form the major ingredient of thermosetting piping, usually reinforced with glass or blue asbestos fibers. They are available in commercial pipe sizes and are joined by either standard screwed or socket-type fittings. Commercial polyester pipe is suitable for temperatures up to 250 F.

The Plastics Pipe Institute lists the following standards for plastics piping:

Polyethylene (PE) = ASTM D2104-68, USASI B72.1-1967
Polyvinyl-chloride (PVC)= ASTM D1785-68, USASI B72.2-1967
Acrylonitrite-
Butadiene Styrene (ABS)= ASTM D1527-67, USASI B72.3-1967

Specifications are also available for fittings and other types of plastic pressure pipe.

The most commonly used and recognized plastic in use today is PVC (Polyvinyl Chloride). PVC has relatively high tensile strength and modulus of elasticity and, therefore, is stronger and more rigid than most other thermoplastics. The maximum service temperature is 150° F. for Type I. PVC has excellent chemical resistance to a wide range of corrosive fluids, but may be damaged by ketones, aromatics and some chlorinated hydro-carbons. It has proved an excellent material for process piping (liquids, gases and slurries), water service, and industrial and laboratory chemical waste drainage.

CPVC (Chlorinated Polyvinyl Chloride) is particularly useful for handling corrosive fluids at temperatures 40° to 60° above the limits for other vinyl plastics. In chemical resistance, it is comparable to PVC. Suggested uses include process piping for hot corrosive liquids, hot and cold water lines in office buildings and residences, and similar applications above the temperature range of PVC. CPVC pipe should be joined by solvent welding or threading. UPC may limit its use and should be consulted.

Penton (Chlorinated Polyether), has very good chemical resistance and is useful up to 250° F. Values of physical properties are "medium" at room temperacure, but these decrease only gradually as the temperature increases. Penton has a contractor's cost two to three times as much as

PVC piping; it is useful where chemical resistance at elevated temperatures is required and at normal temperatures where PVC and other materials lack satisfactory resistance to specific chemicals. It is joined by threading with fittings to match.

Polypropylene is the lightest thermoplastic piping material, yet has higher strength and better general chemical resistance than polyethylene; it may be used at temperatures 30^{o} to 50^{o} above the recommended limits of polyethylene. Polypropylene is an excellent material for laboratory and industrial drainage piping where mixtures of acids, bases and solvents are involved. It has found wide application in the petroleum industry where its resistance to sulfur-bearing compounds is particularly useful, in salt water disposal lines, low-pressure gas gathering systems and crude oil flow piping. It is best joined by heat sealing fusion welding.

Glass Pipe: Glass pipe in use today is available in pressure and pressureless type. Pressure type is generally in use in the food, dairy and chemical industries. Pressure ratings vary, depending on the type system, from 50 psig to 150 psig. Joints are all a variation of the flanged joint. There is a good variety of fittings and valves available for the pressure type pipe.

Pressureless glass piping systems are used for corrosive liquid drainage. Normally this occurs in laboratory sewerage systems where acids or other caustic and corrosive chemicals are likely to be discharged. This system is available with a full compliment of fittings and a stainless steel banding joint method. This system will withstand a pressure of 15 psig.

Other pipe materials not commonly used in the building industry are wood, lead, copper-nickel, aluminum and rubber. When a material is to be used on a project that is not familiar to the Inspector outside reference should be consulted. Two good references are "Piping Handbook", by Sabin Crocker, McGraw-Hill Book Co., and "Mark's Handbook" by Lionel S. Marks, McGraw-Hill Book Co.

Pipe Fittings:

Welding Fittings: Pipe is joined by welding one length to another, or by using fittings. Pipe fittings are made in a variety of forms such as elbows, tees, couplings, reducers, and unions, and may be screwed, flanged, or welded. The type of fitting to be used is determined by the pressure of the fluid being carried, or by the intended use of the pipe line. The materials generally used are steel, cast iron, malleable iron (heat treated cast iron), copper, brass, stainless steel, alloy steel, or bronze. The material used also depends upon the pressure and fluid characteristics.

Fittings are designated and sized in accordance with USASI specifications and are identified by their nominal pipe sizes.

In the case of reducing tees, crosses, and Y-branches (laterals), the size of the largest run opening is given first, followed by the size of the opening at the opposite end of the run. Where the fitting is a tee or Y-branch (lateral), the size of the outlet is given last. Where the fitting is a cross, the largest side-outlet is the third dimension given followed by the opening opposite.

Where an external thread is wanted, the word male follows the size of that opening; female indicates an internal thread.

Allowable pressures for solder-type fittings are given in USAS B16.18-1967, Cast Bronze Solder-Joint Pressure Fittings, and B16.22-1963, Wrought Copper and Bronze Solder-Joint Pressure Fittings.

Steel welding (butt or socket type) fittings may be used for the same pressure as the pipe, provided wall thickness (or schedule number), and also the material, are the same as the pipe on which they are used.

Screwed Fittings: Screwed fittings include: couplings, elbows (45° or 90°), return bends (close and open), tees, crosses, laterals (Y-branches), plugs, caps, lock nuts, flanges, bushings, and reducing fittings (elbows, tees, and couplings). Reducing fittings and bushings may be eccentrically tapped to permit drainage of condensate or eliminate air and vapor traps.

Sometimes nipples are erroneously called fittings. Actually a nipple is a piece of pipe 12 in. long or less, that has been threaded on both ends. Pipe longer than 12 in. is regarded as cut pipe. Nipples are classified as close or full thread, shoulder, short, and long. A close nipple is about twice the length of the pipe thread since the threads actually meet. A shoulder nipple has a shoulder between the threads and is further classified as short or long. All shoulder nipples are cut to specific lengths and sold in that manner.

Fittings for copper tubing are available in soldered, flared, or compression types. Fittings for copper pipe of IPS dimensions are available in screwed or soldered types.

Flanged Joints: As a general rule, flanged joints are used when it is expected that the line will be disassembled quite often. There are four types of joints for attaching the flange to the pipe: screwed, welded, grooved, or lapped.

There are many types of flange facings. The simplest, and the one most commonly used, is the plain face. Others include: male and female face (an insert type face), tongue-and-groove (an adaptation of the male and female type) lapped pipe to flange, lapped pipe to pipe, and ring and groove using neck flanges.

Because it is too expensive to machine flange faces sufficiently to provide watertight joints a gasket is usually inserted between the contact faces of the flanges. The flange bolts then draw the faces up so tight that the gasket deforms into the face imperfections and thereby provides a tight joint.

Gaskets: Gaskets are made of numerous materials, such as: cork, paper, fiber, asbestos, metal (iron, steel, copper, etc.), plastics, neoprene, and combinations of metal and some soft material. The proper gasket material to use depends upon the service of the pipe. The material should not be detrimentally affected by the chemical and thermal conditions of the fluid being carried.

Expansion Joints: Expansion joints are necessary in systems where an appreciable temperature variation is likely to be encountered either in the fluid transported or from exposure to the sun. Expansion joints may be either a manufactured item in the form of a bellows device or a packed or packless piston type. Guides are required for these devices so as to keep the stresses on the center-line axis. Anchors are necessary at the extreme ends of the pipe run and should be inspected for proper fastening to the building and the pipe.

Bends: U bends are often used in lieu of expansion joints. These are calculated for distances between the bends and the length of the U legs. No deviation should be allowed from the dimensions indicated on the drawings. This expansion method requires proper pipe anchoring but guides are not generally used.

Some piping systems require pipe to be bent at a change in direction rather than the use of a fitting. Bends should be inspected carefully for wrinkles on the throat and flattening on the heel. If this is detected the bend shall be rejected.

Dresser Couplings: It is advantageous at times to joint pressure pipe with a limited movement flexible coupling to dampen vibrations or allow for pipe misalignment. Dresser couplings are used for this purpose. The coupling is rubber lined with a flange on both ends connected with through bolts. The coupling slips on the bare pipe end and the bolts tightened to compress the rubber gasket. Ideally, the rubber is the only material touching the pipe wall which gives a flexible joint and dampens out pipe vibrations.

Valves:

Valves are made with the same end connections as fittings. A brief description of each type follows:

1. Flanged Ends: Made in sizes from 1/2 in. diameter to the largest pipe diameter. Used whenever line fittings are flanged, or if frequent removal is contemplated. Flanged valves facilitate installation when large sizes are used.

2. Screwed Ends: Most common-type end. Can be used for all pressures. Usually confined to smaller size because of difficulty in making large screwed joints.

3. Welding Ends: Available in steel only. Generally employed for high-temperature, high-pressure work. Difficult to disassemble in a welded line.

4. Brazing Ends: These ends are available on brass valves. The ends have a special shape to facilitate use of brazing alloys. These valves are used for higher temperatures than solder end valves.

5. Solder Ends: For use with copper tube in plumbing, heating, and air conditioning. Should not be used at high temperatures.

6. Flared Ends: For use with light-wall tubing, either metal or plastic, and for sizes 2 in. NPS or SAE and below. A flaring tool flares the tube end, and a ring nut pulls the flared tubing up against a seat on the valve. This makes a lap joint.

7. Hub Ends: Generally used for water supply and sewage piping. This type joint is used with cast-iron pipe. The joint is a socket type, made by inserting the pipe in the hub, then caulking with oakum. After being caulked, the joint is sealed with molten lead.

Valves are made of brass, iron, steel, and to some extend malleable iron. Brass should not be used for temperatures above 550 F. The brass used in valves is similar to that used in brass pipe and contains some tin and lead as well as copper and zinc.

Gate valves, plug valves, and ball valves are normally used where low line pressure losses are required. These valve have inherently larger ports than other types, with some, having ports equal to the free area of the pipe to which they are connected.

Gate valves are normally used for either full open or full closed service. The design of this valve does not make it suitable nor effective as a throttling device. Gate valves may normally be installed with inlet flow on either side. Gate valves are suitable for use in sewage lines.

Plug valves are suitable for throttling service and are extensively used as balance valves. These valves often are of the lubricated type (lubricated plug cock) so care should be taken to insure the proper lubricant is used for pressure, temperature and fluid compatibility.

Ball valves are also used as throttling devices and also require proper lubrication. These valves must be installed with the designated inlet end connected to the higher pressure pipe end so when closed the pipe pressure forces the valve to seat properly. Both ball valves and plug cocks require periodic relubrication to prevent "freeze up".

Butterfly valves also have very low pressure drop characteristics due to large bore bodies. The butterfly is, however, in the fluid stream. These valves should not be applied for sewage work. Throttling with the butterfly valve is possible providing a ratchet or gear type operator is used but the performance is ragged in comparison to the plug valve.

Butterfly valve bodies are made in lugless and lug type configurations. They are applied between piping flanges and require close inspection to insure parallel flange take up on both faces. Flow direction is usually from either side but the installation instructions supplied with the valves should be consulted.

Globe valves and needle valves are most suitable for throttling service and tight shut off through many open-close cycles. This configuration is seldom used unless tight shut-off is mandatory due to the inherent high pressure drop characteristics. Globe valves must be installed in the system with the pressure side under the seat. In the case of an angle pattern globe this may not put the handle in the most convenient location but the pressure must be under the valve seat.

Saunders type valves are normally used in the food and beverage industries. The body configuration makes them particularly suitable for this service since the valve may be completely disassembled and cleaned with ease; there are no crevices in which contaminating solid particles may become lodged. Installation can be made with flow inlet from either end.

Check valve configurations are swing, wafer, ball and lift. Swing checks are most commonly used but the wafer type is gaining in usage. Outside weight and lever swing checks are the only type check valves suitable for use in sewage systems; when open, they present a pipe bore size opening, with no internal restrictions. With the lever counter weight these valves may be installed in vertical piping.

Most wafer or "silent" check valves are spring loaded which allows their use in horizontal or vertical piping. Due to spring pressure on the seat these checks are slow closing when flow ceases, so prevent water hammer.

Ball checks are suitable for installation in either horizontal or vertical piping. Lift checks should only be used in horizontal piping.

Check valves should always be installed with the direction of flow under the seat. It should be emphasized that most check valves should not be considered as a tight shut off but rather a temporary deterent to flow. Finely machined, special purpose checks, handling clean fluids, are depended upon for tight shut off service but this does not apply to the normal piping system.

Dimensions and Properties of Steel Pipe

Nominal[a] Size	ASTM[b] Schedule	Diameter OD In.	Diameter ID In.	Wall Thickness In.	Surface Area Sq Ft Lin Ft OD	Surface Area Sq Ft Lin Ft ID	Section Area Sq In. OD	Section Area Sq In. ID	Area of Metal Sq In.	Volume Gal Lin Ft	Weight[c] (plain end) Lb/Lin Ft	Working Pressure Psia
1/8	40 (s)	0.405	0.269	0.068	0.106	0.0704	0.129	0.0568	0.0720	0.00295	0.244	314[d]
	80 (x)	0.405	0.215	0.095	0.106	0.0563	0.129	0.0363	0.0925	0.00189	0.314	1084
1/4	40 (s)	0.540	0.364	0.088	0.141	0.0953	0.229	0.104	0.125	0.00541	0.424	649
	80 (x)	0.540	0.302	0.119	0.141	0.0791	0.229	0.0716	0.157	0.00372	0.535	1353
3/8	40 (s)	0.675	0.493	0.091	0.177	0.129	0.358	0.191	0.167	0.00992	0.567	574
	80 (x)	0.675	0.423	0.126	0.177	0.111	0.358	0.140	0.217	0.00730	0.738	1191
1/2	40 (s)	0.840	0.622	0.109	0.220	0.163	0.554	0.304	0.250	0.0158	0.850	697
	80 (x)	0.840	0.546	0.147	0.220	0.143	0.554	0.234	0.320	0.0122	1.09	1266
	XX	0.840	0.252	0.294	0.220	0.0660	0.554	0.0499	0.504	0.00259	1.71	3824
3/4	40 (s)	1.050	0.824	0.113	0.275	0.216	0.866	0.533	0.333	0.0277	1.13	604
	80 (x)	1.050	0.742	0.154	0.275	0.194	0.866	0.432	0.434	0.0225	1.47	1078
	XX	1.050	0.434	0.308	0.275	0.114	0.866	0.148	0.718	0.00768	2.44	3134
1	40 (s)	1.315	1.049	0.133	0.344	0.275	1.36	0.864	0.494	0.0449	1.68	651
	80 (x)	1.315	0.957	0.179	0.344	0.251	1.36	0.719	0.639	0.0374	2.17	1083
	XX	1.315	0.599	0.358	0.344	0.157	1.36	0.282	1.08	0.0146	3.66	2963
1 1/4	40 (s)	1.660	1.380	0.140	0.435	0.361	2.16	1.50	0.669	0.0777	2.27	440
	80 (x)	1.660	1.278	0.191	0.435	0.335	2.16	1.28	0.881	0.0666	3.00	805
	XX	1.660	0.896	0.382	0.435	0.235	2.16	0.630	1.53	0.0328	5.21	2318
1 1/2	40 (s)	1.900	1.610	0.145	0.497	0.421	2.84	2.04	0.800	0.1058	2.72	417
	80 (x)	1.900	1.500	0.200	0.497	0.393	2.84	1.77	1.07	0.0918	3.65	756
	XX	1.900	1.100	0.400	0.497	0.288	2.84	0.950	1.89	0.0494	6.41	2122
2	40 (s)	2.375	2.067	0.154	0.622	0.541	4.43	3.36	1.07	0.174	3.65	376
	80 (x)	2.375	1.939	0.218	0.622	0.508	4.43	2.95	1.48	0.153	5.02	690
	XX	2.375	1.503	0.436	0.622	0.393	4.43	1.77	2.66	0.0922	9.03	1861
2 1/2	40 (s)	2.875	2.469	0.203	0.753	0.646	6.49	4.79	1.70	0.249	5.79	505
	80 (x)	2.875	2.323	0.276	0.753	0.608	6.49	4.24	2.25	0.220	7.66	806
	XX	2.875	1.771	0.552	0.753	0.464	6.49	2.46	4.03	0.128	13.7	2048
3	40 (s)	3.500	3.068	0.216	0.916	0.803	9.62	7.39	2.23	0.384	7.57	454
	80 (x)	3.500	2.900	0.300	0.916	0.759	9.62	6.61	3.02	0.343	10.3	734
	XX	3.500	2.300	0.600	0.916	0.602	9.62	4.15	5.47	0.216	18.5	1829
3 1/2	40 (s)	4.000	3.548	0.226	1.05	0.929	12.6	9.89	2.68	0.514	9.11	425
	80 (x)	4.000	3.364	0.318	1.05	0.881	12.6	8.89	3.68	0.462	12.5	692
	XX *	4.000	2.728	0.636	1.05	0.714	12.6	5.85	6.72	0.304	22.9	1699
4	40 (s)	4.500	4.026	0.237	1.18	1.05	15.9	12.7	3.17	0.661	10.8	403
	80 (x)	4.500	3.826	0.337	1.18	1.00	15.9	11.5	4.41	0.597	14.9	663
	XX	4.500	3.152	0.674	1.18	0.825	15.9	7.80	8.10	0.405	27.5	1602
5	40 (s)	5.563	5.047	0.258	1.46	1.32	24.3	20.0	4.30	1.04	14.6	498[d]
	80 (x)	5.563	4.813	0.375	1.46	1.26	24.3	18.2	6.11	0.945	20.8	825
	XX	5.563	4.063	0.750	1.46	1.06	24.3	13.0	11.3	0.673	38.6	1951
6	40 (s)	6.625	6.065	0.280	1.73	1.59	34.5	28.9	5.58	1.50	18.0	467
	80 (x)	6.625	5.761	0.432	1.73	1.51	34.5	26.1	8.40	1.35	28.6	825
	XX	6.625	4.897	0.864	1.73	1.28	34.5	18.8	15.6	0.978	53.1	1912
8	30 (s)	8.625	8.071	0.277	2.26	2.11	58.4	51.2	7.26	2.68	24.7	351
	40 (s)	8.625	7.981	0.322	2.26	2.09	58.4	50.0	8.40	2.60	28.6	431
	80 (x)	8.625	7.625	0.500	2.26	2.00	58.4	45.7	12.8	2.37	43.4	753
	XX	8.625	6.875	0.875	2.26	1.80	58.4	37.1	21.3	1.93	72.4	1460
10	(s)	10.750	10.192	0.279	2.81	2.67	90.8	81.6	9.18	4.24	31.2	285
	30 (s)	10.750	10.136	0.307	2.81	2.65	90.8	80.7	10.1	4.19	34.2	324
	40 (s)	10.750	10.020	0.365	2.81	2.62	90.8	78.9	11.9	4.10	40.5	405
	60 (x)	10.750	9.750	0.500	2.81	2.55	90.8	74.7	16.1	3.88	54.7	600
12	30 (s)	12.750	12.090	0.330	3.34	3.17	128.	115.	12.9	5.96	43.8	299
	(s)	12.750	12.000	0.375	3.34	3.14	128.	113.	14.6	5.88	49.6	352
	(x)	12.750	11.750	0.500	3.34	3.08	128.	108.	19.2	5.63	65.4	503
14	30 (s)	14.000	13.250	0.375	3.67	3.46	154.	138.	16.0	7.17	54.6	458[d]
	(x)	14.000	13.000	0.500	3.67	3.15	154.	133.	21.2	6.70	72.1	653

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Fig. 4-1a. Steel Pipe Data

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Dimensions and Properties of Steel Pipe (Concluded)

Nominal Size[a]	ASTM[b] Schedule	Diameter OD In.	Diameter ID In.	Wall Thickness In.	Surface Area Sq Ft/Lin Ft OD	Surface Area Sq Ft/Lin Ft ID	Section Area Sq In. OD	Section Area Sq In. ID	Area of Metal Sq In.	Volume Gal/Lin Ft	Weight[c] (plain end) Lb/Lin Ft	Working Pressure Psia
16	30 (s)	16.000	15.250	0.375	4.18	3.99	201.	183.	18.4	9.48	62.4	400[d(3)]
	40 (x)	16.000	15.000	0.500	4.18	3.93	201.	177.	24.3	9.18	82.8	570
18	(s)	18.000	17.250	0.375	4.71	4.52	254.	234.	20.7	12.1	70.6	355
	(x)	18.000	17.000	0.500	4.71	4.45	254.	227.	27.4	11.8	93.5	506
20	20 (s)	20.000	19.250	0.375	5.23	4.51	314.	291.	23.2	15.2	78.6	319
	30 (x)	20.000	19.000	0.500	5.23	4.97	314.	284.	30.6	14.7	104.2	454
24	20	24.000	23.250	0.375	6.29	6.08	452.	426.	26.8	22.1	94.6	265
	(s)	24.000	23.000	0.500	6.29	6.03	452.	415.	36.9	21.5	125.5	378

* 3½ double extra strong is no longer considered in ASTM specification but some pipe of this size is still manufactured.

[a] The sizes for wrought iron are approximately the same except wall thickness is slightly heavier. See *ASTM A-72*.

[b] *American Society for Testing and Materials* Schedule. The numbers 30, 40, etc., refer to the *ASTM* Schedule; the letter (s) refers to the former designation *Standard Weight*, the letter (x) refers to the former designation *Extra Strong*, the letters XX refer to the former designation *Double Extra Strong*.

[c] Weight per foot is based on plain end pipe. Threaded and coupled (T and C) pipe is slightly heavier.

[d] *Working pressure for welded joints—see formula in Table 1. Refer to Table 1 for type of weld.*

(1) Working pressure based on an allowable fiber stress of 6225 psi (for 250 F).

(2) Working pressure based on an allowable fiber stress of 8100 psi (for 250 F).

(3) Working pressure based on an allowable fiber stress of 12000 psi (for 250 F).

Note: Standard-weight pipe is generally furnished with threaded ends in random lengths of 16 to 22 ft, although when ordered with plain ends, 5 percent may be in lengths of 12 to 16 ft. Five percent of the total number of lengths ordered may be jointers which are two pieces coupled together. Extra-strong pipe is generally furnished with plain ends in random lengths of 12 to 22 ft, although 5 percent may be in lengths of 6 to 12 ft.

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Fig. 4-1b.

Dimensions and Properties of Copper Tube

(All Types Except DWV are based on ASTM B-88)

Nominal Size	Type	Diameter OD In.	Diameter ID In.	Wall Thickness In.	Surface Area Sq Ft Lin Ft OD	Surface Area Sq Ft Lin Ft ID	Section Area Sq In. OD	Section Area Sq In. ID	Area of Metal Sq In.	Volume Gal Lin Ft	Weight[a] Lb/Lin Ft	Working Pressure[b] Psia
1/4	K[c]	0.375	0.305	0.035	0.0982	0.0798	0.110	0.0730	0.0374	0.00379	0.145	918
	L[c]	0.375	0.315	0.030	0.0982	0.0825	0.110	0.0779	0.0324	0.00404	0.126	764
3/8	K	0.500	0.402	0.049	0.131	0.105	0.196	0.127	0.0695	0.00660	0.269	988
	L	0.500	0.430	0.035	0.131	0.113	0.196	0.145	0.0512	0.00753	0.198	677
1/2	K	0.625	0.527	0.049	0.164	0.138	0.306	0.218	0.0887	0.0113	0.344	779
	L	0.625	0.545	0.040	0.164	0.143	0.306	0.233	0.0735	0.0121	0.285	625
5/8	K	0.750	0.652	0.049	0.193	0.171	0.441	0.334	0.108	0.0174	0.418	643
	L	0.750	0.666	0.042	0.193	0.174	0.441	0.348	0.0934	0.0181	0.362	547
3/4	K	0.875	0.745	0.065	0.229	0.195	0.601	0.436	0.165	0.0227	0.641	747
	L	0.875	0.785	0.045	0.229	0.206	0.601	0.484	0.117	0.0250	0.455	497
1	K	1.125	0.995	0.065	0.295	0.260	0.994	0.778	0.216	0.0405	0.839	574
	L	1.125	1.025	0.050	0.295	0.268	0.994	0.825	0.169	0.0442	0.655	432
1 1/4	K	1.375	1.245	0.065	0.360	0.326	1.48	1.22	0.268	0.0634	1.04	466
	L	1.375	1.265	0.055	0.360	0.331	1.48	1.26	0.228	0.0655	0.884	387
	M	1.375	1.291	0.042	0.360	0.338	1.48	1.31	0.176	0.0681	0.682	293
	DWV	1.375	1.295	0.040	0.360	0.339	1.48	1.32	0.163	0.0684	0.650	—
1 1/2	K	1.625	1.481	0.072	0.425	0.388	2.07	1.72	0.351	0.0894	1.36	421
	L	1.625	1.505	0.060	0.425	0.394	2.07	1.78	0.295	0.0925	1.14	359
	M	1.625	1.527	0.049	0.425	0.400	2.07	1.83	0.243	0.0950	0.940	289
	DWV	1.625	1.541	0.042	0.425	0.403	2.07	1.86	0.205	0.0969	0.809	—
2	K	2.125	1.959	0.083	0.556	0.513	3.56	3.01	0.532	0.157	2.06	376
	L	2.125	1.985	0.070	0.556	0.520	3.56	3.10	0.452	0.161	1.75	316
	M	2.125	2.009	0.058	0.556	0.526	3.56	3.17	0.377	0.164	1.46	255
	DWV	2.125	2.041	0.042	0.556	0.534	3.56	3.27	0.288	0.142	1.07	—
2 1/2	K	2.625	2.435	0.095	0.687	0.638	5.41	4.66	0.755	0.242	2.93	352
	L	2.625	2.465	0.080	0.687	0.645	5.41	4.77	0.640	0.217	2.48	295
	M	2.625	2.495	0.065	0.687	0.653	5.41	4.89	0.523	0.254	2.03	231
3	K	3.125	2.907	0.109	0.818	0.761	7.67	6.64	1.03	0.345	4.00	343
	L	3.125	2.945	0.090	0.818	0.771	7.67	6.81	0.858	0.354	3.33	278
	M	3.125	2.981	0.072	0.818	0.780	7.67	6.98	0.691	0.362	2.68	220
	DWV	3.125	3.035	0.045	0.818	0.796	7.67	7.23	0.435	0.376	1.69	—
3 1/2	K	3.625	3.385	0.120	0.949	0.886	10.3	9.00	1.32	0.468	5.12	324
	L	3.625	3.425	0.100	0.949	0.897	10.3	9.21	1.11	0.478	4.29	268
	M	3.625	3.459	0.083	0.949	0.906	10.3	9.40	0.924	0.489	3.58	218
4	K	4.125	3.857	0.134	1.08	1.01	13.3	11.7	1.68	0.607	6.51	315
	L	4.125	3.905	0.110	1.08	1.02	13.3	12.0	1.39	0.623	5.38	256
	M	4.125	3.935	0.095	1.08	1.03	13.3	12.2	1.20	0.634	4.66	217
	DWV	4.125	4.009	0.058	1.08	1.05	13.3	12.6	0.67	0.656	2.87	—
5	K	5.125	4.805	0.160	1.34	1.26	20.7	18.1	2.50	0.940	9.67	307
	L	5.125	4.875	0.125	1.34	1.28	20.7	18.7	1.96	0.971	7.61	234
	M	5.125	4.907	0.109	1.34	1.29	20.7	18.9	1.72	0.981	6.66	203
6	K	6.225	5.741	0.192	1.60	1.50	29.4	25.9	3.50	1.35	13.9	308
	L	6.125	5.845	0.140	1.60	1.53	29.4	26.8	2.63	1.39	10.2	221
	M	6.125	5.881	0.122	1.60	1.54	29.4	27.2	2.30	1.42	8.92	190
	DWV	6.125	5.959	0.083	1.60	1.56	29.4	27.9	1.58	1.55	6.10	—
8	K	8.125	7.583	0.271	2.13	1.99	51.8	45.2	6.69	2.34	25.9	330
	L	8.125	7.725	0.200	2.13	2.02	51.8	46.9	4.98	2.43	19.3	239
	M	8.125	7.785	0.170	2.13	2.04	51.8	47.6	4.25	2.47	16.5	200
10	K	10.125	9.449	0.338	2.65	2.47	70.5	70.1	10.4	3.65	40.3	332
	L	10.125	9.625	0.250	2.65	2.52	80.5	72.8	7.76	3.79	30.1	241
	M	10.125	9.701	0.212	2.65	2.54	80.5	73.9	6.60	3.84	25.6	202
12	K	12.125	11.315	0.405	3.17	2.96	115.	101.	11.9	5.24	57.8	334
	L	12.125	11.565	0.280	3.17	3.03	115.	105.	10.4	5.45	40.4	225
	M	12.125	11.617	0.254	3.17	3.01	115.	106.	9.47	5.50	36.7	204

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Fig. 4-2 Copper Tube Data

Application of Pipe, Tube, and Fittings

Application	Materials Commonly Used	Application	Materials Commonly Used
Chilled water	Type K or L hard copper, wrought iron, or black steel, Schedule 40	Hot water heating[b]	Type K or L hard copper, black steel, or wrought iron, Schedule 40
Cooling tower	Type K or L hard copper, wrought iron, or black steel, Schedule 40	Refrigerant[c]	Type K or L hard copper, wrought iron or black steel, Schedule 40
Underground water 2-in. and smaller	Type K soft copper, galvanized wrought iron, or galvanized steel, Schedule 40 (for corrosive soils, a coated steel pipe should be used)	Steam heating supply 125 psi and less	Type L hard copper, black steel, Schedule 40, standard fittings
		125 to 250 psi	Type K hard copper, black steel, Schedule 40.
2½-in. and larger	Type K, soft copper cast iron, Class 150, galvanized wrought iron, or galvanized steel, Schedule 40 (for corrosive soils, a coated steel pipe pipe should be used)	Return pipe All sizes	Type K or L hard copper, black wrought iron or steel, Schedule 40. Standard fittings
City water—inside building	Type K or L hard copper, galvanized wrought iron, or galvanized steel, Schedule 40	Receiver vent All sizes	Copper drainage tube DWV, galvanized wrought iron or steel, Schedule 40. Standard fittings
Panel heating[a]	Type K or L hard or soft copper, black steel or wrought iron, Schedule 40	Gas (all kinds) All sizes	Black steel, Schedule 40, malleable iron fittings

[a] Panel heating copper fittings should be soldered with 95-5 solder. Steel fittings should be welded.

[b] All underground feed and return lines buried in slab, should be equipped with fittings as outlined for panel heating.

[c] Refrigerant fittings on copper pipe must be wrought copper. All welded fittings should be long turn.

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Fig. 4-3 Pipe Application

—Dimensions and Weights of Seamless Brass and Copper Pipe (Iron-pipe Size)
(Table I, ASTM Specifications B42-43 and B43-42)

Size of pipe, inches	Outside diameter, inches	Regular pipe: Thickness, inches	Regular pipe: Nominal weight, pounds per foot of length: Yellow brass	Red brass	Copper	Extra-strong pipe: Thickness, inches	Extra-strong pipe: Nominal weight, pounds per foot of length: Yellow brass	Red brass	Copper
1/8	0.405	0.062	0.246	0.253	0.259	0.100	0.353	0.363	0.371
1/4	0.540	0.082	0.435	0.447	0.457	0.123	0.594	0.611	0.625
3/8	0.675	0.090	0.609	0.627	0.641	0.127	0.805	0.829	0.847
1/2	0.840	0.107	0.908	0.934	0.955	0.149	1.19	1.23	1.25
3/4	1.050	0.114	1.23	1.27	1.30	0.157	1.62	1.67	1.71
1	1.315	0.126	1.73	1.78	1.82	0.162	2.39	2.46	2.51
1 1/4	1.660	0.146	2.56	2.63	2.69	0.194	3.29	3.39	3.46
1 1/2	1.900	0.150	3.04	3.13	3.20	0.203	3.99	4.10	4.19
2	2.375	0.156	4.01	4.12	4.22	0.221	5.51	5.67	5.80
2 1/2	2.875	0.187	5.82	5.99	6.12	0.280	8.41	8.66	8.85
3	3.500	0.219	8.32	8.56	8.75	0.304	11.2	11.6	11.8
3 1/2	4.000	2.250	10.9	11.2	11.4	0.321	13.7	14.1	14.4
4	4.500	0.250	12.3	12.7	12.9	0.341	16.4	16.9	17.3
4 1/2	5.000	0.250	13.7	14.1	14.5	0.375	20.1	20.7	21.1
5	5.563	0.250	15.4	15.8	16.2	0.375	22.5	23.2	23.7
6	6.625	0.250	18.4	19.0	19.4	0.437	31.3	32.2	32.9
7	7.625	0.281	23.9	24.6	25.1	0.500	41.2	42.4	43.4
8	8.625	0.312	30.0	30.9	31.6	0.500	47.0	48.4	49.5
9	9.625	0.344	37.0	38.0	38.9	0.500	52.8	54.4	55.6
10	10.750	0.365	43.9	45.2	46.2	0.500	59.3	61.1	62.4
11	11.750	0.375	49.4	50.8	51.9				
12	12.750	0.375	53.7	55.3	56.5				

Note.—For inside diameter functions of IPS copper and brass pipe, see those for steel pipe on pages 357 to 367.

Fig. 4-4 Copper Pipe Data

Commercial Sizes (IPS) and Weights of Polyvinyl Chloride (PVC) Pipe (Abstracted from ATSM Specification D1785-64T)

Nominal size, in.	Schedule	Wall thickness,** in.	OD, in.	ID, in.	Theoretical weight,* lb/ft	Calculated min bursting pressure, psi	
						Note 1	Note 2
¼	40	0.088	0.540	0.364	0.076	2,490	1,950
	80	0.119	0.540	0.302	0.096	3,620	2.830
½	40	0.109	0.840	0.622	0.153	1,910	1,490
	80	0.147	0.840	0.546	0.195	2,720	2,120
¾	40	0.113	1.050	0.824	0.203	1,540	1,210
	80	0.154	1.050	0.742	0.265	2,200	1,720
1	40	0.133	1.315	1.049	0.305	1,440	1,130
	80	0.179	1.315	0.957	0.385	2,020	1,580
1¼	40	0.140	1.660	1.380	0.409	1,180	920
	80	0.191	1.660	1.278	0.550	1,660	1,300
1½	40	0.145	1.900	1.610	0.489	1,060	830
	80	0.200	1.900	1.500	0.653	1,510	1,180
2	40	0.154	2.375	2.067	0.640	890	690
	80	0.218	2.375	1.939	0.910	1,290	1,010
3	40	0.216	3.500	3.068	1.380	840	660
	80	0.300	3.500	2.900	1.845	1,200	940
4	40	0.237	4.500	4.026	1.965	710	560
	80	0.337	4.500	3.826	2.710	1,040	810

Water-pressure Ratings at 23 C (73.4 F) for Class T Threaded PVC Plastic Pipe (Commercial Standard CS256-63)

Nominal pipe size, in.	Dimension ratio	Pressure ratings[1] for PVC plastic pipe made from		
		PVC1120 PVC1220, psi	PVC4116, psi	PVC2110, psi
⅛	4.15	630	500	315
¼	4.15	630	500	315
⅜	4.15	630	500	315
½	5.0	500	400	250
¾	6.0	400	315	200
1	6.0	400	314	200
1¼	7.3	315	250	160
1½	9.0	250	200	125
2	11.0	200	160	100
2½	11.0	200	160	100
3	13.5	160	125	80
3½	13.5	160	125	80
4	17.0	125	100	63
5	17.0	125	100	63
6	21.0	100	80	50
8	26.0	80	63	NPR[2]
10	32.5	63	50	NPR[2]
12	41.0	50	NPR	NPR[2]

[1] Pressure ratings shown for threaded pipe are one-half those calculated in accordance with

$$\frac{2S}{P} = \mathrm{SDR} - 1 \quad \text{or} \quad \frac{2S}{P} = \frac{\mathrm{OD}}{t} - 1$$

where S = design stress, psi
P = pressure rating, psi
OD = average outside diameter, in.
t = minimum wall thickness, in.
SDR = standard thermoplastic pipe dimension ratio (OD/t for PVC pipe)
Thus, pressure ratings for nonthreaded pipe in Class-T dimensions are twice those given in this table.

[2] NPR = not pressure-rated.

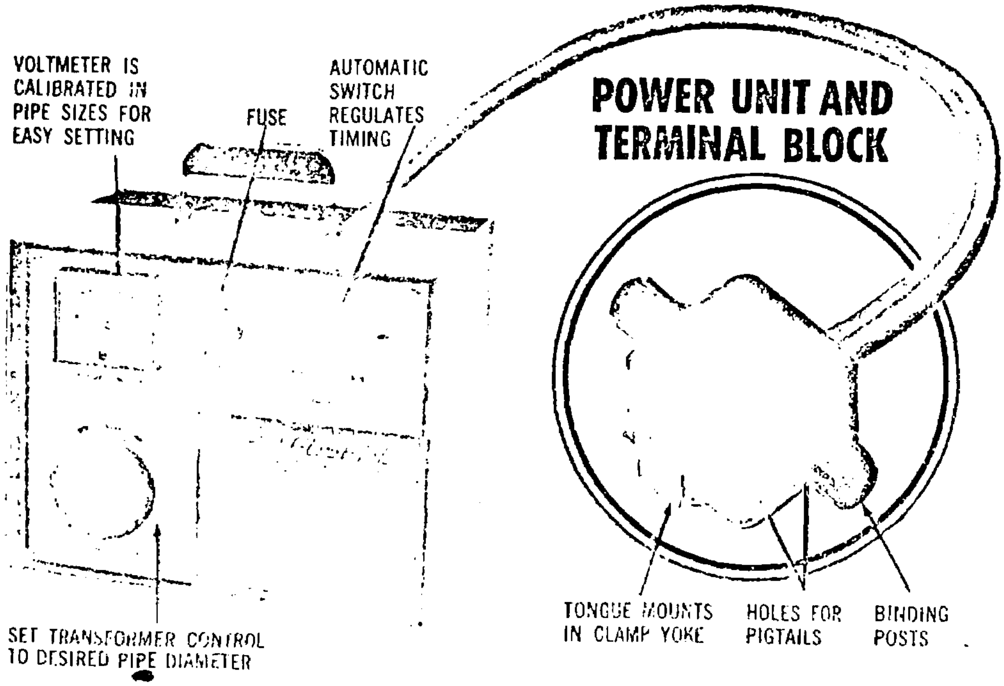
Fig. 4-5 PVC Pipe Data

Pictured at right is the procedure for producing perfect leakproof joints by the GSR FUSEAL Method. The FUSEAL Process applies precisely the right heat within the joint to produce a completely homogenous structure of pipe and fitting. The FUSEAL Equipment used in the process is uncomplicated in use and is designed and built for years of dependable service.

The many advantages of the FUSEAL Process provide the most modern and efficient acid-waste systems with impressive savings in material and initial cost. Your local GSR Distributor or Representative will be pleased to show you how your acid-waste problems can be permanently solved by the installation of a FUSEAL Drainage System to meet your requirements.

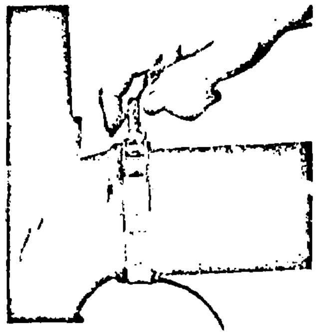
No special electrical skill is needed to operate the power unit. Just plug it into a 120-volt A-C outlet with a minimum capacity of 4 amperes. Temporarily turn the time switch ¼ turn clockwise so that the voltmeter is in operation, then turn the size selector knob clockwise until the voltmeter needle points to the size of the pipe you will be installing. Now turn off the timer switch. The power pack is ready to use as soon as your joint is prepared. COIL SHOULD NOT be connected to the terminal block when making this adjustment.

Within one minute after automatic cutoff of the current, the joint sets up to produce a connection that no longer has an interface. The pipe and fitting are a single homogeneous structure. The wire coil remains in the structure, completely encased in polypropylene and protected against any contact with the pipe contents.

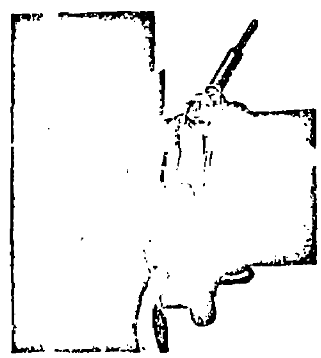


Polypropylene collar containing electrical resistance wire is slipped on pipe, pigtail end first.

Pipe end and collar are inserted in fitting socket so that collar bottoms against counterbore, and the pipe bottoms against the pipe stop.



Compression clamp is applied to give intimate contact between fitting socket, collar and pipe.



GSR FUSEAL Power Unit provides controlled, timed current to make perfect, thermo-electric joints.

Courtesy-
R & G Sloan Mfg. C

Fig. 4-6 Fuseal Process

EQUIPMENT

Equipment necessary to install electrical fusion joined polypropylene drain, waste and vent pipe and fittings consists of an infinitely variable, low voltage alternating current power supply and adjustable quick operating band clamps, sized to fit the outside of the fitting sockets. The power supply consists of a variable voltage transformer, 0-140 VAC output, feeding into a 4:1 stepdown isolation output transformer. A volt meter, calibrated in pipe size, reads output voltage. A 0-3 minute timing switch controls the time of energization of the fusion coils.

JOINT FUSION INSTRUCTIONS

A. ADJUSTMENT OF POWER UNIT:

1. Attach power cord to 120 Volt A.C. source with a 4 amp. minimum capacity.
2. Turn timer knob ¼ turn clockwise.
3. Turn size selector knob clockwise until meter needle is opposite appropriate pipe size mark.
4. Turn timer knob to "off" position.

B. JOINT PREPARATION:

1. Cut pipe end square with axis of pipe. Use fine tooth hand saw and a mitre box, a power cutoff saw, or a plastic tubing cutter to help make a precision cut.
2. Remove all burrs remaining on end of pipe from both inside and outside surfaces.
3. Wipe all dirt and foreign matter from end of pipe and fitting socket, using a clean, dry cloth.
4. Do not handle the freshly cleaned surfaces before assembling the joint.

C. SETTING UP JOINT:

1. Place fusion coil on pipe end, taking care not to touch freshly cleaned surface. The lead wires should point away from the pipe end. Leave the coil end flush with the end of the pipe.
2. Insert pipe end and coil into fitting socket. Push in until pipe end passes small shoulder and touches large shoulder. The coil will slide up the pipe the distance between the small and large shoulders.
3. Fit the steel band clamp to the joint, allowing the clamp to seat flush with the socket end. The sheet metal yoke on the clamp is to be located centrally between the coil leads.
4. Insert the metal tongue on the lower surface of the output cord terminal block into the yoke on the clamp. Back off the binding post nu two turns.
5. Insert the bared ends of the fusion coil leads through the guide holes on the top of the terminal block.
6. Tighten the binding post nuts firmly but do not force them. Serrated surfaces on the binding post nuts will cut through the enamel insulation on the coil leads.

D. FUSING THE JOINT:

1. For 1½ inch through 4 inch turn the timer knob to the 1½ minute index mark. After approximately 60 seconds, tighten the clamp by one turn to effect thorough fusion and penetration of the joint.
2. For 6 inch turn the timer knob to the 3 minute index mark. After approximately 2 minutes, tighten the clamp by one turn to effect thorough fusion and penetration of the joint.
3. After the timer has "timed out," a sharp click will indicate that the power has automatically shut off. Wait at least one minute before removing the clamp from the joint to allow time for initial cooling.
4. In temperatures below 40°F (4°C), increase fusion time to 1¾ minutes or longer, (3½ minutes for 6"), depending on actual temperature.

E. TESTING:

Joints may be pressure tested 10 minutes after fusing.

Courtesy-
R & G Sloan Mfg. Co.

Fig. 4-7 Fusion Instructions

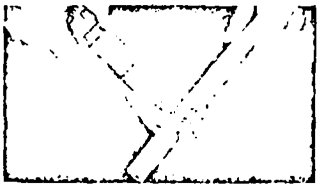
Solvent cementing is the preferred method of joining CPVC (chlorinated polyvinyl chloride) hot and cold water pipe and fittings. Solvent cementing procedures are simple and provide perfect chemically fused joints if each step is handled with reasonable care. Experience shows that field failures almost without exception are due to improperly made solvent cement joints.

KNOW YOUR MATERIAL

GSR® Hi-Temp Pipe and Fittings are made from chlorinated polyvinyl chloride, commonly referred to as CPVC. CPVC is one of the few plastic materials suitable for both hot and cold water piping systems: The method of joining CPVC is similar to, but slightly different than, that of other plastic pipe and fittings. The following instructions should be read carefully. **DO NOT TAKE SHORTCUTS OR OMIT ANY OF THE DETAILED STEPS.**

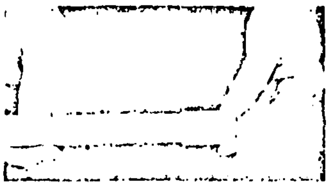
CPVC solvent cement contains highly volatile solvents which evaporate rapidly. Keep the cement can closed when not actually in use. If the cement thickens much beyond its original consistency, discard it! **DO NOT ATTEMPT TO DILUTE IT WITH THINNER.**

Use only GSR #703 Cleaner-Primer and GSR #707 Solvent Cement with GSR CTS-CPVC pipe and fittings.

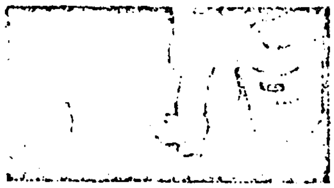


The pipe may be cut to length with a tubing cutter.* Tubing cutters with thin cutting wheels *designed especially for plastic* are recommended. Where tubing cutters are not available, a saw and mitre box may be used.

Remove all saw marks and burrs from the inside and outside of the pipe with a *deburring tool***, *pocket knife, scraper or file*. Then clean both the pipe and fitting with a clean dry rag.



Check the pipe and fitting for an interference fit. GSR CTS-CPVC pipe and fittings are designed to have a dry interference fit. A good dry interference fit exists when the pipe makes contact with the fitting socket wall between 1/3 and 2/3 of the way into the socket. If the pipe can be bottomed dry, or if the pipe will not enter the fitting dry, check the dimensions of the pipe and fitting.



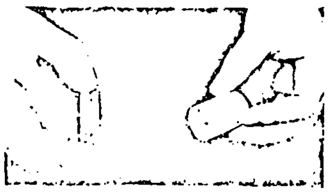
Apply GSR cleaner-primer #703 to the inside surface of the fitting socket. A light coat is normally sufficient. Avoid puddling.

Now apply *cleaner-primer* to the *pipe end* to the depth of the fitting socket.

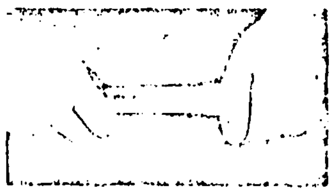
Primed surfaces should be fairly dry or tacky prior to applying the cement.

At temperatures between 40°F and 110°F a cleaning action is all that is required. Do not attempt to soften the surface as is required for regular PVC joints.

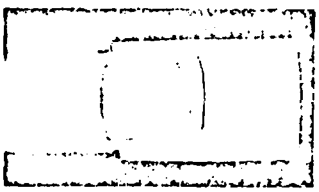
Apply a full, even coating of GSR #707 solvent cement to the pipe end to the depth of the fitting socket.



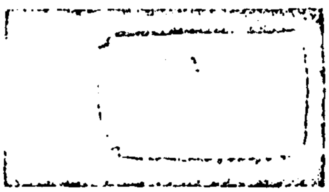
Apply a light, even coating of GSR solvent cement to the inside of the fitting socket including the pipe stop shoulder. Then apply a second full, even coating to the pipe end.



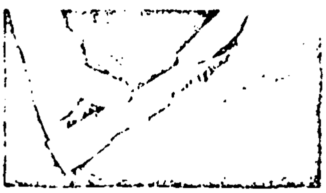
While both surfaces are still wet, insert the pipe in the socket, make a one-quarter turn until the pipe end bottoms against the socket shoulder. Hold the joint together for about 15 seconds to assure the pipe remains bottomed against the socket shoulder.



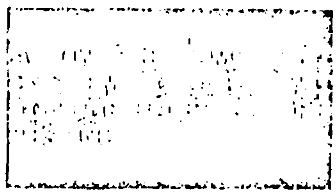
Wrong Way — The pipe end has not bottomed against the socket shoulder.



Right Way — The pipe has bottomed in the socket.



Using a clean rag, remove all excess solvent cement, especially the bead. A full ring of cement should show at the joint. Voids may indicate a defective joint.



SEE

JOINT CURE SCHEDULE

Courtesy-
R & G Sloane Mfg. Co.

Fig. 4-8 Solvent Cementing

COLD WEATHER SOLVENT CEMENTING PROCEDURE

Solvent cement joints should be made at temperatures between 40°F and 110°F. Successful joints can be made at temperatures as low as 0°F if special precautions are taken.

In cold weather, the action of the cleaner-primer is retarded. More than one application of cleaner-primer may be necessary. When properly primed the surfaces should be tacky or slightly softened. To check penetration, scrape a small section of the surface with a knife. When a thin layer can be removed, the surface is properly softened. Cement can now be applied and the joint can be made by following normal procedures.

STORAGE AND HANDLING

CPVC pipe and fittings should be stored under cover to avoid unnecessary dirt accumulation and long term exposure to sunlight. Pipe should be stored with continuous support in straight, uncrossed bundles. Care should be used in handling to ensure that unnecessary abuse such as abrasion on concrete or crushing is avoided. Primer and cement should be stored in a cool, shady place when not in use.

SOLDERING

Soldered metal joints should not be made closer than 18" to an installed plastic-to-metal adapter in the same water line.

PLASTIC TO METAL TRANSITION

The GSR transition tailpiece adapter is recommended in making plastic to metal transitions on the hot water side of the system. The assembly consists of a GSR CPVC transition tailpiece adapter Fig. No. 375 Mod 1*, a GSR CPVC coupling and a ⅝" O.D. or ⅞" O.D. brass compression fitting. Slip the nut from the brass fitting on the CPVC tailpiece adapter. Then solvent cement the adapter to a CPVC coupling. The brass compression ring from the CPVC side of the brass fitting is discarded. Insert the tailpiece adapter into the brass fitting until the rubber gasket butts up against the fitting. The brass locknut is brought tight against the adapter retaining shoulder. In order to prevent the nut from backing off, it must be tightened one to one and a quarter turn past hand tight.

CTS-CPVC male adapters are recommended in making plastic to metal transitions on the cold water side of the system only.

HOSE BIBB CONNECTIONS

The use of metal nipples is recommended in making connections to hose bibbs. The CPVC plastic system should terminate inside the wall.

PRESSURE TESTING

To pressure-test a CPVC water system, use a portable piston water pump equipped with check valves, shut-off valve, and a 0-200 psi gauge. Purge the system of air, pump up the system to 150 psi and shut the valve on the pump outlet. Let stand for one hour. If the gauge still reads 150 psi, there are no leaks. The system has passed the test. If the pressure has dropped, check all valves and joints for leaks. Relieve the pressure after testing.

REPAIR

If a leak is discovered in a joint, that portion of the system should be drained and the joint should be cut out. The pipe should be thoroughly dried and a new section should be installed. Prepare the new section identica. to the one removed and cement couplings to both ends. Let the couplings dry for 10 minutes and then cement the new section into place. After one hour, re-check the system at 150 psi. If there are no other leaks, the system may be put into service.

THERMAL EXPANSION

The linear thermal expansion rate for CPVC is approximately ½ inch per 10°F temperature change for each 100 feet of pipe. When installing long runs of pipe, allow 1/16 inch longitudinal clearance per foot of run to accommodate thermal expansion. Proper design requires an offset of 12 inches or more in every 10 foot straight run of pipe to absorb thermal movement.

SUPPORT SPACING

The recommended spacing between supports is 24 to 36 inches. Pipe should not be anchored rigidly to a support. Choose the proper size plastic clamps which are engineered to allow the pipe to move freely with minimum noise. The use of plastic pipe insulators through wood and metal studs are also recommended.

WATER HEATER CONNECTIONS

When using GSR Hi-Temp pipe and fittings in conjunction with domestic water heaters, stub out with metal pipe for a minimum of 12 inches on both inlet and outlet connections. Proper hot water tank pressure settings and relief valves should be installed and maintained to assure water temperature not in excess of 180°F.

* Fig. No. 375 Mod 1 is a modification of Fig. No. 375. Both models are still in use. Fig. No. 375 is designed with an "O" ring seal and should be used with brass compression fittings manufactured by Brass Craft Co., Inc., Detroit, Michigan. If brass fittings produced by another manufacturer are used, the installer must satisfy himself that a proper fit exists.

JOINT CURE SCHEDULE

TEMPERATURE OF PIPE AND FITTINGS DURING ASSEMBLY AND CURE	TIME ALLOWED BEFORE TESTING AT ROOM TEMPERATURE. TEST PRESSURE 150 PSI MAX.	TIME ALLOWED BEFORE PUTTING SYSTEM INTO SERVICE AT 100 PSI AND 180°F MAX
60°F to 110°F	2 hours	24 hours
40°F to 60°F	4 hours	48 hours

Courtesy-
R & G Sloan Mfg. Co.

Fig. 4-9 Solvent Cementing

ASSEMBLING PLASTIC D-W-V PIPE

1. Use only standardized and approved DWV pipe fittings and solvent cement. Look for the marks , CS270, CS272, NSF and NSF DWV on all products to be sure of the quality.

2. Cut pipe square, using a hand saw and miter box, a mechanical cut off saw, or a plastic pipe cutter which does not raise a burr on the end of the pipe.

3. Don't use a standard wheel cutter. It will raise a flare on the end of the pipe. The flare will scrape the cement from the joint and create a leak.

4. Remove all burrs from the end of the pipe with a file or knife. If all the burrs are not removed they may scrape lines in the cement and create leaks.

5. Clean and dry the pipe and fitting socket of all dirt, moisture, and grease. Use a clean dry rag.

6. Use only solvent cements carrying the ASTM specification number and/or the NSF seal of approval. Use only ABS cement for ABS pipe and fittings and PVC cement for PVC products. Unapproved or unknown brands of cement may contain substances that can damage the pipe & fittings.

7. Don't use thinner to dilute the solvent cement. Discard the cement if it thickens very much in the can. Keeping the cement can closed as much as possible while working will help to prevent thickening.

8. Dry fit the pipe into the fitting socket. It should enter at least ⅓ of the socket depth, and should at least snug up at the socket bottom in ABS parts. For PVC parts, a little looseness at the socket bottom can be tolerated.

9. For ABS components, first coat the inside of the fitting socket, then coat the outside of the pipe. Flow the cement on with a full brush. Assemble parts immediately with a quarter turn to spread the cement evenly.

10. For Type I PVC parts (PVC 1120 or 1220), degloss the pipe and fitting socket with cleaner — MEK, MIBK or acetone, or lightly sand the surfaces before applying cement. Coat the pipe first, then the socket, then a second coat on the pipe. Again, assemble immediately, with a quarter turn. Allow freshly made joints to set a few minutes before moving or applying any force to them.

11. Use only approved thread tape or thread lubricant specifically intended for making up threaded joints. Some of the thread lubricants found satisfactory are:

    VASELINE (commonly available)

    MINERAL OIL (commonly available)

    TEFLON TAPE — 3M COMPANY, 2501 Hudson Rd., St. Paul, Minn.

    PERMATEX NO. 2 — PERMATEX CO., INC., 1720 Avenue Y, Brooklyn 35, N.Y.

    "LA-CO PLASTO-JOINT STIK" — LAKE CHEMICAL CO., 250 N. Washtenaw, Chicago, Ill. 60612

    JOHN CRANE NO. 4 — CRANE PACKING CO., Morton Grove, Ill.

    TIIREDOPE — COLEMAN CO., Everett, Mass.

    IPS WELD-ON 783 — INDUSTRIAL POLYCHEMICAL SERVICE, 17116 S. Broadway, Gardena 47, California

12. Don't use conventional pipe thread compounds, putty, linseed oil base products or unknown mixtures. They can cause cracking of the parts.

13. Threaded connections should be made up one turn past hand tight, using a strap wrench. Overtightening may damage the parts.

14. Don't pull or force pipe into line when assembling. This stresses both pipe and fittings and can lead to future trouble.

15. Allow for thermal expansion in all installations by allowing freedom for the pipe to move with temperature changes. Leave the pipe free to move longitudinally at changes in directions and on long straight runs, but support it at four foot maximum intervals.

16. Refer to IAPMO installation standards IS 5-66 and IS 9-68 for full information on thermal expansion.

17. Use threaded transition fittings when connecting to copper systems. Caulked joints or other approved fittings may be used in connecting plastic to cast iron.

18. Use caution when heating lead for caulked joints. Heat it to just above the melting point. A good rule to follow is to heat the lead to wiping temperature.

19. Use common salt or calcium chloride solutions for antifreeze, where necessary. If preferred, ethylene glycol antifreeze may be used.

20. Don't use alcohol antifreeze in any part of the plastic DWV system.

Courtesy

R & G SLOANE MANUFACTURING COMPANY, INC.

7606 N. CLYBOURN AVENUE, SUN VALLEY, CALIFORNIA 91352

Fig. 4-10

Victaulic

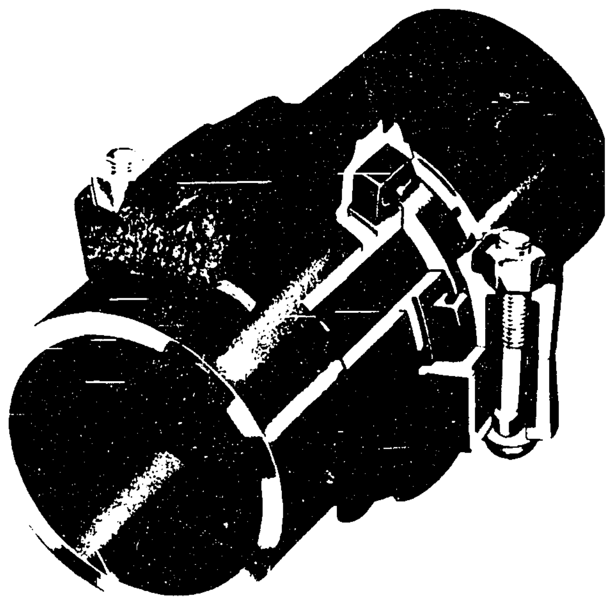
GROOVED PIPING METHOD

The Victaulic method of joining grooved pipe is the most versatile piping method available. It is five times faster than welding; easier and more reliable than threaded or flanged methods. Assures long life, leak tight security and lower installed cost than competitive methods.

The Victaulic method has the versatility of a piping system which provides expansion, flexibility and vibration reduction with a union at each joint. Victaulic can be applied to black or galvanized steel, stainless, aluminum, wrought iron, plastic—almost any pipe of IPS dimensions. A single coupling size fits most types and wall thickness of pipe in its size. (And Victaulic has couplings for cast iron sizes, too.)

The Victaulic grooved piping line is the most complete available. With a variety of couplings in ¾″ through 30″ sizes. A complete line of fittings. Butterfly valves. Plus the unique Vic-Flange, Outlet Couplings and other products available only from Victaulic. Portable groovers for on-site grooving. A nation wide stocking distributor organization, backed by eight Victaulic warehouses across the country.

The Victaulic method is simple yet effective. Based on a groove machined in the pipe end, the system is joined by ductile or malleable iron housings which lock into the grooves enclosing a synthetic gasket to create the seal.



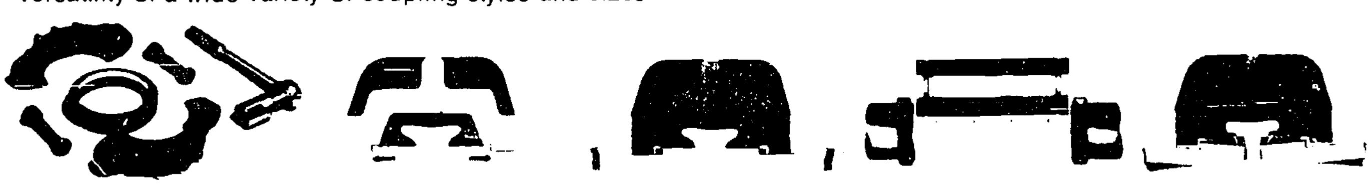
1—**HOUSING**—The housing segments are precisely cast of ductile or malleable iron. The housing key engages the grooves in the pipe around the entire circumference securely joining the pipes.

2—**GASKET**—The gasket is designed to seal under pressure or vacuum. Molded of varied synthetic elastomers, the gasket is designed to provide long life for the intended service.

3—**BOLTS/NUTS**—The steel oval neck track bolts se. in the housing slots permitting assembly with single wrench.

4—**GROOVE**—The groove permits joining of the pipe together without clamping. This provides the con trolled flexibility and permits rapid assembly. Pip is available from mills or distributors grooved fc Victaulic couplings. A complete line of portabl tools adds versatility for easy on-site grooving.

THE METHOD . . . The unique design features of the Victaulic grooved piping method offer many advantages not available with other methods. Victaulic offers the versatility of a wide variety of coupling styles and sizes plus a complete line of fittings, grooving tools and accessories. Quality and reliability are assured by more than 45 years of experience in grooved pipe joining.



Fast, simple assembly | **A permanent joint** | **Expansion and contraction allowance** | **Union at each joint** | **Easy alignment**

Fig. 4-11

Working pressures listed are based on hydrostatic tests with no external load using standard weight steel pipe through 20-inch (XS above 20-inch), square cut grooved to Victaulic standard specifications.

Field test pressures shall not exceed 1½ times rated the working pressure including external loads.

To assure the maximum life for a particular service, refer to Victaulic Gasket Selection Guide and always specify gasket grade when ordering.

VICTAULIC GROOVING DIMENSIONS

for Steel, Wrought Iron, Spiral, Aluminum, Brass, Plastic, and other Pipe of IPS Dimensions

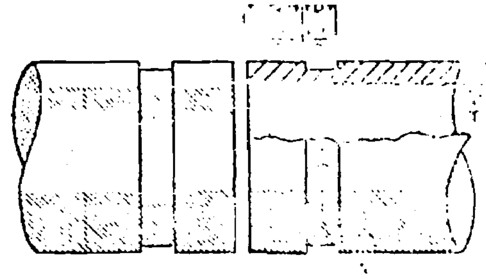


TABLE 3

PIPE		VICTAULIC GROOVE DIMENSIONS					
SIZE	O.D.	A	B	C		D	T (Minimum)
¾	1.050	⅝	5/16	.938	+ 0 — .015	.056	.113
1	1.315	⅝	5/16	1.190	+ 0 — .015	.062	.133
1¼	1.660	⅝	5/16	1.535	+ 0 — .015	.062	.140
1½	1.900	⅝	5/16	1.775	+ 0 — .015	.062	.145
2	2.375	⅝	5/16	2.250	+ 0 — .015	.062	.154
2½	2.875	⅝	5/16	2.720	+ 0 — .018	.078	.187
3" O.D.	3.000	⅝	5/16	2.845	+ 0 — .018	.078	.188
	3.500	⅝	5/16	3.344	+ 0 — .018	.078	.188
3½	4.000	⅝	5/16	3.834	+ 0 — .020	.083	.188
4	4.500	⅝	⅜	4.334	+ 0 — .020	.083	.203
4½	5.000	⅝	⅜	4.834	+ 0 — .020	.083	.203
5	5.563	⅝	⅜	5.395	+ 0 — .022	.084	.203
5½	5.500	⅝	⅜	5.334	+ 0 — .020	.084	.203
O.D.	6.000	⅝	⅜	5.830	+ 0 — .022	.085	.219
6	6.625	⅝	⅜	6.455	+ 0 — .022	.085	.219

TABLE 3 — Continued

PIPE		VICTAULIC GROOVE DIMENSIONS					
SIZE	O.D.	A	B	C		D	T (Minimum)
6⅝	7.000	⅝	⅜	6.830	+ 0 — .022	.085	.219
7	7.625	23/32	15/32	7.447	+ 0 — .025	.089	.238
8" O.D.	8.000	¾	7/16	7.816	+ 0 — .025	.092	.238
8	8.625	¾	7/16	8.441	+ 0 — .025	.092	.238
9	9.625	¾	7/16	9.460	+ 0 — .025	.032	.238
10	10.750	¾	½	10.562	+ 0 — .027	.094	.250
12	12.750	¾	½	12.531	+ 0 — .030	.109	.279
13½	13.500	15/16	½	13.188	+ 0 — .030	.156	.375
14	14.000	15/16	½	13.781	+ 0 — .030	.109	.281
15	15.000	15/16	½	14.781	+ 0 — .030	.109	.312
16	16.000	15/16	½	15.781	+ 0 — .030	.109	.312
18	18.000	1	½	17.781	+ 0 — .030	.109	.312
20	20.000	1	½	19.781	+ 0 — .030	.109	.312
24	24.000	1	9/16	23.656	+ 0 — .030	.172	.437
28 I.D.	28.875	1	9/16	28.531	+ 0 — .030	.172	.437
30 I.D.	31.000	1¼	⅝	30.594	+ 0 — .030	.203	.50

The pipe shall be sufficiently free from indentations, projections, or roll marks from the end of the pipe to the groove, to provide a leak-tight seat for the gasket.

The nominal outside diameter of grooved pipe shall not vary more than ¾" to 1¼" ±1/64"; 1½" to 2½" ± 1%; 3" to 5" +1% —1/32"; 6" and up +1/16" —1/32". Use Column C when grooving. Column D is the calculated normal groove depth.

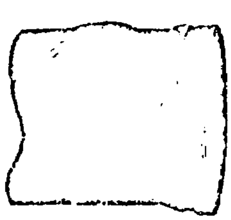
The groove diameter can be measured by means of a tape, provided the pipe is maintained within +1/32 to —1/64 of the nominal outside diameter.

T Minimum—is the lightest grade or thickness of pipe suitable for grooving. Standard weight pipe in all sizes, and some of the lighter grades of 8" and larger, exceed these minimum thicknesses. Pipe of less than T minimum thickness may be adapted with collared ends for use with Victaulic Couplings—see page 24.

NOTE: Pipe to be internally lined with cement or plastic lining requires special grooving dimensions. Write for Victaulic Charts SK-1492 (roll-grooving light wall pipe) and/or SK-1493 (cut-grooving standard wall pipe).

For standard roll-grooving dimensions for light wall pipe, write for Dimension Chart D-40.
For Endseal 'ES' cut-grooving dimensions, write for Dimension Chart D-31,
and for Endseal 'ES' roll-grooving dimensions, write for Dimension Chart D-41.

Fig. 4-12

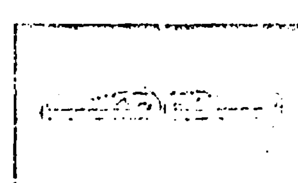


LIGHTWEIGHT SPIRAL PIPE

Lightweight Spiral Pipe of 8, 10, 12 and 14 gauge thickness is widely used with standard Victaulic Couplings. The pipe end, as shown, is simply a short grooved nipple welded on at the mill. Spare nipples can be furnished for field attachment when cutting pipe sections to special length.

PIPE WITH INTERNAL LININGS

Rubber lined pipe and fittings for corrosive and abrasive services are supplied with Victaulic Ends by leading rubber companies. The rubber lining is lapped completely around the ends, as shown, making a rubber-to-rubber seal with the Victaulic Gasket. Cement lined, lead lined, and plastic lined pipe can also be supplied with Victaulic Ends. Consult us for details on any of these applications. For rubber-lining dimensions, write for Dimension Chart D-30.



For information on Victaulic Couplings, Style HP-70ES (Endseal), for use with cement-lined or plastic-lined pipe, write for separate bulletin.

PRODUCT
FACTS

BEST COPY AVAILABLE

Courtesy- JOHNS-MANVILLE

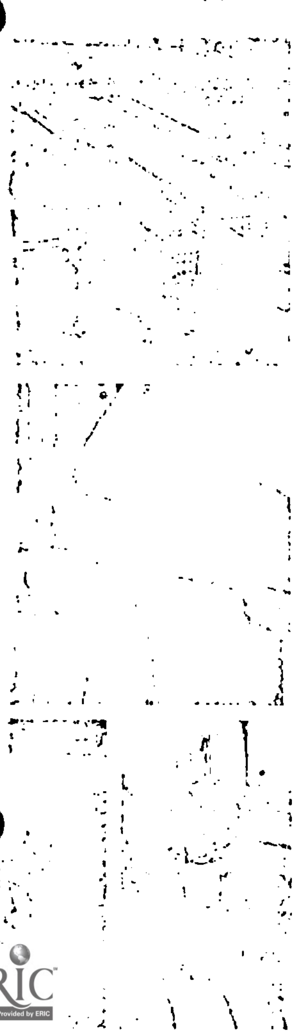
TRANSITE* RING-TITE WATER PI

*TRANSITE is Johns-Manville's registered trademark for its brand of asbestos-cement products

For Supply Lines and Distribution Systems Carrying Water Under Pressure

RESEARCH, MATERIALS MANUFACTURE

ınstant research in one of ɛ world's largest laboratos — controlled blending of sic raw materials (asbestos ers, cement and silica) — odern manufacturing techues and autoclave-curing — duce a uniformly finished, mogeneous pipe which nbines (1) inherent strength (2) density (3) maximum corrosion resistance and (4) long life expectancy. Meets the standard requirements of water service pipe.



SIZES AND WEIGHTS

PIPE SIZE INCHES	CLASS 100 PIPE WGT LBS PER FT*	CLASS 100 CPLG WGT EACH
4	6.1	6.0
6	11.1	10.6
8	16.5	13.5
10	22.2	15.9
12	31.1	24.0
14	39.2	37.1
16	50.0	45.6
18	66.3	68.3
20	80.5	77.8
24	112.5	106.0
30	172.7	183.4
36	242.6	257.4
	CLASS 150 PIPE WGT LBS PER FT*	**CLASS 150** CPLG WGT EACH
4	7.2	7.4
6	12.3	11.3
8	18.7	17.5
10	29.9	26.8
12	41.0	41.5
14	55.0	64.2
16	68.3	81.0
18	90.9	100.8
20	111.1	116.8
24	158.5	159.5
30	248.6	276.6
36	356.4	389.5
	CLASS 200 PIPE WGT LBS PER FT*	**CLASS 200** CPLG WGT EACH
4	8.8	7.4
6	14.5	12.4
8	22.2	18.9
10	34.5	28.9
12	48.2	46.8
14	64.7	72.7
16	83.7	91.8
18	129.5	147.4
20	160.0	178.9
24	226.7	252.6
30	359.1	436.6
36	[illegible]	618.1

*Includes pipe, coupling and rings.

STANDARD LENGTHS (NOMINAL)

PIPE SIZES	STANDARD LENGTHS
4" & 6"	10' and 13'
8" thru 36"	13'

PIPE AND COUPLING DIMENSIONS (INCHES

Class 100

Pipe Size in.	D	D_2	D_3	D_6	D_7*	D_8	D_9*
4	4.00	4.64	4.80	5.38	6.38	4.76	4.92
6	6.00	6.91	7.07	7.65	8.85	7.03	7.19
8	8.00	9.11	9.27	9.85	11.05	9.23	9.39
10	10.00	11.24	11.40	11.98	13.25	11.36	11.47
12	12.00	13.44	13.60	14.18	15.70	13.56	13.74
14	13.59	15.07	15.23	15.95	17.59	15.20	15.51
16	15.50	17.15	17.31	18.03	19.86	17.28	17.65
18	18.00	19.90	20.06	20.78	23.01	20.03	20.44
20	20.00	22.12	22.28	23.00	25.32	22.25	22.68
24	24.00	26.48	26.64	27.36	30.10	26.61	27.12
30	30.00	33.12	33.28	34.02	37.63	33.27	33.80
36	36.00	39.78	39.94	40.68	44.92	39.93	40.46

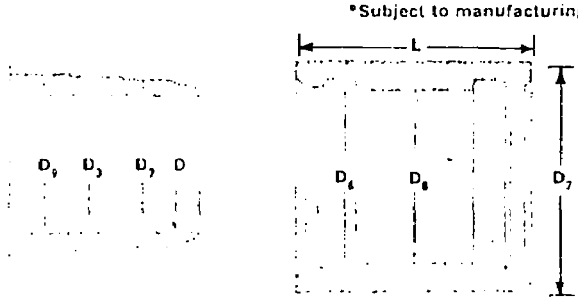
Class 150

Pipe Size In.	D	D_2	D_3	D_6	D_7*	D_8	D_9*
4	4.00	4.81	4.97	5.55	6.67	4.93	5.07
6	5.85	6.91	7.07	7.65	8.96	7.03	7.17
8	7.85	9.11	9.27	9.85	11.52	9.23	9.37
10	10.00	11.66	11.82	12.40	14.51	11.78	11.92
12	12.00	13.92	14.08	14.66	17.15	14.04	14.18
14	14.00	16.22	16.38	17.10	20.00	16.35	16.48
16	16.00	18.46	18.62	19.34	22.64	18.59	18.72
18	18.00	20.94	21.10	21.82	25.12	21.07	21.30
20	20.00	23.28	23.44	24.16	27.65	23.41	23.64
24	24.00	27.96	28.12	28.84	32.92	28.09	28.32
30	30.00	35.00	35.16	35.90	41.20	35.15	35.42
36	36.00	42.04	42.20	42.94	49.28	42.19	42.46

Class 200

Pipe Size In.	D	D_2	D_3	D_6	D_7*	D_8	D_9*
4	4.00	4.81	4.97	5.55	6.67	4.93	5.33
6	5.70	6.91	7.07	7.65	9.10	7.03	7.32
8	7.60	9.11	9.27	9.85	11.66	9.23	9.50
10	9.63	11.66	11.82	12.40	14.69	11.78	11.92
12	11.56	13.92	14.08	14.66	17.48	14.04	14.18
14	13.59	16.22	16.38	17.10	20.42	16.35	16.59
16	15.50	18.46	18.62	19.34	23.11	18.59	18.90
18	18.00	22.18	22.34	23.06	27.73	[illegible]	22.54
20	20.00	24.66	24.82	25.54	30.71	24.79	[illegible]
24	24.00	29.62	29.78	30.50	36.71	29.75	29.58
30	30.00	37.06	37.22	37.96	45.92	37.21	37.48
36	36.00	44.52	44.68	45.42	54.94	44.67	44.94

*Subject to manufacturing tolerances



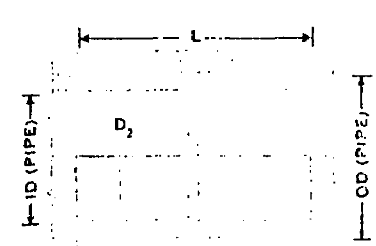


Fig. 4-13

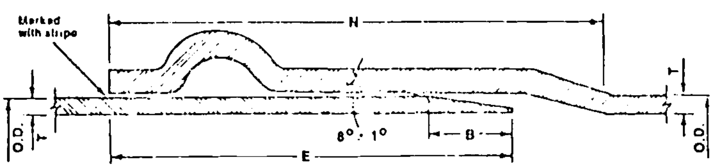
PVC plastic pipe has established itself as a reliable pipe product, superior to metallic pipe in many respects. It is immune to electrolytic and galvanic corrosion. It can absorb stresses under many loads that could break rigid pipe. It is lightweight and, with J-M RING-TITE joints, a PVC pipeline can be installed in less time at less expense.

Now, with CLASS 150 RING-TITE PVC pipe, Johns-Manville makes available the only PVC pipe specifically designed to meet the rigorous standards of the American Water Works industry. It provides the quality that should be present in demanding water-systems service.

An extra-strength pipe (SDR 13.5 dimensions) extruded from clean, virgin, class 12453-B PVC compound conforming to resin specification D-1784. Approved by National Sanitation Foundation for potable water service. Minimum, long-term hydrostatic strength sufficient for 4-to-1 safety factor at 150 psi operating pressure—to meet requirements of accepted water works engineering practice. Integral, thickened-wall bell with deep ring groove to seat a rubber sealing ring as shown.

Specifically designed to satisfy commonly-accepted requirement of 4-to-1 safety factor in municipal water systems primarily. Also for other important services including industrial water supply, firelines, forced sewer mains.

Sizes* (nom. I.D. IPS) 4" and 6"
Laying lengths: 20'±1"
Fittings and Adaptors: 6" J-M Fiber Glass fittings; IPS-metal and other metal fittings. Adaptors available.



DIMENSIONS AND WEIGHTS

Nom. Size IPS	Op. Press. psi @ 73°F.	Pipe Barrel Min. Wall Thickness	Pipe Barrel O.D.	O.D. Tolerance + or -	Wt. lbs. Per Length
4"	150	0.333"	4.500"	.009"	57.2
6"	150	0.491"	6.625"	.011"	124.7

All dimensions are in inches

4-to-1 Safety Factor
CLASS 150 wall thickness with 4000 psi long-term hoop stress provides for an ultimate minimum hydrostatic strength capacity of 600 psi, a 4-to-1 Safety Factor based on 150 psi operating pressure. Provides the extra strength desired in commonly-accepted engineering practice, to resist surges and water hammer.

Tough, Resilient
The extra wall thickness means extra strength to resist strains and stresses that could rupture weaker pipes. Minimum 4000 psi hoop stress in 1000-hour tests. Virtually immune to the impact damage encountered in ordinary handling and operations. Can absorb stresses under heavy loads that, in many instances, could break rigid pipe.

No Metallic Corrosion
Immune to electrolytic and galvanic corrosion. PVC resin is unaffected by the corrosive waters and soils encountered in most water distribution systems. No increase in internal friction or reduction of internal diameter as a result of tuberculation or corrosion. No need for costly lining, wrapping, coating or cathodic protection.

High Flow
Coefficient of flow is C=150 W&H, the best available in common use in water systems. Smooth wall stays smooth during long years of service, no loss in carrying capacity. Permits savings in pumping costs or savings in pipe sizes. See page 4.

Tight Joints
Seated in a deep groove, the flexible rubber ring provides a tight, flexible seal that remains tight and cushions the line against shock, vibration, and earth movements. Also compensates for expansion and contraction of pipe lengths and eliminates the need for "snaking." Eliminates all solvent-weld problems. No field-mixing or application of cement. No weakening of the pipe wall by solvent. No delays while waiting for the solvent to set. Johns-Manville, the pioneer and leader in rubber-ring joints simplifies joint-making and provides the ring joint designed to start tight and stay tight under all conditions of service.

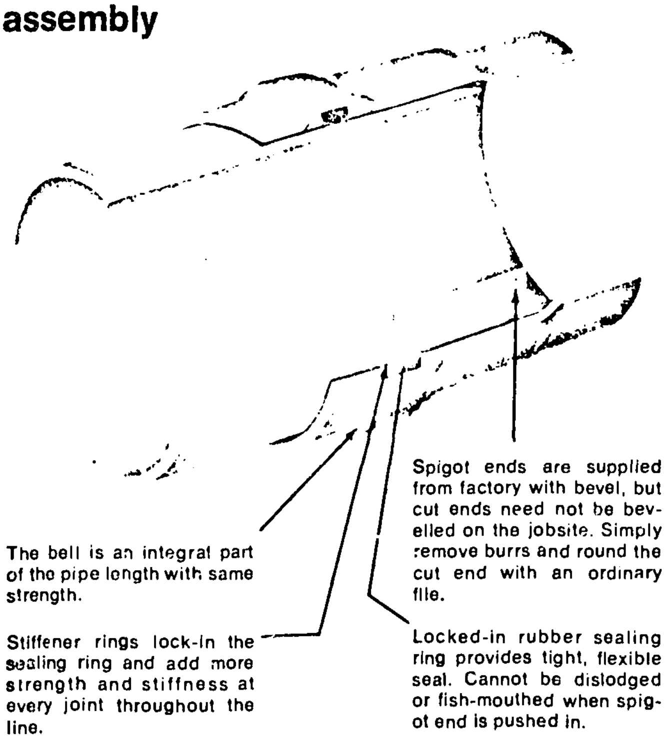
Low Installed Cost
Engineered to reduce the amount of materials required and to save time, J-M CLASS-150 RING-TITE PVC pipe can be installed in a fraction of the time it takes to open and prepare the trench. All lengths can be handled by hand. No costly handling equipment necessary. Long, twenty-foot lengths reduce the numb[illegible] of joints to be made. RING-TI[illegible] [illegible]C joints are made [illegible] seconds. [illegible]eeded fittings and adaptors [illegible]vailable. See the following d[illegible].

Fig. 4-14

NEW J-M RING-TITE PVC SEWER PIPE

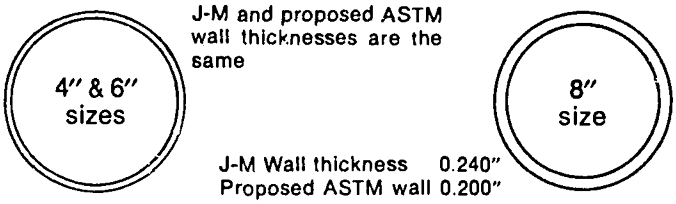
The growing demand for an effective, all-out attack on water pollution, high-lights the need for improved sanitary sewage collection systems. A modern system needs pipe with improved design for joint tightness and improved design for reserve strength and stiffness to increase load-bearing capacity... all within the framework of maximizing sewer system capacity at reasonable cost. New Johns-Manville RING-TITE* PVC Sewer Pipe is designed to meet this need.

New Ring-Tite joint meets exacting tightness requirements, simplifies assembly



The pioneer and largest supplier in the U.S. of pipe with rubber-ring joints, Johns-Manville now introduces another important step forward in joints for gravity sewer pipe. This new RING-TITE joint passes a 25 psi air test in the laboratory, as shown in the Specification on page 5. It provides the basis for exacting exfiltration/infiltration specifications. And the new joint is simpler to assemble. The locked-in ring eliminates separate handling, cleaning, and inserting of the ring. The need for bevelling is eliminated.

20% more wall thickness in 8" size provides greater load-carrying capacity



With 20% more wall thickness, 8" J-M RING-TITE PVC Sewer Pipe has 75% more stiffness than a pipe sized to the proposed ASTM standard. With 75% more "pipe stiffness", the J-M pipe can carry significantly heavier loads than the thinner-wall PVC pipes.

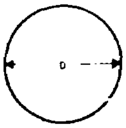
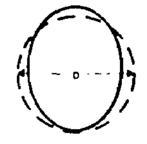
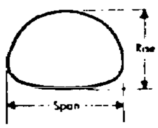
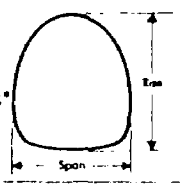
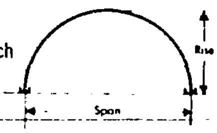
As shown J-M RING-TITE PVC Sewer Pipe in the 4" and 6" sizes are manufactured to the ASTM proposed wall thicknesses. These sizes are usually used in building connections or laterals.

PVC pipes are flexible conduits which are designed to deflect vertically under the weight of the load on the pipe and, by outward deflection at the sides, transmit part of the load to the passive soil resistance of the compacted backfill. Thus the flexible conduit together with properly-compacted backfill and bedding form an interaction system that provides the structural strength that carries the load imposed on the pipe.

Now 8" J-M RING-TITE PVC Sewer Pipe, with more wall thickness and more "pipe stiffness", increases substantially the load-carrying capacity of the soil-conduit interaction system. This capacity is adequate to support heavy loads and to provide in addition substantial reserve strength to cope with variable and unpredictable soil conditions. It provides also reserve strength to withstand stresses and strains ordinarily encountered in handling and installation.

Fig. 4-15

Shapes and Uses of Corrugated Conduits

Shape		Range of Sizes	Common Uses
Round		6 in. to 21 ft	Culverts, subdrains, sewers, service tunnels, etc. All plates same radius. For medium and high fills (or trenches).
Vertically-elongated (ellipse) 5% is common		4 ft to 21 ft nominal; before elongating	Culverts, sewers, service tunnels, recovery tunnels. Plates of varying radii; shop fabrication. For appearance and where backfill compaction is only moderate.
Pipe-arch		span x rise 18 in. x 11 in. to 20 ft 7 in. x 13 ft 2 in.	Where headroom is limited. Has hydraulic advantages. Corner plate radius, 18 inches or 31 inches for structural plate.
Underpass*		5 ft 8 in. x 5 ft 9 in. to 20 ft 4 in. x 17 ft 10 in.	For pedestrians, livestock or vehicles (structural plate).
Arch		5 ft to 21 ft	For low clearance large waterway opening, and aesthetics (structural plate).
Specials		Various	For lining old structures or other special purposes. Special fabrication.

*For equal area or clearance, the round shape is generally more economical and simpler to assemble.

Specifications for Corrugated Steel Drainage Structures

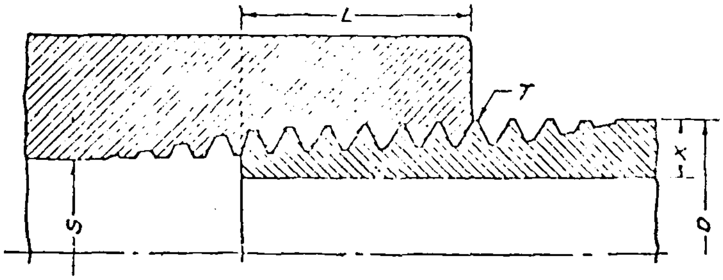
End User	Galvanized	Coated	Structural Plate	Perforated
State and County Highways, Municipal	AASHO M-36	AASHO M-190	AASHO M-167	AASHO M-136
BPR for Federal Highways (including forests, parks, etc.)	(FP-__*)	(FP-__*)	(FP-__*)	(FP-__*)
Fed. Aviation Agency	FAA Standards	FAA Standards		FAA Standards
Railways	AREA 1-4-6	AREA 1-4-13	AREA 1-4-25	AREA 1-4-11
Federal GSA	WW-P-00405 COM-PR (interim)	WW-P-00405 COM-PR (interim)	WW-P-00405 COM-PR (interim)	WW-P-00405 COM-PR (interim)

*Suffix is last two digits denoting year [illegible] published.

Fig. 4-16

American Standard Pipe[1,5]

WELDED WROUGHT IRON



Nominal pipe size	Actual outside diam D	Tap-drill size S	Thds per in. T	Distance pipe enters fittings L	Wall thickness X: Standard 40[2]	Wall thickness X: Extra strong 80[3]	Wall thickness X: Double extra strong[4]	Weight - pounds per foot[6]: Standard 40[2]	Weight - pounds per foot[6]: Extra strong 80[3]	Weight - pounds per foot[6]: Double extra strong[4]
1/8	0.405	11/32	27	3/16	0.070	0.098	.....	0.25	0.32	
1/4	0.540	7/16	18	9/32	0.090	0.122	.....	0.43	0.54	
3/8	0.675	37/64	18	19/64	0.093	0.129	.....	0.57	0.74	
1/2	0.840	23/32	14	3/8	0.111	0.151	0.307	0.86	1.09	1.714
3/4	1.050	59/64	14	13/32	0.115	0.157	0.318	1.14	1.48	2.440
1	1.315	1 5/32	11 1/2	1/2	0.136	0.183	0.369	1.68	2.18	3.659
1 1/4	1.660	1 1/2	11 1/2	35/64	0.143	0.195	0.393	2.28	3.00	5.214
1 1/2	1.900	1 47/64	11 1/2	9/16	0.148	0.204	0.411	2.72	3.64	6.408
2	2.375	2 7/32	11 1/2	37/64	0.158	0.223	0.447	3.66	5.03	9.029
2 1/2	2.875	2 5/8	8	7/8	0.208	0.282	0.565	5.80	7.67	13.695
3	3.5	3 1/4	8	15/16	0.221	0.306	0.615	7.58	10.3	18.583
3 1/2	4.0	3 3/4	8	1	0.231	0.325	.....	9.11	12.5	.....
4	4.5	4 1/4	8	1 1/16	0.242	0.341	0.690	10.8	15.0	27.451
5	5.563	5 5/16	8	1 3/32	0.263	0.388	0.768	14.7	20.8	38.552
6	6.625	6 5/16	8	1 1/4	0.286	0.441	0.884	19.0	28.6	53.160
8	8.625	.....	8	1 15/32	0.329	0.510	0.895	28.6	43.4	72.424
10	10.75	.....	8	1 43/64	0.372	0.606	.....	40.5	61.4	
12	12.75	.....	8	1 7/8	0.411	0.702	.....	53.6	88.6	
14 OD	14.0	.....	8	2	0.437	0.750	.....	62.2	104.	
16 OD	16.0	.....	8	2 13/64	0.500	.....	.....	81.2		
18 OD	18.0	.....	8	2 13/32	0.562	.....	.....	103.		
20 OD	20.0	.....	8	2 19/32	0.562	.....	.....	115.		
24 OD	24.0	.....	8	3						

Dimensions in inches.

[1] For welded and seamless steel pipe—see ASA B36.10 1939.

[2] Refers to American Standard schedule numbers, approximate values for the expression 1,000 × P/S. Schedule 40 - standard weight.

[3] Schedule 80 — extra strong.

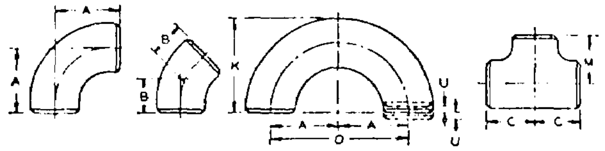
[4] Not American Standard, but commercially available in both wrought iron and steel.

[5] A pipe size may be designated by giving the nominal pipe size and wall thickness, or by giving the nominal pipe size and weight per linear foot.

[6] Plain ends.

Fig. 4-17

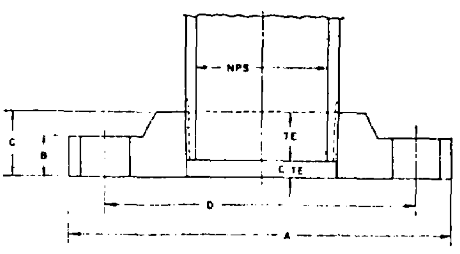
Table 10 .... USA Standard Wrought Steel Butt-Welding Fittings



	Long Radius Elbows			Long Radius Returns			Straight Tees and Crosses		
Nominal Pipe Size	Outside Diameter at Bevel	Center-to-End 90-Deg Elbows A	Center-to-End 45-Deg Elbows B	Outside Diameter at Bevel	Center-to-Center O	Back to Face K	Outside Diameter at Bevel	Center-to-End Run C	Center-to-End Outlet* M
1/2	0.840	1 1/2	5/8	0.840	3	1 7/8	0.840	1	1
3/4	1.050	1 1/8	7/16	1.050	2 1/4	1 11/16	1.050	1 1/8	1 1/8
1	1.315	1 1/2	7/8	1.315	3	2 3/16	1.315	1 1/2	1 1/2
1 1/4	1.660	1 7/8	1	1.660	3 3/4	2 3/4	1.660	1 7/8	1 7/8
1 1/2	1.900	2 1/4	1 1/8	1.900	4 1/2	3 1/4	1.900	2 1/4	2 1/4
2	2.375	3	1 3/8	2.375	6	4 3/16	2.375	2 1/2	2 1/2
2 1/2	2.875	3 3/4	1 3/4	2.875	7 1/2	5 3/16	2.875	3	3
3	3.500	4 1/2	2	3.500	9	6 1/4	3.500	3 3/8	3 3/8
3 1/2	4.000	5 1/4	2 1/4	4.000	10 1/2	7 1/4	4.000	3 3/4	3 3/4
4	4.500	6	2 1/2	4.500	12	8 1/4	4.500	4 1/8	4 1/8
5	5.563	7 1/2	3 1/8	5.563	15	10 5/16	5.563	4 7/8	4 7/8
6	6.625	9	3 3/4	6.625	18	12 5/16	6.625	5 5/8	5 5/8
8	8.625	12	5	8.625	24	16 5/16	8.625	7	7
10	10.750	15	6 1/4	10.750	30	20 3/8	10.750	8 1/2	8 1/2
12	12.750	18	7 1/2	12.750	36	24 3/8	12.750	10	10
14	14.000	21	8 3/4	14.000	42	28	14.000	11	11
16	16.000	24	10	16.000	48	32	16.000	12	12
18	18.000	27	11 1/4	18.000	51	36	18.000	13 1/2	13 1/2
20	20.000	30	12 1/2	20.000	60	40	20.000	15	15
22	22.000	33	13 1/2	22.000	66	44	22.000	16 1/2	16 1/2
24	24.000	36	15	24.000	72	48	24.000	17	17

From *USA Standard for Steel Butt-Welding Fittings*, USAS B16.9-1964.
All dimensions are in inches. Dimension A is equal to ½ of dimension O.
* Outlet dimension M for run sizes 14 in. and larger is recommended but not mandatory.

Dimensions and Drilling for 125-Lb Class Cast Iron Flanges[a,b]



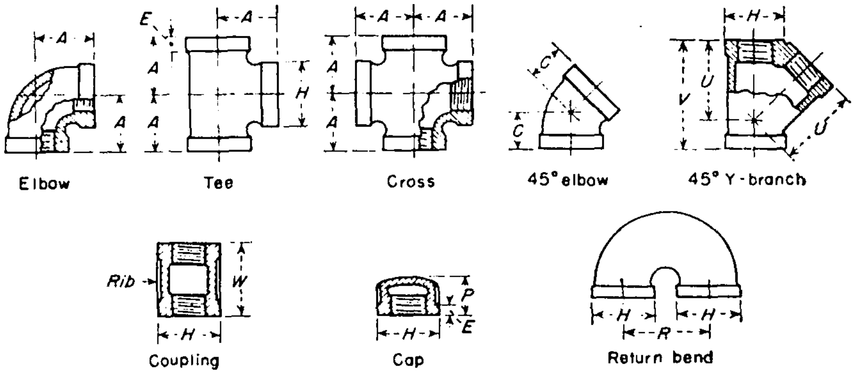
NPS	A	B	C	D	N*	dia*	TE	C-TF
1	4 1/4	7/16	11/16	3 1/8	4	1/2	11/16	0
1 1/4	4 5/8	1/2	13/16	3 1/2	4	1/2	11/16	1/8
1 1/2	5	9/16	7/8	3 7/8	4	1/2	11/16	3/16
2	6	5/8	1	4 3/4	4	5/8	3/4	1/4
2 1/2	7	11/16	1 1/8	5 1/2	4	5/8	15/16	3/16
3	7 1/2	3/4	1 3/16	6	4	5/8	1	3/16
4	9	15/16	1 5/16	7 1/2	8	5/8	1 1/8	3/16
5	10	15/16	1 7/16	8 1/2	8	3/4	1 1/4	3/16
6	11	1	1 9/16	9 1/2	8	3/4	1 5/16	1/4
8	13 1/2	1 1/8	1 3/4	11 3/4	8	3/4	1 7/16	5/16
10	16	1 3/16	1 15/16	14 1/4	12	7/8	1 5/8	5/16
12	19	1 1/4	2 3/16	17	12	7/8	1 3/4	7/16

[a] All dimensions in inches.
[b] From USAS B16.1-1967.
* N = number of bolt holes.

Fig. 4-18 Fitting Dimensions

Dimensions of American 150 Lb Standard Malleable-iron Screwed Fittings (Straight Sizes)*

(All dimensions in inches)



Size	A	H	E	C	V	U	W	P	R Close	R Medium	R Open
1/8	0.69	0.693	0.200	....	....	....	0.96				
1/4	0.81	0.844	0.215	0.73	....	....	1.06				
3/8	0.95	1.015	0.230	0.80	1.93	1.43	1.16				
1/2	1.12	1.197	0.249	0.88	2.32	1.71	1.34	0.87	1.000	1.25	1.50
3/4	1.31	1.458	0.273	0.98	2.77	2.05	1.52	0.97	1.250	1.50	2.00
1	1.50	1.771	0.302	1.12	3.28	2.43	1.67	1.16	1.500	1.875	2.50
1 1/4	1.75	2.153	0.341	1.29	3.94	2.92	1.93	1.28	1.750	2.25	3.00
1 1/2	1.94	2.427	0.368	1.43	4.38	3.28	2.15	1.33	2.188	2.50	3.50
2	2.25	2.963	0.422	1.68	5.17	3.93	2.53	1.45	2.625	3.00	4.00
2 1/2	2.70	3.589	0.478	1.95	6.25	4.73	2.88	1.70	....	....	4.50
3	3.08	4.285	0.548	2.17	7.26	5.55	3.18	1.80	....	....	5.00
3 1/2	3.42	4.843	0.604	2.39	....	....	3.43	1.90			
4	3.79	5.401	0.661	2.61	8.98	6.97	3.69	2.08			
5	4.50	6.583	0.780	3.05	....	....	....	2.32			
6	5.13	7.767	0.900	3.46	....	....	....	2.55			

* The complete standard (ASA B16c, 1939) covers also reducing couplings, elbows, tees, crosses, and service or street elbows and tees.

Fig. 4-19 Fitting Dimensions

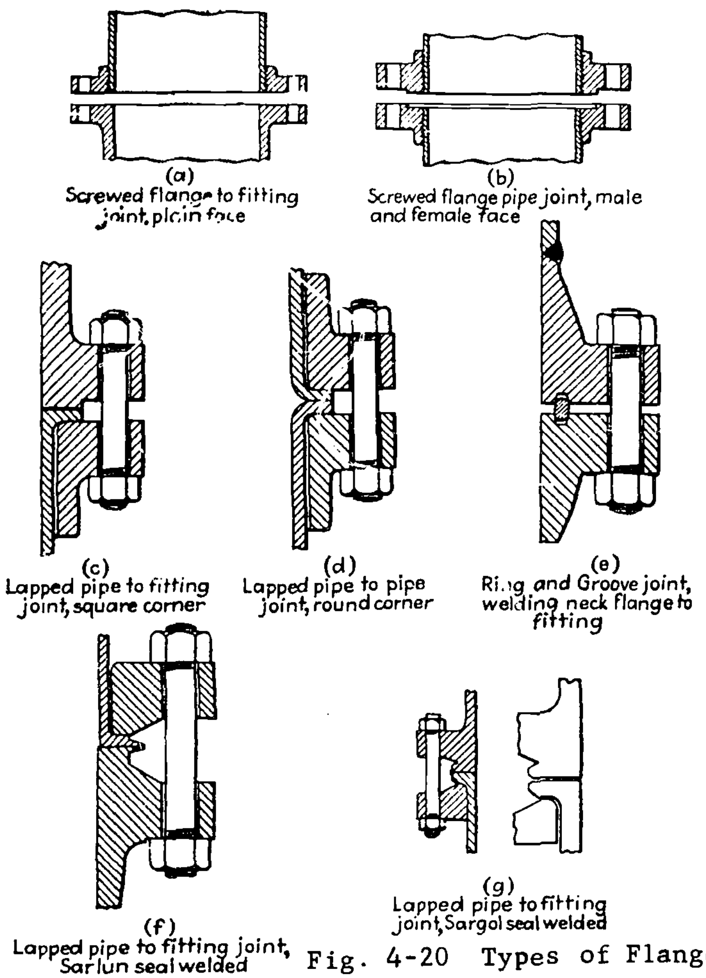
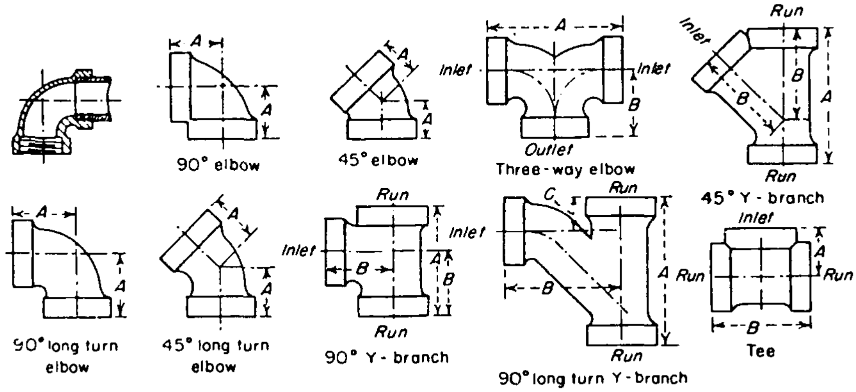


Fig. 4-20 Types of Flanged Joints

Dimensions of American Standard Cast-iron Screwed Drainage Fittings



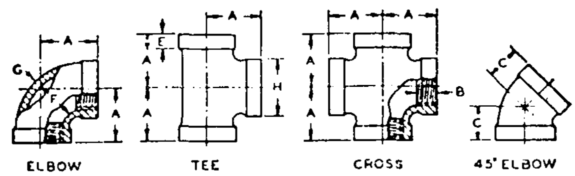
Size, in.	90 deg elbows*	45 deg elbows*	90 deg. long-turn elbows	45 deg. long-turn elbows	Three-way elbows†		Tees*		90 deg Y branches		90 deg long-turn Y branches			45 deg Y branches	
	A	A	A	A	A	B	A	B	A	B	A	B	C	A	B
1 1/4	1 3/4	1 5/16	2 1/4	1 3/4	4 1/2	2 1/4	1 3/4	3 1/2	3 3/4	2 1/4	4 3/4	3 5/8	1 1/8	5	3 1/4
1 1/2	1 15/16	1 7/16	2 1/2	1 7/8	5	2 1/2	1 15/16	3 7/8	4 1/4	2 1/2	5 3/8	4 1/8	1 1/4	5 1/2	3 5/8
2	2 1/4	1 11/16	3 1/16	2 1/4	6 1/8	3 1/16	2 1/4	4 1/2	5 3/16	3 1/16	7	5 1/4	1 3/4	6 1/2	4 3/8
2 1/2	2 11/16	1 15/16	3 11/16	2 5/8	7 5/8	3 11/16	2 11/16	5 5/8	6 5/16	3 11/16	8 1/4	6 1/4	2	7 7/8	5 3/8
3	3 3/16	2 3/16	4 1/4	2 15/16	8 1/2	4 1/4	3 1/16	6 1/8	7 1/4	4 1/4	9 7/8	7 1/2	2 3/8	9	6 3/16
4	3 13/16	2 5/8	5 3/16	3 1/2	10 3/8	5 3/16	3 13/16	7 5/8	8 3/4	5 3/16	13	9 7/8	3 1/8	10 7/8	7 13/16
5	4 1/2	3 1/16	6 1/8	4 1/8	12 1/4	6 1/8	4 1/2	9	10 5/16	6 1/8	15 3/4	12 1/4	3 1/2	12 15/16	9 3/4
6	5 1/8	3 7/16	7 1/8	4 7/8	14 1/4	7 1/8	5 1/8	10 1/4	11 15/16	7 1/8	18 3/4	14 5/8	4 1/8	14 7/8	10 3/4

* Same as adopted for 125 lb Cast-iron Screwed Fittings, ASA B16d, 1941.
† Three-way elbows have same dimensions as 90 deg long-radius elbows.
Double Y branches have the same dimensions as single Y branches.
Other fittings which are available are as follows: 5 5/8, 11 1/4, and 60 deg elbows; basin tees and crosses; double 90 deg Y branches; double 90 deg long-turn Y branches; 45 deg double Y branches; S traps; half S traps; offsets, couplings, increasers, and reducing sizes.

Courtesy-
Marks Handbook
McGraw Hill Book C

Fig. 4-21

Dimensions of Malleable 90-Deg Elbows, Tees, Crosses, and 45-Deg Elbows (Straight Sizes, 150 Lb)

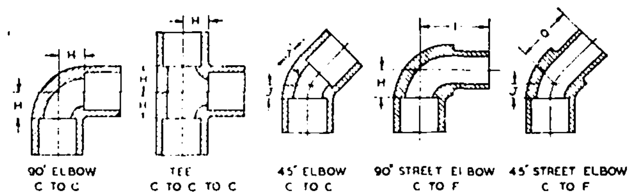


Nominal Pipe Size	Center to End, Elbows, Tees, and Crosses A	Center to End, 45-Deg Elbows C	Length of Thread, Min B	Width of Band, Min E	Inside Diameter of Fitting F Min	Inside Diameter of Fitting F Max	Metal Thickness G	Outside Diameter of Band, Min H
1/8	0.69	. . .	0.25	0.200	0.405	0.435	0.090	0.693
1/4	0.81	0.73	0.32	0.215	0.510	0.584	0.095	0.844
3/8	0.95	0.80	0.36	0.230	0.675	0.719	0.100	1.015
1/2	1.12	0.88	0.43	0.249	0.840	0.897	0.105	1.197
3/4	1.31	0.98	0.50	0.273	1.050	1.107	0.120	1.458
1	1.50	1.12	0.58	0.302	1.315	1.385	0.134	1.771
1 1/4	1.75	1.29	0.67	0.341	1.660	1.730	0.145	2.153
1 1/2	1.94	1.43	0.70	0.368	1.900	1.970	0.155	2.427
2	2.25	1.68	0.75	0.422	2.375	2.445	0.173	2.963
2 1/2	2.70	1.95	0.92	0.478	2.875	2.975	0.210	3.589
3	3.08	2.17	0.98	0.548	3.500	3.600	0.231	4.285
3 1/2	3.42	2.39	1.03	0.601	4.000	4.100	0.248	4.843
4	3.79	2.61	1.08	0.661	4.500	4.600	0.265	5.401
5	4.50	3.05	1.18	0.780	5.563	5.663	0.300	6.583
6	5.13	3.46	1.28	0.900	6.625	6.725	0.336	7.767

From *USA Standard for Malleable-Iron Screwed Fittings*, 150 lb. USAS B16.4-1963. All dimensions given in inches.

Dimensions of Cast-Brass Solder-Joint Elbows, Tees, and 45-Deg Elbows

(Straight Sizes)

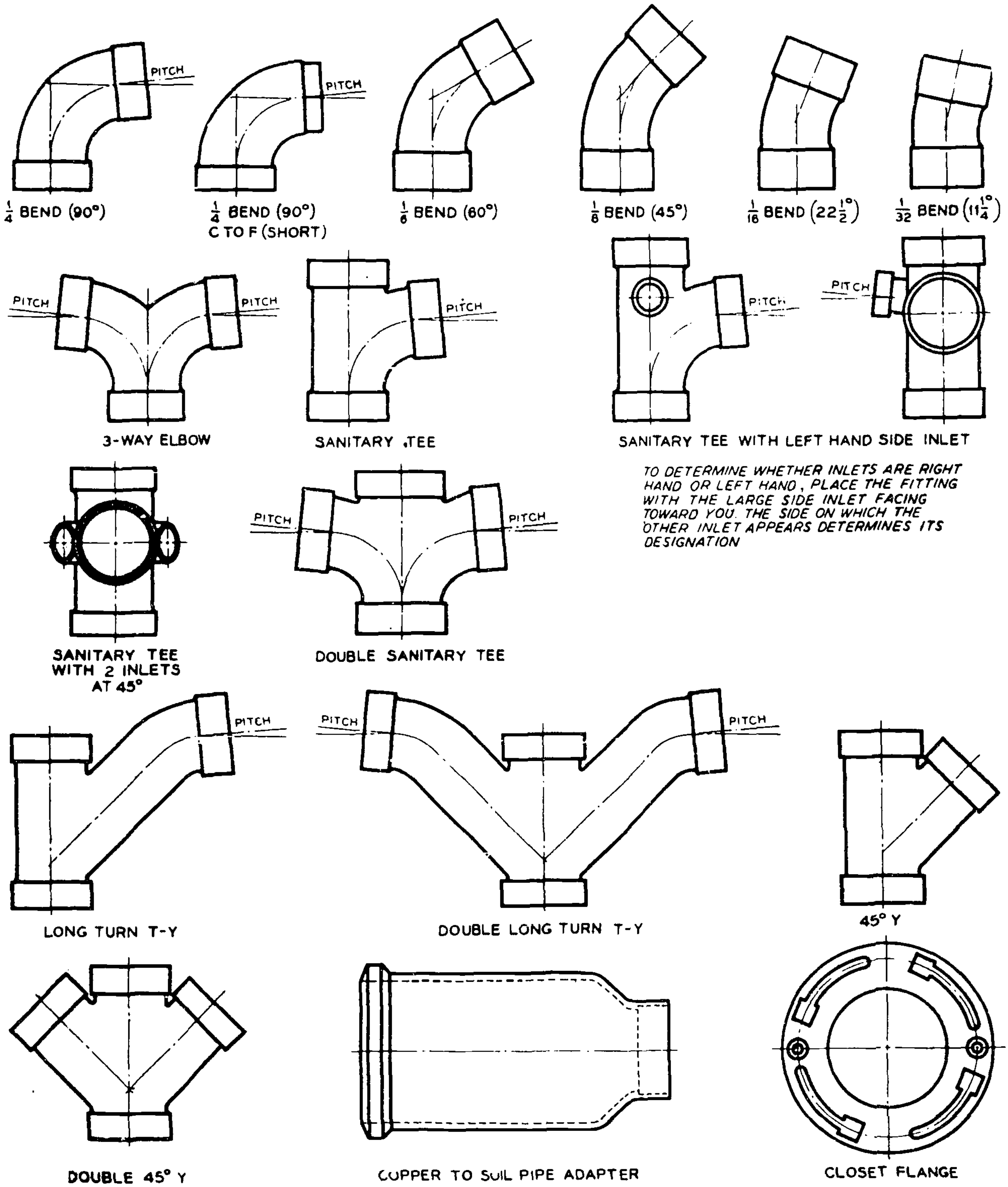


Standard Water Tube Size	Laying Length Tee and Elbow H	Center to End 90-Deg Street Elbow I	Laying Length 45-Deg Elbow J	Center to End 45-Deg Street Elbow Q
1/4	1/4	3/4	—	—
3/8	5/16	7/8	3/16	3/4
1/2	7/16	1 1/8	3/16	7/8
3/4	9/16	1 1/2	1/4	1 3/16
1	3/4	1 27/32	5/16	1 5/16
1 1/4	7/8	2 1/32	7/16	1 9/16
1 1/2	1	2 [illegible]	1/2	1 3/4
2	1 1/4	2 [illegible]	9/16	2 1/8
2 1/2	1 1/2	3 [illegible]	5/8	—
3	1 3/4	3 19/32	3/4	—
3 1/2	2	—	7/8	—
4	2 1/4	4 19/32	15/16	—
5	3 1/8		1 7/16	—
6	3 3/4	-	1 1/4	—
8	4 7/8		2 1/8	—

From *USA Standard for Cast-Brass Solder-Joint Fittings*, USAS B16.18-1963 and addendum USAS B16.18a-1967. All dimensions given in inches.

Fig. 4-22

CAST-BRASS SOLDER-JOINT DRAINAGE FITTINGS



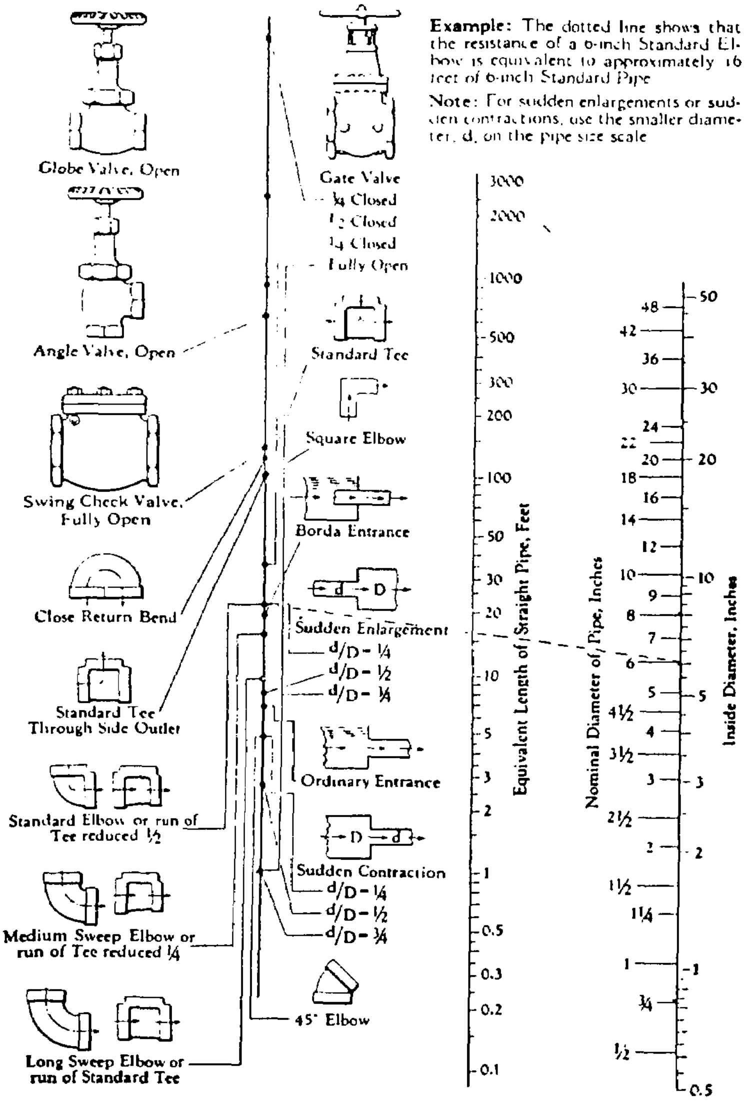
TYPICAL CAST-BRASS SOLDER-JOINT DRAINAGE FITTINGS

NOTE: Inlets to all fittings having openings at nominally 90 deg are pitched at 1/4 inch to the foot with the pitch in the direction as shown (exaggerated for purpose of illustration). Similar types of fittings are pitched likewise.

Courtesy- ASME

Fig. 4-23

Friction losses in pipe fittings



Example: The dotted line shows that the resistance of a 6-inch Standard Elbow is equivalent to approximately 16 feet of 6-inch Standard Pipe.

Note: For sudden enlargements or sudden contractions, use the smaller diameter, d, on the pipe size scale.

Courtesy- THE CRANE COMPANY

Friction Loss in Pipe Fittings in terms of equivalent feet of straight pipe.

These data may be applied to any liquid or gas

Nominal pipe Size D_N Std. Wt.	Actual inside diam. in.	Gate Valve FULL OPEN	45° Elbow	Long-sweep elbow or run of Std tee	Std elbow or run of tee reduced ½	Std tee thru side outlet	Close return bend	Swing check valve FULL OPEN	Angle Valve FULL OPEN	Globe Valve FULL OPEN	Equivalent Resistance of Std. Wt. Welding Elbows Length of Straight Pipe (Feet)[1]* 90° Elbows Short Radius $R/D_N=1$	90° Elbows Long Radius $R/D_N=1½$	45° Elbows Short Radius $R/D_N=1$	45° Elbows Long Radius $R/D_N=1½$
Resistance factor		19	42	6	9	1.8	2.2	2.3	5	10				
½	.622	.35	.78	1.11	1.7	3.3	4.1	4.3	9.3	18.6	‡	0.68	‡	0.44
¾	.824	.44	.97	1.4	2.1	4.2	5.1	5.3	11.5	23.1	‡	0.91	‡	0.58
1	1.049	.56	1.23	1.8	2.6	5.3	6.5	6.8	14.7	29.4	1.6	1.15	1.01	0.74
1¼	1.380	.74	1.6	2.3	3.5	7.0	8.5	8.9	19.3	38.6	2.1	1.5	1.33	0.98
1½	1.610	.86	1.9	2.7	4.1	8.1	9.9	10.4	22.6	45.2	2.4	1.8	1.6	1.14
2	2.067	1.10	2.4	3.5	5.2	10.4	12.8	13.4	29	58	3.1	2.3	2.0	1.6
2½	2.469	1.32	2.9	4.2	6.2	12.4	15.2	15.9	35	69	3.7	2.7	2.4	1.7
3	3.068	1.6	3.6	5.2	7.7	15.5	18.9	19.8	43	86	4.7	3.4	3.0	2.2
4	4.026	2.1	4.7	6.9	10.2	20.3	24.8	26.0	57	113	6.1	4.4	3.9	2.9
5	5.047	2.7	5.9	8.5	12.7	25.4	31	33	71	142	7.7	5.6	4.9	3.6
6	6.065	3.2	7.1	10.2	15.3	31	37	39	85	170	9.2	6.7	5.9	4.3
7	7.024	3.7	8.3	11.8	17.7	35	43	45	98	197	‡‡	‡‡	‡‡	‡‡
8	7.981	4.3	9.4	13.4	20.2	40	49	52	112	224	12.1	8.8	7.7	5.7
10	10.020	5.3	11.8	16.9	25.3	51	62	65	141	281	15.2	11.0	9.7	7.1
12	12.000	6.4	14.1	20.2	30	61	74	77	168	336	18.2	13.2	11.6	8.5
14		7.5	16.5	23.5	35	71	86	90			20.1	14.6	12.8	9.4
16		8.5	18.8	26.9	40	81	99	104			23.1	16.8	14.7	10.8
18		9.6	21.2	30	45	91	111	116			26.2	19.0	16.7	12.2
20		10.7	23.5	34	50	101	123	129			29	21.2	18.6	13.6
24		12.8	28.2	40	61	121	148	155			35	25.6	22.5	16.5
30		16.0	35.3	50	76	151	185	193			44	32	28.3	20.7
36		19.2	42.4	61	91	181	222	232			53	39	34	25.0
42		22.4	49.4	71	106	212	259	271			63	45	40	29.2
48		25.6	57.6	81	121	242	296	310			72	52	46	33

Data on fittings based on information published by Crane Co.
*For 180° bend multiply values for 90° bend by 1.34.
Data are based on *Fanning coefficient of 0.006*, as taken from Chart No. 18 of Catalog 211 of Tube Turns, Inc.
‡Short Radius elbows, $R/D_N=1$, not made in this size and weight.
‡‡Not made in this size.

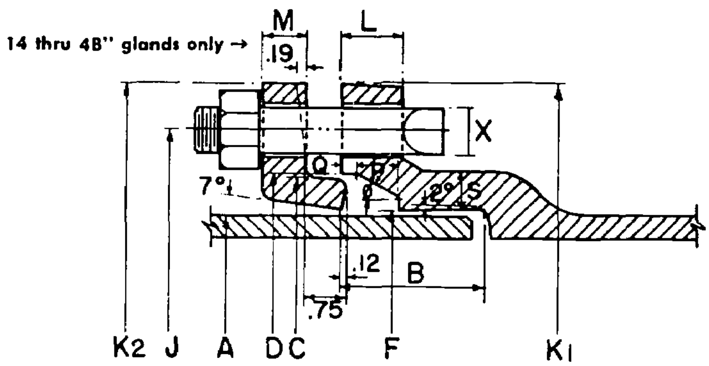
Fig. 4-24

Courtesy- INGERSOLL-RAND COMPANY

MECHANICAL JOINT DIMENSIONS

SAMPLE SPECIFICATION

CAST IRON MECHANICAL JOINT FITTINGS shall be made in strict accordance with AWWA Specifications C110-64, C111-64 and Federal Specifications WW-P-421b and shall conform to details and dimensions published therein.



DIMENSIONS IN INCHES

Size	A	B	C	D	F	φ	X	J	K1	K2	L	M	O	P	S
2	2.50	2.50	3.39	3.50	2.61	28°	3/4	4.75	6.00	6.25	.56	.62	.31	.63	.37
3	3.96	2.50	4.84	4.94	4.06	28°	3/4	6.19	7.62	7.69	.94	.62	.31	.63	.52
4	4.80	2.50	5.92	6.02	4.90	28°	7/8	7.50	9.06	9.12	1.00	.75	.31	.75	.65
6	6.90	2.50	8.02	8.12	7.00	28°	7/8	9.50	11.06	11.12	1.06	.88	.31	.75	.70
8	9.05	2.50	10.17	10.27	9.15	28°	7/8	11.75	13.31	13.37	1.12	1.00	.31	.75	.75
10	11.10	2.50	12.22	12.34	11.20	28°	7/8	14.00	15.62	15.62	1.19	1.00	.31	.75	.80
12	13.20	2.50	14.32	14.44	13.30	28°	7/8	16.25	17.88	17.88	1.25	1.00	.31	.75	.85
14	15.30	3.50	16.40	16.54	15.44	28°	7/8	18.75	20.25	20.25	1.31	1.25	.31	.75	.89
16	17.40	3.50	18.50	18.64	17.54	28°	7/8	21.00	22.50	22.50	1.38	1.31	.31	.75	.97
18	19.50	3.50	20.60	20.74	19.64	28°	7/8	23.25	24.75	24.75	1.44	1.38	.31	.75	1.05
20	21.60	3.50	22.70	22.84	21.74	28°	7/8	25.50	27.00	27.00	1.50	1.44	.31	.75	1.12
24	25.80	3.50	26.90	27.04	25.94	28°	7/8	30.00	31.50	31.50	1.62	1.56	.31	.75	1.22

JOINT DIMENSIONS, ACCESSORIES, WEIGHTS

Size	Bolts No.	Bolts Size	Bolts Lgth.	*Wt. of Gland, Bolts and Gasket, Lbs.	Pipe Barrel O. D.	Pipe Pattern	Size	Bolts No.	Bolts Size	Bolts Lgth.	*Wt. of Gland, Bolts and Gasket, Lbs.	Pipe Barrel O. D.	Pipe Pattern
2	2	5/8	3	5	2.50		12	8	3/4	4	40	13.20	AB
3	4	5/8	3	7	3.96	8CD	14	10	3/4	4	45	15.30	AB
4	4	3/4	3 1/2	10	4.80	A	16	12	3/4	4 1/2	55	17.40	AB
6	6	3/4	3 1/2	16	6.90	A	18	12	3/4	4 1/2	65	19.50	AB
8	6	3/4	4	25	9.05	AB	20	14	3/4	4 1/2	85	21.60	AB
10	8	3/4	4	30	11.10	AB	24	16	3/4	5	105	25.80	AB

*** Weights not part of specifications—for information only.**

CEMENT LINING

Cement mortar lining is prepared in strict accordance with ASA A21.4. The mortar is a thorough mixture of exact proportions of Portland cement, sand and water. The cement is applied by skilled craftsmen, and is cured for 24 hours before tar coating. All castings are cured in a special area to assure even drying and density.

Fig. 4-25

Courtesy- Tyler Pipe

Introduction

Type N

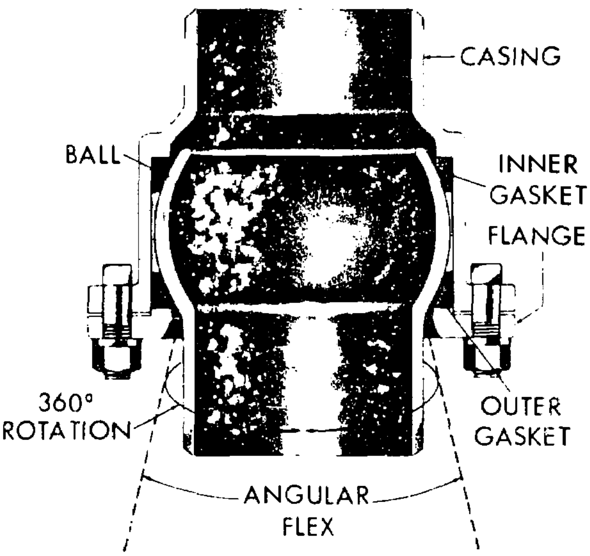


Figure 5

Standard and 600 Series

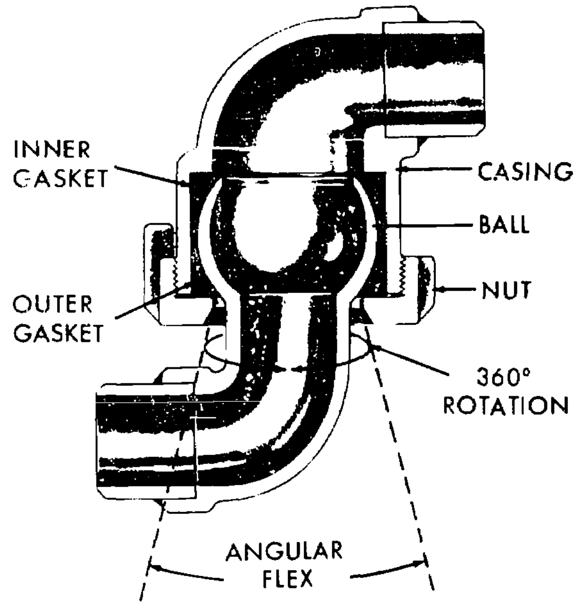


Figure 6

Barco Ball Joints

For over 50 years Barco has manufactured Ball Joints for piping flexibility. In the early 1900's, Barco Ball Joints gained acceptance in the Railroad Industry to provide flexibility in locomotive steam piping and in passenger car steam connections. This acceptance spread to general industry. Barco has proved the reliability of Ball Joints through many years of dependable service and today the use of Ball Joints for accommodating many kinds of pipe movement throughout industry is firmly established.

Construction

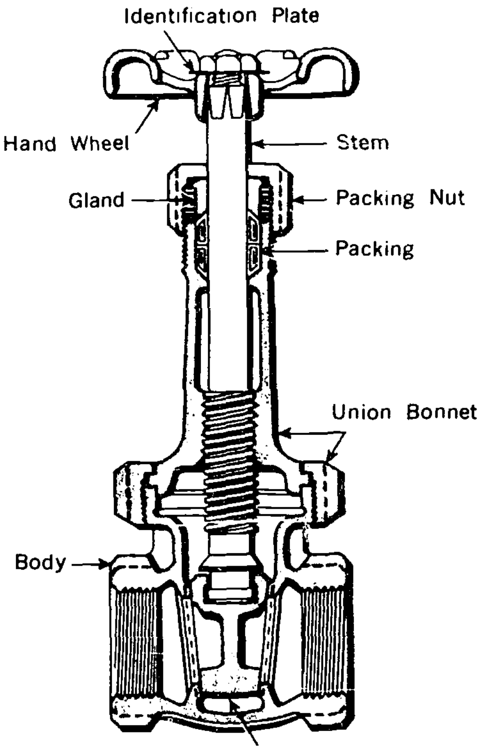
A Barco Ball Joint is made up of four major parts as shown in Figure 5 and Figure 6; a polished spherical ball, a machined casing, sealing gaskets and a retaining flange or nut.

Sealing Principle

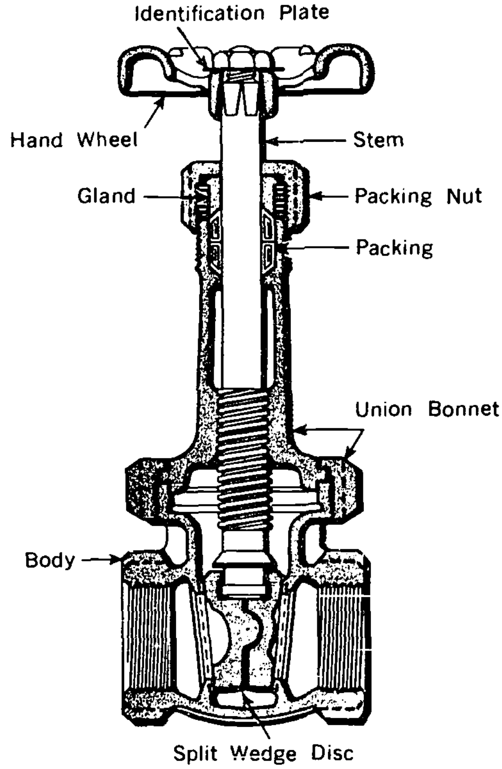
The internal fluid pressure aids in effecting the seal of the ball surface against the gasket, "higher the pressure—tighter the seal". Forces caused by fluid pressure are wholly contained within the ball joints thus imposing no force due to fluid pressure on the system equipment and anchors as is the case with bellows or slip type expansion joints.

Fig. 4-26

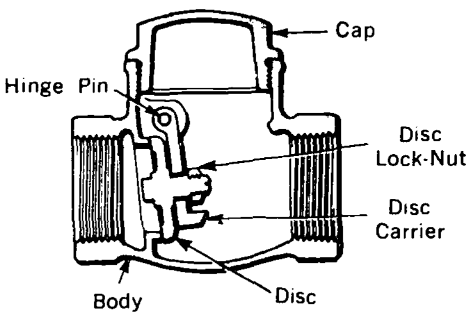
Courtesy-
Barco



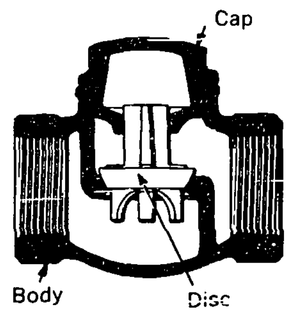
Gate Valves



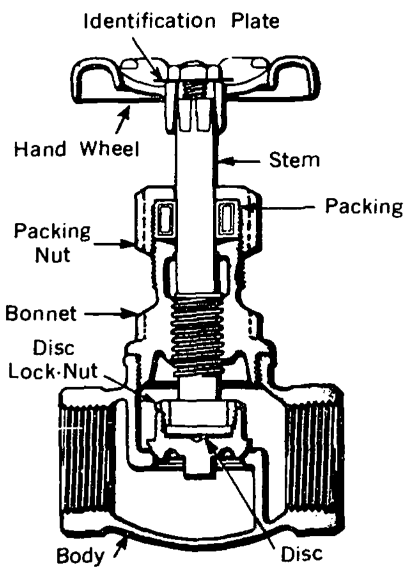
Gate Valves



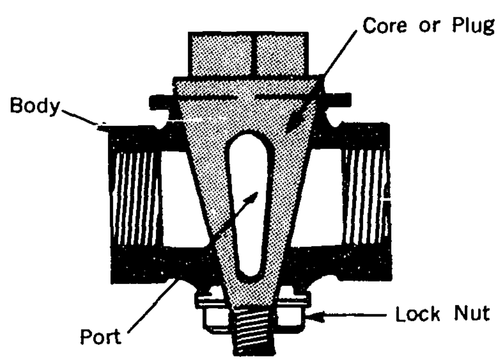
Swing Check



Lift Check

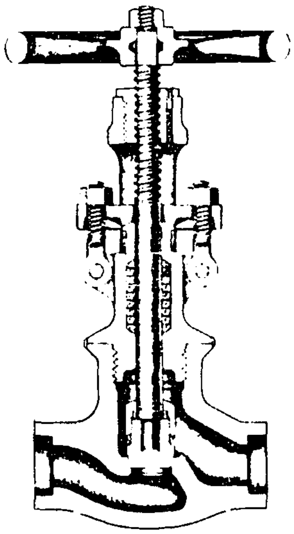


Globe Valve

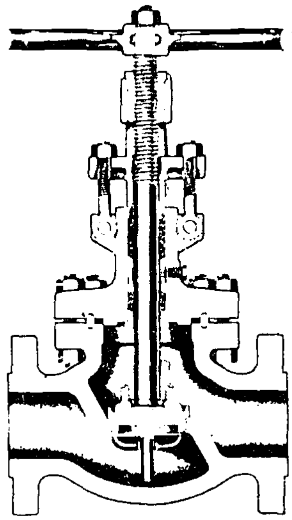


Balancing Valve

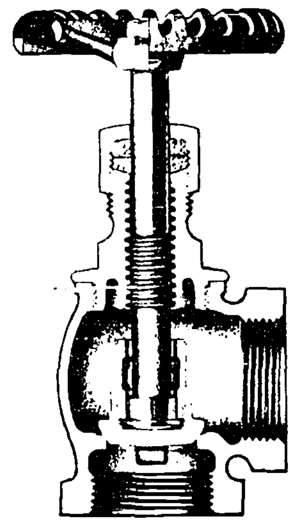
Fig. 4-27a. Types of Valves



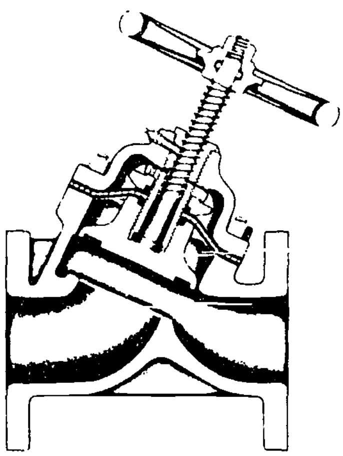
Conventional Globe Valve



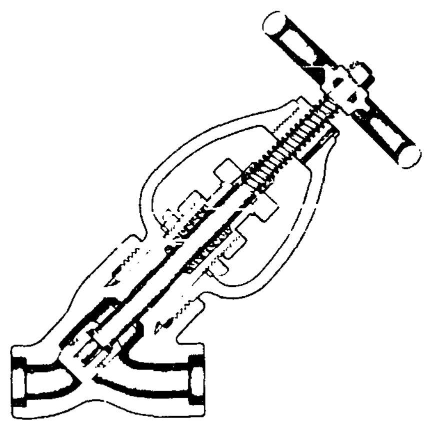
Conventional Globe Valve
With Disc Guide



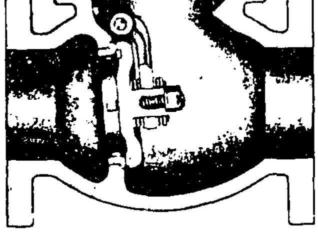
Conventional Angle Valve



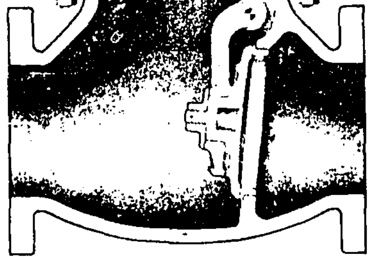
Y-Pattern Globe Valve
With Stem 60 degrees from Run



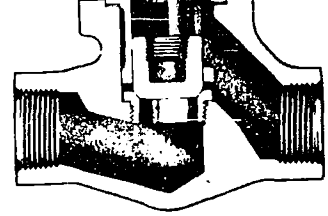
Y-Pattern Globe Valve
With Stem 45 degrees from Run



Conventional Swing Check Valve



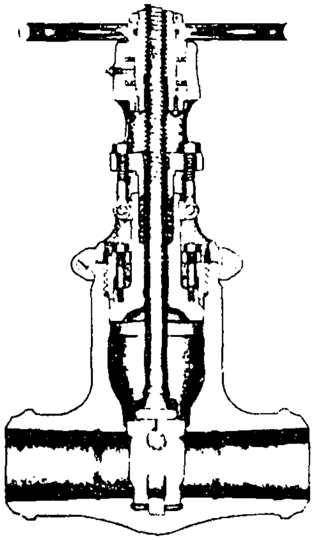
Clearway Swing Check Valve



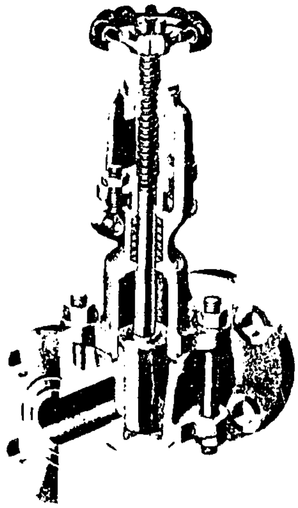
Globe Type Lift Check Valve

Courtesy- Crane Co.

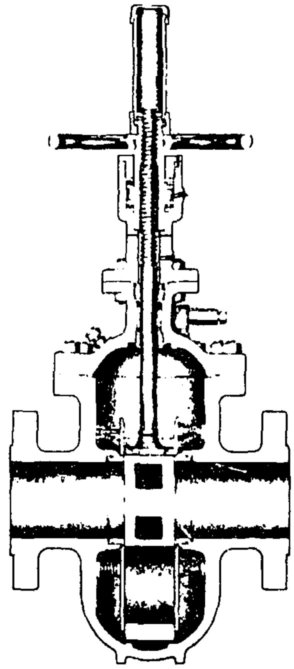
Fig. 4-27b. Types of Valves



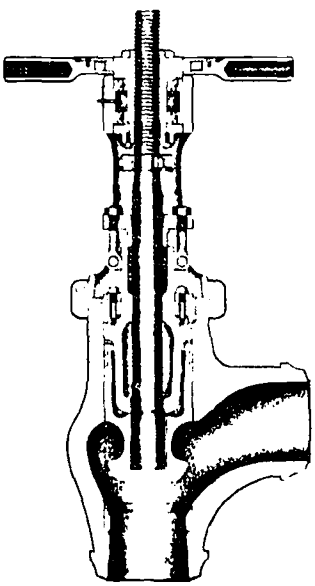
Conventional Gate Valve



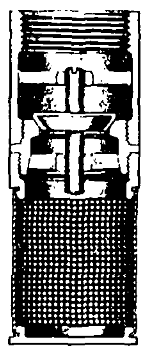
Plug Gate Valve



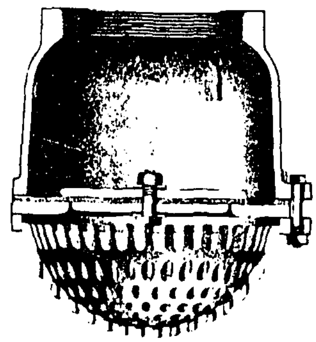
Pipe Line Gate Valve



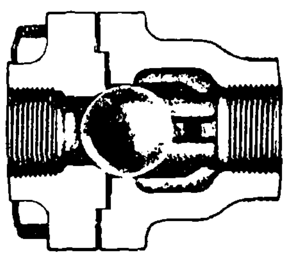
Angle Stop-Check Valve



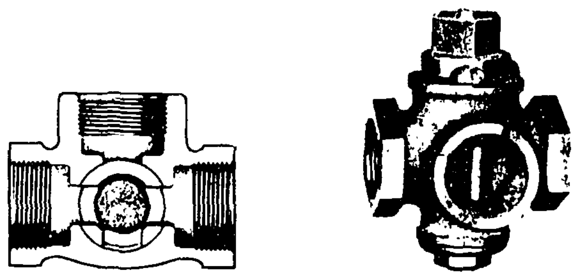
Foot Valve
With Strainer
Poppet Type



Foot Valve
With Strainer
Hinged Type



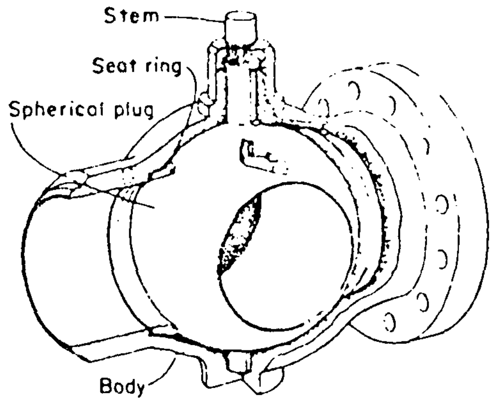
In-Line Ball Check Valve



Three-Way Cock
Sectional and Outside Views

Courtesy- Crane Co.

Fig. 4-27c. Types of Valves



Ball valve in closed position.

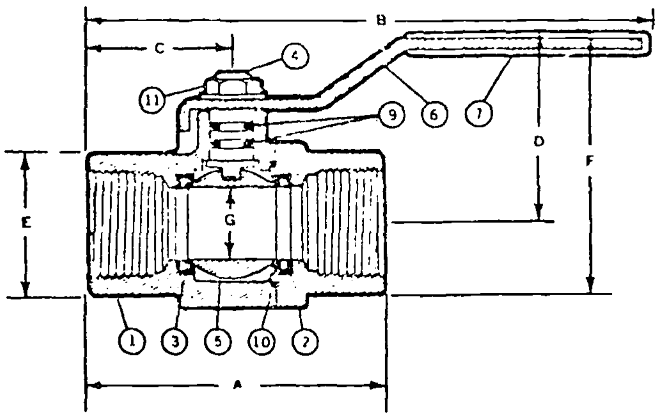
PRESSURE-TEMPERATURE RATINGS

SERVICE	BL-301 BUNA-N	BL-301TF TEFLON
WATER OIL OR GAS	400 psig @ 100°F 300 psig @ 125°F 200 psig @ 150°F 100 psig @ 220°F	400 psig @ 100°F 300 psig @ 200°F 250 psig @ 300°F 200 psig @ 400°F
STEAM		150 psig — Saturated Steam

NOTE: BL-301 with Buna N trim is Underwriters Laboratories approved for use on Liquefied Petroleum Gas at maximum pressure of 250 psig.

TESTS

Hydrostatic Shell — 600 Lbs. psig
Air under Water — 250 Lbs. psig



MATERIALS

1. **BODY.** Forged brass. ASTM B 283.
2. **CAP.** Forged brass. ASTM B 283.
3. **SEAT.** BL-301: Buna N, brass insert.
   BL-301TF: Teflon.
4. **STEM.** Naval brass. ASTM B21 Alloy C.
5. **BALL.** ¼" thru 1": Naval brass ASTM B 21 Alloy C.
   1¼" thru 2": Forged brass ASTM B 283.
6. **HANDLE.** Carbon steel, cadmium plated.
7. **GRIP.** BL 301: Black vinyl.
   BL-301TF: White vinyl.
8. **SCREW.** Carbon steel, cadmium plated.
9. **O-RING.** BL-301: Buna-N.
   BL-301TF: Viton rubber Teflon.
10. **O-RING.** BL-301: Buna-N.
    BL-301TF: Teflon.
11. **SHAKEPROOF NUT:** Carbon steel, cadmium plated.

Courtesy-
R-P-C Valve Co.

Ball valves turn from full closed to full open in one-quarter turn and can be used for steam and water service. The valve stems are sealed with O-rings.

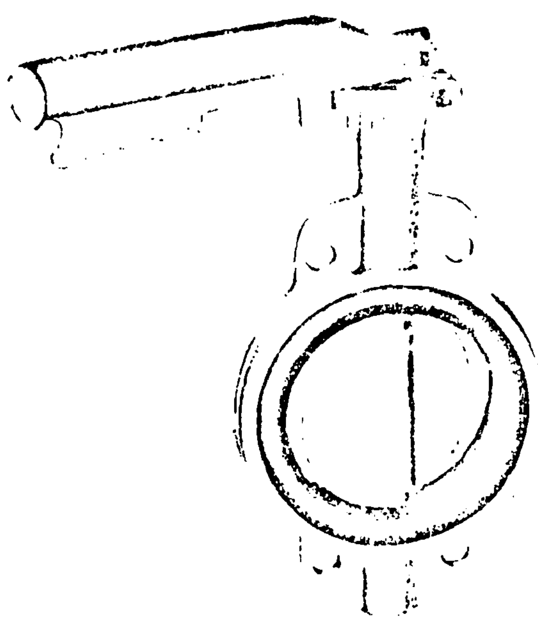
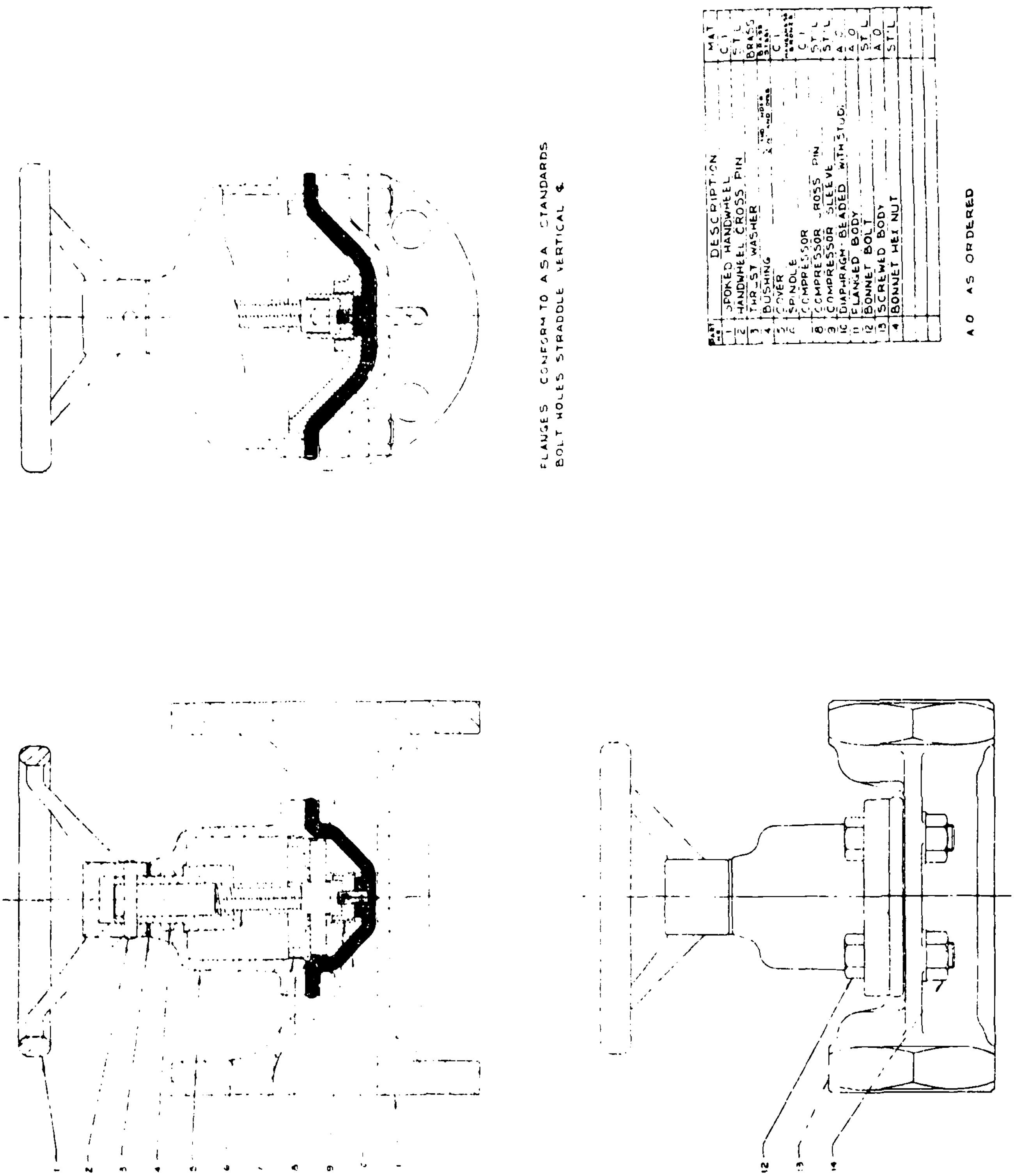


Fig. 4-27d.

Butterfly valves are used for tight shut off and throttling liquids and gases. The disc seats against a Buna-N boot for tight closure. The valve is locked in various positions by means of a ratchet as shown. Gear operators are used for the larger sizes. Discs and liners are available in many different materials and should be checked against the specifications.

Courtesy- Centerline Co.



Courtesy-
Grinell

Fig. 4-27e. Saunders Valve

CHAPTER 5

HANGERS, SUPPORTS AND ANCHORS

General: One of the main functions of the inspection procedure is to make sure that all piping systems are firmly supported and anchored; also that equipment is firmly anchored where required.

Underground water piping or sewer lines frequently are installed on steep slopes which may require large blocks of concrete, referred to as thrust blocks, to hold them in place and prevent slippage.

Water mains, even on level ground, have pads of concrete poured behind a fittings or dead end to prevent the joints from blowing out or leaking. Refer to the table in the Appendix for the pounds of thrust which develops. Water hammer due to the rapid closing of automatic valves, as in a lawn sprinkler system, also builds up tremendous pressure at changes of direction. Tie rods are also used for reinforcing joints, especially on fire sprinkler mains, and large water utility systems, particularly where cast-iron pipe is used.

Plans and specifications on many jobs are not specific regarding the types of hangers or supports which are to be used. The subject is covered in general terms, and the contractor devises his own methods for the attachments and supports.

It is necessary that piping shall be installed without undue strains and stresses; provision must be made in the hanger assemblies for expansion, contraction, and structural settlement.

Hot water piping, particularly copper tubing, expands and contracts as the temperature of the water changes. The hangers should be chosen so that the pipe can expand free of the building structure.

The illustrations in this chapter show the types of supports commonly used for vertical piping. Large size pipes may require metal 3/8" or more in thickness, while small pipes may be one-half this thickness. The clamp rests on the floor as the support for the pipe.

The above illustrations also show typical hangers used to support horizontal piping. The variety and types of design for support run into the hundreds, with the design varying with each manufacturer. The turnbuckles shown on the threaded rods are used to set the elevations of the pipe where it is critical. Larger pipes may require a roll type hanger to compensate for expansion and contraction.

Where several piping systems parallel each other, as in laboratory piping or manufacturing plants, a trapeze hanger is used. The channel is supported by steel rods hung from concrete inserts. The roller supports are bolted to the trapeze and allow some expansion and contraction of the piping.

Fire sprinkler manuals illustrate a variety of hangers which are acceptable to the National Board of Fire Underwriters for sprinkler installations.

Where the lines are long, and the expansion may be extensive, as in copper tubing, patented expansion devices may be used, or loops incorporated in the piping to handle the expansion. The piping must then be anchored on each side of the loop, in order to keep the piping in alignment and make the loop effective. The anchoring is usually done at the trapeze hangers by angular bracing to concrete inserts set in the slab or welded to steel beams. The force exerted by the expansion of the piping can be considerable, so the angular bracing must be carefully done.

Where concrete inserts are used they must be set in the slab forms prior to the concrete pour and before the reinforcing bars are placed. There are many manufacturers of such devices and many different types.

The Inspector should be aware of the need for the supports and should have a knowledge of the types of supports required. The Contractor should provide samples of the devices he proposes to use prior to actual installation. The interested parties will be able to approve or disapprove and each craft will know the space requirements of the other, such as electrical, plumbing, or fire sprinkler.

Often the hanger assembly can be designed so that more than one piping system can use the same trapeze or racks. In a large laboratory or hospital, a system of pipe tunnels may connect the various buildings. Steel racks are then installed on one or both sides of the walk through tunnels on which all the piping for the various services is installed. Installations of this type are detailed and described in the plans and specifications prepared by the Architect/Engineer.

<u>Equipment Anchors</u>:

The California Code requirements governing school construction administered by the Schoolhouse Section of the Office of Architecture and Construction require that water storage tanks, pumps, water heaters, institutional type kitchen equipment, sterilizers, and all such equipment shall be firmly anchored to the base supporting it. The type and size of anchors is determined at the time the plans and specifications are checked by the above Agency.

The history of earthquakes in California has resulted in this requirement. The recent severe earthquake centered at Sylmar in Southern California has caused a tightening of the standards. The Inspector should be aware of this requirement when checking such work.

Fixture Supports:

Supports needed for all fixtures must be supplied and installed by the Plumbing Contractor in most cases.

If it involves wood backing for lavatories and openings in the walls or floors, the Plumbing Contractor is responsible for dimensional data and the actual framing or forming will be done by the General Contractor.

Heavy items, such as institutional fixtures, wall hung water closets, surgeons' sinks, and others, will require steel plates for backing and support, or special supports supplied specifically for the fixture.

Sec. 316 — Hangers and Supports

(a) **Vertical Piping**

(1) Attachment—Vertical piping shall be secured at sufficiently close intervals to keep the pipe in alignment and carry the weight of the pipe and contents. Stacks shall be supported at their bases, and if over two (2) stories in height at each floor, by approved metal floor clamps.

(2) Cast iron soil pipe—Cast iron soil pipe shall be supported at not less than at every story height and at its base. Hubless or compression gasket joint — supported at no less than at every story height, at its base and sufficiently close intervals to keep the system in alignment and to adequately support the weight of the pipe and its contents.

(3) Screwed pipe—Screwed pipe (IPS) shall be supported at not less than every other story height.

(4) Copper tubing—Copper tubing shall be supported at each story for piping one and one-half (1½) inches and larger in diameter and at not more than six (6) foot intervals for piping one and one-quarter (1¼) inches and smaller in diameter.

(5) Lead Pipe—Lead pipe shall be supported at intervals not exceeding four (4) feet.

(6) Plastic Pipe—Plastic pipe shall be maintained in the straight alignment.

(b) **Horizontal Piping**

(1) Supports—Horizontal piping shall be supported at sufficiently close intervals to keep it in alignment and prevent sagging.

(2) Cast iron soil pipe—Where joints occur, suspended cast iron soil pipe shall be supported at not more than five (5) foot intervals; except that pipe exceeding five (5) feet in length, may be supported at not more than ten (10) foot intervals. Supports shall be adequate to maintain alignment and prevent sagging and shall be placed within eighteen (18) inches of the hub or joint. Hubless or compression gasket joints must be supported at least at every other joint except that when the developed length between supports exceeds four (4) feet, they shall be provided at each joint. Supports shall also be provided at each horizontal branch connection. Supports shall be placed on or immediately adjacent to the coupling. Suspended lines shall be suitably braced to prevent horizontal movement.

(3) Screwed pipe—Screwed pipe (I.P.S.), except as provided in Section 1213(f) and Table 12-5, shall be supported at approximately ten (10) feet intervals.

(4) Copper tubing—Copper tubing shall be supported at approximately six (6) foot intervals for piping one and one-half (1½) inches and smaller in diameter and ten (10) foot intervals for piping two (2) inches and larger in diameter.

(5) Lead pipe—Lead pipe shall be supported by strips or otherwise for its entire length.

(6) In ground—Piping in the ground shall be laid on a firm bed for its entire length, except where support is otherwise provided which is adequate in the judgment of the Administrative Authority.

(7) Plastic pipe—Plastic pipe shall be supported at not to exceed four (4) feet.

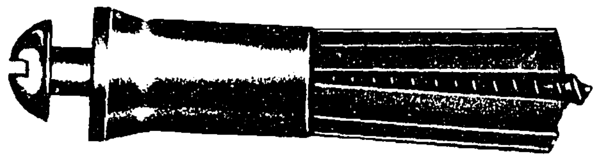
(c) **Hangers and Anchors**

(1) Material—Hangers and anchors shall be of metal of sufficient strength to maintain their proportional share of the weight of pipe and contents.

(2) All piping, fixtures and equipment shall be adequately supported to the satisfaction of the Administrative Authority.

Power-Activated Fasteners.

A modified firearm designed to fire a pin or stud into concrete. This tool should be used only by persons thoroughly checked out in safety procedures by a qualified power-tool expert. This tool is prohibited in some localities.

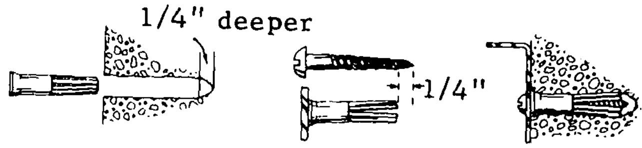


Lead Anchor

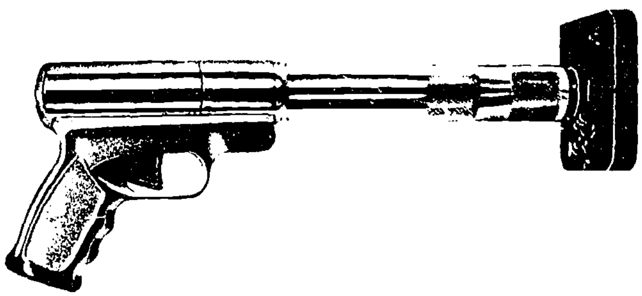
Standard

The installation procedure for a lead anchor is:

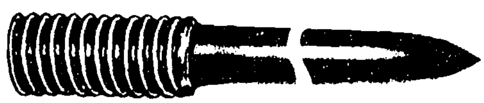
1. No. A. Drill hole ¼″ deeper than the length of the lead anchor and insert the anchor into the hole.
2. No. B. Select a wood screw as long as the thickness of the fixture or fixture hanger **plus** the length of the lead anchor **plus** ¼″.
3. No. C. Insert the wood screw through the fixture or fixture hanger into the anchor and tighten. The anchor will expand and hold firmly in the wall.



Installation of Lead Anchor



Heavy Duty
Power Activated Fasteners



Power Stud

Steel Plate & Rods →

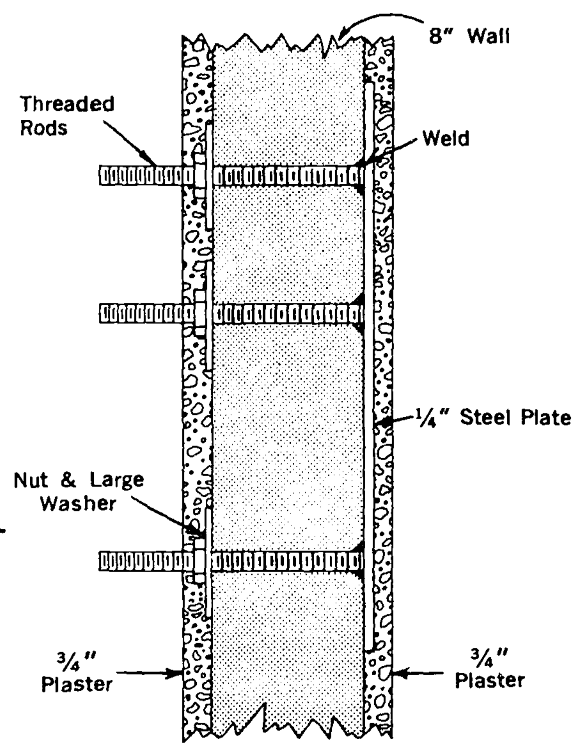


Fig. 5-1 Types of Fasteners

1. Wood screw:
   a) Tapered body,
   b) Slotted head for screw driver use.
2. Lag screw:
   a) Tapered end,
   b) Fewer threads per inch,
   c) Square or hex head for tightening with a wrench.
3. Machine screw:
   a) Straight body,
   b) Must be used with a tapped anchor,
   c) Higher number of threads per inch,
   d) Slotted head for screwdriver, or square or hex head for wrench use.
4. All slotted screws can be obtained with flat, oval, or round head.

Standard Wood Screw Information

Size No.	Threads per In.	Diameter in In. Decimal	Diameter in In. Fraction (Approx.)
0	32	.064	1/16
1	28	.077	3/32
2	26	.090	
3	24	.103	1/8
4	22	.116	
5	20	.129	
6	18	.142	5/32
7	16	.155	
8	15	.168	
9	14	.181	3/16
10	13	.194	
11	12	.207	
12	11	.220	
14	10	.246	1/4
16	9	.272	
18	8	.298	5/16
20	8	.324	
24	7	.376	3/8

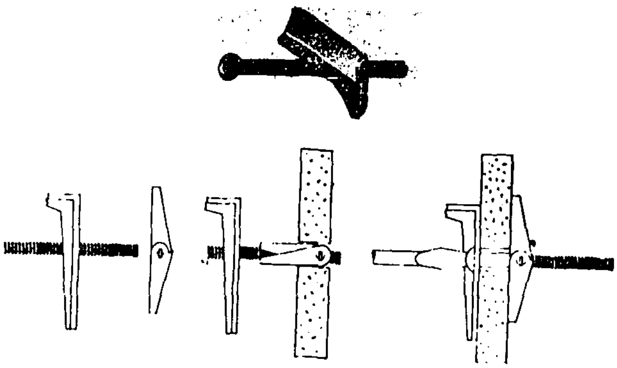
* Note.—The length of wood screws advances by 1/8" up to 1"; lengths from 1" to 3" advance by 1/4"; from 3" to 6", the lengths advance by 1/2".

A 1 x 10 is a No. 10, 1" long, 13 threads to the inch, approximately 3/16" in diameter.

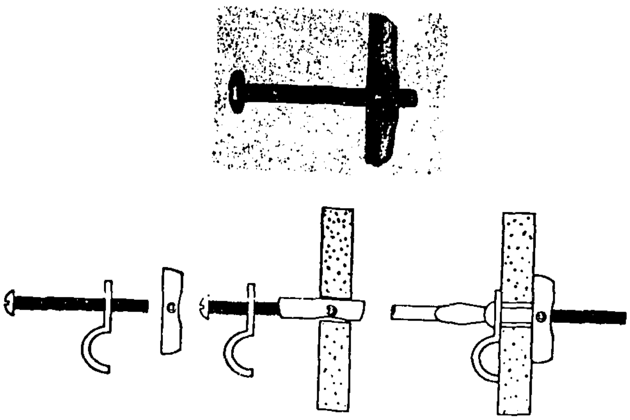
Machine Screw Information

Size	Threads per In.	O.D. of Thread (In.)
1	64	.0730
2	56	.0860
3	48	.0990
4	40	.1120
5	40	.1250
6	32	.1380
8	32	.1640
10	24	.1900
12	24	.2160

A 10 x 24 x 1 machine screw is size 10, 24 threads per inch, 1" long.



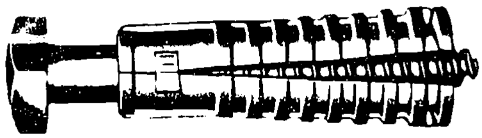
Spring-Loaded Folding Toggle



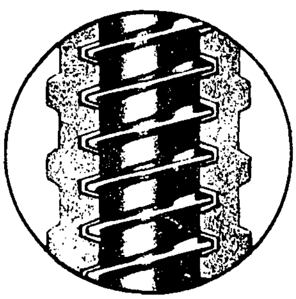
Tumbling Toggle

Fig. 5-2 Screw Data

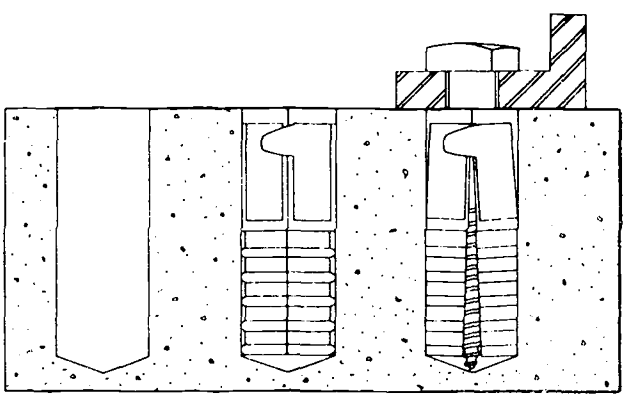
The lag screw expansion shield is installed primarily in concrete and solid masonry such as brick and stone. The shield has internal threads to receive a lag screw (No. 2) and can be used for heavy-duty fastening for loads not subject to extreme vibration, tension, or shear. The lag screw shield is safest when installed in a horizontal position as shown in No. 3.



1



2



3

1. Drill hole of proper diameter to depth of shield.
2. Clean hole with compressed air or wet swab.
3. Insert shield in hole and tap with hammer for proper positioning.
4. Place object to be fastened over shield.
5. Insert lag screw through object and into shield. Tighten.

Fig. 5-3 Lag Screw

pictorial guide

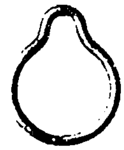
pipe rings

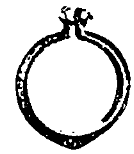

adj. swivel ring
solid ring type
fig. 101
¾ to 8 in. pipe


adj. swivel ring
with boss
fig. 101B
2 to 8 in. pipe


adj. swivel ring
split ring type■
fig. 104
¾ to 8 in. pipe


adj. clip ring
fig. 105
¾ to 2 in. pipe

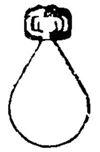

pear shape ring
fig. 232
½ to 6 in. pipe


split ring
fig. 108
⅜ to 8 in. pipe
fig. CT-109 ½ to
4 in. copper tubing

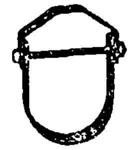
pipe rings


split ring
with socket
fig. 107
⅜ to 8 in. pipe


split ring
with turnbuckle
adjuster fig. 115
⅜ to 8 in. pipe

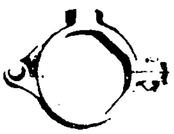

adj. wrought
ring■ fig. 97
½ to 8 in. pipe
fig. CT-99
½ to 4 in. tubing

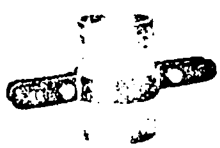

adj. wrought
ring hanger
fig. 95
½ to 8 in. pipe

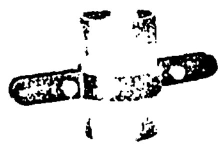

adj. wrought
clevis fig. 260
½ to 24 in. pipe;
light weight clevis
fig. 65, ⅜ to 4 in. pipe


adj. wrought
ring
fig. 269
½ to 8 in. pipe

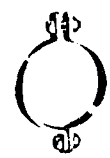
clamps

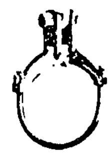

extension split clamp
fig. 138
⅜ to 3 in. pipe
fig. CT-122
½ to 2 in. tubing


extension pipe or
riser clamp ■
fig. 261
¾ to 20 in. pipe;


copper tubing
riser clamp■
fig. CT-121
½ to 4 in. tubing

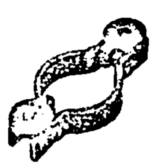

wrought double-bolt
pipe clamp
fig. 295
1½ to 24 in. pipe


wrought pipe clamp
medium fig. 212
½ to 24 in. pipe;
heavy fig. 216
3 to 16 in. pipe

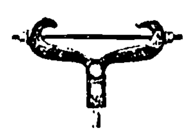

alloy pipe
clamp
fig. 224
4 to 16 in. pipe

clamps • socket clamps • beam clamps


heavy-duty
alloy pipe clamp
fig. 246
10 to 24 in. pipe


socket clamp
fig. 600
4 to 24 in. pipe


socket clamp
fig. 595
4 to 24 in. pipe


malleable beam clamp
with extension piece
fig. 229; without, fig. 218
safe load: 610 to 1365 lb


I-beam clamp
fig. 131
safe load: 540 lb

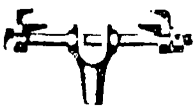
Courtesy-
GRINNELL

ph-1

Fig. 5-4a.

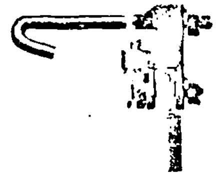
pictorial guide

beam clamps

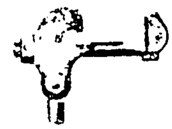


center I-beam clamp
fig. 217
safe load: 150 lb

Simplex top beam clamp
fig. 267
safe load: 610 to 3770 lb



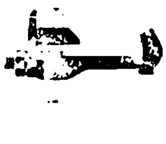
swinging top beam
clamp fig. 270
safe load: 610 to 2650 lb



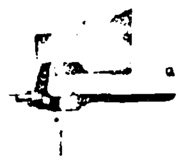
Universal channel
clamp fig. 226
safe load:
390 to 1140 lb

channel extension
clamp fig. 219
safe load:
610 lb

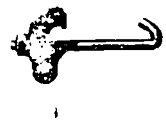
beam clamps



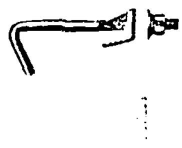
Simplex channel
clamp fig. 266
safe load:
460 to 1740 lb



Simplex side I-beam
clamp fig. 265
safe load:
460 to 1740 lb



Universal side I-beam
clamp fig. 225
safe load:
390 to 1140 lb

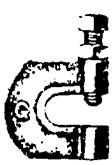


top beam clamp
fig. 227
safe load:
940 lb

UFS beam clamp
with weldless eye
nut fig. 292
safe loads:
up to 11,500 lb

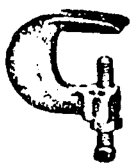
UFS beam clamp
with UFS nut
fig. 228
safe loads:
up to 11,500 lb

beam clamps and attachments



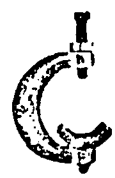
C-clamp
figs. 83, 84,
85, 86, 87, 88
3/8 to 3/4 in. rod

C-clamp and
ring hanger
fig. 94
1 to 2 in. pipe

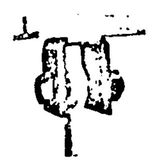


top beam
C-clamp
fig. 64
3/8 to 1/2 in. rod

bar joist clip
fig. 67
1/2 to 7/8 in. joist



G-clamp hanger
fig. 92, 93
1/2 to 4 in. pipe



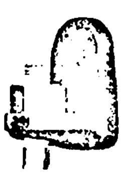
welded
beam attachment
fig. 66
3/8 to 2 1/2 in. rod

steel washer plate
fig. 60
3/8 to 2 1/2 in. rod

brackets

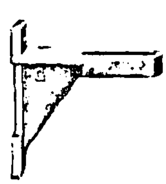
adj. wrought
beam attachment
fig. 252
3/8 to 7/8 in. rod

earthquake
brace
fitting
fig. 204

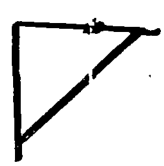


side beam
bracket
fig. 202
load: 390 to
830 lb

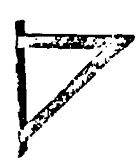
side column
bracket
fig. 203
load: 610 to 1130 lb



cast iron
bracket
fig. 213
load: 180 lb



light welded
steel bracket
fig. 194
max load: 750 lb
clip fig. 193



welded steel brackets
medium fig. 195
max load 1500 lb;
heavy fig. 199
max load 3000 lb

* For copper tubing.

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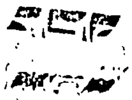
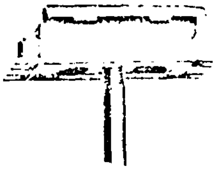
Fig. 5-4b.

concrete inserts


CB-Universal concrete insert
fig. 282
3/8 to 7/8 in. rod


CB-Junior concrete insert
fig. 279
3/8 to 1/2 in. rod


screw concrete insert
fig. 152
3/8 to 7/8 in. rod


light weight steel concrete insert
fig. 285
1/4 to 5/8 in. rod


wedge type concrete insert
fig. 281
1/4 to 7/8 in. rod


expansion case closed back type
fig. 117
1/4 to 1 in. rod

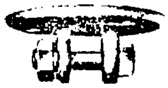

rod coupling
fig. 208;
3/8 to 7/8 in. rod
toggle bolt fig. 209

ceiling flanges


pipe hanger flange
fig. 153
for 3/8 to 7/8 in. rod


swivel hanger flange
fig. 154
for 3/8 to 7/8 in. rod

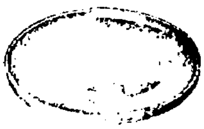

adj. swinging hanger flange
fig. 155
for 3/8 to 7/8 in. rod

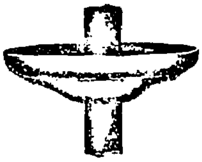

swinging hanger flange only
fig. 156
for 3/4 to 12 in. pipe

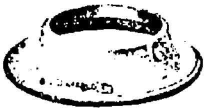

ceiling flange
pipe threaded fig. 128
1/8 to 3/4 in. IPS;
rod threaded fig. 128R
3/8 and 1/2 in. rod

ceiling flanges • ceiling plates • floor plate


adj. ceiling flange
fig. 116
3/8 in. rod size


ceiling plates
spring fig. 133
3/8 to 3/4 in. rod


ceiling plate
fig. 127
3/8 to 1/2 in. rod


ceiling plate
fig. 395
1/2 to 8 in. pipe

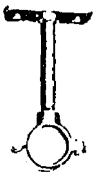

floor plate
fig. 396
1/2 to 8 in. pipe

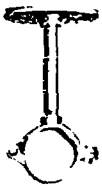
assemblies


split ring with socket and coach screw


split ring, socket and ceiling flange


solid ring and coach screw rod


extension split clamp hanger
fig. 139 (pipe)


extension split clamp hanger
fig. CT-130 (tubing)


adjustable ring hanger
fig. 106

* For copper tubing.

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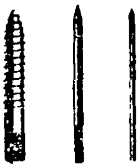
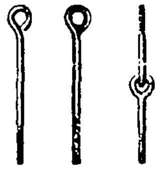
Fig. 5-4c.

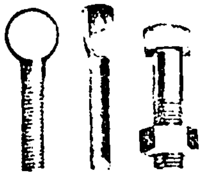
pictorial guide

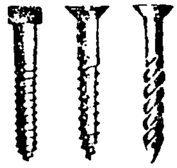
rods • screws • bolts


hanger rods
machine threaded:
both ends; one end
only; continuous


coach screw rods:
other end pipe or
machine threaded
or not threaded


eye rods:
not welded
welded
linked


bolts:
extension eye
flattened end
machine with nut


screws:
square head coach
wood
drive

rod attachments

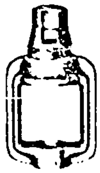

socket
pipe thr'd fig. 110
1/8 to 3/4 in. IPS;
rod thr'd fig. 110R
1/4 to 7/8 in. rod


extension piece
fig. 157
3/8 to 7/8 in. rod


weldless
eye nut
fig. 290
3/8 to
2 1/2 in. rod


forged steel
clevis
fig. 299
3/8 to
2 1/2 in. rod

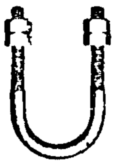

rod
coupling
fig. 136
1/4 to
1 in. rod

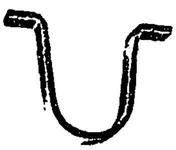

adj. swivel
coupling
fig. 134
3/8 to
7/8 in. rod


turnbuckle
adjuster
fig. 114
1/4 to
3/4 in. rod


forged steel
turnbuckle
fig. 230
3/8 to 2 1/2 in. rod

U-bolts • straps • hooks


st'd U-bolt■ fig. 137
1/2 to 24 in. pipe;
light-weight U-bolt
fig. 120
1/2 to 10 in. pipe


wrought strap
long fig. 263
short fig. 262
1/2 to 4 in. pipe


one hole clamp
fig. 126
3/8 to 4 in. pipe

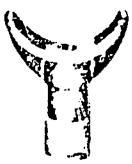

tin strap
fig. 231
1/4 to 2 in. pipe

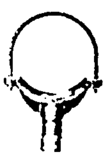

tube strap
fig. CT-124
1/4 to 1 in.
copper tubing


U hook
fig. 205
3/4 to 8 in. pipe


single hook
fig. 168
1/2 to 3 in. pipe

pipe saddles • anchor chair • protection saddle


pipe saddle
support
fig. 25?
4 to 36 in. pipe


pipe stanchion
saddle
fig. 259
4 to 36 in. pipe


adjustable pipe
saddle support
fig. 264
2 1/2 to 36 in. pipe


anchor chair
fig. 197
4 to 24 in. pipe


pipe covering
protection
saddle
fig. 160


insulation
protection
shield
fig. 167

* For copper tubing. ■ Also available plastic coated.

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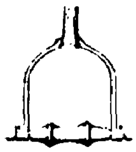
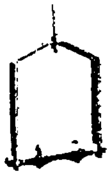
Fig. 5-4d.

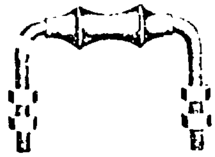
pipe rolls



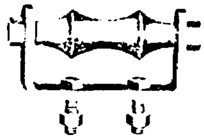
adj. swivel
pipe roll
fig. 174
2½ to 12 in. pipe



adj. steel yoke
pipe roll
fig. 181
2½ to 20 in. pipe



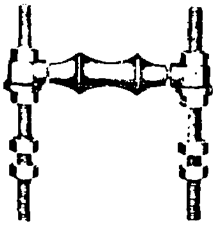
roller support
fig. 176
2 to 8 in. pipe



roller chair
fig. 175
2 to 12 in. pipe

single pipe roll
fig. 171
1 to 30 in. pipe

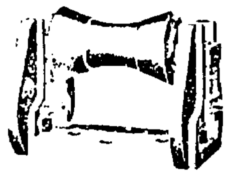
pipe rolls



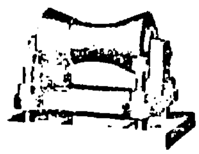
adjustable pipe
roll support
fig. 177
1 to 30 in. pipe

pipe roll and plate
fig. 277
2 to 30 in. pipe

pipe roll stand
complete
fig. 271
2 to 42 in. pipe

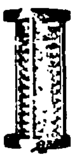


adjustable pipe
roll stand
fig. 276
4 to 30 in. pipe

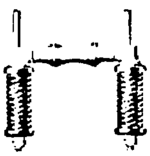


adjustable pipe roll
with base fig. 274;
without base fig. 275
2 to 30 in. pipe

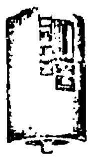
spring hangers



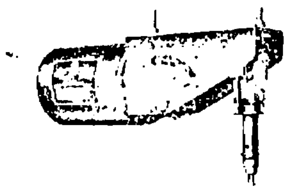
light duty
spring hanger
fig. 247



spring cushion
for pipe rolls
fig. 178



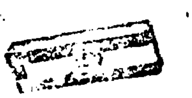
Pre-Engineered
spring hanger
figs. 82, 98, B-268



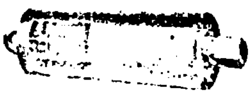
Constant Support hanger
load: 27 to 57500 lb
horizontal: fig. 81-H

Constant Support hanger
load: 27 to 57500 lb
vertical: fig. 80-V

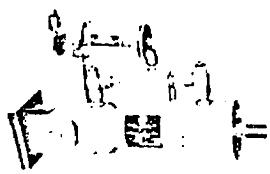
traveler • sway brace • shock suppressor • stress-trol



horizontal
traveler
fig. 170



vibration control
and sway brace
fig. 296



hydraulic shock and
sway suppressor
fig. 200

stress-trol

Courtesy-
GRINNELL

ph-5

Fig. 5-4e.

CHAPTER 6

PIPE JOINTS AND CONNECTIONS

General: The joining of pipe to contain gases and fluids within and prevent unwanted infiltration from without can be categorized into three main system types: 1. Pressure, 2. Pressureless and 3. Vacuum.

Pressure: These systems carry water, gases, fuels and chemicals or process materials all above atmospheric pressure (0 lbs. per square inch gage). In some instances, systems normally considered to be pressureless such as sewerage systems, may also incorporate force mains that occur on the discharge side of sewerage lift pumps. Sewerage effluent and solids are lifted through the pumps and forced uphill under a pressure above 0 psig until a suitable elevation is obtained to allow transport by gravity flow.

Pressureless: Examples of pressureless systems are sewer, storm water drains, vents, fill lines, and overflow piping. Generally any flow of fluids by gravity can be considered pressureless. Characteristics of these systems change only when a stoppage in the piping causes a back up of fluids and creates pressures greater than atmospheric.

It is difficult to keep water out of the underground systems if joints are improperly made, the pipe has deteriorated, or vibration and earth movement has cracked the pipe or loosened the joints. Infiltration into underground municipal systems caused by high ground water tables has created an overload condition for many sewerage treatment plants.

Vacuum: As the name implies vacuum applies to systems operating below atmospheric pressure. Floor vacuum systems and medical vacuum systems qualify for discussion here. Joints in these systems are intended to keep unwanted air out except at the designated pick up points. Lift lines on the suction side of some pumps that operate under a vacuum also qualify here.

The integrity of any piping system depends on properly made joints using the correct methods and materials.

Criteria for Good Joints: Proper preparation of materials is the foremost criteria necessary before any joining can be executed. All surfaces of both pipe and fittings shall be clean regardless of the type of joint to be made. Pipe materials shall be handled with reasonable care to prevent nicks or cracks on the surface that may end up in a joint location. This is particularly necessary with cast-iron, clay, glass and plastic pipe.

Materials to be used shall be checked against the specifications for the project. If there are no specifications to follow then the Inspector shall request manufacturers' literature showing the type of services for which the material is recommended, pressure limitations, and the proper assembly method. All materials proposed for use shall be inspected for identifying marks which will often show manufacturer's name, pressure ratings, agency approvals, type of service for which intended, and many other useful markings. Familiarity in reading these markings is very useful. The types of markings will depend upon the manufacturer and the standards governing the product.

Special tools may be required for the preparation or assembly of some joints. Tools with cutting surfaces for grooving or threaded pipe should be sharp so as to leave well defined ridges on threads and smooth cuts on grooving. Observation of ragged cuts should be brought to the attention of the Plumber. This is also true of beveling machines where welded joints are being prepared. Here, however, the sharpness of cut is not as important as the angle of cut. Welding machines and soldering torches shall also be the proper size and have the capability for the work at hand.

It is a good idea to generally scrutinize any machinery or tools to be used on the job site from the safety standpoint.

Execution of the joining process, once underway, should follow an orderly procedure. The proper alignment of the parts is vital, and the makeup of any joint should not proceed until this has been achieved. Normally, fittings or pipe bending is necessary to make an offset.

Tolerance in alignment on underground drainage and water mains is sometimes allowed based on the data of the pipe and fitting manufacturer and job conditions. Above ground, refer to NO-HUB and BAND-SEAL joints and others.

<u>Types of Joints and Joining Method</u>:

<u>Screwed</u>: Detailed specifications for pipe threads are covered in the publication, American Standard Pipe Threads, ASA B2.1. Thread cuts are generally machine made after piping is cut to length. Pipe should be cut square and trimmed inside and out with reamer or file. Observation of the care used here is a good indication of the overall quality of the pipe installation. As the threads are cut a good grade of cutting oil shall be used to prevent tearing away the metal instead of cutting it.

Total thread length is critical since effective thread length (the net amount of thread to thread engagement) determines whether or not a leak proof joint is made. For each pipe size there is an effective thread length from which there shall be no deviation. Knowing ahead of time the amount of pipe length lost in thread engagement allows the Fitter to cut and join pipe, fitting it to predetermined dimensions. Finished threads shall be sharp with no metal tear visible.

Thread sealing or lubricating compound is normally applied TO THE MALE THREAD ONLY and worked into the thread groove with brush or finger before making up a joint. A pipe vise or backing wrench normally holds the work, with the actual makeup being done with another wrench.

If the work being joined cannot tolerate wrench marks on pipe or fittings, special tools must be used such as the Parmelle or strap wrench. Joints shall be wiped clean of thread compound since any outside the joint does not help the seal and may prevent paint from sticking.

Soldered: Soldering encompasses the use of low (soft solder) and medium (hard solder) temperature melting point metals for joining pipe into fittings. This method should never be allowed on a butt joint with pipe only.

Soft solder, either 50/50 (50% tin and 50% lead) or 95/5 (95% tin and 5% lead) is considered low temperature soldering with melting point 620° F. to 460° F. Sil-Fos and silver solder are high melting point joint materials flowing at approximately 1100° F. Their composition is silver and copper.

Either soldering material requires the same preparation and execution. Since this method is used mainly on non-ferrous joints the discussion will be concentrated here. Soft solder and silver solder may be used on ferrous materials but Sil-Fos should always be restricted for use on non-ferrous material.

Pipe shall be cut square and trimmed free of burrs. Pipe and fitting shall be cleaned thoroughly to remove all oxides. After cleaning, the metal shall appear shiny. Flux shall be applied to all work with a brush and the pipe well seated into the fitting socket. Heat is applied evenly and the solder drawn into the joint. Over heating or under heating can result in a bad joint. On large joints it may be desirable to "wipe" the pipe and fitting prior to the actual soldering process. If it is suspected that a good solder penetration is not being achieved, a sample joint shall be cut open and the fitting and pipe peeled back.

Finishing off the joint with a small fillet is acceptable practice for hard solder joints since there is some strength added. A fillet of soft solder adds nothing to the strength of the joint and may be used to disguise a poor job.

Welded: Preparation of the joint usually requires beveling with machine or flame cutting in preparation of the usual vee weld. The surfaces to be welded shall be clean and free from paint, oil, rust or scale. Parts shall be properly aligned so that no part is offset more than 20 per cent of the pipe thickness. Tack welds are usually applied before the final welds are attempted. Final weld application may require one, two, or three passes and sometimes more depending on material thickness.

Backing rings may at times be required to allow good penetration for the first pass root weld and to prevent weld spatter from reaching the interior; there shall be no protrusions of welding material inside.

Electrodes for electric arc welding shall be kept dry. Powder fluxes, where used, shall also be kept dry. During wet weather this may require storage of electrodes and fluxes in portable ovens kept at the project site.

Joints in steel pipe with a 1/2 inch or greater wall and a carbon content in excess of 0.35 per cent and in carbon-molybdenum steel require uniform preheating to a temperature of not less than 400° F. These joints shall be stress relieved after welding by heating uniformly to a temperature of between 1100 and 1250° F. Temperature must be maintained for a period of one hour per inch of pipe wall thickness for carbon steel and two hours per inch of pipe wall thickness for carbon-molybdenum.

Joint brazing generally follows the same procedures as gas welding but is applied at a lower temperature.

Flanged: Flanges may be attached to piping by threading, welding, soldering, expanding, brazing or other suitable means. Flange alignment is very important especially on raised face flanges. Tightening the bolts on a flange must keep both faces parallel and tension must be evenly applied to all bolts in turn.

Specifications, where governing the work, shall be checked for gasket and bolt material description. Gasket material must be suitable for temperature, pressure and service of pipe system. Bolt material, too, must be suitable for temperature and exposure conditions of the project.

Bolt tightening for larger flanges shall follow in succession around the flange perimeter with minimum take up on each bolt. For smaller flanges, jumping across to bolts directly opposite one another with minimum take up on each bolt, will usually hold flange faces parallel. Raised face flanges should always have opposite bolts tightened.

Plastic Socket: Plastic piping joints are normally jointed with two methods: 1. Solvent cementing, and 2. Heat fusion sealing. As in all previous methods pipe and fittings shall be clean with pipe ends square cut and free from burrs. Wheel cutters shall never be allowed for cutting plastic pipe.

Solvent cleaner shall be applied to pipe and fitting in an undiluted state and allowed to dry. Attaching solvent is then applied to pipe, up to depth of fitting penetration, then to fitting and then again to pipe. Fitting is then seated on pipe until socket shoulder engages pipe end. Excess solvent shall be removed especially the bead at the fitting shoulder. Excess solvent left here can cause a weak pipe wall.

Heat fusion is used on waste pipe joints and systems. Preparation of pipe is the same as for solvent cementing. A polypropylene collar containing an electrical resistance wire is slipped on the pipe. The pipe end and collar are inserted in the fitting socket so that pipe and collar bottom against their respective stops. A compression clamp is then applied over the fitting socket shoulder and tightened. The wire coil pig tails protruding from the fitting are connected to leads on a power pack unit that supplies current to the coil. The coil acts as a resistance heater and melts the surrounding plastic surfaces of the pipe and fitting. The power pack unit is automatically timed and shuts off when sufficient heat has been applied. The resulting connection is without interface and appears as one homogeneous structure leaving the electric coil embedded in the plastic.

This joint can also be made with a torch and a metal wrap-around. The Plumber simultaneously heats pipe end and inside of fitting. When the plastic on each softens enough to weld, the pipe and fitting are brought together. Only a very experienced Plumber is successful in this operation so two or three test joints shall be cut, and inspected before this method is approved.

<u>Caulked</u>: This method of joining is one of the oldest in use today and is still effective on both pressure and pressureless joints. The make up of this joint is simple and quick but the Plumber must carry out all the procedures properly. This joint is used with bell type clay or cast-iron pipe. The hubless joint has made great inroads into the use of the caulked joint but the bell and spigot joint is still alive and well.

The bell should be wiped clean of all dirt and the spigot end inserted. If the work is arranged in a vertical position the Plumber's job is eased. The annular space between the pipe and the bell is packed with oakum and seated with caulking tools leaving about one inch of depth of the hub for pouring in lead or bituminous compound. When the oakum is well seated in several layers the lead is poured up to the rim of the bell and seated with inside and outside caulking tools. These tools are chisel shaped and force the lead into an intimate seal between pipe wall and bell wall. If the fitter is working a wet joint it is common practice to pour a small amount of kerosene on the wet oakum to prevent lead spattering.

When it is necessary to make up a joint in the horizontal position the Plumber follows the same procedure with the oakum. When that is seated a running rope is wrapped around the pipe tight against the bell. The pouring opening is left near the top a little off center. The hot lead or bituminous compound is poured slowly into the pouring opening while hot gases are escaping from the same hole. Caulking tools are used to seat the lead after it has cooled.

Care shall be taken to check the oakum and make sure it is not some other substitute substance. Cotton and hemp may be used but oakum gives the best results and will last longer. Lead shall be virgin pig lead in ingot form and not reclaimed, or worse, scrap lead.

The pipe shall be properly aligned although a slight deflection is allowable in this joint.

No-Hub and Band Seal: No-Hub and Band Seal are registered trade marks and generally describe a hubless or spigot only method of joining pipe. This requires the use of neoprene rubber coupling and stainless steel bands with hex head bolts. These joints are normally restricted to pressureless type systems on cast-iron and clay pipe.

Pipe spigots shall be clean and cut as square as possible. Couplings are slipped on each pipe spigot and sealed on the interior rubber shoulder ring. The stainless steel band is then tightened with torque wrenches to a specified foot pound torque for each joint. Plumbers will often use a liquid joint seal; this is not necessary nor is it recommended.

Band seal couplings are similar but suited to clay pipe. Joints between clay and cast-iron pipe must be made with special adapter couplings.

Pipe systems joined with rubber couplings may be misaligned without leaks. No published data exists on the amount of deflection allowable but a figure of 5^{o} is generally acceptable. Any system that is to be warped should be tested with the misalignment in place.

Compression: Rubber compression rings (as opposed to rubber couplings) may be used on pressure systems and pressureless systems. There is such a wide range of uses for the rubber compression ring it would not be possible to cover them all here. We will concern ourselves with the two most common applications: 1. Bell and spigot cast-iron sewer and drainage pipe and 2. Asbestos-cement pressure pipe and couplings.

Cast iron pipe bells are fitted with a compression ring and the lubricated plain end of the next section inserted and seated completely to the bottom of the hub. The rubber ring may be lubricated but not the inside of the bell. This joint will absorb vibrations and may be deflected 5^{o} without leakage. Care should always be exercised to insure complete penetration of the spigot into the bell.

Asbestos-cement joints usually consist of a coupling fitted between two lengths of pipe. The rubber rings are inserted into the grooves inside the coupling, lubricated, and the spigot inserted into the coupling. The spigot end must be machined with the necessary taper if the piping is cut in the field. Depth of penetration into the coupling is regulated by the shoulder on the tapered pipe end and should be checked with depth guage. Systems joined with this method are used with pressures up to 200 psi.

Victualic: Victualic couplings are normally used on pressure systems and are available for use on cast-iron, steel, brass, aluminum and other materials. The victualic system uses a rubber ring compressed by a two piece coupling on the butt joint of two pieces of pipe. Grooves are cut in the pipe ends to receive the coupling shoulder which locks the pipe together and prevents lateral movement.

Grooving the pipe end is done in the field on a machine similar to a threading machine. Cutting oil should be applied so the resulting groove will have sharp shoulders and a smooth cut. Specifications should be checked for gasket type since system operating temperature and gasket should be compatible. The pipe is usually aligned but deflections of from $1/2^{o}$ to 6^{o} are allowable depending on pipe size and coupling type.

Mechanical: Mechanical joints employ a variation of flange, compression gasket and sliding flange for cast-iron and steel pipe joints. The male spigot end is seated into the socket or modified bell end where the fixed flange is located. The gasket is fit up into the annular space between the bell and spigot wall. The sliding flange on the spigot end is then started with bolts and drawn to the fixed flange. A shoulder on the sliding flange compresses the gasketing between the bell and spigot wall.

Bolt tightening should progress as for other flanged joints. The gasket compression shall be stopped short of the two flange faces meeting.

Manufacturers' Standards and Instructions: Each joint and joint material has definite limitations, which will restrict the use of the joint. These limits are set by the parameters dealing with the composition of the fluid or material in the pipe, pressures, and flexibility, among others.

The Inspector shall obtain from the Contractor, the manufacturers' literature covering the material being installed. The Inspector must then satisfy himself that the materials are suitable.

Most manufacturers will list design limitations for their products and also list recommended uses. Also available, are instructions with illustrations for proper installation. When in doubt regarding the methods or materials that are being used, the Inspector shall either consult with the Architect/Engineer or, if there is no independent engineer, contact the manufacturer's representative and ask for sufficient data to enable a proper evaluation of the installation.

The above discussion regarding manufacturers' literature is very important and is repeated here for emphasis.

Over a period of time a library of reference publications should be assembled on the various types of materials used in joining pipe, and proper installation and design limitations. Factory catalog literature carefully culled makes good reference material. Engineering specifications describing installation methods and system materials are also useful as reference material.

Joint Inspection: The Inspector cannot watch each joint being assembled, but generally will witness enough to satisfy himself that the work is being properly done. As job conditions change the Inspector shall be alert to possible changes in assembly.

A visual inspection will soon detect a reduction in quality of workmanship. Misaligned, dirty and sloppy looking work is a tip off that a closer look is necessary. Repeated often enough it may require a sample joint to be sectionalized with a hack saw to get a good look at the internal quality. There should be no reluctance in requesting whatever is required to ensure that the Contractor is following the job specifications or manufacturers' instructions. When the construction documents are signed the Contractor obligates himself to produce a proper job in accordance with the job bid documents or acceptable good practice if there are no bid documents.

The pressure test is the final act in certifying a joint. Once it has passed this test over the prescribed time period it is safe to approve the installation. This does not guarantee that there will be no joint failures once the system has been put in operation but its the best tool available at the time.

Building movement, pipe expansion or vibration could open up welding holidays or cocked flanges even after the pressure tests are passed.

During the pressure test the entire system shall be carefully checked at each joint. The pressure guage reading shall be recorded periodically. The job specifications shall be followed explicitly regarding test pressures and duration of the test. If the requirement calls for NO leakage, a system with one joint dripping one drop per hour of water DOES NOT COMPLY and should be made over.

JOINTS AND CONNECTIONS

Section 801 — Tightness

Joints and connections in the plumbing system shall be gastight and watertight for the pressures required by test.

Sec. 802 — Types of Joints

(a) **Caulked Joints**—Caulked joints for cast-iron bell-and-spigot soil pipe and other similar joints shall be firmly packed with oakum or hemp and filled with molten lead to a depth of not less than one (1) inch. The lead shall be caulked thoroughly at the inside and outside edges of the joint, after caulking the finished joint shall not extend more than one-eighth (1/8) inch below rim of hub. No paint, varnish or other coatings shall be permitted on the joining material until after the joint has been tested and approved.

(b) **Threaded Joints**—Threads on iron pipe size (I.P.S.) pipe shall be standard taper pipe threads. Tubing threads shall conform to fine tubing thread standards. All burrs shall be removed. Pipe ends shall be reamed or filed out to full size of bore and all chips shall be removed. If a pipe joint material is used, it shall be applied only on male threads and such materials shall be of approved types, insoluble in water and non-toxic. Cleanout plugs and caps shall be lubricated with a water-soluble non-hardening material.

(c) **Wiped Joints**—Joints in lead pipe or fittings or between lead pipe or fittings and brass or copper pipe, ferrules, solder nipples or traps, shall be full-wiped joints. Wiped joints shall have an exposed surface on each side of a joint not less than three-fourths (3/4) inch and at least as thick as the material being jointed. Wall or floor flange lead-wiped joints shall be made by using a lead ring or flange placed behind the joint at wall or floor. Joints between lead pipe and cast iron, steel or wrought iron shall be made by means of a caulking ferrule or soldering nipple.

(d) **Solder and Sweat Joints**—Joints in copper tubing shall be made by the appropriate use of approved brass or copper fittings. Surface to be joined by soldering shall be cleaned bright by manual or mechanical means. The joints shall be properly fluxed with an approved non-corrosive type flux and made up with approved solder. All solder and fluxes shall be manufactured to approved standards.

(e) **Flared Joints**—Flared joints for soft-copper water tubing shall be made with fittings meeting approved standards. The tubing shall be expanded with a proper flaring tool.

(f) **Hot-Poured Joints**—Hot poured compound for clay sewer pipe joints shall conform to recognized standards and shall not be water absorbent and when poured against a dry surface shall have a bond of not less than one hundred (100) pounds per square inch. All surfaces of the joint shall be cleaned and dried before pouring. If wet surfaces are unavoidable, a suitable primer shall be applied. Compound shall not soften sufficiently to destroy the effectiveness of the joint when subjected to a temperature of one hundred and sixty (160) degrees Fahrenheit nor be soluble in any waste carried by the drainage system. Approximately twenty-five (25) percent of the joint space at the base of the socket shall be filled with jute or hemp. A pouring collar, rope or other device shall be used to hold the hot compound during pouring. Each joint shall be poured in one operation until the joint is filled. Joints shall not be tested until one (1) hour after pouring.

(g) **Cement Mortar Joints**—Except for repairs and connections to existing lines constructed with such joints, cement mortar joints are prohibited on building sewers less than eight (8) inches in diameter.

Where permitted, cement mortar joints shall be made in the following manner. A layer of jute or hemp shall be inserted into the base of the annular joint space and packed tightly to prevent mortar from entering the interior of the pipe or fitting. Not more than twenty-five (25) per cent of the annular space shall be used for jute or hemp. The remaining space shall be filled in one continuous operation with a thoroughly mixed mortar composed of one (1) part cement and two (2) parts sand, with only sufficient water to make the mixture workable by hand. Additional mortar of the same composition shall then be applied to form a one (1) to one (1) slope with the barrel of the pipe. The bell or hub of the pipe shall be left exposed and when necessary the interior of the pipe shall be swabbed to remove any mortar or other material which may have found its way into such pipe.

(h) **Burned Lead Joints**—Burned (welded) lead joints shall be lapped and the lead shall be fused together to form a uniform weld at least as thick as the lead being joined.

(i) **Asbestos Cement Sewer Pipe Joints**—Joints in asbestos cement pipe shall be a sleeve coupling of the same composition as the pipe and sealed with rubber rings or joined by an approved type compression coupling. Joints between asbestos cement pipe and other approved pipe shall be made by means of an approved adaptor coupling.

(j) **Bituminized Fiber Pipe Joints**—Joints in bituminized pipe shall be made with tapered type couplings or fittings of the same material as the pipe or of other compatible non-metallic materials. Joints between bituminous fiber pipe and metal pipe shall be made by means of an adaptor coupling caulked as required in Subsection (a) of this section.

(k) **Packing Additives Prohibited**—The addition of leak sealing additives to joint packing is prohibited.

(l) **Flexible Compression Factory-fabricated Joints**—When pipe is joined by means of flexible compression joints, such joints shall conform to approved standards and shall not be considered as slip joints.

(m) **Solvent Weld-Plastic Pipe**—Solvent Weld-Plastic pipe and fittings designed to be joined by solvent welding shall have a surface free of burrs, dust, dirt and moisture. A moderate even coating of solvent cement shall be applied to the pipe end and to the socket of the fitting. Joint shall be made quickly by inserting the pipe into the fitting socket to its full depth. All solvent weld materials shall be manufactured to approved recognized standards.

(n) **Mechanical Joints**—Mechanical joints for cast iron water pipe shall conform to nationally recognized standards.

Sec. 803 — Use of Joints

(a) **Clay Sewer Pipe**—Joints in vitrified clay pipe or between such pipe and metal pipe shall be made as provided in subsection (f), (g) or (l) of Section 802.

(b) **Cast-iron Pipe**—Joints in cast-iron pipe shall be made as provided in subsections (a), (b), (1), or (n) of Section 802.

(c) **Screw Pipe to Cast-iron**—Joints between wrought-iron, steel, brass or copper pipe and cast-iron pipe shall be either caulked or threaded joints made as provided in subsections (a) or (b) of Section 802 or shall be made with approved adapter fittings.

(d) **Lead to Cast Iron, Wrought-iron or Steel**—Joints between lead and cast-iron. wrought-iron or steel pipe shall be made by means of wiped joints to a caulking ferrule, soldering nipple or bushing as provided in subsection (c) of Section 802.

(e) **Copper Water Tube**—Joints in copper tubing shall be made by the appropriate use of approved fittings properly soldered or brazed together, or by means of approved compression fittings as provided in subsection (d) or (e) of Section 802.

(f) **ABS and PVC Pipe**—Joints in ABS and PVC pipe shall be made as provided in sub-section (m) of Section 802.

Sec. 804 — Special Joints

(a) **Copper Tubing to Screw Pipe Joints**—Joints from copper tubing to threaded pipe shall be made by the use of brass adapter fittings. The joint between the copper tubing and the fitting shall be properly sweated or soldered, and the connection between the threaded pipe and the fitting shall be made with a standard pipe size screw joint.

(b) **Brazing or Welding**—Brazing or welding shall be performed in accordance with requirements of recognized published standards of practice and by licensed or otherwise qualified mechanics, except when it is determined by the Administrative Authority to be equivalent procedure for the purpose of this code.

(c) **Slip Joints**—In drainage work and traps, slip joints of approved materials may be used in accordance with their approvals. In water piping slip joints may be used only on the exposed fixture supply.

(d) **Expansion Joints**—Expansion joints shall be accessible and may be used where necessary to provide for expansion and contraction of the pipes.

(e) **Unions**—Approved unions may be used in drainage work when accessibly located in the trap seal or between a fixture and its trap; in the vent system, except underground or in wet vents; at any point in the water supply system and in gas piping as permitted by subsection (h) of Section 1213.

Unions shall be installed in a water supply system within twelve (12) inches of regulating equipment, water heating, conditioning tanks, and similar equipment which may require service by removal or replacement in a manner which will facilitate its ready removal.

(f) **Ground Joint, Flared or Ferrule Connections**—Brass or copper ground joint, flared or ferrule type connections which allow adjustment of tubing, but provide a rigid joint when made up, shall not be considered as slip joints.

(g) **ABS and PVC to Other Materials**—When connecting plastic pipe to other types of piping use only approved types of fittings and adaptors, designed for the specific transition intended.

Sec. 805 — Flanged Fixture Connections

(a) Fixture connections between drainage pipes and water closets, floor outlet service sinks, pedestal urinals and earthen ware trap standards shall be made by means of approved brass, hard-lead or iron flanges caulked, soldered or screwed to the drainage pipe. The connection shall be bolted with an approved gasket, washer, or setting compound between the earthenware and the connection. The bottom of the flange shall be set on top of the finished floor on an approved firm base.

(b) Closet bends or stubs must be cut off so as to present a smooth surface even with the top of the closet ring before rough inspection is called.

(c) Wall mounted water closet fixtures shall be securely bolted to an approved carrier fitting. The connecting piping between the carrier fitting and the fixture shall be approved metal and designed to accommodate an adequately sized gasket. Gasket material shall be graphite impregnated asbestos, felt or similar approved types.

Sec. 806 — Prohibited Joints and Connections

(a) Drainage System—Any fitting or connection which has an enlargement, chamber or recess with a ledge, shoulder or reduction of pipe area, that offers an obstruction to flow through the drain is prohibited.

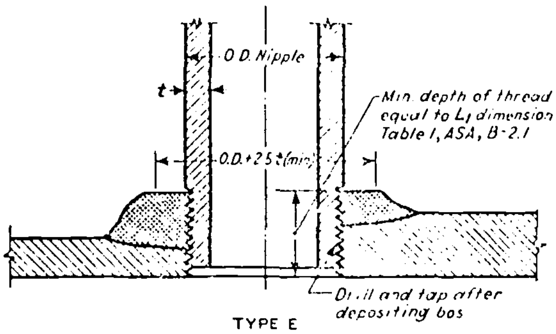
(b) No fitting or connection that offers abnormal obstruction to flow shall be used. The enlargement of a three (3) inch closet bend or stub to four (4) inches shall not be considered an obstruction.

Sec. 807 — Waterproofing of Openings

Joints at the roof around pipes, ducts or other appuretenances shall be made water tight by the use of lead, copper, galvanized iron or other approved flashings or flashing material. Exterior wall openings shall be made water tight. Counterflashing shall not restrict the required internal cross-sectional area of the vent.

Sec. 808 — Increasers and Reducers

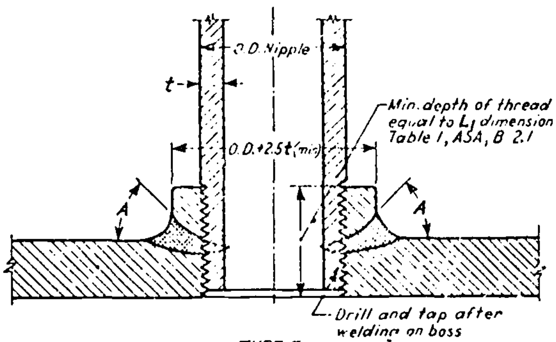
Where different sizes of pipes or pipes and fittings are to be connected, the proper size increasers or reducers or reducing fittings shall be used between the two sizes. Brass or cast-iron body cleanouts shall not be used as a reducer or adapter from cast-iron soil pipe to steel or wrought iron pipe.



TYPE E

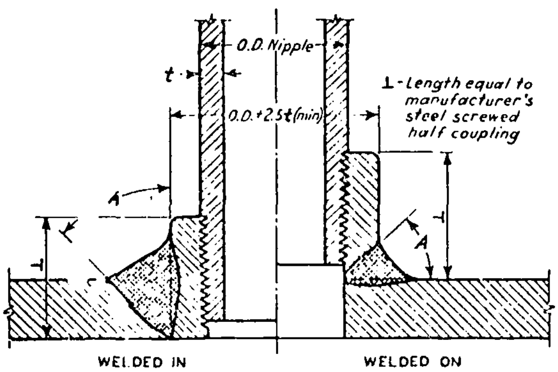
FIG. 13(E) BUILT-UP WELDED TAPPED BOSS*

* Built up bosses as shown by Types D and E are generally used with smaller diameters of pipe but can be employed on larger sizes if necessary. They are not recommended above $1^1/_4$ in. nominal pipe size.



TYPE F

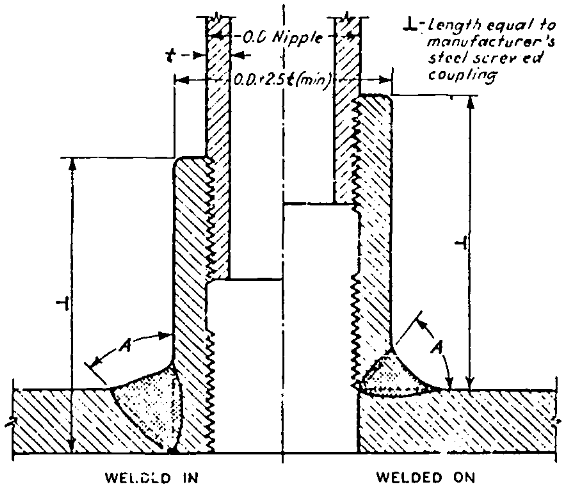
FIG. 13(F) WELDED-ON TAPPED PAD*



TYPE G

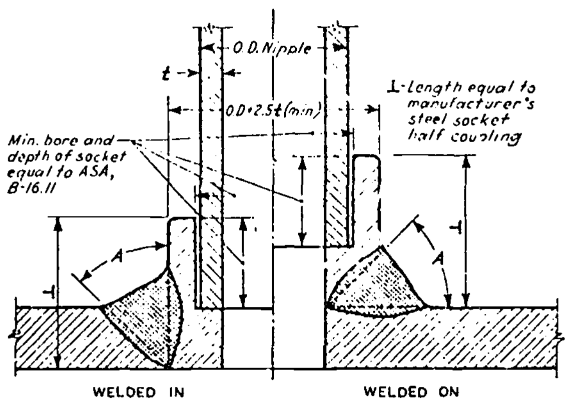
FIG. 13(G) WELDED HALF TAPPED COUPLING*

* Coupling may either be pre-tapped or drilled and tapped after attachment. Truing up of thread after welding is recommended.



TYPE H

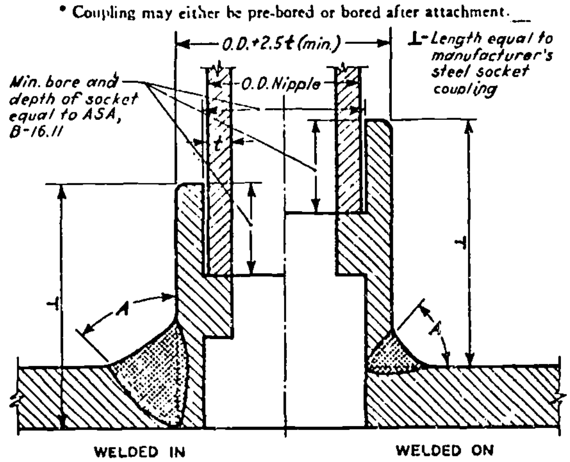
FIG. 13(H) WELDED FULL TAPPED COUPLING



TYPE I

FIG. 13(I) WELDED HALF SOCKET COUPLING*

* Coupling may either be pre-bored or bored after attachment.



TYPE J

FIG. 13(J) WELDED FULL SOCKET COUPLING

Fig. 6-1

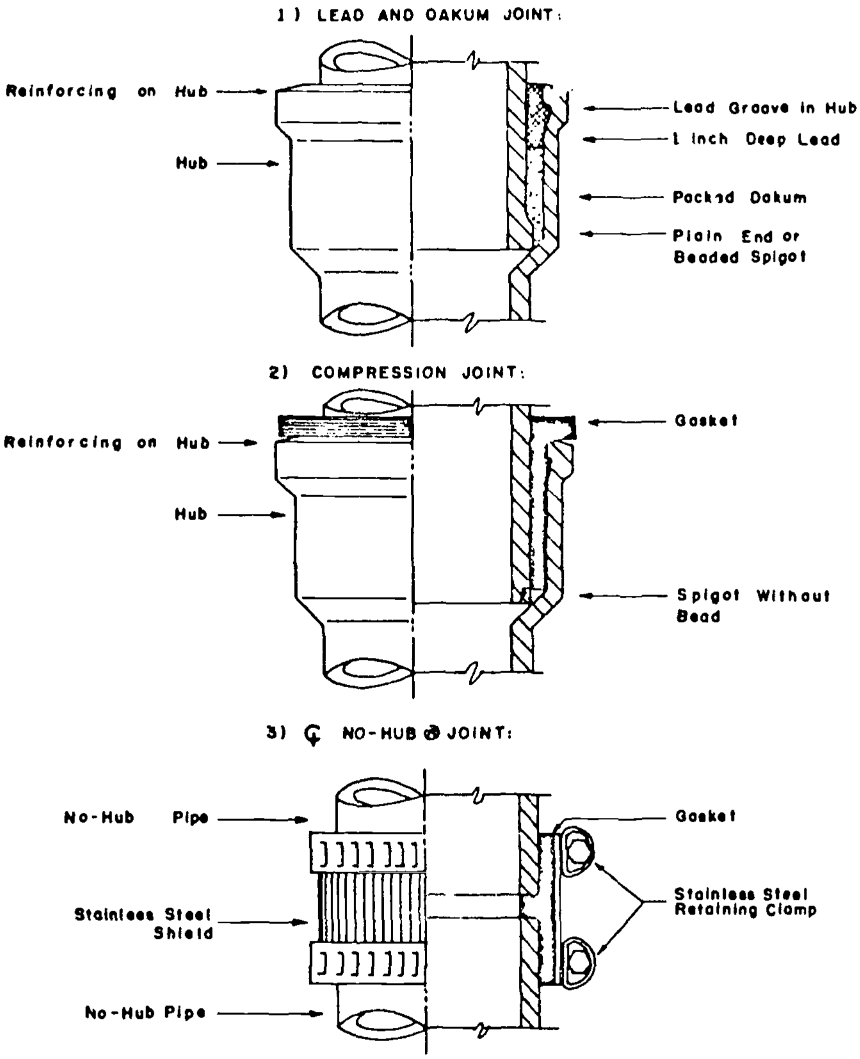


Fig. 6-2 -The Various Joints Presently Being Used to Connect Cast Iron Soil Pipe and Fittings

CHAPTER 7

UTILITIES

The Plumbing Inspector is concerned with the installation of sewer, water and gas piping after the design is accomplished and the plans and specifications have been prepared.

Generally, investigations have been made that have determined the routing, nature of the soil, grades and locations of other underground pipe in the area.

The utilities are placed underground and lead from building walls to the mains in the case of the sewer and water, and from the central meter location in the case of the gas service.

The economics of modern building construction require that the projects be completed in a relatively short period of time. Improved methods and modern construction equipment have made this possible. This requires careful planning to ensure that the project utilities are installed early in order to take advantage of the clear site; they must be carefully protected after installation, however. It is often impossible to detect leakage caused by pipe settlement which may be caused by heavy trucking over the pipe.

Good design and proper selection of materials is useless if the inspection of the project allows sloppy practices and the piping is unprotected during construction. Serious leaks can cause damage to surrounding structures and cause health problems from raw sewage.

If heavy loads must pass over the pipes, then heavy planking should be used to span the trench with sufficient width for maximum protection. The protection is the responsibility of the General Contractor, and the plans and specifications should clearly indicate this.

Trenching and backfilling are an important part of the utility work. The type soil at the site governs the methods used in many cases. The pipe must not be allowed to sag, which, in the case of sanitary piping, may cause rupture and leakage, or reduced flow or settling out of solids; when the pipe is adequately supported the risk is minimized. The design and slope of the trench is generally determined by the sanitary sewer since it must slope at minimal requirements set by the Architect/Engineer. Other considerations might be mains which must be crossed; generally the sewer should cross under water mains, to minimize contamination in case of leakage.

Where the soil is stable and the trench is carefully dug and graded, the barrel of the pipe must be supported for its entire length. This requires that bell holes must be provided at the joints. If the trenches are not uniform, then either sand or crushed rock should be carefully placed to provide uniform support and slope.

If the pipe must pass over an area which has been recently filled, it is unreasonable to expect that it will compact sufficiently in a short time to prevent sagging. In this case piling driven to firm support, or a cradle of timber or other substantial material should be used, depending on the size of the pipe and the depth of the fill.

The shape of the trench is determined by the type of the soil. In hard clay, the trench is excavated with vertical sides, by machines. Sloping sides are used where the cut will not maintain its shape. The Excavation Contractor is generally familiar with the best method to use under the circumstances. Where the trenches, because of depth, or soil conditions, could be dangerous to workmen, then wood siding must be used to prevent the sides of the trench from caving.in. The State Department of Industrial Safety has rules governing such conditions.

The backfill material and placement is equally important. The backfill material for at least 6 inches above the pipe should be carefully selected, and should contain no rocks, nor large material. It should be carefully tamped around the pipe, being careful not to disturb the pipe. Often sand is specified for this purpose. Water, if used, should only be used in amounts suitable for the job and not flooded. The remainder of the backfill should then be placed in uniform layers, and hand or machine tamped to the compaction specified. As previously mentioned, the rate of construction progress is such that 95% compaction is often required as soon as the trenchwork is complete. This requires careful selection of materials and good compaction technique.

Inspection should be thorough on the underground work, and the slope of the sewer should be carefully monitored, by whatever method employed, to insure that the slope is uniform.

Other utilities, such as water and gas may be placed in the same trench if it is economically feasible to do so. Water should always be placed at least 12 inches above the top of the sewer pipe and offset from the pipe on a shelf; this is to prevent contamination if there is a leak in the sewer line.

Where open trenches are not possible, it is necessary to resort to tunneling. This may be simple, if only to go under a sidewalk. If it is necessary to run lines under streets, or railroads, it can be complicated. Generally it consists of boring or jacking galvanized iron culvert under the road, then extending the sewer, or water line through it on a bed of sand, carefully sloped and supported.

Excavations for manholes, and other appurtenances, should be done with the same care as the trenching. The designs and locations of the manholes are generally shown on the plans. Open trenches and excavations for any purpose can be a hazard, and lead to injury of children or workmen; they should be protected by barricades, or other means; trenches and open excavations should be kept open only long enough to get the work accomplished.

Sanitary sewer systems on the exterior, are usually constructed from vitrified clay pipe, asbestos-cement pipe, concrete sewer pipe, and cast iron soil pipe with fittings suitable for the pipe being used. The type of pipe selected will depend on the nature of the installation, size of pipes, and durability. Generally, cast-iron soil pipe is used where future accessibility is a problem, like under sidewalks, or where tree roots will be a factor. Local codes are also a determining factor in the selection of materials. Storm drain piping is usually the same as the sanitary piping. The less expensive materials are ordinarily used, compatible with the conditions at the job.

Where chemical wastes are being handled, more expensive materials like high silicon iron pipe and fittings are used. Acid resistance is usually the factor in selecting the proper material along with other considerations noted.

The joints used in sewer mains are generally hot poured lead and mechanical joints for cast-iron; rubber ring gaskets for concrete; cement and bituminous hot-poured joints for concrete and clay bell and spigot pipe. Where pressure is involved (force mains) mechanical or slip joints are usually used.

Combination sewers carrying rain water and sewage were the accepted method of design when most sewers terminated at the nearest river, lake, or ocean. When pollution is a problem and treatment plants are necessary the storm drain system is designed separately from the sewage system because of the problem of the rainwater passing through the treatment plant; during rainstorms it necessitate passing portions of the raw sewage around the treatment plant, to the point of disposal. Treatment plants are not designed for the added load. Flooding by storm water is often caused by the back up when the sewer size in the street is inadequate to handle the combination of sewage and storm water.

Water piping may be cement-asbestos, galvanized steel, copper, or possibly screwed cast-iron. In 4 inch and larger the pipe is generally cement-asbestos; house or branch lines are galvanized steel, or type K or L copper, wrapped or protected for corrosion resistance.

Gas piping is black steel wrapped or copper tubing. Plastic pipe is also being extensively used by Utility Companies to convey gas. It eliminates the corrosion problem.

Sewer and water utilities are considered to terminate 2 or 3 feet from the building, depending on the codes and the Plans and Specifications. Gas piping is run to the meter location by the utility.

The connection of the building sewer to the public sewer may be made in several ways depending on the size and respective elevation of the sewer. The common method is to use a saddle which is made to conform to the size of the sewer main. A hole is tapped in the clay, concrete, or asbestos cement pipe, and the saddle is cemented in place. Usually, if the street sewer is not at least two pipe sizes larger than the entering line, then a wye connection must be cut into the street sewer. The same is true of cast-iron which is difficult to tap. Manholes may be required if the building sewer is large, or access at intervals is required for inspection and maintenance. If there are several building lines which terminate in the same location, then a manhole is the most feasible method of termination.

Where the building sewer is at a lower elevation than the main in the street, a lift station is necessary. Basically, the station consists of pumping the sewage from a lower level to a higher level through a line connected to the discharge of the pumps (usually two operating in tandem). This force main terminates in a manhole where possible. This is to prevent back-up in case of a line stoppage, or sluggish flow, in the main.

Water piping is installed in trenches similar to those described for sewer piping. Additional care must be taken, however, because of the pressures involved; burial must be deep enough to prevent freezing. The main distribution lines are generally concrete pipe or steel pipe. The trunk lines are often cast-iron, or more recently cement asbestos pressure pipe. Water service pipe may be cement asbestos, copper, steel, or plastic. Some materials may be restricted because of local code practice. Joining the piping runs the gamut and the method is generally specified by the Architect/Engineer. The following are examples of the types of joints which may be encountered and with which the Inspector should be familiar.

<u>Concrete Pipe</u>: Rubber gasket or lead gasket joints.

<u>Steel Pipe</u>: Welded, flanged, screwed, or mechanical joints.

<u>Cast-Iron Pipe</u>: Mechanical, flanged, push-on, molten poured or caulked joints.

<u>Copper</u>: Flared, sweat, flanged, or brazed joints.

Transite Pipe: Push-on, rubber ring joints.

Plastic Pipe: Bonded, welded, or clamped joints.

Since water piping is under pressure, usually 30 psi to 100 psi, care must be taken to prevent blow-outs, or pulling apart of the fitting at abrupt turns, or dead ends.

Cast-iron pipe joints are frequently reinforced by a method called "rodding" where a clamp is placed on either side of the joint, and two rods on opposite sides are run between the clamps. Fire sprinkler mains are always handled in this manner.

Another method used to prevent joints and fittings from separating is the installation of "kick blocks" or thrust blocks. They are pads of concrete poured behind a fitting to take the thrust, either from normal pressure, or occasional surges, brought on by the rapid shut-off of the flow of water, by automatic valves, or other means. The force can be tremendous in large fittings - Refer to the Table and illustration in the Appendix.

Gas piping is installed by the Utility Company from the main to the meter location. From this point it is the responsibility of the Plumber. Generally, in large installations such as schools, or where one owner is involved, the Utility will install only one large meter. The distribution system may become extensive on the site. The same precautions noted for water or sewer piping underground should be observed. Standard black steel pipe with either welded or screwed fittings is used in most cases. The pipe is wrapped for protection against corrosion.

Corrosion protection for the underground systems is provided where required by the methods described in Chapter 17, Corrosion.

The Plumbing Inspector should be thoroughly familiar with the plans and specifications by the time that the site preparation is accomplished and the Plumber starts his work. This is usually the first contact that the Inspector and Superintendent will have under job conditions. First impressions are strong ones and a good relationship for the duration of the job can be established. This is treated more fully in Chapter 1, Plumbing and Piping Inspection.

The Inspector must not tell the Contractor, thru the Superintendent, or otherwise, how to do his work. He is only responsible for seeing that it is properly installed in accordance with plans and specifications, tested, and accepted. This does not mean that the Inspector should not be helpful in pointing out pitfalls and areas of concern. It is too late after the work is done, and costly changes are necessary.

The Inspector's field duties will begin when the site layout of the services starts. By this time approved lists of materials with catalogue cuts, numbers and other data should be in the Inspector's files. The material should be inspected upon arrival and accepted or rejected; reasons for the action should be noted if rejected. Rejected material should be removed from the job-site.

As the installation progresses, nearly continuous inspection should be made of the trenching, soil conditions, slopes of the lines, and quality of the joints. Tests should be closely adhered to, and any faults noted. If repairs are necessary they should be made as soon as possible. Backfill should be watched closely to avoid damage to the pipes due to careless practice.

The quality of the workmanship, and the close working relationship between the Plumbing Contractor and the Inspector can set the pattern for the successful completion of the entire project.

Sec. 317 — Trenching, Excavation and Backfill

(a) Use of mechanical excavating equipment is prohibited within two (2) feet of existing piping or appurtenances.

(b) Tunneling and driving may be done in yards, courts, or driveways of any building site. Where sufficient depth is available to permit, tunnels may be used between open cut trenches. Tunnels shall have a clear height of two (2) feet above the pipe and shall be limited in length to one-half (½) the depth of the trench, with a maximum length of eight (8) feet. When pipes are driven, the drive pipe shall be at least one (1) size larger than the pipe to be laid.

(c) Open trenches—All excavations required to be made for the installation of a building-drainage system or any part thereof, within the walls of a building, shall be open trench work and shall be kept open until the piping has been inspected, tested and accepted.

(d) All excavations shall be completely backfilled as soon after inspection as practicable. Adequate precaution shall be taken to insure proper compactness of backfill around piping without damage to such piping. Trenches shall be backfilled in thin layers to twelve (12) inches above the top of the piping with clean earth which shall not contain stones, boulders, cinderfill or other materials which would damage or break the piping or cause corrosive action. Mechanical devices such as bulldozers, graders, etc., may then be used to complete backfill to grade. Fill shall be properly compacted. Suitable precautions shall be taken to insure permanent stability for pipe laid in filled or made ground.

(e) Water services pipes or any underground water pipes shall not be run or laid in the same trench with non-metallic building sewer or drainage piping, except as provided in this section.

The water service pipe may be placed in the same trench with such building drain and building sewer, provided **both** of the following conditions are met:

The bottom of the water service pipe, at all points, shall be at least twelve (12) inches above the top of the sewer line.

The water service pipe shall be placed on a solid shelf excavated at one side of the common trench.

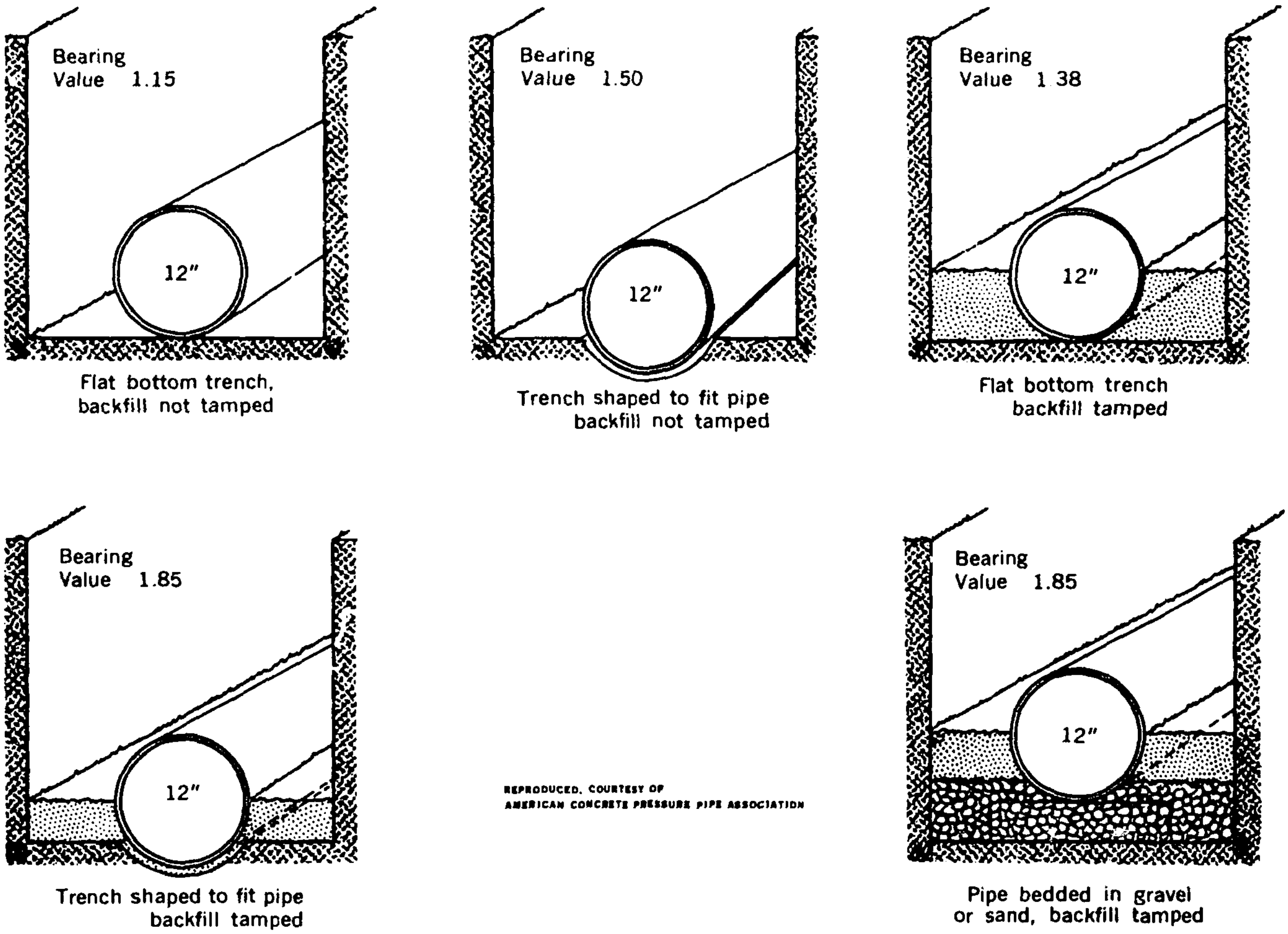
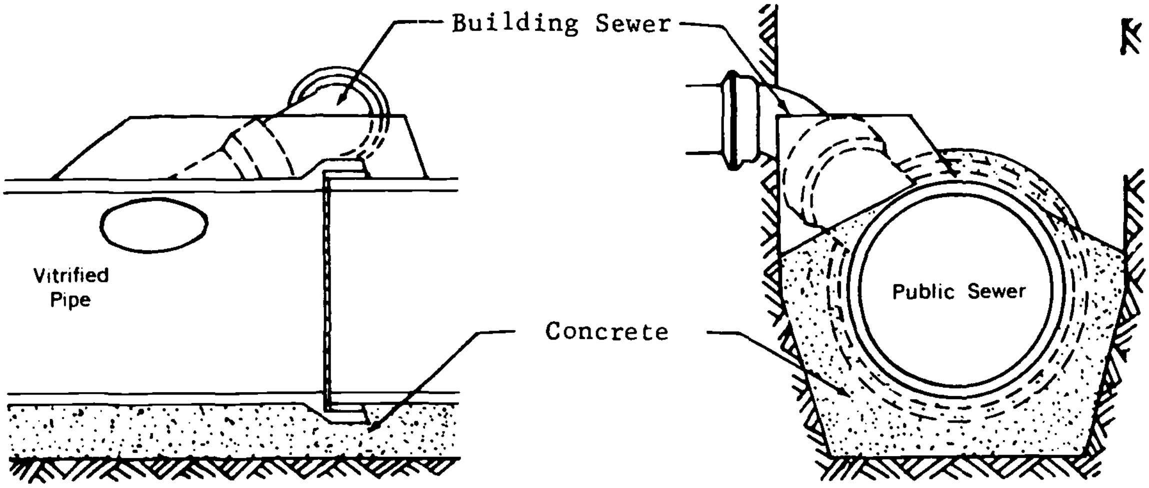


Fig. 7-1 Methods of Bedding Pipe and Bearing Values



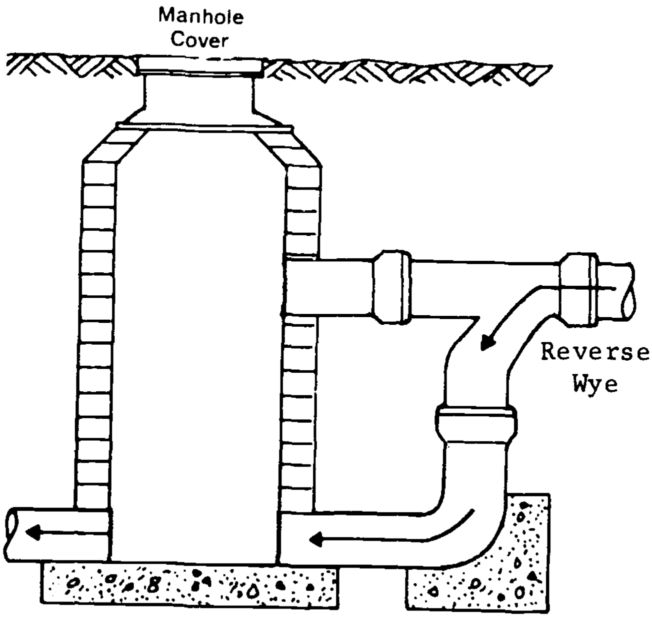
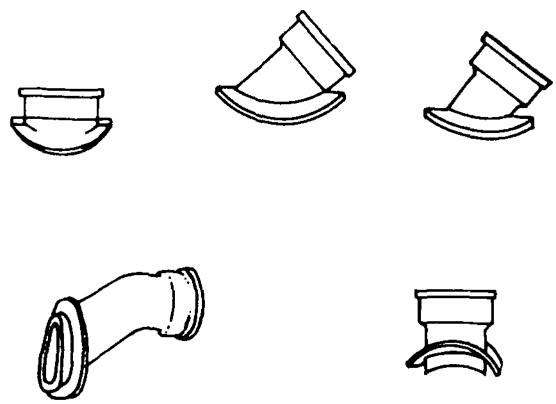


Fig. 7-2 Manhole Detail

Most manholes are concrete precast construction and vary in detail to suit job conditions.

Deep manholes must have ladder rungs or other means of access.

The drop inlet is usually used on deep manholes to keep workmen dry.



Building sewers are connected to public sewers by means of sewer saddles which fit over or into a hole tapped in the pipe (clay, concrete, asbestos cement, fiber). The saddle is usually held in place by cement.

If the public sewer is cast iron, wye connections are generally used because tapping is very difficult. In housing developments, wye connections for each lot are usually incorporated into the public sewer at the time it is being installed.

Some codes demand that if the size of the building sewer is not in a certain ratio to the public sewer, a wye connection must be used instead of a saddle because too large tappings would severely reduce the strength of the pipe being tapped. An example: "No public sewer that is not at least two sizes larger than the building sewer shall be tapped with a saddle. The public sewer shall be cut and a wye connection installed."

Fig. 7-3 Sewer Connections

CHAPTER 8

PRIVATE SEWER AND WATER SYSTEMS

General: There are still many suburban areas where street sewer facilities are not available. This is true where many schools, apartment houses and even small communities are located. It then becomes necessary to dispose of the waste liquid on the property or other approved area in a manner approved by local plumbing and health authorities. It is becoming increasingly difficult to get approval for the well-known septic tank, distribution box and leaching field or pits as they have been used in the past. Health authorities have insisted on more stringent regulations governing such systems. There are still enough in operation, however, and new systems being installed that some familiarity with them is desirable.

Several factors should be kept in mind regarding the location of the septic tank. If future municipal sewer facilities will be installed, the building sewer should leave the structure in a location that will allow the hookup; future building expansion should be investigated so that it will not render the septic tank useless; septic tanks must be cleaned periodically, so access must be provided for cleaning equipment.

Septic Tank: The septic tank consists of a reinforced concrete structure; access manholes, or covers are extended up to grade; the outlet runs to a distribution box which is also accessible at grade; generally, a loose baffle is provided so that the effluent can be diverted from one section of the leaching field to another, allowing time for alternate sections to dry out.

The leaching field must be adequate to handle the amount of effluent delivered to it; sandy soil will allow much greater percolation than dense clay; percolation tests must be taken, and the results approved by the responsible health authorities before the system is installed.

Septic Tank Maintenance: The size of a septic tank is based on a retention period of the sewage so that the solid material in sewage settles to the bottom; it is then decomposed by bacteria into gas and liquid. The biological treatment of the sewage in ~~a septic~~ tank and other treatment facilities is made possible by the helpful bacteria; they may be aerobic (oxygen present) or anaerobic (no oxygen present). No disinfecting chemical or other material should be discharged into the tank which may inhibit the bacterial action. A scum is formed on the surface of the liquid in the tank when the rising gas lifts some of the solids from the bottom. The scum is subject to bacterial action as well as the sludge in the bottom of the tank. This is not undesirable until the liquid space is reduced by about one half, i.e. the space between the sludge and the scum. When the septic action in the tank is adequate, the tank may need pumping out at infrequent intervals. If for any reason the action is slowed, or stopped, pumping must be done at more frequent intervals.

To clean the tank, the contents must be stirred, then a suction hose is lowered and the contents pumped into a tank truck. Water may be added, if necessary, to dilute the sludge to facilitate pumping. The removed material may be deposited where directed by the Administrative Authority. The gases in a septic tank may be dangerous to health, or even explosive, so care should be exercised when working around the tank so that injury will not result.

If the septic tank is abandoned for any reason, it should be emptied and filled with sand or similar material so that it will not constitute a hazard.

<u>Disposal System</u>: The septic tank system of sewage disposal is still the most common type for isolated installations such as apartment houses, schools, or mobile home parks where a public sewer system is not available. It readily lends itself to expansion where all the factors needed to meet code requirements are present. It is because of its wide application that so much of the Uniform Plumbing Code is quoted at the end of the Chapter. This should be carefully reviewed because of its importance.

If the depth of the sewer lines become too great because of long runs it may be necessary to install duplex sewer pumps to lift the sewage to a level where the septic tank can be installed at a reasonable depth below grade. In some cases the septic tank effluent must be lifted by means of sewage pumps so that the distribution lines will not be too deep, particularly if there is a high water table.

Where soil conditions are such that subsoil absorption is not practicable, the septic tank liquid may be discharged into holding ponds or ditches. After it has been rendered harmless and odorless by chlorination it may be used for athletic field irrigation or wasted to an area where designated by the local authorities.

The testing procedures allowed for percolation tests should be checked with local officials before any design is begun on disposal systems. It can vary in detail depending on whether it is a Federal, State, or Local agency which is financing the project.

Seepage pits are sometimes substituted for leaching trenches where there may be an underlying layer of hardpan that make the trenches impracticable. In theory, they act as vertical trenches, but because of the depth, pits or wells, as they are sometimes called, can pollute water tables. Percolation tests must be made in the prescribed manner before the wells are drilled. There have been instances where seepage wells have been drilled 36 inches in diameter to a depth of 40 to 50 feet (5 to 10 feet above the water table, at least) and 50 to 60 or more wells drilled to accommodate the effluent. It is obviously expensive but may be the only answer, especially for isolated schools or mobile home parks.

Care must be taken during the installation of the septic tank system to assure that the proper results will be achieved. The absorption trenches should not be dug while the ground is wet; the compaction will reduce the percolation value. The trenches should be protected from silt which may get into the trenches from rain runoff. The gravel bed and pipe should be uniformly and carefully installed with a spacing of 1/8" to 1/4" and the joints should be protected by permanent covering; backfilling and tamping must be closely watched so the pipe will not be disturbed. If there is a high water table in the area, the septic tank, of whatever material, should be filled with water until ready for use if there is danger of flotation.

Package Units: It has become increasingly difficult in some areas to find land in sufficient area for a leaching field. Manufacturers now have available a residential unit with a 7500 gallon tank capacity and rates up to 3750 gallons per day. The complete unit consists of a tank with baffles, buried like a septic tank and an air compressor. The effluent is superior to that from a septic tank, and while percolation is still necessary the space requirements are considerably less.

Package type commercial units are available in a variety of types and sizes. They are considerably more expensive than the septic tank systems. The effluent, however, is of a higher quality, and can be disposed of more readily, or used, depending on the degree of treatment.

Systems of this type approach the sophistication of municipal systems. They are beyond the scope of this manual. The proper disposal of sewage is very important for health and environmental reasons. The Plumbing Inspector engaged in this type of inspection must be aware of his responsibility for the proper disposal of sewage.

Wells: The most satisfactory sources of potable water for an individual supply, or even a small municipality, are wells. It is generally possible to locate the wells near the area where the water is to be used.

Wells are classified on the basis of construction and may be dug, bored, driven, or drilled. The type of well to be constructed will depend on the geology of the area and the depth of the water bearing strata.

The location of the well should take into account the sources of contamination such as a leaching field, and the permeability of the soil.

Dug wells are not recommended, because they can be easily contaminated. They are simply large holes, usually circular, dug to a shallow depth. Surface water can easily enter the dug well. Where such wells are used, chlorination and treatment is a necessity. They are usually found in mountainous areas where it is not possible to drill a well, and surface water, or a developed spring is the only water available.

A driven well is not practical beyond a depth of approximately 60 ft. since the well consists of a well point attached to the supply pipe and then driven into the ground.

A drilled well is the most common because it is the most practical. It consists of a circular hole drilled to the depth required to get an adequate supply of water. It can be drilled through granite or other rock formations if necessary. The depth drilled depends on the amount of water needed and the drawdown of the water in the well. This may require a well 100 ft. deep to perhaps 2000 ft. deep.

A well casing is then lowered into the well and "bottomed" at the water bearing strata, usually. The diameter of the casing, 6 in. to perhaps 20 in. diameter, will depend on the amount of water to be pumped, and the diameter of the pump bowls required.

A bored well is made by an earth auger boring a hole larger in diameter than the casing. This system is primarily for shallow wells. After the water strata is reached, the casing is inserted and the well is sealed by pouring concrete around the casing to a depth to seal off the surface water, usually about 25 ft.

Most health regulations require that a drilled well be sealed by providing a steel casing about 6 to 8 in. larger than the well casing, which shall be terminated at a depth to seal off surface water. The annular space between the two casings shall be sealed with grout. The casing is terminated at least 6 in. above the ground, and the space between the casing and the pump shall be sealed.

This is a brief description of the types of wells used for a private water supply. There is much more to the design of a good well than the description given here. Generally, large capacity wells are not the responsibility of the Plumbing Contractor, and require scientific study and test unless other wells in the area will determine the characteristics of the well to be provided.

The well and assembly must be chlorinated after completion and before being placed in service. This is accomplished by pouring a gallon or more of commercial high-test hypochlorite, into the well after the pump is installed. A 2 in. capped nipple is set in the pump platform terminating on the interior of the casing, for the convenience of introducing the hypochlorite.

Deep Well Pumps: There are many types of pumps used to get water from the well to the surface, and if the head is not too great, to an elevated tank or directly into a hydropneumatic tank under pressure.

The average size sub-division or suburban shopping center will have a hydropneumatic tank located near the well and the pump will connect directly to the tank thru a check valve. The tank will maintain a pressure at its discharge of 40 - 60 psi and the pump will maintain the water level in the tank at 1/2 to 2/3 full. The balance will be air, usually supplied by the water pump at each starting cycle, or may be supplied by a separate air compressor. The compressed cushion of air reduces the start and stop cycles of the pump. The tank will vary in cubic capacity from 3000 - 5000 gallons.

The well pump is normally not the Plumber's responsibility, but some information is given here because of its relationship to the hydropneumatic water system.

The common pump installation is a motor driven vertical centrifugal pump with the motor being mounted above the well on a shaft. The number of impellers may be 20 or more and the pump may work against a head of 400 ft. (174 psi) or more. They are of the screw or propeller type with vanes leading to the impeller above. The bearings for the vertical shaft may be metal, and oil lubricated; if hard rubber, they are water lubricated. The water lubricated type bearings are gaining in popularity.

Another type deep well centrifugal pump has the motor mounted below the impellers; a waterproof cable supplies electric current to the motor. This arrangement is more simple, and may have a lower operating cost as well as first cost.

Descriptive data on each type is shown at the end of the chapter. There are many manufacturers of each type.

Jet Pump: Another type of pump frequently used on wells is the jet pump. Its main use is on suburban homes where a domestic water supply and a small amount of water for irrigation is required. They frequently are supplied as a self-cor ined unit with the tank and controls. The illustration at the end of the chapter shows a common type.

It is a centrifugal pump mounted near the well casing. Water is forced in a pipe to the water supply in the well; the pipe is connected to a jet or venturi device at this level. The velocity of the forced flow thru the venturi draws in additional water which is conducted to the surface through a second pipe.

The efficiency of the pump is quite low, possibly 30%, compared to the deep well types where the centrifugal unit is located at the pre-determined level in the well itself. The efficiency of this type may run 70 - 80%.

More sophisticated types are being developed, but the jet principle has limitations in this application.

<u>Centrifugal Pumps</u>: The most common type of pump for which the Plumber will be responsible is the horizontal centrifugal pump. He may encounter it on a hydropneumatic tank used to boost pressure for a large building; a non-storage type independent system or on a fire protection system; also to boost pressure; it is used on a swimming pool installation to recirculate the water between the pool and the water quality control equipment; lawn sprinkling systems may also have a pump installed, particularly a system using impulse heads which may require a pressure at the head of 70 - 80 psi.

The advantages of a centrifugal pump are many, compared to other types such as piston pumps. Some are:

1. Simple parts; pump can be easily modified.
2. Can produce very high heads, up to several thousand feet, by multi-staging.
3. Relatively silent; do not require much space; easily maintained.
4. Can pump solids and abrasives.
5. Low first cost. Satisfactory efficiencies.
6. Can accommodate a variety of drives. Some are: coupled, belt, or steam turbine driven.

They will not operate under a suction lift, and are not self priming. A single stage pump will operate only within a narrow range. Designers have overcome this by the use of many stages (multi-stage) so that the head pressures have been increased to several thousand feet. As the liquid passes from one stage to another the pressure is increased. They are usually limited to a maximum pressure of 300 ft. per stage and to a total of six stages. The strength of materials is usually the limiting factor.

The following installation practices should be followed regarding centrifugal pumps:

1. Locate pump close to the liquid to be pumped, to reduce suction pipe friction and possible cavitation.

2. Provide an adequate foundation sufficient to absorb pump vibration.

3. Level the pump on its foundation and tie down securely with anchor bolts; grout in place.

4. Connect piping to the pump so there is no strain on the pump casing. Make proper allowance for expansion and contraction of the piping; use flexible connectors or Dresser couplings in some cases. Support piping independent of the pump.

5. Use eccentric fittings at the pump and straight lengths of pipe on intake and discharge to provide for smooth flow of the fluid.

6. Check for angular misalignment (shafts not parallel between motor and pump).

7. Check for parallel misalignment (shaft ends do not meet).

8. Locate pump where there is adequate space for maintenance, and repairs; there should be no chance of flooding, and ventilation should be adequate.

Water Treatment: When the private water supply source is a well, or from some other body of water, the amount of treatment needed to make it palatable and free from contaminants may run the gamut from simple filtration and possible chlorination to more sophisticated processes approaching those necessary for a good municipal plant.

Many areas are blessed with a good underground supply which requires no treatment; the water is simply pumped, stored, and distributed.

After the well and pump assembly is chlorinated, or even while the well is being pumped by the well driller for proper development, a sample of the water should be taken and analyzed. This involves the following procedure:

Secure approximately a 16 oz. sample of water in a sterile bottle; have a local Health Agency test the sample for bacteria.

A mineral analysis should be made by a laboratory for iron and other minerals, based on the same size of sample.

If the sample is taken from faucets, the water should run long enough to assure that the lines are thoroughly washed out before the sample is taken.

The written reports from the laboratories, with the recommendations should be followed closely in selecting the equipment needed to produce the type of water wanted.

A potable water suitable for a household may contain some mineral impurities without it being considered harmful. The same quality of water supplied to a food processing plant may be highly objectionable, and may require extensive treatment.

The chart at the end of the chapter lists several objectionable qualities and possible remedies.

The selection of the proper equipment should be made by experts, and in some cases they do not always agree on the proper remedies.

The filtration and chlorination procedure is similar to that required for swimming pools.

In most areas State or local health agencies make periodic checks of private water supplies for bacterial contamination.

Conclusion: The Plumbing Inspector has the responsibility to see that the systems of sewage disposal and water supply are properly installed and tested. If the plans and specifications are not clear in any respect the Architect/Engineer should be consulted for a clarification.

Well drilling is not an exact science and conditions may be encountered which were not anticipated at the outset. If the well hole is out of plumb, it may be impossible to install the deep-well pump; the quantity of water available without excessive drawdown may result in a redesign of the storage facilities; the "bottoming" of the well casing may present problems requiring an expert opinion.

The leaching field facilities may likewise present unforeseen problems during installation. Rainy weather could be one.

The well and pump may not be the Plumbing Contractor's responsibility but it may well be the Plumbing Inspector's duty to keep abreast of the work. The same may be true of the septic tank and leaching field.

Good inspection practices are as important with this work as they are with any other part of the Plumbing Inspector's work.

BUILDING SEWERS AND PRIVATE SEWAGE DISPOSAL SYSTEMS

Section 1101 — Sewer Required

(a) Every building in which plumbing fixtures are installed and every premises having drainage piping thereon, shall have a connection to a public or private sewer, except as provided in Section 320 and in subsections (b) and (d) of this section.

(b) When no public sewer, intended to serve any lot or premises, is available in any thoroughfare or right of way abutting such lot or premises, drainage piping from any building or works shall be connected to an approved private sewage disposal system.

(c) Within the limits prescribed by subsection (d) hereof, the rearrangement or subdivision into smaller parcels of a lot which abuts and is served by a public sewer shall not be deemed cause to permit the construction of a private sewage disposal system, and all plumbing or drainage systems on any such smaller parcel or parcels shall connect to the public sewer.

(d) The public sewer may be considered as not being available when such public sewer or any building or any exterior drainage facility connected thereto, is located more than two hundred (200) feet from any proposed building or exterior drainage facility on any lot or premises which abuts and is served by such public sewer.

(e) No permit shall be issued for the installation, alteration or repair of any private sewage disposal system or part thereof, on any lot for which a connection with a public sewer is available.

(f) On every lot or premises hereafter connected to a public sewer, all plumbing and drainage systems or parts thereof, on such lot or premises shall be connected with such public sewer.

Exception: Single family dwellings and buildings or structures accessory thereto, existing and connected to an approved private sewage disposal system prior to the time of connecting the premises to a public sewer may, when no hazard, nuisance or insanitary condition is evidenced and written permission has been obtained from the Administrative Authority, remain connected to such properly maintained private sewage disposal system when there is insufficient grade or fall to permit drainage to the sewer by gravity.

Sec. 1102 — Damage to Public Sewer or Private Sewage Disposal System

(a) It shall be unlawful for any person to deposit, by any means whatsoever, into any plumbing fixture, floor drain, interceptor, sump, receptacle or device which is connected to any drainage system, public sewer, private sewer, septic tank or cesspool any ashes, cinders, solids, rags, flammable, poisonous or explosive liquids or gases, oils, grease and any other thing whatsoever which would, or could cause damage to the public sewer, private sewer or private sewage disposal system.

(b) No rain, surface or subsurface water shall be connected to or discharge into any drainage system, unless first approved by the Administrative Authority.

(c) No cesspool, septic tank, seepage pit or drainfield shall be connected to any public sewer or to any building sewer leading to such public sewer.

(d) No commercial food waste grinder shall be connected to a private sewage disposal system unless permission has first been obtained from the Administrative Authority.

(e) An approved type watertight sewage or waste water holding tank, the contents of which, due to their character, must be periodically removed and disposed of at some approved off-site location, shall be installed only when required by the Administrative Authority or the Health Officer to prevent anticipated surface or subsurface contamination or pollution, damage to the public sewer, or other hazardous or nuisance condition.

Sec. 1103 — Building Sewer Materials

(a) The building sewer, beginning two (2) feet from any building or structure, shall be of such materials as may be approved by the Administrative Authority under the approval procedures set forth in Chapter 2 of this code.

(b) Joining methods and materials shall be as prescribed in Chapter 8 of this code.

Sec. 1104 — Markings

All pipe, brick, block, prefabricated septic tanks, prefabricated septic tank or seepage pit covers or other parts or appurtenances incidental to the installation of building sewers or private sewage disposal systems, shall conform to the approval requirements of Chapter 2 of this code and shall be marked and identified in a manner satisfactory to the Administrative Authority.

Sec. 1105 — Size of Building Sewers

The minimum size of any building sewer shall be determined on the basis of the total number of fixture units drained by such sewer, in accordance with Table 4-3.

Sec. 1106 — Grade, Support and Protection of Building Sewers

(a) Building sewers shall be run in practical alignment and at a uniform slope of not less than one-fourth (¼) of an inch per foot toward the point of disposal; provided, that where it is impractical, due to the depth of the street sewer or to the structural features or to the arrangement of any building or structure, to obtain a slope of one-fourth (¼) of an inch per foot, any such pipe or piping four (4) inches or larger may have a slope of not less than one-eighth (⅛) of an inch per foot when approved by the Administrative Authority.

(b) Building sewer piping shall be laid on a firm bed throughout its entire length, and any such piping laid in made or filled in ground shall be laid on a bed of approved materials and shall be adequately supported to the satisfaction of the Administrative Authority.

(c) No building sewer or other drainage piping or part thereof, which is constructed of materials other than those approved for use under or within a building, shall be installed under or within two (2) feet of any building, or structure or part thereof, nor less than one (1) foot below the surface of the ground. The provisions of this subsection include structures such as porches and steps, whether covered or uncovered, breezeways, roofed portecocheres, roofed patios, car-ports, covered walks, covered driveways and similar structures or appurtenances.

Sec. 1107 — Cleanouts

(a) Cleanouts shall be placed inside the building near the connection between the building drain and building sewer or installed outside the building at the lower end of a building drain and extended to grade.

Additional building sewer cleanouts shall be installed at intervals not to exceed one hundred feet (100') in straight runs.

(b) When a building sewer or a branch thereof does not exceed ten (10) feet in length and is a straight line projection from a building drain which is provided with a cleanout, no cleanout will be required at its point of connection to the building drain.

(c) Every change in alignment or grade in excess of twenty-two and one-half (22½) degrees in a building sewer shall be served by a cleanout, except that no cleanout shall be required for not to exceed one (1) forty-five (45) degree change of direction or one (1) forty-five (45) degree offset. The extension of building sewer cleanouts to grade is optional. When building sewers are located under buildings the cleanout requirements of Section 406 shall apply.

(d) Each cleanout shall be installed so that it opens in a direction opposite to the flow of the soil or waste or at right angles thereto, and except in the case of "wye" branch and end-of-line cleanouts, vertically above the flow of the pipe.

(e) Cleanouts installed under concrete or asphalt paving shall be made accessible by yard boxes, or extending flush with paving with approved materials and be adequately protected.

(f) Approved manholes may be installed in lieu of cleanouts when first approved by the Administrative Authority. The maximum distance between manholes shall not exceed 300 feet.

Sec. 1108 — Sewer and Water Pipes

Non-metallic building sewer or drainage piping shall not be run or laid in the same trench with water service pipes or any underground water pipes unless both of the following requirements are met:

1. The bottom of the water piping at all points shall be at least twelve (12) inches above the top of the sewer piping.
2. The water piping shall rest on a solid shelf at one side of the common trench.

Sec. 1109 — Drawings and Specifications

The Administrative Authority, Health Officer or other Department having jurisdiction may require any or all of the following information before a permit is issued for a building sewer or a private sewage disposal system, or at any time during the construction thereof.

(a) Plot plan drawn to scale completely dimensioned, showing direction and approximate slope of surface, location of all present or proposed retaining walls, drainage channels, water supply lines or wells, paved areas and structures on the plot, number of bedrooms or plumbing fixtures in each structure and location of the building sewer and private sewage disposal system with relation to lot lines and structures.

(b) Details of construction necessary to assure compliance with the requirements of this chapter together with a full description of the complete installation including quality, kind and grade of all materials, equipment, construction workmanship and methods of assembly and installation.

(c) A log of soil formations and ground water level as determined by test holes dug in close proximity to any proposed seepage pit or disposal field, together with a statement of water absorption characteristics of the soil at proposed site as determined by approved percolation tests.

Sec. 1110 — Location

(a) Except as provided in subsection (b) of this section, no building sewer or private sewage disposal system or parts thereof, shall be located in any lot other than the lot which is the site of the building or structure served by such sewer or private sewage disposal system; nor shall any building sewer or private sewage disposal system or part thereof be located at any point having less than the minimum distances indicated in Table 11-1.

(b) Nothing contained in this code shall be construed to prohibit the use of all or part of an abutting lot to:

1. Provide access to connect a building sewer to an available public sewer, when proper cause and legal easement not in violation of other requirements has been first established to the satisfaction of the Administrative Authority.

Sec. 1111 — Private Sewage Disposal (General)

(a) Where permitted by Section 1101, the building sewer may be connected to a private sewage disposal system complying with the provisions of this chapter. The type of system shall be determined on the basis of location, soil porosity, and ground water level and shall be designed to receive all sanitary sewage from the property. The system, except as otherwise provided, shall consist of a septic tank with effluent discharging into a subsurface disposal field, into one or more seepage pits or into a combination of subsurface disposal field and seepage pits.

(b) Where conditions are such that the above system cannot be expected to function satisfactorily; for commercial, agricultural and industrial plumbing systems; for installations where appreciable amounts of industrial or indigestible waste are produced; for hotels, hospitals, office buildings, schools and other occupancies not listed in Table 11-3; for occupancies producing abnormal quantities of sewage or liquid waste; or when grease interceptors are required by other parts of this code, the method of sewage treatment and disposal shall be first approved by the Administrative Authority. Special sewage disposal systems for minor, limited or temporary uses shall be first approved by the Administrative Authority.

(c) Disposal systems shall be designed to utilize the most porous or absorptive portions of the soil formation. Where the ground water level extends to within twelve (12) feet or less of the ground surface or where the upper soil is porous and the underlying stratum is rock or impervious soil, a septic tank and disposal field system shall be installed.

(d) All private sewage disposal systems shall be so designed that additional seepage pits or subsurface drain fields, equivalent to at least 100% of the required original system, may be installed if the original system cannot absorb all the sewage. No division of the lot or erection of structures on the lot shall be made if such division or structure impairs the usefulness of the 100% expansion room for its intended purpose.

(e) No property shall be improved in excess of its capacity to properly absorb sewage effluent in the quantities and by the means provided in this code.

(f) When there is insufficient lot area or improper soil conditions for adequate sewage disposal for the building or land use proposed, and the Administrative Authority so finds, no building permit shall be issued and no private sewage disposal shall be permitted. Where space or soil conditions are critical, no building permit shall be issued until engineering data and test reports satisfactory to the Administrative Authority have been submitted and approved.

(g) Nothing contained in this chapter shall be construed to prevent the Administrative Authority from requiring compliance with higher requirements than those contained herein where such higher requirements are essential to maintain a safe and sanitary condition.

Sec. 1112 — Capacity of Septic Tanks

The liquid capacity of all septic tanks shall conform to Tables 11-2 and 11-3 as determined by the number of bedrooms or apartment units in dwelling occupancies and the occupant load or the number of plumbing fixture units as determined from Table 4-1, whichever is greater in other building occupancies. The capacity of any one septic tank and its drainage system shall be limited by the soil structure classification as specified in Table 11-5.

TABLE 11-5

Required Sq. ft. of LeachingArea/100 gals. Septic Tank Capacity	Maximum Septic Tank Size Allowable
20-25	7500
40	5000
60	3500
90	3000

Sec. 1113 — Area of Disposal Fields and Seepage Pits

The minimum effective absorption area in disposal fields in square feet of trench bottom, and in seepage pits in square feet of side wall, shall be predicated on the required septic tank capacity in gallons and shall conform to Table 11-4 as determined for the type of soil found in the excavation, and shall be as follows:

1. When disposal fields are installed, a minimum of one hundred and fifty (150) square feet of trench bottom shall be provided for each system exclusive of any hard pan, rock, clay or other impervious formations. For large specially designed and approved system, side wall area in excess of the required twelve (12) inches and not to exceed thirty-six (36) inches below the leach line may be added to the one hundred and fifty (150) square feet trench bottom area when computing absorption areas.
2. The minimum effective absorption area in any seepage pit shall be calculated as the excavated side wall area below the inlet exclusive of any hardpan, rock, clay or other impervious formations.

   The minimum required area of porous formation shall be provided in one or more seepage pits. No excavation shall extend into the water table nor to a depth where sewage may contaminate underground water stratum that is usable for domestic purposes.

   Each seepage pit shall have a minimum side wall, not including the arch, of ten (10) feet below the inlet.
3. Soils, other than those appearing in Table 11-4, shall be tested for porosity as required by Section 1114.

TABLE 11-4

RATED ABSORPTION CAPACITIES
OF 5 TYPICAL SOILS

Type of Soil	Required sq. ft. of leaching area/100 gals.	Maximum absorption capacity gals./sq. ft. of leaching area for a 24-hour period.
1. Coarse sand or gravel	20	5
2. Fine sand	25	4
3. Sandy loam or sandy clay	40	2.5
4. Clay with considerable sand or gravel	60	1.66
5. Clay with small amount of sand or gravel	90	1.11

Sec. 1114 — Percolation Tests

(a) Wherever practicable disposal field and seepage pit sizes shall be computed from Table 11-4.

(b) In order to determine the absorption qualities of questionable soils other than those listed in Table 11-4, the proposed site shall be subjected to percolation tests acceptable to the Administrative Authority.

(c) Each test shall be made with clear water in an excavation which has been thoroughly soaked prior to the test.

(d) When a percolation test is required, the proposed system shall have the capability to absorb a quantity of clear water in a 24 hour period equal to at least 5 times the liquid capacity of the proposed septic tank. No private disposal system shall be permitted to serve a building if a percolation test shows that absorption capacity of the soil is less than 1.11 gals. per square feet of leaching area per 24 hrs.

Sec. 1115 — Septic Tank Construction

(a) Plans for all septic tanks shall be submitted to the Administrative Authority for approval. Such plans shall show all dimensions, reinforcing, structural calculations and such other pertinent data as may be required. Independent laboratory tests and calibrations shall be provided on prefabricated septic tanks as required by the Administrative Authority.

(b) Septic tanks shall be constructed of sound durable materials, not subject to excessive corrosion or decay and shall be watertight. Each such tank shall be structurally designed to withstand all anticipated earth or other loads and shall be installed level and on a solid bed.

(c) The walls and floor of each poured-in-place, concrete septic tank shall be monolithic; the maximum length of any section of unreinforced concrete septic tank wall shall be six (6) feet, and no cross section of any such unreinforced concrete wall or floor shall be less than five (5) inches in thickness. The minimum compressive strength of any concrete septic tank wall, top and covers, or floor shall be twenty-five hundred (2500) pounds per square inch.

(d) Concrete septic tank covers shall be reinforced and shall have a minimum compressive strength of twenty-five hundred (2500) pounds per square inch.

(e) All septic tank covers shall be capable of supporting an earth load of not less than three hundred (300) pounds per square foot when the maximum coverage does not exceed three (3) feet.

(f) The minimum wall thickness of any steel septic tank shall be No. 12 U.S. gauge (.109) and each such tank shall be protected from corrosion both externally and internally by an approved bituminous coating or by other acceptable means.

(g) Septic tank design shall be such as to produce a clarified effluent consistent with accepted standards and shall provide adequate space for sludge and scum accumulations.

(h) Septic tanks shall have a minimum of two (2) compartments. The inlet compartment of any septic tank shall be not less than two-thirds (2/3) of the total capacity of the tank nor less than five hundred (500) gallons liquid capacity, and shall be at least three (3) feet in width and five (5) feet in length. Liquid depth shall be not less than two (2) feet and six (6) inches nor more than six (6) feet. The secondary compartment of any septic tank shall have a minimum capacity of two hundred fifty (250) gallons and a maximum capacity of one-third (1/3) of the total capacity of such tank. In septic tanks having over fifteen hundred (1500) gallons capacity, the secondary compartment may be not less than five (5) feet in length.

(i) Access to each septic tank shall be provided by at least two (2) manholes twenty (20) inches in minimum dimension or by an equivalent removable cover slab. One access manhole shall be located over the inlet and one (1) access manhole shall be located over the outlet. Wherever a first compartment exceeds twelve (12) feet in length, an additional manhole shall be provided over the baffle wall. Septic tanks installed under concrete or black top paving shall have the required manholes accessible by either extending the manhole openings to grade in a manner acceptable to the Administrative Authority, or by providing a removable concrete or other approved section, not less than 20" in the least dimension, in such concrete or black top paving, which is located directly over the required septic tank manholes.

(j) The inlet and outlet pipe or baffle shall extend four (4) inches above and at least twelve (12) inches below the water surface. The invert of the inlet pipe shall be at a level not less than two (2) inches above the invert of the outlet pipe.

(k) Inlet and outlet pipe fittings or baffles, and compartment partitions shall have a free vent area equal to the required cross sectional area of the house sewer or private sewer discharging thereinto to provide free ventilation above the water surface from the disposal field or seepage pit through the septic tank, house sewer and stack to the outer air.

(l) The total depth shall not be less than nine (9) inches greater than liquid depth. The cover of the septic tank shall be at least two (2) inches above the back vent openings.

(m) Partitions or baffles between compartments shall be of sound durable material and shall extend at least four (4) inches above the liquid level. An inverted fitting equivalent in size to the tank inlet, but in no case less than four (4) inches in size, shall be installed in the inlet compartment side of the baffle with the bottom of the fitting placed midway in the depth of the liquid. Wooden baffles are prohibited.

(n) All concrete septic tanks shall be protected from corrosion by coating the inside with an approved bituminous coating or by other acceptable means. The coating shall extend to at least four (4) inches below the water line, and shall cover all of the internal area above that point.

Sec. 1116 — Disposal Fields

(a) Distribution lines shall be constructed of tile laid with open joints, except that perforated clay tile, perforated bituminous fiber pipe, or other approved materials may be used, provided that sufficient openings are available for distribtuion of the effluent into the trench area.

(b) Before placing filter material or drain lines in a prepared excavation, all smeared or compacted surfaces shall be removed from trenches by raking to a depth of 1 inch and the loose material removed. Clean stone, gravel, slag or similar filter material acceptable to the Administrative Authority, varying in size from ¾" to 2½" shall be placed in the trench to the depth and grade required by this section. Drain pipe shall be placed on filter material in an approved manner. The drain lines shall then be covered with filter material to the minimum depth required by this section and this covered with untreated building paper, straw or similar porous material to prevent closure of voids with earth backfill. No earth backfill shall be placed over the filter material cover until after inspection and acceptance.

(c) When seepage pits are used in combination with disposal fields, the filter material in the trenches shall terminate at least five (5) feet from the pit excavation and the line extending from such points to the seepage pit shall be approved pipe with watertight joints.

(d) Where two (2) or more drain lines are installed, an approved distribution box of sufficient size to receive lateral lines shall be constructed at the head of each disposal field. The inverts of all outlets shall be level and the invert of the inlet shall be at least one (1) inch above the outlets. Suitable baffles shall be provided to insure equal flow. Distribution boxes shall be built on a level concrete slab installed in natural or compacted soil.

(e) All laterals from an aproved distribution box to the disposal field where the grade exceeds six (6) inches per one hundred (100) feet shall be bell and spigot vitrified clay or other approved pipe with watertight joints. Multiple disposal field laterals, wherever practicable, shall be of uniform length.

(f) Connections between a septic tank and a distribution box, or between a distribution box and drainfield, shall be laid with approved watertight joints on natural ground or compacted fill.

(g) Automatic siphon or dosing tanks shall be installed when required or as permitted by the Administrative Authority.

(h) Disposal fields shall be constructed as follows:

Minimum number of drain lines per field	1
Maximum length of each line	100 feet
Minimum bottom width of trench	18 inches
Maximum bottom width of trench	36 inches
Minimum spacing of lines center to center	6 feet
Minimum depth of earth cover over lines	12 inches
Preferred depth of cover of lines	18 inches
*Maximum grade of lines	6 inches per 100 feet
*Minimum grade of lines	3 inches per 100 feet
Minimum filter material under drain lines	12 inches
Minimum filter material over drain lines	2 inches

Minimum spacing between trenches or leaching beds: Shall be four (4) feet plus two (2) feet for each additional foot of depth in excess of one (1) foot below the bottom of the drain line.

*Minimum grade of lines ....3 inches per 100 feet
Minimum filter material under drain lines ....12 inches
Minimum filter material over drain lines ....2 inches
Minimum spacing between trenches or leaching beds: Shall be four (4) feet plus two (2) feet for each additional foot of depth in excess of one (1) foot below the bottom of the drain line.

*When perforated pipe is used it shall be laid level and with the end of the line capped.

Where leaching beds are permitted in lieu of trenches the area of each such bed shall be at least fifty (50) percent greater than the tabular requirements for trenches. Distribution drain lines in leaching beds shall not be more than six (6) feet apart on centers and no part of the perimeter of the leaching bed shall be more than three (3) feet from a distribution drain line.

When necessary on sloping ground to prevent excessive line slope, leach lines or leach beds shall be stepped. The lines between each horizontal section shall be made with watertight joints and shall be designed so each horizontal leaching trench or bed shall be utilized to the maximum capacity before the effluent shall pass to the next lower leach line or bed. The lines between each horizontal leaching section shall be made with approved watertight joints.

Sec. 1117 — Seepage Pits

(a) The capacity of seepage pits shall be based on the quantity of liquid waste discharging thereinto, and on the character and porosity of the surrounding soil and shall conform to Section 1113 of this chapter.

(b) Multiple seepage pit installations shall be served through an approved distribution box or be connected in series by means of a water tight connection laid on undisturbed or compacted soil, the outlet from the pit shall have an approved fitting extending at least 12 inches below the inlet fitting.

(c) Each seepage pit shall be circular in shape and shall have an excavated diameter of not less than four (4) feet. Each such pit shall be lined with approved type whole new hard burned clay brick, concrete brick, concrete circular type cesspool blocks or other approved materials. Approval shall be obtained prior to construction for any pit having an excavated diameter greater than five (5) feet.

(d) The lining in every seepage pit shall be laid on a firm foundation. Lining materials shall be placed tight together and laid with joints staggered. Except in the case of approved type pre-cast concrete circular sections, no brick or block shall be greater in height than its width and shall be laid flat to form at least a four (4) inch wall. Brick or block greater than twelve (12) inches in length shall have chamfered matching ends and be scored to provide for seepage. Excavation voids behind the brick, block or concrete liner shall have a minimum of six (6) inches of clean ¾" gravel or rock and shall be progressively backfilled while the lining is being installed.

(e) All brick or block used in seepage pit construction shall have a minimum compressive strength of twenty-five hundred (2500) pounds per square inch.

(f) Each seepage pit shall have a minimum sidewall (not including the arch) of ten (10) feet below the inlet.

(g) The arch or dome of any seepage pit may be constructed in one of three ways:

(1) Approved type hard burned clay brick or solid concrete brick or block laid in cement mortar.

(2) Approved brick or block laid dry.
In both of the above methods an approved cement mortar covering of at least two (2) inches in thickness shall be applied, said covering to extend at least six (6) inches beyond the sidewalls of the pit.

(3) Approved type one or two piece reinforced concrete slab of twenty-five hundred (2500) pounds per square inch minimum compressive strength, not less than five (5) inches thick and designed to support an earth load of not less than four hundred (400) pounds per square foot. Each such cover shall be provided with a nine (9) inch minimum inspection hole with plug or cover and shall be coated on the under side with an approved bituminous or other nonpermeable protective compound.

(h) The top of the arch or cover must be at least eighteen (18) inches but not more than four (4) feet below the surface of the ground.

(i) An approved vented inlet fitting shall be provided in every seepage pit so arranged as to prevent the inflow from damaging the sidewall.

Sec. 1118 — Cesspools

(a) A cesspool shall be considered only as a temporary expedient, pending the construction of a public sewer, as an overflow facility when installed in conjunction with an existing cesspool, or as a means of sewage disposal for limited, minor or temporary uses when first approved by the Administrative Authority.

(b) Where it is established that a public sewer system will be available in less than two (2) years and soil and ground water conditions are favorable to cesspool disposal, cesspools without septic tanks may be installed for single family dwellings or for other limited uses when first approved by the Administrative Authority.

(c) Each cesspool, when permitted, shall contorm to the construction requirements set forth in Section 1117 of this chapter for seepage pits and shall have a minimum sidewall (not including the arch) of twenty (20) feet below the inlet, provided, however, that when a strata of gravel or equally pervious material of four (4) feet in thickness is found, the depth of such sidewall need not be more than ten (10) feet below the inlet.

(d) When overflow cesspools or seepage pits are added to existing installations the effluent shall leave the existing pit through an approved vented leg extending at least twelve (12) inches downward into such existing pit and having its outlet flow line at least six (6) inches below the inlet. All pipe between pits shall be laid with approved watertight joints.

Sec. 1119 — Abandoned Sewers and Sewage Disposal Facilities

(a) Every abandoned building (house) sewer or part thereof, shall be plugged or capped in an approved manner within five (5) feet of the property line.

(b) Every cesspool, septic tank and seepage pit which has been abandoned or has been discontinued otherwise from further use or to which no waste or soil pipe from a plumbing fixture is connected, shall have the sewage removed therefrom and be completely filled with earth, sand, gravel, concrete or other approved material.

(c) The top cover or arch over the cesspool, septic tank, or seepage pit shall be removed before filling and the filling shall not extend above the top of the vertical portions of the sidewalls or above the level of any outlet pipe until inspection has been called and the cesspool, septic tank or seepage pit has been inspected. After such inspection, the cesspool, septic tank or seepage pit shall be filled to the level of the top of the ground.

(d) No person owning or controlling any cesspool, septic tank, or seepage pit on the premises of such person or in that portion of any public street, alley or other public property abutting such premises, shall fail, refuse or neglect to comply with the provisions of this section or upon receipt of notice so to comply from the Department having jurisdiction.

(e) Where disposal facilities are abandoned consequent to connecting any premises with the public sewer, the permittee making the connection shall fill all abandoned facilities as required by the Administrative Authority within 30 days from the time of connecting to the public sewer.

TABLE 11-1

LOCATION OF SEWAGE DISPOSAL SYSTEM

Minimum Horizontal Distance In Clear Required From:	Building Sewer	Septic Tank	Disposal Field	Seepage pit or Cesspool
Buildings or Structures [1]	2 feet	5 feet	8 feet	8 feet
Property line adjoining private property	Clear	5 feet	5 feet	8 feet
Water supply wells	50 feet [2]	50 feet	100 feet	150 feet
Streams	50 feet	50 feet	50 feet	100 feet
Large trees	—	10 feet	—	10 feet
Seepage pits or cesspools	—	5 feet	5 feet	12 feet
Disposal field	—	5 feet	4 feet [3]	5 feet
Domestic water line	1 foot [4]	5 feet	5 feet	5 feet
Distribution box	—	—	5 feet	5 feet

NOTE:

When disposal fields and/or seepage pits are installed in sloping ground the minimum horizontal distance between any part of the leaching system and ground surface shall be fifteen (15) feet.

[1] Including porches and steps whether covered or uncovered, breezeways, roofed porte-cocheres, roofed patios, car ports, covered walks, covered driveways and similar structures or appurtenances.

[2] All non-metallic drainage piping shall clear domestic water supply wells by at least fifty (50) feet. This distance may be reduced to not less than twenty-five (25) feet when approved type metallic piping is installed.

Where special hazards are involved the distance required shall be increased, as may be directed by the Health Officer or the Administrative Authority.

[3] Plus two (2) feet for each additional foot of depth in excess of one (1) foot below the bottom of the drain line. (See also Section 1116).

[4] See Section 1108.

TABLE 11-2

Cacapity of Septic Tanks*

Single family dwellings—number of bedrooms	Multiple dwelling units or apartments—one bedroom each	Other Uses: Maximum Fixture Units Served Per Table 4-1	Minimum septic tank capacity in gallons
1 or 2		15	750
3		20	1000
4	2 units	25	1200
5 or 6	3	33	1500
	4	45	2000
	5	55	2250
	6	60	2500
	7	70	2750
	8	80	3000
	9	90	3250
	10	100	3500

Extra bedroom, 150 gallons each.
Extra dwelling units over 10, 250 gallons each
Extra fixture units over 100, 25 gallons per fixture unit

*NOTE:
Septic tank sizes in this table include sludge storage capacity and the connection of domestic food waste disposal units without further volume increase.

TABLE 11-3

TYPE OF BUILDING	DAILY PER CAPITA*	BASIC FACTOR
Grammar School	15 gallons	
Grammar School with Cafeteria	20 gallons	35 students per class room
High School with Cafeteria and shower baths	25 gallons	
Factories	20 gallons (without showers)	Each 8-hour shift
	25 gallons (with showers)	Each 8-hour shift
Restaurants	50 gallons	Per seat
Trailer Parks—Community Baths	50 gallons	3 person per trailer
Trailer Parks—Private Baths or independent trailers	60 gallons	3 persons per trailer
Motels—Baths and Toilets	50 gallons	3 persons per unit
Motels—Bath, Toilet & Kitchen	60 gallons	3 persons per unit
Self-Service Laundry	300 gallons per machine per day	
Drive-in Theaters	5 gallons per car per day	

*Normal sludge storage capacity is included excepting waste from food disposal units.

UPC-73

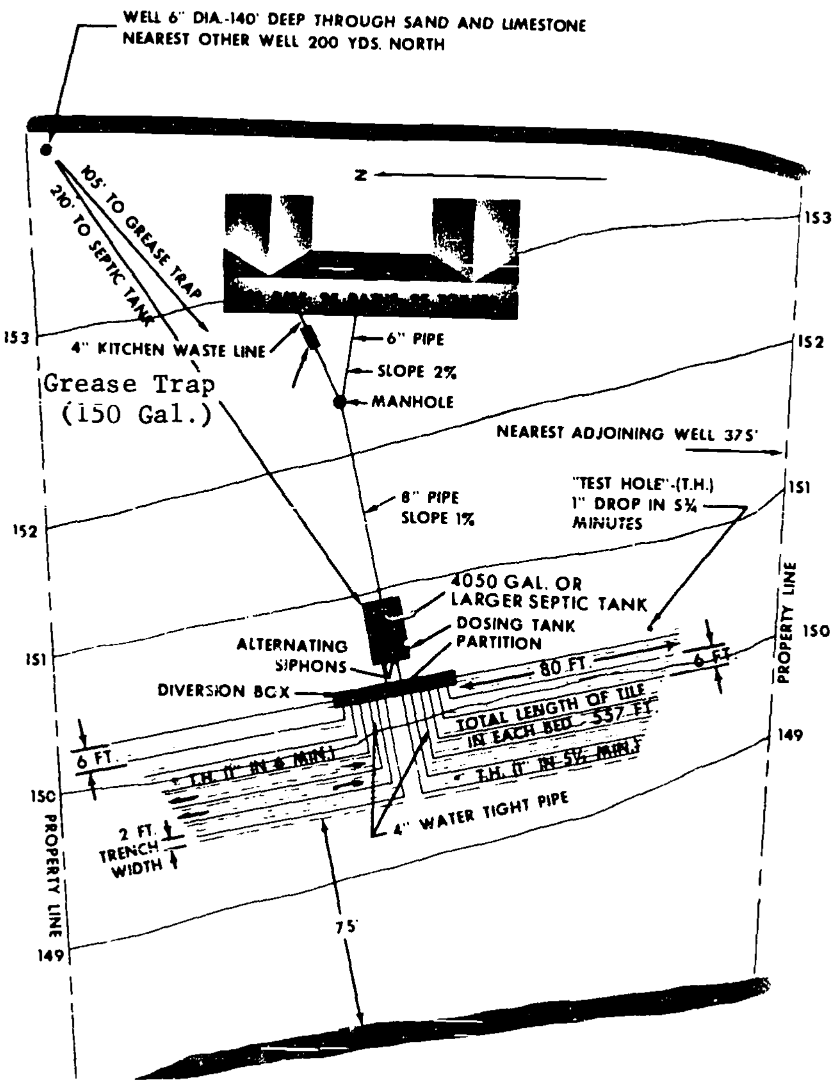


Fig. 8-1 Typical Leaching Field Layout
Check Local Code

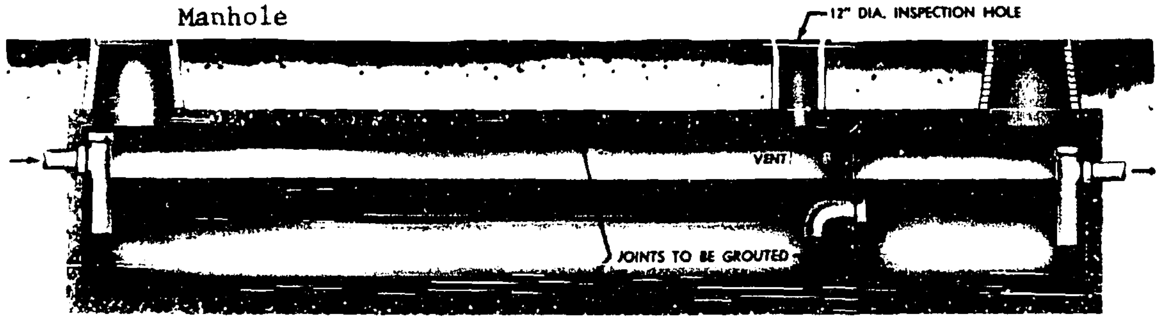
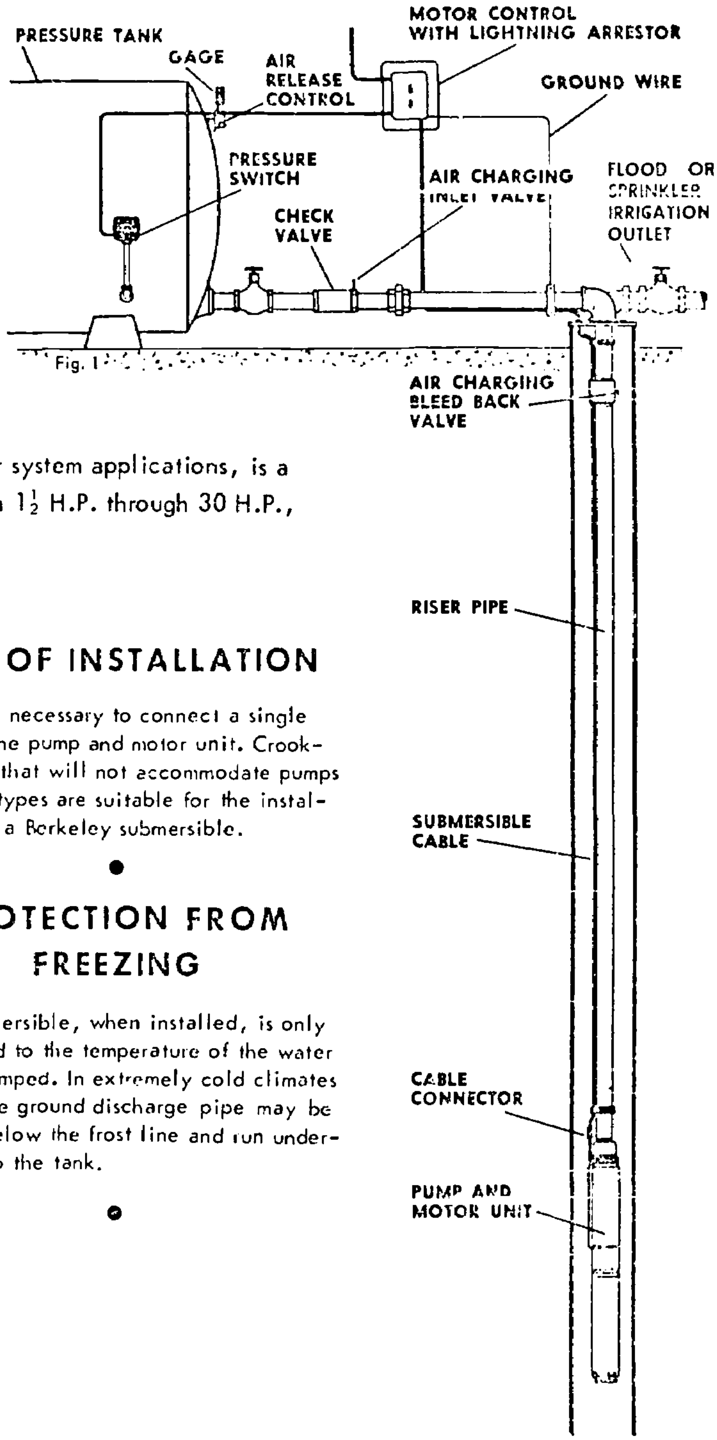


Fig. 8-2 Typical Septic Tank

BERKELEY Submersibles are unsurpassed for industrial, municipal and agricultural applications. The pump and motor are completely submerged in the well - - connected to the surface by a single riser pipe. Noise from the pumping unit is minimal - - a feature which is most desirable for motel, hotel, and hospital installations.



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This submersible series, while ideally suited for larger water system applications, is a "natural" for sprinkler or flood irrigation. Sizes range from $1\frac{1}{2}$ H.P. through 30 H.P., 3450 R.P.M., 60 Cycle, with 6" and 7" bowl diameters.

ECONOMY OF OPERATION

The higher efficiency provided by a Berkeley submersible is your assurance of low operating cost.

•

LOWER INITIAL COST

Due to the higher Berkeley submersible efficiency, it is usually possible to select a pump of lower horsepower to meet given capacity and pressure requirements.

•

BETTER FIRE PROTECTION

The pump and motor unit located at the bottom of the well is not susceptible to damage by fire.

EASE OF INSTALLATION

It is only necessary to connect a single pipe to the pump and motor unit. Crooked wells that will not accommodate pumps of other types are suitable for the installation of a Berkeley submersible.

•

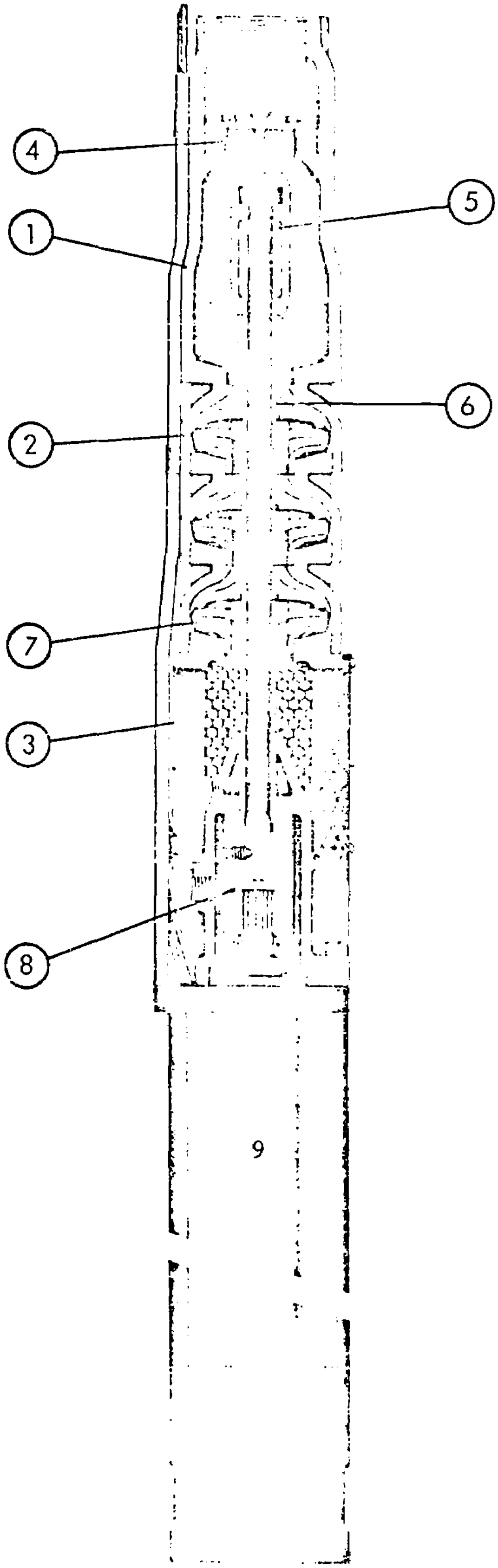
PROTECTION FROM FREEZING

The submersible, when installed, is only subjected to the temperature of the water being pumped. In extremely cold climates the above ground discharge pipe may be buried below the frost line and run underground to the tank.

•

Fig. 8-3

Courtesy-
Berkeley Pump Co.



① Top case is cast grey iron of sturdy construction. Streamlined internal passages minimize friction loss.

② Bowls are of cast grey iron - - threaded together. Modern hydraulic design provides the ultimate in efficiency.

③ Enclosed bracket is cast grey iron - - constructed to provide precision alignment between pump and motor and protection from sand and other foreign materials.

④ Check valve is the non-slam, low-loss Berkeley design, proven dependable through years of service. Rubber clack, bronze seat, monel spring.

⑤ Bronze top and bottom case bearings are grease lubricated - - assuring quiet operation and maximum life.

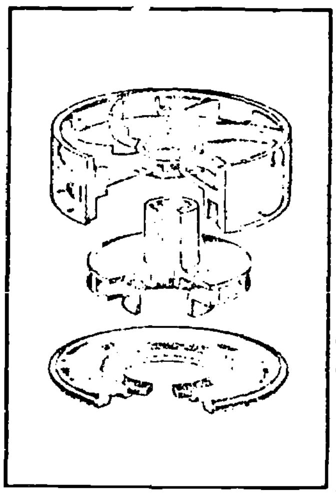
⑥ Bowl bearing is of long wearing hi-lead bronze - - water lubricated.

⑦ Impellers are bronze - - carefully machined and balanced. Modern hydraulic design achieves highest efficiencies possible.

⑧ Shaft coupling is stainless steel - - keyed and set screwed securely to pump shaft. Precision machined to maintain motor and pump alignment.

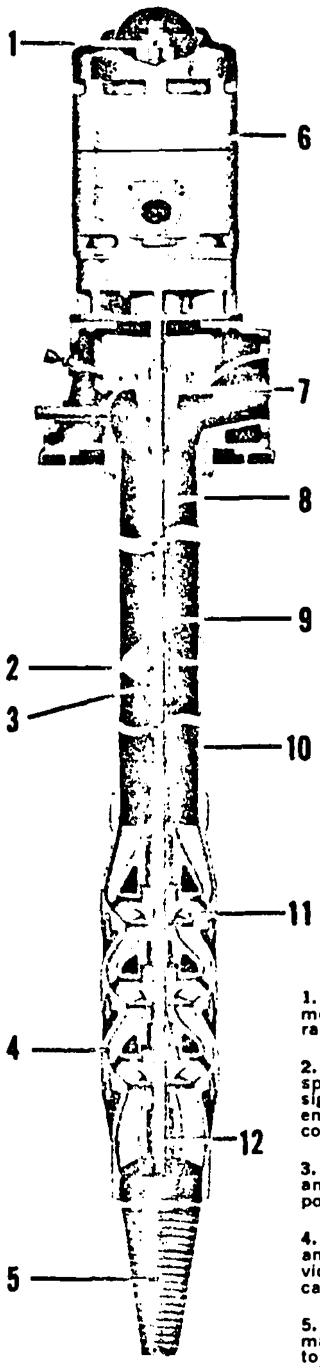
9. Motor assembly.

Molded from new space-age thermo-plastic materials polycarbonate, the impellers in the Berkeley 6A series submersibles are smoother; water passes with minimum friction loss. The non-porous, non-abrasive and non-corrosive characteristics of polycarbonate are especially resistant to abrasion. Wear rings provide proper impeller bowl clearance, minimize wear, and maintain new pump performance.

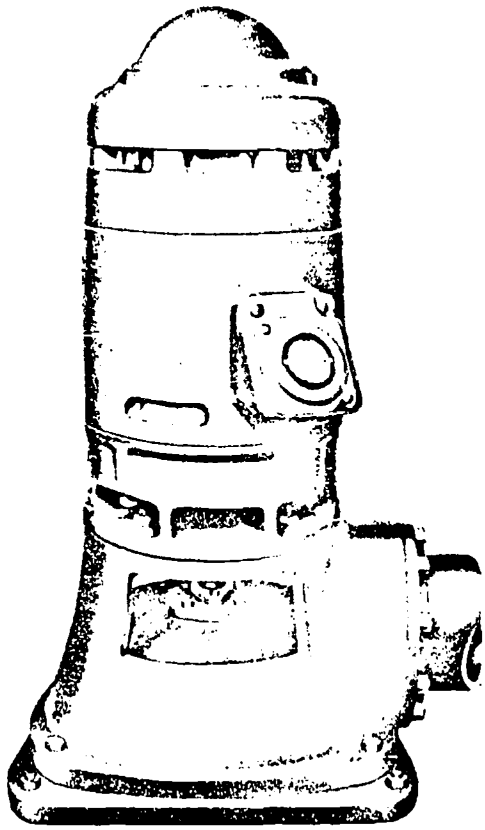


Courtesy-
Berkeley Pump Co.

Fig. 8-4



Fairbanks-Morse turbine pumps are scientifically designed and precision built of the finest materials available. They have been developed to cover a wide range of capacities and heads to meet numerous requirements. Pumps of the Figure 6977 line feature highly efficient semi-open impellers and water lubricated shaft bearings.



SPECIFICATIONS

1. **ADJUSTING NUT**—Provides a simple and efficient means of proper impeller adjustment to meet a wide range of pumping conditions.

2. **COLUMN BEARINGS**—Water-lubricated revolvable spiral-grooved rubber bearings are specifically designed to assure smooth operation, long life, and enduring economy under the most adverse pumping conditions.

3. **BEARING RETAINERS**—These are of cast bronze and streamlined for minimum friction loss. Correct porting provides essential flushing of grit.

4. **PUMP BOWLS**—The bowls are made of POMOLOY, an especially close-grained, high-tensile cast iron providing greater resistance to corrosion than ordinary cast iron.

5. **SUCTION PIPE ANO STRAINER**—Suction pipe is machined from discharge column stock and coupled to a galvanized Cornucopia-type strainer, assuring adequate suction opening and protection from large particles.

6. **FAIRBANKS-MORSE MOTOR**—The vertical hollow-shaft electric motor incorporates the non-reverse ratchet. This feature is positive assurance that the shaft cannot be unscrewed by accidental phase reversal. The non-reverse ratchet also prevents undue stress created when the motor starts at a time of shaft reversal. Both pump and motor are built by one reliable manufacturer, thus assuring the advantage of undivided responsibility.

7. **PACKING BOX**—The discharge head is designed with extra height so that the packing box is readily accessible at the surface for periodic inspection and adjustment.

8. **STILLING TUBE**—The stilling tube prevents the entrance of suspended material to the packing box. Servicing is thereby reduced to a minimum.

9. **DRIVE SHAFT**—Each drive shaft is made to an exact standard length of SAE 1045 high-strength steel, "Fairmortected" for corrosion resistance. A non-corrosive field replaceable sleeve of polished stainless metal is provided on every length at the bearings, and high-strength shaft couplings are accurately machined from bar stock.

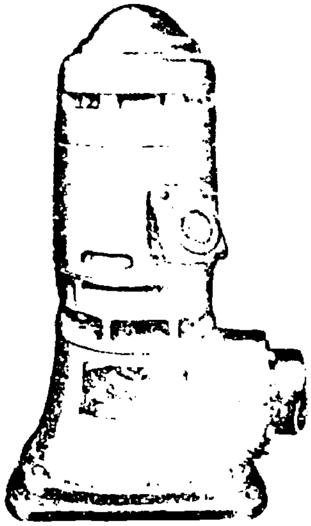
10. **COLUMN PIPE**—Column is machined in our own factories to exact lengths. This assures ease in handling and proper matching with rotating parts. The threads are cut and the ends are faced so that each column butts squarely in its coupling. The couplings are made from extra-strong seamless tubing.

11. **IMPELLERS**—Semi-open impellers are accurately finished and balanced in special machines to maintain consistently superior quality. The impellers are securely locked to the stainless steel impeller shaft with a tapered sleeve and locknut. The impeller assembly is adjusted vertically by the top-shaft adjusting nut to vary water capacity to match existing field conditions and compensate for eventual wear. This design is absolutely free from sand locking.

12. **BOWL BEARINGS**—The Water-lubricated bowl bearings are of high-quality natural rubber specifically designed for maximum life. Each intermediate stage is fitted with a bearing, and extra-long bearings are used in the suction and discharge bowls, to assure adequate support for the impeller shaft.

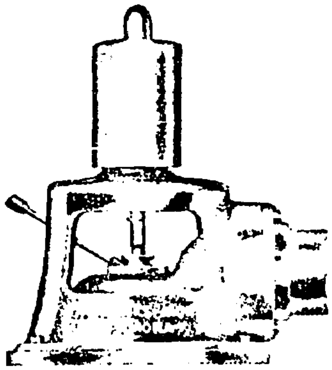
Courtesy-
Fairbanks-Morse Co.

Fig. 8-5



ELECTRIC DRIVE

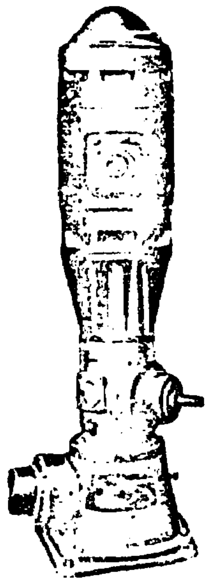
To properly recommend a pump for a specific service, certain information is required. This includes: (1) Inside diameter of well. (2) Depth of well. (3) Depth to water when pumping. (4) Capacity required in G.P.M. (5) Draw-down when pumping desired capacity. (6) Length and diameter of pipe beyond discharge head. (7) Vertical distance from pump base to highest level water is to be raised. (8) Type of drive—if the pump is motor driven, give phase, frequency and voltage; if the pump is belt driven, give horsepower and speed in R.P.M. and diameter of pulley. In case the well is not straight, and of true diameter for its length, a complete description should accompany the inquiry.



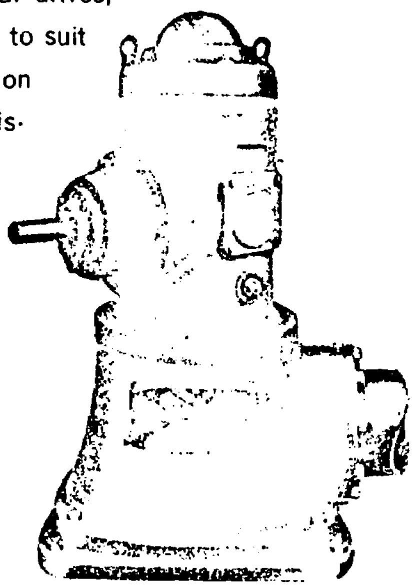
BELTED DRIVE

DISCHARGE HEADS

Turbine pump discharge heads are designed for mounting electric motors, gear drives, belt assemblies, or other drivers to suit local power supply. Illustrated on this page are various types of discharge heads and drives offered with Fairbanks Morse turbine pumps.



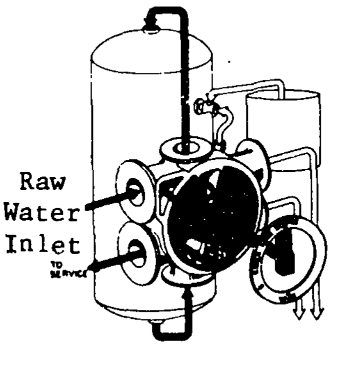
COMBINATION GEARED DRIVE



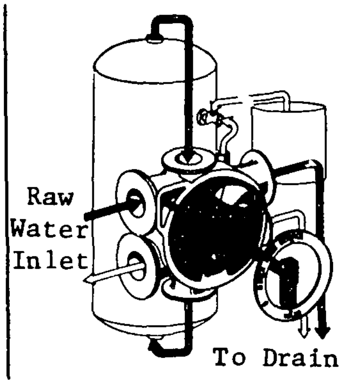
GEARED DRIVE

Courtesy-
Fairbanks-Morse Co.

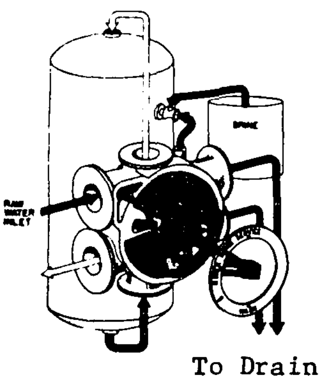
Fig. 8-6



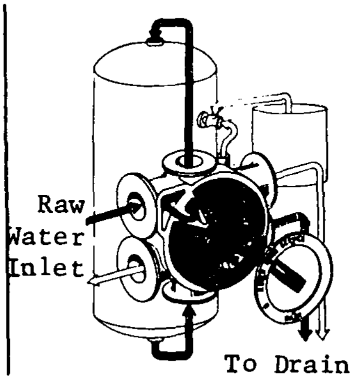
Service—Raw water enters valve, flows from top of tank to bottom where softened water is collected and directed through valve to service.



Backwash—Raw water enters valve, flows from bottom of tank to top, return to valve and out to drain.



Regeneration—Raw water enters valve, draws in brine, flows down through the bed to bottom of tank, returns to valve and out to drain.



Rinsing—Raw water enters valve, flows from top of tank to bottom where water is directed through valve to drain.

Fig. 8-7 Typical Water Softener

Note: It illustrates the flow of water through a multiport valve in each of its operating positions.

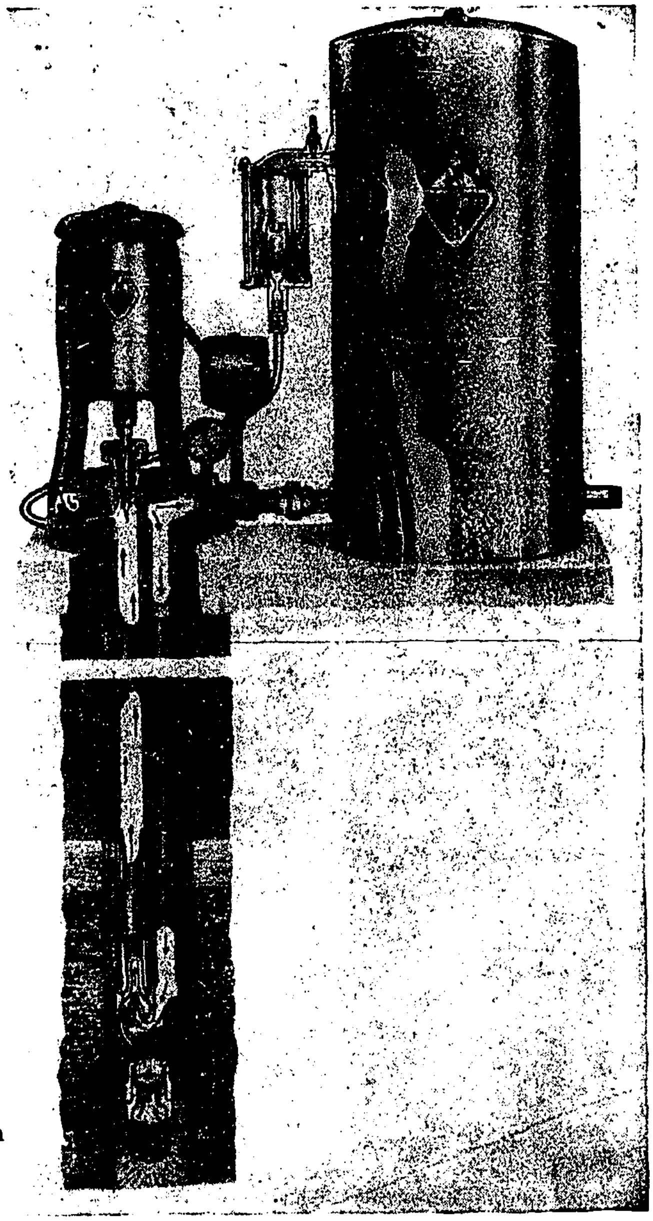


Fig. 8-8

Typical cross-section of 2-pipe jet pump discharging into a hydropneumatic tank.

Note the supply line which feeds the jet.

Courtesy-
Jacuzzi Pump Co.

WATER PROBLEMS

PROBLEM	CAUSE	CORRECTIVE MEASURE
Scale in water heaters and plumbing. Soap curd problems in kitchen, laundry, and bath.	Calcium and magnesium hardness.	Removal by zeolite or resinous (ion exchange) water softeners.
Porcelain and fabrics stained brown to black. Metallic taste Water clear when drawn but turbidity appears on standing.	Iron and/or manganese.	Removal by a resinous softener. Removal by an iron filter. Aeration and removal by filter.
"Rotten egg" odor. Sulfur taste. Silver tarnishes rapidly.	Hydrogen sulfide gas. "Sulphur water." Sulfate reducing bacteria.	Aeration and filtration. Chlorination and filtration.
Red stains in laundry (Corrosion in iron or galvanized piping and water heating system).	Acid water (Low pH) caused by excessive carbon dioxide (CO_2) in water.	Removal by acid neutralizing filter. Removal by aeration.
Blue stains in laundry (Corrosion in copper piping).	Dissolved oxygen.	Cannot be economically removed. Corrosion can be minimized by use of Bru-Cex polyphosphate to form a film on metal surfaces.
Coarse sediment, sand etc. (Particles settle readily).	Sand pumped from well. Material from city mains.	Simple filtration.
Cloudy or turbid water.	Fine suspended matter.	Flocculation by alum followed by filtration. Diatomite filters.
Water tastes and odors.	Organic matter.	Activated carbon filters will remove most tastes and odors. Special cases may require chlorination and filtration.
	Alkali or brackish water.	Cannot be economically treated. It is generally necessary to seek another source of supply or haul drinking water.

Fig. 8-9

CENTRIFUGAL PUMP PROBLEMS

If the operation of the centrifugal pump is not satisfactory at startup or after being in operation, the cause can probably be found in the table.

No Discharge

Lack of discharge from a pump may be caused by any of the following conditions:

- Pump not primed
- *Speed too low
- Discharge head too high
- Suction lift higher than that for which pump is designed
- Impeller completely plugged
- Wrong direction of rotation

Insufficient Discharge

Insufficient discharge from a pump may be caused by any of the following conditions:

- Air leaks in suction line or stuffing boxes
- *Speed too low
- Discharge head higher than anticipated
- Suction lift too high. Check with gauges; check also for clogged suction line or screen
- Impeller partially plugged
- Not enough suction head for hot or volatile liquids
- Mechanical defects:
  - Wearing rings worn
  - Impeller damaged
- Foot valve too small
- Foot valve or suction opening not submerged deeply enough
- Impeller installed backwards
- Wrong direction of rotation

Insufficient Pressure

Insufficient pressure from a pump may be caused by any of the following conditions:

- *Speed too low
- Air or gases in liquid
- Mechanical defects:
  - Wearing rings worn
  - Impeller damaged
- Impeller diameter too small
- Impeller installed backwards
- Wrong direction of rotation

Loss of Suction Following Period of Satisfactory Operation

Loss of suction under these conditions may be caused by any of the following conditions:

- Leaky suction line
- Waterseal plugged
- Suction lift too high
- Casing gasket defective

Excessive Power Consumption

Excess power consumption may be caused by any of the following conditions:

- Speed too high
- Head lower than rating; pumps too much liquid
- Specific gravity or viscosity of liquid pumped is too high
- Mechanical defects:
  - Shaft bent
  - Rotating element binds
  - Stuffing boxes too tight
  - Wearing rings worn

*When directly connected to electric motors, determine whether or not the motor is across the line and receives full voltage. When directly connected to steam turbines, make sure that the turbine receives full steam pressure.

Fig. 8-10

CHAPTER 9

DRAINAGE AND VENT SYSTEMS

General: The information the Plumber requires to properly install the drainage and vent systems are shown on the plans and described in the specifications.

The Plumbing Inspector must be alert and familiar with all phases of the drainage and vent systems during the roughing-in stages; also during the setting of the fixtures and other finish. The drainage and vent systems affect the health of the building occupants and can be the source of an epidemic if the workmanship is not proper. The local codes must be interpreted and followed.

The requirements for drainage and vent systems are that the pipes will carry the waste water rapidly away from the fixtures without clogging, and that the production of siphonage and back pressures will be avoided. The systems must also prevent the passage of air, odors, or vermin from the sewer into the building. The pipes must be gas, air, and water tight as proven by test. The systems must be economically justified based on the life expectancy of the building. A 10 to 25 year life expectancy building may be designed differently from a 75 to 100 year life expectancy building. In any case, the pipes must be durable and installed so that they will not leak nor be damaged under normal usage of the building. This means that they will withstand vibration from traffic or possible earthquake tremors.

Since a modern building is complex it generally will have air conditioning ducts, electrical conduit, storm drain piping, fire sprinkler piping, and structural components, all vying for space in the ceiling or walls. Often the plans will not be coordinated to the point where all piping can be accommodated in the space allowed. The Inspector can be helpful here in assisting the various crafts to use the space to the best advantage; if the problems cannot be resolved, then they must be referred through proper channels for a decision.

Building Drains: Many buildings are constructed with the concrete slab on grade, so that the groundwork, socalled, becomes the first consideration. After grading is accomplished the trench work should be similar to that described in Chapter 7, Utilities. The underfloor sanitary piping is cast iron with caulked joints, usually.

The ends of the pipe should abut against each other, so there shall be no shoulder nor unevenness of any kind along the inside bottom half of the drain. Any sharp points or abrasions may cause tissue to catch and cause a backup. The lowest point on the inside circumference of the pipe should not deviate more than 1/16 inch from the designed elevation and uniform slope. Backfilling should be prompt after the pipe has been laid, inspected, and tested. The backfilling will require compaction, generally to 95% of the surrounding soil, or may require sand fill, so that the slab can be poured as soon as possible. Openings larger than the pipe must be provided where penetrating floor slabs, whether on grade or above grade; also at the foundation walls. The annular space around the pipe and the sleeve must be sealed water tight with oakum and lead, or other means.

<u>Drainage and Vent Pipes</u>: Drainage and vent pipes must be installed in straight alignment and made with the proper fittings arranged for ease of access and maintenance; they should be free from drops or sags and connected to drain back to the soil or waste pipe by gravity.

Vent pipes are subjected to the same pressures and corrosion factors as the drainage pipes. The local plumbing code governs on the acceptable materials for each.

Vent branches should be taken off above the center line of a horizontal soil or waste pipe and connect at least 6 inches above the flood level of the fixture it is venting, before connecting to its main tie-in vent.

Vent stacks terminate above the roof so that the noxious odors can be quickly dispersed; most codes require that a distance of several feet separate the vent terminal from windows, air intakes, and property lines. If snow or frost is a problem, a minimum size may be specified, probably 1 or 2 sizes larger from 1 foot below the roof.

The drainage and vent pipes are installed in the finished portions of a building in concealed spaces such as walls or plenums. Access holes or inspection plates shall be installed at critical points or cleanout locations to facilitate repairs. This is the responsibility of the Plumber.

Pipes shall be supported so that the weight does not bear on a caulked joint. Bell and spigot pipe shall be supported at each joint at the hub, while other piping shall be supported at about 10 foot intervals. Vertical piping shall be supported at each floor level if cast iron. Local codes govern this, as in other requirements.

<u>Traps</u>: Traps in the sanitary drainage system perform several functions, but the primary purpose is to prevent the passage of odors carried by air from the sewer into the building; also vermin of various types are kept out of the system. Like most things the ideal trap has not yet been designed, but some of the desirable features of traps are:

1. It must be self-cleaning; it must have no recesses nor pockets, which cannot be scoured by the flow of sewage through the trap.

2. The inner surface must be smooth, so that the scouring can be complete.

3. The water seal must be 2 inches deep approximately; the sewage must pass freely without mechanical aid; sewer gas must be effectively trapped so that it cannot pass in either direction, even when sewage is not flowing.

4. The design must incorporate features so that there are no gaskets nor packing on the sewer side of the seal which may later allow leakage of sewer gas.

In addition to the ordinary traps used in plumbing systems, there is a class known as interceptors which, as the name implies, are used to remove objectionable materials before they enter the drainage system and cause clogging or other troubles. Most interceptors are equipped with non-corrosive metal baskets which allow liquids to flow but trap the solids which may be anything from grease, as in a restaurant, to hair, as in a beauty shop; such special traps must be vented the same as a sanitary trap; in large installations the interceptors may be constructed of concrete outside the building to facilitate cleaning; garages, washracks, canneries, and commercial restaurants are usually equipped with such interceptors. The design may vary, but the purpose is the same.

Every fixture shall be separately trapped; there are minor exceptions; these are usually covered by the local codes, usually in relation to compartmented sinks or floor drains.

Sewage Pumps: In many installations the sanitary sewer may be at a higher elevation than some portions of the building sewer, particularly in large buildings where fixtures are installed in the basement. A sewage pump is required to lift that portion of the waste into the building sewer so that it can flow by gravity away from the project. Such pumps, usually in duplicate, are nearly always controlled automatically by a float or probe mechanism; the rates of flow determine the size of the storage basin, and the pumping rates of the ejectors.

Tests: On larger jobs the installation may be tested in sections as the work progresses. Where repairs are necessary they can be made more readily. A final test can be made after fixtures are set and before the work is accepted. The water test and the air test can be made during construction. The odor test and the smoke test are usually made on systems which are in operation. A description of the various types of tests is given in Chapter 19, Inspection and Testing.

DRAINAGE SYSTEMS

Section 401 — Materials

(a) Drainage pipe shall be cast iron, galvanized steel, galvanized wrought iron, lead, copper, brass, ABS, PVC or other approved materials having a smooth and uniform bore, except: 1. That no galvanized wrought iron or galvanized steel pipe shall be used underground and shall be kept at least six (6) inches above ground. 2. ABS or PVC installations limited to residential construction not more than two (2) stories in height.

(b) Drainage fittings shall be of cast iron, malleable iron, lead, brass, copper, ABS, PVC or other approved materials having a smooth interior waterway of the same diameter as the piping served and all such fittings shall conform to the type of pipe used.

1. Fittings on screwed pipe shall be of the recessed drainage type. Burred ends shall be reamed to the full bore of the pipe.

2. The threads of drainage fittings shall be tapped so as to allow one fourth (¼) inch per foot grade.

Sec. 402 — Fixture Unit Equivalents

The unit equivalent of plumbing fixtures shown in Table 4-1 shall be based on the size of the trap required, and the unit equivalent of fixtures and devices not shown in Table 4-1 shall be based on the rated discharge capacity in GPM (gallons per minute) in accordance with Table 4-2.

Maximum trap loadings for sizes up to four (4) inches are as follows:

1¼" — 1 unit
1½" — 3 units
2" — 4 units
3" — 6 units
4" — 8 units

Exception on self-service laundries.

Sec. 403 — Size of Drainage Piping

(a) The minimum sizes of vertical and/or horizontal drainage piping shall be determined from the total of all fixture units connected thereto, and additional, in the case of vertical drainage pipes, in accordance with their length.

(b) Table 4-3 shows the maximum number of fixture units allowed on any vertical or horizontal drainage pipe, building drain or building sewer of a given size; the maximum number of fixture units allowed on any branch interval of a given size; the maximum length (in feet) of any vertical drainage pipe of a given size.

TABLE 4-1

Kind of Fixture	Minimum Trap & Trap Arm Size	Units
Bathtubs	1½"	2
Bidets	1½"	2
Dental Units or Cuspidors	1¼"	1
Drinking Fountains	1¼"	1
Floor Drains	2"	2
*Interceptors for grease, oil, solids, etc.	2"	3
*Interceptors for sand, auto wash, etc.	3"	6
Laundry tubs	1½"	2
Clothes Washers	2"	2

*Receptors (floor sinks) indirect waste receptors for refrigerators, coffee urn, water stations, etc.	1½"	1
*Receptors, indirect waste receptors for commercial sinks, dishwashers, airwashers, etc.	2"	3
Showers, single stalls	2"	2
*Showers, gang, (one unit per head)	2"	
Sinks, bar, private (1½" min. waste)	1½"	1
Sinks, bar, commercial (2" min. waste)	1½"	2
Sinks, commercial or industrial, schools, etc. including dishwashers, wash up sinks and wash fountains (2" min. waste)	1½"	3
Sinks, flushing rim, clinic	3"	6
Sinks, and/or dishwashers (residential) (2" min. waste)	1½"	2
Sinks, service	2"	3
Trailer park traps (one for each trailer)	3"	6
Urinals, pedestal	3"	6
Urinals, stall	2"	2
Urinals, wall (2" min. waste)	1½"	2
Urinals, wall trough (2" min. waste)	1½"	3
Wash basins (lavatories) single	1¼"	1
Wash basins, in sets	1½"	2
*Water closet tank type	3"	4
Water closet flush valve type	3"	6

*NOTE—The size and discharge rating of each indirect waste receptor and each interceptor shall be based on the total rated discharge capacity of all fixtures, equipment or appliances discharging thereinto in accordance with Table 4-2.

Drainage piping serving batteries of appliances capable of producing continuous flows shall be adequately sized to provide for peak loads. Clothes washers in groups of 3 or more shall be rated at 6 units each for the purpose of common waste pipe sizing.

Tank type toilets shall be computed as 6 fixture units when determining septic tank size based on Section 1112.

Trap sizes shall not be increased to a point where the fixture discharge may be inadequate to maintain their self scouring properties.

TABLE 4-2

DISCHARGE CAPACITY (In Gals. per min.)

For Intermittent Flow Only

Up to 7½	Equals	1 Unit
8 to 15	Equals	2 Units
16 to 30	Equals	4 Units
31 to 50	Equals	6 Units

Over 50 gals. shall be determined by the Administrative Authority.

For a continuous flow into a drainage system, such as from a pump, pump ejector, air conditioning equipment, or similar device, two fixture units shall be allowed for each gal. per minute of flow.

Sec. 404 — Fixture Connections (Drainage)

(a) Drainage piping shall be provided with approved inlet fittings for fixture connections, correctly located according to the size and type of fixture proposed to be connected.

(b) Two fixtures set back to back or side by side, within the distance allowed between a trap and its vent, may be served by a single drainage pipe provided that each fixture wastes separately into an approved double fitting having inlet openings at the same level

Sec. 405 — Changes in Direction of Drainage Flow

(a) Changes in direction of drainage piping shall be made by the appropriate use of approved fittings and shall be of the angles presented by a one-sixteenth (1/16) bend, one-eighth (1/8) bend, or one-sixth (1/6) bend, or other approved fittings of equivalent sweep.

(b) Horizontal drainage lines, connecting with a vertical stack, shall enter through forty-five (45) degree "Y" branches, sixty (60) degree "Y" branches, combination "Y" and one-eighth (1/8) bend branches, sanitary tee or sanitary tapped tee branches, or other approved fittings of equivalent sweep. No fitting having more than one (1) branch at the same level shall be used unless such fitting is constructed so that the discharge from one (1) branch cannot readily enter any other branch. Double sanitary tees may be used when the barrel of the fitting is at least two (2) pipe sizes larger than the largest branch, (pipe sizes recognized for this purpose are 2", 2½", 3", 3½", 4", 4½", 5", 6", etc).

(c) Horizontal drainage lines connecting with other horizontal drainage lines shall enter through forty-five (45) degree "Y" branches, combination "Y" and one-eighth (1/8) bend branches, or other approved fittings of equivalent sweep.

(d) Vertical drainage lines connecting with horizontal drainage lines shall enter through forty-five (45) degree branches, or other approved fittings of equivalent sweep. Sixty (60) degree branches or offsets may be used only when installed in a true vertical position.

Sec. 406 — Cleanouts

(a) Each horizontal drainage pipe shall be provided with a cleanout at its upper terminal, and each run of piping, which is more than one hundred (100) feet in total developed length shall be provided with a cleanout for each one hundred (100) feet or fraction thereof, in length of such piping.

Exceptions:

1. Cleanouts may be omitted on an horizontal drain line less than five (5) feet in length unless such line is serving sinks or urinals.

2. Cleanouts may be omitted on any horizontal drainage pipe installed on a slope of seventy-two (72) degrees or less from the vertical angle (angle of 1/5 bend).

3. Excepting the building drain and its horizontal branches, a cleanout shall not be required on any pipe or piping which is above the first floor of the building.

4. An approved type of two-way cleanout fitting installed inside the building wall near the connection between the building drain and building sewer or installed outside of a building at the lower end of a building drain and extended to grade may be substituted for an upper terminal cleanout.

(b) An additional cleanout shall be provided in a horizontal line for each aggregate change of direction exceeding one hundred and thirty-five (135°) degrees.

(c) Each cleanout shall be installed so that it opens in a direction opposite to the flow of the soil or waste or at right angles thereto and, except in the case of "wye" branch and end-of-line cleanouts, shall be installed vertically above the flow line of the pipe.

(d) Each cleanout extension shall be considered as drainage piping and each ninety (90°) degree cleanout extension shall be extended from a "Y" type fitting or other approved fitting of equivalent sweep.

(e) Each cleanout for an interceptor shall be outside of such interceptor.

(f) Each cleanout, unless installed under an approved cover plate, shall be above grade, readily accessible, and so located as to serve the purpose for which it is intended. Cleanouts located under cover plates shall be so installed as to provide the clearances and accessibility required by this section.

(g) Each cleanout in piping two (2) inches or less in size shall be so installed that there is a clearance of not less than twelve (12) inches in front of the cleanout. Cleanouts in piping larger than two (2) inches shall have a clearance of not less than eighteen (18) inches in front of the cleanout. Cleanouts in underfloor piping shall be extended to or above the finished floor or shall be extended outside the building when there is less than eighteen (18) inches vertical and thirty (30) inches horizontal clearance from the means of access to such cleanout. No underfloor cleanout in any residential occupancy shall be located more than twenty (20) feet from an access door, trap door or crawl hole.

(h) Cleanout fittings shall be not less in size than that given in Table 2-3.

(i) Cleanouts shall be provided for pressure drainage systems as classified under Section 409 (g).

Sec. 407 — Grade of Horizontal Drainage Piping

Horizontal drainage piping shall be run in practical alignment and a uniform slope of not less than one-fourth (¼) of an inch per foot or two (2) percent toward the point of disposal; provided, that where it is impractical due to the depth of the street sewer or to the structural features or to the arrangement of any building or structure to obtain a slope of one-fourth (¼) of an inch per foot or two (2) percent, any such pipe or piping four (4) inches or larger in diameter may have a slope of not less than one-eighth (⅛) of an inch per foot or one (1) percent when first approved by the Administrative Authority.

Sec. 408 — Gravity Drainage Required

Wherever practicable all plumbing fixtures shall be drained to the public sewer or private sewage disposal system by gravity.

Sec. 409 — Drainage Below Curb and Also Below Main Sewer Level

(a) Drainage piping serving fixtures, the flood level rims of which, are located below the elevation of the curb or property line, at the point where the building sewer crosses under the curb or property line, and above the crown level of the main sewer, shall drain by gravity into the main sewer, and shall be protected from back flow of sewage by installing an approved type back water valve, and each such backwater valve shall be installed only in that branch or section of the drainage system which receives the discharge from fixtures located below the elevation of the curb or property line.

(b) Drainage piping serving fixtures that are located below the crown level of the main sewer, shall discharge into an approved water-tight sump or receiving tank, so located as to receive the sewage or wastes by gravity. From such sump or receiving tank the sewage or other liquid wastes shall be lifted and discharged into the building drain or building sewer by approved ejectors, pumps or other equally efficient approved mechanical device.

(c) The minimum size of any pump or any discharge pipe from a sump having a water closet connected thereto shall be not less than two (2) inches.

(d) The discharge line from such ejector, pump or other mechanical device shall be provided with an accessible back-water or swing check valve and gate valve, and if the gravity drainage line to which such discharge line connects is horizontal, the method of connection shall be from the top through a "wye" branch fitting.

(e) Building drains or building sewers receiving discharge from any pump or ejector shall be adequately sized to prevent over-loading. Two (2) fixture units shall be allowed for each gallon per minute of continuous flow.

(f) Back-water valves, gate valves, motors, compressors, air tanks or other mechanical devices required by this section, shall be located where they will be readily and easily accessible for inspection and repair at all times, and unless continuously exposed, shall be enclosed in a water tight masonry pit fitted with an adequately sized removable cover.

(g) The drainage and venting systems in connection with fixtures, sumps, receiving tanks and mechanical waste lifting devices, shall be installed under the same requirements as provided for in this code for gravity systems.

(h) Sumps and receiving tanks shall be watertight and shall be constructed of concrete, metal or other approved materials. If constructed of poured concrete, the walls and bottom shall be adequately reinforced and designed to recognized acceptable standards. Metal sumps or tanks shall be of such thickness as to serve their intended purpose and shall be treated internally and externally to resist corrosion.

(i) All such sumps and receiving tanks shall be automatically discharged and when in any "public use" occupancy shall be provided with dual pumps or ejectors arranged to function independently in case of overload or mechanical failure. The lowest inlet shall have a minimum clearance of two (2) inches from the high water or 'starting' level of the sump.

(j) Sumps and receiving tanks shall be provided with substantial covers having a bolt and gasket type manhole or equivalent opening to permit access for inspection, repairs, and cleaning. The top shall be provided with a vent pipe which shall extend separately through the roof, or when permitted, may be combined with other vent pipes. Such vent shall be large enough to maintain atmospheric pressure within the sump under all normal operating conditions and in no case shall be less in size than that required by Table 4-3 for the number of fixtures discharging into the sump, nor less than one and one-half (1½) inches in diameter. When the foregoing requirements are met and the vent, after leaving the sump, is combined with vents from fixtures discharging into the sump, the size of the combined vent need not exceed that required for the total number of fixtures discharging into the sump. No vent from an air-operating sewage ejector shall combine with other vents.

(k) Air tanks shall be so proportioned as to be of equal cubical capacity to the ejectors connected therewith in which there shall be maintained an air pressure of not less than two (2) pounds for each foot of height the sewage is to be raised. No water operated ejectors shall be permitted.

(l) When subsoil drainage systems are installed, they shall be discharged into an approved sump or receiving tank and shall be discharged in a manner satisfactory to the Administrative Authority.

TABLE 4-3

Lists Maximum Unit Loading and Maximum Length of Drainage and Vent Piping

Size of Pipe (inches)	1¼"	1½"	2"	2½"	3"	4"	5"	6"	8"	10"	12'
Max. Units											
Drainage Piping[1]											
Vertical	1	2[2]	16[3]	32[3]	48[4]	256	600	1380	3600	5600	8400
Horizontal[5]	1	1	8[3]	14[3]	35[4]	216	428	720	2640	4680	8200
Max. Length (Feet)											
Drainage Piping											
Vertical	45	65	85	148	212	300	390	510	750		
Horizontal Unlimited											
Vent Piping											
Horizontal and Vertical											
Max. Units	1	8[3]	24	48	84	256	600	1380	3600		
Max. Lengths (See Note)	45	60	120	180	212	300	390	510	750		

[1] Excluding trap arm.

[2] Except sinks and urinals.

[3] Except six-unit traps or water closets.

[4] Only four water closets or six-unit traps allowed on any vertical pipe or stack and not to exceed three water closets or six-unit traps on any horizontal branch or drain provided any one of the three discharges is separated from the other two by a minimum horizontal developed length of fifteen (15) feet whether connecting to vertical or horizontal piping.

[5] Based upon one-fourth inch (¼") per foot slope. For one-eighth-inch (⅛") per foot slope multiply horizontal fixture units by a factor of 0.8.

NOTE: The diameter of an individual vent shall not be less than one and one-fourth inches (1¼") nor less than one-half the diameter of the drain to which it is connected. Fixture unit load values for drainage and vent piping shall be computed from Tables Nos. 4-1 and 4-2. Not to exceed one-third of the total permitted length of any vent may be installed in a horizontal position. When vents are increased one pipe size for their entire length, the maximum length limitations specified in this table do not apply.

VENTS AND VENTING

Section 501 — Vents Required

Each plumbing fixture trap, except as otherwise provided in this code, shall be protected against siphonage and back pressure, and air circulation shall be assured throughout all parts of the drainage system by means of vent pipes installed in accordance with the requirements of this chapter and as otherwise required by this code.

Sec. 502 — Vents Not Required

(a) Where permitted by the Administrative Authority, vent piping may be omitted on an interceptor when such interceptor acts as a primary settling tank and discharges through a horizontal indirect waste pipe into a secondary interceptor which is located within twenty-five (25) feet of the primary tank. The secondary interceptor shall be properly trapped and vented.

(b) Traps serving sinks which are part of the equipment of bars, soda fountains and counters, need not be vented when the location and construction of such bars, soda fountains and counters is such as to make it impossible to do so. When such conditions exist, said sinks shall discharge by means of approved indirect waste pipes into a floor sink or other approved type receptor.

Sec. 503 — Materials

(a) Vent pipe shall be cast iron, galvanized steel, galvanized wrought iron, lead, copper, brass, ABS, PVC or other approved materials; except that no galvanized steel or galvanized wrought iron pipe shall be used underground and shall be kept at least six (6) inches above ground.

(b) Vent fittings shall be cast iron, galvanized malleable iron or galvanized steel, lead, copper, brass, ABS, PVC, or other approved materials except that no galvanized malleable iron or galvanized steel fittings shall be used underground and shall be kept at least six (6) inches above ground.

(c) Changes in direction of vent piping shall be made by the appropriate use of approved fittings and no such pipe shall be strained or bent. Burred ends shall be reamed to the full bore of the pipe.

Sec. 504 — Size of Vents

(a) The size of vent piping shall be determined from its length and the total number of fixture units connected thereto, as set forth in Table 4-3 of this code. In addition, the drainage piping of each building and each connection to a public sewer or a private sewage disposal system shall be vented by means of one or more vent pipes, the aggregate cross-sectional area of which shall not be less than that of the largest required building sewer as determined from Table 4-3.

Exception: When connected to a common building sewer, the drainage piping of two or more buildings located on the same lot and under one ownership may be vented by means of piping sized in accordance with Table 4-3 provided the aggregate cross-sectional area of all vents is not less than that of the largest required common building sewer.

(b) A vent may exceed ⅓ of the maximum horizontal length as limited by Table 4-3 provided the vent is increased one pipe size for its entire length.

Sec. 505 — Vent Pipe Grades and Connections

(a) All vent and branch vent pipes shall be free from drops or sags and each such vent shall be level or shall be so graded and connected as to drip back by gravity to the drainage pipe it serves.

(b) Where vents connect to a horizontal drainage pipe, each vent pipe shall be taken off above the center line of such pipe ahead of the trap being served.

(c) Unless prohibited by structural conditions, each vent shall rise vertically to a point not less than six (6) inches above the flood level rim of the fixture served before offsetting horizontally, and whenever two or more vent pipes converge, each such vent pipe shall rise to a point at least six (6) inches in height above the flood level rim of the plumbing fixture it serves before being connected to any other vent. When horizontal vents are less than six (6) inches above the flood level rim of the fixture, the horizontal portion shall be installed with approved drainage material.

(d) All vent pipes shall extend undiminished in size above the roof, or shall be reconnected with the main soil or waste vent.

(e) The vent pipe opening from a soil or waste pipe, except for water closets and similar fixtures, shall not be below the weir of the trap.

(f) Two (2) fixtures may be served by a common vent pipe when each such fixture wastes separately into an approved double fitting having inlet openings at the same level.

Sec. 506 — Vent Termination

(a) Each vent pipe or stack shall extend through its flashing and shall terminate vertically not less than six (6) inches above the roof nor less than one (1) foot from any vertical surface.

(b) Each vent shall terminate not less than ten (10) feet from or at least three (3) feet above any window, door, opening, air intake or vent shaft, nor less than three (3) feet in every direction from any lot line; alley and street excepted.

(c) Vent pipes shall be extended separately or combined, of full required size, not less than six (6) inches above the roof or fire wall. Flagpoling of vents is prohibited except where the roof is used for purposes other than weather protection. In such cases the vent shall extend not less than seven (7) feet above the roof and be securely stayed.

(d) Vent pipes for outdoor installations shall extend at least ten (10) feet above the surrounding ground and shall be securely supported.

(e) Joints at the roof around vent pipes, shall be made watertight by the use of approved flashings or flashing material.

Sec. 507 — Vent Stacks and Relief Vents

(a) Each drainage stack which extends ten or more stories above the building drain or other horizontal drain, shall be served by a parallel vent stack which shall extend undiminished in size from its upper terminal and connect to the drainage stack at or immediately below the lowest fixture branch. Each such vent stack shall also be connected to the drainage stack at each fifth floor below the uppermost fixture branch by means of a relief yoke vent, the size of which shall be not less in diameter than either the drainage or the vent stack, whichever is smaller.

(b) The yoke vent intersection with the vent stack shall be placed not less than forty-two (42) inches above the floor level, and the yoke vent intersection with the drainage stack shall be by means of a 'wye' branch fitting placed below the fixture branch serving that floor.

INDIRECT WASTE PIPING, WET VENTED SYSTEMS, AND SPECIAL WASTES

Section 601 — Indirect Waste Conditions

No evaporative cooler, air washer or similar air conditioning equipment and no cold storage room, refrigerator, cooling counter, compartment, receptacle, appurtenance or device which is used, designed or intended to be used for the storage or holding of food or drink shall have any drain pipe in connection therewith directly connected to any soil, waste or vent pipe. Such equipment shall be drained by means of indirect waste pipes as defined in Chapter 1 of this code and all wastes drained by them shall discharge through an air break into an open floor sink or other approved type receptor which is properly connected to the drainage system.

The foregoing does not apply to any dishwashing or culinary sink in any food preparation room, unless such receptacle is used for soaking or washing ready-to-serve food, or to walk-in refrigerators and combination walk-in, reach-in refrigerators used for storage and sales of products packaged in bottles, cartons or containers.

Sec. 602 — Approvals

No plumbing fixtures served by indirect waste pipes or receiving discharge therefrom shall be installed until first approved by the Administrative Authority.

Sec. 603 — Indirect Waste Piping

Except as hereinafter provided, the size and construction of indirect waste piping shall be in accordance with other sections of this code applicable to drainage and vent piping. No vent from indirect waste piping shall combine with any sewer connected vent, but shall extend separately to the outside air.

Indirect waste pipes exceeding five (5) feet, but less than fifteen (15) feet in length shall be directly trapped, but such traps need not be vented. Indirect waste pipes less than fifteen (15) feet in length need be no larger in diameter than the drain outlet or tailpiece of the fixture, appliance or equipment served, but in no case less than one-half (½) inch in size. Angles and changes of direction in such indirect waste pipes shall be provided with cleanouts so as to permit flushing and cleaning.

Sec. 604 — Indirect Waste Receptors

(a) All plumbing fixtures or other receptors receiving the discharge of indirect waste pipes shall be approved for the use proposed and shall be of such shape and capacity as to prevent splashing or flooding and shall be located where they are readily accessible for inspection and cleaning. No stand-pipe receptor for any clothes washer shall extend more than thirty (30) inches, nor less than eighteen (18) inches above its trap. No trap for any clothes washer standpipe receptor shall be installed below the floor, but shall be roughed-in not less than six (6) inches and not more than eighteen (18) inches above the floor. No indirect waste receptor shall be installed in any toilet room, closet, cupboard or storeroom, nor in any other portion of a building not in general use by the occupants thereof; except standpipes for clothes washers may be installed in toilet and bathroom areas when the clothes washer is installed in the same room.

(b) Where water service connections are installed for a clothes washer, an approved method of waste disposal shall be provided.

Sec. 605 — Pressure Drainage Connections

Indirect waste connections shall be provided for drains, overflows or relief vents from the water supply system, and no piping or equipment carrying wastes or producing wastes or other discharges under pressure shall be directly connected to any part of the drainage system.

The foregoing shall not apply to any approved sump pump or to any approved pressure-wasting plumbing fixture or device when the Administrative Authority has satisfied himself that the drainage system is adequately sized to accommodate the anticipated discharge thereof.

Sec. 606 — Food Waste Disposers

No commercial or domestic food waste disposer shall be connected to any drainage system until a production prototype thereof has first been tested and approved.

Sec. 607 — Sterile Equipment

Appliances, devices or apparatus such as stills, sterilizers and similar equipment requiring water and waste and used for sterile materials shall be indirectly connected or provided with an air gap between the trap and the appliance.

Sec. 608 — Appliances

Appliances, devices, equipment or other apparatus not regularly classed as plumbing fixtures, which are equipped with pumps, drips or drainage outlets, may be drained by indirect waste pipes discharging into an approved type open receptor.

No domestic dishwashing machine shall be directly connected to a drainage system or food waste disposer without the use of an approved dishwasher air-gap fitting on the discharge side of the dishwashing machine.

Sec. 609 — Cooling Water

When permitted by the Department having jurisdiction, clean running water used exclusively as a cooling medium in an appliance, device or apparatus, may discharge into the drainage system through the inlet side of a fixture trap in the event that a suitable fixture is not available to receive such discharge. Such trap connection shall be by means of a pipe connected to the inlet side of an approved fixture trap, the upper end terminating in a funnel shaped receptacle set adjacent to, and not less than six (6) inches above, the overflow rim of the fixture.

Sec. 610 — Drinking Fountains

Drinking fountains may be installed with indirect wastes.

Sec. 611 — Steam and Hot Water Drainage Condensors and Sumps

(a) No steam pipe shall be directly connected to any part of a plumbing or drainage system, nor shall any water having a temperature above one hundred and forty degrees Fahrenheit be discharged under pressure directly into any part of a drainage system. Such pipes may be indirectly connected by discharging into an open or closed condensor, or intercepting sump of approved type, that will prevent the entrance of steam or such water under pressure into the drainage system. All closed condensors or sumps shall be provided with a vent, which shall be taken off the top and extended separately, full size above the roof. All condensors and sumps shall be properly trapped at the outlet with a deep seal trap extending to within 6 inches of the bottom of the tank. The top of the deep seal trap shall have a ¾ inch opening located at the highest point of the trap to serve as a syphon breaker. Outlets shall be taken off from the side in such manner as to allow a water line to be maintained that will permanently occupy not less than one-half (½) the capacity of the condensor or sump. All inlets shall enter above the water line. Wearing plate or baffles shall be installed in the tank to protect the shell. The sizes of the blowoff line inlet, the water outlets, and the vent shall be as shown in Table 6-1. The contents of condensors receiving steam or hot water under pressure must pass through an open sump before entering the drainage system.

(b) Sumps, condensors or intercepting tanks which are constructed of concrete shall have walls and bottom not less than four (4) inches in thickness, and the inside shall be cement plastered not less than one-half (½) inch in thickness. Condensors constructed of metal shall be not less than No. 12 U. S. Standard gauge (.109") and all such metal condensors shall be protected from external corrosion by an approved bituminous coating.

(c) Sumps and condensors shall be provided with suitable means of access for cleaning and shall contain a volume of not less than twice the volume of water removed from the boiler or boilers connected thereto when the normal water level of such boiler or boilers is reduced not less than 4 inches.

TABLE NO. 6-1
Pipe Connections in Blowoff
Condensors and Sumps

Boiler Blowoff	Water Outlet	Vent
*¾	¾	2
1	1	2½
1¼	1¼	3
1½	1½	4
2	2	5
2½	2½	6

* To be used only with boilers of 100 sq/ft. of heating surface or less.

Sec. 612 — Chemical Wastes

(a) Chemical or industrial liquid wastes which are likely to damage or increase maintenance costs on the sanitary sewer system, detrimentally affect sewage treatment or contaminate surface or subsurface waters, shall be pretreated to render them innocuous prior to discharge into a drainage system. Detailed plans and specifications of the pretreatment facilities may be required by the Administrative Authority.

Piping conveying industrial, chemical or process wastes from their point of origin to sewer connected pretreatment facilities, shall be of such material and design as to adequately perform its intended function to the satisfaction of the Administrative Authority. Drainage discharge piping from pretreatment facilities or interceptors shall conform to standard drainage installation procedure.

(b) Each waste pipe receiving or intended to receive the discharge of any fixture in which acid or corrosive chemical is placed and each ventilating pipe connected thereto, shall be constructed of chemical resistant glass, high silicon iron pipe, lead pipe not less than one-eighth (⅛) inch wall thickness, an approved type of ceramic glazed or un-glazed vitrified clay or other approved corrosion resistant materials.

(c) All jointing materials shall be of approved type and quality.

(d) Wherever practicable all piping shall be readily accessible and installed with the maximum of clearance from other services.

(e) The owner shall make and keep a permanent record of the location of all piping and venting carrying chemical waste.

waste and vent system shall be approximately equal to one-half (½) the cross-sectional area of the drain pipe served.

(d) Each waste pipe and each trap in any such system shall be at least two (2) pipe sizes larger than the sizes required by Chapter 7 of this code, and at least two (2) pipe sizes larger than any fixture tail piece or connection.

(e) Unless specifically required or permitted by the Administrative Authority, no vertical waste pipe shall be used in any such system, except the tail piece or connection between the outlet of a plumbing fixture and the trap therefor. Such tail pieces or connections shall be as short as possible, and in no case shall exceed two (2) feet.

(f) Cleanouts may not be required on any wet vented branch serving a single trap when the fixture tail pieces or connection is not less than two (2) inches in diameter and provides ready access for cleaning through the trap.

(g) Except where permitted to discharge into a wet-vented trailer park drainage system, no water closet or urinal shall be installed on any such system. Other one (1), two (2) or three (3) unit fixtures remotely located from the sanitary system and adjacent to a combination waste and vent system may be connected to such system in the conventional manner by means of waste and vent pipes of regular sizes, providing that the two (2) pipe size increase required in subsection (d) of this section is based on the total fixture unit load connected to the system.

TRAPS AND INTERCEPTORS

Section 701 — Traps Required

(a) Each plumbing fixture, excepting those having integral traps, shall be separately trapped by an approved type waterseal trap.

(b) It is provided, however, that one (1) trap may serve a set of not more than three (3) single compartment sinks or laundry tubs of the same depth or three (3) lavatories immediately adjacent to each other and in the same room, if the waste outlets are not more than thirty (30) inches apart and the trap is centrally located when three (3) compartments are installed. The depth requirement may be waived in the case of approved type pump discharged fixtures or appliances.

(c) No food waste disposal unit shall be installed with any set of restaurant, commercial or industrial sinks served by a single trap; each such food waste disposal unit shall be connected to a separate trap. Each domestic clotheswasher and each laundry tub shall be connected to a separate and independent trap; except that a trap serving a laundry tub may also receive the waste from a clotheswasher set adjacent thereto. No clotheswasher or laundry tub shall be connected to any trap for a kitchen sink.

(d) The vertical distance between a fixture outlet and the trap weir shall be as short as practicable, but in no case shall the tail piece from any fixture exceed twenty-four (24) inches in length.

(f) No chemical vent shall intersect vents for other services.

(g) No chemical wastes shall be discharged into the ground, local sewer or other means without approval of the local Administrative Authority.

(h) The provisions in this section relative to materials and methods of construction, need not apply to minor installations such as small photographic or x-ray dark rooms or small research or control laboratories where minor amounts of adequately diluted chemicals are discharged.

Sec. 613 — Vertical Wet Venting

(a) Wet venting is limited to vertical drainage piping receiving the discharge from the trap arm of 1 or 2 fixture unit fixtures that also serves as a vent for not to exceed four (4) fixtures. All wet vented fixtures must be on the same floor level.

(b) The vertical piping between any two consecutive inlet levels shall be considered a wet vented section. Each wet vented section shall be a minimum of one (1) pipe size larger than its upper fixture inlet.

(c) Common vent sizing shall be the sum of the fixture units served but in no case smaller than the minimum vent pipe size required for any fixture served.

Sec. 614 — Special Venting for Island Fixtures

Traps for island sinks and similar equipment shall be roughed in above the floor and may be vented by extending the vent as high as possible, but not less than the drainboard height and then returning it downward and connecting it to the horizontal sink drain immediately downstream from the vertical fixture drain.

The returned vent shall be connected to the horizontal drain through a Y-branch fitting and shall in addition be provided with a foot vent taken off the vertical fixture vent by means of a Y-branch immediately below the floor and extending to the nearest partition and thence through the roof to the open air or may be connected to other vents at a point not less than six (6) inches above the flood level rim of the fixtures served. Drainage fittings shall be used on all parts of the vent below the floor level and a minimum slope of one-quarter (¼) inch per foot back to the drain shall be maintained. The return bend used under the drainboard shall be a one piece fitting or an assembly of a forty-five (45) degree, a ninety (90) degree, and a forty-five (45) degree elbow in the order named. Pipe sizing shall be as elsewhere required in this code.

Sec. 615 — Combination Waste and Vent System

(a) Combination waste and vent systems shall be permitted only where structural conditions preclude the installation of conventional systems as otherwise prescribed by this code.

(b) Plans and specifications for each combination waste and vent system shall be first approved by the Administrative Authority before any portion of any such system is installed.

(c) Each combination waste and vent system shall consist of a wet vented installation of waste piping as hereinafter provided in this section in which the trap for one or more plumbing fixtures is not separately and independently vented, and in which the waste pipes or piping shall be provided with an adequate vent or vents to assure free circulation of air therein, and in which any branch more than fifteen (15) feet in length is separately vented in an aproved manner. The area of any vent installed in a combination

Sec. 702 — Traps Protected by Vent Pipes

(a) Each plumbing fixture trap, except as otherwise provided in this code, shall be protected against syphonage and back pressure, and air circulation assured throughout all parts of the drainage system, by means of a vent pipe installed in accordance with the requirements of this code.

(b) Each fixture trap shall have a protecting vent so located that the developed length of the trap arm from the trap weir to the inner edge of the vent shall be within the distance given in Table 7-1.

TABLE 7-1

Horizontal Distance of Trap Arms
(Except for water closets and similar fixtures)

Trap Arm	Distance Trap to Vent Feet	Distance Trap to Vent Inches
1¼	2	6
1½	3	6
2	5	0
3	6	0
4 and larger	10	0

Slope one-fourth (¼) inch per foot

(c) A trap arm may change direction without the use of a cleanout when such change of direction is accomplished by the use of not more than two (2) forty-five (45) degree fittings or one (1) ninety (90) degree fitting of approved radius.

(d) The vent pipe opening from a soil or waste pipe, except for water closets and similar fixtures, shall not be below the weir of the trap. The developed length between the trap of a water closet* or similar fixture and its vent shall not exceed six (6) feet.

* Measure from top of floor flange to inner edge of vent.

Sec. 703 — Traps Described

(a) Each trap, except that for an interceptor or similar device shall be self-cleaning. Traps for bathtubs, showers, lavatories, sinks, laundry tubs, floor drains, hoppers, urinals, drinking fountains, dental units and similar fixtures shall be of standard design and weight and shall be of lead, cast iron, cast brass, ABS, PVC or other approved materials. An exposed and readily accessible drawn brass tubing trap, not less than 17 B & S gauge (.045") may be used on fixtures discharging domestic sewage but shall exclude urinals. Each trap shall have the manufacturer's name stamped legibly in the metal of the trap and each tubing trap shall have the gauge of the tubing in addition to the manufacturer's name. Every trap shall have a smooth and uniform interior waterway.

(b) No more than one approved slip joint fitting may be used on the outlet side of the trap.

(c) The size (nominal diameter) of a trap for a given fixture shall be sufficient to drain the fixture rapidly, but in no case less than given in Table 4-1. No trap shall be larger than the trap arm to which it is connected.

Sec. 704 — Traps Prohibited

No form of trap which depends for its seal upon the action of movable parts or concealed interior partitions shall be used. Full "S" traps are prohibited. Bell traps are prohibited. Crown-vented traps are prohibited. No fixture shall be double trapped. Drum traps may be installed only when permitted by the Administrative Authority for special conditions. No drum trap shall be installed without a vent.

Sec. 705 — Trap Seals

Each fixture trap shall have a water seal of not less than two (2) inches and not more than four (4) inches, except where a deeper seal is found necessary by the Administrative Authority for special conditions. Traps shall be set true with respect to their water seals and where necessary they shall be protected from freezing.

Sec. 706 — Floor Drain Traps

Floor drains shall connect into a trap so constructed that it can be readily cleaned and of a size to serve efficiently the purpose for which it is intended. The drain inlet shall be so located that it is at all times in full view. When subject to back flow or back pressure, such drains shall be equipped with an approved backwater valve.

Sec. 707 — Trap Seal Protection

Floor drain or similar traps directly connected to the drainage system and subject to infrequent use shall be provided with an approved means of maintaining their water seals, except where not deemed necessary for safety or sanitation by the Administrative Authority.

Sec. 708 — Industrial Interceptors and Separators

(a) **When Required**—Interceptors (including grease, oil and sand interceptors, etc.) shall be provided when, in the judgment of the Administrative Authority, they are necessary for the proper handling of liquid wastes containing grease, flammable wastes, sand, solids, acid or alkaline substances or other ingredients harmful to the building drainage system, the public or private sewer or to public or private sewage disposal.

(b) **Approval**—The size, type and location of each interceptor or separator shall be approved by the Administrative Authority in accordance with its standards and, except where otherwise specifically permitted, no wastes other than those requiring treatment or separation shall be discharged into any interceptor.

(c) **Design**—Interceptors for sand and similar heavy solids shall be so designed and located as to be readily accessible for cleaning and shall have a water seal of not less than six (6) inches.

(d) **Relief Vent**—Interceptors shall be so designed that they will not become air bound if closed covers are used. Each interceptor shall be properly vented.

(e) **Location**—Each interceptor shall be so installed as to provide ready accessibility to the cover and for servicing and maintaining the interceptor in working and operating condition. The use of ladders or the removal of bulky equipment in order to service interceptors shall constitute a violation of accessibility. Location of all interceptors shall be shown on the approved building plan.

Sec. 709 — Slaughter Houses, Packing Establishments, etc.

Every fish, fowl and animal slaughter house or establishment and every fish, fowl and meat packing or curing establishment and every soap factory, tallow rendering, fat rendering and hide curing establishment, or any other establishment from which considerable amounts of grease are likely to be discharged into any plumbing system, sewer system or private sewage disposal system, shall be connected to and shall drain or discharge into a grease interceptor of an approved design.

Sec. 710 — Minimum Requirements for Auto Wash Rack

Every private or public wash rack and/or floor or slab used for cleaning machinery or machine parts shall be adequately protected against storm or surface water and shall drain or discharge into a sand and grease interceptor of an approved design.

Sec. 711 — Grease Interceptors

(a) When, in the judgment of the Administrative Authority waste pretreatment is required an approved type grease interceptor complying with the provisions of this section shall be installed in the waste line leading from sinks, drains and other fixtures or equipment in the following establishments; restaurants, cafes, lunch counters, cafeterias, bars and clubs; hotel, hospital, sanitarium, factory or school kitchens, or other establishments where grease may be introduced into the drainage or sewerage system in quantities that can effect line stoppage or hinder sewage treatment or private sewage disposal. A grease interceptor is not required for individual dwelling units or for any private living quarters.

(b) Plans shall be submitted to and approval obtained from the Administrative Authority prior to the installation of any waste pretreatment facilities in any food establishment set forth in subsection (a) of this section.

(c) No grease interceptor shall be installed which has an approved rate of flow of more than fifty-five (55) gallons per minute, except when specially approved by the Administrative Authority, provided, however, that this prohibition shall not apply to any grease interceptor required by Section 708, 709 and 710 of this code.

(d) No grease interceptor shall be installed which has an approved rate of flow of less than twenty (20) gallons per minute. Each plumbing fixture or piece of equipment connected to a grease interceptor shall be provided with an approved type flow control or restricting device installed in a readily accessible and visible location in the tail piece or drain outlet of each such fixture. Flow control devices shall be so designed that the total flow through such device or devices shall at no time be greater than the rated capacity of the interceptor. No flow control device having adjustable or removable parts shall be approved.

(e) Each grease interceptor required by this section shall have an approved rate of flow which is not less than that given in Table 7-2 for the total number and size of fixtures connected thereto or discharging thereinto, and the total capacity in gallons of fixtures discharging into any such interceptor shall not exceed two and one-half (2½) times the certified g.p.m. flow rate of the subject interceptor as per Table 7-2.

It is further provided, however, that any grease interceptor installed or located in such a manner that the inlet thereto is more than four (4) feet lower in elevation than the outlet of any fixture discharging into such interceptor, shall have an approved rate of flow which is not less than fifty (50) per cent greater than that given in Table 7-2. Not to exceed four (4) separate fixtures shall be connected to or discharged into any one (1) grease interceptor.

For the purpose of this section, the term "fixture" shall mean and include each plumbing fixture, appliance, apparatus or other equipment required to be connected to or discharged into a grease interceptor by any provision of this section.

(f) Each grease interceptor shall be vented as required elsewhere in this code and each fixture discharging into a grease interceptor shall be individually trapped and vented in an approved manner, except that an approved type grease interceptor may be used as a fixture trap for a single fixture when the horizontal distance between the fixture outlet and the grease interceptor does not exceed four (4) feet and the vertical tail pipe or drain does not exceed two and one-half (2½) feet.

(g) Each grease interceptor shall be so installed and connected that it shall be at all times easily accessible for inspection, cleaning and removal of the intercepted grease.

(h) Interceptors shall be maintained in efficient operating condition by periodic removal of the accumulated grease. No such collected grease shall be introduced into any drainage piping, public or private sewer.

(i) Each grease interceptor shall be constructed of durable materials satisfactory to the Administrative Authority and shall have a full size gas tight cover which can be easily and readily removed.

(j) No water jacketed grease interceptor shall be approved or installed.

(k) Each grease interceptor shall have an approved water seal of not less than two (2) inches in depth or the diameter of its outlet, whichever is the greater.

(l) No grease interceptor required by this code shall be installed until the type or model of each size thereof has been subjected to, and has fully complied with tests acceptable to the Administrative Authority and has been subsequently approved by same; provided, however, that this provision need not apply to any interceptor required by Sections 709 or 710 of this code.

(m) The Administrative Authority may require such tests as may be necessary to determine the grease collecting efficiency of the various types and kinds of grease interceptors to establish the rate of flow or other rating thereof. Such test requirements may be revised or modified from time to time as may be deemed necessary by said Authority. A list of approved and acceptable interceptors shall be kept on file in the office of the Administrative Authority.

(n) No grease interceptor shall be hereafter installed which does not comply in all respects with a type or model of each size thereof approved and accepted by the Administrative Authority. Whenever it shall come to the attention of said Authority that any grease interceptor does not so comply, said Authority shall immediately suspend or revoke such approval.

TABLE 7-2 — Grease Interceptors

Total Number of Fixtures Connected	Maximum capacity of fixtures connected, Gallons	Required Rate of flow per minute, Gallons	Grease Retention Capacity, Pounds
1	50	20	40
2	65	25	50
3	90	35	70
4	125	50	100

Sec. 712 — Food Waste Disposal Prohibited

Unless specifically required or permitted by the Administrative Authority, no food waste disposal unit shall be connected to or discharge into any interceptor.

EXPLANATORY NOTES ON COMBINATION WASTE AND VENT SYSTEMS

(See Section 616 for specific limitations)

B1 Combination waste and vent systems, as outlined in Section 616 of the Installation Requirements of this code covers the horizontal wet venting of a series of traps by means of a common waste and vent pipe. Line sizes at least two (2) pipe sizes larger than those required for a conventional system are designed to maintain a wetted perimeter or flow line low enough in the waste pipe to allow adequate air movement in the upper portion, thus balancing the system. Sinks, lavatories and other fixtures that rough in above the floor, should not be permitted on a combination waste and vent system, which, at best, is merely an expedient designed to be used in locations where it would be structurally impractical to provide venting in the conventional manner.

Combination waste and vent systems are intended primarily for extensive floor or shower drain installations where separate venting is not practical, for floor sinks in markets, demonstration or work tables in school buildings, or for similar applications where the fixtures are not adjacent to walls or partitions. Due to its oversize characteristics, such a waste system is not self scouring and consequently care should be exercised as to the type of fixtures connected thereto, and to the location of clean-outs. In view of its grease producing potential, restaurant kitchen equipment should not be connected to a combination waste and vent system.

B2 Caution must be exercised to exclude appurtenances delivering large quantities or surges of water (such as pumps, sand interceptors, etc.) from combination waste and vent systems in order that adequate venting will be maintained. Small fixtures with a waste producing potential of less than seven and one-half (7½) gallons per minute may be safely assigned a loading value of one (1) unit. Long runs should be laid at the minimum permissible slope in order to keep tail pipes as short as possible. Tail pipes should not exceed two (2) feet in length which may necessitate slopes up to forty-five (45) degrees* on some branches.

B3 It is essential that the pneumatics of such a system be properly engineered as the air pressure within the line must at all times balance that of the outside atmosphere in order to prevent either trap seal loss or air locking between traps. Long mains should be provided with additional relief vents located at intervals of about one hundred (100) feet. Each such relief vent should equal approximately one-half (½) of the area of the wet vented drain served.

B4 Trap sizes are required to be equivalent to the branches they serve [two (2) pipe sizes larger than normal] and tail pipes between fixtures or floor drains and such traps should be reduced to normal size.

B5 Duplicate layout drawings of each such proposed piping system must be presented to the Department having jurisdiction, and approval obtained before any installation is made. Complicated layouts should be checked by qualified personnel.

B5.1 **Example of sizing:** A floor drain normally requires a two (2) inch trap and waste. On a combination waste and vent system both the trap and waste must be increased two (2) pipe sizes (through 2½" and 3") which would make the trap three (3) inch, (pipe sizes recognized for this purpose are 2", 2½", 3", 3½", 4", 4½", 5", 6", etc.). The tail piece between the floor drain and its trap should be two (2) inches (or normal size) to insure that the amount of waste water entering the trap only partially fills the waste branch. A three (3) inch floor drain would thus require a four (4) inch trap, a four (4) inch floor drain, a five (5) inch trap, etc., for the reasons previously stated.

Wet vented trailer park drainage systems are similar in principle to the foregoing. It is provided, however, that a three (3) inch trap serving a house trailer may have a three (3) inch tailpiece when the horizontal trap branch does not exceed six (6) feet in length, if three (3) inches in diameter; or fifteen (15) feet in length if four (4) inches in diameter. (See also Appendix E.)

WHEN IN DOUBT CHECK WITH YOUR LOCAL ADMINISTRATIVE AUTHORITY.

Battery Drainage System

A horizontal branch, soil or waste pipe, to which two (2) or more water closets (except blow-out type), pedestal urinals, shower stalls, or floor drains are connected in a battery, may be vented by a circuit or loop vent.

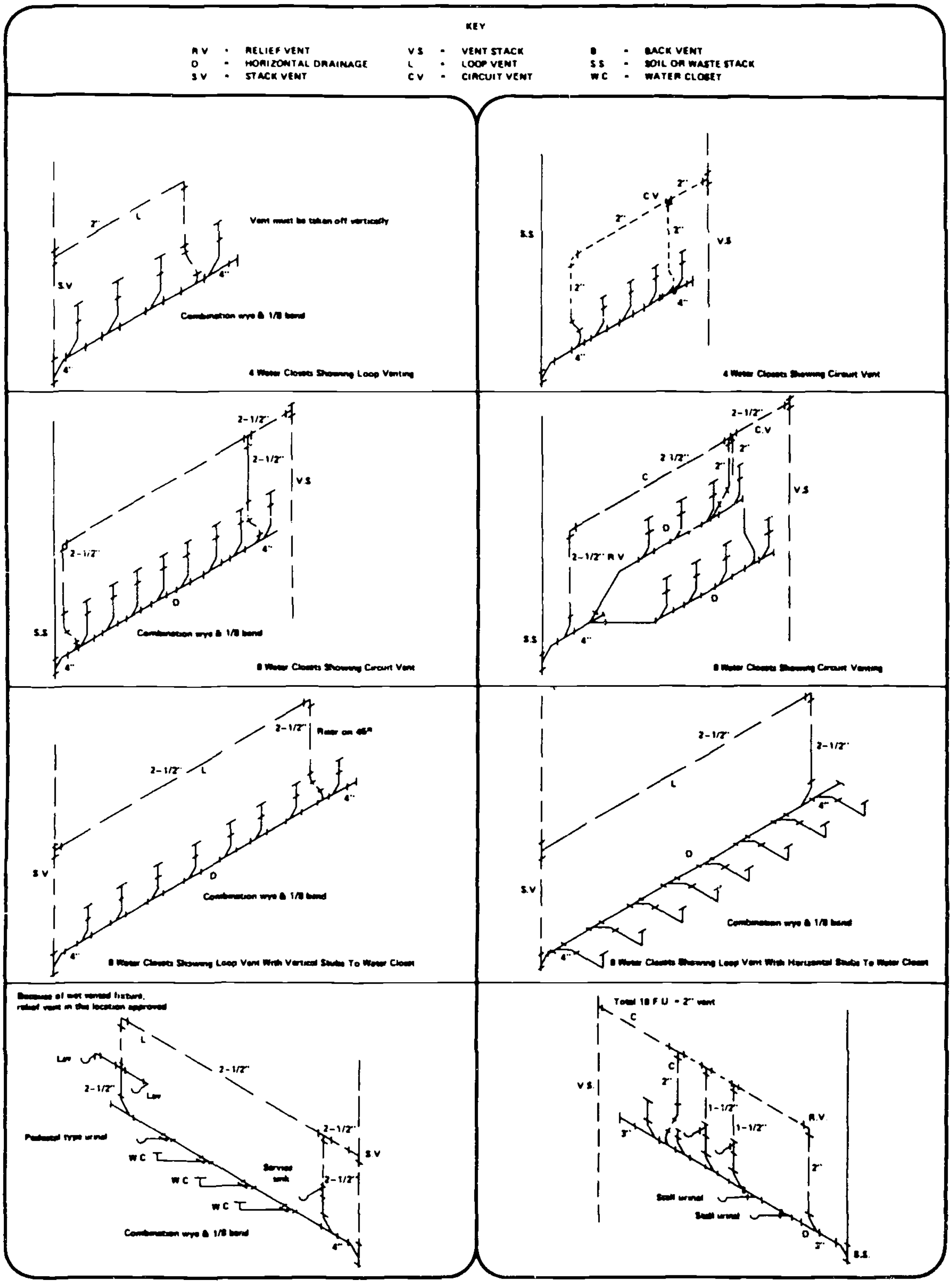
When lavatories or similar fixtures discharge above such branches, each vertical branch shall be provided with a continuous vent which may be connected to the circuit or loop vent of the battery.

The circuit or loop vent of a battery drainage system shall be installed vertically in front of the last upstream fixture. In addition, lower floor branches serving more than three (3) water closets shall be provided with a relief vent taken off vertically in front of the first fixture connection.

No more than eight (8) water closets may be connected to a battery drainage system. The fixture unit value for all fixtures shall be as listed in Table 4-1 and 4-2. The horizontal branch for its full length to the furthest fixture shall be uniformly sized as listed in Table 4-3, based on the total number of fixtures.

The vent of a battery drainage system shall be sized for the fixture unit demand of the battery system according to Table 4-3 based on the total number of fixtures. The relief vent may be wet vented with a fixture drained vertically into the battery drainage system, such vent shall be the same size as the circuit vent it intersects.

All vents shall rise vertically to six (6) inches above the flood level of the highest fixture on the system.


KEY
R V - RELIEF VENT
D - HORIZONTAL DRAINAGE
S V - STACK VENT
V S - VENT STACK
L - LOOP VENT
C V - CIRCUIT VENT
B - BACK VENT
S S - SOIL OR WASTE STACK
W C - WATER CLOSET
Vent must be taken off vertically
Combination wye & 1/8 bend
4 Water Closets Showing Loop Venting
4 Water Closets Showing Circuit Vent
8 Water Closets Showing Circuit Vent
8 Water Closets Showing Circuit Venting
Riser on 45°
8 Water Closets Showing Loop Vent With Vertical Stubs To Water Closet
8 Water Closets Showing Loop Vent With Horizontal Stubs To Water Closet
Because of wet vented fixture, relief vent in this location approved
Pedestal type urinal
Service sink
Total 18 F U = 2" vent
Stall urinal

UPC-73

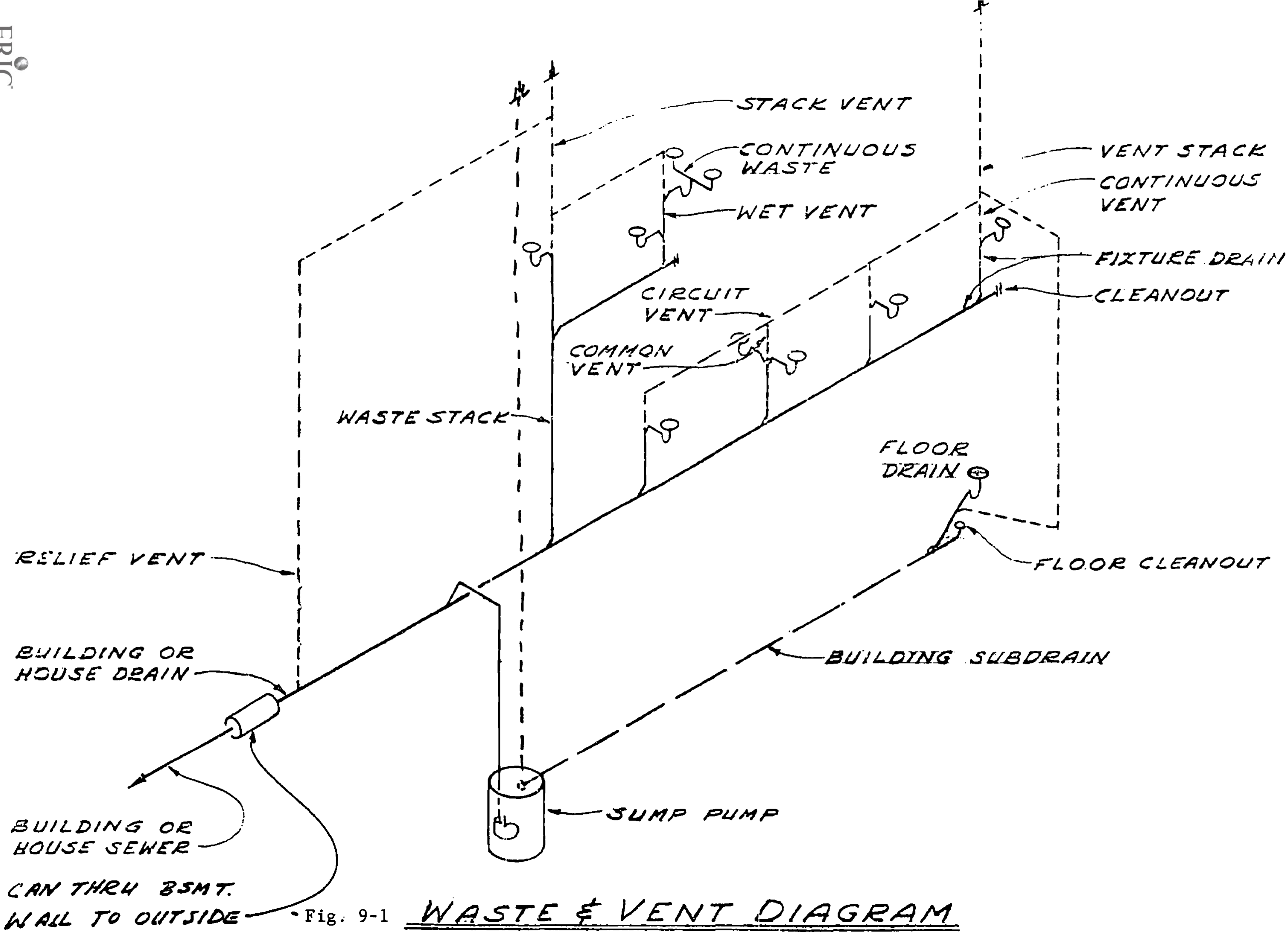
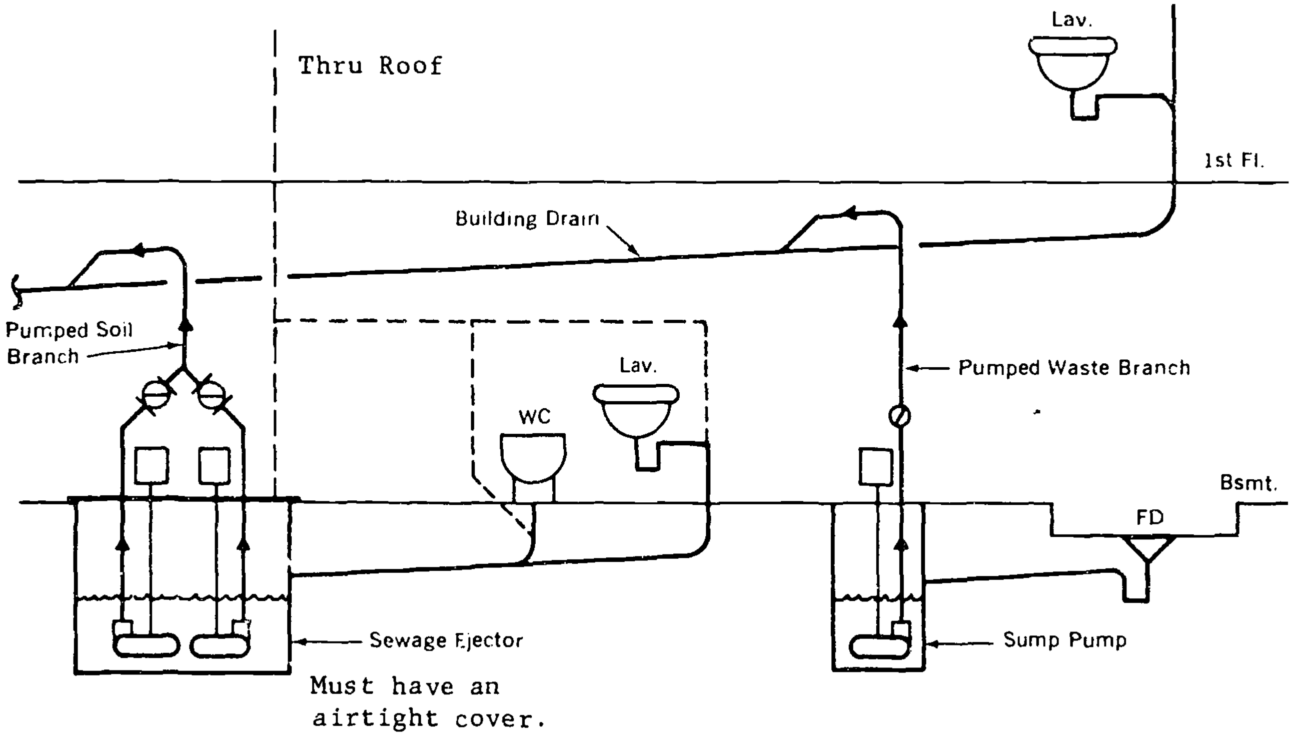
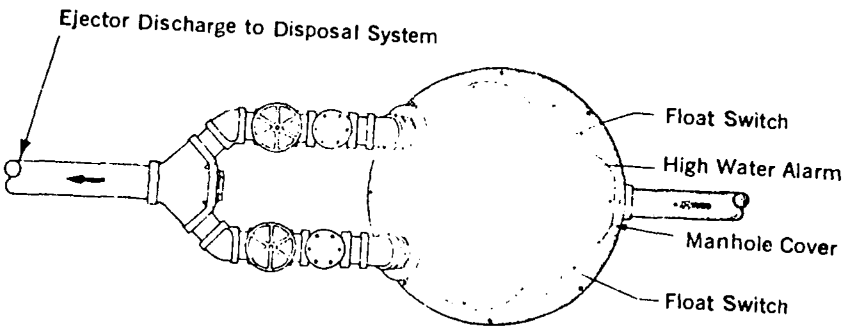


Fig. 9-1 WASTE & VENT DIAGRAM

NO SCALE (ALL REQ'D. PIPING NOT SHOWN)





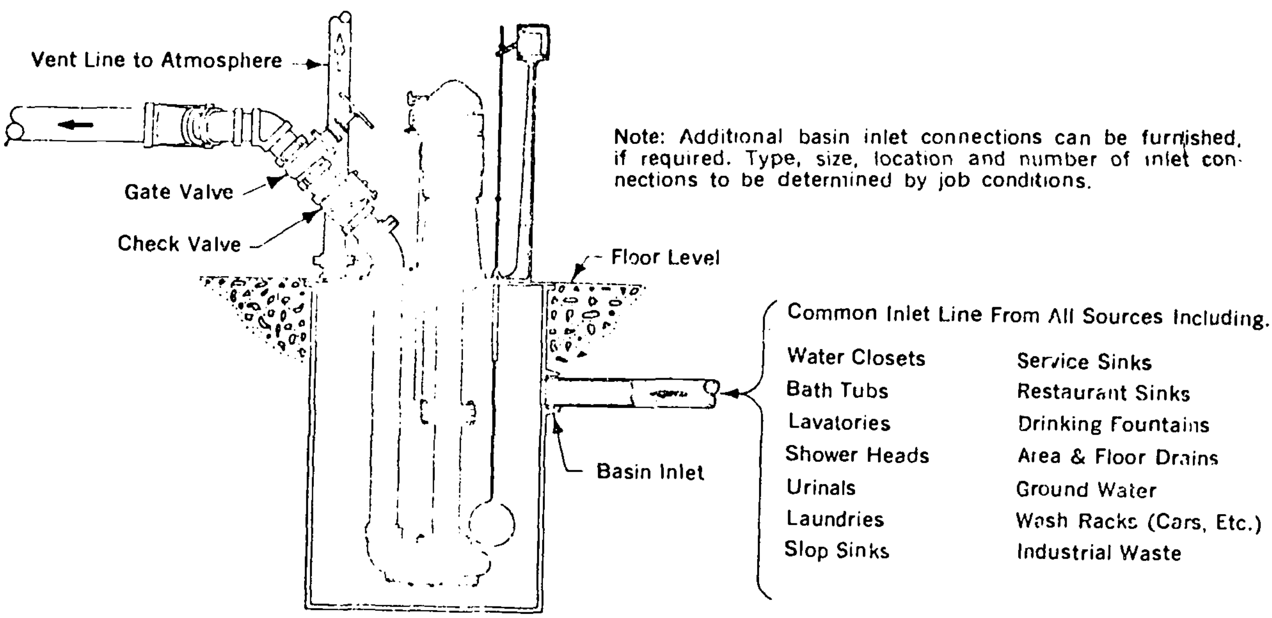
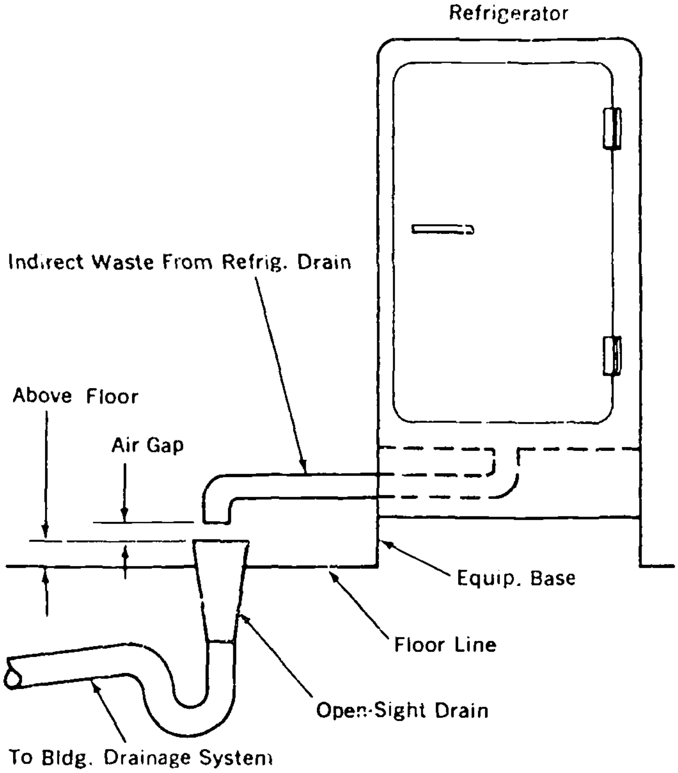
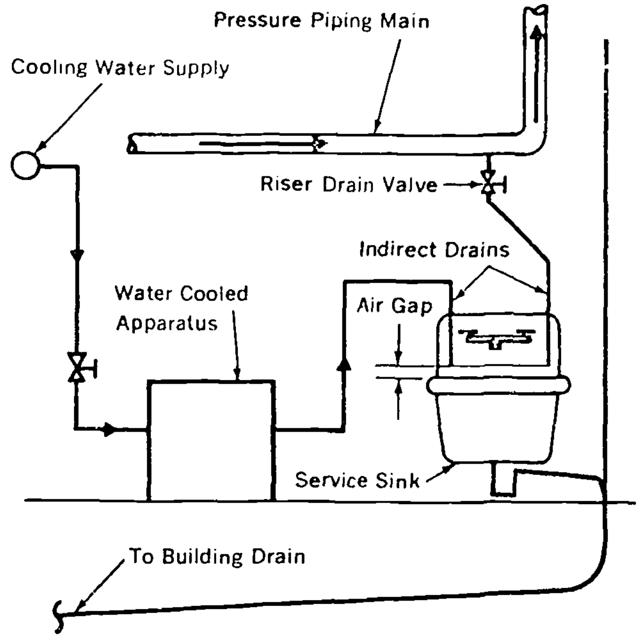


Fig. 9-2 Sewage Ejector Piping



Typical Indirect Waste



Pressure Piping Employing Indirect Drains
Check local codes for point of discharge.

Fig. 9-3 Indirect Drains

CHAPTER 10

WATER DISTRIBUTION SYSTEMS

This Chapter will discuss the piping systems within the building which convey the cold water from the water service to the fixture or the point of its use, and the hot water from its heater.

The Plumbing Inspector is concerned with this system particularly, as it can be a source of contamination if improperly installed; poor workmanship may lead to frequent shutdowns with consequent inconvenience or health hazards.

Where two systems of water supply are provided, one potable and the other not potable, or contaminated, special care must be taken to prevent the two from becoming mixed through the probability of a cross-connection. Laboratories usually have two or three types of water being piped to point of use. Where water is scarce potable and non-potable water will both be provided.

If the pressure in the incoming water supply to the building is not adequate to furnish the required pressure at the highest fixture, then usually pumps are required to increase the pressure to the upper floors of a multi-story building. This is discussed more fully later in this chapter.

Water supply systems that are properly installed and designed will supply an adequate amount of water at the proper pressures to each point of use, and is quiet in operation, without water hammer, or rushing and rattling sounds.

The first consideration for the Plumber is to organize his work, the same as in other parts of the plumbing systems. The Plumbing Inspector should insist that the Plumber be aware of the locations of electrical conduit, fire sprinkler system or other building components which may interfere with the proper installation of his work. The layout of the work on the project in cooperation with other crafts is important so that good relations can be maintained and the ultimate goal of a well planned and successful plumbing system is reached.

The plans and specifications provided for the project may have taken months or even years to prepare; during this time many changes will have been made and many compromises will have been incorporated, either because of economic considerations or functional reasons. Several engineers and draftsmen will have worked on the project and experienced engineers will have checked each detail. The information needed by the Plumber is shown on the plans or defined in the specifications. This will include the kinds of pipe and fittings to be used and their sizes; locations of each pipe, fixture, and piece of equipment; kinds of supports and limitations for their use. The set of plans and specifications will also include the separate sections for the structural, architectural, electrical, fire sprinkler, and any other units which are to be incorporated in the finished building.

Coordination of the plumbing systems with the other elements is the responsibility of each craft if the project is to be successfully completed. A single thin line on the 1/4 inch scale drawing may graphically represent an 8 inch water pipe. The Plumber and the Inspector must be certain that the pipe will fit into the space designated for it. The Plumber is not too concerned with the design of the systems on larger projects, but he is vitally concerned with the layouts.

After, or even before the Plumber has set up the physical location for the storage of his materials and tools, he will be busy acquainting himself with the plans and making sketches for his own use.

On larger jobs, particularly reinforced concrete construction, a "canning" or sleeving plan must be prepared showing the exact position of each opening through the deck or wall for each floor. These must then be set in place before the concrete is poured. The same is true for hangers or inserts required to support the pipes. If this work is not carefully done, it may require that extra expense be incurred to remedy the defect later. This subject is treated more in detail in Chapter 5, Hangers, Supports and Anchors.

The Plumbing Inspector may frequently be consulted during the layout phase because of possible conflicts among the crafts regarding priority for the piping in the allocated spaces. Water piping should be installed so that the entire system can be drained. We speak of the system piping as running horizontally when actually there should be a slope to the low points to facilitate drainage; a valve is provided at this point. Frequently, on small jobs where freezing is not a problem, the slope for drainage is omitted. It is still good practice, however, to consider maintenance and drainage. Pipes should be run parallel to, or at right angles to the building for appearance; bends and dips should be avoided in order not to have air pockets and sediment traps. The piping should be well supported and not rest on other piping or ductwork. Allowance should be provided between the pipe and its support for movement. All buildings are subject to some movement, due to expansion and contraction, settlement or even wind pressure in some areas. Where noise may be transmitted through the supports it may be necessary to provide a dampening material such as felt or a rubber grommet between the pipe and the supports. Pipes should not be encased in concrete nor plaster. Raceways should be provided.

The Plumbing Inspector must be alert to those things which can cause trouble for the Owner in the future. It is not his responsibility to check all design areas and calculations, but he should have a general knowledge of the adequacy of various parts of the plumbing system.

Pipes can fail because of defective material at the time of manufacture; unrelieved stresses during installation; poorly made up joints and connections; building or floor movements due to any reason; freezing in the colder climates and destructive pressures due to water hammer.

If a leak occurs in a pipe for any reason, it can cause severe damage to the building and its contents; if it occurs above a ceiling or in the wall, it may ruin the plaster, or if it occurs when the building is unoccupied the results can be disastrous. The economic loss resulting from the water wasted to the sewer or ground where the leak is undetected can be considerable, based on the cost for water. The value of shutoff valves strategically located becomes apparent when it is necessary to isolate a portion of the piping.

The problem of noise due either to water flowing through the pipes at a high velocity, water hammer, cavitation, or transmitted noise from pumps, flushing of fixtures, or vibration, are all annoying and may even lead to leaky or broken pipes.

The location of the source of the noise is often troublesome. Sound travels rapidly through the pipes, or building frame and may be annoying many feet away from where it is generated.

When the noise is generated by valves or equipment which emit a hissing sound the remedy is usually found in replacing the valve or equipment; a loose washer is often the culprit in small faucets. The slow closing of regulating valves produces a piercing sound that travels a great distance.

Water hammer produces a banging noise; it is usually caused when valves or faucets are suddenly closed, either automatically, as a solenoid valve or manually, where the valves are of the quick closing type. Since water is practically incompressible, the abrupt stopping sets up a shock which travels back and forth along the pipe until it is finally damped out. The force is sufficiently great so that it may loosen pipe joints or even burst the pipe, as it vibrates along the walls of the pipe.

Water hammer can be controlled or prevented by the installation of an air chamber or shock absorber near the valve that is causing the water hammer. It should be installed vertically, so that entrapped air will rise to that point. The intensity of the pressure varies directly with the velocity of flow in the pipe. For this reason the installation of a pressure reducing valve on the supply will control the velocity and the intensity of pressure. The use of large sized pipes will also control the intensity of the "hammer."

When the air chamber becomes water logged it is necessary to drain the water out and recharge it, usually by opening petcocks at the bottom and top of the chamber. A shutoff valve must be provided so that the water supply cannot reach the air chamber during the recharging period. To be effective, an air chamber must be of adequate size, usually not less than 18 inches; where a bank of toilets or urinals are installed a 2 or 3 inch diameter water supply header is provided with a full size air chamber 2 to 3 feet long is frequently installed; most large installations are provided with shock absorbers which are rated by the manufacturer.

The turbulence and rushing sounds often heard in a water system are usually due to high velocities or abrupt changes in direction; lower velocities in the pipe lines and smoother fittings will usually remedy the problem.

Freezing of water in pipes is a problem in cold climates, where the piping is exposed to temperatures below 32° F. for a period of time. It takes time for the surrounding air to remove heat from the water and pipe. A cold snap of short duration may not freeze, but a longer period with a milder temperature will cause freezing.

Water expands on freezing about 8% of its volume, and it is this increase which causes the pipe to burst. If the water is not confined, the excess pressure due to freezing will push the ice along and damage to the pipe may not occur until an obstruction such as a valve or fitting stops it.

Where freezing conditions are known to exist, the pipes should be located in inside partitions, or temperatures above 32° F. should be maintained when the building is unoccupied; if this cannot be done, the pipes should be drained. Insulation of pipes in unheated spaces and where exposed in attics should also be done as a precaution, even if freezing is an infrequent occurrence.

When pipes become frozen they can be thawed if made accessible by heating the pipe by electrical means, open flame, or by pouring hot water on the pipe. If an electrical means is used it should be done by an experienced person, or it can be extremely dangerous. There are electric heat cables on the market which are reasonably safe to use on small jobs. A method used on longer lengths of frozen pipe involves the use of an electric welding machine where a terminal is connected to the pipe on each side of the frozen portion. Freezing often occurs during the construction phase when the building is unheated and open to chilly winds. Since ice will move along the pipe until it is stopped by a valve or fitting, the thawing must be done where the ice is located and not at the exposed point where freezing took place.

If a fitting or pipe is damaged by the freeze, then replacement becomes necessary; it is better to anticipate such trouble and prevent it or at least recognize the risk involved.

Materials for the water systems in a building are determined by the design engineer and shown on the plans or specified. The selection is generally based on local code requirements, the use, and the amount of money available. An expensive building will have higher quality materials than a temporary structure. The economics is usually the Owner's decision in cooperation with his advisors. Usually the water supply will be copper tubing, either type K or L, with copper or brass fittings and soldered joints, or schedule 40 galvanized pipe with galvanized screw fittings. Shutoff valves, where no regulation is required are gate valves. In places where the flow is to be controlled globe valves or balance cocks are specified. A check valve is used where the water is permitted to flow in only one direction. If the pressure is to be reduced, then a pressure reducing valve is used. Valves which are automatically controlled generally are equipped with globe type bodies. Materials are more fully discussed in Chapter 4, Pipe, Fittings and Valves.

Cross Connections: The Plumbing Inspector must be alert to the existence of a connection which can be the potential source of contamination of the drinking water, or that water fit for human consumption. A definition is formalized in the back of the book under DEFINITIONS. If contamination occurs typhoid fever, dysentery, or even cholera are diseases which can be transmitted in this manner. The first evidence of contamination is illness. The cross connection may be direct, if an actual connection is made, or it may be indirect if there is a gap or space across which polluted water can be blown, sucked, or otherwise gets into the drinking water supply.

The most common source is due to back siphonage; when the pressure in the water system falls below atmospheric pressure of 14.7 psi at sea level, then a partial vacuum occurs and air or liquid can be forced into the system through any open water outlet. This could occur, for instance, if a hose were left dangling in a service sink while connected to an open faucet. If the water pressure should drop below 14.7 psi (sea level) and the end of the hose were submerged, then atmospheric pressure on the contaminated water could force this water into the supply pipe; the extent of it would depend on the pressure, or lack of it, in the supply lines. This could occur, for instance, if the building supply is shut off, and a faucet is opened on a lower floor which would create the negative pressure (less than atmospheric). Water would then be siphoned or pushed into the pipe.

Back flow is caused by a direct connection to a contaminated source which is at a higher line pressure than the potable supply. The polluted supply is forced into the main against the lesser pressure.

Sometimes a mechanical break in the piping will allow contamination to take place by gravity flow. This is particularly true when underground services are being repaired or installed and a leaky sewer line or septic leaching field is nearby.

Since the plumbing codes are concerned with health and safety all require preventive devices or installation practices which will preclude the possibility of a cross connection. Proper maintenance and repair of systems after installation is also necessary. Public Health Inspectors are always on the alert for violations when inspecting markets, restaurants, hospitals, or any areas of this type.

Preventive devices may consist of an air gap, as a faucet above the overflow rim of a fixture, or a fitting which has openings on the side that constitute an air gap; atmospheric vacuum breakers are used at fixtures to break the vacuum; such a unit might be installed at the faucet to which a hose is connected for washing garbage cans. Flushometer valves are also equipped with vacuum breakers. A vacuum breaker of the pressure type will withstand normal operating pressures of the water system; such a type might be installed on a water cooler. It must be installed above the rim of the fixture.

Where there is a possibility of backflow under pressure twin check valves are often used; a connection between a fire line and the domestic supply might be connected in this manner. Usually the fire line or any such connection will not lead to contamination. Other such devices are available; some are quite sophisticated in construction and expensive. The safeguards used are determined by the types of systems being installed. Laboratories, for instance, may have contaminants that require special treatment to guard the health of the employees.

<u>Pressure Systems</u>: The pressure head loss is 4.3 psi for each 10 foot elevation of the building. Tall buildings must be equipped with a means of increasing the pressure in the lines to reach the highest point and still have adequate pressure required for the fixtures. The pressure in the incoming main is normally 45 to 60 psi, so pressure pumps are used to boost this pressure the required amount. This is a preferred method to elevated storage tanks and does not require the extra weight of the tank and water on the roof. This has been made possible by the improvement in the design of multiple stage and variable speed pumps. A multiple pump system can be designed to accommodate a maximum flow required at peak hours, to weekend use when only an occasional fixture is used. The

smaller pump in the system, or "jockey" pump runs at minimum flows. Pressure sensitive switches activate the pumps in a predetermined manner as the pressure drops in the mains. As the demand becomes too great for one pump additional pumps are activated. In 20 or 30 story buildings pump stations may be located on 2 or 3 upper floors, depending on the design characteristics of the building plumbing system. Frequently, pressure reducing valves are installed on both the hot and cold water lines on upper floors to reduce the pressure from 80 to 90 psi or higher to 30 to 40 psi for use at the fixtures.

A recent development is the variable speed pump which pumps more water within desired pressure limits as the demand increases. Pressure sensitive switches are programmed to increase the motor speed and consequent horsepower as required. Multiple use of these pumps can also be made.

Some design engineers still specify the hydropneumatic tank as a means of providing adequate pressure. Usually dual pumps are used, but the pumps operate less frequently because the air cushion in the tank smooths out the pressure available. It has the added advantage of storage, the amount depending on the building area and water demand. In larger buildings it may have a cubic capacity of 3000 to 5000 gallons, half to two-thirds filled with water and a cushion of air on top of the water. The fire line may also be connected to the tank and thus an emergency supply of water is available in case the water source is cut off.

The pumps introduce water into the tank under pressure; this compresses the air in the tank, thus increasing the pressure on the water in the tank. Since the water will absorb air to a certain extent, depending on the pressure, a small air compressor is provided to replenish the air in the tank. Usually the air occupies about 1/3 of the volume of the tank at the maximum water pressure desired. The tank should be equipped with a pressure relief valve to avoid excessive pressure in the event of a malfunction of the controls. A guage glass provides a visual check of the amounts of air and water in the tank. The pumps and the air compressor are controlled by pressure sensitive devices which actuate the motor controls.

Hot Water Supply: The information given regarding the cold water distribution system and materials is also applicable to the hot water system. The hot water system should provide an adequate supply at the temperature desired for the particular fixture or piece of equipment. The temperature requirements can vary greatly, from an average of 120° F. to 130° F. for ordinary purposes to 180° F. for the rinse cycle on a dishwasher.

Small buildings generally are supplied by a non-continuous system where the distance from the source to the fixture is short and the temperature is not critical. Large buildings generally require continuous circulation where a small pump in the return line at the heater will keep the water in motion in the pipe. Gravity circulation is also used occasionally where it is possible to have the return or returns drop from a higher elevation to the heater. Air relief valves must be provided at the high points of the gravity system.

It is important that the pressures in the cold water and hot water lines be approximately equal at each faucet. In order to accomplish this, the pipe sizing may be different. A sudden demand for cold water, as at a urinal, may cause the cold water pressure to drop and allow hot water into the cold water pipes, unless a check valve is provided in the hot water line.

Buildings which do not require a large amount of hot water generally are supplied by the electric storage water heater, or the gas fired storage water heater. Both are equally effective in heating water to a desired temperature, storing it, and automatically controlling the energy source when the water reaches the desired temperature. The water can be circulated through the piping system, either by gravity, or forced, with either heater. Since the gas-fired heater requires a vent, its location is more restricted.

Local plumbing codes require safety devices to protect against explosion of the heater or rupture of the water lines. This may be severe enough to cause loss of life, or at least severe property damage. The safety devices are necessary because water expands when heated. If the system is closed, which most are, the pressure increases. A pressure relief, or a combination pressure and temperature relief must be placed on the heater so that it is affected by the top 12% of the tank water supply, with the element in the tank. No check valve nor shutoff valve shall be installed between the heater and the safety device. The discharge from the relief must be connected to a pipe which runs to an indirect waste.

Heaters which are used in commercial application may need to meet special job temperatures or volumes of water. They generally are of heavier construction, have higher heat inputs and have larger tank sizes or auxiliary storage capacity. All heaters must meet safety standards set up by regulatory agencies. Most codes designate the standards which must be met or the emblems must be clearly visible on the appliance. Gas-fired water heaters bear the American Gas Association (AGA) emblem, and electric water heaters have the Underwriters Laboratories (UL) seal of approval. The American Society of Mechanical Engineers (ASME) provide inspection service for all sizes of pressure vessels used for water storage.

WATER DISTRIBUTION

Section 1001 — Running Water Required

Except where not deemed necessary for safety or sanitation by the Administrative Authority, each plumbing fixture shall be provided with an adequate supply of potable running water piped thereto in an approved manner, so arranged as to flush and keep it in a clean and sanitary condition without danger of backflow or cross-connection. Water closets and urinals shall be flushed by means of an approved tank or flushometer valve.

Sec. 1002 — Unlawful Connections

(a) No installation of potable water supply piping or part thereof shall be made in such a manner that it will be possible for used, unclean, polluted or contaminated water, mixtures or substances to enter any portion of such piping from any tank, receptacle, equipment or plumbing fixture by reason of back siphonage, by suction or any other cause, either during normal use and operation thereof or when any such tank, receptacle, equipment or plumbing fixture is flooded, or subject to pressure in excess of the operating pressure in the hot or cold water piping.

(b) No person shall make a connection or allow one to exist between pipes or conduits carrying domestic water supplied by any public or private water service system, and any pipes, conduits or fixtures containing or carrying water from any other source or containing or carrying water which has been used for any purpose whatsoever, or any piping carrying chemicals, liquids, gases, or any substances whatsoever, unless there is provided an approved backflow prevention device.

(c) No plumbing fixture, device or construction shall be installed or maintained or shall be connected to any domestic water supply, when such installation or connection may provide a possibility of polluting such water supply or may provide a cross-connection between a distributing system of water for drinking and domestic purposes and water which may become contaminated by such plumbing fixture device or construction unless there is provided an approved backflow prevention device.

(d) No water piping supplied by any private water supply system shall be connected to any other source of supply without the approval of the Administrative Authority, Health Department or other department having jurisdiction.

Sec. 1003 — Cross-Connection Control

No person shall install any water operated equipment or mechanism, or use any water treating chemical or substance, if it is found that such equipment, mechanism, chemical or substance may cause pollution of the domestic water supply. Such equipment or mechanism may be permitted only when equipped with an approved backflow prevention device.

Approval of Devices — Before any device is installed for the prevention of backflow or back siphonage, it shall have first been approved by the Administrative Authority. Devices shall be tested in conformity with recognized standards or other standards acceptable to the Administrative Authority which are consistent with the intent of this code.

All devices installed in a potable water supply system for protection against backflow shall be maintained in good working condition by the person or persons having control of such devices. The Administrative Authority or other department having jurisdiction may inspect such devices and, if found to be defective or inoperative, shall require the repair or replacement thereof. No device shall be removed from use or relocated or other device substituted, without the approval of the Administrative Authority.

(a) **Water Closet Flushometer Valves** shall be equipped with an approved vacuum breaker. Each such device shall be installed on the discharge side of the flushometer valve with the critical level at least six (6) inches above the overflow rim of the bowl.

(b) **Water Closet and Urinal Tanks** shall be equipped with an approved ball-cock. The ball-cock shall be installed with the critical level at least one (1) inch above the full opening of the overflow pipe. In cases where the ball-cock has no hush tube, the bottom of the water supply inlet shall be installed one (1) inch above the full opening of the overflow pipe. Water closets having any portion of the tank below the flood level rim of the closet bowl shall have the ball-cock installed in a separate and isolated compartment of the tank, or other approved protection acceptable by the Department.

(c) **Urinal Flushometer Valves.** Urinals when served by a flushometer valve shall be equipped with an approved vacuum breaker installed on the discharge side of the flushometer. The critical level shall be not less than six (6) inches above the highest part of the fixture.

(d) **Over Rim Supplies to Plumbing Fixtures** shall be at least one (1) inch above the flood level rim of the fixture.

(e) **Direct Connections Between Potable Water Piping and Sewer Connected Wastes** shall not exist under any condition with or without backflow protection. Where potable water is discharged to the drainage system it shall be by means of an approved air gap of two (2) pipe diameters of the supply inlet, but in no case shall the gap be less than one (1) inch. Connection may be made to the inlet side of a fixture trap provided that an approved vacuum breaker is installed not less than six (6) inches above the flood level rim of such trapped fixture, so that at no time will any such device be subjected to any back pressure.

(f) **No Potable Water Piping** shall be installed or maintained within any piping or device conveying sewage, wastes or other materials hazardous to health and safety.

(g) **Inlets to Tanks, Vats, Sumps and other Receptors** when protected by an approved vacuum breaker shall have such device installed on the discharge side of the last valve with the critical level not less than six (6) inches above the overflow rim of such equipment. Water supply inlets not protected by vacuum breakers shall be installed not less than two (2) pipe diameters, but in no case less than one (1) inch above the overflow rim of such tank, vat, or similar equipment.

(h) **Lawn Sprinkling Systems** shall be equipped with an approved vacuum breaker installed on the discharge side of each of the last valves. The vacuum breaker shall be installed at least six (6) inches above the surrounding ground and above a sufficient number of heads so at no time will the vacuum breaker be subjected to back pressure or drainage.

(i) **Fixture Inlets or Valved Outlets With Hose Attachments** which may constitute a cross-connection shall be protected by an approved backflow prevention device or by an approved vacuum breaker installed at least six (6) inches above the highest point of usage and located on the discharge side of the last valve. Fixtures with integral vacuum breakers manufactured as a unit may be installed in accordance with their approval requirements.

(j) **Medical, Therapeutic, Surgical, Mortuary or similar equipment** shall have all water outlets protected by approved vacuum breakers on the discharge side of the last valves and installed not less than five and one-half (5½) feet above the floor, and at no time less than thirty-six (36) inches above any fixture or equipment served, unless such vacuum breaker is an integral part of the fixture or equipment having an approval as a unit, and provided the "unit" vacuum breaker will not be subjected to back pressures under any condition.

(k) **Water Cooled Compressors, Degreasers or any other Water Cooled Equipment** shall be protected by an approved vacuum breaker installed ahead of the equipment on the discharge side of the last valve and at least six (6) inches above the highest point reached by any water passing through or discharging from such equipment.

Equipment subject to continuous flows for periods of more than twelve (12) hours shall be provided with an approved "pressure type" vacuum breaker installed at least twelve (12) inches above the highest point reached by any water passing through or discharging from such equipment.

Exception: When in the opinion of the Administrative Authority no hazard to the potable water supply system is evident, special approval may be obtained to omit the vacuum breakers.

(l) **Aspirators** shall not be directly connected to a sewer connected waste pipe, but may be connected to the inlet side of a trap and shall be equipped with an approved vacuum breaker installed at least six (6) inches above the aspirator unit. The discharge pipe from the aspirator unit shall be designed for free flow and shall discharge through an approved air gap. The length of such discharge pipe or tube from the aspirator shall at no time exceed twelve (12) inches.

(m) **Vacuum Breakers for Hot Water Over 160°** shall be of approved type designed to operate at temperatures of one hundred sixty (160) degrees F or more without rendering any portion of the device inoperative.

(n) **Steam and Steam Boiler Connections** shall be protected by an approved backflow prevention device as set forth in subsection (o) of this section.

(o) **Non-potable Water Piping.** In cases where it is impractical to correct individual cross-conections on the domestic water line, the line supplying such outlets shall be considered a non-potable water line. No drinking or domestic water outlets shall be connected to the non-potable water line. Backflow or back-siphonage from the non-potable water line into the domestic water line shall be prevented by the installation of a gravity tank or by a tank having a pump for desired non-potable water. The domestic water inlets to the non-potable water tank shall have an approved air gap as required elsewhere in this chapter. Where it is impractical to install tanks, as set forth above, an approved pressure type backflow or back-siphonage prevention device shall be installed as follows:

Where reverse flow due only to gravity or a vacuum within the line can occur, an approved pressure type vacuum breaker unit or other approved backflow prevention device shall be installed in the supply line.

Each pressure type vacuum breaker unit shall be installed at a height of at least twelve (12) inches above the highest tank, equipment or point of usage of the non-potable water. Other approved backflow prevention devices shall be installed in a manner satisfactory to the Administrative Authority, but in no case less than twelve (12) inches above the surrounding ground or floor.

Where backflow can occur due to steam boilers, pumps, etc., creating a higher pressure in the non-potable water line, an approved backflow prevention device shall be installed in the supply line. Such backflow prevention device shall be installed at least twelve (12) inches above the surrounding ground or floor.

Whenever possible, all portions of the non-potable water line shall be exposed and all exposed portions shall be properly identified in a manner satisfactory to the Administrative Authority. Each outlet on the non-potable water line which may be used for drinking or domestic purposes shall be posted: DANGER — UNSAFE WATER.

(p) Vacuum breakers shall be located outside any enclosure or hooded area containing fumes that are toxic or poisonous.

Sec. 1004 — Materials

(a) Water pipe and fittings shall be of brass, copper, cast iron, galvanized malleable iron, galvanized wrought iron; galvanized steel, lead or other approved materials. Asbestos-cement, PE, or PVC water pipe manufactured to recognized standards may be used for cold water distribution systems outside a building. All materials used in the water supply system, except valves and similar devices shall be of a like material, except where otherwise approved by the Administrative Authority.

(b) Cast iron fittings up to and including two (2) inches in size, when used in connection with potable water piping shall be galvanized.

(c) All malleable iron water fittings shall be galvanized.

(d) Piping and tubing which has previously been used for any purpose other than for potable water systems shall not be used.

Sec. 1005 — Valves

(a) Valves up to and including two (2) inches in size shall be brass or other approved material. Sizes over two (2) inches may have cast iron or brass bodies. Each gate valve shall be a fullway type with working parts of non-corrosive material.

(b) A fullway gate valve controlling all outlets shall be installed on the discharge side of each water meter and on each unmetered water supply. Water piping supplying more than one building on any one premises shall be equipped with a separate fullway gate valve to each building, so arranged that the water supply can be turned on or off to any individual or separate building; provided however, that supply piping to a single family residence and building accessory thereto, may be controlled by one valve. Such shutoff valves shall be readily accessible at all times. A fullway valve shall be installed on the discharge piping from water supply tanks at or near the tank. A fullway valve shall be installed on the cold water supply pipe to each water heater at or near the water heater.

A fullway gate valve shall be installed for each apartment or dwelling of more than one (1) family. In lieu of the main supply shut-off in each apartment individual shut-off valves may be provided at each fixture.

(c) All valves used to control two (2) or more openings shall be fullway gate valves or other approved valves designed and approved for the service intended.

(d) A control valve shall be installed immediately ahead of each water supplied appliance and immediately ahead of each slip joint or non-metallic fixture supply or appliance supply.

(e) All required shutoff or control valves shall be readily accessible.

(f) A single control valve shall be installed on a water supply line ahead of any automatic metering valve which supplies a battery of fixtures.

Sec. 1006 — Gravity Supply Tanks

Gravity tanks for potable water shall be tightly covered, and have not less than a sixteen (16) square inch overflow screened with copper screen having not less than fourteen (14) nor more than eighteen (18) openings per linear inch.

Sec. 1007 — Water Pressure, Pressure Regulators and Pressure Relief Valves

(a) **Inadequate Water Pressure.** Whenever the water pressure in the main or other source of supply will not provide a water pressure of at least fifteen (15) pounds per square inch, after allowing for friction and other pressure losses, a tank and pump or other means which will provide said fifteen (15) pound pressure shall be installed.

(b) **Excessive Water Pressure** — Where local water pressure is in excess of eighty (80) pounds per square inch, an approved type pressure regulator preceded by an adequate strainer shall be installed and the pressure reduced to eighty (80) pounds per square inch or less. For potable water services up to and including 1½" regulators, provision shall be made to prevent pressure on the building side of the regulator from exceeding main supply pressure. Approved regulators with integral by-passes are acceptable. Each such regulator and strainer shall be accessibly located and shall have the strainer readily accessible for cleaning without removing the regulator or strainer body or disconnecting the supply piping. All pipe size determinations shall be based on eighty (80) per cent of the reduced pressure.

(c) On any water system provided with a pressure regulating device or check valve at its source or any water system containing water heating equipment shall be provided with an approved, listed, adequately sized pressure relief valve.

(d) Each pressure relief valve shall be an approved automatic type with drain, and each such relief valve shall be set at a pressure of not more than one hundred fifty (150) pounds per square inch.

(e) Relief valves located inside a building shall be provided with a full size drain of galvanized steel or hard drawn copper piping and fittings and shall extend from the valve to the outside of the building with the end of the pipe not more than two (2) feet nor less than six (6) inches above the ground and pointing downward. Such drain may terminate at other approved locations. No part of such drain pipe shall be trapped and the terminal end of the drain pipe shall not be threaded.

(f) Any water heating device connected to a separate storage tank and having valves between said heater and tank shall be provided with an approved water pressure relief valve.

(g) Nothing contained herein shall prevent the use of an approved combination temperature and pressure relief valve. Each such approved combination temperature and pressure relief valve shall be installed on the water heating device in an approved location based on its listing requirements and the manufacturer's instructions. Each such combination temperature and pressure relief valve shall be provided with a drain as required in Subsection (e) of this section.

Sec. 1008 — Installation, Inspection and Testing

(a) **Installation.** All water piping shall be adequately supported to the satisfaction of the Administrative Authority. Burred ends shall be reamed to the full bore of the pipe. Changes in direction shall be made by the appropriate use of fittings, except that changes in direction in copper tubing may be made with bends having a radius of not less than six (6) diameters of the tubing, providing that such bends are made by the use of forming equipment which does not deform or create a loss in cross sectional area of the tubing. Approved provisions shall be made for expansion in hot water piping. All piping, equipment, appurtenances and devices shall be installed in a workmanlike manner in conformity with the provisions and intent of the code.

(b) Water service pipes or any underground water pipes, shall not be run or laid in the same trench with non-metallic building sewer or drainage piping, except as provided in this section.

The water service pipe may be placed in the same trench with such building drain and building sewer provided both of the following conditions are met:

(1) The bottom of the water service pipe, at all points, shall be at least twelve (12) inches above the top of the sewer line.

(2) The water service pipe shall be placed on a solid shelf excavated at one side of the common trench.

(c) Water piping installed within a building and in or under a concrete floor slab resting on the ground shall be installed in accordance with the following requirements:

(1) Ferrous piping shall have a protective coating of an approved type, machine applied and conforming to recognized standards. Field wrapping shall provide equivalent protection and is restricted to those short sections and fittings necessarily stripped for threading. Zinc coating (galvanizing) shall not be deemed adequate protection for piping or fittings. Approved non-ferrous piping need not be wrapped.

(2) Copper tubing shall be installed without joints where possible. Where joints are permitted, they shall be brazed and fittings shall be wrought copper.

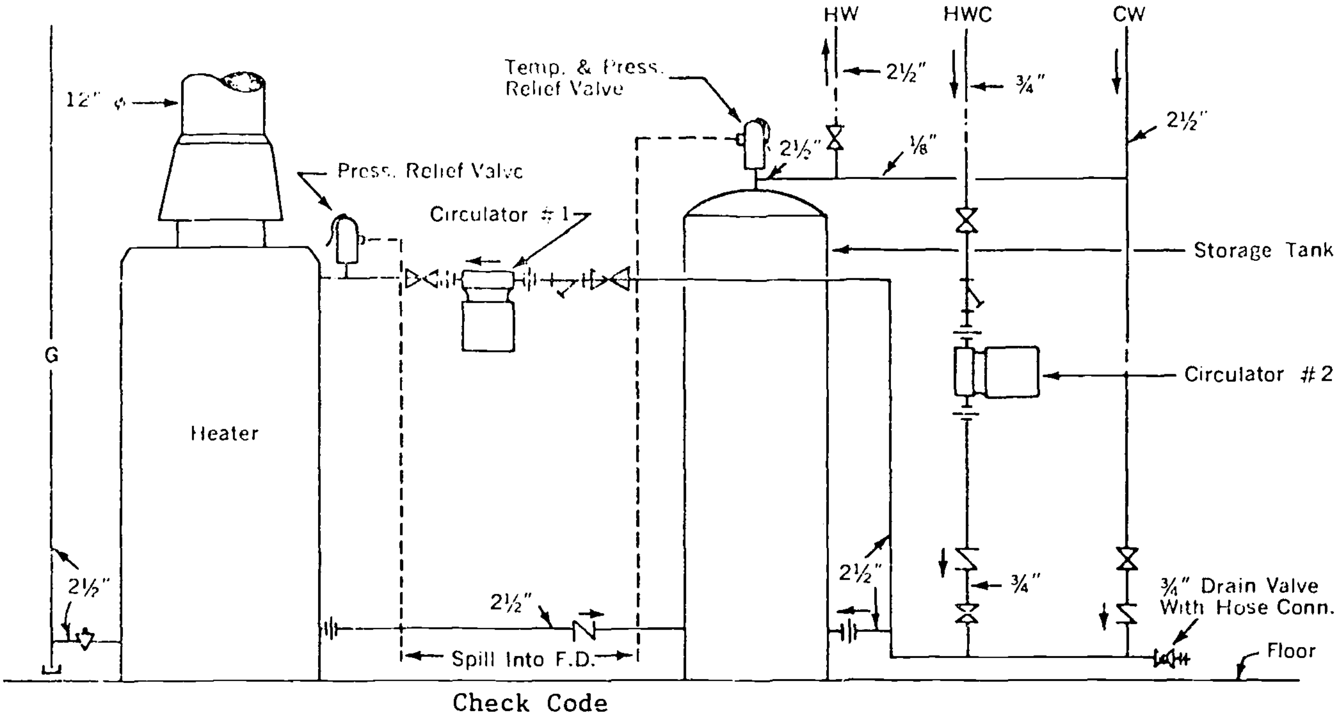


Fig. 10-1 Typical Water Heater Piping
No Scale

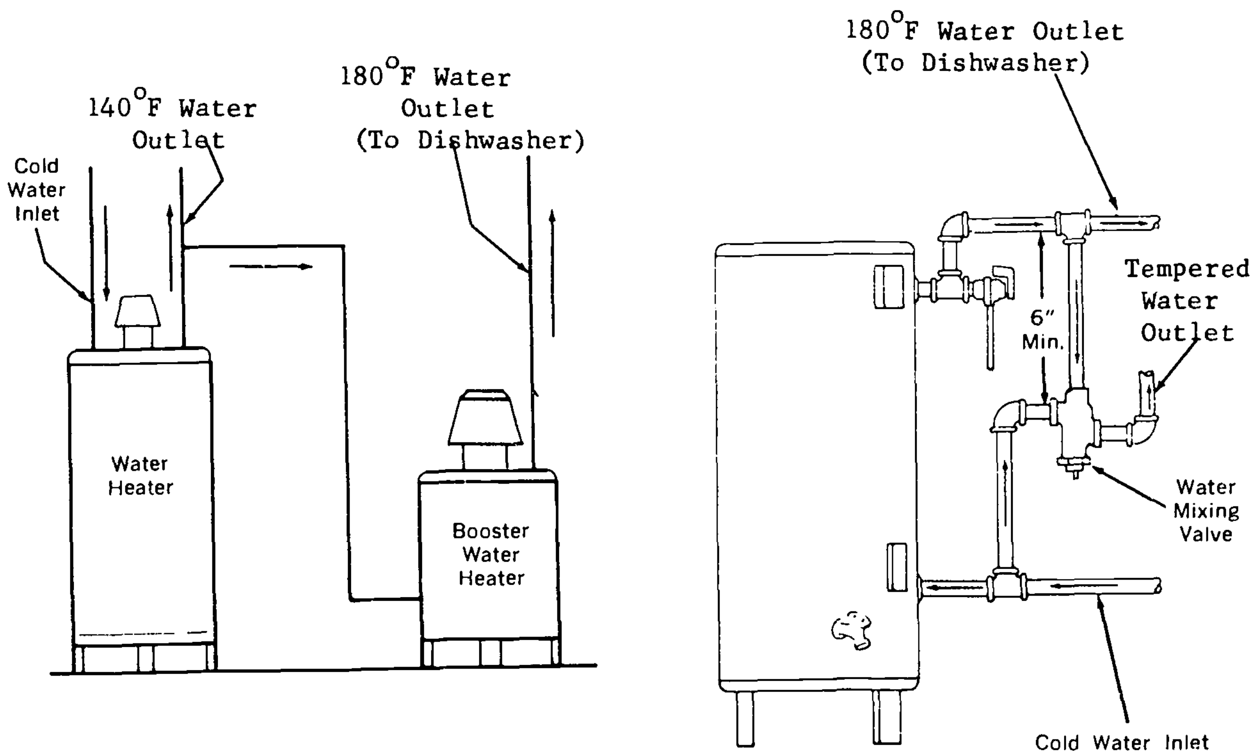


Fig. 10-2 Typical 2-Temperature Water Heater Systems
No Scale

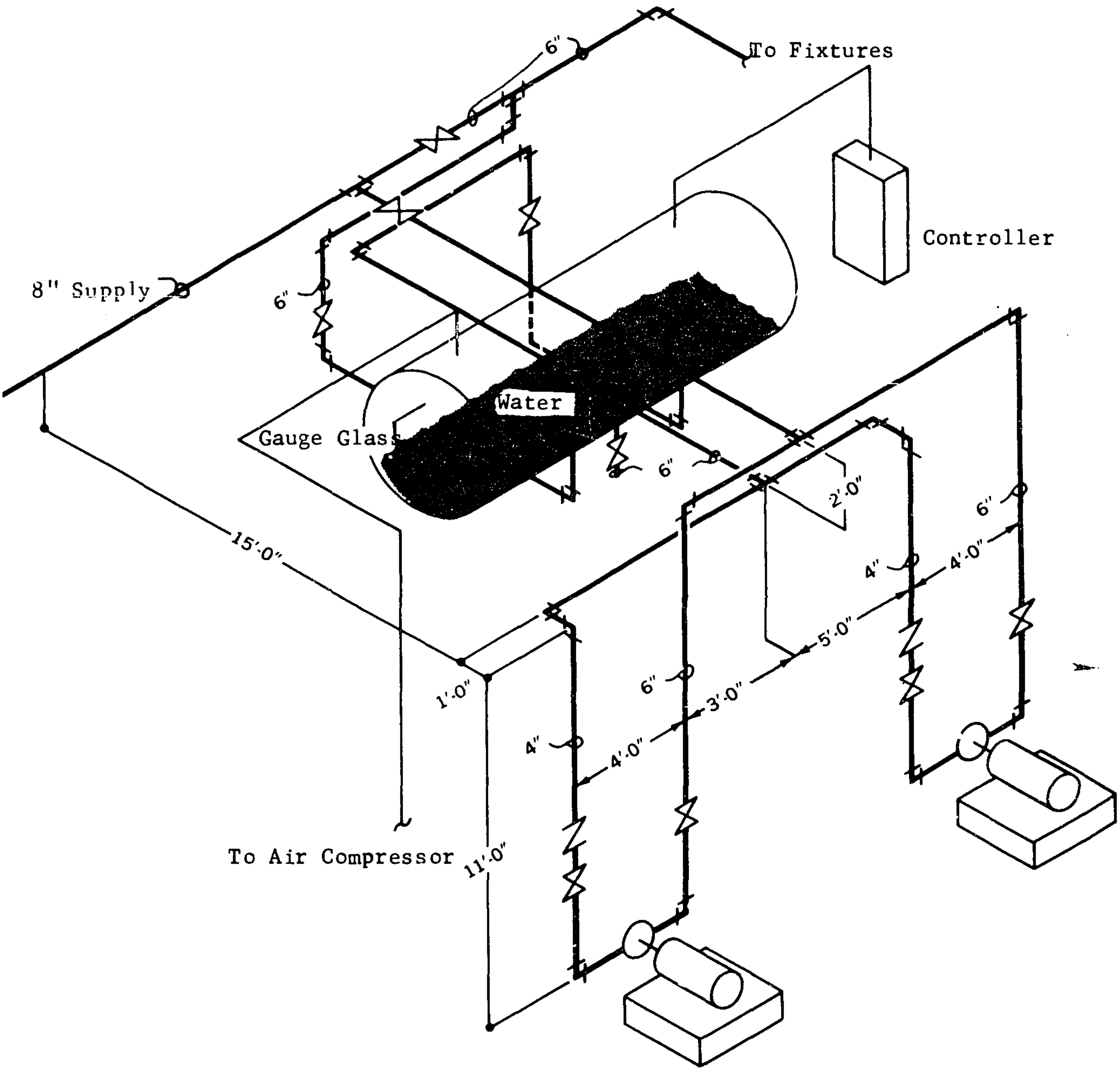


Fig. 10-3 Typical Hydropneumatic Water Pressure System

SIZES OF AIR CHAMBERS FOR REDUCING WATER-HAMMER PRESSURES

(Air Chamber Sizes in Cubic Inches)

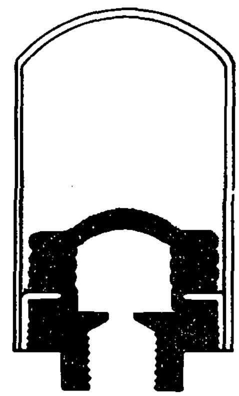
Length of Pipe	Nominal Pipe Diameter														
	½"			¾"			1"			1½"			2"		
	Water Velocity in Feet Per Second														
	5	10	15	5	10	15	5	10	15	5	10	15	5	10	15
	For Flow Pressure of 15 lbs. per Sq. Inch														
25	2	5	12	3	10	20	4	13	28	7	28	64	13	50	113
50	3	10	22	5	17	38	7	25	56	14	56	127	25	100	225
100	5	20	44	10	35	76	13	50	112	28	112	253	50	200	450
200	10	40	88	18	68	152	25	100	225	56	225	506	100	400	900
500	25	100	215	42	170	380	62	250	560	140	562	1260	250	1000	2250
	For Flow Pressure of 30 lbs. per Sq. Inch														
25	3	8	18	4	14	30	5	20	45	12	45	100	20	80	180
50	4	16	35	7	27	60	10	40	90	24	90	202	40	160	360
100	8	32	70	14	54	120	20	80	180	45	180	405	80	329	720
200	16	62	140	27	108	240	40	160	360	90	360	810	160	640	1440
500	40	150	346	58	270	600	100	400	900	225	900	2025	400	1600	3600
	For Flow Pressure of 60 lbs. per Sq. Inch														
25	4	15	33	7	26	58	10	38	85	22	85	190	38	150	340
50	8	30	65	13	50	115	19	75	170	42	170	380	75	300	675
100	15	60	130	26	100	230	38	150	338	85	340	760	150	600	1350
200	30	105	260	50	200	450	75	300	665	170	675	1520	300	1200	2700
500	74	290	645	125	500	1135	188	750	1640	420	1690	3800	750	3000	6700

One means of controlling water hammer is by providing an air chamber adjacent to the point of sudden shut-off, where a cushion of air can absorb the shock of the water hammer. Recommended sizes for the air chamber type of shock absorber are shown.

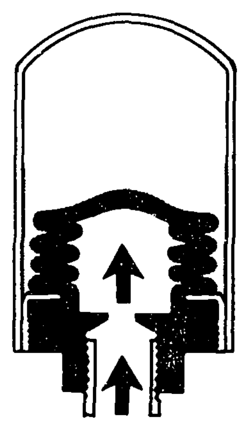
After a period of time, the air in a chamber may become absorbed by water filling the chamber completely. When the chamber becomes "waterlogged" in this way, it cannot protect against water hammer until after the water has been drained and air readmitted to the chamber.

There are several other types of manufactured shock absorbers which mechanically prevent water hammer by means of a bellows, piston, or diaphragm. These latter devices have the advantage of never becoming waterlogged.

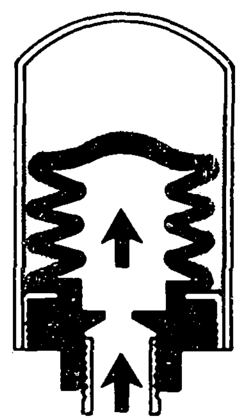
Fig. 10-4 Sizes of Air Chambers for Reducing Water-Hammer Pressures



1. *Before installation*, the bellows are held in a full compressed position by pressurized gas in the upper part of the chamber.

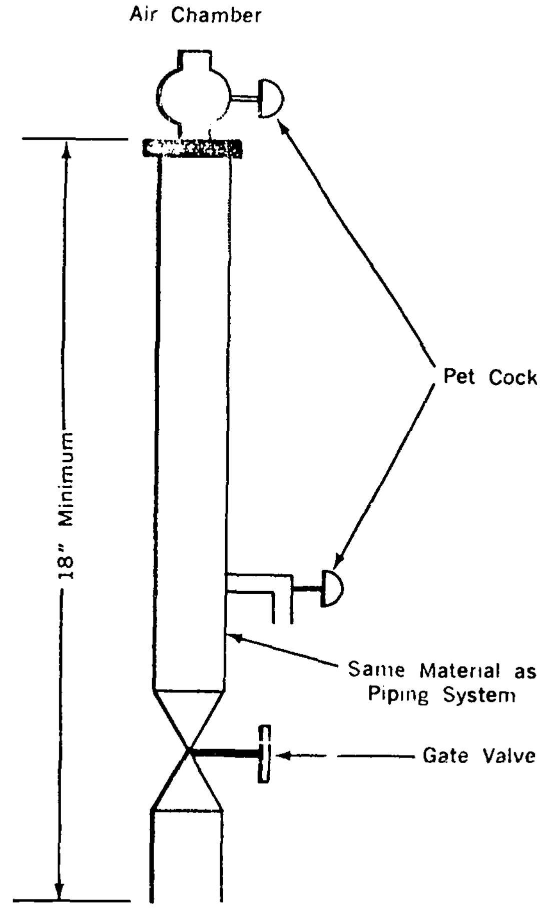


2. *After installation*, normal line pressure slightly extends and flexes the bellows until the pressure inside and outside the bellows is equal.



3. When *hydrostatic shock* occurs, the suddenly increased pressure in the line instantly extends the bellows thereby absorbing the shock. After shock, the bellows returns to its normal position shown in preceding *illustration*.

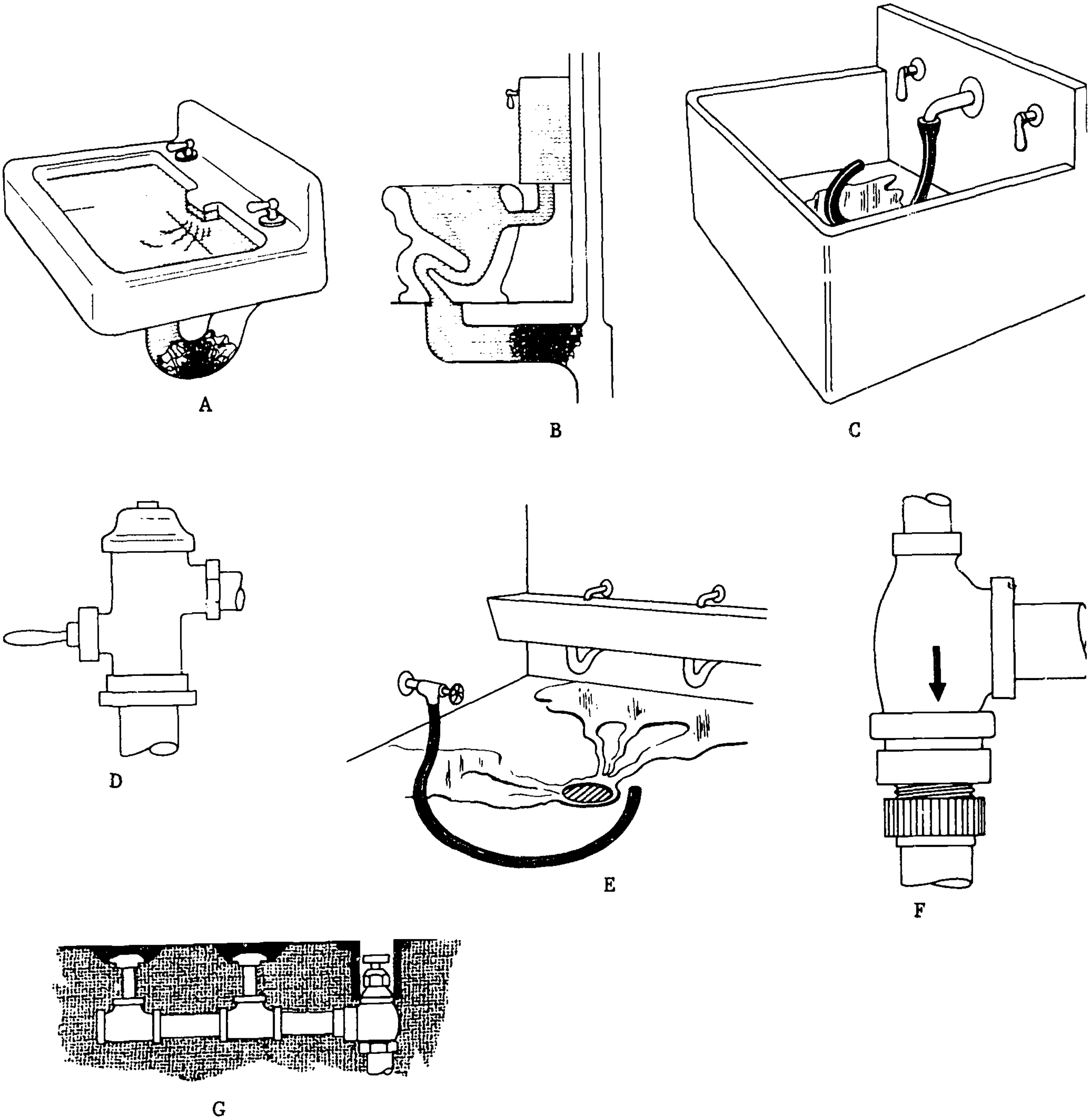
Fig. 10-5 Shock Absorber



An air chamber is a section of water piping on which the upper end is closed, and the lower end is connected to the piping system. On horizontal piping, it is connected by means of a side outlet tee; on risers and water supply branches, it is installed at the top.

The air trapped in the upper part of the air chamber is compressed by the shock wave of water hammer and absorbs the kinetic energy of the shock wave. Then the high pressure generated by the quick closing of the valve against the water flow subsides, and the air in the chamber expands to its normal volume under the normal pressure of the system.

Fig. 10-6 Air Chamber



A - Lavatory inlet below rim
B - Water closet - no vacuum breaker
D - Flushometer - no vacuum breaker
C - E - F - Hose connections - no vacuum breaker
G - Lawn sprinkler - no vacuum breaker

Fig. 10-7 Back Siphonage

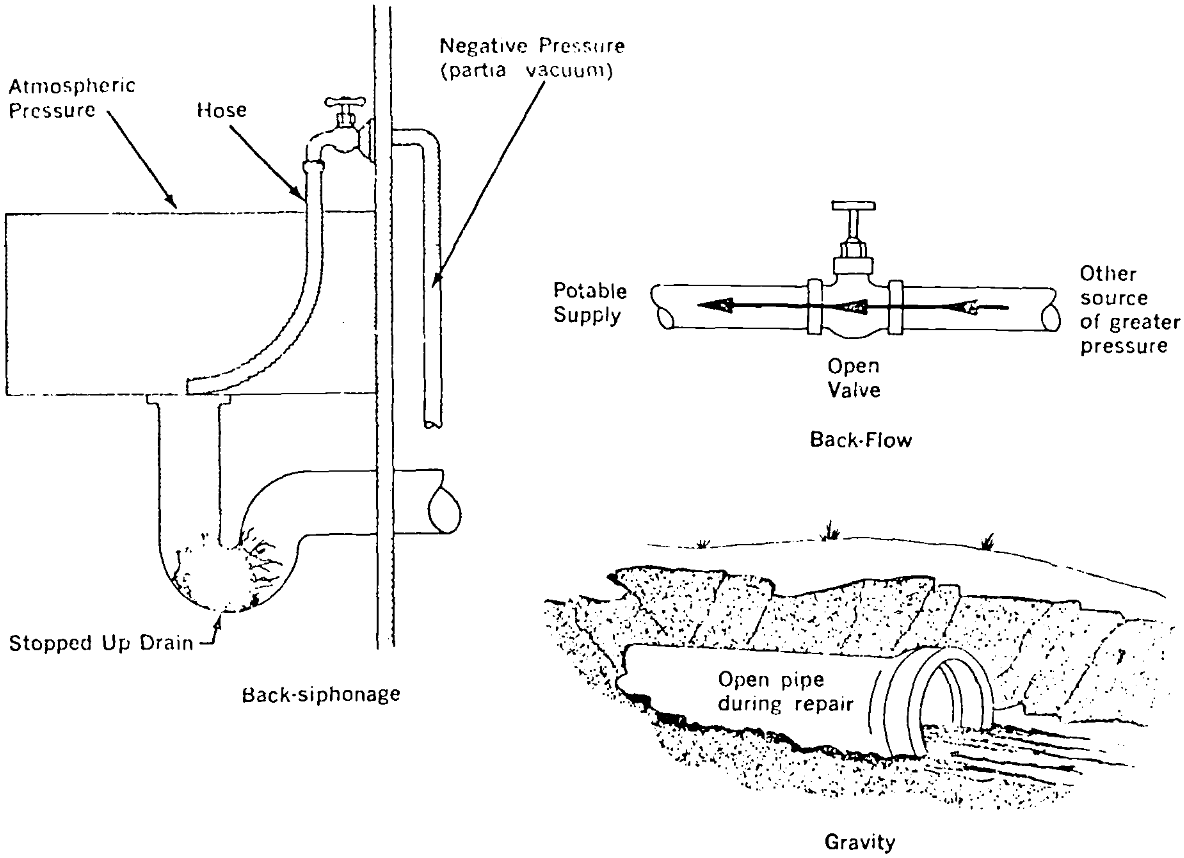


Fig. 10-8 Methods of Contamination

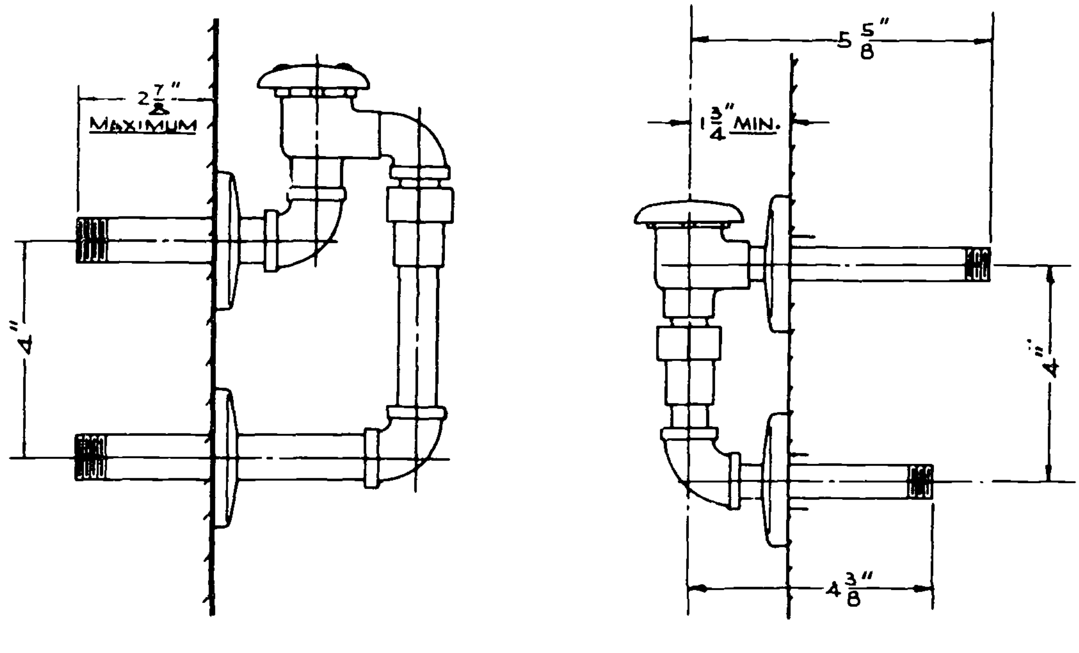
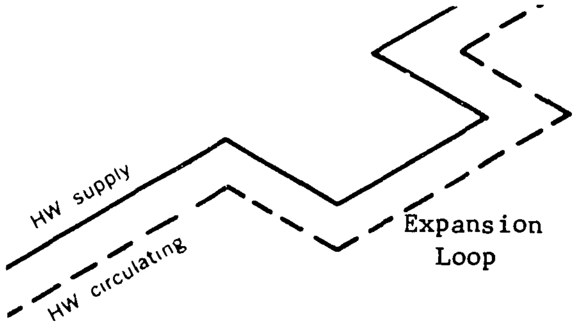
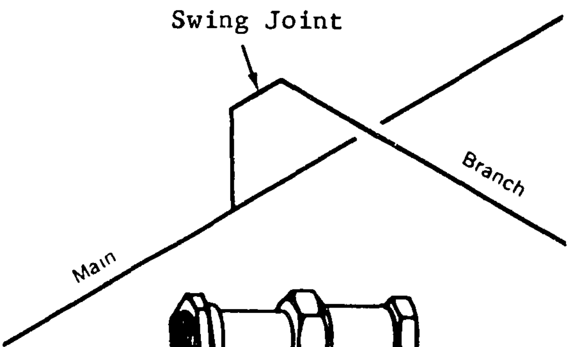


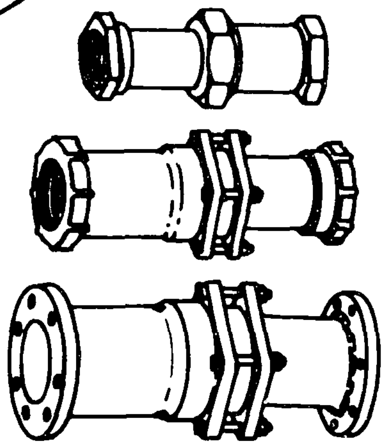
Fig. 10-9 Vacuum Breakers





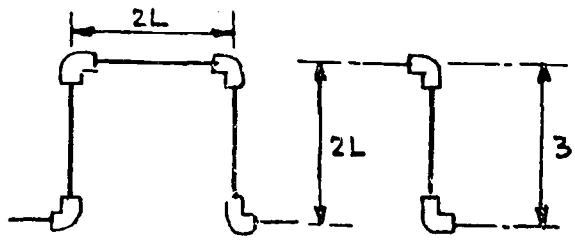
(Inches per 100 feet)

TEMP RANGE (F)	COPPER TUBING	STEEL PIPE
0	0	0
50	.56	.37
100	1.12	.76
150	1.69	1.15
200	2.27	1.55
250	2.85	1.96
300	3.45	2.38
350	4.05	2.81
400	4.65	3.25
450	5.27	3.70
500	5.89	4.15



Expansion Joints

COPPER EXPANSION LOOPS AND OFFSETS



Expansion Loop Offset

TUBE OD (in.)	LENGTH—L (INCHES) For Travel of								
	½"	1"	1½"	2"	2½"	3"	4"	5"	6"
⅞	10	15	19	22	25	27	30	34	38
1⅛	11	16	20	24	27	29	33	38	42
1⅜	11	17	21	26	29	32	36	42	47
1⅝	12	18	22	28	31	35	39	46	51
2⅛	14	20	25	31	34	38	44	51	57
2⅝	16	22	27	32	37	42	47	56	62
3⅛	18	24	30	34	39	45	53	60	67
4⅛	20	28	34	39	44	48	58	66	75
5⅛	22	31	39	44	49	54	62	70	78
6⅛	24	34	42	48	54	59	68	76	83

Data from Mueller Bross Co.

As an example, copper tube expands 1.14" in 100' per 100° F temperature. A copper line 200' long, heated from 40° to 140°, would expand in length 2.28", or 2¼". This expansion can be provided for by installing expansion loops, swing joints, or mechanical expansion joints.

Fig. 10-10 Pipe Expansion Data

CHAPTER 11

FIXTURES AND APPLIANCES

The Plumber and the Inspector have been concerned up to this point with the proper rough-in for all the plumbing fixtures and appliances to be used on the job. Data supplied by the manufacturer has been consulted to assure that the measurements for water and waste locations have been properly made, backing is securely fastened for adequate support and the pipes in the wall are firmly strapped to eliminate rattle. Other considerations as discussed in previous chapters have also been noted.

The Owner and the public judges a plumbing system primarily by what they can see. If fixtures are not true to line and the trim is poorly installed the impression will be that it is a poor job.

Most codes define plumbing fixtures as approved type installed receptacles. devices or appliances which are supplied with water or which receive liquid or liquid borne wastes and discharge such wastes into the drainage system to which they may be directly or indirectly connected. Processing equipment, such as tanks, are not plumbing fixtures, but may be connected to or discharged into approved traps, or plumbing fixtures.

Plumbing fixtures are generally classified as residential, commercial and industrial, or institutional. The commercial and institutional fixtures usually get heavier usage than the residential type, and for this reason are designed with this in mind, including heavier trim. The toilet seats are the open type to facilitate cleaning, and the toilets and urinals are equipped with flush valves.

Most plumbing codes state that plumbing fixtures shall be made of durable, smooth, nonabsorbent, and corrosion resistant material and shall be free from concealed fouling surfaces.

The U. S. Department of Commerce, in cooperation with fixture manufacturers and distributors, publishes voluntary minimum standards for the manufacture of plumbing fixtures. Most plumbing codes have adopted the standards by including them, thus making the standards mandatory.

There are a tremendous variety of fixtures and trim which can be used. Most manufacturers provide cuts, or pictures of the fixtures and dimensions, for identification purposes. The Inspector should have such material in his job file to assure that the proper fixture and trim is being installed at the proper location. This becomes very important in institutional work, such as hospitals, laboratories, or prisons, because the same fixture, such as a deep sink, may have different trim, depending on its location.

Most manufacturers of fixtures and appliances, as well as other materials have Sales Engineers in the area where the material is being used. If there is any question on the part of the Plumber or Inspector regarding its use, a telephone call to the representative will secure the proper answer.

While most plumbing installations are governed by the local code restrictions there are certain principles which apply, and must be enforced. The water supplied to fixtures for domestic purposes must be potable; no cross-connections must be allowed; water pressure must be adequate without objectionable noise; water and waste piping must be water and gastight at the operating pressure; each fixture must be properly protected by a trap; the above limitations are discussed in more detail in other chapters.

Water Closets: The design of water closets may vary, depending on their application. A residential closet is generally equipped with a flush tank instead of a flushometer valve. The tank is quieter in operation, and the service is not so severe as it is in a commercial or institutional building.

A closet is almost universally made of vitreous china, molded to the shapes desired. It is nonporous and nonabsorbent, thus is easier to keep clean and sanitary. Enameled metal can chip, and expose the metal to rust or absorption of undesirable odors.

All closets are equipped with integral traps (built-in). This insures that the trap will flush the closet through siphonic action.

The reverse trap closet is cleansed by having the water enter through diagonal slots around the circumference of the bowl. The swirling action, thus created, forms a jet which produces the required siphonic action. The advantages claimed for this type are a quieter flush, and less water is used, although it may take longer to flush.

The washdown closet has the trap path at the front of the bowl. This bowl is harder to clean because the top of the trap is above the water level. Many codes do not allow its use.

The siphon jet closet is the most popular and satisfactory type because it is quick flushing, and has the deepest trap seal; the water level is also lower in the bowl.

The blowout water closet is used in buildings, such as schools or offices where the bowl may be loaded with paper products. This closet requires a minimum pressure of 25 psi at the flush valve. The trap is larger than in the other closets mentioned.

Closets are floor or wall mounted, and may vary considerably depending on the application. The same is true of the seats, which may be closed front, open front, rounded, elongated and provided with check hinges, self-sustaining or self-raising hinges. They may be equipped with covers, particularly in residential work.

Lavatories and Sinks: Lavatories or wash basins and sinks come in a variety of styles; unlike water closets, however, they may be made from a variety of materials. These include enameled cast iron, molded counter top types, stamped sheet steel with a thin enamel coating, and stainless steel. An undercoating is usually applied to the steel fixtures to deaden the sound caused by vibration.

Stainless steel is becoming popular for lavatories, sinks, and other fixtures because it is easily cleaned, lightweight with high strength, easily fabricated and is heat resistant.

Urinals: Urinals are generally made of vitreous china or enameled cast-iron, although other non-absorbent materials may be used.

The trough urinal may accommodate two or more and is less costly than the individual type. There is no privacy with this type, and it can become a trash catcher.

The stall urinal allows privacy but can also become a trash catcher. Since it is floor mounted, the strainer can become clogged and allow overflow to occur. The wall hung washout urinal is similar to the stall urinal with no siphonic action; it is less sanitary than the siphon jet or blowout urinal designs.

The siphon jet, either wall-hung or pedestal-mounted, and the blowout urinal are similar in action to their similarly named water closet types. The blowout urinal requires 30 psi water pressure and for this reason is noisy in operation. Flushing action for urinals is by direct flushometer valve, which may be manually operated by hand or foot, or it can be by means of a timed cycle with a small motor mounted on the flushometer valve. The flushometer valve may be concealed in the pipe space with only a handle or button protruding if vandalism is a problem. There are other automatic flushing systems which are designed to save water and only flush when the fixture is used.

Bathtubs and Showers: There are a variety of tubs which may be installed in residences, hospitals, nursing homes, or other areas with 24-hour occupancy. This class of fixtures, along with the stall urinal, are installed after the framing is complete and before wall finishes are applied. Tubs must be adequately secured and protected during construction. Where a tub and shower combination is installed the wall must be waterproofed to approximately 6'-0" above the finished floor.

Shower receptors which are built-in must be equipped with a waterproof pan to a height of 4" to 6" to prevent leakage. Pans may be made of lead, copper, or trade-marked composition of the types allowed by the local codes.

Trim for these fixtures may be of various types, generally of the same materials used for other fixtures.

Other fixtures commonly seen in residences, commercial buildings, or small plants may be service sinks, gang shower rooms, circular wash sinks with foot controls, laundry trays, drinking fountains, and many others.

Institutions, such as hospitals, laboratories, prisons, or universities, require many more fixtures than the ordinary job; the severity of the service may require heavier fixtures and special trim.

In addition to the water closets, lavatories, sinks and tubs and showers which are used in a hospital, for instance, there are pieces of specialized equipment which must be installed as a part of the plumbing work. This may include several types of sterilizers, bed-pan washers, built-in electric drinking fountains, and others which require special treatment and handling. Some may be supplied by other than the Plumbing Contractor, but must be installed by him. Much of the trim may be exposed, and may be iron pipe size polished chrome. Any material required for connections must match this.

<u>Floor Drains</u>: Most plumbing codes consider a floor drain a plumbing fixture because it receives a liquid discharge from some source. In many cases, it may be only for emergency use, such as a stoppage, causing overflow. For this reason, most codes also require a hose bibb near the drain, in order that the floor drain trap may be supplied with water to replace that lost by evaporation. More elaborate means are sometimes used to accomplish this purpose; one way is to supply water to the top by connecting it to a source which supplies water in a small quantity each time the source is used. The floor drains should be placed so that the floor slopes to them, and preferably, they are out of the way of the room traffic.

<u>Appliances</u>: Most plumbing codes consider appliances the same as plumbing fixtures, since they are connected to the water supply, drainage system, or both. They are sometimes referred to as plumbing equipment. The most common type are the dishwasher, garbage disposal, washing machine, hot water heater, ice makers, and many others, which add to the convenience of modern living. Since it is not possible to discuss each appliance in detail some generalizations will be made regarding them as well as fixtures and accessories.

Accessories: The plumbing craft has the responsibility of installing all accessories which are metal. The ceramic items, such as soap dishes and toilet paper holders are installed by the tile setter. There are a great number of accessory items; a few are towel holders, toilet tissue holders, grab bars, medicine cabinets, mirrors and coat hooks; whether surface mounted or recessed, they must be recognized in advance and preparation made for them, by providing backing or openings as required. It is the Plumber's responsibility to request the backing or opening, although the General Contractor may be required to provide it.

The Plumbing Inspector who is engaged in the supervision of the construction or installation end of the business as contrasted with the manufacturing end will usually be concerned with the proper installation as detailed on the plans and described in the specifications as provided by an architect or engineer engaged by the Owner. It is not always practicable to show each individual detail and phrases such as "install in a manner," "provide proper backing," or "anchor securely" may show on the plans or be expressed in the specifications. It then becomes necessary for the Plumber to draw on his experience and knowledge of the job to make the necessary provisions for the backing or anchoring. The Plumbing Inspector cannot tell the Plumber how to do the work or what to provide, but he must be sufficiently informed so that he knows if the work is being done properly, and that the crafts involved are cooperating fully.

Since a hospital job of moderate size, for instance, would have one or several of most of the fixtures and appliances mentioned here, and others of similar characteristics, it will serve as an illustration of the planning and installation work which must be done by a competent Plumbing Superintendent and his men; the Plumbing Inspector relates with him as well as others to successfully complete the project.

This pre-supposes that the various steps outlined, and the duties and obligations of the Plumbing Inspector discussed in Chapter 1, Plumbing Inspection, are thoroughly understood.

The job progress to the point of installing the fixtures and appliances has not been haphazard. All work has been carefully scheduled by all crafts to within a week or two, for instance, on a job which may take two years to complete. This scheduling assures that materials and labor will be available when needed. The Inspector is thoroughly familiar with the plans and specifications, not only for the plumbing work, but for all other crafts working on the job.

In order to successfully complete the job, the work which is on display, the "finish" as opposed to the "rough-in" has been planned in advance. All services for fixtures and appliances have been roughed-in as shown and specified. All tests and inspections have been completed. Each fixture dimension has been verified from the manufacturer's data supplied as discussed in Chapter 1. These "rough-in" cuts, as they are called, show the exact position of the waste and supplies, as well as trim and mounting instructions.

Plumbing fixtures are generally stored in a safe place until they are to be installed. Some fixtures, such as bathtubs or clinic sinks are heavy and are moved by handcarts or other safe means. Most fixtures are delivered with the trim in separate cartons; this is usually left in storage until needed, as it is expensive and subject to damage. Each fixture should be carefully examined before installation; this may show hairline cracks in urinals, crazing in the vitreous china, warping so fixtures do not set flush to the wall. A complex job like a hospital requires good organization of the work so that there will be no delay in the final acceptance of the work.

In addition to the plumbing fixtures, the appliances are also installed by the Plumbing Contractor. The modern hospital kitchen will be equipped with a large commercial dishwasher, garbage grinders, potato peelers, coffee urns, and other appliances which will require water or gas connections and means to drain, usually indirectly. It is necessary to check appliance installations closely to assure that no cross-connections exist which can cause contamination.

Relief valves must be installed on the water heater and other closed vessels for safety reasons.

After the fixtures and appliances are installed, leveled, plumbed and securely fastened or anchored, the trim is installed where required. The Plumber should then run the water at the fixtures to clean out the pipes. Many specifications, particularly on institutional jobs will require chlorination of the supply water systems as a health precaution, especially if the lines have been installed for a long period before being put into use. Refer to Chapter 19, Inspection and Testing, for one way to do this. The water and waste connection should be visually checked for leaks. If any are found, which is quite likely, the fixture may have to be removed and reset, or the fittings may need to be replaced. Cracked fittings or improperly made joints may not be evident before this time.

Each fixture and appliance should be checked for proper operation. The water pressure must be checked; there should be no splashing over the rims of lavatories, nor from stall urinals; drainage should be proper; there should be no gurgling nor rattling of pipes due to water hammer; tank toilets should refill within the time specified by the manufacturer. Other tests are described in the chapter on Inspection and Testing. They may not all be required depending on the specifications.

The Plumber usually starts to set the fixtures as soon as the space is ready, which may be after the finish painting is complete, or in the case of stall urinals and bathtubs, among others, must be installed during the rough-in stage. Protection of the fixtures until final completion and acceptance of the building is the responsibility of the Plumbing Contractor. This must be properly done to avoid damage and consequent extra cost for replacement or repair. The methods of protecting the fixtures will vary with the job and with the Contractor. Sometimes empty cartons are placed over the fixture, or specific coverings are sprayed or brushed on. Trim may be covered with masking tape; other similar methods may be used, so long as they are effective.

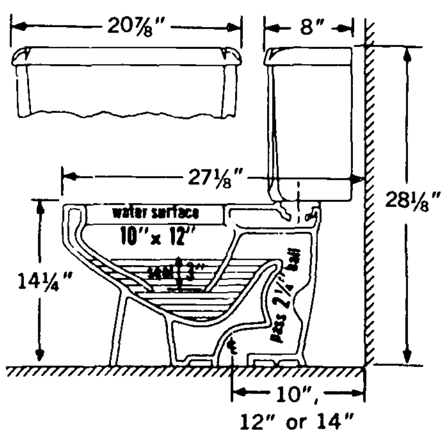
Cleanliness is an important factor in institutions, as it is in other buildings; it may be more complicated to achieve because of the number of fixtures. Glazed fixtures should be grouted at the wall and floor areas where dirt could collect. Grout is a white cement mixed with water to form a paste and smoothed into the cracks in a continuous line. On smaller jobs a commercial product may be used, but it is more expensive.

It is also the responsibility of the Plumbing Contractor to clean all fixtures, before the final inspection and the punch list is made up. The amount of dirty cleaning required will be in direct proportion to the lack of care which was used in protecting the fixtures and appliances.

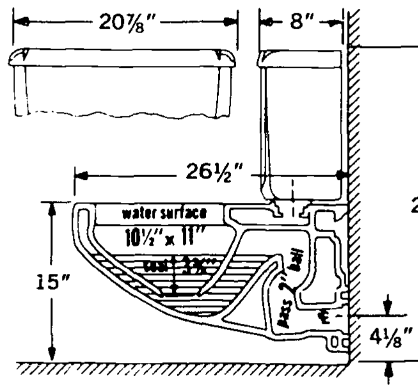
The punch list is made up by the Plumbing Inspector when the Plumbing Superintendent reports that all the work is complete and ready for inspection. If there has been close cooperation between the Inspector and the Superintendent, most defective items will have been fixed as the job progresses. It is only when all defective items have been satisfactorily solved, that the responsible parties will accept the building and recommend acceptance to the Owner.

There are many types of water closet combinations manufactured for residential use. Nos. 1-4 show some of the designs available to the consumer.

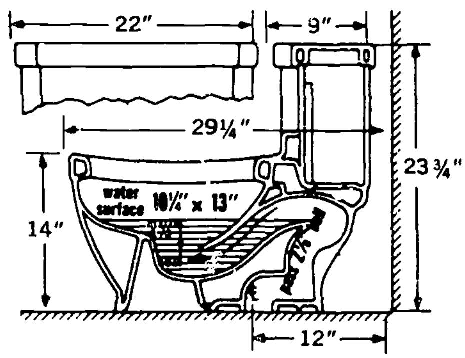
1. No. 1 is a floor-mounted close-coupled tank and bowl combination. *Close-coupled* means the flush tank is fastened directly over the closet bowl. This design is the most common among residential water closets because it is the most economical to install.
2. No. 2 is a wall-mounted close-coupled tank and bowl combination. This design is popular because the off-the-floor installation makes it easier to maintain a clean, sanitary bathroom.
3. No. 3 is a one-piece floor-mounted tank and bowl combination. The flushing action of this design is quieter than the usual siphon jet because a siphon vortex, or swirling motion, is used to flush the bowl.
4. No. 4 is a floor-mounted one-piece low tank and bowl combination. Because the water head is insufficient to give a satisfactory rim wash, a water supply connection is made from the float valve to the flushing rim. This washes the side of the bowl and aids in the flushing of the fixture. A minimum water pressure of 30, psi at the fixture supply is required to operate this fixture.



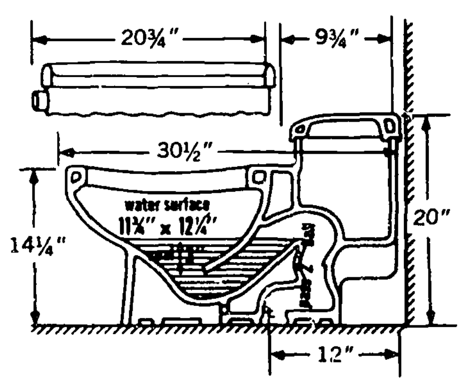
No. 1



No. 2



No. 3



No. 4

Fig. 11-1 Residential Water Closets

15B–17 GENERAL REQUIREMENTS OF PLUMBING FIXTURES:

A. All fixtures shown on plans shall be set, connected and tested by the Contractor. He shall also make all water, waste, vent, soil and other service connections to fixtures as shown on plans or as directed, and shall set, furnish, connect and test all necessary fittings.

B. All fittings, escutcheons, faucets, traps, exposed piping, etc., shall be brass, chrome plated over nickel plate with polished finish. Any hanger nuts visible shall likewise be chrome plated over nickel plate.

C. This Contractor shall furnish and set all hangers, support brackets, etc., requiring support. Such supports shall be in accordance with the recommendations of the manufacturers of the fixtures, and if built into partitions or walls shall be set as the wall progresses. This Contractor will be held responsible for the stability of all fixtures, furnishing all chair carriers or other materials necessary to accomplish this. Setting of fixtures not in this contract will be done by others.

15B–18 PLUMBING FIXTURES:

A. Plumbing fixtures shall be as manufactured by American-Standard, Crane Co., or Kohler. Fixture designations are for American-Standard.

P–1 WATER CLOSET (Patients)

2222.032 "Madera"
4020.012 bolt caps
S.R. 115YV Flush valve
7586.027 bedpan cleanser "SPRA-FLEX"
7679 012 Bedpan Cleanser
7837.016 Backflow preventer
5320.114 white seat—open front—no cover

P–2 WATER CLOSET (General)

2222.016 "New Madera" with Sloan Royal 113 YV flush valve and 9500 white seat

P–3 WATER CLOSET (Specimen)

9436.015 "Tribor specimen toilet"
4020.012 bolt caps
7679.020 bedpan cleanser modified for cold water only
7837.024 vacuum breaker
7867.013 nozzle w/hook—4' hose w/spray
7544.018 supply pipe assembly
5320.114 white seat—open front—no cover
S.R. #115 YV Flush valve (same as P–1)

P–4 URINAL

F 6530 "Lynbrook" with Sloan Royal #180YV flush valve

P–5 LAVATORY (Patients' and Kitchen)

0350.132 "Lucerne" 20 × 18
7506.140 gooseneck faucet, 4" wrist handles, aerator, grid drain
2340.016 straight tailpieces
2302.115 supply pipes w/loose key stops
4429.015 1¼ × 1½" P trap w/cleanout
4446.019 1½" pipe nipple w/escutcheon

P–6 LAVATORY (Exam-Treatment)

0350.421 "Lucerne" 20 × 18
7522.030 gooseneck spout, aerator
2340.016 tailpiece
(Type B) 7546.054 supply pipe assembly
7676.018 knee action mixing valve—supplies—wall support
2411.015 grid drain
2429 015 1¼ × 1½" P trap w/cleanout
4446.019 1½" pipe nipple w/escutcheon

P–7 LAVATORY (General)

F 351 20×18" "Lucerne"
2101.013 Centerset w/aquaseal & pop-up drain
2341.030 offset tailpieces
2306.017 ⅜" wall supplies
4419.016 1¼ × 1½" P trap w/cleanout
4446.019 1½" pipe nipple w/escutcheon

P–8 BATHTUB (Patients')

P2265 R/67R 5' "Bildor" with Stan-Sure
Leonard M–10–CST thermostatic mixing valve
Sloan model AC–110 shower head
1576.289 waste w/lever operated drain
1624.014 tub filler

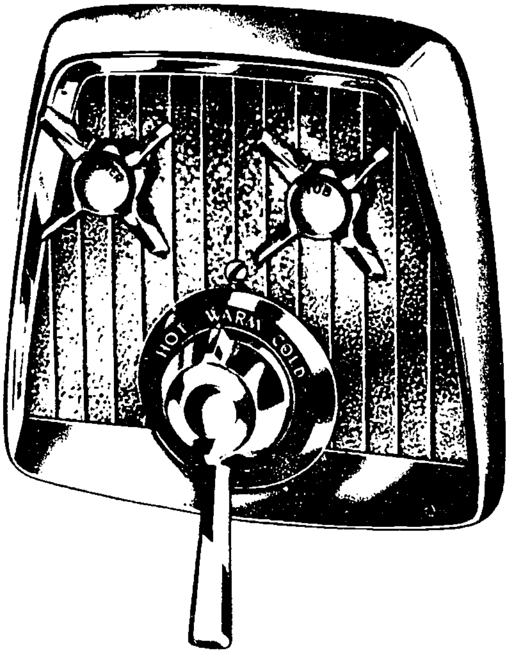
P–9 SITZ BATH

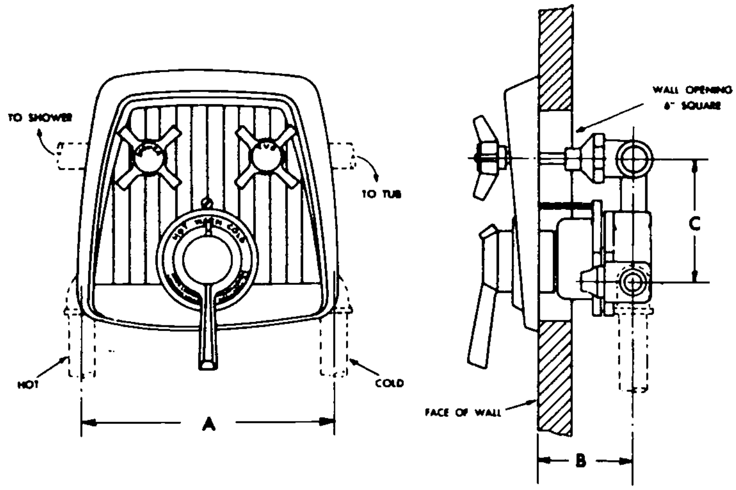
9040.015 Bath
9041.013 Pedestal
Leonard M–10–CR with thermometer
7564.040 supply
4419.016 "P" trap
4446.019 trap nipple
9041.021 vinyl overflow

P–10 SHOWER (Patients') (Not Shown)

Leonard M–10–C mixing valve and Sloan model AC–110 shower head

Fig. 11-2 Fixture Specification

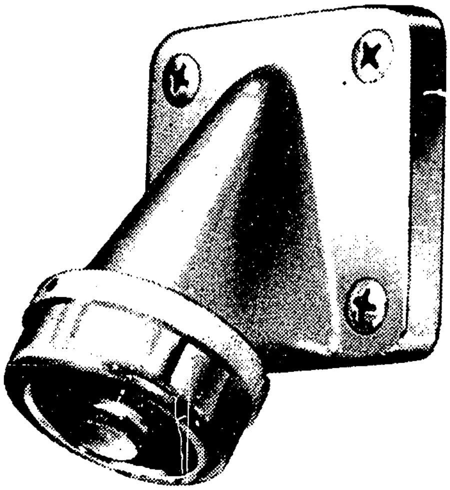




ROUGHING-IN DIMENSIONS

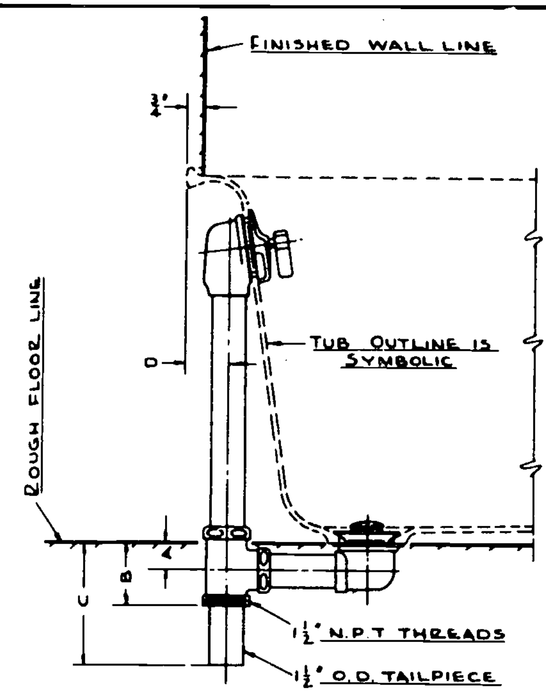
MODEL	A	B	C
M-10-CST	8	3	3 13/16
M-20-CST	8½	3	3 13/16

TRIM FOR P–8



INSTITUTIONAL SHOWER HEAD
Model AC-110 with Back Inlet and without Volume Control.

TRIM FOR P–8



TRIM FOR P–8

Fig. 11-3 Trim Detail

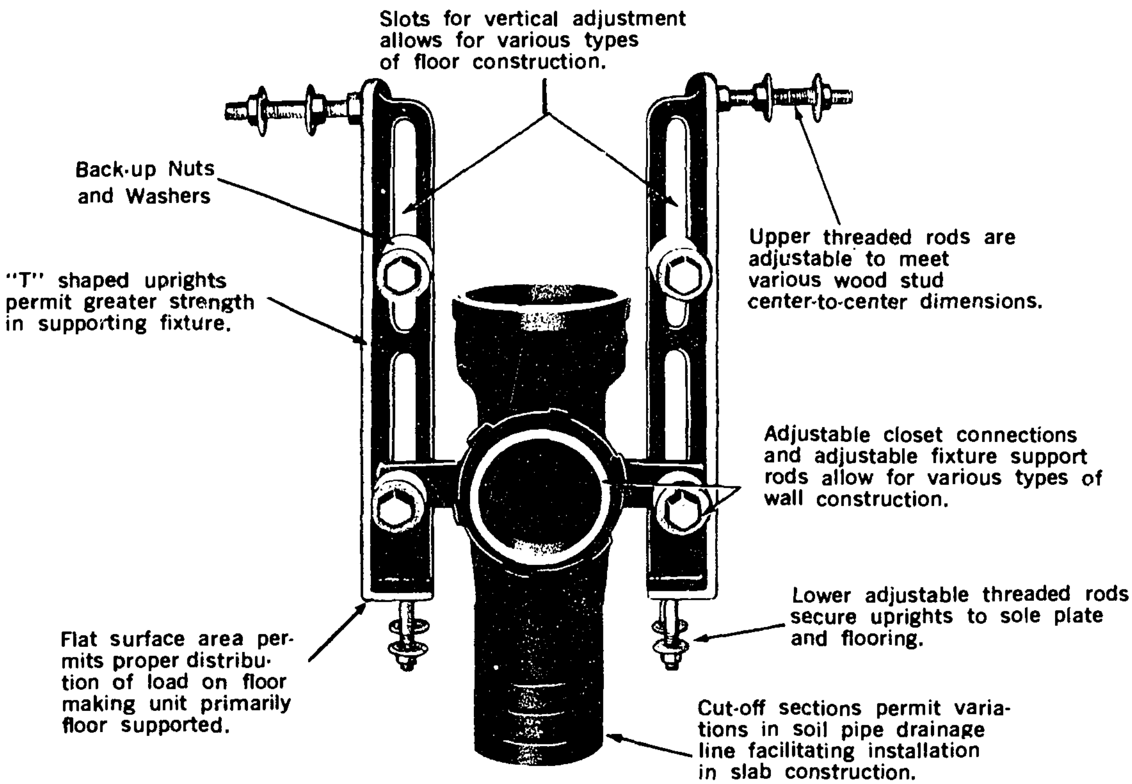
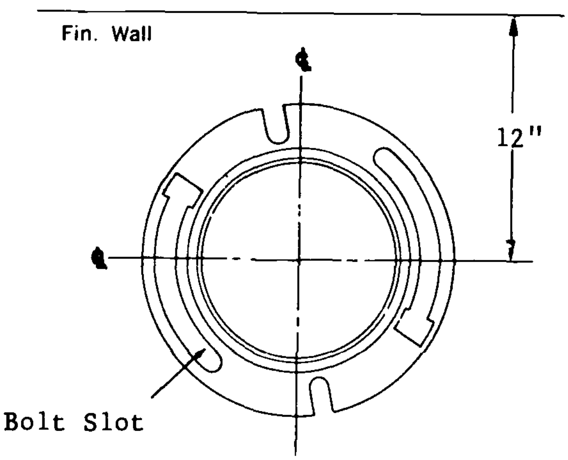
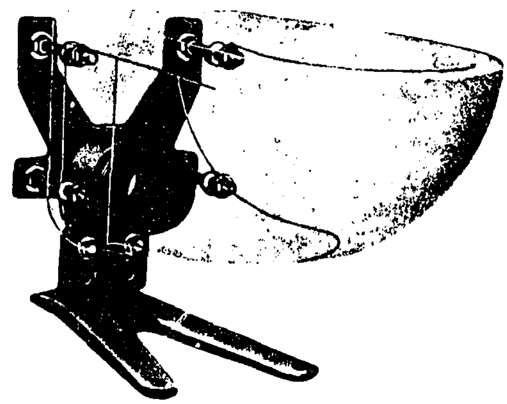


Fig. 11-4 Residential Chair Carrier



Plan of Floor Flange



Bowl with Concealed Chair Carrier

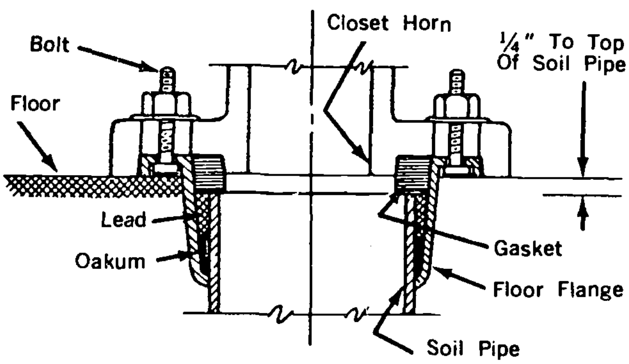


Fig. 11-5 Water Closet Supports

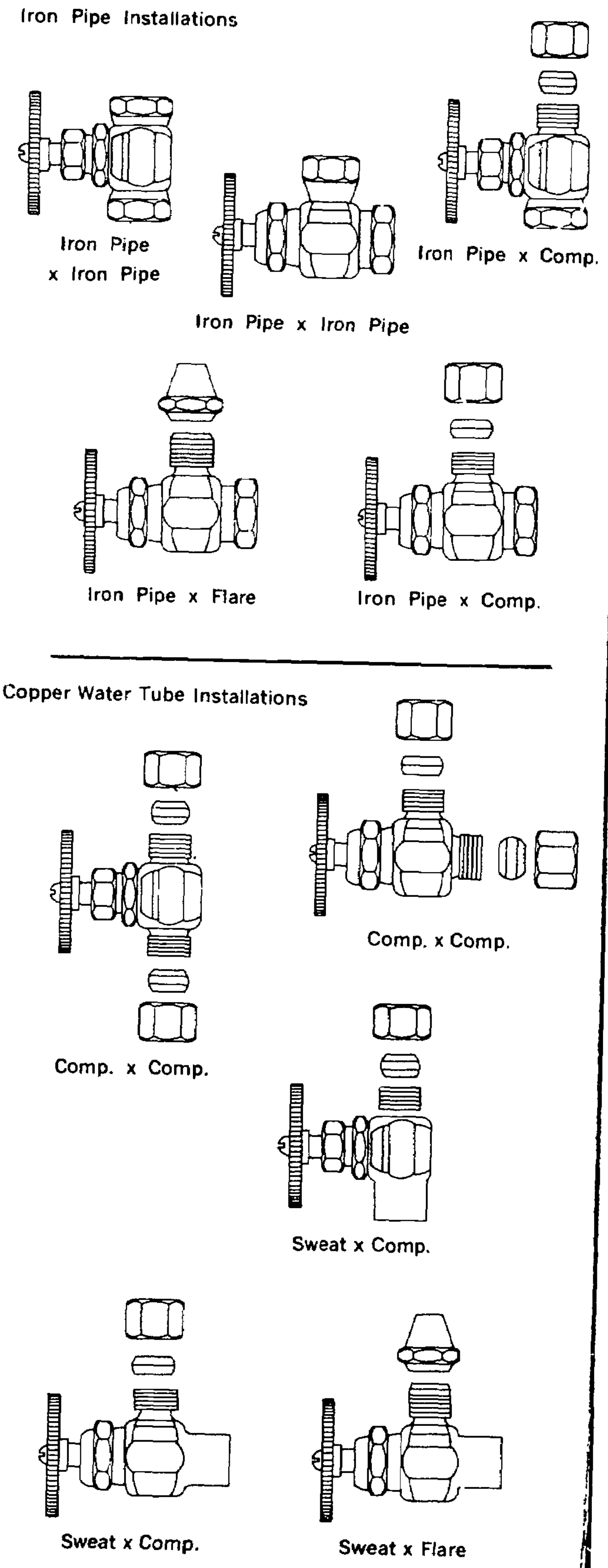


Fig. 11-6 Lavatory Valves

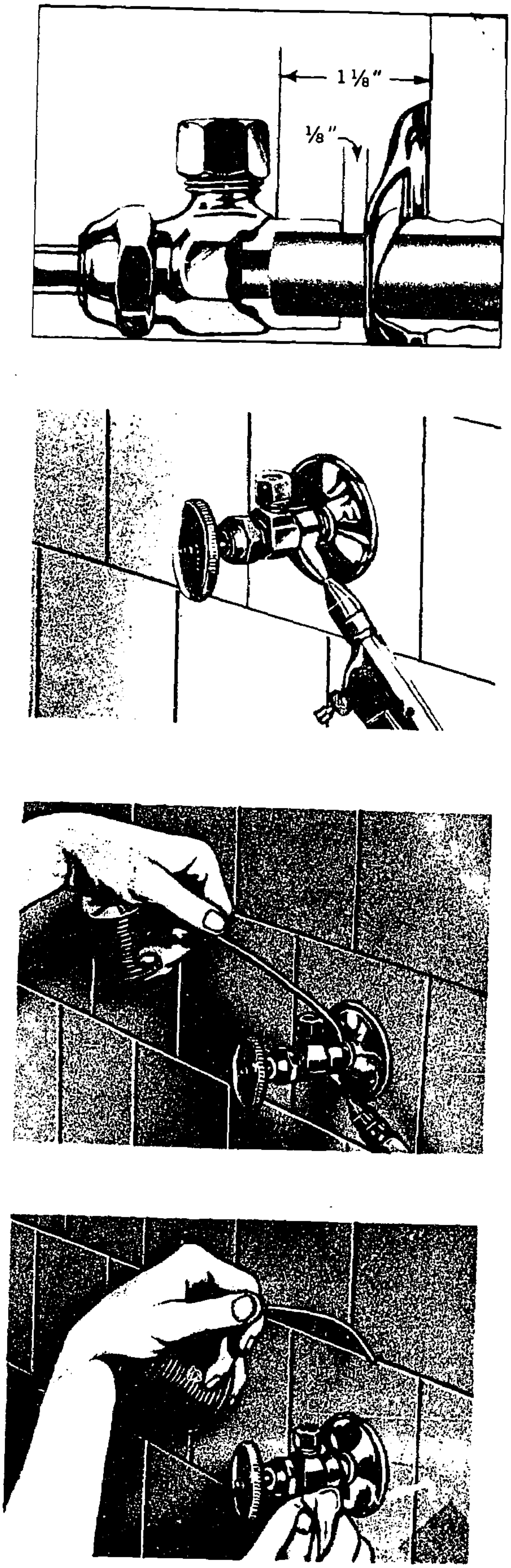
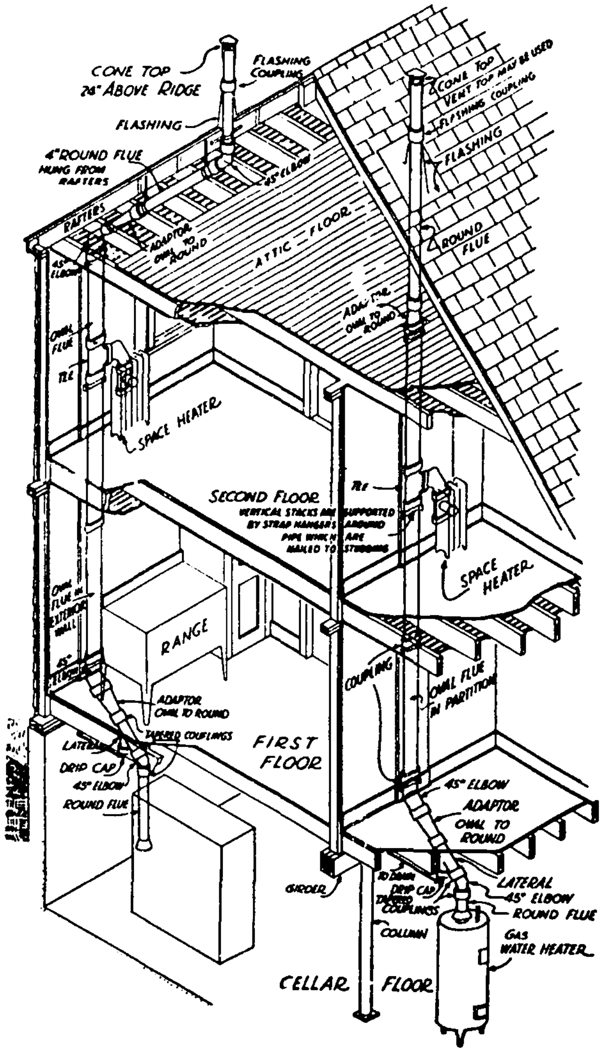
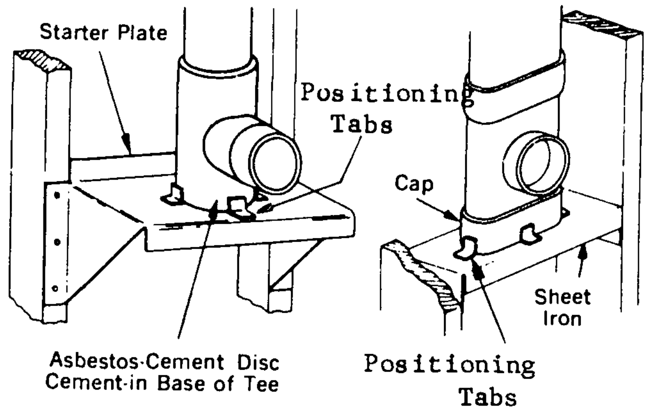


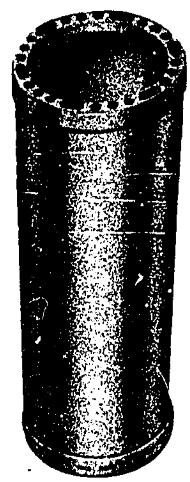
Fig. 11-7 Sweat Connection



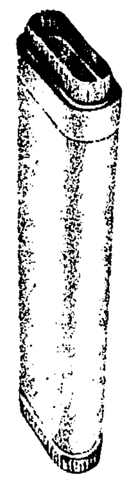


MINIMUM CLEARANCES
For Cement-Asbestos Gas Vents

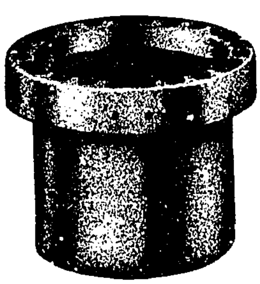
Shape	Sizes	Clearance
Round	3"-7"	1½ inches
Round	8"-12"	3 inches
Oval	No. 3 & No. 4	In 2x6 studing; or 1½ inches
Oval	No. 5 & No. 6	3 inches



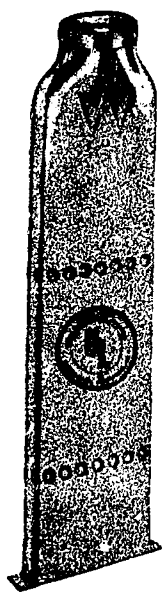
Double-Wall
Pipe



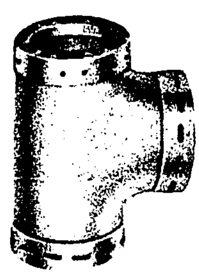
Oval Double-
Wall Vent Pipe



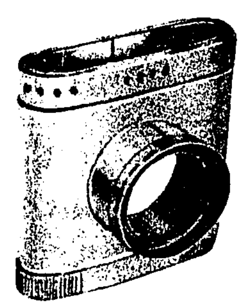
Draft Hood
Connector



Wall Heater Vent



Tee



Tee

Fig. 11-8 Gas Vent Details

CHAPTER 12

FUEL SYSTEMS

Types of Fuels: The most common fuels the Inspector is likely to encounter are gaseous and liquid. These may occur in all of the various structures from residential to institutional. Liquified petroleum products may occur in both the liquid and gaseous state.

The gaseous fuels most commonly encountered are: natural gas, propane air mix, butane, and acetylene. Most gases are odorless so are treated with skunk oil to make them noticeable when a leak occurs.

Other gaseous petroleum fuels not encountered frequently are methane, ethane, pentane, hexane, hystane and octane. All fuel gases are compounds of hydrocarbons that contain hydrogen and carbon in varying proportions. The principle hydrocarbon found in natural gas is methane which is 80 to 95% of the composition.

The heating value of gases generally vary from 800 BTU/cu ft. to 1200 BTU/cu ft. Utility companies make an effort to mix gases of low value with those of a higher value in order to average out to approximately 1000 BTU/cu ft. Low heating value gas wells are usually capped and not developed.

Liquified petroleum (L.P.) gases commonly used for fuel are propane and butane. Propane is the more widely used fuel. Propane has a heating value of over twice that of natural gas at an average of 2516 BTU/cu ft. Enclosed spaces with L.P. gas piped in, require venting to the outside of the floor level since L.P. vapors are heavier than air.

Some small communities and large building complex groups use a propane air mix with the resulting heating value at or near that of natural gas. This mixture is piped in an underground distribution system of the same type as that used for natural gas.

Distribution systems for the public utility companies may vary in pressure from 8 oz. to 150 psi depending on the source and the proximity to the nearest booster pump systems. Usually the Inspector will only be involved with in-house systems which are normally 7 inches water column or 5 psi. Some variations between these limits may be allowed by the gas company but rarely will pressures be allowed above or below them.

Liquified petroleum (L.P.) gas pressures vary with the vapor pressure of the liquid, which varies with the temperature. In cold climates where fuel tanks may be installed unprotected above ground a gas generator is usually employed. This device adds heat to the liquid stored in the tank thereby increasing the vapor pressure. Distribution pressures from tank to house may vary between 11 inches water column to 50 psi. Primary regulators are usually installed at the tank to regulate this pressure. House distribution pressures are usually 11 inches water column unless some appliance such as a large boiler requires a higher pressure.

Acetylene is used most commonly in metal shops in conjunction with an oxygen system for gas torch welding and cutting. Distribution pressures may be the same as those in the storage or bulk tank but is usually limited by a primary regulator to less than that. Secondary regulation is necessary at the point of use. Piping method is much the same here as for natural gas (to be discussed later) except, in necessary cases, for higher pressure rated fittings and pipe.

Liquid fuels are: Propane, gasoline, kerosene and fuel oils from No. 2 diesel to No. 6 crude black. Also included for later discussion will be lubricating oils. Although these are not considered fuels many of the piping practices applicable to combustible liquids apply to lube oils.

Liquid fuels mentioned above are distillates of liquid hydrocarbons. Propane has the highest energy content, 21,591 BTU per pound followed closely by gasoline with 21,400 BTU per pound. Both fuels have very low flash points and are considered very dangerous. Piping systems for both must be very carefully installed and tested so as to eliminate any possibility of leakage. Diesel oil and other fuel oils are safer to handle mostly due to higher flash points but are still high in energy content; 18,320 to 19,650 BTU per pound.

Pipe Systems: Gas piping system installations are completely covered in Chapter 12 of the UPC including type of materials, testing and sizing for both natural gas and L.P. gas. Appendix F in the UPC covers medium pressure gas system installations. It is suggested the student read both the aforementioned chapters.

Work covered by plans and specifications prepared by an Architect/Engineer will usually require underground piping to be of welded steel construction. Once this system is tested and the corrosive or cathodic protective coating added, it is superior to a threaded system due to the lack of metal removing threads. The threaded joint is more vulnerable when unprotected.

Test pressure requirements will usually be more stringent for a job with specifications governing the work as compared to the UPC. These usually higher and longer duration tests are for the added protection of the building Owner and occupants and should not be set aside in favor of a lesser test as prescribed by the UPC.

The protection of all types of underground fuel piping from corrosion is ver critical. It is recommended the student review Chapter 17, Corrosion.

Gasoline and fuel oil piping systems are best covered in the NFPA Manual No. 30, Flammable and Combustible Liquids Code. This, too, is recommended reading.

Steel piping is usually used for fuel piping, especially underground installations. Cathodic and/or other protection to prevent corrosion is mandatory. Piping installed above ground should also be treated with a coating where subject to corrosion. Other types of piping materials such as aluminum, brass, plastics or fiberglass, require care in installation the same or greater than steel. Low melting point materials should not be used as a fuel conduit in a high fire hazard area for obvious reasons.

Underground fuel tanks are usually steel, coated for corrosion protection, and in some cases protected with cathodic protection devices. Fiberglas tanks have come into some use recently. All connected piping, vents, fill, suction and return lines, shall be sloped to the tank. Tank tops shall be located below the floor level served with fuel in order to prevent gravity syphonage. If the tank is located above the level served the necessary back-syphonage valves should be installed in the suction piping.

Careful inspection of all underground fuel appurtenances is necessary to detect any abrasions or holidays in the protective coatings.

Underground L.P. tanks are a special case and the student is directed to NFPA Code No. 58. Special design considerations are necessary to protect this critical vessel from corrosion. Test plates are often required to be buried with the tank and dug up from time to time to check the rate of deterioration of the metals used. This is necessary because of high internal pressures.

Above ground L.P. tanks as described in NFPA No. 58 require very restrictive clearances from structures and property lines depending on their volume. The specialized tank appurtenances are usually supplied with the tank by the L.P. supplier and will not concern the Inspector. Piping from the tank to the building is governed by the UPC.

Lube oil tanks and waste oil tanks are in the same category as gasoline tanks. Although not highly flammable, oil can be hazardous when leakage allows accumulation in unwanted areas. Inspection of these installations is as critical as gasoline tanks.

Various agencies control the manufacture, transportation, installation and use of fuels. A few have been mentioned. Others are Pacific Gas & Electric Company, Public Utility Commission, American Gas Association, Factory Mutual Insurance, Underwriters' Laboratories. This is not a total list but will give the Inspector some idea of scope of control over this very important segment of the construction industry.

Sec. 1203 — Permit

(a) It shall be unlawful for any person to install, alter or repair or cause to be installed, altered or repaired any gas piping, without first obtaining a permit from the Administrative Authority to do so, provided however, no permit shall be required from a serving gas supplier to disconnect defective gas piping or equipment when authorized by Section 1209.

(b) Permits for gas piping shall show the total number of gas outlets to be provided for on each system, and such other information as may be required by the Administrative Authority.

Sec. 1204 — Plans Required

The Administrative Authority may require the submission of plans, specifications, drawings and such other information as he may deem necessary, prior to the commencement of, and at any time during the progress of any work regulated by this code.

Sec. 1205 — Workmanship

No gas piping shall be strained or bent and no appliance shall be supported by or develop any strain or stress on its supply piping. Gas piping supplying appliances designed to be supported by the piping may be used to support such appliances when first approved by the Administrative Authority.

Sec. 1206 — Inspections

(a) Upon completion of the installation, alteration or repair of any gas piping, and prior to the use thereof, the Administrative Authority shall be notified that such gas piping, is ready for inspection.

(b) All excavations required for the installation of underground piping shall be kept open until such time as the piping has been inspected and approved. If any such piping is covered or concealed before such approval, it shall be exposed upon the direction of the Administrative Authority.

(c) The Administrative Authority shall make the following inspections and shall either approve that portion of the work as completed, or shall notify the permit holder wherein the same fails to comply with this code.

(1) **Rough Piping Inspection:**

This inspection shall be made after all gas piping authorized by the permit has been installed, and before any such piping has been covered or concealed, or any fixture or appliance has been attached thereto. This inspection shall include a determination that the gas piping size, material and installation meet the requirements of this code.

(2) **Final Piping Inspection:**

This inspection shall be made after all piping authorized by the permit has been installed and after all portions thereof which are to be covered or concealed are so concealed and before any fixtures, appliance or shutoff valve has been attached thereto. This inspection shall include an air pressure test, at which time the gas piping shall stand a pressure of not less than ten (10) pounds per square inch gauge pressure, or at the discretion of the Administrative Authority the piping and valves may be tested at a pressure of at least six (6) inches of mercury measured with a manometer or slope gauge. Test pressures shall be held for a length of time satisfactory to the Administrative Authority, but in no case for less than fifteen (15) minutes with no perceptible drop in pressure. For welded piping, and for piping carrying gas at pressures in excess of fourteen (14) inches water column pressure, the test pressure shall not be less than sixty (60) pounds per square inch and shall be continued for a length of time satisfactory to the Administrative Authority, but in no case for less than thirty (30) minutes. These tests shall be made using air pressure only, and shall be made in the presence of the Administrative Authority. All necessary apparatus for conducting tests shall be furnished by the permit holder.

(d) In cases where the work authorized by the permit consists of a minor installation of additional piping to piping already connected to a gas meter, the foregoing inspections may be waived at the discretion of the Administrative Authority. In this event, the Administrative Authority shall make such inspection as he deems advisable in order to assure himself that the work has been performed in accordance with the intent of this code.

Sec. 1207 — Certificate of Inspection

(a) If, upon final piping inspection the installation is found to comply with the provisions of this code, a certificate of inspection may be issued by the Administrative Authority.

(b) A copy of the certificate of such final piping inspection shall be issued to the serving gas supplier supplying gas to the premises.

(c) It shall be unlawful for any serving gas supplier or person furnishing gas to turn on, or cause to be turned on, any gas meter or meters, until such certificate of final inspection, as herein provided, shall have been issued.

Sec. 1208 — Authority to Render Gas Service

(a) It shall be unlawful for any person, firm or corporation, excepting an authorized agent or employee of a person, firm or corporation engaged in the business of furnishing or supplying gas and whose service pipes supply or connect with the particular premises, to turn on or reconnect gas service in or on any premises where and when gas service is at the time not being rendered.

(b) It shall be unlawful to turn on or connect gas in or on any premises unless all outlets are properly and securely connected to gas appliances or capped or plugged with screw-joint fittings.

Sec. 1209 — Authority to Disconnect

(a) The Administrative Authority or the serving gas supplier is hereby authorized to disconnect any gas piping or appliance or both which shall be found not to conform to the requirements of this code or which may be found defective and in such condition as to endanger life or property.

(b) Where such disconnection has been made, a notice shall be attached to such gas piping or appliance or both, which shall state the same has been disconnected, together with the reasons therefor.

(c) Such attached notice shall not be removed, nor shall either gas piping or appliance be reconnected until authorized by the Administrative Authority to do so.

(d) It shall be unlawful to remove or disconnect any gas piping or gas appliance without capping or plugging with a screw joint fitting the outlet from which said pipe or appliance was removed. All outlets to which gas appliances are not connected shall be left capped gas-tight on any piping system which has been installed, altered or repaired.

Sec. 1210 — Temporary Use of Gas

Where temporary use of gas is desired and the Administrative Authority deems the use necessary, a permit may be issued for such use for a period of time not to exceed that designated by the Administrative Authority, provided that such gas piping system otherwise conforms to the requirements of this code regarding material, sizing and safety.

Sec. 1211 — Gas Meter Locations

(a) All gas meter locations shall be approved by the Administrative Authority and the serving gas supplier.

(b) Where more than one (1) meter is set on a particular premises, they shall all be set at one location, except where this is impractical. In multiple meter installations each separate gas piping system shall be identified by the permittee in a manner satisfactory to the serving gas supplier serving the gas.

(c) All gas meters shall be preceded by a main supply shut-off valve and shall be so placed as to be at all times readily accessible for inspection, reading, testing and shutting off the gas supply. All service piping or main supply shutoff valves must be outside of the building and readily accessible.

(d) In order that gas may be supplied, the gas piping inlet shall be located with respect to the proposed meter location, in accordance with the local serving gas supplier instructions.

(e) Access to enclosed gas meters, except those located in an approved vault supplied by the serving gas supplier, shall be through an opening or door not less in size than twenty-two (22) inches by twenty-four (24) inches, but in no event smaller than that specified by the local serving gas supplier.

(f) Gas meters shall not be located under a show window or under interior stairways or in engine, boiler, heater or electric meter rooms. Where not prohibited by other regulation, gas meters may be located in the open under exterior stairways.

Sec. 1212 — Material for Gas Piping

(a) All pipe used for the installation, extension, alteration, or repair of any gas piping shall be standard weight wrought iron or steel (galvanized or black), yellow brass (containing not more than seventy-five (75) per cent copper), or internally tinned or equivalently treated copper of iron pipe size.

(b) All such pipe shall be either new, or shall previously have been used for no other purpose than conveying gas; it shall be in good condition and free from internal obstructions. Burred ends shall be reamed to the full bore of the pipe.

(c) All fittings used in connection with the above piping shall be of malleable iron or yellow brass (containing not more than seventy-five (75) per cent copper).

(d) All valves and appurtenances used in connection with the above piping shall be of a type designed and approved for use with fuel gas.

Sec. 1213 — Installation of Gas Piping

(a) All joints in the piping system, unless welded, shall be screwed joints, having approved standard threads. Such screwed joints shall be made up with approved pipe joint material, insoluble in the presence of fuel gas and applied to the male threads only.

(b) No gas piping shall be installed in or on the ground under any building or structure and all exposed gas piping shall be kept at least six (6) inches above grade or structure. Concealed unprotected gas piping may be installed above grade in approved recesses or channels.

Exception: When necessary due to structural conditions, approved type gas piping may be installed in other locations when permission has first been obtained from the Administrative Authority.

(c) Where water vapor is present in the fuel gas served, accessible drip pipes shall be provided at points where condensation will tend to collect.

(d) Ferrous gas piping installed underground in exterior locations shall be protected from corrosion by approved coatings or wrapping materials and all such horizontal piping shall have at least twelve (12) inches of earth cover or other equivalent protection. Risers shall be wrapped to a point at least six (6) inches above grade.

(e) All gas pipe protective coatings shall be approved types, machine applied and conform to recognized standards. Field wrapping shall provide equivalent protection and is restricted to those short sections and fittings necessarily stripped for threading or welding. Zinc coatings (galvanizing) shall not be deemed adequate protection for piping below ground. Ferrous metals in exposed exterior locations shall be protected from corrosion in a manner satisfactory to the Administrative Authority.

(f) All gas piping shall be adequately supported by metal straps or hooks at intervals not to exceed those shown in Table 12-5. Gas piping installed below grade shall be effectively supported at all points on undisturbed or well compacted soil. Material used for backfill around the pipe, shall be free of rocks, building materials, ashes and trash.

(g) Gas piping supplying more than one building on any one premises shall be equipped with separate shut-off valves to each building, so arranged that the gas supply can be turned on or off to any individual or separate building. Such shut-off valve shall be located outside the building it supplies and shall be readily accessible at all times. Buildings accessory to single family residences are exempt from the requirements of this subsection.

(h) Where unions are necessary, right and left nipples and couplings shall be used. Ground-joint unions may be used at exposed fixture, appliance or equipment connections and in exposed exterior locations immediately on the discharge side of a building shut off valve. Heavy duty flanged type unions may be used in special cases when first approved by the Administrative Authority. Bushings shall not be used in concealed locations.

(i) When air, oxygen or other special supplementary gas under pressure is introduced with the regularly supplied gas either directly into the gas piping system or at burners, a device approved by the Administrative Authority and the serving Gas supplier shall be installed to prevent backflow of such special gas into the gas piping system or serving Gas supplier's meter. This device shall be located between the source of the special gas and the serving Gas supplier's meter and shall be on the gas line leading to the appliance using the special gas. This device may be either a spring loaded or diaphragm type check valve and shall be capable of withstanding any pressures which may be imposed on it.

(j) When liquefied petroleum or other stand-by gas is interconnected with the regular gas piping system, an approved three-way two-port valve or other adequate safeguard acceptable to the Administrative Authority and the serving Gas supplier shall be installed to prevent backflow into either supply system.

(k) Valves used in connection with gas piping shall be approved types.

(l) All gas outlets located in a barbecue or fireplace shall be controlled by an approved operating valve located in the same room and outside the hearth, but not more than four (4) feet from such outlets. When piping on the discharge side of any such control valve is standard weight brass or galvanized steel, such piping may be embedded in or surrounded by not less than two (2) inches of concrete or masonry.

(m) An accessible shut off valve of a type set forth in subsection (k) of this section, shall be installed in the fuel supply piping outside of each appliance and ahead of the union connection thereto, and in addition to any valve on the appliance. Shutoff valves shall be within three (3) feet of the appliance.

Shutoff valves may be located immediately adjacent to and inside or under an appliance when placed in an accessible and protected location and when such appliance may be removed without removal of the valve.

Shutoff valves may be accessibly located inside wall heaters and wall furnaces listed for recessed installation where necessary maintenance can be performed without removal of the shutoff valve.

Sec. 1214 — Appliance Connectors

(a) Appliance connections shall at no time have a diameter less than that of the inlet connection to the appliance as provided by the manufacturer and each appliance shall be rigidly connected to the gas piping with materials as provided in Section 1212.

Exception:

A gas appliance may be connected with an approved listed metal appliance connector under the following conditions:

(1) Listed metal appliance connectors shall have an overall length of not to exceed 3' except a range connector, which may not exceed 6'.

(2) No part of such connector shall be concealed within or extended through any wall, floor or partition.

(3) A listed accessible appliance connector valve not less than the nominal size of the connector shall be provided at the gas piping outlet immediately ahead of the connector.

(4) All connectors shall be of such size as to provide the total demand of the connected appliance based on the applicable Tables 12-3 or 12-3A.

(5) Aluminum alloy connectors may be used only in interior locations where they shall not be in contact with masonry, plaster or insulation or are not subject to repeated corrosive wettings.

(6) The connection of an indoor appliance with any type of gas hose is prohibited, except when used with laboratory or shop equipment or equipment that requires mobility during operation. Such connections shall have the shut-off or stopcock installed at the connection to the building piping. When gas hose is used, it shall be of the minimum practical length, but not to exceed six (6) feet, except for hand torches and special mobile equipment, and shall not extend from one room to another nor pass through any walls, partitions, ceilings or floors. Under no circumstances shall gas hose be concealed from view or used in a concealed location. Only listed gas hose shall be used and only in accordance with its listing. Gas hose shall not be used where it is likely to be subject to excessive temperatures (above 125°F) nor shall it be used as a substitute for a standard appliance connector.

(7) Outdoor portable appliances may be connected with an approved outdoor hose connector not to exceeed fifteen (15) feet in length provided it connects outdoors to approved gas piping including an approved valve at the inlet of the hose connector.

Sec. 1215 — Liquefied Petroleum Gas Facilities and Piping

In addition to the requirements of this code for gas piping, the facilities and piping for use with liquefied petroleum gas shall meet the following requirements:

(a) All liquefied petroleum gas facilities shall conform to approved standards. All such facilities and their locations shall be acceptable to the Administrative Authority and shall conform to state and local fire prevention regulations.

(b) Where liquefied petroleum gas facilities serve more than one (1) customer through separate piping systems, each system shall be identified in a manner satisfactory to the Administrative Authority and the gas supplier.

(c) All liquefied petroleum gas facilities shall be so placed as to be at all times readily accessible for inspection, reading, testing and shutting off the gas supply. All service piping and main supply shut-off valves shall be outside of the building. All main supply valves shall be of approved type and readily accessible.

(d) In order that gas may be supplied, the gas piping inlet shall be located with respect to the proposed liquefied petroleum gas facility location in accordance with the requirements of this section and the supplier's instructions.

(e) Liquefied petroleum gas facilities shall not be located in any pit or basement, under show windows or interior stairways, in engine, boiler, heater or electric meter rooms. When not prohibited by another regulation, approved liquefied petroleum gas metering devices may be located in the open under exterior stairways.

(f) Liquefied petroleum gas piping shall not serve any gas water heater located in a pit or basement where heavier than air gas might collect to form a flammable mixture.

(g) Pipe joint compounds used on thread connections shall be insoluble in liquefied petroleum gas.

(h) Every valve and appurtenance used on such piping shall be designed and approved for use with liquefied petroleum gas.

(i) Discharge from relief valves shall be into open air and shall be not less than five feet (5') horizontally away from any opening into a building which is below such discharge.

Sec. 1216 — Leaks

(a) Leaks in gas piping shall be located by applying soapy water to the exterior of the piping.

(b) Fire or acid shall not be used to locate or repair leaks, nor shall any substance other than air be introduced into the gas piping.

(c) It shall not be permissible to repair defects in gas piping or fittings, but upon having been located, the defective pipe, or fitting shall be removed and replaced with sound material.

Sec. 1217 — Interconnections of Gas Piping Systems

(a) It shall be unlawful to connect any gas appliance in such a manner that such appliance may receive gas from more than one system of gas piping.

(b) The installation, use or maintenance of a gas valve which makes it possible to turn on, control or otherwise direct the flow of gas from one system of gas piping to another, where such systems are supplied with gas from separate meters, is hereby prohibited and any such valves or other inter-connection between separate systems of gas piping shall be removed upon order of the Administrative Authority.

TABLE 12-1
Minimum Demand of Typical Gas Appliances in BTU Per Hour

Appliance	Demand in BTU
Domestic Gas Range	65,000
Domestic recessed top burner section	40,000
Domestic recessed oven section	25,000
Storage Water Heater — up to 30-gal. tank	30,000
Storage Water Heater — 40 to 50-gal. tank	50,000
Domestic Clothes Dryer	35,000
Fireplace Log Lighter (Residential)	25,000
Fireplace Log Lighter (Commercial)	50,000
Barbecue (Residential)	50,000
Gas Refrigerator	3,000
Bunsen Burner	3,000
Mobile Homes - Each (See Appendix E)	*
Gas Engines (per horsepower)	10,000
Steam Boilers (per horsepower)	50,000

Sec. 1218 — Required Gas Supply

(a) The following regulations as set forth in this section and in Section 1219 "Required Gas Piping Size" shall be the standard for the installation of gas piping. All natural gas regulations and tables are based on the use of gas having a specific gravity of sixty-five hundredths (.65), supplied at six (6) to eight (8) inches water column pressure at the outlet of the meter. For undiluted liquefied petroleum gas, gas piping may be sized for 2500 BTU per cu. ft. at eleven (11) inches water column and specific gravity of one and fifty-two hundredths (1.52).

(b) The hourly volume of gas required at each piping outlet shall be taken as not less than the maximum hourly rating, as specified by the manufacturer of the appliance or appliances to be connected to each such outlet.

(c) Where the gas appliances to be installed have not been definitely specified, Table 12-1 may be used as a reference to estimate requirements of typical appliances.

(d) The size of the supply piping outlet for any gas appliance shall be not less than one-half (½) inch.

The minimum size of any piping outlet for a freestanding gas range or a mobile home shall be three-quarter (¾) inch.

TABLE 12-3

Capacities of Listed Metal Appliance Connectors
For use with gas pressures not less than an eight (8") inch water column

Semi-Rigid Connector O.D.	Flexible Connector Nominal I.D.	Capacities for Various Lengths in Thousands BTU/Hr. (Based on Pressure Drop of 0.4" Water Column Natural Gas of 1100 BTU Cu. Ft.)							
		All Gas Appliances					Ranges Only		
		1 foot	1½ foot	2 foot	2½ foot	3 foot	4 foot	5 foot	6 foot
⅜"	¼"	40	33	29	27	25			
½"	⅜"	93	76	66	62	58			
⅝"	½"	189	155	134	125	116	101	90	80
	¾"	404	330	287	226	244			
	1"	803	661	573	534	500			

NOTES: 1) Flexible connector listings are based on nominal internal diameter; 2) Semi-rigid connector listings are based on outside diameter; 3) Gas connectors are certified by the testing agency as complete assemblies including the fittings and valves. Capacities shown are based on the use of fittings and valves supplied with the connector; 4) Capacities for LPG are 1.6 times the Nat. Gas capacities shown.

Example: Capacity of a ¼" flexible connector one foot long is 40,000 x 1.6 = 64,000 BTU/Hr.

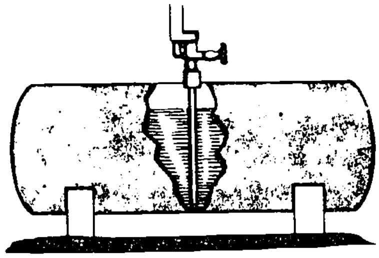
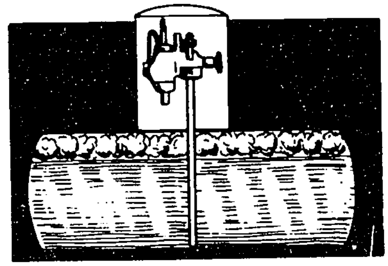
TABLE 12-3A

Capacities of Listed Metal Appliance Connectors
For use with gas pressures less than an eight (8") inch water column

Semi-Rigid Connector O.D.	Flexible Connector Nominal I.D.	Capacities for Various Lengths in Thousands BTU/Hr. (Based on Pressure Drop of 0.2" Water Column Natural Gas of 1100 BTU Cu. Ft.)							
		All Gas Appliances					Ranges Only		
		1 foot	1½ foot	2 foot	2½ foot	3 foot	4 foot	5 foot	6 foot
⅜"	¼"	28	23	20	19	17			
½"	⅜"	66	54	47	44	41			
⅝"	½"	134	110	95	88	82	72	63	57
—	¾"	285	233	202	188	174			
—	1"	567	467	405	378	353			

NOTES: 1) Flexible connector listings are based on nominal internal diameter; 2) Semi-rigid connector listings are based on outside diameter; 3) Gas connectors are certified by the testing agency as complete assemblies including the fittings and valves. Capacities shown are based on the use of fittings and valves supplied with the connector; 4) Capacities for LPG are 1.6 times the Nat. Gas capacities shown.

Example: Capacity of a ¼" flexible connector one foot long is 28,000 x 1.6 = 44,800 BTU/Hr.

Above Ground   Below Ground

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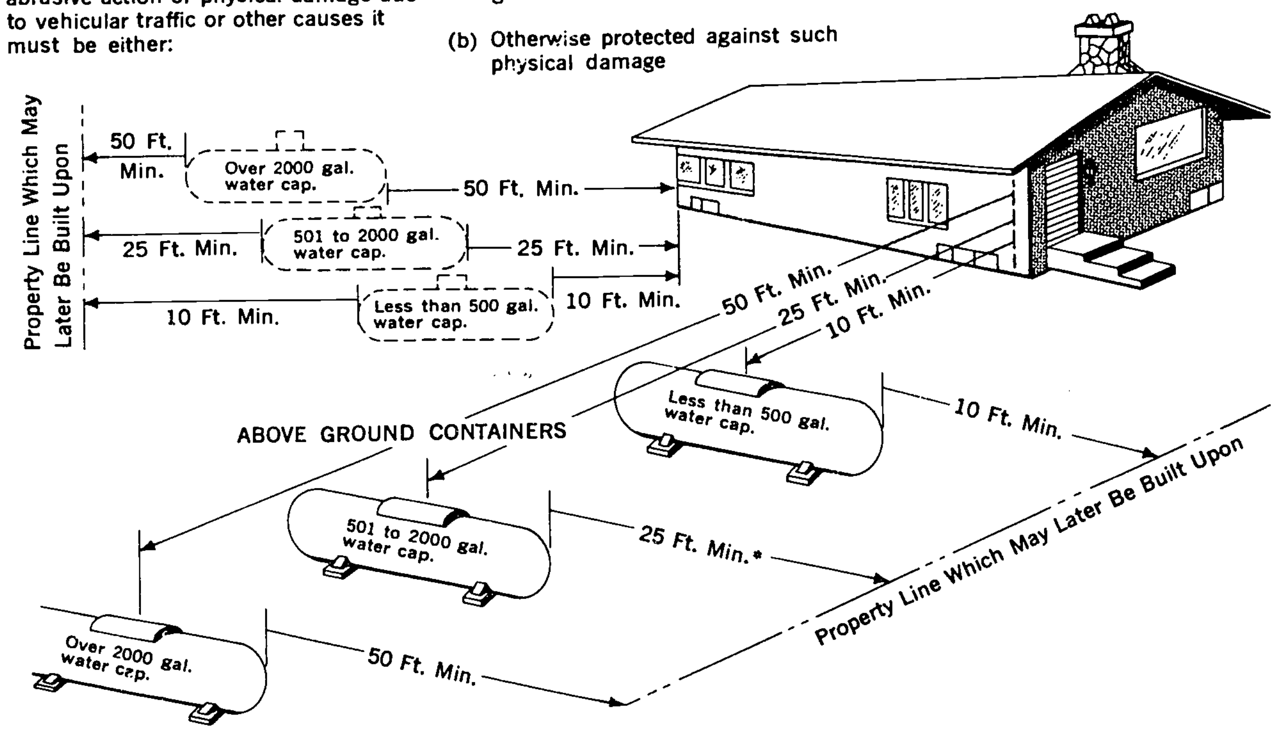
Where the container may be subject to abrasive action or physical damage due to vehicular traffic or other causes it must be either:

(a) Placed not less than 2 feet below grade

(b) Otherwise protected against such physical damage



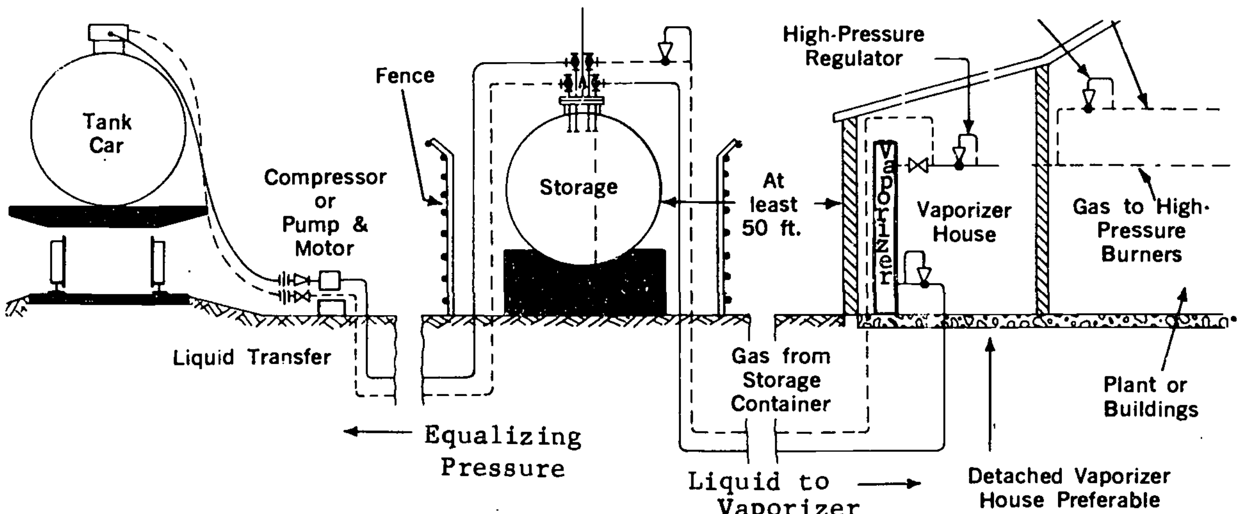
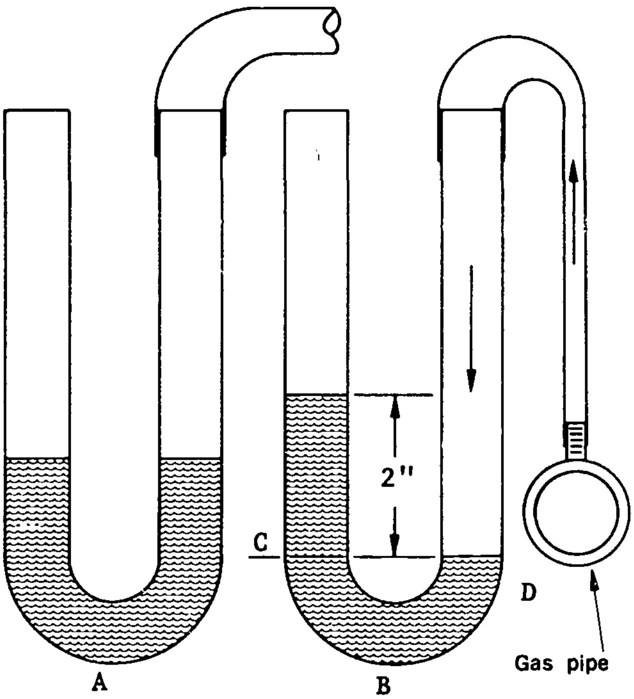


Fig. 12-1 L-P Gas Installation Details



No. 1

The very low pressures on the house side of a gas meter make the use of a "U-tube water gauge" (manometer) practical for measuring gas pressures.

In Fig. 2, we have a glass tube bent in a U shape and containing an amount of water (manometer partially filled with water) which, under no-pressure conditions, lies at equal depths in each leg—see U-tube at A.

In *B*, the U-tube has been connected to the gas pipe by a flexible tube that conducts the pressure of the gas from pipe to right-hand leg of the U-tube. The gas pressure pushes down on the water in the right leg until the water rises in the left leg to a point where its weight just balances (is equal to) the gas pressure in the right leg. The water in the bottom of the U-tube from *C* to *D* acts like a balance scale: it exactly balances the 2" high column of water on the left with the gas pressure on the right. The measurement indicated is a gas pressure of 2" of water column, or 2" w.c. This reading is a direct, accurate, legitimate expression of pressure.

A manometer is so constructed that, in use, the pressure of the gas is measured as a force applied against the surface of a quantity of liquid in a U-shaped tube. The pressure of the gas on one side of the tube forces the liquid to rise in the other leg of the tube. The liquid rises in that leg until the weight of the liquid column equal the pressure being applied.

Generally, manometers used in testing gas piping or appliances are filled with water. These manometers are read in inches and decimal fractions of an inch of water column.

It takes a water column of about 23' to balance a pressure of only 10 psi. But if we use a liquid like mercury in the gauge, we can measure pressures up to about 13 times higher.

Fig. 12-2 Manometer Description

CHAPTER 13

SPECIAL GAS SYSTEMS

General: Special gases, most often encountered by the Inspector, will occur in medical type facilities. These gases include oxygen, nitrous oxide, nitrogen, and medical air. Although not normally thought of as a "special gas system", vacuum piping systems must also be considered in this category. This would include both medical and floor vacuum. Other gases to be discussed are hydrogen and acetylene.

Most special gases, due to their hazardous characteristics, are carefully regulated by the National Fire Protection Association (NFPA) series of publications; they are considered codes by many building departments. Excerpts from the NFPA material will be used as the authoritative source for discussions in this Chapter.

Most gas systems are supplied from either bulk storage containers or a multiplicity of smaller cylinders. These storage areas are set aside in specially designated and designed spaces.

Manifold piping for cylinder systems are usually prefabricated by one of the recognized manufacturers of medical gas system specialties. Manifolds sold by acetylene systems for shop use may be prefabricated or field fabricated. In either case, master pressure regulating devices must be used at some point between the cylinders and the house supply line. Manifold construction and materials shall be as for the piping systems.

Oxygen and Nitrous Oxide: Oxygen is probably the best known of all medical gases but not often thought of in industrial use. Many large metal working shops pipe oxygen, along with acetylene, for gas welding and cutting use. Oxygen gas is odorless, colorless, tasteless and non toxic. Oxygen, by itself is nonflammable but supports and enhances combustion.

Nitrous oxide is also considered a hazardous gas since it too enhances combustion. Suggested regulations and practices for oxygen piping also apply to nitrous oxide.

Nitrous oxide is used as an anesthetic gas piped from a central cylinder system. This gas is usually restricted to surgery areas where it is commonly used.

Nitrogen piping systems should be installed the same as for oxygen piping except for more stringent requirements for pipe protection. Nitrogen is normally used in cast rooms to power bone saws.

All medical gas systems, regardless of the gas use, must be kept scrupulously clean inside throughout the entire installation. Careful inspection is necessary here.

(Refer to paragraph 415 of #56F-15) Recent accidents involving nitrous oxide have caused some cities to adopt more rigid regulations regarding protection of both oxygen and nitrous oxide piping. Thin wall electric metal tubing (EMT) is required as a conduit in nearly all locations: this includes above ceilings, in walls, in tunnels, and all areas where a possibility of damage exists perpetrated by unauthorized persons.

Hydrogen: Hydrogen is a flammable gas. It is colorless, odorless, tasteless and non-toxic. Central storage may include either cylinders or bulk. Since this gas is flammable, the NFPA recommends special fireproof construction for in house cylinder storage and a separate detached facility for a bulk storage tank.

Piping practices are much the same as for oxygen. Testing should also be similar to oxygen.

Acetylene and Oxygen: Acetylene and oxygen central distribution systems are used in metal shops for gas torch burning and welding systems. Steel piping is used for distribution since it could easily be subject to abuse. NFPA manual 51 describes the installation of these systems beginning with Chapter 4. Excerpts from this publication follow those from NFPA manual #56F-15.

Medical Vacuum: Most medical vacuum systems use type K soft temper copper with wrought copper or cast brass fittings. Water is rarely taken through this piping since separator bottles are used at each inlet station. Some specifications require that this piping be graded so it would be possible to flush and achieve gravity drainage. When so specified care must be taken to insure that the Contractor abides by the provisions of the specification.

Zoning valves are often used to facilitate branch piping isolation for extension or service. Ferrous pipe hangers, as on all copper piping systems must be isolated at contact points from the piping.

Listed below are piping specifications suggested by Ohio Chemical Company.

Piping Materials:

1. Piping: Concealed piping shall be seamless copper tubing, type K soft temper. ASTM designation No. B-88 for assembly with braze-joint fittings.

   Exposed piping shall be seamless copper tubing, type K, hard temper, ASTM designation No. B-88 for braze-joint fitting.

2. Fittings: Fittings for copper tubing (hard or soft temper) shall be wrought copper, brass or bronze designed expressly for brazing.

3. Brazing Alloy: For assembling braze-joint fittings Aircosil 45 silver brazing alloy, or a brazing alloy of equivalent melting point and physical properties shall be used.

4. Flux: Aircosil flux, or equal, shall be employed. Borax and alcohol mixtures or resin and similar flux shall not be used.

Fabrication:

1. Cleaning: Before erection, all pipe, valves, and fittings shall be examined for dirt and grease. If cleaning is required, use a hot solution of sodium carbonate or trisodium phosphate mixed in the proportions of one pound to three gallons of water. After washing, rinse parts in clean hot water.

2. Pipe and Tubing Joints: All joints in the pipe and tubing, except those at equipment requiring screwed connections, shall be made with bronze braze-joint type wrought fittings. Suitable adapters shall be employed for the installation of equipment provided with threaded connections.

   All brazed connections shall be made with the type of brazing alloy and flux specified in "Piping Materials", items 3 and 4. The joining process shall be that recommended by the manufacturer of the pipe or tubing and fittings. Avoid leaving excess flux inside of pipe and fittings.

   Brush flux back over entire end of fitting all around. This prevents oxidation of the end. Wash joints with hot water after assembly to crack and wash off flux. Use a wire brush if necessary.

*3. Screwed Connections: (A thin paste of litharge and glycerine shall be applied to the external threads only.) Leave first thread clean if possible. Use of excess glycerine shall be avoided. Key Abso-Lute, oxygen sealing compound can be employed.

4. Bends: All changes in direction requiring turns at offsets of radius less than five times the pipe or tubing outside diameter shall be made by Wal-seal or braze-type wrought copper, brass or bronze fittings or by pipe or tubing shaped by bending tools. All bends shall be free from any appreciable flattening, buckling or thinning of the tube wall at any point.

*Authors Note: Litharge (lead monoxide) and glycerine are no longer recommended for use here. A non-hardening thread lubricant by 3M is advised.

5. Erection: All pipe and tubing shall be cut accurately to measurements obtained at the site of the system and shall be installed without springing or forcing. All pipe and tubing shall be protected against mechanical injury in a manner satisfactory to authorities having jurisdiction.

6. Supports: To be spaced correctly for adequate support of all lines so that the weight shall be on the supports and not the joints.

   For horizontal piping 3/4 inch and larger, supports to be 10 feet apart. For 1/2 inch, they shall be 6 to 8 feet apart. On vertical lines the supports to be one to each story for piping one inch and smaller, and one support for each two stories for larger piping.

Testing:

After installation of the piping, but before attaching the vacuum line to the vacuum pump and before installation of the station outlet valves, the line shall be blown clear by means of (water-pumped) oil-free nitrogen or air.

Upon completion, the entire system, with outlets in place, shall be subjected to a test pressure of 150 psi, for a period of 24 hours, by means of water-pumped (oil-free) nitrogen or air. No pressure drop will be permitted except that due to temperature change.

If the system is found to be leaking, check each joint with a solution of soapy water. All leaks shall be properly repaired and the system retested.

Medical Air:

Air for inhalation therapy is rapidly growing in use in hospitals. Pipe installations are essentially the same as for oxygen without the necessity of hazard protection. Valves are located in accessible valve boxes alongside the oxygen and nitrous oxide zone valves.

The specifications suggested for this system are the same as those specified for the medical vacuum system.

Floor Vacuum:

Floor vacuum systems may be either dry or wet-dry. The latter is intended to handle water vacuumed up from the floor during a wet mop floor cleaning operation. This system must slope continuously to a moisture separator and accumulation tank installed ahead of the vacuum pump; the code requiremetns for a drainage line installation apply.

Copper or plastic tubing with drainage type long sweep fittings, is usually used for the wet-dry system with plastic or steel tubing applicable to the dry systems. Long sweep fittings are used for the dry system. Valves are not normally installed although a 100% area ball valve or plug cock could be used.

Specifications usually call for an air pressure test of 50 psi or less. Fittings are bubble tested with a soapy water solution and pressure sustained for 8 hours.

The dry vacuum systems are gaining popularity for residential use and also in other buildings where frequent cleaning is required.

NOTE: It is prudent here to reiterate the primary precaution in oxygen piping: KEEP ALL OIL AND GREASE FROM ENTERING THE OXYGEN SYSTEM.

Standard for NONFLAMMABLE MEDICAL GAS SYSTEMS

NFPA No. 56F — 1970

Chapter 1. General

Although oxygen and nitrous oxide are nonflammable gases, they accelerate combustion and, therefore, it is important to guard against leakage or rupture of any part of the piping system.

11. Scope

111. This standard applies to piped oxygen for therapeutic purposes, and also applies to the piping of oxygen or nitrous oxide and other nonflammable gases to any area of a hospital for medical purposes. Piping systems shall not be used for the distribution of combustible anesthetic gases.

112. Wherever the term "oxygen" occurs in this standard, the requirements shall apply to systems for nitrous oxide except as specifically provided in 212, 213, 222, 233 and 542.

113. This standard does not apply to the administration of nonflammable medical gases. The Standard for Inhalation Therapy, NFPA No. 56B, covers this area.

12. Definition

121. A piped distribution system consists of a central supply system with control equipment, and a system of piping extending to the points in the hospital where nonflammable medical gases may be required, and suitable station outlet valves at each use point.

122. A BULK OXYGEN SYSTEM is an assembly of equipment, such as oxygen storage containers, pressure regulators, safety devices, vaporizers, manifolds, and interconnecting piping, which has storage capacity of (a) more than 13,000 cubic feet of oxygen connected in service or ready for service, or (b) more than 25,000 cubic feet of oxygen including unconnected reserves on hand at the site. The bulk oxygen system terminates at the point where oxygen at service pressure first enters the supply line. The oxygen containers may be stationary or movable, and the oxygen may be stored as gas or liquid.

123. OPERATING SUPPLY is the portion of the supply system which normally supplies the piping systems. The operating supply consists of a primary supply or a primary and secondary supply.

124. The PRIMARY SUPPLY is that portion of the equipment which is actually supplying the system.

125. The SECONDARY SUPPLY, when one exists, automatically supplies the system when the primary supply becomes exhausted. This is a normal operating procedure of the equipment.

126. The RESERVE SUPPLY, when one exists, refers to that portion of the supply equipment which automatically supplies the system in the event of failure of the operating supply. The reserve supply only functions in an emergency and not as a normal operating procedure.

127. OIL FREE, DRY AIR — Air complying, as a minimum, with Grade D in Compressed Gas Association, Inc., Pamphlet G-7.1, "Commodity Specification for Air"*, and having a maximum dewpoint of minus 63°F.

128. OIL FREE, DRY NITROGEN — Nitrogen complying, as a minimum, with Grade D in Compressed Gas Association, Inc., Pamphlet G-10.1, "Commodity Specification for Nitrogen."*

*Available from the Compressed Gas Association, Inc., 500 Fifth Avenue, New York, N. Y. 10036.

Chapter 2. Source of Supply

21. Central Supply Systems

The central supply system shall be a system of cylinders and necessary supply equipment assembled as described in either 211 or 212, or a bulk supply system (213) which may be of the permanently installed type or the trailer type.

211. CYLINDER SYSTEM WITHOUT RESERVE SUPPLY: (See Figure 1.)

2111. A cylinder manifold system shall have two banks (or units) of cylinders which alternately supply the pipeline, each bank having a pressure regulating valve and cylinders connected to a common header. It is recommended that each bank contain a minimum of two cylinders or at least an average day's supply unless normal delivery schedules require a greater supply. When the content of the primary bank becomes exhausted, the secondary bank shall automatically operate to supply the pipeline.

2112. A check valve shall be installed between each cylinder lead and the manifold header.

NOTE: The purpose of this check valve is to prevent the loss of gas from the manifolded cylinders in the event the safety relief device on an individual cylinder should function or a cylinder lead (pigtail) should fail.

212. CYLINDER SUPPLY SYSTEMS WITH RESERVE SUPPLY: (See Figure 2.)

2121. A cylinder supply system with reserve supply shall consist of:

(a) A primary supply which supplies the pipeline.

(b) A secondary supply which shall operate automatically to supply the pipeline as the primary supply becomes exhausted.

(c) A reserve supply which shall operate automatically in the event both the primary and secondary supplies are unable to supply the pipeline.

2122. The reserve supply shall consist of three or more manifolded high pressure cylinders connected as required under 222 and (a) shall be equipped with check valves as required in 2112 or (b) shall be provided with an alarm switch which shall operate the emergency alarm signal when the reserve supply drops to 75 per cent of capacity.

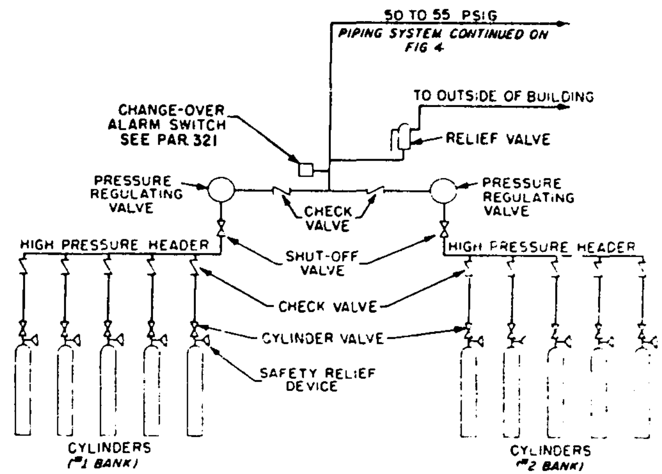


Fig. 1. Typical Oxygen or Nitrous Oxide Cylinder Supply System without Reserve Supply (Schematic)

Supply systems with different arrangements of valves and regulators are permissible if they provide equivalent safeguards.

2123. A liquid oxygen cylinder supply system shall be installed either (a) as indicated in Figure 2, or (b) as indicated in Figure 1 with the addition of a reserve supply connected as shown in Figure 2.

2124. When liquid oxygen cylinder supply systems are designed to prevent the loss of gaseous oxygen produced by the evaporation of liquid oxygen in the secondary supply, they shall be designed so that the gaseous oxygen produced shall pass through the line regulating valve before entering the oxygen piping.

2125. Liquid oxygen cylinder supply systems shall be constructed to withstand high pressure (2200 psig) or shall be provided with suitable pressure relief devices upstream of the control unit.

2126. Cylinder supply systems designed in accordance with 212, do not require check valves between each cylinder lead and the manifold header on the primary and secondary supply.

213. Bulk Oxygen Systems: (See Figure 3.)

2131. The bulk oxygen system shall consist of at least two sources of supply at all times. There are two common types of bulk supply systems:

(a) The alternating type with two or more units alternately supplying the pipeline. When the primary supply is exhausted, the secondary supply automatically becomes the primary supply and a new secondary supply is connected when or before this change-over takes place.

(b) The continuous type with one or more units continuously supplying the pipeline while another unit remains as the reserve supply and operates only in case of an emergency.

2132. The secondary supply referred to in 2131 (a), and the reserve supply referred to in 2131 (b), shall contain at least an average day's supply and shall consist of:

(a) three or more manifolded cylinders connected as required under 2112 and 222, or

(b) one or more containers provided an alarm switch is installed which shall operate the emergency alarm signal when the primary source is in operation and the reserve supply is down to 75 per cent of capacity or one day's average supply.

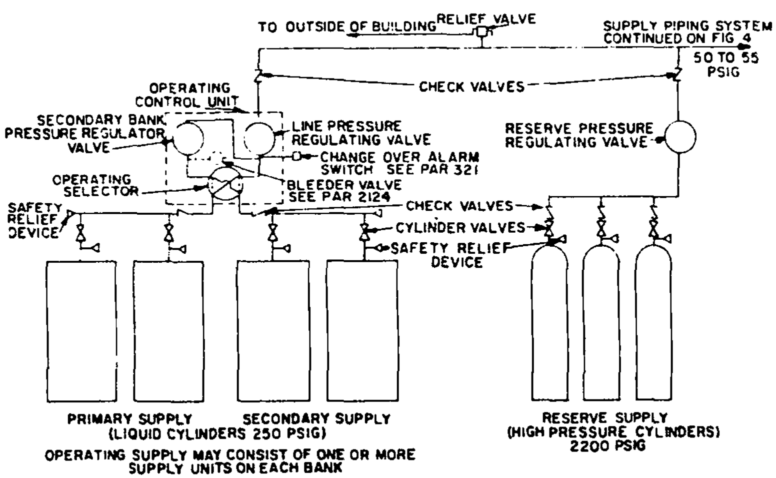


Fig. 2. Typical Oxygen Cylinder Supply System with Reserve Supply

Supply systems with different arrangements of valves and regulators are permissible if they provide equivalent safeguards.

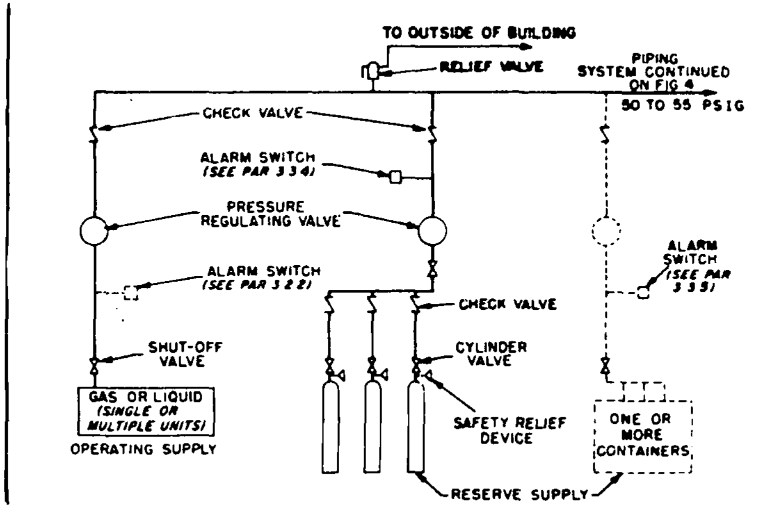


Fig. 3. Typical Oxygen Bulk Supply System (Schematic)

Bulk supply systems with different arrangements of valves, regulators, and gas supply units are permissible if they provide equivalent safeguards. Equipment shown in dotted lines indicates a reserve supply arrangement outlined in paragraph 2132(b).

22. General Requirements for Central Supply Systems

221. Cylinders shall be designed, constructed, tested and maintained in accordance with U.S. Dept. of Transportation (DOT) Specifications and Regulations.

222. Manifolds shall be of substantial construction and of a design and materials suitable for the service pressures involved. Mechanical means shall be provided to assure the connection of cylinders containing the proper gas to the manifold. Cylinder outlets for oxygen shall have a .903 inch — 14NGO-RH-EXT outside diameter for oxygen, industrial and medical (Connection No. 540, American-Canadian Standard for Compressed Gas Cylinder Valve Outlet and Inlet Connections, ANSI B57.1–1965, CSA B96–1965),* and for nitrous oxide .825 inch — 14NGO-RH-EXT standard cylinder valve outlet connection for nitrous

*Available from the Compressed Gas Association, 500 Fifth Avenue, New York, N. Y. 10036. Price $3.00 each. (CGA Pamphlet V-1.)

oxide (Connection No. 1320, American-Canadian Standard for Compressed Gas Cylinder Valve Outlet and Inlet Connections, ANSI B57.1–1965, CSA B96–1965).* When other nonflammable gases or gas mixtures are to be piped, care should be taken to assure noninterchangeability with other medical gases.

NOTE: It is advisable to obtain manifolds from, and have them installed under the supervision of, a manufacturer familiar with proper practices for their construction and use.

223. The pipeline system shall be capable of delivering 50–55 psig to all outlets at the maximum flow rate. Pressure regulating equipment, capable of maintaining a minimum dynamic delivery pressure of 50 psig at maximum flow rate of the pipeline system, shall be installed in the supply main upstream of the final line pressure relief valve (see 225).

224. A manually operated shutoff valve shall be installed upstream of each pressure regulating valve and a shutoff valve or a check valve shall be installed downstream.

225. A pressure relief valve set at 50 per cent above normal pipeline pressure shall be installed downstream of the pressure regulating valve, ahead of any shutoff valve. This pressure relief valve may be set at a higher pressure provided another pressure relief valve set at 50 per cent above normal pipeline pressure is installed in the main supply line. All pressure relief valves shall close automatically when excess pressure has been released. Pressure relief valves set at 50 per cent above normal pipeline pressure shall be vented to the outside if the total capacity of the manifolded cylinders is in excess of 1500 cubic feet of gas. Pressure relief valves shall be of brass or bronze and especially designed for oxygen service.

226. Enclosures for supply systems shall be provided with doors or gates which may be locked. Rooms for supply systems shall not be used for storage purposes other than for cylinders containing the nonflammable gases which are to be distributed through the pipeline. Storage of empty cylinders disconnected from the supply equipment pending their removal is permissible.

2261. Ordinary electrical wall fixtures in supply rooms shall be installed in fixed locations not less than 5 feet above the floor to avoid physical damage.

*See footnote, page 56F–10.

2262. When enclosures (interior or exterior) for supply systems are located near sources of heat such as furnaces, incinerators or boiler rooms, they shall be of construction so as to protect cylinders from overheating. Open electrical conductors and transformers shall not be located in close proximity to enclosures. Such enclosures shall not be located adjacent to oil storage tanks.

2263. Smoking shall be prohibited in supply system enclosures.

227. Supply systems complying with 212 or 213 (see Figures 2 and 3) shall have a check valve in the primary supply main, upstream of the point of intersection with the secondary or reserve supply main.

23. Location

231. Oxygen supply systems or storage locations of a total capacity in excess of 1500 cubic feet, but not exceeding the quantities specified in 233, when located within a hospital or similar occupancy, shall be enclosed in a separate room or enclosure within a room with a fire resistance rating of at least one hour. Enclosures shall not communicate directly with anesthetizing locations or storage locations for combustible anesthetic agents. The manifold enclosure shall be vented to the outside.

232. Oxygen supply systems of a total capacity of less than 1500 cubic feet may be enclosed in rooms not vented to the outside. Doors to such rooms shall be provided with louvres at top and bottom. Such rooms shall not communicate directly with anesthetizing locations or storage locations for combustible anesthetic agents.

233. Oxygen supply systems or storage locations of a total capacity of (a) more than 13,000 cubic feet connected in service or ready for service, or (b) more than 25,000 cubic feet of oxygen including unconnected reserves on hand at the site shall comply with the Standard for Bulk Oxygen Systems at Consumer Sites (NFPA No. 566).

Chapter 3. Warning Systems

31. General

311. Alarm signals and pressure gages shall be located to assure continuous responsible observation. Each signal and gage shall be appropriately labeled. The primary signal shall be installed in the office or principal working area of the individual responsible for maintenance of the oxygen system.

NOTE: To assure continuous surveillance, an auxiliary visual and audible signal should be located at the telephone switchboard, the security office, or other suitable location.

312. All the signal systems shall be energized by the normal and emergency electrical power systems.

32. "Operating" Alarm Systems

321. An operating alarm system shall be provided when a piping system is supplied by a manifold or bulk system having as a part of its normal operation a change-over from one portion of the supply to another portion, to indicate by audible and visual signals when or just before this change-over occurs. The visual signal in this system shall be different than the "emergency" alarm system described in paragraph 331.

322. When the operating supply of a bulk system is normally used down to the pressure setting of the reserve supply regulating valve, an alarm switch shall be installed so as to actuate the operating alarm system when the quantity of oxygen in the operating supply is an average day's supply unless normal delivery schedules require a greater quantity.

33. "Emergency" Alarm Systems

331. An emergency alarm system shall be provided to indicate, by audible and visual primary signals, that the oxygen supply system (manifold or bulk) is not functioning properly. This alarm system shall be actuated by any one of the following conditions: low or high line pressure (see 332), operation of (emergency) reserve supply (see 334), or loss of reserve supply (see 335).

332. An automatic pressure switch shall be connected to the main supply line which will actuate the emergency alarm system when the line pressure drops approximately 20 percent below normal operating pressure or increases approximately 20 percent above normal operating pressure.

333. To facilitate surveillance of the oxygen supply for the anesthetizing and other vital life support locations (such as the recovery room, intensive care unit, and coronary care unit), a separate secondary visual and audible low/high pressure signal (actuated by the pressure in the line being monitored) and an indicating pressure gage shall be provided. These secondary signals and pressure gages may be located at nurses stations or other suitable locations near the point of use.

334. When a bulk supply consists of one or more units which continuously supply the pipeline while another unit remains as the (emergency) reserve supply, an alarm switch shall operate the emergency alarm system when or just before the (emergency) reserve supply goes into operation.

335. When check valves are not provided in each cylinder lead of a reserve supply, an alarm switch shall operate the emergency alarm system when the reserve supply drops to 75 per cent of capacity or 1 day's supply.

Chapter 4. Pipeline Systems

41. Pipelines

411. Pipelines shall be seamless Type K or L (ASTM B-88) copper tubing or standard weight (Schedule 40) brass pipe. Copper tubing should preferably be hard temper for exposed locations and soft temper for underground or concealed locations. Pipe sizes shall be in conformity with good engineering practice for proper delivery of maximum volumes specified. Gas piping shall not be supported by other piping but shall be supported with pipe hooks, metal pipe straps, bands or hangers suitable for the size of pipe, and of proper strength and quality at proper intervals, so that piping cannot be moved accidentally from the installed position as follows:

½-inch pipe or tubing	6 feet
¾-inch or 1-inch pipe or tubing	8 feet
1¼ inch or larger (horizontal)	10 feet
1¼ inch or larger (vertical)	every floor level

412. All fittings used for connecting copper tubing shall be wrought copper, brass, or bronze fittings made especially for solder or brazed connection, except as provided in 413. Brass pipe shall be assembled with screw type brass fittings or with bronze or copper brazing type fittings. (See also 512.)

413. Approved gas tubing fittings may be used on gas distribution lines when pipe sizes are one-half inch nominal or less if the fitting is so installed as to be visible in the room. Such fittings may also be used in connecting copper tubing of three-quarter inch nominal or less to shutoff valves described in Section 42 providing the fittings are readily accessible.

414. Buried piping shall be adequately protected against frost, corrosion and physical damage. Ducts or casings may be used. Oxygen piping may be placed in the same tunnel, trench or duct with fuel gas pipelines, electrical lines or steam lines, if separated, provided there is good natural or forced ventilation. Oxygen pipelines shall not be placed in a tunnel, trench or duct where exposed to contact with oil.

* **415.** Oxygen pipelines installed in combustible partition shall be protected against physical damage by installation within pipe or conduit. Openings for pipelines installed in concealed spaces shall be fire-stopped with construction having a fire resistance equal to or greater than the original construction. Oxygen risers may be installed in pipe shafts if suitable protection against physical damage, effects of excessive heat, corrosion, or contact with oil is provided. Oxygen risers shall not be located in elevator shafts.

416. Exposed oxygen pipelines should not be installed in storage rooms for combustible materials, kitchens, laundries, or other areas of special hazard. Where installation of oxygen pipelines in such locations is unavoidable, the piping shall be protected by an enclosure which will prevent the liberation of oxygen within the room should leaks occur in the piping system installed in the enclosure.

417. Pipelines exposed to physical damage, such as might be sustained from the movement of portable equipment such as carts, stretchers, and trucks, in corridors and other locations shall be provided with suitable protection.

418. The gas content of pipelines shall be readily identifiable by appropriate labeling with the name of the gas contained. Such labeling shall be by means of metal tags, stenciling, stamping, or with adhesive markers, in a manner that is not readily removable. Labeling shall appear on the pipe at intervals of not more than 20 feet and at least once in each room and each story traversed by the pipeline.

419. Piping systems for gases shall not be used as a grounding electrode.

42. Shutoff Valves

421. All shutoff valves accessible to other than authorized personnel shall be installed in valve boxes with frangible windows large enough to permit manual operation of valves and labeled in substance as follows:

CAUTION — OXYGEN VALVES.

DO NOT CLOSE EXCEPT IN EMERGENCY.

THIS VALVE CONTROLS OXYGEN SUPPLY TO..................

422. The main oxygen supply line shall be provided with a shutoff valve so located as to be accessible in an emergency.

423. Each riser supplied from the main line shall be provided with a shutoff valve adjacent to the riser connection.

424. Patient outlet stations shall not be supplied directly from a riser unless a manual shutoff valve located in the same story is installed between the riser and the outlet with a corridor wall intervening (see Figure 4). This valve shall be readily operable from a standing position in the corridor on the same floor which it serves. Each lateral branch line serving patient rooms shall be provided with a shutoff valve that controls the flow of oxygen to the patient rooms. Branch line shutoff valves shall be so arranged that shutting off the supply of oxygen to one branch will not affect the supply of oxygen to the rest of the system.

425. Anesthetizing locations shall be supplied directly from the riser without intervening valves except as provided in paragraph 426 or 427.

426. A shutoff valve (see also paragraph 427) shall be located outside or inside each anesthetizing location in each oxygen or nitrous oxide line, so located as to be readily accessible at all times for use in an emergency. These valves shall be so arranged that shutting off the supply of gas to any one operating room or anesthetizing location will not affect the others. Valves shall be of approved type, mounted on a pedestal or otherwise properly safeguarded against physical damage, and marked to prohibit tampering or inadvertent closing, such as, "OXYGEN — DO NOT CLOSE."

427. A shutoff valve located immediately outside anesthetizing locations (paragraph 426) is not required provided that service valves for oxygen and nitrous oxide located within anesthetizing locations are equipped with pipes extending at least six feet horizontally which terminate with female members of approved noninterchangeable quick-couplers for oxygen and nitrous oxide.

43. Station Outlets

431. Each station outlet for oxygen or nitrous oxide shall be equipped with either a manually operated or automatic shutoff valve and shall be legibly labeled with the name of the gas.

432. Manually operated valves shall be equipped with non-interchangeable connections complying with Diameter-Index Safety System (A Standard for Noninterchangeable Low Pressure Connections for Medical Gases, Air and Suction) CGA Pamphlet V-5.* Threaded outlets shall be provided with a cap and chain to protect the outlet when not in use or shall be installed in a recessed valve box equipped with a door.

*Available from the Compressed Gas Association, Inc., 500 Fifth Avenue, New York, N. Y., 10036. (CGA Pamphlet V-5.)

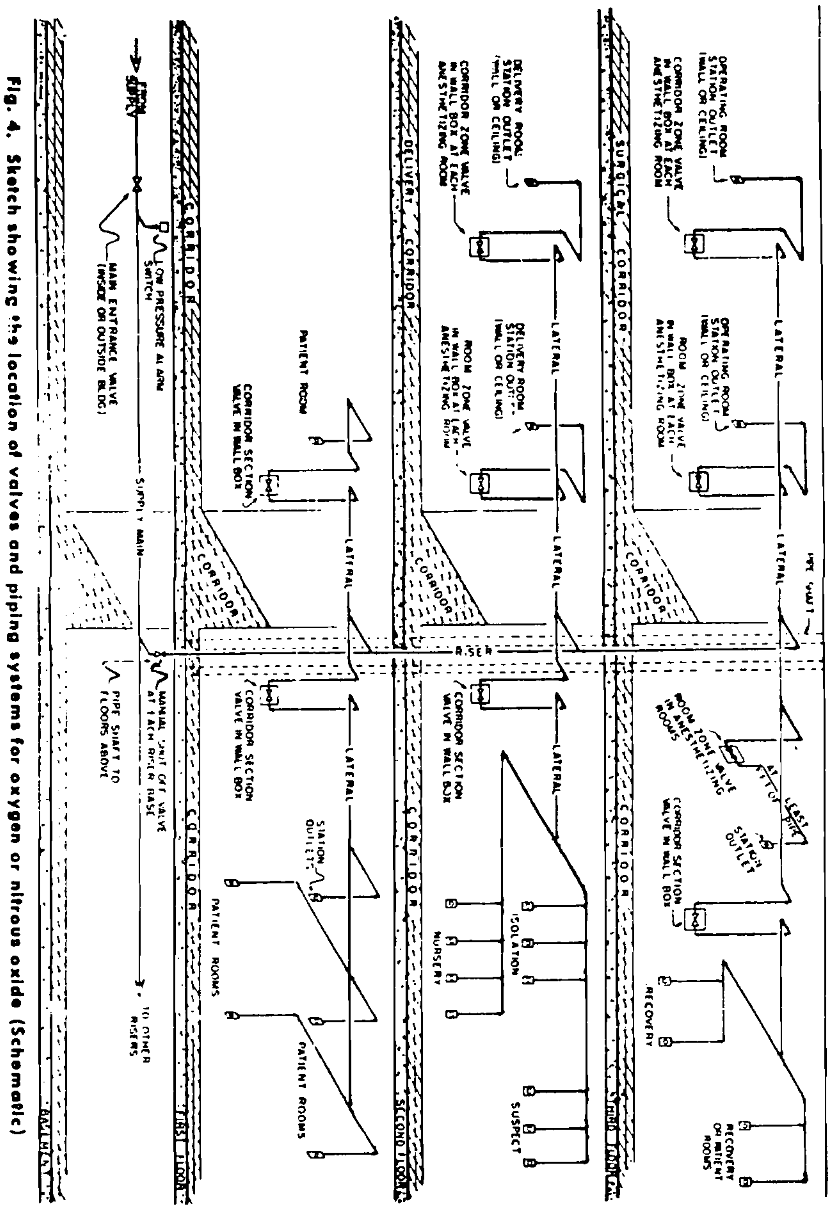


Fig. 4. Sketch showing the location of valves and piping systems for oxygen or nitrous oxide (Schematic)

433. Each station outlet equipped with a female member of an approved quick-coupler of the noninterchangeable type for oxygen or nitrous oxide service, and so identified, shall be provided with an automatic shutoff valve incorporated in such a manner that when the quick-coupler is removed from the pipeline for repair, the flow of oxygen or nitrous oxide shall be shut off until the female member of the quick-coupler is reattached.

434. Female members of the quick-couplers of the noninterchangeable types for oxygen or nitrous oxide may be attached to manually operated noninterchangeable station shutoff valves for oxygen or nitrous oxide service.

435. Each oxygen delivery line servicing anesthetic apparatus through a yoke insert shall have a back-check valve installed in the line immediately adjacent to the yoke insert. Each back-check valve shall be designed to hold a minimum pressure of 2400 psi.

NOTE: The purpose of the back-check valve is to prevent back-flow of oxygen from a small cylinder containing oxygen under high pressure which may be attached to the same pressure reducing valve. This arrangement will prevent accidental rupture of the connecting hose and pipe system should it be necessary to open the small cylinder in emergency. If the oxygen delivery line servicing anesthetic apparatus can be directly connected to the oxygen flow meter, independent of the emergency supply of oxygen from a high pressure cylinder, a back-check valve will not be necessary.

436. Station outlets in patients' rooms shall be located approximately five feet above the floor or suitably recessed to avoid physical damage to the valve or control equipment, such as humidifying bottles, when attached.

437. All pressure gauges and manometers for oxygen, including gauges applied temporarily for testing purposes, shall be those manufactured expressly for that gas and labelled: OXYGEN — USE NO OIL!

Chapter 5. Installation and Testing of Piping Systems

51. General

511. BEFORE ERECTION, all piping, valves and fittings — except those supplied especially prepared for oxygen service by the manufacturer and received sealed on the job — shall be thoroughly cleaned of oil, grease and other readily oxidizable materials by washing in a hot solution of sodium carbonate or trisodium phosphate (proportion of one pound to three gallons of water). THE USE OF ORGANIC SOLVENTS; FOR EXAMPLE, CARBON TETRACHLORIDE, IS PROHIBITED. Scrubbing shall be employed where necessary to insure complete cleaning. After washing, the material shall be rinsed thoroughly in clean, hot water. After cleaning, particular care shall be exercised in the storage and handling of all pipe and fittings. Pipe and fittings shall be temporarily capped or plugged to prevent recontamination before final assembly. Tools used in cutting or reaming shall be kept free from oil or grease. Where such contamination has occurred, the items affected shall be rewashed and rinsed.

512. All joints in the piping, except those permitted to be approved brass flared type gas tubing fittings and those at valves or at equipment requiring screw connections shall be made with silver brazing alloy or similar high melting point (at least 1000 F.) brazing metal. Particular care shall be exercised in applying the flux to avoid leaving any excess inside the completed joints. The outside of the tube and fittings shall be cleaned by washing with hot water after assembly.

513. Screw joints used in shutoff valves, including station outlet valves, shall be installed by tinning the male thread with soft solder. Litharge and glycerin or an approved oxygen luting or sealing compound are acceptable.

514. After installation of the piping, but before installation of the outlet valves, the line shall be blown clear by means of oil free, dry air or nitrogen (see 127 and 128).

52. Pressure Testing

521. After installation of station outlet valves, each section of the pipeline systems shall be subjected to a test pressure of one and one-half (1½) times the maximum working pressure, but not less than 150 psig, with oil free, dry air or nitrogen (see

127 and 128). This test pressure shall be maintained until each joint has been examined for leakage by means of soapy water or other equally effective means of leak detection safe for use with oxygen.

5211. A visual inspection of each brazed joint is recommended to make sure that the alloy has flowed completely in and around the joint and that hardened flux has not formed a temporary seal which holds test pressure. Remove all excess flux for clear visual inspection of brazed connections. All leaks shall be repaired and the section retested.

522. After completing the testing of each individual pipeline system, all of the associated pipeline systems shall be subjected to a 24-hour standing pressure test at one and one-half (1½) times the maximum working pressure, but not less than 150 psig. The test gas shall be oil free, dry air or nitrogen (see 127 and 128).

5221. After the pipeline systems are filled with test gas, the supply valve and all outlet valves should be closed and the source of test gas disconnected. The system shall remain leak-free for 24 hours.

NOTE: When making the standing pressure test, the only allowable pressure changes during the 24-hour test period shall be those caused by variations in the ambient temperature around the pipeline system. Such changes can be checked by means of the pressure-temperature relationship: calculated final absolute pressure (absolute pressure is gage pressure plus 14.7 psi if gage is calibrated in "psi") equals the initial absolute pressure times the final absolute temperature (absolute temperature is temperature reading plus 460°F if thermometer is calibrated in Fahrenheit degrees), divided by the initial ansolute temperature. $\left(P_f = \frac{P_i \times T_f}{T_i}\right)$

53. Cross Connection Testing

531. To determine that no cross connection to other pipeline systems exists, reduce all systems to atmospheric pressure. Disconnect all sources of test gas from all of the systems with the exception of the one system to be checked. Pressure this system with oil free, dry air or nitrogen (see 127 and 128) to a pressure of 50 psig. With appropriate adaptors matching outlet labels, check each individual station outlet of all systems installed to determine that test gas s being dispensed from only the outlets of this system.

532. Disconnect the source of test gas and reduce the system tested to atmospheric pressure. Proceed to test each additional pipeline system in accordance with 531.

54. Final Testing — Purging and Analyzing

541. When all medical gas piping systems have been tested in accordance with Sections 52 and 53, the source of test gas shall be disconnected and the proper gas source of supply connected to each respective system. Following this connection and pressurization, all outlets shall be opened in a progressive order, starting nearest the source and completing the process of purge flushing at the outlet farthest from the source. Gas shall be permitted to flow from each outlet until each system is purged of test gas used during previous tests.

542. After completion of purge flushing of the pipeline system in accordance with 541, the outflow from each designated and labeled oxygen outlet station shall be tested, using an oxygen analyzer to confirm the presence of the desired purity of oxygen.

543. The test specified in 542 shall be conducted whenever changes are made to a piping system.

NOTE: A similar procedure should be followed at the outlet of anesthesia machines and other oxygen dispensing equipment supplied by the oxygen pipeline system.

43. Piping, Tubing and Fittings.

431. Piping, tubing and fittings shall be suitable for hydrogen service and for the pressures and temperatures involved. Cast iron pipe and fittings shall not be used.

432. Piping and tubing shall conform to Section 2—"Industrial Gas and Air Piping"—USA Standard Code for Pressure Piping (USA B.31.1).*

433. Joints in piping and tubing may be made by welding or brazing or by use of flanged, threaded, socket or compression fittings. Gaskets and thread sealants shall be suitable for hydrogen service.

44. Equipment Assembly.

441. Valves, gauges, regulators and other accessories shall be suitable for hydrogen service.

442. Installation of hydrogen systems shall be supervised by personnel familiar with proper practices with reference to their construction and use.

443. Storage containers, piping, valves, regulating equipment and other accessories shall be readily accessible, and shall be protected against physical damage and against tampering.

444. Cabinets or housings containing hydrogen control or operating equipment shall be adequately ventilated.

445. Each mobile hydrogen supply unit used as part of a hydrogen system shall be adequately secured to prevent movement.

446. Mobile hydrogen supply units shall be electrically bonded to the system before discharging hydrogen.

45. Marking.

451. The hydrogen storage location shall be permanently placarded as follows: "HYDROGEN—FLAMMABLE GAS—NO SMOKING—NO OPEN FLAMES," or equivalent.

* Obtainable from United States of America Standards Institute, 10 East 40th St., New York, N. Y. 10016 or The American Society of Mechanical Engineers, 29 West 39th St., New York, N. Y. 10018.

46. Testing.

461. After installation, all piping, tubing and fittings shall be tested and proved hydrogen gas tight at maximum operating pressure.

5. Location of Gaseous Hydrogen Systems

51. General.

511. The system shall be located so that it is readily accessible to delivery equipment and to authorized personnel.

512. Systems shall be located above ground.

513. Systems shall not be located beneath electric power lines.

514. Systems shall not be located close to flammable liquid piping or piping of other flammable gases.

515. Systems near aboveground flammable liquid storage shall be located on ground higher than the flammable liquid storage except when dikes, diversion curbs, grading, or separating solid walls are used to prevent accumulation of flammable liquids under the system.

52. Specific Requirements.

521. The location of a system, as determined by the maximum total contained volume of hydrogen, shall be in the order of preference as indicated by Roman numerals in Table 1.

TABLE 1

Nature of Location	Size of Hydrogen System: Less than 3,000 CF	3,000 CF to 15,000 CF	In Excess of 15,000 CF
Outdoors	I	I	I
In a separate building	II	II	II
In a special room	III	III	Not Permitted
Inside buildings not in a special room and exposed to other occupancies	IV	Not Permitted	Not Permitted

or an approved hydraulic back-pressure valve is installed at each outlet. Outlets provided on headers for oxygen service may be fitted for use with pressure-reducing regulators or for direct hose connection.

336. Each service outlet on portable outlet headers shall be provided with a valve assembly that includes a detachable outlet seal cap, chained or otherwise attached to the body of the valve.

337. Materials and fabrication procedures for portable outlet headers shall comply with Sections 40, 41 and 44.

338. Portable outlet headers shall be provided with frames which will support the equipment securely in the correct operating position and protect them from damage during handling and operation.

34. Manifold Operating Procedures

341. The pressure in the gas cylinders connected to and discharged simultaneously through a common manifold shall be approximately equal.

CHAPTER 4. SERVICE PIPING SYSTEMS

40. Materials and Design

401. General

4011. Piping and fittings shall comply with Section 2 (Industrial Gas and Air Piping Systems) of the USA Standard Code for Pressure Piping, USA B31.1 — 1955* insofar as it does not conflict with Section 41 and except as follows:

a. Pipe shall be at least Schedule 40 and fittings shall be at least standard weight in sizes up to and including 6-inch nominal.

*Available from American Society of Mechanical Engineers, 345 East 47th Street, New York, New York 10017.

b. Copper tubing shall be Types K or L in accordance with the Standard Specification for Seamless Copper Water Tube, ASTM B88-62.*

4012. Piping shall be steel, wrought iron, brass or copper pipe, or seamless copper, brass or stainless steel tubing, except as provided in 402 and 403.

402. Oxygen Piping

4021. Oxygen piping and fittings at pressures in excess of 700 psig, shall be stainless steel or nonferrous metal.

4022. Hose connections and hose complying with Section 54 may be used to connect the outlet of a manifold pressure regulator to piping providing the working pressure of the piping is 250 psig or less and the length of the hose does not exceed 5 feet. Hose shall have a minimum bursting pressure of 1000 psig.

4023. When oxygen is supplied to a service piping system from a low-pressure oxygen manifold without an intervening pressure regulating device, the piping system shall have a minimum design pressure of 250 psig. A pressure regulating device shall be used at each station outlet when the connected equipment is intended for use at pressure less than 250 psig.

403. Piping for Acetylene and Methylacetylene-propadiene, stabilized

4031. Piping shall be steel or wrought iron.

4032. Unalloyed copper shall not be used except in listed equipment.

4033. Acetylene shall not be piped (except in approved cylinder manifolds) or utilized at a pressure in excess of 15 psig.

NOTE: This provision is not intended to apply to the storage of acetylene in cylinders manufactured to DOT(ICC)** Specifications.

41. Piping Joints

411. Joints in steel or wrought iron piping shall be welded, threaded or flanged. Fittings, such as ells, tees, couplings and unions, may be rolled, forged or cast steel, malleable iron or nodular iron. Gray or white cast-iron fittings are prohibited.

*Available from American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pa. 19103.

**See Definitions.

412. Joints in brass or copper pipe shall be welded, brazed, threaded or flanged. If of the socket type, they shall be brazed with silver-brazing alloy or similar high melting point filler metal.

413. Joints in seamless copper, brass, or stainless steel tubing shall be approved gas tubing fittings or the joints shall be brazed. If of the socket type, they shall be brazed with silver-brazing alloy or similar high melting point filler metal.

414. Threaded connections in oxygen pipe shall be tinned or made up with litharge and glycerine, litharge and water, or other joint compound approved for oxygen service applied to the male threads only.

42. Installation

421. Piping shall be run as directly as practicable, protected against corrosion and physical damage, and allowance made for expansion, contraction, jarring and vibration.

422. Oxygen piping may be placed in the same tunnel, trench or duct with fuel gas pipelines, provided there is good natural or mechanical ventilation and there is no contact with oil.

423. Low points in piping carrying moist gas shall be drained into drip pots constructed so as to permit pumping or draining out the condensate at necessary intervals. Drain valves shall be installed for this purpose having outlets normally closed with screw caps or plugs. Open-end valves or petcocks shall not be used, except that in drips located outdoors and underground and not readily accessible, valves may be used at outlets if they are equipped with means to secure them in the closed position. Pipes leading to the surface of the ground shall be cased or jacketed where necessary to prevent loosening or breaking.

424. Readily accessible gas valves shall be provided to shut off the gas supply to buildings in cases of emergency. A shutoff valve shall be installed in the discharge from the generator, gas holder, manifold or other source of supply.

425. Fittings and lengths of pipe shall be examined internally BEFORE ASSEMBLY and, if necessary, freed from scale or dirt. Oxygen piping and fittings shall be washed out with a suitable solution which will effectively remove grease and dirt but will not react with oxygen.

Note: Hot water solutions of caustic soda or trisodium phosphate are effective cleaning agents for this purpose.

426. Piping shall be thoroughly blown out after assembly to remove foreign materials. For oxygen piping, oil-free air or oil-free nitrogen shall be used. For other piping, air or inert gas may be used.

43. Painting and Signs

431. Underground pipe and tubing and outdoor ferrous pipe and tubing shall be covered or painted with a suitable material for protection against corrosion.

432. Aboveground piping systems shall be marked in accordance with USA Standard A13.1-1956, "Scheme for Identification of Piping Systems."*

433. Station outlets shall be marked to indicate their intended usage.

434. Signs clearly establishing the location and identity of section shutoff valves should be provided.

44. Testing

441. Piping systems shall be tested and proved gastight at one and one-half times the maximum operating pressure, and shall be thoroughly purged of air before being placed in service. The material used for testing oxygen lines shall be oil-free and nonflammable. Flames shall not be used to detect leaks.

442. When combustible gas lines or other parts of equipment are being purged of air or gas, sources of ignition shall not be permitted near uncapped openings.

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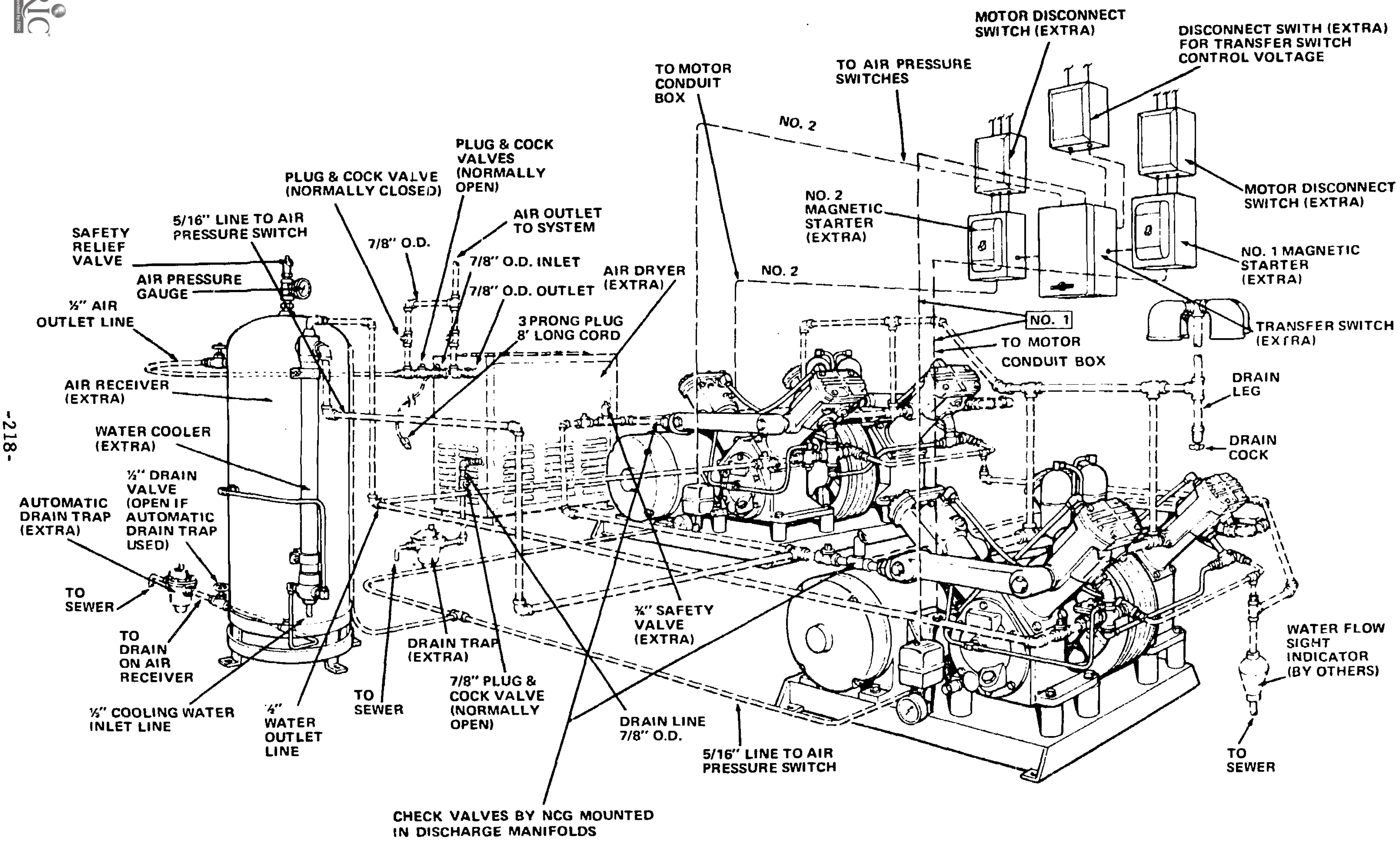
*Available from American Society of Mechanical Engineers, 345 East 47th Street, New York, N. Y. 10017.



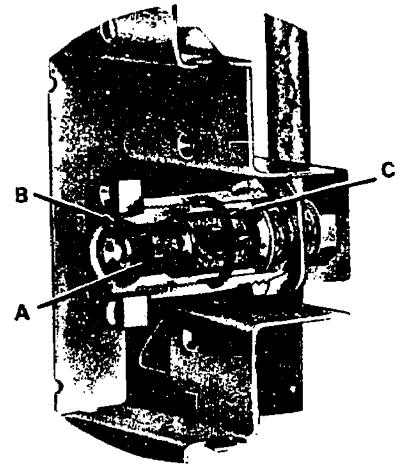
MEDICAL AIR COMPRESSOR TYPICAL PIPING

-No Scale-

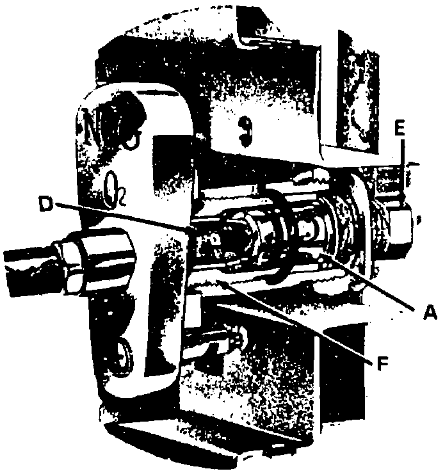
Courtesy-
National Cylinder Gas Co.

Fig. 13-1

MEDICAL GAS OUTLET CUTAWAY

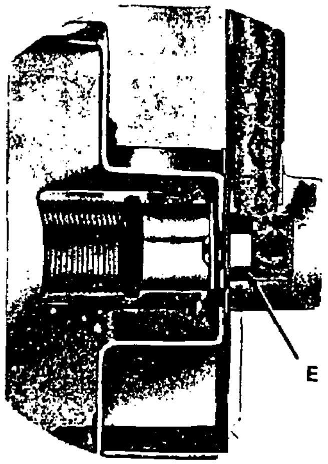


When not in use, this is the non-flowing condition of a gas outlet installed in hospital wall. Poppet "A" maintains gas seal, utilizing O-Ring "B". Valve body seal is maintained by O-Ring "C".



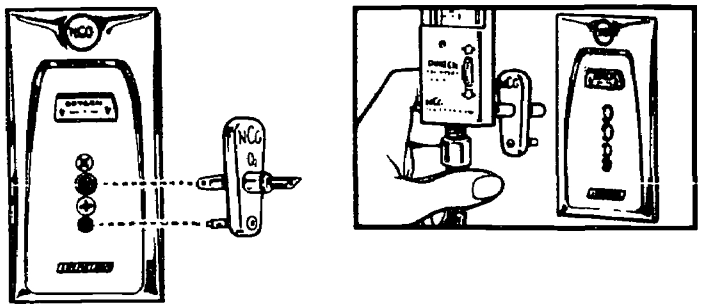
Nose "D" of the inserted adapter has moved poppet "A inward, through O-Ring seal, and gas flows through the adapter. Leakproof seal of adapter is accomplished around the O-Ring encircling the barrel. Marring and nicking of adapter nose does not minimize effectiveness since the adapter is *not* of nose seating design.

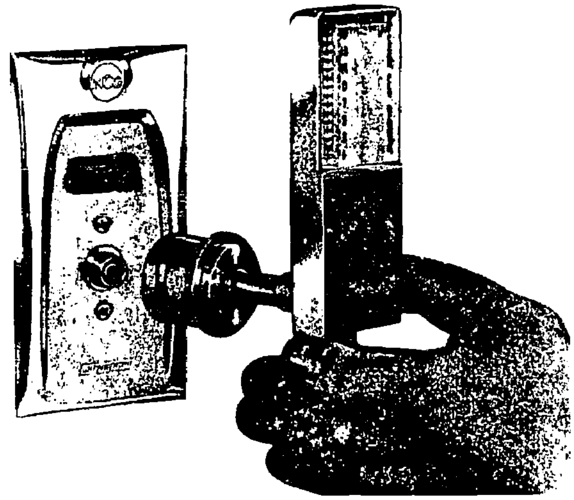
Note the normally open position of the secondary check valve "E", as contrasted to its closed position during maintenance in the following illustration.



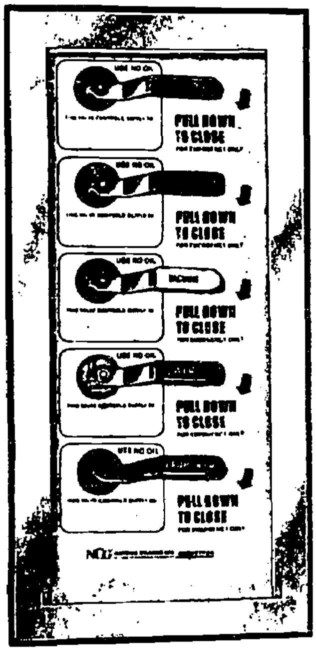
Upon removal of primary valve body ("F" above), for maintenance, release of restraint exerted by spring and button against secondary check valve "E" allows line pressure to move the secondary check valve into its seat, sealing gas loss during period of maintenance

BAYONET CONNECTOR





"QUICK-DISS" CONNECTORS



GAS ZONE VALVES

Fig. 13-2 Medical Gas Accessories

Courtesy-
National Cylinder Gas Co.

CHAPTER 14

FIRE PROTECTION SYSTEMS

General:

The most common method of fire protection involves the use of water. Since the water is conveyed in pipes, it is considered plumbing. All discussion and laws of physics affecting water and its distribution apply to fire protection systems.

Fire hydrants on city streets or in suburban areas are generally a part of the utility system and come under the jurisdiction of the local Fire District.

The fire protection system will vary depending on the size of the building and the type of occupancy. Some types of buildings may not require a system based on the national or local fire codes, but the Owner may request it for the protection of property or for a better fire insurance rate. The protection may consist of a standpipe system with hose outlets, or it may be a sprinklered system consisting of automatic sprinklers that discharge water automatically when the air temperature around any of them reaches a predetermined level. A fusible link melts to open the head, or to actuate a central valve. Some systems involve the use of chemicals.

All fire protection systems, whether simple or complex should be designed and inspected in accordance with the recommendations of the National Board of Fire Underwriters, and the codes of the National Fire Protection Association.

The National Fire Protection Association publishes over 60 pamphlets setting forth criteria and specifying workmanship and materials for many types of occupancies from office buildings to warehouses.

Fire Standpipe System:

This is the most common type and consists of vertical riser pipes with hose connections at strategic points throughout the building. The 2-1/2 inch hose is 100 feet in length so the pipes can be located where they are not conspicuous. The standpipes are usually filled with water if they are not subject to freezing, leaks, vandalism, or other objection. The standpipes should be located where they are readily accessible in case of fire. This means that they are placed in smoke towers or near a fire escape.

The Owner may request additional facilities to the standpipe system which exceed the code requirements. The usual request is for small stream hose stations, which can be readily used by the building occupants. This fire hose is 1-1/2 in. diameter, with a 3/8 or 1/2 in. nozzle. This first aid (1-1/2 in.) hose as it is called, must be connected to a standpipe that is filled with water under pressure at all times.

The following is quoted from the National Board of Fire Underwriters regarding interior supplies:

> Minimum supplies for use by fire department or specially trained men (2-1/2 in. hose and 1-1/8-in. nozzle) shall be calculated upon the basis of not less than 250 gpm for each standpipe riser. Capacity of supplies should be such that for a period of 1 hr. there will be available a pressure of at least 50 lb. at topmost 2-1/2 in. outlet (not including roof outlet) while water is being discharged through 50 ft. of 2-1/2 in. cotton rubber-lined hose and a 1-1/8-in. nozzle from the topmost outlet. When the supply is from fire pump or tank, the minimum sizes which should be recognized are: Approved fire pump, 500 gpm; pressure tank, 4,500 gal; gravity tank, 5,000 gal. with bottom elevated 40 ft. above highest hose outlet.
>
> Minimum supplies for standpipes for use by occupants of buildings as first-aid fire protection, shall be calculated on the basis of 100 gpm. flowing with 25-lb. pressure at highest hose outlet. This will afford two good first aid streams simultaneously. Supply may be from adequate city waterworks system, fire pump, from supplies for large standpipe systems, pressure tanks, and/or gravity tanks elevated 25 ft. above highest hose outlet. Minimum supplies shall conform to those required for large (2-1/2-in.) hose, except that when supply is furnished by a domestic gravity tank a minimum of 3,000 gal. of water shall be reserved exclusively for fire protection.

The following excerpts from the publications of the National Board of Fire Underwriters constitutes the basis for design of standpipe systems and are those generally incorporated in local codes. This information is given so that the Inspector will have some familiarity with the subject and perhaps explain why certain design is followed in the plans and specifications; fire codes should be consulted for more comprehensive design data.

> For standpipes supplying two small fire streams, with 1/2-in. nozzles or smaller, with a combined discharge of not more than 100 gpm; and for buildings not more than four stories or 50 ft. high, use 2-in. standpipes; and for buildings higher than four stories, use 2-1/2-in. pipes. For standpipes supplying 2-1/2-in. hose with 1- to 1-1/8-in. nozzles; and for buildings not more than six stories or 75 ft. high, use 4-in. pipes; and for higher buildings use 6-in. pipe.

Standpipe Connections:

Connections from gravity tanks (on buildings) and pressure tanks should be made to the top of the standpipe system except where the tanks are used as a supply to standpipes in several buildings or sections of a building, in which cases they should be made at the base of the standpipes. Connections to standpipes for the larger streams shall be at least 4 in. Those to standpipes for the smaller streams shall be at least 2-1/2 in.

Connections from fire pumps and sources outside the building should be made at the base of the standpipes. The connections from each supply shall be large enough to deliver its full rated capacity without excessive friction losses.

Where two or more standpipes are installed in the same building or section of a building they should be interconnected at the bottom. Where standpipes in a single building are supplies by tanks they should be interconnected at the top.

Valves and Fittings:

Connections to each water supply, except fire department hose connections, should be provided with an approved gate and check valve located close to the supply, as at tank, pump, and the connection from the waterworks system. Where the water supply feeds the standpipes in more than one building or section of a building, the check valves should be placed in a safe position in the underground connections or where not exposed to danger from fire or falling buildings.

Where there is more than one standpipe in a single building, each standpipe riser should be controlled by an approved gate valve located at the base of the riser.

Connections to public waterworks should, where feasible, be controlled by post indicator valves of an approved type and located not less than 40 ft. from the building protected; or if this cannot be done, placed where they will be readily accessible in case of fire and not subject to injury. Where post indicator valves cannot readily be used, as in a city block, underground gates should conform to the above as far as possible and their locations and directions to open be plainly marked on the buildings. All post indicator valves should be plainly marked with the service they control.

Where the standpipes are supplied from a yard main or header in another building, the connection should be provided with an approved outside post indicator valve at a safe distance from the building or an approved indicator valve at the header.

Fire department hose connections shall be provided with an approved straightway check valve located in the building or valve pit, but not with a gate valve. Piping between the check valve and outside hose connections shall be arranged to drain automatically.

Gate and check valves shall be of the approved extra-heavy flanged pattern where the pressures are in excess of 150 psi or where the pressures are likely to be in excess of this amount, if required by the inspection department having jurisdiction.

Fittings should be of the flanged pattern for sizes in excess of 6 in. Screwed fittings may be used for the smaller sizes but are not recommended on account of the difficulty in making tight joints.

Fittings in the main water connections to standpipes shall be of the long-turn pattern.

Approved expansion joints should be provided where necessary.

Pipe Drains:

The system should be provided with a system of drain pipes large enough to carry off the water from the open drains while they are discharging under pressure.

The drains should be so arranged as to be free from the possibility of causing water damage and not exposed to freezing. If practicable, the drain should be so arranged that the discharge will be visible from the point of operation on the drain valve.

Tests and Maintenance:

At the time of installation standpipe systems shall be tested and proved tight at a hydrostatic pressure at least 25 per cent in excess of the highest normal working pressure to which they will be subjected. Tests should be for 2-hr. duration and pressure should be taken at the base of the system.

NOTE: Where standpipes or connections are built in the walls or partitions the above tests should be made before they are covered in or permanently concealed.

Annual tests of standpipe systems shall be made by delivering the required quantity of water at the required pressure through hose lines from the topmost outlet of the standpipe.

NOTE: In old systems a tolerance of 10 per cent in quantity delivered is satisfactory; greater deficiencies demand attention.

Old dry systems should be tested with air at a pressure not exceeding 25 lb. to determine their tightness before water is turned into them.

NOTE: This test is suggested to avoid water damage to buildings in the event that pipes have broken or become disconnected.

Sprinkler Systems:

The Plumber is the artisan who is responsible for the installation and maintenance of the sprinkler system. The plans and specifications are a part of the complete set in new construction, or the Owner may contract separately, if it is renovation, and no great amount of architectural work is involved.

The design and installation of sprinkler systems in large structures is highly specialized and is usually done by Specialty (Sprinkler) Contractors who are thoroughly familiar with such work; they cooperate closely with the Insurance Services Organization (ISO), Factory Mutual, and other rating agencies, and rely on them for the proper evaluation of the systems. The fire rates for the structures are based on the completeness of the protection. The plans must be stamped approved, the final installation must be inspected, and the maintenance procedures must be proper. The Contractor must be licensed for this type of work. This is done to provide uniformity on such installations.

Sprinklers quickly supply water to the fire before it can gain headway. Complete systems are provided with an alarm gong, or may be connected to the fire station by leased telephone line, so that the alarm is given as soon as water starts to flow in the pipe. One sprinkler discharging is enough to set off the alarm; these are usually the water motor alarm type.

Sprinkler systems are classified as:

1. Wet-pipe system, which is defined as a system employing automatic sprinklers attached to a piping system containing water and connected to a water supply so that water discharges immediately from sprinklers opened by a fire.

2. Dry-pipe system, which is defined as a system employing automatic sprinklers attached to a piping system containing air under pressure, the release of which air from the opening of sprinklers permits the water pressure to open a valve known as a "dry-pipe valve." The water then flows into the piping system and out the opened sprinklers.

   This type of system is only used where the wet-pipe system is impracticable, as in areas subject to freezing.

   This is a more complicated type of system.

3. Pre-action system, which is defined as a system employing automatic sprinklers attached to a piping system containing air that may or may not be under pressure, with a supplemental heat responsive system of generally more sensitive characteristics than the automatic sprinklers themselves, installed in the same areas as the sprinklers; actuation of the heat responsive system, as from a fire, opens a valve which permits water to flow into the sprinkler piping system and to be discharged from any sprinklers which may be open.

4. Deluge system, which is defined as a system employing open sprinklers attached to a piping system connected to a water supply through a valve which is opened by the operation of a heat responsive system installed in

the same areas as the sprinklers. When this valve opens, water flows into the piping system and discharges from all sprinklers attached thereto.

This system floods an entire area in response to a heat sensitive device and may be used in a highly flammable process area.

Systems are classified also by the type of occupancy as:

1. Light hazard, such as apartments, dormitories, schools, or office buildings.

2. Ordinary hazard, such as dry cleaning plants, restaurants, theatres and auditoriums.

3. Extra hazard, such as paint shops, aircraft hangers, and other occupancies involving processing.

Combination of the above systems may be used on a single structure, such as a manufacturing plant.

Sprinkler systems, employing water pressure, are only as efficient as the water quantity and pressure available. The NBFU has rigid standards regarding water supplies and pressures. This is fully covered in the literature.

Tests:

The following recommendation is made by NBFU with respect to testing sprinkler systems after installation.

> All systems including yard piping should be tested at not less than 200 psi for 2 hr. or at 50 psi in excess of the normal pressure when the normal pressure is in excess of 150 psi. Emergency tests of dry-pipe systems, under at least 50 psi. air pressure, should be made at seasons of the year which will not permit testing out under water pressure.
>
> Branches from underground mains to inside sprinklers should be flushed out before connecting the sprinkler riser.
>
> Piping between the check valve in the fire department inlet pipe and the outside connection should be tested the same as the balance of the system.

To prevent the possibility of serious water damage in case of a break, pressure should be maintained by a small pump, the main controlling gate being meanwhile kept shut.

In the case of dry systems with a differential type of dry-pipe valve, the valve should be held off its seat during the test to prevent injuring the valve.

In dry systems an air pressure of 40 psi should be pumped up, allowed to stand 24 hr., and all leaks stopped which allow a loss of pressure of over 1-1/2 psi for the 24 hr.

A working test of the dry-pipe valve should be made, if possible, before acceptance.

In addition to those systems using water as the fire fighting medium, there are specialized piping systems using carbon dioxide, or some other chemical, where water is not practical, as fires in an electric substation, or transformer space, or where water would cause untold damage. Airplane fires, or oil fires, are other examples. Portable fire extinguishers are also the chemical type in most cases.

The standpipe systems described herein are usually designed by competent engineers and the plans and specifications are complete.

Contractors:

The sprinkler systems, if the project is fairly large, are bid by specialty Sprinkler Contractors. The successful bidder will prepare his own complete working plans from the layouts shown in the bid plans and specifications. These plans then are approved by the Rating Bureau before installation is started; they are also approved by the Architect/Engineer and the Owner.

The plans prepared by the Sprinkler Contractor are thorough and include dimensional lengths of pipe for the system with lists of valves, heads, and specialty items shown. The large pipe is all prefabricated and marked at the Contractor's shop, which in some cases may be several hundred miles away. The plumbing fitters who install the piping systems are usually "old hands" at such work, and know their specialty thoroughly.

Responsibility:

The big responsibility of the Inspector is to insure that the crafts are cooperating fully in the installation of the various piping systems. The spaces above ceilings and in chases are limited. A single line piping diagram may not adequately show the actual space required for an insulated pipe or sheet-metal duct. Drainage lines must slope continuously, and fire sprinkler mains must be installed for proper drainage. The Inspector should insist that no piping be installed until space allocations are checked and that the designated pipes will fit in the space allotted on the architectural plans. No matter how conscientiously the plans are prepared, there is always a chance for error; the Inspector can be helpful to all concerned by calling attention to potential trouble spots.

Outline:

The following outline of FIRE PROTECTION SYSTEMS will serve as a good review of this important subject. The student may wish to refer to the NFPA Bulletin which discusses in detail the subject touched upon in the outline.

FIRE PROTECTION SYSTEMS - OUTLINE

Manual Systems

a. Fire hydrants

2 1/2" hose and 4" pumper connections
Wet and dry barrel types
Fire department preferences
Shut-off valves
Break-off sections
Height above grade adjusted with bury and/or spool pieces

b. Fire hose cabinets - wet standpipes

Various types of hoses and varying lengths
Stream and spray nozzles
1 1/2" and 2 1/2" valves - standard black pipe
Insurance Underwriter or building code requirements
Cabinet and door styles
Space for extinguishers

c. Dry standpipes

Hose connections on each floor above 1st. floor in smoke tower
Fire department connections and drain
Roof siameze outlet
300 lb. test pressure - galvanized steel pipe

d. Fire extinguishers

A, B, C and dry chemical
Various sizes and capacity ratings
Cabinet and door styles

II. Automatic Systems

a. Fixed temperature systems

Fire detected and system activated by fusible link sprinkler at fixed temperature.

1. Wet pipe system

Control valve
Alarm check - water motor gong
Fire department connection

Main drain valve
Electric bell - flow switch
Water where no danger of freezing
Anti-freeze solution where subject to low temperatures

2. Dry pipe system

Similar to wet pipe except with air pressure in pipes operation:

(a) Heat from fire melts link in sprinkler
(b) Air pressure escapes thru fused sprinkler
(c) Reduced pressure in pipe allows check valve to open
(d) Opening of valve starts alarm
(e) Water flows thru fused sprinkler to extinguish fire
(f) If air pressure fails, signal is given by low pressure alarm

b. Rate-of-temperature-rise Systems

Fire detected and system activated by heat actuated devices, responsibe to abnormally rapid temperature rise.

1. Pre-action system

Sprinklers and piping similar to dry pipe system
Closed automatic sprinklers
Heat actuated devices (HAD) located at ceiling and spaced per listing
If rate-of-rise is greater than vent will allow air to escape, valve is opened
Increased heat rises pneumatic pressure in HAD piping
Open valve fills piping with water and sounds alarm
If fire continues, sprinkler is fused and extinguishes fire
Supervision of air system - alarm sounds if failure occurs
Accidental breakage of sprinkler or piping will not cause water damage
Loss of air pressure releases valve but closed sprinklers contain water within system, water flow alarm sounds.

2. Deluge System

Sprinklers open - rapid extinguishment of fast-spreading fires
Uniform water coverage through exact flow calculations

Areas of large buildings zoned
Entire zone deluged with water when fire is detected
Rate-of-rise system same as pre-action system
Thermo-pneumatic system supervised. Alarm with failure
Water flow causes alarm

c. Fire-Fog Systems

Basically a deluge system with fog nozzle sprinklers used in extreme hazards (explosives, propane storage, cracking units, etc.) Many times a spot protection, rather than full building coverage.

III. Special Systems

a. Air-Foam Systems

Used where water supply is limited, where water drainage is problem, or where water might be undesirable.
Foam smothers fire rather than cooling flammable below ignition temperature as does water
Systems may be activated manually or automatically

b. CO_2 System

Liquid CO_2 stored under pressure is released and forms dense cloud of finely divided dry ice particles at minus 110° F. Thus, a very effective extinguisher.

Non-conductor of electricity
No residue
Manual or rate-of-rise activated - can operate alarms
Usually for localized small areas

c. Dry Chemical Systems

Similar in application to CO_2 and used in same kinds of hazards
Relatively new Halogen requires much less storage volume because of greater expansion upon release
Halogen is not so dangerous as CO_2 to occupants.

d. Chemical Foam Systems

Similar to air foam except chemical foam consists of bubbles of CO_2 rather than air bubbles

Chemical foam is formed by mixing bicarbonate of soda with aluminum sulphate solution and a stabilizer
These systems largely being replaced with air-foam

IV. Methods of Fire Detection

a. Fixed temperature detection

Fusible links
Fixed temperature thermostats

b. Rate-of-Rise devices

Heat actuated devices
With supervision, the safest and surest method

c. Smoke detection

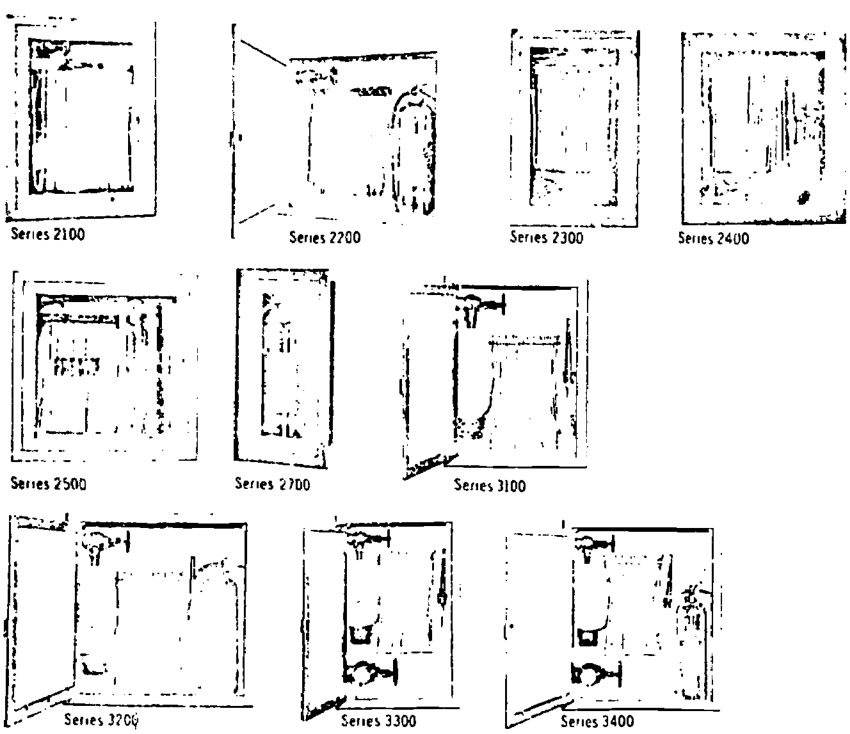
Photo-electric cell
Detector transmits signal to control panel

d. Flame or flash detection

Photo-electric cell
For detection in extremely hazardous occupancies
(Coupled with fire-fog system, can extinguish fire in less than a second)

e. Ion particles detection and vapor detection

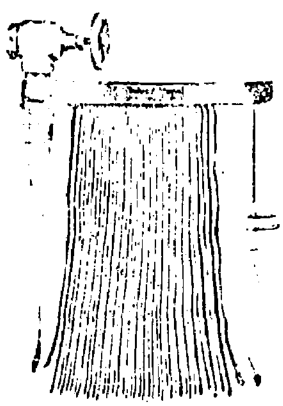
Samples air (as in ducts)
Sounds alarm, shuts down blower, etc. as particles or explosive vapors reach a predetermined maximum.

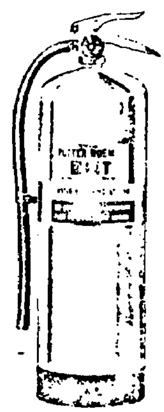


Potter-Roemer offers a complete selection of cabinets for fire hose and extinguishers. By following the six steps outlined below, you will be able to select the cabinet and accessories required without fear of leaving out any items.

1. Select cabinet style:

SERIES 2100: Cabinets for one angle valve and a fire hose rack assembly.
SERIES 2200: Cabinets for one angle valve, a fire hose rack assembly, and a fire extinguisher.
SERIES 2300: Cabinets for one angle valve, a fire hose rack assembly, and a fire department valve.
SERIES 2400: Cabinets for one angle valve, a fire hose rack assembly, a fire department valve and a fire extinguisher.
SERIES 2500: Bubble-type cabinets for use in 2 x 4 stud walls – accommodates one 1½" angle valve, a hose rack assembly and a fire extinguisher.
SERIES 2700: Fire extinguisher cabinets.
SERIES 3100: U/L listed and FM approved cabinets for one angle valve and a fire hose.
SERIES 3200: U/L listed and FM approved cabinets for one angle valve, a fire hose and a fire extinguisher.
SERIES 3300: U/L listed and FM approved cabinets for one angle valve, a fire hose and a fire department valve.
SERIES 3400: U/L listed and FM approved cabinets for one angle valve, a fire hose, a fire department valve and a fire extinguisher.


Hose rack assembly


Extinguisher

Potter-Roemer supplies a complete line of the finest U/L and FM approved portable fire extinguishers, engineered for cabinet installation, wall attachment or special placement within a building. Select the size and type you need by the type of fire likely to occur.

Dry Chemical = sodium bicarbonate base.
ABC Dry Chemical = ammonium phosphate base.

N.F.P.A. CLASSIFICATIONS — PAMPHLET #10

Class of Fire	Type of Hazard	Recommended Extinguisher
Class A Fire	Paper, wood, cloth, rubbish, etc.	Pressurized water, ABC dry chemical
Class B Fire	Burning liquids – gasoline, paint, oil, etc.	Carbon Dioxide, Dry Chemical, ABC dry chemical
Class C Fire	Electrical	Carbon Dioxide, Dry Chemical, ABC dry chemical

Fig. 14-1 Fire Extinguisher Cabinets

Potter-Roemer offers a complete line of equipment for both dry and combination standpipe systems. This equipment meets all code requirements for adequate fire protection for building of four or more stories.

Be aware that listed below is the minimum uniform building code and that large cities have their own individual building codes some of which have more demanding requirements.

For assistance with the details of standpipe requirements in your area contact your nearest Potter-Roemer representative.

Shown below are the minimum requirements of the 1970 Uniform building code for buildings of four (4) or more stories.

Dry Standpipe Systems

Fire Department Connections

Height	Pipe Size	Inlet	Model No.
0-75'	4"	2 way	290-2
75'-150'	6"	4 way	290-4 or 292

Floor Outlets

2½" Hose Gate Valves with cap & chain #281

Roof Outlets	Pipe Size	Outlet	Model No.
0-75'	4"	2 way	296
75'-150'	6"	2 way	296

Combination Standpipe Systems

Fire Department Connections

Height	Pipe Size	Inlet	Model No.
150' or higher	6" or larger	*4 way	292

Floor Outlets

100' 2½" Hose rack unit 403 AFD

Roof Outlets	Pipe Size	Outlet	Model No.
150-Up	6"	3 way	297

*3 or more risers on one system require two 4 way Connections.

SUGGESTED SPECIFICATIONS

1. For buildings 4 stories to 75' in height:

A. FIRE DEPT. CONNECTION: Potter-Roemer #290-2 4" two way cast brass inlet siamese complete with 2½" spring check inlet snoots, plug and chain and #291 brass beveled nameplate lettered "DRY STANDPIPE" install vertically (or horizontally) all exposed parts to be polished brass (or polished chrome plate.)

B. FLOOR OUTLETS: Potter-Roemer #281 2½" (or #290 3x2½) 300# U/L listed hose gate valve with cap and chain. Install #300 cast brass wall flange with set screw. Finish to be polished brass (or polished chrome plated.) Handwheel to be red enamel finish.

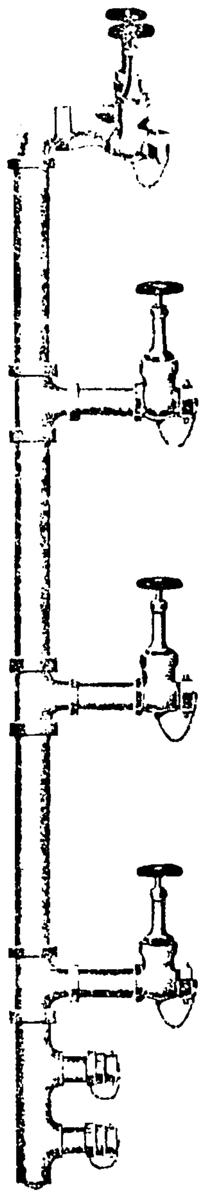
C. ROOF OUTLET: Potter-Roemer #296 4" two way cast brass roof manifold. Each outlet shall be equipped with 300# U/L listed hose gate valves with cap and chain: Finish to be rough brass.

2. For buildings 75' to 150' in height:

A. FIRE DEPT. CONNECTION: Potter-Roemer #292 6" four way square cast brass inlet siamese complete with 2½" spring check inlet snoots, plug and chain and #293 brass beveled nameplate lettered "DRY STANDPIPE"
All exposed parts to be polished brass (or polished chrome plate)

B. FLOOR OUTLETS: Same as 1)B above:

C. ROOF OUTLET: Potter-Roemer #296 6" two way cast brass roof manifold. Each outlet shall be equipped with 300# U/L listed hose gate valves with cap and chain: Finish to be rough brass.



3. For buildings 150' or higher:

A. FIRE DEPT. CONNECTION: Potter-Roemer #292 6" four way square cast brass inlet siamese* complete with 2½" spring check inlet snoots, plug and chain and #293 brass beveled nameplate lettered "DRY STANDPIPE".
All exposed parts to be polished brass (or polished chrome plate).

*Three or more risers require 2 four way fire dept. connections.

B. FLOOR OUTLETS (1): Second thru fourth floor: Potter-Roemer #157-U 2½" 300# U/L listed angle valve with cap and chain. Install #300 cast brass wall flange with set screw. Finish to be polished brass (or polished chrome plated.)
(2) Fifth floor and above: Potter-Roemer #403 AFD recessed cabinet with break glass door and lock. Potter-Roemer #C-90 100' Hose rack assembly complete with 2½" #158-U u/l valve 2½" U/L labeled linen hose #199 2½" Drain Vent and 2½"x 12"x1" nozzle. 3" decal to read "FIRE DEPT. USE ONLY" to be installed after final painting.

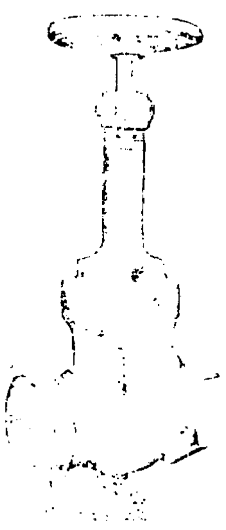
C. ROOF OUTLETS: Potter-Roemer #295 6" 3 way cast brass roof manifold. Each outlet shall be equipped with #157-U 2½" 300# U/L listed angle valves with cap and chain. Finish to be rough brass.

Fig. 14-2 Standpipe Systems

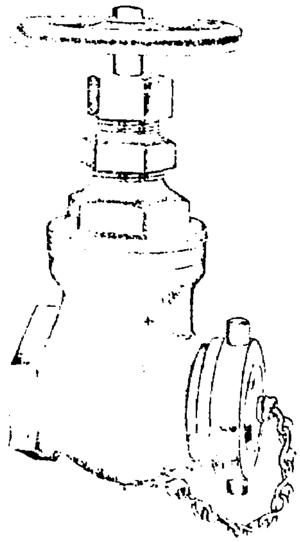
Hose Gate Valves (Cast Brass)

Female pipe thread inlet to make hose thread outlet, with solid wedge disc, tapered seats, red iron band wheel, and brass cap and chain. Available in rough, satin or polished brass, or chrome plated finish

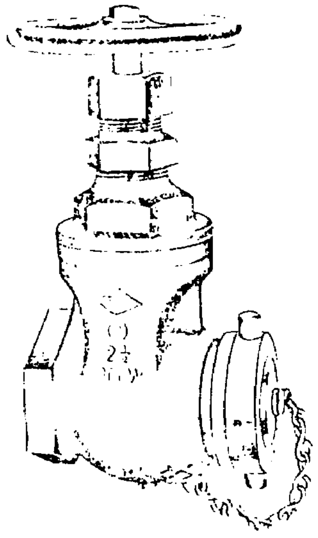
No. 280 (Rising Stem) – Sizes 2½", 3"x2½"* 3"x3"*
No. 280 A (Non-rising Stem) – Sizes 1½", 2½", 3"x2½"*
No. 281 (Non-rising Stem) 2½"* size only
*U/L listed for 300 lb. rating



No. 280
200 lb./300 lbs. Hose Gate Valve



No. 280A
200 lb. Hose Gate Valve



No. 281
300 lbs. U/L Hose Gate Valve

No. 294
Roof Manifold — two way

No. 295
Roof Manifold — three way

No. 296
Roof Manifold — two way 90°

No. 297
Roof Manifold — three way 90°

Hose Gate Valves	Size	A	Closed B	C	Closed D	Open D
No. 280	2½"x2½"	6½	12½	2½	15	17½
No. 280	3"x2½"	7	12½	2⅝	15⅛	18
No. 280	3"x3"	8¼	14⅜	3	17⅜	20⅞
No. 280A	1½"x1½"	4⅝	7	1½	8½	8½
No. 280A, 281	2½"x2½"	6½	10¾	2½	13¼	13¼
No. 280A	3"x2½"	7	11	2⅝	13⅝	13⅝

Roof Manifold Connections (Cast Brass)

These connections provide a means for attaching the required number of hose valves to the roof end of the standpipe system.

No. 294-Two-way
4 x 2½ x 2½
4 x 3 x 3
5 x 2½ x 2½
5 x 3 x 3
6 x 2½ x 2½
6 x 3 x 3
8 x 2½ x 2½

No. 295-Three-way
5 x 2½ x 2½ x 2½
5 x 3 x 3 x 3
6 x 2½ x 2½ x 2½
6 x 3 x 3 x 3
8 x 2½ x 2½ x 2½

No. 296-2-way 90°
4 x 2½ x 2½
4 x 3 x 3
5 x 2½ x 2½
5 x 3 x 3
6 x 2½ x 2½
6 x 3 x 3

No. 297-Three-way 90
5 x 2½ x 2½ x 2½
5 x 3 x 3 x 3
6 x 2½ x 2½ x 2½
6 x 3 x 3 x 3

Four way (not shown)
6 x 3 x 3 x 3 x 3

Fig. 14-3 Standpipe Valves

Brass = S.A.E. Specification No. 40 85 copper/5 zinc/5 tin/5 lead

CHAPTER 15

STORMWATER AND SPECIAL WASTE SYSTEMS

This Chapter will discuss the collection system for storm water including the subsoil and foundation drains; also special waste systems. Generally, the rainwater will be discharged into an underground drain leading to a storm water main in the street. In some areas it is still permissible to discharge into the sanitary sewer where storm water and sewage is combined. Refer to Chapter 7, Utilities, for the underground system outside the building or to Chapter 16, Landscape Piping.

The types of material used to collect the water will vary greatly, depending on the costs of material and the use of the building. Usually, galvanized steel, cast-iron, copper tubing, or plastic pipe are the choices. Local codes will determine the final selection. Rain leaders are usually enclosed within the building for the sake of appearance, safety, or less possibility of freezing. Since they are designed to run full at maximum rainfall, they must be supported more substantially than sanitary piping. It is very important that the roof drains have provision for a watertight attachment to the surface being drained and to the roof or planter drain. If the leaders are placed outside, they are frequently fabricated from sheetmetal and connected to the roof gutter. This method is used for shingle roofs and the less expensive types of building construction. Where the sheetmetal leader connects to an underground main, an extension should be made above ground to a height of 5 to 6 feet with cast-iron or galvanized iron pipe for protection from damage.

If the rainwater leaders connect to a sanitary sewer it is essential that a trap be provided unless the piping is gas tight and terminates at a roof drain where objectionable odors will not be a problem. Sewer gas will discharge through the leader the same as through a vent. Any trap installed must be accessible. If a rainwater leader connects to a house sewer there is a danger of flooding if a stoppage occurs in the sewer and a fixture is at a level which will be susceptible to overflow.

Foundation or subsoil drains are properly a part of the storm drain or clear water collection system and ultimately will discharge into the storm sewer or combination sewer. The purpose is to prevent water from entering the building or to relieve the upward pressure on floors which are at a lower elevation than the surrounding grade. The subsoil drain, synonymous with foundation drain, may consist of terra cotta, perforated terra cotta, or bituminous fiber pipe, or perforated plastic pipe; other materials may also be used which are allowable by code and economically feasible for gathering water. The foundation drain should be held out a minimum of 3 feet from the foundation wall and it should be out as far horizontally as it is vertically below the wall. This is to prevent disturbing the compaction of the soil below the footing. The pipe is surrounded with clean gravel to a point at least 1 foot above the pipe, then backfilled for the remainder with larger gravel or other porous material. A subsoil drain should not be connected directly to a sanitary sewer. Even if a backwater valve is used, it is subject to clogging and will not do a satisfactory job. If a connection must be made to the sewer, then the subsoil drains should discharge into an open sump and the sump in turn should be connected through a trap to the sewer. Sumps for the collection of rainwater do not require vents. The subsoil drains shall be provided with cleanouts located in accessible places so that any stoppage can be cleared. They shall be placed where a stoppage is most likely to occur.

Any clear waste water which is uncontaminated may also discharge into the storm piping if allowed by local codes. Drain lines from the drip pans of air conditioning coils, cooling tower drains, and other such discharges can all be connected to the storm system.

It is common practice in tall buildings to provide expansion joints near the roof drains. This is done to reduce any strain between the piping and the structure. If the piping can be offset from the drain to the vertical leader an expansion joint may not be required.

Roof drain manufacturers have been alert to the many materials now used in roof construction, and to the variety of insulations and coverings being used on roofs. Preformed steel decks, thin shell concrete, and precast concrete slabs have all required some modifications or additions to the drains previously used in wood plank roofs.

The steel deck requires that a hole be cut for the drain. Care must be taken to assure that the roof is not weakened in the process and that reinforcement is provided if needed. A clamping ring is required to hold the drain in place.

Special types of tar and gravel roofs may require a special dam around the drain to keep the hot tar from running into the drain opening. The Inspector should watch the installation carefully to insure that the manufacturer's instructions are followed carefully. Leaks around the drains, or a stopped up drain due to insulation, tar and gravel debris can prove to be very costly. Refer to a typical roof drain installation at the end of this Chapter.

In addition to the storm water waste system, provision must frequently be made for the conveying and discharge of special wastes which may be of various categories. The materials to be discharged are generally classified as being a hazard to public health and safety. Acid or radioactive wastes from laboratories, or disease carrying waste which are contagious from hospitals require special treatment.

Industrial wastes, a branch of special wastes, may contain materials that would damage the public sewer system if conditions were right.

Greasy or oily wastes from a garage, or wash rack, will deposit on the inner surfaces of the piping and in time restrict or stop the flow. Spilled gasoline, or cleaning fluids may be volatile and present an explosion hazard if proper ventilation is not provided.

Disease carrying wastes frequently must be sterilized at high temperatures to eliminate the danger of an epidemic.

The discharge from boiler blowoff tanks, is extremely hot, and will loosen joints in the piping due to expansion and contraction.

In order to prevent the harmful effects of special or industrical wastes to health, safety, or the physical facilities, holding basins variously called sumps, pits, grease or oil interceptors, condensing tanks, or sediment interceptors, are installed in the lines where the waste is intercepted, and the harmful ingredients treated or removed before discharge into the sewer lines.

The design of such facilities vary greatly, and usually will be detailed on the plans or spelled out in the specifications. The instructions for installing such facilities should be closely followed in order that they will be effective.

Usually, it is preferable to locate the intercepting or neutralizing device as close to the source of contamination as possible.

Beauty parlors, for instance, should have special traps at each sink to catch hair before it gets into the branch lines.

Grease traps from restaurants, kitchens, or butcher shops should be located near enough to the source so the grease or fat will not congeal in the lines before reaching the interceptors (this type of interceptor discharges into the sanitary sewer).

Blowoff tanks may be equipped with a cold water supply to hasten the cooling of the blowoff water which is at a high temperature.

A most important consideration in the placement, of course, is that the sumps or devices shall be readily accessible for cleaning or inspection, properly vented if required, and adequate for the purpose. The Inspector should be alert to the restrictions necessary for a proper installation.

Indirect wastes are required by code for certain types of discharge. This type of waste provides for an air gap between the discharge and the receptacle which connects to the drainage system. It may be a funnel drain which extends above the floor line, or even a service sink.

Code restrictions usually require that equipment which is used to prepare, store and serve food; discharge from medical equipment, such as medical sterilizers; any kind of mechanical equipment such as drains from air conditioning units, or fire protection systems; and piping systems under pressure, must all drain through indirect wastes which provide the air gap feature. The end of the outlet must be located above the overflow rim of the fixture, and spill across the air gap. The air gap insures that the sewage cannot enter the lines even if there is a stoppage in the building drainage system. The air gap also serves the purpose of a visual means of determining if the flow is correct.

Occasionally floor drains are used as indirect wastes, but generally are not acceptable because the water strikes the grating of the floor drain, splashes and causes an unsanitary condition around the drain. Open drains, like a funnel drain, are not installed at floor level, because they soon become stopped up from dirt and trash drained into it. Floor sinks, so-called, are popular in restaurant kitchens, and refrigeration rooms where several wastes can discharge into a common fixture. They normally are about 1 foot square, 8 inches deep, and are designed to set about 1-1/2 to 2 inches above the floor. Some are equipped with removable grates, and are enameled iron for sanitary reasons.

Often, portions of the clear water waste system will be below the level of the sewer and it will not be possible to drain by gravity. This may be true of foundation drains, areaway drains, refrigerator drains, or others. Pumping is then necessary to get the waste to an elevation so that it can drain by gravity.

The sump pump installation, automatically controlled by float or other means, must be used. The size and complexity of the installation will depend on the amount of water. The sump may be cast-iron, or frequently is constructed of reinforced concrete. The pump or pumps are of centrifugal design and may be single, or two pumps may be used. The installation is similar to that for sewage ejectors. Refer to Chapter 9, Drainage Systems.

The Inspector should insist that the rain leader lines, floor drains, and other open piping is plugged during construction so that debris, such as gravel, plaster, or paper do not clog them prior to finish work in the building. It is the Plumbing Contractor's responsibility to protect his work during construction.

Rainwater Systems

General

The purpose of this appendix is to provide drainage from roof areas, courts and court yards where it is necessary to collect storm water and deliver to an approved point of disposal not in conflict with other ordinances or regulations.

Part A

Rainwater Systems

D1.0 **Materials:**

(a) Rainwater piping placed within the interior of a building or run within a vent or shaft shall be of cast iron, galvanized steel, wrought iron, brass, copper or lead or other approved materials.

(b) Rainwater piping located on the exterior of a building shall be not less than 26 ga. galvanized sheet metal. When the conductor is connected to a building storm drain or storm sewer, a drain connection shall be extended above the finished grade and jointed at a point protected from injury.

(c) Rainwater piping located underground within a building shall be of service weight cast iron soil pipe or Type L copper tube.

(d) Rainwater piping commencing two (2) feet from exterior of a building may be of any approved material permitted in the Installation Requirements of this Code.

D1.1

(a) Rainwater piping shall not be used as soil, waste or vent pipes nor shall a soil, waste or vent line be used as a rainwater pipe.

(b) Rainwater piping installed in locations where they may be subjected to damage shall be protected.

(c) Roof drains, overflow drains, and rainwater piping when concealed within the construction of the building, shall be tested in conformity with the provisions of this code for testing drain, waste and vent systems.

Part B

Roof Drains

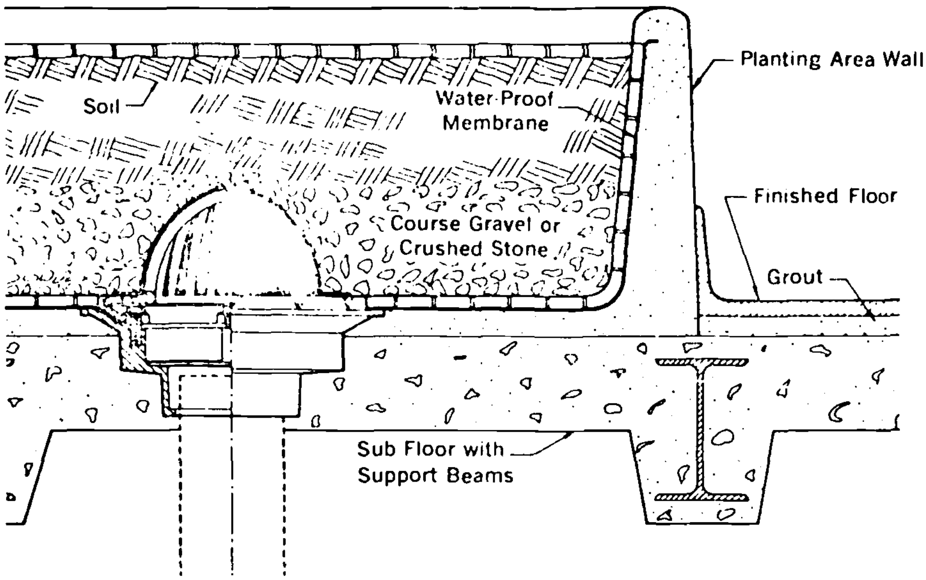
D2.0 **Materials:** Roof drains shall be of cast iron, copper, lead or other corrosion resisting material.

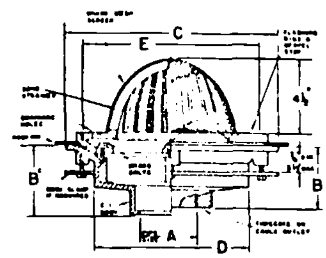
D2.1 **Strainers:**

(a) Roof drains shall be equipped with strainers extending not less than four (4) inches above the surface of the roof immediately adjacent to the drain. Strainers shall have a minimum inlet area one and one-half (1½) times the pipe to which it is connected.

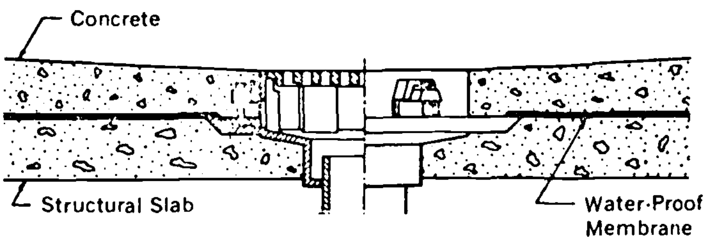
(b) Roof deck strainers for use on sun decks, parking decks and similar occupied areas may be of an approved flat-surface type which is level with the deck. Such drains shall have an inlet area not less than two (2) times the area of the pipe to which the drain is connected.

(c) Roof drains passing through the roof into the interior of a building shall be made water tight at the roof line by the use of a suitable flashing material.





Drain shown installed in typical planting area. Heavy wire screening is securely attached to dome strainer.



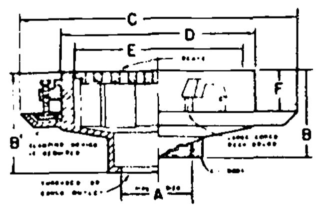
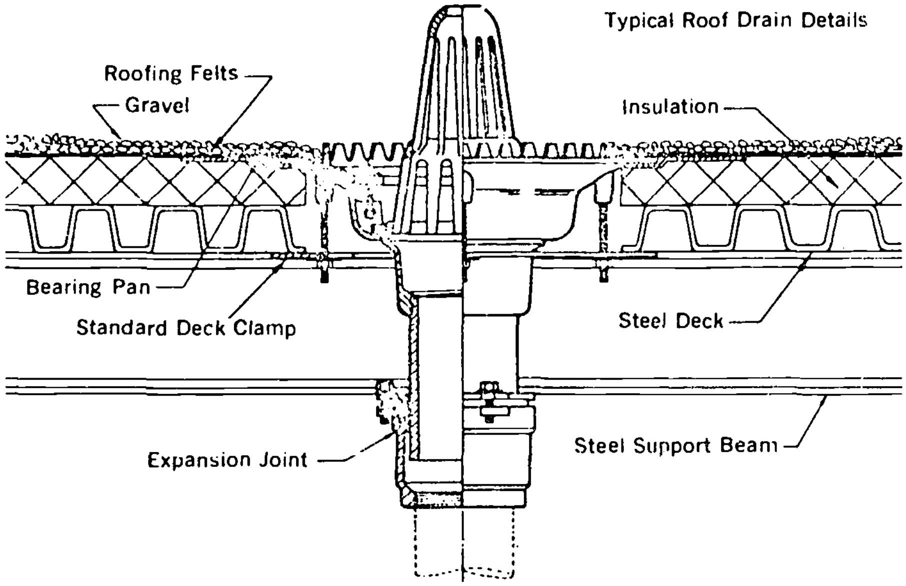
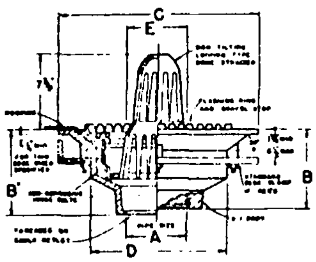


Fig. 15-1 Planting and Area Drains



Roof drain shown installed in a steel deck in combination with the expansion joint.
Note that the use of the bearing pan insures a recessed drain at the leader. The expansion joint absorbs deck contraction and deflection.



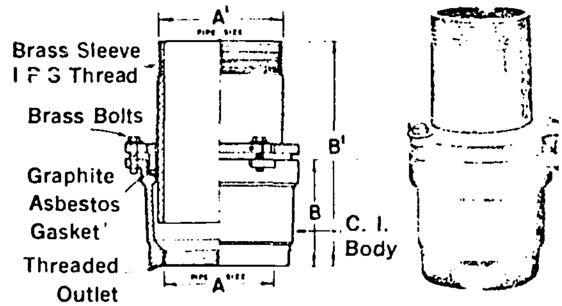


Fig. 15-2 Roof Drain Details

CHAPTER 16

LANDSCAPE PIPING SYSTEMS

General: The systems covered in this Chapter are those which are not necessary for the proper functioning of the building, although they probably will connect to the building sewer and/or water lines.

The plumbing code will govern, and the installations are subject to inspection the same as the building plumbing systems.

The systems covered here are swimming pools, both public and private, decorative fountains, lawn sprinkling installations, and yard and planter drains.

Swimming Pools: The National Swimming Pool Institute has established standards for construction of public swimming pools. The catalogs of the manufacturers who specialize in pool equipment are a good source of information regarding the implementation of the Standards. The Plumbing Contractor may not be interested in the physical shape of the pool if it is one that has been designed by an Architect/Engineer, but he must be aware of any health hazards which may develop because of faulty materials or workmanship. Some of these are:

1. The water supply to the pool must be potable unless it is fed by some other source which has the approval of the Regulating Agency; this could be ocean salt water, or a clear stream.

   The "flow through" systems using water on a continuing replenishment basis are becoming less common because of stringent health standards.

2. Any plumbing which can cause contamination of the potable supply must be avoided. An air gap is provided so the pool water cannot enter the potable supply; this is usually an "over the rim" supply.

3. The systems must be installed so that they can be easily maintained. This applies to the hair and lint strainer, the filtration system, the chlorination unit, vacuum cleaning apparatus, and the pump/motor and controls. If equipment is inaccessible, or nearly so, it will probably be neglected.

4. The recirculation rate must be such that the pool water passes through the filtration system at least three times in 24 hours.

5. No parts of piping systems nor the equipment shall be undersized; this leads to noisy operation, improper filtration, poor treatment of the pool water, improper skimming of leaves or debris from the surface of the water, and generally an unsatisfactory job for the Owner.

   If the installation is properly made the pool water will be free of disease producing bacteria, cloudiness, algae, and scale deposits. The public demands a clean pool, of good color, and a PH level which is neutral, not too alkaline nor too acid.

Recirculation System: This is the most common type of system to accomplish the above because it reuses the treated and heated water.

The feature of the recirculation system is that the water is drawn from the pool, treated as required, and returned to the pool.

Filtration, either rapid sand, or diatomaceous earth type is used to remove suspended particles in the water.

Chemicals are added to the filtered water to handle disinfection, oxidation, and PH control.

Leaves and other floating debris are removed at the pool, either by having an overflow gutter extend around the pool or by the use of one or several skimmers located at the water line.

The overflow gutter is drained by gutter outlets spaced at frequent intervals in the gutter.

The skimmers are spaced on the perimeter usually one for each 500 square feet of pool surface. The surface debris is trapped in a removable strainer in each skimmer. It also helps to keep the hair and lint strainer at the pump from becoming clogged with the larger debris. An equalizing connection is also incorporated in each skimmer, so the pump will not break suction if the strainer becomes clogged.

When the filter becomes dirty, the recirculation cycle is reversed by means of suitable valving, and the water is run in the opposite direction through the sand filter and wasted through a suitable air gap, to the sump and sewer. The accumulated dirt is washed out of the sand. The rate of backwash is about five times greater than during normal operation.

The diatomaceous earth filter also must be backwashed. Most codes prohibit disposing of the used earth into the sewer. It must be caught in an interceptor which will keep it from getting into the sewer. The backwash water flows to the sewer from the interceptor.

Chlorination of the pool water is accomplished in one of three different ways: 1. Raw chlorine may be fed through a metering device into the filtered water line at a predetermined rate, or 2. A common chlorine bleach, such as Clorox, may be fed into the line, or 3. The Clorox bleach may be dumped directly into the pool. The first two methods operate whenever filtered water is flowing to the pool.

The treatment of the pool water can be sophisticated or it may be quite simple, especially for small residential pools.

The piping systems must be compatible and are usually standard galvanized pipe and fittings, or plastic pipe and fittings. The selection of materials are those which would normally be used in a plumbing system of comparable size carrying water.

Most pool supply contractors have a variety of materials and equipment available for pool installation and maintenance. All are designed to accomplish the objectives which have been enumerated.

If a pool heater is to be used it is usually installed in the filtered water supply to the pool; a bypass is provided so all the circulating water does not pass through the heater. The water entering the pool should never be much greater than 100^{o} F. because of its effect on the pool chemicals. Most pools are kept at a temperature of 80^{o} F. plus or minus 2 - 3^{o} F. Therapeutic pools are operated at a higher temperature.

The size of the heater is determined by the velocity of the wind passing over the pool surface, the air temperature, and the water temperature desired.

If it is desired to raise the pool temperature 1^{o} F. per hour gas heater manufacturers use the following formula:

> Surface area in sq. ft. x maximum temperature rise x 15 = Btu per hour required to raise and maintain the pool temperature. The energy input to the heater will depend on the efficiency of the unit.

Lawn Sprinkling Systems: Lawn sprinkling systems have increased in size and number during the past few years, particularly in temperate climates where freezing is not a problem. Many large buildings are being constructed in suburban areas, and the grounds are being beautified with lawns, shrubs and trees.

Controls and valves are installed on most large systems, so they are completely automatic, turning on when the ground is dry and off when not needed.

The variety of heads and controls is such that football fields or the smallest shrub can be watered automatically and properly. It is estimated that automatic controls will pay for themselves in first cost because of the simplified layouts which are possible and also in the savings generated by requiring less personnel. Another plus feature is that the watering can be done at periods when it is less objectionable because of the use of the areas. In many localities there is less wind early in morning or evening, which makes it a good time to use the sprinklers. This can all be arranged automatically with the controls available to the sprinkling system designer.

System Design: The factors involved in the design of a system are many. Some are:

1. Budget money available for the space to be sprinklered. Assume that the landscape plan is available.

2. Amount of automatic control equipment to be incorporated.

3. Source, quantity, and pressure of the water supply available.

4. Wind and weather conditions under which the system will operate.

5. Permanency of the installation and anticipated future building which may affect the location of the mains.

6. Type of terrain, steep slopes or level.

Materials: The answers to the above questions will determine how the design evolves. The manufacturers of sprinkler equipment have catalog data on the performance of their sprinkler heads and controls. These should be consulted for the particular job being designed or installed.

Pipe and Fittings: The installation on the pressure side of the sprinkling system, that is, leading up to the shutoff valves, should be the same as used for water systems on other parts of the project.

The pipe and fittings on the discharge side of the system can be the same, or plastic pipe and fittings. Local code provisions should be consulted.

Sprinkler Heads: Sprinkler heads are two basic types: Impulse heads, either pop-up or surface, and spray heads. Refer to the end of this chapter for examples of each, and characteristics of each.

It is not feasible to mix spray and impulse heads in an installation because of the varying rates of application and pressures required. This would lead to underwatering in some areas and overwatering in others.

Wind will cause the pattern covered by a sprinkler to become deformed. The large radius, or impulse type heads are more affected than the smaller radius spray heads. The prevailing wind conditions are usually considered when the Architect/Engineer designs the job.

Automatic Controllers: A typical installation utilizing a low voltage (usually 24 volts) automatic controller and electric control valves is shown at the end of this chapter. Since the sprinkler piping is installed underground the valve and wiring are also installed underground.

The automatic controller can be set to turn each circuit on and off at the preset times. The controls can be simple or quite complex depending on the requirements of the job.

The electric type automatic controller is illustrated; the controller and valves can also be hydraulically operated. The hydraulic valves may be either diaphragm or piston type and operate similar to automatic direct flush valves.

Both types of valves operate on the principle of pressure differential, that is, hydraulic pressure is either released or admitted to a chamber to activate the valve; the electric system is more popular than the hydraulic system because it is more trouble free.

Back-Flow Preventers: The illustration at the end of the chapter shows a typical installation. Where the system runs uphill to the heads, the preventer is necessary because of the pressure generated by the difference in elevation between the heads and the supply could lead to contamination. The vacuum breaker shown as a separate installation guarantees against back siphonage, as lawn sprinkling systems are a potential cross connection if improperly installed. They can be a source of contamination without the protection devices. If the sprinkling system is not served from the potable water supply the devices may not be necessary.

Decorative Fountains: The same care should be exercised with the systems for the fountains as shown for other plumbing systems.

Fountains circulate water stored in a reservoir by means of a pump and piping system. The pump may be submerged or located in a dry spot. The small simple fountains usually are equipped with a submersible pump. The large fountains may have several pumps located remotely and be operated by a complex control system.

Most of the details of installation and materials discussed in other chapters may be applicable here, depending on the type of design. These are:

1. Provide necessary sleeving and locate outlets, drains and drain lines.

2. Provide all waterproofing for pipes and drains which penetrate the reservoir construction.

3. Check closely to avoid cross connections.

4. Follow the design layout to avoid any interference with the desired effect from the fountain.

5. The design of the fountain is done by the Architect/Engineer, but the Plumber should provide secure fastening for his pipes and equipment.

6. Provide for easy maintenance of all drains and equipment.

Planter and Yard Drains: The types of drains shown in Chapter 15, Storm Water and Special Waste Systems, are also applicable here. These include overflow drains, drains with clamping ring for a waterproof installation. A mesh screen is usually placed around the dome strainer to keep the soil in the planter.

Overflow drains carry away the water not absorbed by the soil during heavy rains, or watering. If the planter is large, a perforated drain may be installed, similar to a foundation drain.

Yard drains vary in complexity and type; they must be adequate for the location and the traffic pattern. Many are installed with intercepting sumps to catch debris and dirt before it enters the sewer lines.

Swimming Pools

G1–Swimming pool waste water shall be disposed of as hereinafter set forth in this Section and the type of disposal proposed shall be approved by the Administrative Authority prior to the commencement of any work. A means of disposal of the total contents of the pool (periodic emptying) without surface run-off shall be established to the satisfaction of the Administrative Authority.

G2–Except as provided in G3, when a public sewer or storm drain of adequate capacity is available for use, swimming pool waste water shall be discharged thereinto and permission shall be obtained in writing from the proper authority to do so. A copy of such permission stating the maximum size of the waste line between the receptor and the sewer, and other specific requirements, shall accompany any applications for a permit made to the Administrative Authority.

G3–Where space and conditions are such that no hazard, nuisance or insanitary condition is evidenced, swimming pool waste water may be used for irrigation by surface or subsurface spreading.

G4–When no other means of waste water disposal is available a drywell may be installed. Each such drywell shall be constructed in the manner prescribed for cesspools in Chapter 11 of this Code, and drywells receiving only filter backwash shall have a capacity of at least twice the amount of effluent discharged during one normal backwash operation, but shall in no case have less than a five-foot (5') vertical sidewall. When pool emptying or other drains are proposed, the size and leaching capacity of such drywall shall be proportionately increased to the satisfaction of the Administrative Authority. No waste water other than that from swimming pool shall discharge into any such dry well, and no waste water from any swimming pool shall discharge into a private sewage disposal system.

G5–No direct connection shall be made between any storm drain, sewer, drainage system, drywell or subsoil irrigation line and any line connected to a swimming pool.

G6–Waste water from any filter, scum gutter, overflow, pool empyting line or similar apparatus or appurtenance shall discharge into an approved type receptor. The flood level rim of each such receptor shall be at least six inches (6") above the flood level of the adjacent ground. Each such receptor when permitted to be connected to any part of a drainage system shall be provided with a three-inch (3") trap.

G7–Except as provided in G8, the discharge outlet terminal from any pool or filter shall be protected from backflow by an air gap at least six inches (6") above the flood rim of the receptor.

G8–No scum gutter drain, overflow drain, backwash discharge drain, or pool emptying line shall enter any receptor below the rim unless the pool piping at its deepest point, the bottom of the filters, and the bottom of the scum gutter drain through or overflow inlets are at least six inches (6") above the overflow rim of the receptor.

G9–A positive point of potable water supply to each swimming pool shall be established and shall be installed as required by Chapter 10 of this Code.

G10–Plans for other than private swimming pools shall be approved by the Health Officer before any water supply or waste discharge permit is issued.

1. Water Supply

1-1. The water supply serving the pool shall meet the requirements of the health department for potable water.

1-2. All portions of the potable water supply system serving the swimming pool and auxiliary facilities shall be protected against backflow.

1-3. Potable water introduced into the swimming pool, either directly or to the recirculation system, shall be supplied through an air gap or other approved means.

2. Inlets and Outlets

2-1. Pool inlets and outlets shall be provided and arranged to produce a uniform circulation of water and the maintenance of uniform chlorine or equivalent disinfectant residual throughout the pool; provisions shall be made to adjust the flow through all inlets.

2-2. The number of inlets shall be based on either one inlet per 500 sq. ft. of pool area or one inlet per 9,000 gallons of pool capacity, whichever is greater.

2-3. Two outlets shall be provided at the lowest point of the pool floor to completely drain the pool floor. The floor outlets should not permit a flow of greater than 2 ft. per second through the grating, and slotted openings in the grate should not exceed ½" in width.

2-4. The two outlets will serve as part of the recirculation suction system and together will circulate 50% of the design flow rate.

3. Recirculation and Filtration

3-1. The pool equipment shall be of adequate size to turn over the entire pool water capacity three (3) times every twenty-four (24) hours.

3-2. Pool piping shall be sized to permit the rated flows for filtering and cleaning without exceeding the maximum head at which the pump will provide such flows.

3-3. The water velocity in the discharge or return system shall not exceed ten (10) fps, and the head loss in the piping should be below ten (10) psi/100 ft.

3-4. The suction velocity shall not exceed five (5) fps.

3-5. The overflow drain shall be sloped at ¼" per ft. and shall be provided with a cleanout at every 90° horizontal change of direction.

3-6. A suitable hair and lint strainer shall be installed ahead of the pump. The strainer basket will have an effective screening area equal to four (4) times the main suction line area.

3-7. The gutter overflow system shall be capable of continuously removing sixty (60) percent of the design flow rate.

3-8. The overflow system shall discharge into a surge tank whose capacity is equal to one-half (½) gallon for each square foot of pool surface area.

3-9. A self-priming centrifugal pump and motor shall be provided to recirculate the water. The pump shall be capable of filtering and backwashing at the maximum total dynamic head of the system.

4. Filter

4-1. The filter system shall be a pressure high-rate permanent sand filter.

4-2. The design filter and backwash rate should not exceed 15 gpm per square foot of filter area.

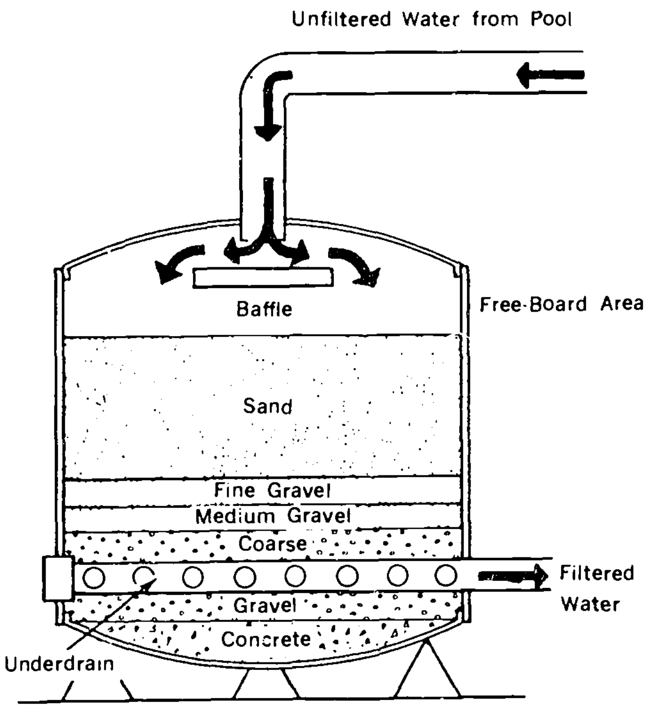
4-3. The filter shall be equipped with pressure gauges on the influent and effluent sides.

4-4. A sight glass shall be installed on the waste discharge.

5. Schedule of Materials and Minimum Sizes

System	Material	Min. Size
Overflow drains—gravity	Cast iron, bell and spigot	2"
Suction piping	Galvanized, std. wt	
Suction fittings	Cast iron, flanged	
Return pressure piping	Galvanized, std. wt.	1½"
Return pressure fittings	Cast iron, flanged 4" and above	
Return pressure fittings	Galvanized, ips 3½" and below	
Make-up	Galvanized, std. wt.	
Vacuum	Galvanized, std. wt.	2"
Piping	Std. wt.	

Fig. 16-1 Pool Piping Specification

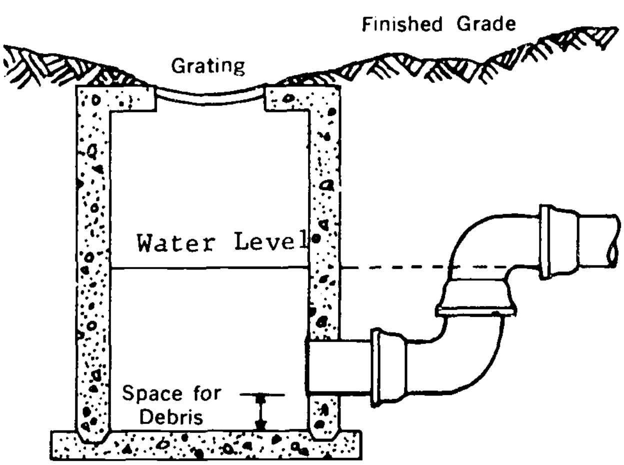


The filtering process starts with the delivery of pool water to the top of the filter tank. The water is pressure-forced through descending layers of sand and fine, medium, and coarse gravel, and then—filtering completed—it is collected in a perforated pipe (underdrain) and returned to the pool.

The generally accepted maximum rate of flow through a rapid sand filter is 3 gpm for every square foot of effective filter area.

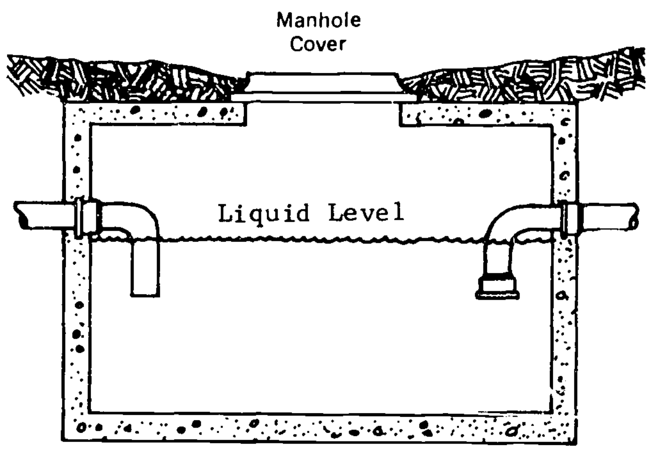
The backwash rate should be a minimum of 15 gpm per square foot of filter area, whereas (as already noted) the filter rate is 3 gpm.

Fig. 16-2 Pressure Sand Filter



Yard Drain

Catch basins for roadway drains are similar in design.



Interceptor

Fig. 16-3 Drain and Interceptor

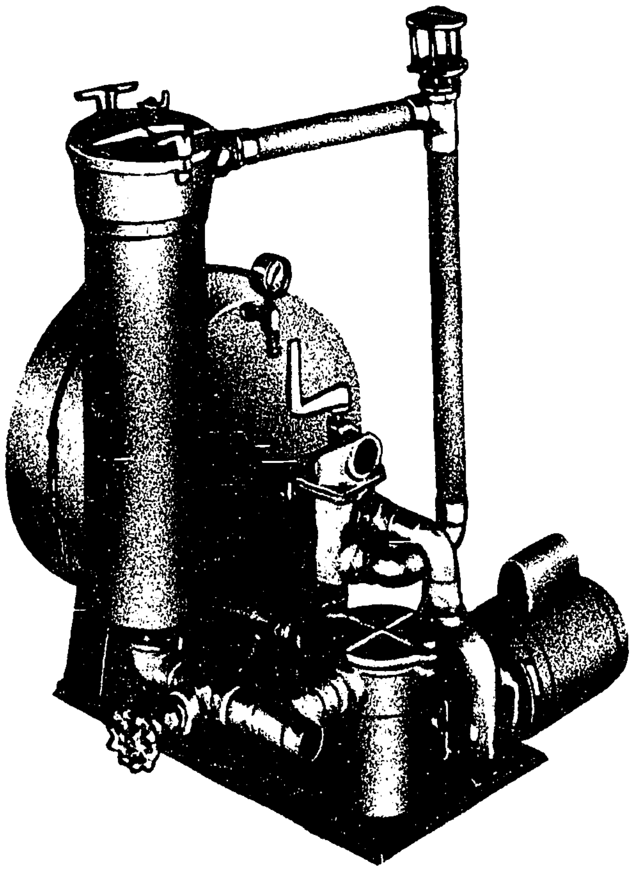


Fig. 16-4 Preassembled Filter Assembly

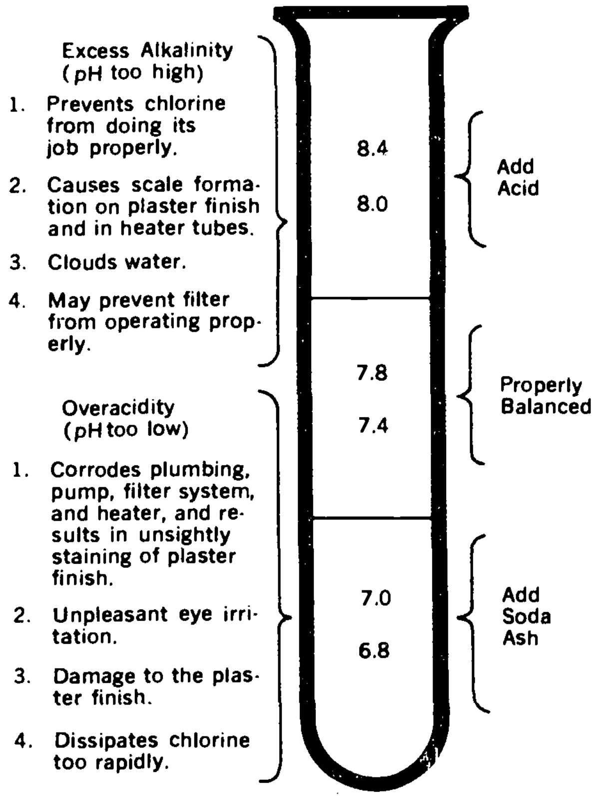


Fig. 16-6 pH Scale

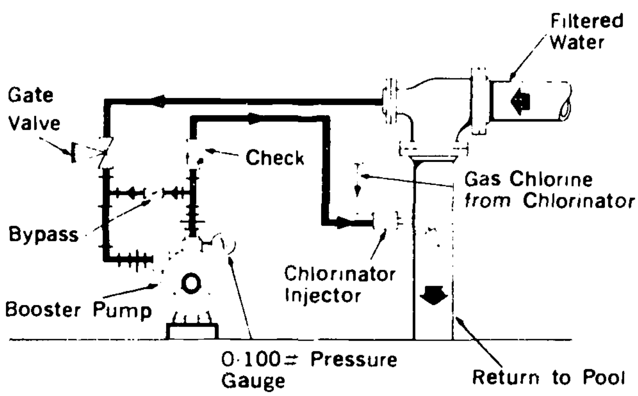
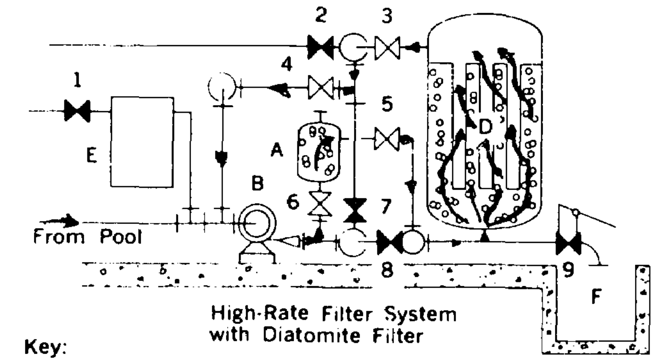


Fig. 16-5 Chlorinator



High-Rate Filter System with Diatomite Filter

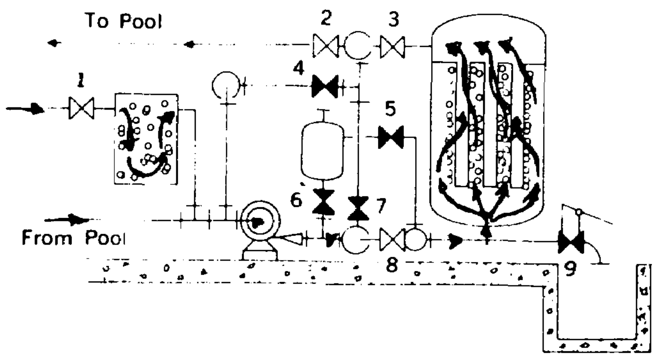
Key:

A—Precoat Pot
B—Pump
C—Diatomite Filter
D—Wire Screen (Septum)
E—Body Feeder
F—Sump

Diatomite
Open
Closed

No. 1

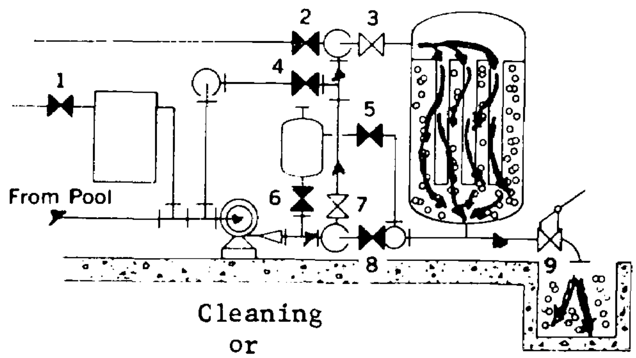
No. 1. In a typical diatomite filter, a liquid slurry (mixture of diatomaceous earth and water) is circulated through the filter to precoat the septum with a cake of diatomaceous earth.



No. 2

No. 2. After the filter has been precoated—charged—the valve arrangement is changed and the normal filtering cycle is started. A small amount of diatomaceous earth is constantly fed to the filter from the body feeder to prevent dirt from covering the septum with a slime that could hinder or stop the filtering action. This process is called *slurry*, or *body, feeding.*

The diatomaceous earth filter must be cleaned after a certain length of filtering time, depending on the dirt content of the pool. No. 3 shows cleaning by backwashing the filter. Flow through the filter is reversed, and dirt and diatomaceous earth are flushed off the septum to the sump.



Cleaning
or
Backwash

No. 3

Fig. 16-7 Filter Details

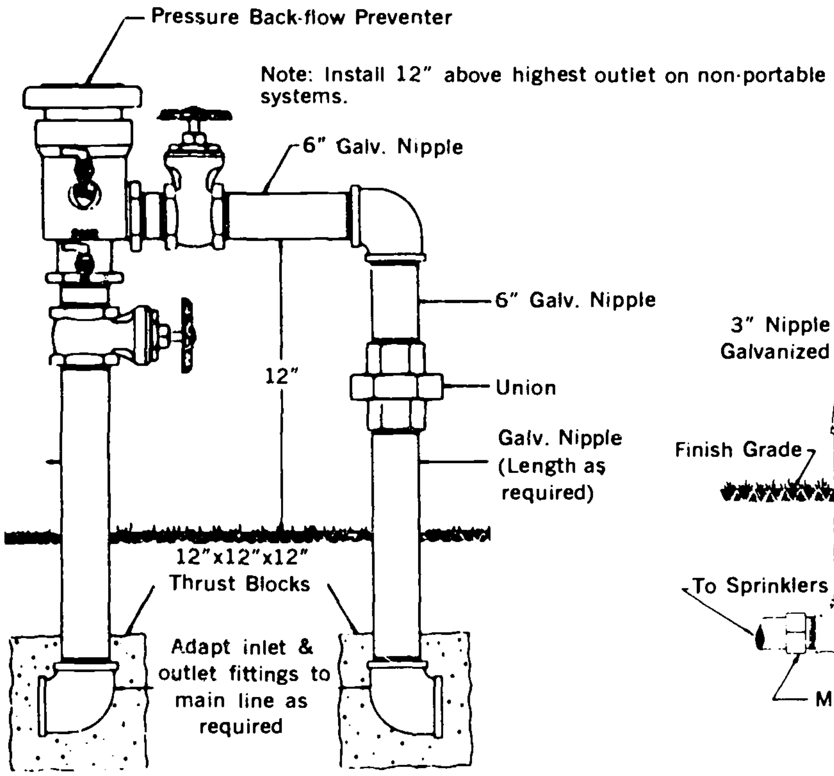


Fig. 16-8 Typical Back-flow Preventer Assembly Detail

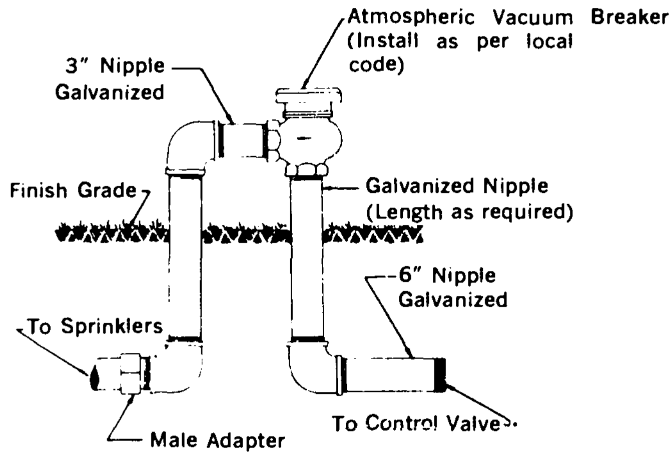


Fig. 16-10 Atmospheric Vacuum Breaker Detail

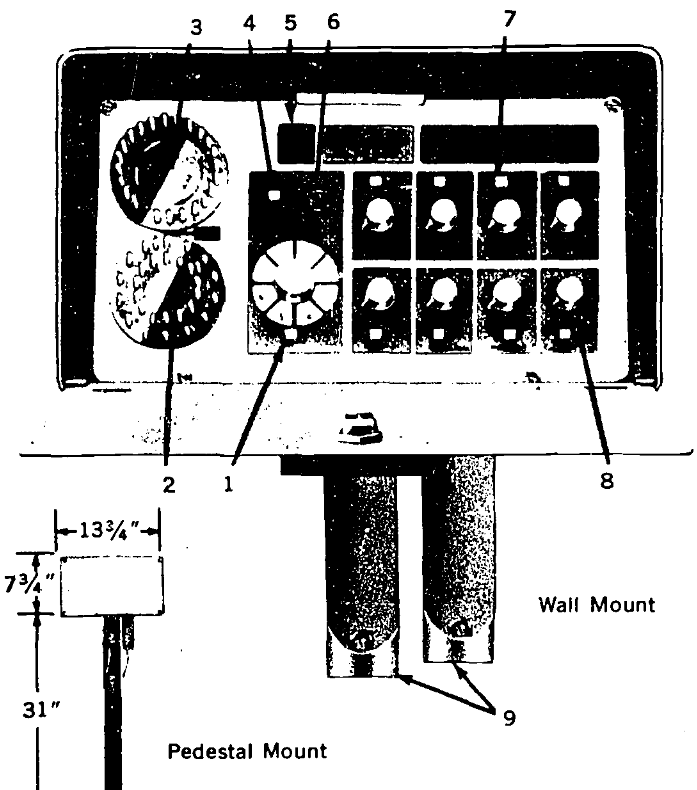


Fig. 16-9 Automatic Controller

1. **Auto-Manual Control**—In "Auto" position the selector/indicator dial rotates to show station being watered. In "Manual" position, the dial may be manually advanced to any desired station for watering.
2. **14-Day Clock**—Push-turn pins set the days watering is desired. Outer circle of pins controls the lawn stations. Inner circle of pins controls the shrub stations.
3. **24-Hour Clock**—Push-turn pins set the hours that start the watering cycles. All pins are captive to prevent loss.
4. **Master Switch**—Shuts off all power to stations while allowing program clock to run.
5. **Circuit Breaker**—Protects controller from damage due to excessive loads.
6. **Pilot Light**—Indicates when watering is in progress.
7. **Station Switch**—"Off" position eliminates station from watering program. With switch in "Auto" position, station will water for time set on dial control. In "Off" position, station time must elapse before controller will sequence to next station.
8. **Dial Control**—The watering duration of each station is accurately and independently adjustable from 1 to 30 minutes.
9. **1" Junction Boxes**—For complete protection of 117-volt line connection and direct burial wires to electric valves.

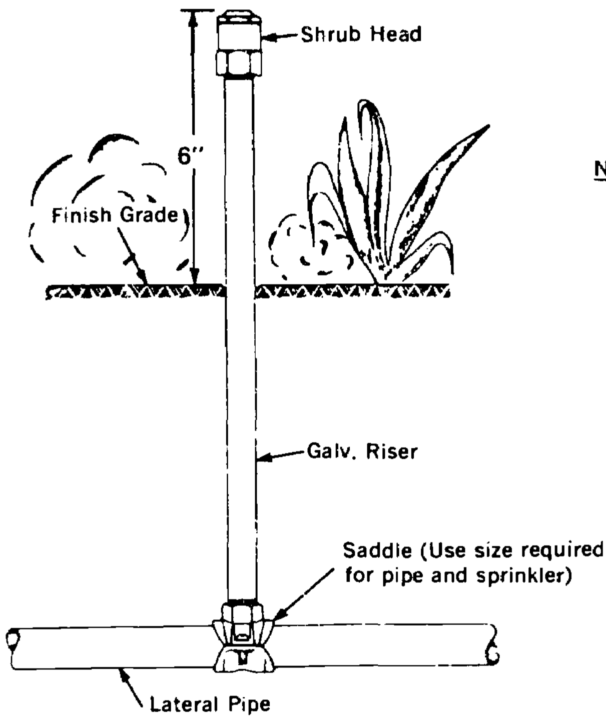


Fig. 16-11 Typical Shrub Head Installation Detail

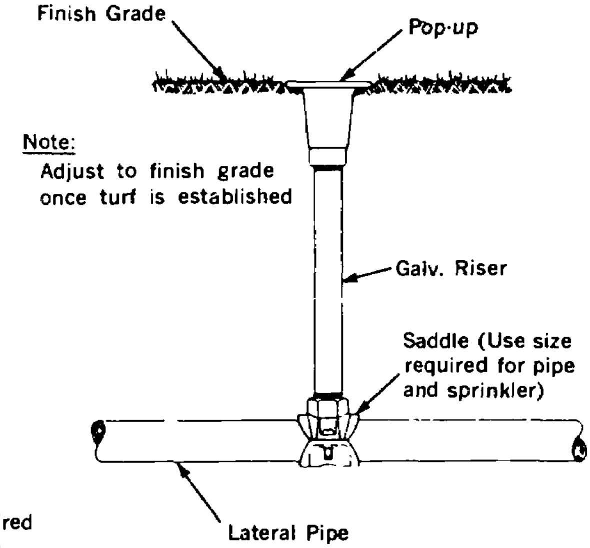


Fig. 16-12 Typical Pop-up Installation Detail

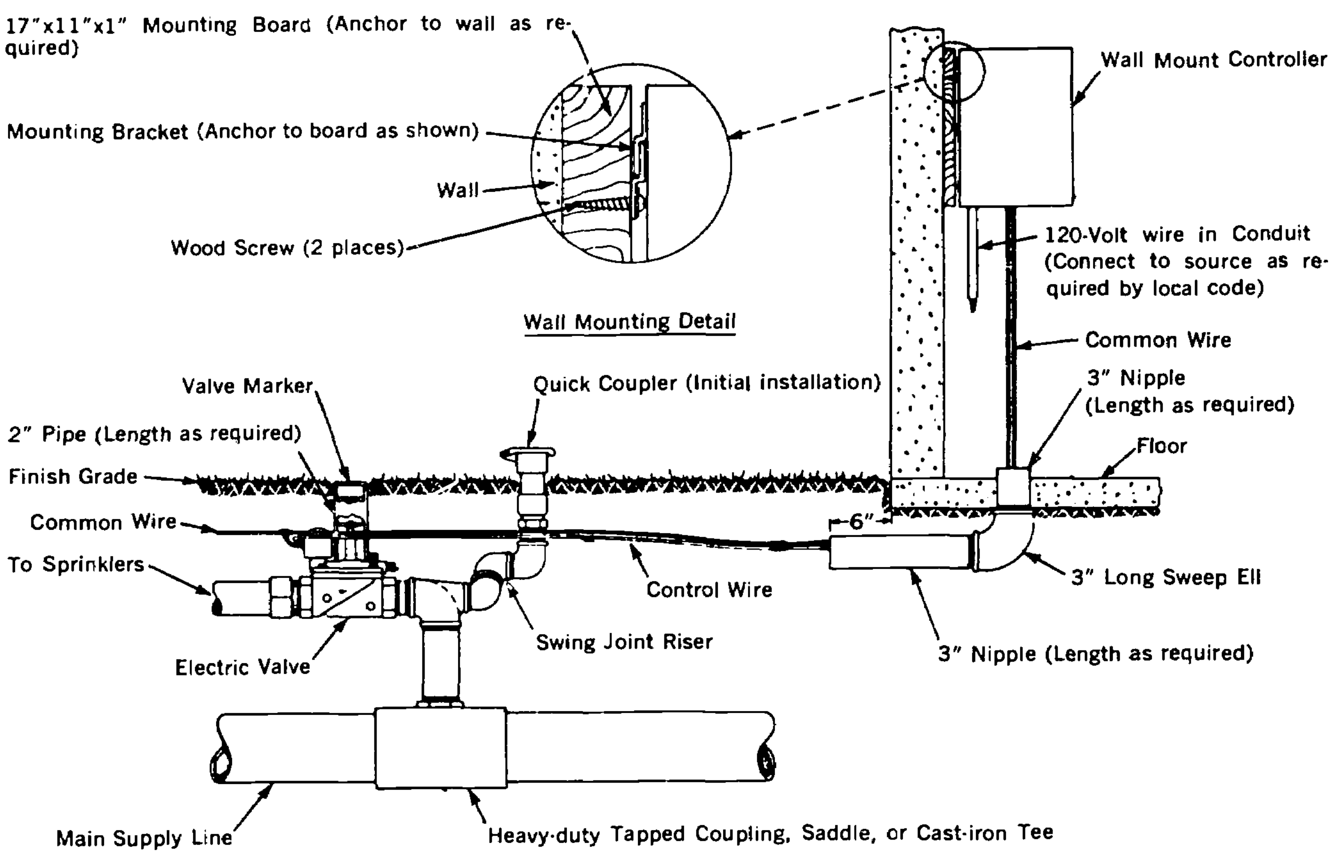


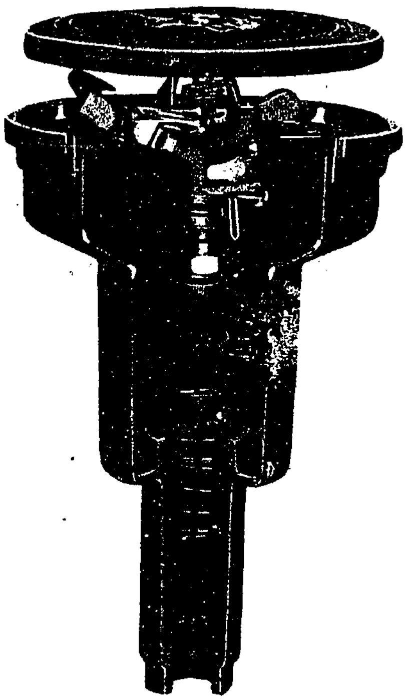
Fig. 16-13 Typical Electric Controller & Valve Assembly Detail

Four features that distinguish impulse heads are:

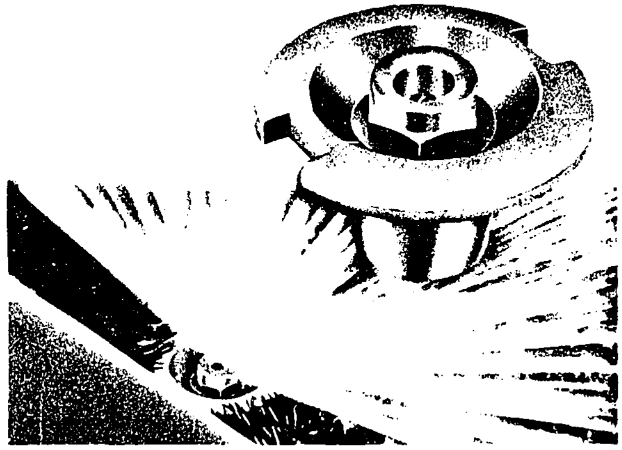
1. They operate at pressures of 30–80 psi;
2. Each covers an area 40'–100' in radius;
3. Apply water a rate of .20"–.50" per hour;
4. Are most economical for large, open areas.

Four features are typical among spray heads:

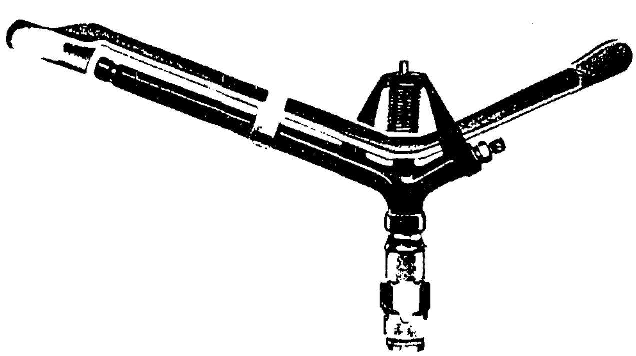
1. They operate at pressures of 15–30 psi;
2. Each head covers an area of 10'–20' in radius;
3. Water is applied at a rate of 1"–2" per hour;
4. Their use is most economical for small or irregularly shaped areas.



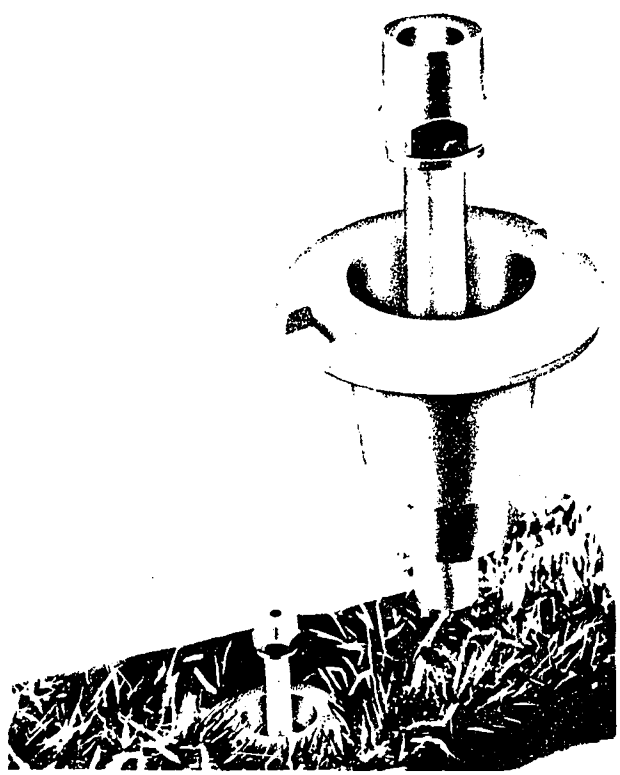
Impulse Head



Surface Type Spray Head



Impulse Head

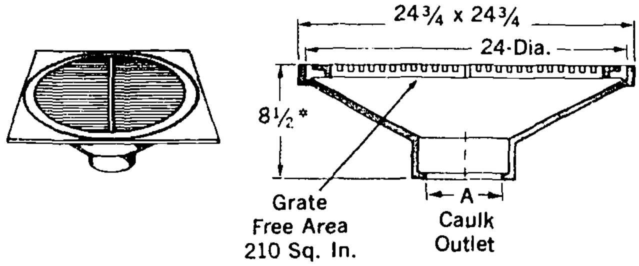


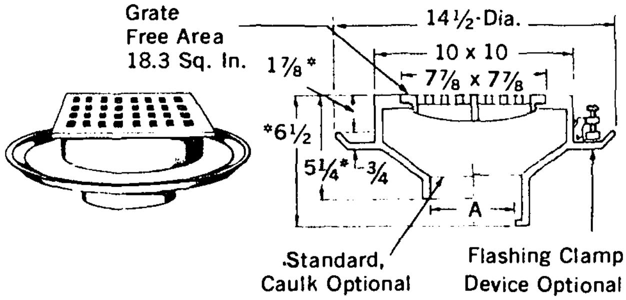
Pop-up Type Spray Head

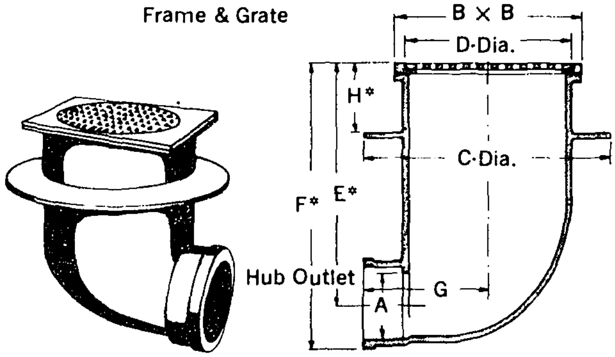
Fig. 16-14 Sprinkler Heads

The drains used in ornamental fountains can be classified as follows:

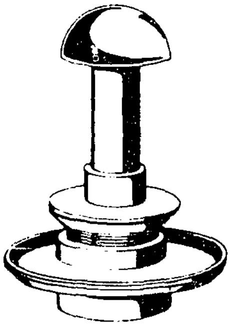
1. Skimmer drains,
2. Overflow drains,
3. Area or floor drains.

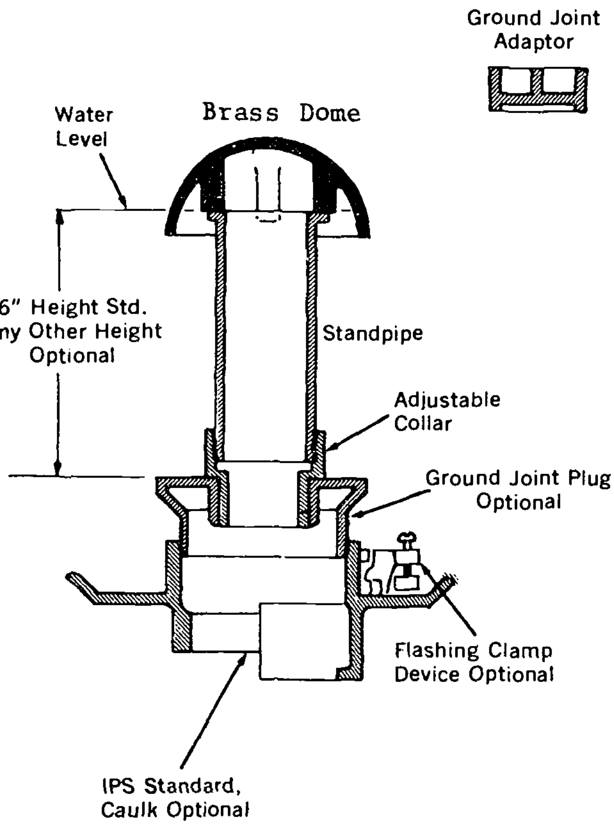




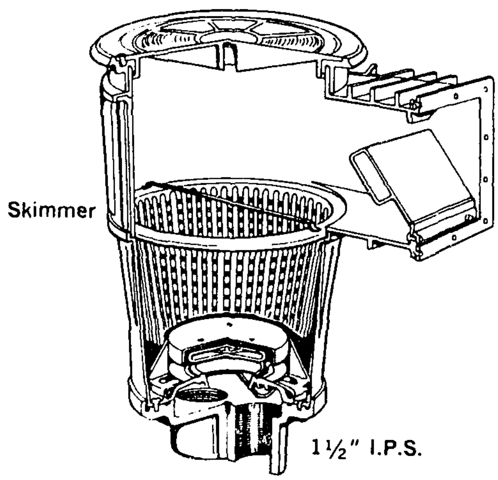


Area Drains





Overflow Drain



Skimmer Drain

Fig. 16-15 Typical Fountain Drains

CHAPTER 17

CORROSION

Corrosion is a chemical change which occurs in metals when exposed to unfavorable conditions. It may weaken the metal to the point where it is useless, or alter its appearance. The rust on steel products is a familiar example; the tarnishing of silver objects alters their appearance.

The Inspector must be aware of the dangers of corrosion and how it may be prevented and reduced. The corrosion problem is extremely complex and cannot be treated fully in this text. The physical rate of corrosion of the metal, and the economic loss of the facility are the two factors which generally govern the steps justified to inhibit or prevent corrosion.

The Plumber is confronted almost daily with rusted pipes and corroded lines; patching and replacing of leaking mains and branches is a familiar occurrence. The loss in time and material runs into the billions of dollars in the United States each year.

Most corrosion processes are electrochemical; this means that it is an electrical circuit which produces a chemical reaction at the terminals; the effect is corrosion of the metals involved in the circuit. This process requires an aqueous solution, whether immersed in water, buried in damp ground, or exposed to a humid atmosphere. The process is the same.

Pure distilled water will not conduct electricity. If an acid, an alkali, or a salt is dissolved in water, it becomes an electrolyte and the solution is capable of conducting electricity. Generally, water found in nature is not pure and is therefore capable of conducting electricity. This flow of direct current electricity will leave the metal surface where corrosion is active, and return to the metal surface where corrosion is not active. Where the electrical current leaves the metal surfaces it deteriorates or rusts (anode); where it returns the metal does not rust (cathode).

The corrosion or rusting of iron in air (other than 100% dry), water or soil is the result of the formation of a corrosion cell based on the above explanation. A common example is the dry cell battery. The dry cell battery contains a zinc electrode which corrodes (anode) a chemical filter (electrolyte) and a carbon rod that receives the current (cathode). The zinc is caused to corrode when the terminals are electrically shorted, and the electrical corrosion currents produce useful electricity. When steel corrodes, the anode and cathode are on the one piece of metal, and the "short" producing electricity is always present.

Almost all metal surfaces contain or will accumulate impurities that produce circuits caused by the impurities. As long as the metal remains dry, little corrosion is noted. Where the metal is exposed to water, acids, or alkalies, like pipes buried in the ground, local action current is produced. This is responsible for the corrosion of buried pipe lines.

Several types of corrosion exist in plumbing systems. Basic types include:

> Uniform attack: Examples are the rusting of iron and the oxidation or tarnishing of lead.
>
> Pitting: A localized attack, greater in some areas of the affected metal than others. The depth of pitting is expressed as the pitting factor. Iron buried in soil shows corrosion in the form of shallow pits.
>
> Dezincification: The zinc contained in, or the zinc coating on, a metal corrodes. In yellow brass, the corroding of the zinc leaves the alloy with less ductility and tensile strength. In galvanized tanks, the black steel is exposed to corrosion after dezincing.
>
> Intergranular corrosion: This occurs between the grain boundaries of a metal. The result is a loss in strength and ductility.
>
> Cracking: If a metal cracks when subjected to repeated tensile stresses in a corrosive environment, it is said to fail by corrosive fatigue.
>
> Graphitization: Applied to cast iron, the iron will corrode and dissipate into the soil, the remaining graphite will stay in place. The pipe may appear to be in perfect condition, and may still carry low pressure flows.

In addition to the visual detection of corrosion based on the above types, corrosion can be detected by electrical measurements. These measurements are normally obtained by using a sensitive voltmeter.

Chemical measurement, by analyzing the water for iron content is sometimes used. The greater the iron content, the greater the corrosion. The electro-chemical series is a practical scale to determine the corrosion rate. It evaluates the relative activity of metals.

ELECTROCHEMICAL SERIES

Most Active - Magnesium
Zinc
Aluminum
Steel
Castiron
Lead
Brasses
Copper
Silver
Graphite

Least Active - Gold

The farther apart on the chart, the more severe will be the corrosive action.

Where the plans and specifications on a project do not supply information on corrosion prevention, the Inspector, and Plumbing Contractor may find the following information useful in detecting causes of corrosion or preventing it.

The rate of corrosion of metals in adjacent locations may offer a clue as to what to expect. Since environmental conditions may change with the passage of time it is well to have soil conditions checked. A soil that is wet will have a lower sensitivity than dry soil.

The corrosion of steel is normally considered to be more rapid in acid than in alkaline soil. Distilled water is neutral, and has a PH of 7.0. Any soil that has a PH of less than 7.0 is said to be acid. The smaller the number, the greater its acidity.

Underground pipe lines are frequently protected by the cathodic method. In order to prevent the electricity from discharging into the soil, the application of electricity to the pipe prevents the natural corrosion currents. The pipe has been forced to be a cathode, which does not corrode. This is accomplished either by galvanic anodes or impressed current anodes.

Galvanic, or sacrificial, anodes are generally made of magnesium, aluminum, or zinc, because it would have the greatest voltage between it and steel. The anodes must be electrically connected to the pipe by a material that will allow the current to flow between the anode and the pipe. The current will then flow thru the soil to the surface of the pipe. Generally, this system is not used for complete protection, except in small installations where the soil has a low sensitivity, or where an electrical source is not available.

Impressed current anodes requires the application of a direct current, which may be of any voltage required for the application; this is contrasted with a maximum voltage of about .6 volts for the sacrificial anode system. The use of the high voltage system may cause stray currents to corrode adjacent systems. For this reason, the systems must be carefully engineered, and come under the supervision of the Electrical Inspector. All major pipeline installations underground are protected by such systems. Generally, a less expensive metal, such as scrap iron, is used as the anode, and is connected to the positive terminal. The negative terminal is connected to the pipeline.

In addition to the cathodic method of protection there are other safeguards which may be used, and frequently are, either in conjunction with the cathodic method or separately.

Coatings: These may be of various types depending on the economics involved. They are insulators, and prevent the galvanic cell from being formed. A natural coating of corrosion, such as rust on castiron or steel, will slow down the corrosion process, if not prevent it. A bituminous coating such as asphaltum, on soil pipe is an inexpensive one frequently encountered. Sometimes a wrapping of roofing felt is applied over the asphaltum for further protection.

The problem which all coatings have in common, is that if it is damaged in a small area, the corrosion attack will be more severe, as the corrosion will concentrate in the unprotected area, due to the current flow.

The Plumbing Inspector, in the course of his work, will encounter many forms of protection for metal, all having for their purpose, the prevention of corrosion. These may include cement linings in storage tanks and pipes; glass linings for tanks; coatings of paints or mastics; tapes of various types and wrappings; porcelain enamel coatings.

The inspection must be thorough enough to insure that there are no breaks or scars, in the protective coating or lining, which will allow corrosion to occur, by allowing electricity to flow from the metal thru the electrolyte. Visual inspection generally will reveal breaks or scars. Wrapped or coated underground pipes and structures are often tested with an electric brush or probe which will reveal breaks if metal to metal contact is made because of poor or damaged coatings.

In addition to the non-metallic coatings there are metallic coatings which are used. Galvanizing (zinc coatings) is one frequently encountered, such as galvanized water pipe. Tin, cadmium, lead, aluminum, are also familiar to the trade. Many others, such as neoprene; rubber; copper lining in water tanks, are frequently encountered. All have the same purpose, which is to prevent corrosion. Again, such materials must be carefully inspected to assure that the covering has no damage, which will partially destroy its usefulness.

In addition to the coatings described, which are used generally because they are less expensive, it is possible to select materials which have a natural resistance, and while generally more expensive, are more dependable and maintenance free.

Non-metallic piping materials, such as asbestos, cement, terra cotta, plastic, are most corrosion resistant. Other considerations, such as impact strength, pressure limitations and sizes, may limit their uses.

Copper bearing steels, silicon alloys, bronze, and tin, all have special corrosion resistance, and are used for special purposes.

Other means of controlling corrosion are listed here. The reason the method is effective is obvious, based on the previous discussion. The Inspector should be diligent in requiring that the work be done properly:

Dissolved oxygen: Neutralize it by chemical means or remove by heating the liquid.

Stray electrical currents: Provide cathodic protection, or insulating couplings in the pipe line. Sometimes the pipe system is bonded to the source of the current, such as electric rapid transit systems.

Corrosive soils: Provide a bed of clean dry sand 6" to 12" thick completely surrounding the pipe.

High velocity of the liquid: Where piping is undersized, the high velocity of the fluid at sharp bends causes erosion of the protective material, such as galvanizing, and further attack occurs.

Cavitation causes high velocities when the air bubbles collapse. The flashing of hot liquid into a vapor as pressure is suddenly reduced will also cause instantaneous high velocities which are highly destructive.

Corrosive atmosphere: Industrial wastes which have not been properly processed can be highly corrosive. Salt air is also a culprit in this regard.

Metallic corrosion may also be caused by biological action. Bacteria may be of two types.

The sulfate reducing bacteria, which functions in the absence of oxygen, reacts with the organic compounds containing sulfur to produce hydrogen sulfide, which reacts with the metal.

The iron consuming bacteria remove compounds of iron that are in solution. The consumed compounds of iron are deposited by the bacteria as iron rust. The effect is known as tuberculation.

The field of corrosion science is a large one, and is growing in scope because of the huge costs involved in the deterioration and destruction of metallic materials. The need for Inspectors who are capable in this field is also growing. For those who are interested and wish to learn more about corrosion, the Corrosion Handbook by H. H. Uhlig, is a fine reference. The National Association of Corrosion Engineers has a publication "Corrosion" which publishes up-to-date material on various problems and the latest theories regarding the problems.

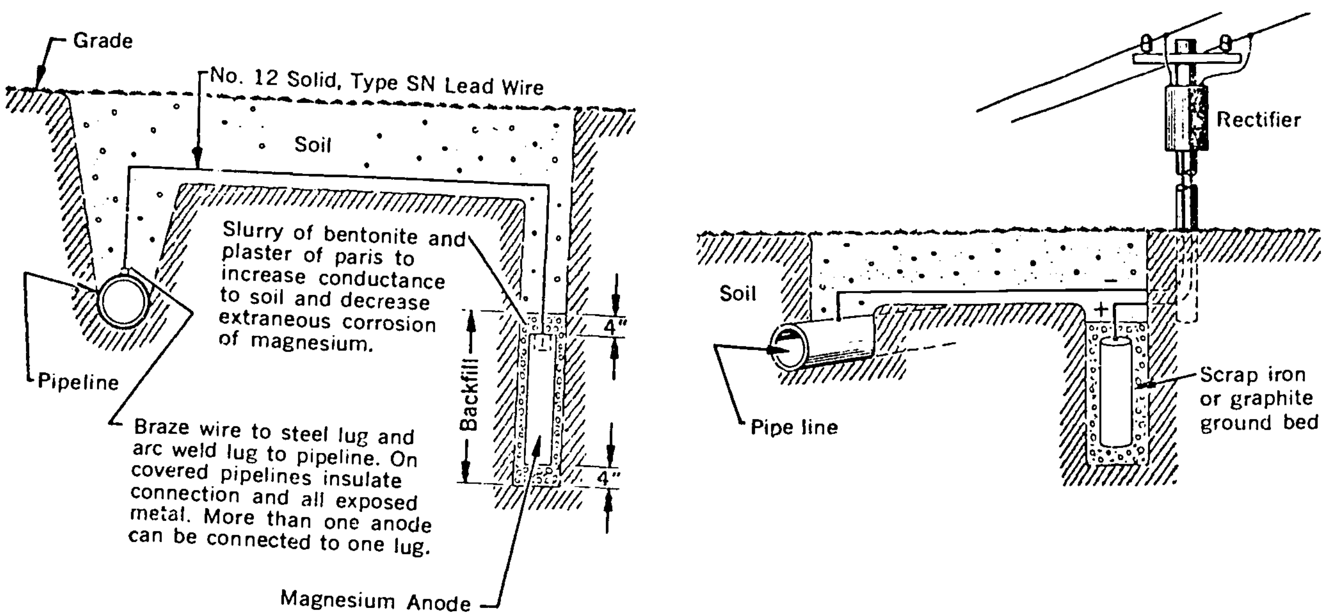


Fig. 17-1 Cathodic Protection

CHAPTER 18

INSULATION

General: Pipe and tank insulation has the function of minimizing heat loss on hot lines or tanks and to protect persons from being burned if the protected surface has a temperature to the touch of greater than 160° F. (State Department of Industrial Relations Safety requirement).

Pipe lines or tanks carrying chilled water must be insulated to minimize heat gain to within acceptable limits; prevent condensation on the pipe or tank by barring the passage of moisture-laden air; also keep the outside surface of the insulation dry by keeping that surface above the dew point of the surrounding air.

Measurement: The thermal conductivity or K-factor is the unit which measures the effectiveness of an insulation. It is defined as the amount of heat in Btu per hour per square foot which will flow thru a panel 1 ft. square and 1 in. thick with a temperature difference of 1° F. on opposite sides of the panel. The formula for the heat transfer of the insulation then becomes:

Btu per hour per sq. ft. = K x temp. diff./in. thickness

At 100° F. mean temperature the average values of K will vary from 0.30 for fiber glass to 0.25 for glass wool blankets; flexible foamed plastic has a value of 0.26. 85% magnesia has a K = 0.39.

The thickness of the insulation applied is based on a balance of the permissible heat gain or loss and the cost of the material and application.

Selection of Material: Desirable features of an insulating material aside from a high thermal efficiency as shown by an acceptable K value are:

1. It must be in a form which is easily applied.
2. It will not accelerate corrosion, and will not swell, shrink, nor rot.
3. It will not disintegrate if it becomes wet from any cause, such as a leaky joint.
4. It must meet U-L Fire Hazard Standards and applicable Specification Compliance for the particular job.
5. The vapor barrier jacket for cold lines must have a low permeability rating, based on the applicable ASTM procedures.

Where the temperature is not below 50° F. the vapor seal jacket is a thin wrapping for the piping and also the fittings. The colder the fluid in the lines, the more important the vapor seal becomes.

6. It must be provided with a weatherproof jacket if recommended for outdoor service. It may vary from a coated asbestos paper, heavy plastic tape wrap, or medium gage metal jacket to a custom type for severe service.

7. Underground installations must be designed so the insulation is kept absolutely dry. This may require a concrete trench or special conduit.

8. Insulating blanket, or blocks, usually about 1-1/2 in. thick are used for insulating hot water tanks. After the insulation is securely fastened a 1/4" finishing coat of cement is applied and trowelled to a smooth finish.

9. Insulation must be sturdy enough to withstand mechanical abuse to which it may be subjected.

Installation: The following should be observed for a proper installation:

1. The recommendations of the manufacturer should be followed regarding the accessory finishes and tapes to be used in the installation of his product.

2. Adequate space should be available between parallel pipe runs to provide uninterrupted covering.

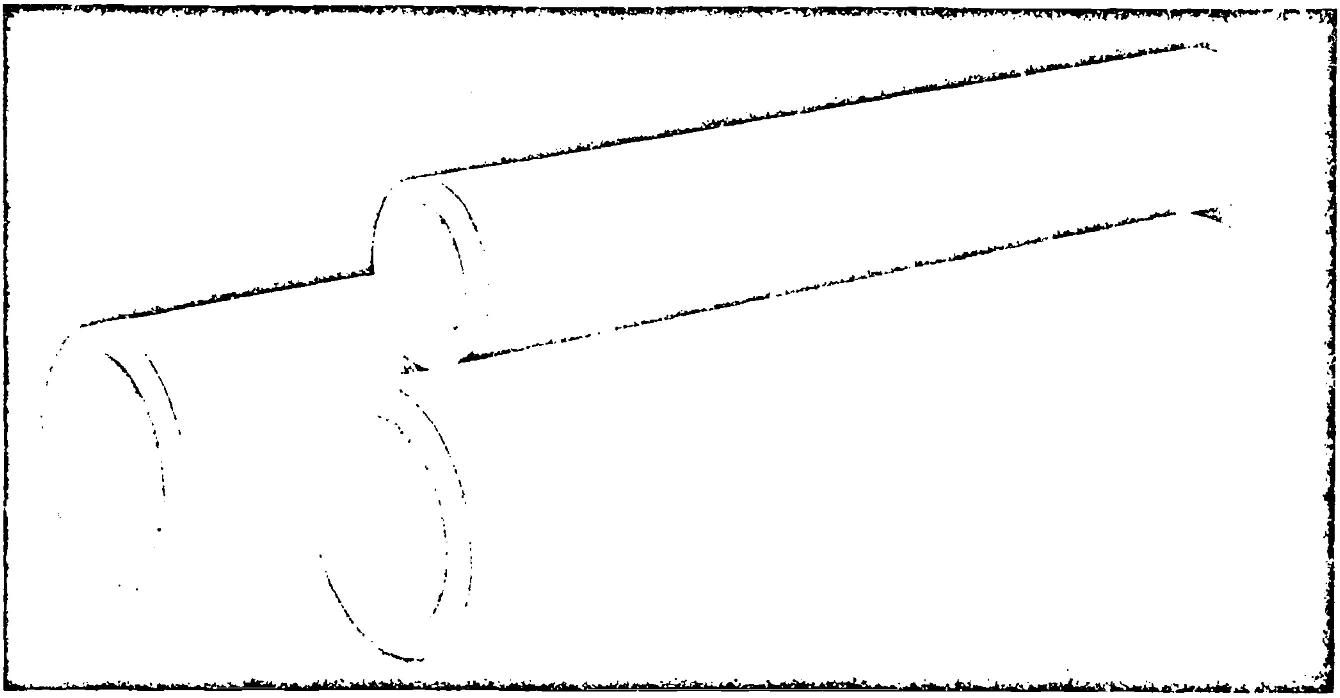
3. Hangers should be appropriate for the size, location and service. Hot water lines of small diameter may have the hangers directly on the pipe; the covering will run continuously with a cut-out for the hanger. Larger pipes will have the hanger outside the pipe with a metal shield between the hanger and the pipe to protect the covering. Larger pipes, 5" dia. and up will have protection saddles. Illustrations of types of hanger material are shown at the end of Chapter 5.

4. All insulation shall be continuous through walls and floors. The sleeves shall be large enough to accommodate the insulation. Escutcheon plates or metal shields at walls or floors shall be installed outside the covering.

5. Cold piping (less than 50° F.) shall have an adequate vapor barrier including all fittings. All metal contact with the pipes, including the hangers shall be insulated to prevent sweating.

6. All insulation shall be applied with the joints tightly butted, and staggered. Coat liberally with the joining material recommended.

The Inspector shall understand the purposes of the insulation work, and insist that the workmanship will accomplish this.



PPG Fiber Glass Insulation for medium temperature lines is designed primarily for use on hot, cold and chilled water lines, low pressure steam lines and similar indoor applications within the 50F to 250F temperature range.

It is made of fine glass fibers bonded together with an inert thermosetting resin, then preformed into cylindrical sections three feet long, slit lengthwise for easy application. Inside diameters of the sections conform to standard iron pipe and copper water tubing sizes; thicknesses are ½ inch and ¾ inch.

This insulation is tough, resilient, light weight; it will not shrink, swell or rot; it will neither cause nor accelerate corrosion. Its thermal efficiency is high in comparison with most other types of insulation and it resists thermal shock and aging.

Sizes and Thicknesses

Iron Pipe

Nominal Size (inches)	*Thicknesses Available (inches)*
½ through 14	½
½ through 6	½; ¾

Copper Water Tubing

Nominal Size (inches)	*Thicknesses Available (inches)*
⅝ through 6⅛	½; ¾

Jacket

The jacket for medium service lines is of the noncombustible, light duty (LD-FRJ), vapor barrier type. It is a "sandwich" of 0.00035-inch embossed foil, glass fiber reinforcing yarn, and white creped kraft. The layers are bonded together by a special self-extinguishing adhesive. Permeability rating is 0.30 (ASTM E-96, Procedure A).

Physical Properties

Density: Nominal 4 lb/cu ft.

Moisture Absorption: Less than 1.0% by weight.

Alkalinity: Less than 0.25% expressed as Na_2O.

Corrosivity: Does not cause or accelerate corrosion.

Thermal Diffusivity: 0.025 sq ft/hr at 75F mean temp.

Thermal Conductivity:

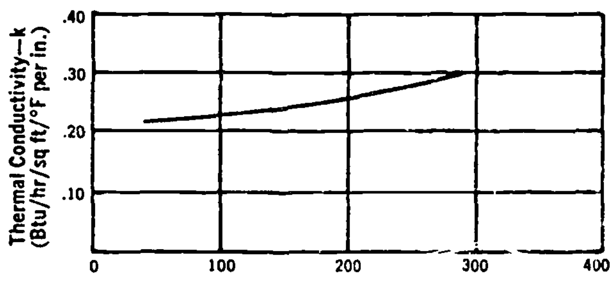


Fig. 18-1 Fiber Glass Insulation

Heat losses, efficiencies and surface temperatures

(Ambient temperature at 80 F)

Insulation wall thickness ½ in.

Pipe temperature	130 F			180 F			230 F		
Temperature difference	50 F			100 F			150 F		
IPS	HL	E	Ts	HL	E	Ts	HL	E	Ts
½	7	71	88	14	74	97	23	75	106
¾	7	76	86	15	78	94	24	79	102
1	9	74	88	19	76	98	31	78	109
1¼	10	77	88	21	79	97	34	81	106
1½	12	75	90	27	77	101	42	78	113
2	14	77	89	29	79	99	47	81	110
2½	16	78	89	34	80	100	54	81	111
3	21	76	91	44	78	103	70	80	116
3½	23	76	91	49	79	103	78	80	117
4	25	77	91	52	79	102	83	81	115
4½	27	77	91	58	79	103	92	81	116
5	30	77	91	64	79	103	102	81	117
6	37	77	92	78	79	105	123	80	119
7	42	76	92	90	78	105	143	80	120
8	47	76	92	101	78	106	160	80	121
9	49	78	91	104	80	104	165	81	118
10	59	76	93	126	78	107	199	80	122
11	64	76	93	136	78	107	216	79	122
12	59	79	91	126	81	103	200	82	116
14	70	78	92	148	80	105	235	81	120

Insulation wall thickness ¾ in.

½	6	76	85	12	78	91	19	79	98
¾	6	80	80	12	82	90	20	83	95
1	7	79	86	16	81	92	25	82	100
1¼	8	82	85	17	84	91	26	85	97
1½	9	82	86	20	83	93	31	84	100
2	11	82	86	23	84	93	37	85	101
2½	12	84	87	27	84	94	43	85	102
3	15	82	87	33	84	96	53	85	105
3½	17	83	87	36	84	95	58	85	105
4	19	83	87	40	84	96	64	85	105
4½	20	84	87	42	85	95	68	86	104
5	22	83	88	48	84	96	77	85	106
6	26	83	88	56	85	97	89	85	107

IPS: nominal pipe size (in.). **HL**: heat loss (Btu per linear foot of pipe); **E**: efficiency of insulation (%); **Ts**: temperature of outside surface of insulation (°F).

Recommended Thicknesses

Wall thickness of insulation for cold water or chilled water lines depends on pipe temperature and on atmospheric conditions (temperature and relative humidity).

Most commonly, ambient conditions will not be more severe than 90F temperature and 70% relative humidity. Under these conditions, and with pipe surface temperature of 50F, insulation thickness of ½ inch will prevent condensation on pipe of all sizes through 10 inch. For larger sizes or more severe conditions, use the thicknesses and jacket recommended for Cold Lines.

The suitability of PPG medium service insulation for heated lines, in any specific installation, can be determined from the table at the left. If heat losses or insulation surface temperatures must be lower than those obtainable with this insulation, refer to recommendations in PPG Bulletin covering Hot Water and Steam Lines.

Underwriters' Laboratories Fire Hazard Classification (UL Standard 723)

	Foil Exposed	*Kraft Exposed*
Flame Spread	5	25
Fuel Contributed	0	0
Smoke Developed	0	40

Specification Compliance

HH-I-552: Insulation Pipe Covering, Thermal, and Insulation Blanket, Thermal Pipe Covering, Type I, Molded, Class A and Class B.

HH-I-562: Insulation, Thermal, Mineral Wool, Block or Board, and Pipe Insulation (Molded) Type II, Classes 1, 2 and 3.

HH-I-558a: Insulation, Thermal (Mineral Fiber). Form D, Type III, Class 12. *Note:* This specification supersedes HH-I-552 and HH-I-562.

ASTM-C547-64T: Mineral Fiber Preformed Pipe Insulation.

MIL-I-22344B: Insulation, Pipe Covering, Thermal, Fibrous Glass.

Fig. 18-2 Fiber Glass Specification

Fiber Glass PPG INDUSTRIES

PPG INDUSTRIES • FIBER GLASS DIVISION
ONE GATEWAY CENTER • PITTSBURGH, PENNSYLVANIA 15222

Because of its insulating efficiency and ease of application PPG Flexible Insulation Tubing is exceptionally suitable for use on many residential and commercial piping systems within the 0F to 220F temperature range. These include refrigerant and chilled water lines, hot water and heating lines, and dual-temperature lines from a central system to individual air-conditioning units. Limitations of uses are primarily those imposed by size (Maximum ID, 4½") and wall thickness (Maximum ¾").

PPG Flexible Insulation Tubing is a foamed elastomer extruded to form a tough, flexible tube. The foaming process produces innumerable tiny, closed air cells, giving this tubing a high thermal insulating value.

Water absorption and vapor transmission are very low, assuring maintenance of insulating properties even under severe moisture conditions. No jacket or other protection is needed. The Tubing may, however, be color-coated if desired for appearance or for coding the lines.

This insulation is also highly resistant to deterioration from exposure to oxygen, ozone, moisture, corrosive atmospheres and oils and solvents. It resists fungus and vermin. It is self-extinguishing.

PPG Flexible Insulation Tubing can be quickly and easily snapped over existing piping or slipped on new pipe before it is installed. It follows the contour of gradual bends; where covers for fittings are required they are easily fabricated from the Tubing. Adhesive, used at all joints, bonds the insulation on a whole system into virtually a single unit.

Sizes and Thicknesses

Iron Pipe

Nominal Size (inches)	*Thicknesses Available (inches)*
¼" through 2"	⅜", ½", ¾"
2½" through 4"	½", ¾"

Copper Water Tubing

Nominal Size (inches)	*Thicknesses Available (inches)*
⅜" through 2⅛"	⅜", ½", ¾"
2⅝" through 4⅛"	½", ¾"

All tubing is supplied in 6-foot lengths, unslit. On special order the same material can be supplied in sheet form. Standard sheets are 24" by 60"; thicknesses from ⅛" to 1".

Physical Properties*

Density: 5.5 to 6.5 lb/cu ft. (ASTM D 1667-64)

Water Absorption: Maximum 10% by weight. (ASTM D 1056-62T)

Temperature Range: —50F to 220F.

Flame Resistance: Self-extinguishing. (ASTM D 1692-59T)

Fungus and Vermin Resistance: Excellent.

Cementability: Excellent.

"k" Factor @ 75F: 0.28 Btu/hr/sq ft/°F/inch. (ASTM C 177-63)

Ozone Resistance: Excellent.

Odor: Negligible

Water Vapor Permeability: 0.12 perm-in max. (ASTM C 355-64)

Linear Shrinkage: (ASTM C 548-64T) 28 days @ 150F, 1.8% max.; at 200F, 3.2% max.; @ 220F, 3.6% max.

*Determined on tubing of ½" wall thickness. May vary slightly for other thicknesses.

Specification Compliance

HH-I-00573a (GSA-FSS): Insulation, Thermal, Flexible Unicellular Sheet and Pipe Covering.

MIL-P-15280 D: Plastic Foam, Unicellular, Sheet and Tubular Form, Elastomeric.

ASTM C 534-64T: Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.

Fig. 18-3 Flexible Insulation Tubing

CHAPTER 19

INSPECTION AND TESTING

General: One of the major duties of the Plumbing Inspector is to make sure that all of the work shown on the plans and specified is installed to comply with the requirements of the documents.

The inspection and testing procedure will continue during the progress of the work and until acceptance by the Owner or his representative. The quality of the work will usually be the best where the tests are performed in progressive stages.

Visual: The inspection of materials begins when they arrive on the job. The actual item should be checked against the approved material list which is in the Inspector's files. Any deviations should be noted, and reported to the Architect/Engineer.

The quality of the finish material should be checked for any defects such as hairline cracks in fixtures, chrome peeling on the brass fixtures, warped backs on vitreous fixtures so that they do not set true to the wall line, and similar conditions.

All pipe and fixtures must be checked to assure that the supports are adequate, and the piping has room for expansion.

The testing procedures as reproduced herein from the Uniform Plumbing Code, 1973 Edition, are those normally used; the test of time has proved them to be adequate for the piping systems under normal circumstances.

Drainage and Vent System:

Water Test: The water test is simpler to make than the air test for drainage and vent systems. Some types of joints, however, will not withstand as much pressure as others. About 100-120 ft. vertically is the maximum for cast iron pipe with poured joints. Screwed pipe can be tested at one filling to a vertical height of 200-250 ft. Copper tubing with sweat joints can also be tested to a similar height.

Air Test: It is more difficult to find leaks at the joints with an air test unless soap and water is used at the suspected joint.

Smoke Test: Where the smoke test is used, it is made by filling all traps with water, then filling the entire system with a pungent, thick smoke, usually produced by a smoke machine. When the smoke appears at the highest opening, it is closed, and a pressure of 1 in. water column is produced and held for at least 15 minutes before an examination of all joints is made. The doors and windows should be kept closed during this test to confine the smoke, as it is difficult to detect a small leak if the smoke disperses rapidly. A soap solution will often show up the leak when applied externally to the joint.

Odor Test: This is accomplished by closing all openings except the top of one stack. About 1 oz. of oil of peppermint for every 25 ft. of stack, but not less than 2 oz. is introduced, followed by a gallon or more of boiling water. The stack is closed, and a search is made for the smell of peppermint. This is a simple test, but may not be conclusive because of lack of pressure in the pipes, or the odor may be so pervasive that the source of the leak cannot be detected.

Final Test: After all fixtures are in place and the fixture traps are filled with water the final test should be made. It is quite important. The odor test or smoke test is often used under these circumstances.

The building sewer should be tested with water or air to assure that it is tight. Often, the water and sewer are laid in the same trench, so there is a chance for contamination unless a suitable water or air test is applied.

Water Supply System:

The entire hot and cold water system must be tested before the pipes are concealed in the walls or ceiling. The test can be made with water or air as described in the Uniform Plumbing Code. Large projects usually require that the water pressure shall be 50 to 100% higher than normal operating pressure. This will make allowance for any surges in the system. Since water is practically incompressible, a small hand force pump connected at a convenient point can apply the extra pressure needed. Any drop in pressure after the pump is stopped will indicate a leak. A water test will usually show a leak faster than air because of its visibility. This testing may be done progressively, but a final test should be made after all fixtures and appliances are in place.

Storm Water System:

The entire storm water system installed within the building should be tested the same as the drainage system.

Fuel Gas Systems:

The fuel gas systems as well as other gas systems must be tested. Refer to the respective chapter headings for the testing procedure.

Fire Protection Systems:

Refer to Chapter 14 for the tests to be performed, or to the NFPA pamphlets for the particular type of system being installed.

Landscape Piping:

Drainage and vent piping on the exterior should be tested the same as specified for utility or interior systems.

The water piping on the pressure side of the shutoff valves shall likewise be tested the same as specified for utility or interior piping.

Disinfection:

The potable water supply system must be kept free from contamination during the installation of both the interior and exterior piping and equipment. As an extra safeguard, all piping must be thoroughly flushed by opening valves at the ends of the lines and let the water run at full force. After this is done, it is good practice to fill the hot and cold water systems with a solution containing 50 parts per million of available chlorine and allow it to stand for at least 6-1/2 hours before flushing and returning the line to service. During this time a trickle should be allowed at each fixture outlet for a thorough disinfection job. If a solution containing 100 parts per million is used the time can be reduced 50%. Flush the lines thoroughly after disinfecting them.

Not all codes require the disinfection. The Inspector should be guided by the plans and specifications prepared by the Architect/Engineer.

Welding Procedures:

The student is referred to the Air Conditioning, Heating and Ventilating Manual, Section 2 of the Course of Study - Construction Supervision and Inspection - for a discussion regarding the inspection of welded joints.

Normally, the welding included under that Section is much more inclusive than is required in the Plumbing Section.

The procedure for the certification of welders for various classes of work is also included under the same Section.

Piping Systems:

The following itemized list is repeated from the above reference, Section 3, because it is applicable to all piping systems discussed in this manual.

Piping Check Points; verify that:

1. Pipe and fittings delivered to the job meet specifications.

2. Pipe is stored in a clean location.

3. All welders have current certifications, and have an assigned identification stamp.

4. Pipe sleeves are in the proper location in walls and allow for the horizontal pitch of the pipe.

5. Sleeves are large enough to permit some pipe movement, and large enough to allow for pipe insulation if called for in the specifications.

6. Where pipes pass vertically through a waterproof floor slab with a membrane, the membrane is flashed or otherwise made watertight around a permanent sleeve.

7. Pipe hanger inserts and anchor attachments are placed in the forms prior to the concrete pour. Inserts are on the specified center distances, and at changes of direction of the piping.

8. There is enough room between pipes to insulate, wrap, and paint them.

9. Spring hangers are provided to support hot pipes that may lift off the supports.

10. Thrust blocks are in place prior to test and backfilling for slip-joint type underground piping.

11. Provision has been made for venting and draining piping.

12. Provision has been made for expansion of piping to protect pumps and similar equipment from excessive forces.

13. Thread engagement is correct.

14. Threaded pipe ends are reamed.

15. Size reductions and increases are made with bell reducers, not bushings.

16. Pipe hangers supporting pipe subject to movemer_ from thermal expansion have a non-rigid connection to the structure, such as linked eye-rods.

17. Pipe has the proper pitch, as covered in this section.

18. Pipes are sufficiently supported to take the weight off of flexible connectors.

19. Restrainer bolts are installed on flexible connectors to prevent them from blowing apart when pressurized.

20. Hangers are adjusted for equal load. Clevis hangers bolted to hanger rod with two nuts; above and below upper strap.

21. Steam strainers blow off to a safe place.

22. Strainer baskets can be withdrawn without interference.

23. Strainer blow off valve same size as connection on strainer body.

24. Relief valves discharge to a safe place, and drained in the case of a vertical riser so water will not collect against the top of the seat.

25. Vents from natural gas pressure regulators are piped to a safe place (to a vented firebox, or to atmosphere).

26. Shut-off valves located for easy accessibility.

27. Gas shut-off valve located outside the building.

Fixtures:

Operate all fixtures to check for leaks around the trim, splashing, noisy pipes, proper flushing, and generally satisfactory operation.

Punch List:

This list is prepared when the Contractor notifies the Architect/Engineer that all systems are complete and functioning properly. If there has been a good relationship between the Inspector and the Contractor the final list should not be extensive. It will include any unfinished items of work, items denoting poor workmanship, missing or faulty trim or fixtures.

The Contractor shall operate all systems and all equipment long enough to prove that they meet the requirements of the contract documents.

The Inspector shall be present when the Contractor operates the equipment and instructs the personnel of the Owner in its use.

The final detailed list is prepared and submitted to the Architect/Engineer for review before transmittal to the General Contractor.

After an agreed upon time to complete the work outlined on the list, a re-inspection is made before final certification is given that the work is satisfactory. This generally leads to acceptance of the work by the Owner.

<u>Acceptance by the Owner</u>:

The acceptance by the Owner does not relieve the Contractor of all future obligation regarding the work.

The Contract Documents generally contain a clause that provides the Owner with a guarantee on workmanship and materials for one year after acceptance, and also a clause on latent defects and omissions that could not be reasonably observed during inspection, such as concealed items; this may extend beyond one year.

The more diligent the Inspector is, the less likely that defects will later occur, that could lead to costly litigation.

It is suggested that the student review Chapter 1, Plumbing Inspection, to assess the valuable position of the Inspector in the construction industry.

Sec. 309 — Workmanship

(a) All design, construction and workmanship shall be in conformity with accepted engineering practices and shall be of such character as to secure the results sought to be obtained by this code.

(b) It is unlawful to conceal cracks, holes or other imperfections in materials by welding, brazing or soldering or by using therein or thereon any paint, wax, tar or other leak-sealing or repair agent.

Sec. 310 — Prohibited Fittings and Practices

(a) No double hub fitting, single or double tee branch, single or double tapped tee branch, side inlet quarter bend, running thread, band or saddle shall be used as a drainage fitting, except that a double hub sanitary tapped tee may be used on a vertical line as a fixture connection.

(b) No drainage or vent piping shall be drilled and tapped for the purpose of making connections thereto, and no cast iron soil pipe shall be threaded.

(c) No waste connection shall be made to a closet bend or stub of a water closet or similar fixture.

(d) Except as hereinafter provided in Sections 613, 614 and 615, no vent pipe shall be used as a soil or waste pipe.

(e) No fitting, fixture and piping connection, appliance, device or method of installation which obstructs or retards the flow of water, wastes, sewage or air in the drainage or venting systems in an amount greater than the normal frictional resistance to flow, shall be used unless it is indicated as acceptable in this code or is approved by the Administrative Authority as having a desirable and acceptable function and as of ultimate benefit to the proper and continuing functioning of the plumbing system. The enlargement of a three (3) inch closet bend or stub to four (4) inches shall not be considered an obstruction.

(f) Except for necessary valves, where intermembering or mixing of dissimilar metals occur, the point of connection shall be confined to exposed or readily accessible locations.

(g) All valves, pipes and fittings shall be installed in correct relationship to the direction of flow.

Sec. 315 — Protection of Piping, Materials and Structures

(a) All piping passing under or through walls shall be protected from breakage. All piping passing through or under cinders or other corrosive materials, shall be protected from external corrosion in an approved manner. Approved provisions shall be made for expansion of hot water piping. Voids around piping passing through masonry floors on the ground shall be appropriately sealed.

(b) All piping in connection with a plumbing system shall be so installed that piping or connections will not be subject to undue strains or stresses, and provisions shall be made for expansion, contraction and structural settlement. No piping shall be directly embedded in concrete or masonry walls or footings. No structural member shall be seriously weakened or impaired by cutting, notching or otherwise, and unless impractical due to structural conditions, all wood beams, girders, joists, studs and similar construction shall be bored with holes approximately the same diameter as the pipes passing through them.

Sec. 318 — Inspection and Testing

1. Inspections

(a) Scope—All new plumbing work and such portions of existing systems as may be affected by new work, or any changes, shall be inspected by the Administrative Authority to insure compliance with all the requirements of this code and to assure that the installation and construction of the plumbing system is in accordance with approved plans.

(b) Advance notice—It shall be the duty of the person doing the work authorized by the permit to notify the Administrative Authority orally or in writing that said work is ready for inspection. Such notification shall be given not less than twenty-four (24) hours before the work is to be inspected.

(c) Responsibility—It shall be the duty of the holder of a permit to make sure that the work will stand the test prescribed before giving the notification.

(d) Retesting—If the Administrative Authority finds that the work will not pass the test, necessary corrections shall be made and the work shall then be resubmitted for test or inspection.

(e) Test—Tests shall be conducted in the presence of the Administrative Authority or of his duly appointed representative.

(f) Corrections—Notices of correction or violation shall be written by the Administrative Authority and may be posted at the site of the work or mailed or delivered to the permittee or his authorized representative. Refusal, failure or neglect to comply with any such notice or order within ten days of receipt thereof, shall be considered a violation of this code, and shall be subject to the penalties set forth elsewhere in this code for violations.

(g) Approval—Upon the satisfactory completion and final test of the plumbing system, a certificate of approval shall be issued by the Administrative Authority to the permittee on demand.

(h) Covering or Using—No plumbing or drainage system, building sewer, private sewer disposal system or part thereof, shall be covered, concealed or put into use until it has been tested, inspected and accepted as prescribed in this code.

(i) Uncovering—Any drainage or plumbing system, building sewer, private sewage disposal system or part thereof, which is installed, altered or repaired, is covered or concealed before being inspected, tested and approved, as prescribed in this code, it shall be uncovered for inspection after notice to uncover the work has been issued to the responsible person by the Administrative Authority.

2. Testing

(a) Responsibility—The equipment, material and labor necessary for inspection or tests shall be furnished by the person to whom the permit is issued or by whom inspection is requested.

(b) Media—The piping of the plumbing, drainage and venting systems shall be tested with water or air. The Administrative Authority may require the removal of any cleanouts, etc., to ascertain if the pressure has reached all parts of the system. After the plumbing fixtures have been set and their traps filled with water, they shall be submitted to a final test.

(c) Water test—The water test shall be applied to the drainage and vent systems either in its entirety or in sections. If applied to the entire system, all openings in the piping shall be tightly closed, except the highest opening, and the system filled with water to point of overflow. If the system is tested in sections, each opening shall be tightly plugged except the highest opening of the section under test, and each section shall be filled with water, but no section shall be tested with less than a ten (10) foot head of water. In testing successive sections at least the upper ten (10) feet of the next preceding section shall be tested, so that no joint or pipe in the building (except the uppermost ten (10) feet of the system) shall have been submitted to a test of less than a ten (10) foot head of water. The water shall be kept in the system, or in the portion under test, for at least fifteen (15) minutes before inspection starts; the system shall then be tight at all point

(d) Air test—The air test shall be made by attaching an air compressor testing apparatus to any suitable opening, and, after closing all other inlets and outlets to the system, forcing air into the system until there is a uniform gage pressure of five (5) pounds per square inch or sufficient to balance a column of mercury ten (10) inches in height. The pressure shall be held without introduction of additional air for a period of at least fifteen (15) minutes.

(e) Building sewer test—Building sewers shall be tested by plugging the end of the building sewer at its points of connection with the public sewer or private sewage disposal system and completely filling the building sewer with water from the lowest to the highest point thereof, or by approved equivalent low pressure air test, or by such other test as may be prescribed by the Administrative Authority. The building sewer shall be water-tight at all points.

(f) Water piping—Upon completion of a section or of the entire hot and cold water supply system, it shall be tested and proved tight under a water pressure not less than the working pressure under which it is to be used. The water used for tests shall be obtained from a potable source of supply. A fifty (50) pounds per square inch air pressure may be substituted for the water test. In either method of test the piping shall withstand the test without leaking for a period of not less than fifteen (15) minutes.

(g) Defective systems—An air test shall be used in testing the sanitary condition of the drainage or plumbing system of any building or premises when there is reason to believe that it has become defective. In buildings or premises condemned by the proper Administrative Authority because of an insanitary condition of the plumbing system or part thereof, the alterations in such system shall conform to the requirements of this code.

(h) Moved Structures—All parts of the plumbing systems of any building or part thereof that is moved from one foundation to another, or from one location to another shall be completely tested as prescribed elsewhere in this section for new work, except that walls or floors need not be removed during such test when other equivalent means of inspection acceptable to the Administrative Authority are provided.

(i) Test waived—No test or inspection shall be required where a plumbing system or part thereof, is set up for exhibition purposes and has no connection with a water or drainge system.

(j) Exceptions—In cases where it would be impractical to provide the aforementioned water or air tests, or for minor installations and repairs, the Administrative Authority at his discretion, may make such inspection as he deems advisable in order to assure himself that the work has been performed in accordance with the intent of this code.

(k) Tests for Shower Receptors—Shower receptors shall be tested for water tightness by filling with water to the level of the rough threshold. The test plug shall be so placed that both upper and under sides of the subpan shall be subjected to the test at the point where it is clamped to the drain.

APPENDIX

A-1 - DEFINITIONS

ABS: Acrylonitrile-Butadiene-Styrene. (UPC)

Administrative Authority: The Administrative Authority is the individual official board, department or agency established and authorized by a state, county, city, or other political subdivision created by law to administer and enforce the provisions of the plumbing code as adopted or amended. (UPC)

Airbreak: An airbreak is a physical separation which may be a low inlet into the indirect waste receptor from the fixture, appliance or device indirectly connected. (UPC)

Airgap: The unobstructed vertical distance thru the free atmosphere between the lowest opening from any pipe or faucet conveying water or waste to a tank, plumbing fixture, receptor or other device and the flood level rim of the receptacle. (UPC)

Airlock: Air or other gas entrapped in a liquid in a pipe or container so that the flow of the liquid is slowed or stopped by the entrapped gas.

Appurtenance: A device which adds no additional requirement or load to the system, and which contributes to the operation, maintenance, servicing, or safety of the system.

Backflow: The flow of water or other liquids, mixtures, or substances into the distributing pipes of a potable supply of water from any source or sources other than its intended source. (UPC)

Back Siphonage: The flowing back of used, contaminated, or polluted water from a plumbing fixture or vessel into a water supply pipe due to a negative pressure in such pipe. (UPC)

Blowoff: A valved outlet from a pipeline used to discharge water, steam, sludge, or other fluid waste, such as boiler blowoff.

Branch Vent: A vent connecting one or more individual vents with a vent stack or stack vent. (UPC)

Brazed Joint: A brazed joint is any joint obtained by joining of metal parts with alloys which melt at temperatures higher than 1000° F, but lower than the melting temperature of the parts to be joined. (UPC)

Building Drain: The building drain is that part of the lowest piping of a drainage system which receives the discharge from soil, waste and other drainage pipes inside the walls of the building and conveys it to the building sewer beginning two (2) feet outside the building wall. (UPC)

Building Sewer: The building sewer is that part of the horizontal piping of a drainage system which extends from the end of the building drain and which receives the discharge of the building drain and conveys it to a public sewer, private sewer, individual sewage-disposal system or other point of disposal. (UPC)

Bull-Headed Tee: A tee in which the branch is larger than the run.

Circuit Vent: A branch vent that serves two or more traps and extends from in front of the last fixture connection of a horizontal branch to the vent stack. (UPC)

Combination Waste and Vent System: A specially designed system of waste piping embodying the horizontal wet venting of one or more sinks or floor drains by means of a common waste and vent pipe adequately sized to provide free movement of air above the flow line of the drain. (UPC)

Continuous Vent: A vertical vent that is a continuation of the drain to which it connects. (UPC)

Continuous Waste: A drain connecting the compartments of a set of fixtures to a trap or connecting other permitted fixtures to a common trap. (UPC)

Cross Connection: Any connection or arrangement, physical or otherwise, between a potable water supply system and any plumbing fixture or any tank, receptacle, equipment or device, through which it may be possible for non-potable, used, unclean, polluted and contaminated water, or other substances to enter into any part of such potable water system under any condition. (UPC)

Durham System: A term used to describe soil or waste systems where all piping is of threaded pipe, tubing or other such rigid construction, using recessed drainage fittings to correspond to the types of piping. The system must present a smooth and continuous interior surface. (UPC)

Flush Valve: A device located at the bottom of the tank for the purpose of flushing water closets and similar fixtures. (UPC)

Flushometer Valve: A device which discharges a predetermined quantity of water to fixtures for flushing purposes and is actuated by direct water pressure. (UPC)

Industrial Waste: Any and all liquid or water borne waste from industrial or commercial processes except domestic sewage. (UPC)

Insanitary: A condition which is contrary to sanitary principles or is injurious to health.

Conditions to which the word "insanitary" shall apply include the following:

1. Any trap which does not maintain a proper trap seal.

2. Any opening in a drainage system, except where lawful, which is not provided with an approved water-sealed trap.

3. Any plumbing fixture or other waste discharging receptacle or device, which is not supplied with water sufficient to flush it and maintain it in a clean condition.

4. Any defective fixture, trap, pipe or fitting.

5. Any trap, except where in this code exempted, directly connected to a drainage system the seal of which is not protected against siphonage and back pressure by a vent pipe.

6. Any connection, cross-connection, construction or condition, temporary or permanent which would permit or make possible by any means whatsoever, for any unapproved foreign matter to enter a water distribution system used for domestic purposes.

7. The foregoing enumeration of conditions to which the term "insanitary" shall apply shall not preclude the application of that term to conditions that are in fact insanitary. (UPC)

Interceptor: A device designed and installed so as to separate and retain deleterious, hazardous, or undesirable matter from normal wastes and permit normal sewage or liquid wastes to discharge into the disposal terminal by gravity. (UPC)

Liquid Waste: The discharge from any fixture, appliance or appurtenance in connection with a plumbing system which does not receive fecal matter. (UPC)

Listed: Equipment or materials included in a list published by a listing agency that maintains periodic inspection on current production of listed equipment or materials and whose listing states either that the equipment or material complies with approved standards or has been tested and found suitable for use in a specified manner. (UPC)

Loop Vent: Any vent connecting a horizontal branch or fixture drain with the stack vent of the originating waste or soil stack. (UPC)

Nuisance: Nuisance includes, but is not limited to:

1. Any public nuisance known at common law or in equity jurisprudence.

2. Whenever any work regulated by this code is dangerous to human life or is detrimental to health and property.

3. Inadequate or unsafe water supply or sewage disposal system. (UPC)

Plumbing: The business, trade or work having to do with the installation, removal, alteration or repair of plumbing and drainage systems or parts thereof. (UPC)

Plumbing Fixtures: Approved type installed receptacles, devices or appliances which are supplied with water or which receive liquid or liquid borne wastes and discharge such wastes into the drainage system to which they may be directly or indirectly connected. Industrial or commercial tanks, vats and similar processing equipment are not plumbing fixtures, but may be connected to or discharged into approved traps or plumbing fixtures when and as otherwise provided for elsewhere in this code. (UPC)

Plumbing System: The plumbing system means and includes all potable water supply and distribution pipes, all plumbing fixtures and traps, all drainage and vent pipe and all building drains, including their respective joints and connections, devices, receptacles and appurtenances within the property lines of the premises and shall include potable water piping, potable water treating or using equipment, fuel gas piping, water heaters and vents for same. (UPC)

Roughing-In: The installation of all parts of the plumbing system which can be completed prior to the installation of fixtures. This includes drainage, water supply, gas piping, and vent piping and the necessary fixture supports. (UPC)

Sewage: Any liquid waste containing animal or vegetable matter in suspension or solution and may include liquids containing chemicals in solution. (UPC)

Shall: The word "shall" is a mandatory term. (UPC)

Soldered Joint: A soldered joint is a joint obtained by the joining of metal parts with metallic mixtures or alloys which melt at a temperature below 1000° F. and above 300° F. (UPC)

Special Wastes: Wastes which require some special method of handling such as the use of indirect waste piping and receptors, corrosion resistant piping, sand, oil or grease interceptors, condensers, or other pretreatment facilities. (UPC)

Stack: The vertical main of a system of soil, waste or vent piping extending through one or more stories. The extension above the highest horizontal drain connected to it is called the stack vent. (UPC)

Trap: A fitting or device so designed and constructed as to provide when properly vented, a liquid seal which will prevent the back passage of air without materially affecting the flow of sewage or waste water through it. (UPC)

Tucker Fitting: A cast iron coupling one opening of which is threaded for screw pipe and the other opening of which has a hub to receive the spigot end of a pipe.

Vacuum Breaker: A device to prevent the creation or formation of a vacuum. Often referred to as a backflow preventer.

Vent Stack: A vertical vent pipe installed primarily for the purpose of providing circulation of air to and from any part of the drainage system. (UPC)

Vent System: A pipe or pipes installed to provide a flow of air to or from a drainage system or to provide a circulation of air within such system to protect trap seals from siphonage and back pressure. (UPC)

Waste Pipe: A pipe which conveys only liquid wastes free of fecal matter. (UPC)

Welded Joint or Seam: A welded joint or seam is any joint or seam obtained by the joining of metal parts in the plastic molten state. (UPC)

Welder, Pipeline: A person who specializes in welding of pipes and holds a valid certificate of competency from a recognized testing laboratory, based on the requirements of the A.S.M.E. Boiler and Pressure Vessels Code Section 9. (UPC)

Wet Vent: A vent which also serves as a drain. (UPC)

Yoke Vent: A pipe connecting upward from a soil or waste stack to a vent stack for the purpose of preventing pressure changes in the stacks. (UPC)

Plumbing Material Standards

Abbreviations used in Table A refer to standards or specifications issued by the organizations identified below:

AHAM	Association of Home Appliance Manufacturers, 20 North Wacker Drive, Chicago, Illinois 60606
ANSI	American National Standards Institute, 1430 Broadway, New York, New York 10018. (Formerly ASA, USASI)
ASTM	American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pennsylvania 19103. Publish Standards and Tentative Standards.
CS	Commercial Standards, representing voluntary standards of trade, prepared under the procedure of the National Bureau of Standards and published by the United States Department of Commerce. Obtainable from the Superintendent of Documents, United States Government Printing Office, Washington, D.C. 20402
FS	Federal Specifications, published by the Federal Specifications Board. Obtainable from the Superintendent of Documents, United States Government Printing Office, Washington, D.C. 20402
IAPMO (UPC)	International Association of Plumbing and Mechanical Officials, 5032 Alhambra Avenue, Los Angeles, California 90032. Publish Installation (IS) and Product (PS) Standards.
PDI	Plumbing and Drainage Institute, 1018 North Austin Boulevard, Oak Park, Illinois 60302
UL	Underwriters' Laboratories, Incorporated, 207 East Ohio Street, Chicago, Illinois 15420

All standards and specifications for materials are subject to change. Designations, carrying indication of the year of issue, may thus become obsolete.

TABLE A — PLUMBING MATERIAL STANDARDS

MATERIALS AND PRODUCTS	ANSI	ASTM	FS	IAPMO	OTHER STANDARDS	FOOTNOTES REMARKS
FERROUS PIPE AND FITTINGS:						
Black and galvanized steel pipe	B125.2(1970)	A120-69	WW-P-406c(1)1971			
Cast iron pressure fittings	A21.10(1964)					
Cast iron pressure pipe	A21.1(1967)	A377-66	WW-P-421c(1967)			
Cast iron screwed fittings (125 and 250 lbs.)	B16.4(1963)	A126-66	WW-P-501d(1967)			
Cast iron soil pipe and fittings	A112.5.1(1968)	A74-69	WW-P-401d(1969)			
Cast iron threaded drainage fittings	B16.12(1971)		WW-P-491b(1967)			
Hubless cast iron soil pipe and fittings (Installation)				IS 6-72		
Malleable iron screwed fittings (150 and 300 lbs.)	B16.3(1971)		WW-P-521F(1968)			
Pipe threads (Except Dryseal)	B2.1(1968)					
Special cast iron fittings (UPC-specials)				PS 5-71		
Subdrains for built up shower pans				PS 16-66		
Threaded cast iron pipe for DWV services	A40.5(1943)		WW-P-356a(1967)			
Welded wrought iron pipe	B36.2(1969)	A72-68				
NONFEROUS PIPE & FITTINGS:						
Cast brass and tubing "P" — traps				PS 2-66		
Cast bronze fittings for flared copper tubes	B16.26(1967)					
Cast bronze screwed fittings (125 and 250 lbs.)	B16.15(1971)		WW-P-460b(1967)			
Cast bronze solder-joint drainage fittings	B16.23(1969)					
Cast bronze solder-joint pressure fittings	B16.18(1963)					
Copper drainage tube (DWV)		B306-72				
Copper or red brass tube and drainage tube (Installation)				IS 3-69		
Diversion tees and twin waste elbow				PS 9-66		
Drains for prefabricated and precast showers				PS 4-66		
Flexible copper water connectors				PS 14-71		
Seamless brass tube		B135-71A	WW-T-791a(1971)			
Seamless copper pipe	H26.1-1967	B42-72	WW-P-377d(1962)			
Seamless copper tube		B75-72	WW-T-797c(1963)			
Seamless copper water tube (K, L & M)	H23.1-1970	B88-72	WW-T-799b(1971)			
Seamless red brass pipe	H27.1-1967	B43-72	WW-P-351a(1963)			
Tubing trap wall adapters				PS 7-66		
Welded red brass (copper allow 230) drainage tube				PS 29-69		
Welded red brass (copper allow 230) water tube				PS 28-69		
Wrought copper and bronze solder joint pressure fittings	B16.22-1963					
Wrought copper and wrought copper alloy solder-joint drainage fittings	B16.29-1968					
NONMETALLIC PIPING:						
Acrylonitrile-butadiene-styrene (ABS) — DWV pipe and fittings (Installation)				IS 5-71		
Acrylonitrile-butadiene-styrene (ABS) — DWV pipe and fittings/with Addendum				PS 17-71		
Asbestos cement non-pressure small diameter sewer pipe		C644-71				Note 4
Asbestos cement pressure pipe		C296-72	SS-P-351c(1968)			
Asbestos cement plumbing vent pipe				MS 2-55		Notes 1 & 2
Compression joints, vitrified clay pipe, bell and spigot pipe		C425-71				
Extra strength clay pipe		C200-69				
Fittings for joining polyethylene pipe for water service and yard piping				PS 25-69		
Homogenous bituminized fiber drain and sewer pipe		D1861-69				Note 1
Hot pour joints (clay pipe)			SS-S-169(1954)			
Nonmetallic building house sewers (Installation)				IS 1-71		
One piece molded rubber coupling for plain end vitrified clay sewer pipe joints				PS 19-66		
Polyethylene building supply (water service lines)....(Installation)				IS 7-72		

TABLE A — PLUMBING MATERIAL STANDARDS

MATERIALS AND PRODUCTS	ANSI	ASTM	FS	IAPMO	OTHER STANDARDS	FOOTNOTES REMARKS
Polyethylene pipe (building supply)				PS 24-72		
Polyethylene (PE 3406) natural gas yard piping				IS 12-71		
Poly (vinyl chloride) (PVC) natural gas yard piping				IS 10-71		
Poly (vinyl chloride) (PVC) — DWV (Installation)				IS 9-71		
Poly (vinyl chloride) (PVC) — DWV Pipe & Fittings		D2665-68				
PVC Pipe and fittings with rubber gasketed joints for cold water service and yard piping				IS 14-72		
Rubber rings for asbestos cement pipe		D1869-66				
Solvent cemented poly (vinyl chloride) (PVC) pipe for water yard piping (Installation)				IS 8-71		
Supplemental to ASTM Standard D 2665 — PVC-DWV				PS 27-69	CS 77-63	
PLUMBING FIXTURES:						
Cultured marble lavatory				PS 18-72		
Enameled cast iron plumbing fixtures						
Grease interceptors				PS 13-66		PDI Standard
Job fabricated shower receptors (Installation)				IS 4-69		G101 by
Plumbing fixtures for land use			WW-V-541(1971)			reference
Prefabricated shower receptors, shower enclosures and metallic bathtubs	Z124.1(1967)			PS 11-72		
Stainless steel fixtures	Z124.2(1967)				CS 243-62	
Staple vitreous china plumbing fixture					CS 20-63	
Tile lined Roman bath tubs (Installation)				IS 2-65		
VALVES:						
Backflow prevention devices				PS 31-71		
Back water, sewer				PS 8-71		
Bronze gate			WW-V-54c(1966)			
Cast Iron Gate			WW-V-58a(1966)			
			WW-V-58b(1971)			
Globe-type log lighter valves (gas)				PS 10-66		
L.P. gas					UL 125 1968	
Pressure reducing and regulating valves				PS 15-66		
Relief valves and automatic gas shutoff devices for hot water supply systems	Z21.22-1964			PS 15-71	UL 132 1958	
	Z21.22-1971					
APPLIANCES AND EQUIPMENT:						
Automatic storage type water heaters with input less than 50,000 Btu per hour, Approval requirements for, Vol. 1	Z21.10.1-1971					
Circulating tank, instantaneous and large automatic storage type water heaters, Approval requirements for, Vol. III	Z21.10.3-1971					
Draft hoods, Listing requirement for	Z21.12-1971					
Electric water heaters					UL 174 1956	
Gas fired steam and hot water boilers	Z21.13-1967					
Addenda to Z21.13-1967, Z21.13B-1971	Z21.13a-1968					
Metal connectors for gas appliances	Z21.24-1967					
Addenda to Z21.24-1967, Z21.24B-1969	Z21.24a-1968					
Oilfired boilers					UL 726 1963	
Oilfired water heaters					UL 732 1955	
Vents, gas					UL 441 1964	
MISCELLANEOUS:						
Compound — plumbing fixture setting			HH-C-536a(1954)	PS 20-65		
Copper sheet, strip, plate and rolled bar		B152-71-A				
Dishwasher drain airgaps				PS 23-69	AHAM HS-1	
Leaded yellow brass sand castings for general purposes		B146-70				Note 3
Prefabricated concrete septic tanks				PS 1-66		
Plant applied protective pipe coatings				PS 22-71		
Protectively coated pipe, installation of				IS 13-71		
Rubber gaskets for cast iron soil pipe and fittings		C-564-70				
Sheet lead			QQ-L-201f(2)(1970)			
Sheet steel or iron, galvanized		A525-70				
Solder metal		B32-70	QQ-S-571d(1963)			

1 Limited to domestic sewage
2 Sizes 3" and larger, when installed six (6) inches above the uppermost fixture in the building
3 Classification 6A for cleanout plugs
4 Type II only

QUALITY AND WEIGHTS OF MATERIALS
ALTERNATE MATERIALS
ALTERNATE METHODS OF CONSTRUCTION

Section 201 — Minimum Standards

(a) Unless otherwise provided for in this code, all materials, fixtures or devices used or entering into the construction of plumbing and drainage systems or parts thereof, shall be submitted to the Administrative Authority for his approval and shall conform to approved applicable standards or to other equivalent standards acceptable to the Administrative Authority and shall be free from defects. All pipe, pipe fittings and fixtures shall be listed or labeled by a listing agency or shall be approved by the Administrative Authority when listing or labeling by a listing agency is not available.

(b) Each length of pipe and each pipe fitting, trap, fixture, material and device used in a plumbing system shall have cast, stamped, or indelibly marked on it the maker's mark or name, the weight and the quality of the product, when such marking is required by the approved standard that applies. All materials and devices used or entering into the construction of plumbing and drainage systems or parts thereof shall be marked and identified in a manner satisfactory to the Administrative Authority.

(c) Standards listed or referred to in this chapter cover materials which will conform to the requirements of this code, when used in accordance with the limitations imposed in this or other chapters thereof. Design and materials for special conditions or materials not provided for herein may be used only by special permission of the Administrative Authority after he has satisfied himself as to their adequacy. For the convenience of users of this code a list of generally accepted plumbing material standards is included at the end of this Manual, in Table "A".

(d) In existing buildings or premises in which plumbing installations are to be altered, repaired or renovated, the Administrative Authority has discretionary powers to permit deviation from the provisions of this code, provided that such a proposal to deviate is first submitted for proper determination in order that health and safety requirements as they pertain to plumbing shall be observed.

(e) The provisions of this code are not intended to prevent the use of any alternate material or method of construction provided any such alternate has been first approved and its use authorized by the Administrative Authority.

Sec. 202 — Iron Pipe Size (I.P.S.) Pipe

Wrought iron, steel, brass and copper pipe shall be standard weight iron pipe size (I.P.S.) pipe. Threads used in assembling such pipe shall be standard taper pipe threads.

Sec. 203 — Use of Copper Tubing

(a) Copper tube for underground drainage and vent piping shall have a weight of not less than that of copper water tube Type L.

(b) Copper tube for above ground drainage and vent piping shall have a weight of not less than that of copper drainage tube Type D.W.V.

(c) Copper tube shall not be used for chemical or industrial wastes as defined in Section 612 of this code.

(d) Copper tube for water piping shall have a weight of not less than that of copper water tube Type L. Exception: Type M copper tubing may be used for water piping when piping is above ground in a building, or underground outside of structures.

(e) In addition to the required incised marking, all hard drawn copper tubing shall be marked by means of a continuous and indelibly colored stripe at least one quarter (1/4) inch in width as follows: Type K, green; Type L, blue; Type M, red; Type DWV, yellow.

Sec. 204 — Lead

See Table A. Sheet lead shall be not less than the following:

For safe pans—not less than four (4) pounds per square foot.

For flashings of vent terminals—not less than three (3) pounds per square foot.

Lead bends and lead traps shall be not less than one-eighth (1/8) inch wall thickness.

Sec. 205 — Ferrules and Bushings

(a) Caulking ferrules shall be manufactured from bronze or copper and shall be in accordance with Table 2-1.

(b) Soldering bushings shall be of bronze or copper in accordance with Table 2-2.

Sec. 206 — Floor Flanges

(a) Floor Flanges for water closets or similar fixtures shall be of an approved type and shall be bronze, copper, hard lead, cast iron, galvanized malleable iron, ABS, PVC or other approved materials. Each such flange shall be approximately seven (7) inches in diameter and when installed shall, together with the soil pipe, present a one and one-half (1-1/2) inch wide flange or face to receive the fixture gasket.

(b) Caulked-on flanges shall be not less than one-fourth (1/4) inch thick and not less than two (2) inches in overall depth.

(c) Flanges shall be burned or soldered to lead bends or stubs, shall be caulked to cast iron soil pipe, shall be solvent welded to ABS and PVC and shall be screwed or fastened in an approved manner to other materials.

(d) All such flanges shall be adequately designed and secured to support fixtures connected thereto.

(e) Closet screws, bolts, washers and similar fasteners shall be of brass, copper or other equally corrosion resistant metal. All such screws and bolts shall be of adequate size and number to properly support the fixture installed.

Sec. 207 — Cleanout Fittings

(a) Each cleanout fitting for cast iron pipe shall consist of a cast iron or brass body, and an approved plug. Each cleanout for galvanized wrought iron, galvanized steel, copper or brass pipe shall consist of a brass plug as specified in Tables 2-3, 2-4, or a standard weight brass cap, or an approved ABS or PVC plastic plug. Plugs shall have raised square heads or approved countersunk rectangular slots. Countersunk heads shall be used where raised heads may cause a hazard.

(b) Each cleanout fitting and each cleanout plug or cap shall be of an approved type. Materials used for cleanouts shall conform to approved standards acceptable to the Administrative Authority.

(c) Each cleanout shall be maintained gas and watertight. Where a thread lubricant is used, such lubricant shall be an approved non-hardening type. No gasket, packing or washer shall be used to maintain any cleanout in a gas and watertight condition.

Sec. 208 — Thread or Solder Cup Type Fittings

(a) All plain screwed fittings shall be of cast iron, malleable iron, bronze or copper of standard weights and dimensions.

(b) Drainage fittings shall be of cast iron, malleable iron, bronze, copper, ABS or PVC with smooth interior waterway, having threads tapped out of solid metal except threaded fittings of ABS and PVC shall be molded. The threads of drainage fittings shall be tapped so as to allow one-fourth (¼) inch per foot grade. The solder cup of solder type fittings shall be formed so as to allow one-fourth (¼) inch per foot grade. No wrought copper or wrought bronze drainage fittings shall be installed below ground.

(c) Cast iron fittings, up to and including two (2) inch, used for water distribution, shall be galvanized.

(d) All malleable iron vent or water fittings shall be galvanized.

Sec. 209 — Back Water Valves

Back water valves shall have cast iron or brass bodies, non-corrosive bearings, seats and self aligning discs, and shall be so constructed as to insure a positive mechanical seal and to remain closed, except when discharging wastes. Such valves shall remain sufficiently open during periods of low flows to avoid screening of solids and shall not restrict capacities or cause excessive turbulence during peak loads. Valve access covers shall be bolted type with gasket and each valve shall bear the manufacturer's name cast into body and cover.

Sec. 210 — Valves and Fittings

(a) Gate valves when used on drainage work shall be full way type with working parts of corrosion resistant metal. Sizes four (4) inches or more in diameter shall have cast iron bodies, and sizes less than four (4) inches, cast iron or brass bodies.

(b) Valves up to and including two (2) inches shall be brass or other approved material and all fittings used for water shall be galvanized cast iron, galvanized wrought iron, copper, brass or other approved material, except that cast iron fittings used for water need not be galvanized if over two (2) inches in size.

Caulking Ferrules - 2-1

Pipe size (inches)	Inside diameter (inches)	Length (inches)	Minimum weight each Lb.	Oz.
2	2¼	4½	1	0
3	3¼	4½	1	12
4	4¼	4½	2	8

TABLE 2-2

Soldering Bushings

Pipe size (inches)	Minimum weight each Lb.	Oz.	Pipe size (inches)	Minimum weight each Lb.	Oz.
1¼	0	6	2½	1	6
1½	0	8	3	2	0
2	0	14	4	3	8

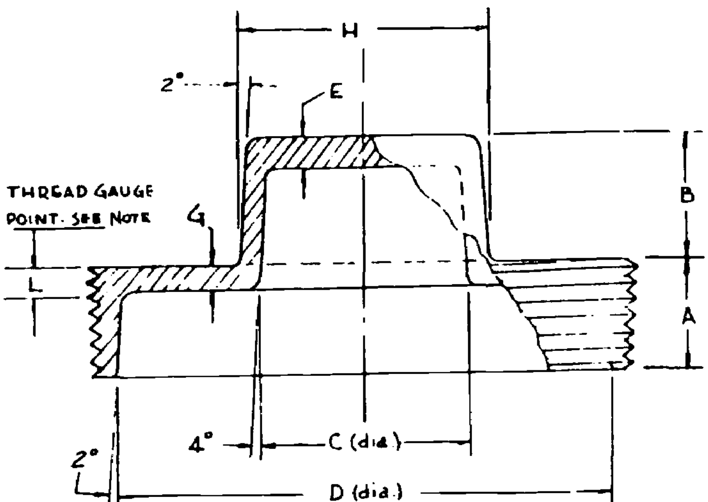
TABLE 2-3

Cleanouts

Size of Pipe	Size of Cleanout	Threads per inch
1½ inch	1½ inch	11½
2 inch	1½ inch	11½
2½ inch	2½ inch	8
3 inch	2½ inch	8
4 inch & larger	3½ inch	8

TABLE 2-4

Cleanout Plugs — I.P.S. — Brass



Iron pipe size (inches)	Dimensions in inches A	B	C	D	E	G	Across flats H	L (see note)
1½	⅝	¾	¾	1½	3/16	⅛	1	3/16
2	⅝	¾	1	2	3/16	⅛	1¼	3/16
2½	¾	¾	15/16	2⅜	3/16	5/32	1¼	¼
3	¾	1	1- 5/16	2-15/16	3/16	5/32	1⅝	¼
3½	¾	1	1¼	3- 7/16	¼	3/16	1⅝	¼
4	⅞	1	1⅝	3-15/16	¼	3/16	2	5/16
4½	⅞	1	1- 9/16	4- 7/16	5/16	7/32	2	5/16
5	1	1	1-15/16	4-15/16	5/16	7/32	2⅜	⅜
5½	1	1	1-15/16	5- 7/16	5/16	7/32	2¾	⅜
6	1	1	1⅞	5-15/16	⅜	¼	2⅜	⅜

Note—When thread gauge is screwed tightly on plug by hand, large end of gauge shall be the distance "L" ±1½ turns, from surface of plug.

USEFUL TABLES
CONVERSION TABLES

MULTIPLY	BY	TO OBTAIN
Acres	43,560	Square feet
Acre-feet	43,560	Cubic feet
Acre-feet	325,851	Gallons
Atmospheres	76.0	Cms. of mercury
Atmospheres	29.92	Inches of mercury
Atmospheres	33.90	Feet of water
Atmospheres	14.70	Lbs./sq. inch
B.T.U./min.	12.96	Foot-lbs./sec.
B.T.U./min.	0.02356	Horse-power
Centimeters	0.3937	Inches
Centimeters of mercury	0.01316	Atmospheres
Centimeters of mercury	0.4461	Feet of water
Centimeters of mercury	27.85	Lbs./sq. ft.
Centimeters of mercury	0.1934	Lbs./sq. inch
Cubic feet	1728	Cubic inches
Cubic feet	0.03704	Cubic yards
Cubic feet	7.48052	Gallons
Cubic feet	29.92	Quarts (liq.)
Cubic feet/minute	472.0	Cubic cms./sec.
Cubic feet/minute	0.1247	Gallons/sec.
Cubic feet/minute	62.43	Pounds of water/min.
Cubic feet/second	0.646317	Million gals./day
Cubic feet/second	448.831	Gallons/min.
Cubic yards	27	Cubic feet
Cubic yards	202.0	Gallons
Feet of water	0.02950	Atmospheres
Feet of water	0.8826	Inches of mercury
Feet of water	62.43	Lbs./sq. ft.
Feet of water	0.4335	Lbs./sq. inch
Feet/min.	0.01667	Feet/sec.
Feet/min.	0.01136	Miles/hr.
Feet/sec.	0.6818	Miles/hr.
Feet/sec.	0.01136	Miles/min.

A-4 (continued)

USEFUL TABLES

MULTIPLY	BY	TO OBTAIN
Gallons	3785	Cubic centimeters
Gallons	0.1337	Cubic feet
Gallons	231	Cubic inches
Gallons	4	Quarts (liq.)
Gallons water	8.3453	Pounds of water
Gallons/min.	0.002228	Cubic feet/sec.
Gallons/min.	8.0208	Cubic ft./hr.
Gallons water/min.	6.0086	Tons water/24 hours
Inches	2.540	Centimeters
Inches of mercury	0.03342	Atmospheres
Inches of mercury	1.133	Feet of water
Inches of mercury	0.4912	Lbs./sq. ft.
Inches of water	0.002458	Atmospheres
Inches of water	0.07355	Inches of mercury
Inches of water	5.202	Lbs./sq. ft.
Inches of water	0.03613	Lbs./sq. inch
Liters	1000	Cubic centimeters
Liters	61.02	Cubic inches
Liters	0.2642	Gallons
Miles	5280	Feet
Miles/hr.	88	Feet/min.

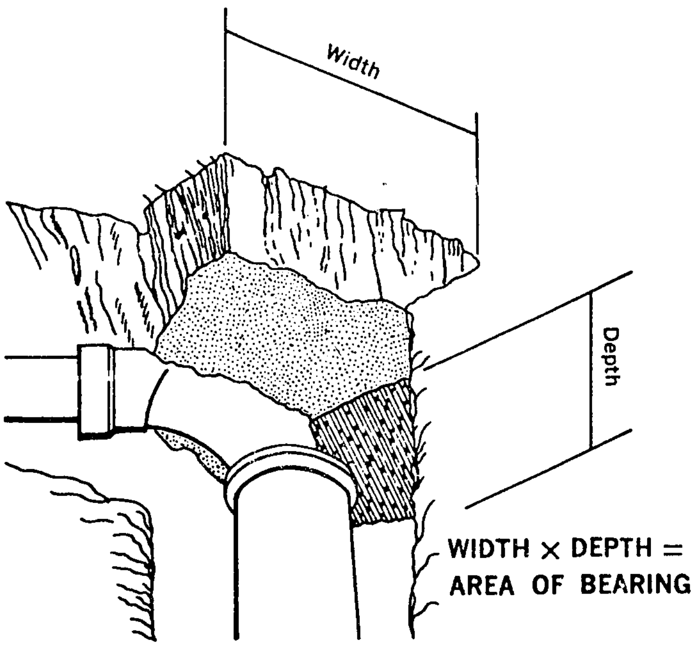
MULTIPLY	BY	TO OBTAIN
Miles/hr.	1.467	Feet/sec.
Millimeters	0.1	Centi neters
Millimeters	0.03937	Inches
Million gal./day	1.54723	Cubic ft./sec.
Pounds of water	0.01602	Cubic feet
Pounds of water	27.68	Cubic inches
Pounds of water	0.1198	Gallons
Pounds/cubic inch	1728	Lbs. cubic foot
Pounds/sq. foot	0.01602	Feet of water
Pounds/sq. inch	0.06804	Atmospheres
Pounds/sq. inch	2.307	Feet of water
Pounds/sq. inch	2.036	Inches of mercury
Quarts (dry)	67.20	Cubic inches
Quarts (liq.)	57.75	Cubic inches
Square feet	144	Square inches
Square miles	640	Acres
Square yards	9	Square feet
Temp. (°C.) + 273	1	Abs. temp. (°C.)
Temp. (°C.) + 17.28	1.8	Temp. (°F.)
Temp. (°F.) + 460	1	Abs. temp. (°F.)
Temp. (°F.) — 32	5/9	Temp. (°C.)
Tons (short)	2000	Pounds
Tons of water/24 hours	83.333	Pounds water/hour
Tons of water/24 hours	0.16643	Gallons/min.
Tons of water/24 hours	1.3349	Cu. ft./hr.

THRUST BLOCKING REQUIREMENTS FOR UNDERGROUND WATER PIPING

Note: Where thrust blocking is not practicable, proper tie rodding must be used.

THRUST FORCE AT FITTINGS

Pipe Size	Thrust in Pounds, at 1 psi of Water Pressure				
	Dead End or Tee	90° Elbow	45° Elbow	22½° Elbow	Side Thrust per Degree of Deflection in Pipe Line Joint
3	12	17	9	5	.24
4	19	26	14	8	.35
6	38	54	29	15	.72
8	66	93	50	26	1.22
10	107	151	82	42	1.97
12	153	216	117	60	2.78
14	207	293	159	81	3.77
16	268	397	205	105	4.86
18	344	485	264	134	6.65
20	426	600	326	165	7.90
24	615	867	472	239	11.50
30	963	1358	740	375	18.80
36	1390	1960	1166	540	26.60



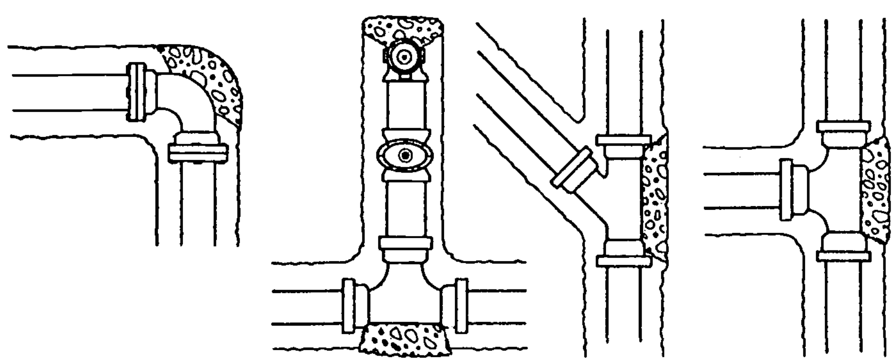
Typical thrust block at 90° Bend

BEARING LOADS OF DITCH BANKS OF VARIOUS SOIL COMPOSITIONS

Note: The safe bearing loads given in the following table are for horizontal thrusts when the depth of cover over the pipe exceeds 2 feet.

Soil Composition	Safe Bearing Load Lb. per Sq. Ft.
*Muck, peat, etc.	0
Soft clay	1000
Sand	2000
Sand and gravel	3000
Sand and gravel cemented with clay	4000
Hard shale	10000

*In muck or peat, all thrusts are resisted by piles or tie rods to solid foundations or by removal of muck or peat and replacement with ballast of sufficient stability to resist thrusts.



Method of blocking pipe at bends, tees, and dead ends

A-6

FRACTIONS AND DECIMAL EQUIVALENTS

Numerator ÷ Denominator = Decimal Equivalent

Fraction	Decimal	Fraction	Decimal
1/64	.0156	33/64	.5156
1/32	.0313	17/32	.5313
3/64	.0469	35/64	.5469
1/16	.0625	9/16	.5625
5/64	.0781	37/64	.5781
3/32	.0938	19/32	.5938
7/64	.1094	39/64	.6094
1/8	.125	5/8	.625
9/64	.1406	41/64	.6406
5/32	.1563	21/32	.6563
11/64	.1719	43/64	.6719
3/16	.1875	11/16	.6875
13/64	.2031	45/64	.7031
7/32	.2188	23/32	.7188
15/64	.2344	47/64	.7344
1/4	.25	3/4	.75
17/64	.2656	49/64	.7656
9/32	.2813	25/32	.7813
19/64	.2969	51/64	.7969
5/16	.3125	13/16	.8125
21/64	.3281	53/64	.8281
11/32	.3438	27/32	.8438
23/64	.3594	55/64	.8594
3/8	.375	7/8	.875
25/64	.3906	57/64	.8906
13/32	.4063	29/32	.9063
27/64	.4129	59/64	.9219
7/16	.4375	15/16	.9375
29/64	.4531	61/64	.9531
15/32	.4688	31/32	.9688
31/64	.4844	63/64	.9844
1/2	.5	1	1

A-7

APPROXIMATE CAPACITIES OF CYLINDRICAL TANKS IN U.S. GALLONS FOR EACH FOOT OF LENGTH

Diameter in Inches	Gallons	Diameter in Inches	Gallons
12	6	54	120
18	13	60	150
24	24	66	180
30	37	72	216
36	54	84	290
42	72	96	380
48	96	120	600

To find capacity in Imperial Gallons, multiply by .833

A-8

TEMPERATURE CONVERSION TABLE

$F = (9/5 \times C) + 32$; $C = 5/9 (F - 32)$

Degrees Fahrenheit	Degrees Centigrade	Degrees Fahrenheit	Degrees Centigrade
—20	—28.9	140	60.0
—10	—23.3	150	65.6
0	—17.8	160	71.1
10	—12.2	170	76.7
20	—6.7	180	82.2
30	—1.1	190	87.8
32	0	200	93.3
40	4.4	210	98.9
50	10.0	212	100
60	15.6	220	104.4
70	21.1	230	110.0
80	26.7	240	115.6
90	32.2	250	121.1
100	37.8	260	126.7
110	43.3	270	132.2
120	48.9	280	137.8
130	54.4	290	143.3

A-9

BOILING POINTS OF WATER ON FAHRENHEIT SCALE

Vacuum, in inches of Mercury	Boiling Point	Gauge Pressure in Pounds per sq. in.	Boiling Point
29	76.6	0	212
25	133.2	2	218.5
20	161.2	4	224.4
15	178.9	6	229.8
10	192.2	8	234.8
8	196.7	10	239.4
6	200.9	25	266.8
4	204.9	50	297.7
2	208.5	75	320.1
1	210.3	100	337.9

A-10

PRESSURE CONVERSION TABLE

Feet of Water (Head)
to
Pounds Per Square Inch

Feet of Water × .433 = Psi

Feet of Water	Pounds per Square Inch
1	.43
2	.87
3	1.30
4	1.73
5	2.17
6	2.60
7	3.03
8	3.46
9	3.90
10	4.33
15	6.50
20	8.66
25	10.83
30	12.99
40	17.32
50	21.65
60	25.98
70	30.31
80	34.64
90	38.97

A-11

PRESSURE CONVERSION TABLE

Pounds Per Square Inch
to
Feet of Water (Head)

Psi × 2.309 = Feet of Water

Pounds per Square Inch	Feet of Water
1	2.31
2	4.62
3	6.93
4	9.24
5	11.55
6	13.85
7	16.16
8	18.47
9	20.78
10	23.09
15	34.64
20	46.18
25	57.73
30	69.27
40	92.36
50	115.45
60	138.54
70	161.63
80	184.72
90	207.81

A-12

WEIGHT OF WATER AT VARIOUS TEMPERATURES

Temperature Degrees Fahrenheit	Pounds per Cubic Foot
32	62.416
35	62.421
39.3	62.424
40	62.423
45	62.419
50	62.408
55	62.390
60	62.366
65	62.336
70	62.300
75	62.261
80	62.217
85	62.169
90	62.118
95	62.061
100	61.998
110	61.865
120	61.719
130	61.555
140	61.386
150	61.203
160	61.006
170	60.799
180	60.586
200	60.135
212	59.843

A-13

STEEL PIPE DATA
STANDARD WEIGHT

Nominal Pipe Diam. in Inches	Actual Inside Diam. in Inches	Actual Outside Diam. in Inches	Weight per Foot Pounds	Length in Feet Containing One Cubic Foot	Gallons in One Lineal Foot
3/8	.493	.675	.567	754.360	.010
1/2	.622	.840	.850	473.910	.016
3/4	.824	1.050	1.130	270.030	.028
1	1.049	1.315	1.678	166.620	.045
1 1/4	1.308	1.660	2.272	96.275	.078
1 1/2	1.610	1.900	2.717	70.733	.106
2	2.067	2.375	3.652	49.913	.174
2 1/2	2.469	2.875	5.793	30.077	.249
3	3.068	3.500	7.575	19.479	.384
4	4.26	4.500	10.790	11.312	.661
5	5.04	5.563	14.617	7.198	1.039
6	6.065	6.625	18.974	4.984	1.501

A-14

WATER SUPPLY REQUIREMENTS FOR THE MOST COMMON PLUMBING FIXTURES

Fixture	Flow Pressure in PSI	Flow in GPM	Individual Branch Size (Inches)
Ordinary basin faucet	8	3.0	3/8
Self-closing basin faucet	12	2.5	3/8
3/8" Sink faucet	10	4.5	1/2
1/2" Sink faucet	5	4.5	1/2
Bathtub faucet	5	6.0	1/2
1/2" Laundry tub cock	5	5.0	1/2
Shower	12	5.0	1/2
Ball-cock for closet	15	3.0	3/8
Flush valve for closet	10-20	20-40*	1
Flush valve for urinal	15	15.0	3/4
50' Garden hose and sill cock	30	5.0	1/2

* Since a considerable variation exists in design and type of flush-valve closets, consideration should be given to the type used.

A-15

PIPE AREA: INTERNAL CROSS-SECTIONAL AREA IN SQUARE INCHES

Nominal Size (Inches)	Copper Type K	Copper Type L	Copper Type M	Steel Schedule 40	Steel Schedule 80
1/4	.073	.078	—	.104	.071
3/8	.127	.145	.159	.191	.141
1/2	.218	.233	.254	.304	.234
3/4	.436	.484	.517	.533	.432
1	.778	.825	.874	.864	.719
1 1/4	1.22	1.26	1.31	1.495	1.283
1 1/2	1.72	1.78	1.83	2.04	1.77
2	3.01	3.09	3.17	3.36	2.95
2 1/2	4.66	4.77	4.89	4.79	4.24
3	6.64	6.81	6.98	7.39	6.61
3 1/2	9.00	9.21	9.40	9.89	8.89
4	11.7	12.0	12.2	12.7	11.50
5	18.1	18.7	18.9	20.0	18.2
6	25.9	26.8	27.2	28.9	26.1
8	45.2	46.9	47.6	50.0	45.7
10	70.1	72.8	73.9	78.8	71.8
12	101.0	105.0	106.0	111.9	101.6

A-16

REASONABLE VELOCITIES OF FLOW THROUGH PIPE

City water mains	Up to 7 ft./sec.
General service water	5 to 10 ft./sec.
Pump suction	4 to 6 ft./sec.
Pump discharge	6 to 8 ft./sec.
Pressure drain lines	4 to 7 ft./sec.
Gravity horizontal drains	2 to 10 ft./sec.

Note: Water velocities in excess of 15 ft./sec. may cause water hammer.

NOTE: Check local code requirements: re: Tables

A-17

INDIVIDUAL FIXTURES RATES

Type of Fixture	Dicharge Rate G.P.M.
Lavatory	7.5
Closet	45
Bathtub	15
Residence sink	15
Hotel or restaurant sink	20
Slop sink with flush valve	35
Shower stall	30
Laundry tub	20
Urinal	35
Instrument sterilizer	4
Bed-pan sterilizer	40
Floor drain, ordinary	8
Bidet	15
Drinking fountain	3
Dental cuspidor	3

A-18

VERTICAL STACK RATES

Diameter of Stack in Inches	Maximum Flow G.P.M.
3	90
4	180
5	350
6	560
8	1200

A-19

HORIZONTAL DRAIN RATES

Size in Inches	Slope 1/8" per foot Velocity Ft./Sec.	Slope 1/8" per foot Discharge G.P.M.	Slope 1/4" per foot Velocity Ft./Sec.	Slope 1/4" per foot Discharge G.P.M.	Slope 1/2" per foot Velocity Ft./Sec.	Slope 1/2" per foot Discharge G.P.M.
2	1.50	15.	2.10	21.	3.00	30.
2 1/2	1.75	27.	2.45	38.	3.50	54.
3	2.00	44.	2.80	62.	4.00	88.
4	2.40	96.	3.40	135.	4.80	192.
5	2.80	174.	3.95	250.	5.60	348.
6	3.15	280.	4.45	400.	6.30	560.
8	3.80	600.	5.35	850.	7.60	1200.
10	4.45	1100.	6.30	1550.	8.90	2200.
12	5.05	1780.	7.10	2500.	10.10	3560.

METRIC CONVERSION TABLE

Convert 3.7643 meters to feet, inches and fractions

3.7643 meters		
3.6556	=	12 ft
108.70 mm		
107.95	=	4 1/4 in.
.75	=	1/32"
3.7643 meters	=	12'–4 9/32"

Convert 15'–6 7/16" to meters

15'	=	4.5720 meters
6 7/16"	=	.163513 meters
15'–6 7/16"	=	4.735513 meters

INCHES AND FRACTIONS—MILLIMETERS

Inches	Millimeters	Inches	Millimeters	Inches	Millimeters	Inches	Millimeters	Inches	Millimeters	Inches	Millimeters
1/16	1.5875	2 1/16	52.3876	4 1/16	103.188	6 1/16	153.988	8 1/16	204.788	10 1/16	255.588
1/8	3.1750	2 1/8	53.9751	4 1/8	104.775	6 1/8	155.575	8 1/8	206.375	10 1/8	257.176
3/16	4.7625	2 3/16	55.5626	4 3/16	106.363	6 3/16	157.163	8 3/16	207.963	10 3/16	258.763
1/4	6.3500	2 1/4	57.1501	4 1/4	107.950	6 1/4	158.750	8 1/4	209.550	10 1/4	260.351
5/16	7.9375	2 5/16	58.7376	4 5/16	109.538	6 5/16	160.338	8 5/16	211.138	10 5/16	261.938
3/8	9.5250	2 3/8	60.3251	4 3/8	111.125	6 3/8	161.925	8 3/8	212.725	10 3/8	263.526
7/16	11.1125	2 7/16	61.9126	4 7/16	112.713	6 7/16	163.513	8 7/16	214.313	10 7/16	265.113
1/2	12.7000	2 1/2	63.5001	4 1/2	114.300	6 1/2	165.100	8 1/2	215.900	10 1/2	266.701
9/16	14.2875	2 9/16	65.0876	4 9/16	115.888	6 9/16	166.688	8 9/16	217.488	10 9/16	268.288
5/8	15.8750	2 5/8	66.6751	4 5/8	117.475	6 5/8	168.275	8 5/8	219.075	10 5/8	269.876
11/16	17.4625	2 11/16	68.2626	4 11/16	119.063	6 11/16	169.863	8 11/16	220.663	10 11/16	271.463
3/4	19.0500	2 3/4	69.8501	4 3/4	120.650	6 3/4	171.450	8 3/4	222.250	10 3/4	273.051
13/16	20.6375	2 13/16	71.4376	4 13/16	122.238	6 13/16	173.038	8 13/16	223.838	10 13/16	274.638
7/8	22.2250	2 7/8	73.0251	4 7/8	123.825	6 7/8	174.625	8 7/8	225.425	10 7/8	276.226
15/16	23.8125	2 15/16	74.6126	4 15/16	125.413	6 15/16	176.213	8 15/16	227.013	10 15/16	277.813
1	25.4001	3	76.2002	5	127.000	7	177.800	9	228.600	11	279.401
1 1/16	26.9876	3 1/16	77.7877	5 1/16	128.588	7 1/16	179.388	9 1/16	230.188	11 1/16	280.988
1 1/8	28.5751	3 1/8	79.3752	5 1/8	130.175	7 1/8	180.975	9 1/8	231.775	11 1/8	282.576
1 3/16	30.1626	3 3/16	80.9627	5 3/16	131.763	7 3/16	182.563	9 3/16	233.363	11 3/16	284.163
1 1/4	31.7501	3 1/4	82.5502	5 1/4	133.350	7 1/4	184.150	9 1/4	234.950	11 1/4	285.751
1 5/16	33.3376	3 5/16	84.1377	5 5/16	134.938	7 5/16	185.738	9 5/16	236.538	11 5/16	287.338
1 3/8	34.9251	3 3/8	85.7252	5 3/8	136.525	7 3/8	187.325	9 3/8	238.125	11 3/8	288.926
1 7/16	36.5126	3 7/16	87.3127	5 7/16	138.113	7 7/16	188.913	9 7/16	239.713	11 7/16	290.513
1 1/2	38.1001	3 1/2	88.9002	5 1/2	139.700	7 1/2	190.500	9 1/2	241.300	11 1/2	292.101
1 9/16	39.6876	3 9/16	90.4877	5 9/16	141.288	7 9/16	192.088	9 9/16	242.888	11 9/16	293.688
1 5/8	41.2751	3 5/8	92.0752	5 5/8	142.875	7 5/8	193.675	9 5/8	244.475	11 5/8	295.276
1 11/16	42.8626	3 11/16	93.6627	5 11/16	144.463	7 11/16	195.263	9 11/16	246.063	11 11/16	296.863
1 3/4	44.4501	3 3/4	95.2502	5 3/4	146.051	7 3/4	196.850	9 3/4	247.650	11 3/4	298.451
1 13/16	46.0376	3 13/16	96.8377	5 13/16	147.638	7 13/16	198.438	9 13/16	249.238	11 13/16	300.038
1 7/8	47.6251	3 7/8	98.4252	5 7/8	149.225	7 7/8	200.025	9 7/8	250.825	11 7/8	301.626
1 15/16	49.2126	3 15/16	100.013	5 15/16	150.813	7 15/16	201.613	9 15/16	252.413	11 15/16	303.213
2	50.8001	4	101.600	6	152.400	8	203.200	10	254.001	12	304.801

FEET INTO METERS

Feet	Meters	Feet	Meters	Feet	Meters	Feet	Meters	Feet	Meters	Feet	Meters	Feet	Meters
1	0.3048	16	4.8768	31	9.4488	46	14.021	61	18.593	76	23.165	91	27.736
2	0.6096	17	4.1816	32	9.7536	47	14.326	62	18.898	77	23.470	92	28.041
3	0.9144	18	5.4864	33	10.058	48	14.630	63	19.202	78	23.774	93	28.346
4	1.2192	19	5.7912	34	10.363	49	14.935	64	19.507	79	24.079	94	28.650
5	1.5240	20	6.0960	35	10.668	50	15.240	65	19.812	80	24.384	95	28.955
6	1.8288	21	6.4008	36	10.973	51	15.545	66	20.117	81	24.689	96	29.260
7	2.1336	22	6.7056	37	11.278	52	15.850	67	20.422	82	24.994	97	29.565
8	2.4384	23	7.0104	38	11.582	53	16.154	68	20.726	83	25.297	98	29.870
9	2.7432	24	7.3152	39	11.887	54	16.459	69	21.031	84	25.602	99	30.174
10	3.0480	25	7.6200	40	12.192	55	16.764	70	21.336	85	25.907	100	30.480
11	3.3528	26	7.9248	41	12.497	56	17.069	71	21.641	86	26.212		
12	3.6556	27	8.2296	42	12.802	57	17.374	72	21.946	87	26.517		
13	3.9624	28	8.5344	43	13.106	58	17.678	73	22.250	88	26.822		
14	4.2672	29	8.8392	44	13.411	59	17.983	74	22.555	89	27.126		
15	4.5720	30	9.1440	45	13.716	60	18.288	75	22.860	90	27.432		