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WATER MAIN CONSTRUCTION GUIDELINE

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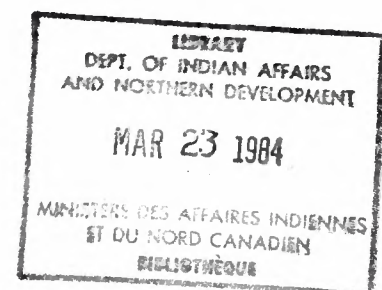
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WATER MAIN CONSTRUCTION GUIDELINE

October 1983

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Lignes directrices pour l'installation
de conduites principales d'eau

WATER MAIN CONSTRUCTION GUIDELINE

Table of Contents

| | |
|--|--|
| 1.0 | INTRODUCTION |
| 2.0 | ALIGNMENT AND GRADES |
| 2.1 | Definitions |
| 2.2 | Water Main Alignment |
| 2.3 | Water Main Grades |
| 3.0 | EXCAVATION, INSTALLATION AND MATERIALS |
| 3.1 | General Remarks |
| 3.2 | Receiving and Handling Pipe |
| 3.3 | Trench Excavation |
| 3.4 | Bedding |
| 3.5 | Pipelaying |
| 3.6 | Materials and Jointing |
| 3.7 | Thrust Blocking |
| 3.8 | Backfilling |
| 4.0 | WATER MAIN APPURTENANCES |
| 4.1 | General Remarks |
| 4.2 | Gate Valves |
| 4.3 | Fire Hydrants |
| 4.4 | Water Service Corrections |
| 5.0 | TESTING AND DISINFECTION |
| 5.1 | General Remarks |
| 5.2 | Pressure Test |
| 5.3 | Flushing |
| 5.4 | Disinfection |
| Appendix 1 Sample Calculations for Pipeline Chlorination | |

WATER MAIN CONSTRUCTION GUIDELINE

1.0 INTRODUCTION

This publication outlines the methods and procedures for installing a water main and its associated appurtenances such as valves, hydrants and house connections.

This guideline is intended as a 'how to' manual for Indian bands and would also be useful to construction supervisors or others directly involved in water main construction.

The procedures are described step-by-step with illustrations provided where necessary. It is assumed however, that the reader has some basic construction experience.

2.0 ALIGNMENT AND GRADES (refer to Figure 1)

2.1 Definitions

Alignment: the horizontal location of the water main.

Grade: the vertical location (elevation) of the water main.

Offset: the distance between the proposed location of the water main and the survey stake used to mark its location.

2.2 Water Main Alignment

The alignment of the water main is usually determined at the design stage. If other underground utilities are present, then the water main must be positioned and constructed so that it will not interfere with them.

When the alignment of the main has been decided, the proposed location is usually marked on the construction site by placing survey stakes far enough away to allow workers and machinery to move between

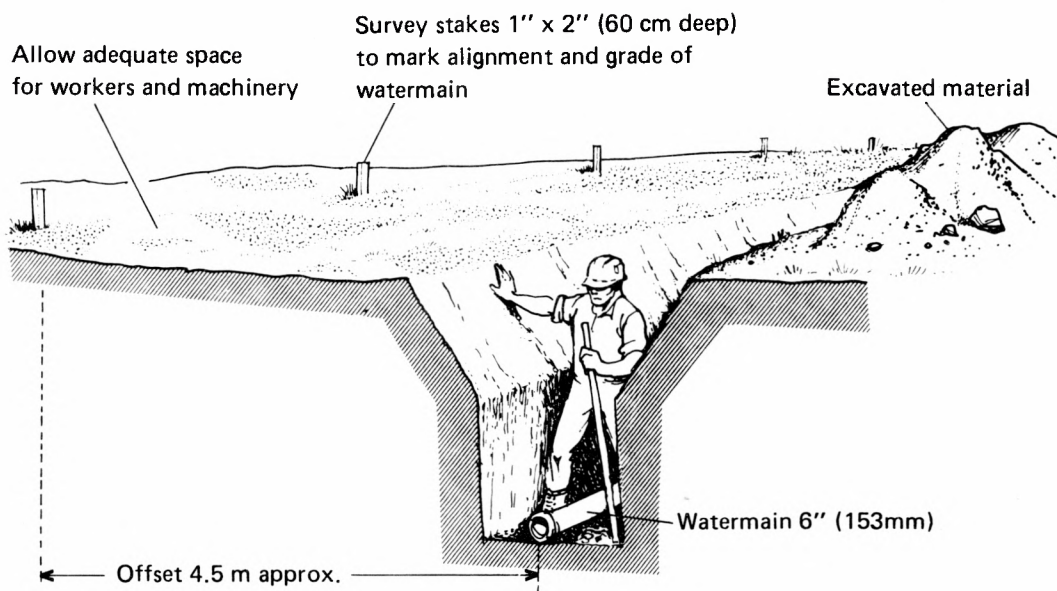


Fig. 1 Typical Offset Location

21/10/83

the stakes and the edge of the trench. This distance is known as the offset (see Figure 1).

2.3 Water Main Grades

The grade or elevation of the water main is generally predetermined to be a certain distance below the ground surface. Depending on the climate, the main might be placed at a depth below frost penetration. In northern areas, the depth of frost penetration makes this impractical and the main is placed at a lesser depth and protected from freezing by some other means.

Generally, the main is installed at design grade by the construction crew simply measuring down the required amount from the edge of the trench.

3.0 EXCAVATION, INSTALLATION AND MATERIALS

3.1 General Remarks

This section provides information on:

- a. receiving and handling pipe;
- b. trench excavation;
- c. bedding;
- d. pipe laying, materials and jointing; and
- e. backfilling.

3.2 Receiving and Handling Pipe

Pipe shipments should be inspected upon arrival on the job site - it is up to the receiver of the pipe to make certain that there has been no loss or damage.

All pipe should be handled with care and should never be dragged or rolled along the ground. This causes scratches and gouges which can weaken the pipe and can result in corrosion, leakage or failure.

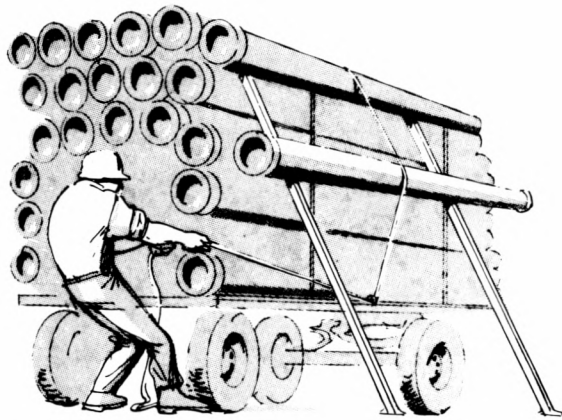
The following are general procedures when receiving pipe:

- Step 1 Make a general inspection of the load. If it seems to be intact, an ordinary inspection while unloading (spot checking) should be adequate to ensure each pipe is in good condition.
- Step 2 If the load has shifted on the truck or shows signs of rough treatment, inspect each pipe for damage. Rough treatment in transit is usually evident from broken tie straps or crushed wooden blocking.
- Step 3 Check the total quantities of each item against the delivery tally sheet (pipe, rings, fittings, lubricants, etc.)
- Step 4 Note any missing or damaged pieces on the delivery receipt - the carrier must be notified immediately so that claims can be made in accordance with their instructions.
- Step 5 It is the responsibility of the customer to decide how to unload the pipe, however, the pipe manufacturers will supply information on the preferred methods. Their instructions should be followed - if possible use mechanical equipment although small diameter pipe can be unloaded by hand. (See Figure 2).

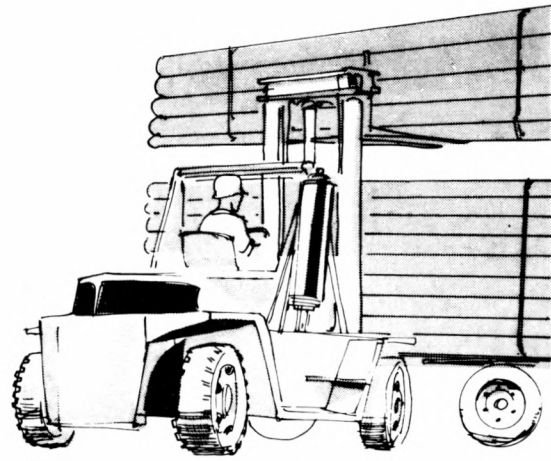
3.3 Trench Excavation

3.3.1 General Remarks

Do not excavate the trench too far ahead of the water main placement in order to reduce the possibility of flooding or cave-ins caused by ground water (see Figure 3). As well, open trenches are a safety hazard. Accidents involving open trenches and children or vehicles occur too frequently even when the open trench is barricaded. Backfill the trench as soon as possible after the water main has been placed.



By hand (plastic pipes)



Using a forklift

Fig. 2 Unloading of Pipes

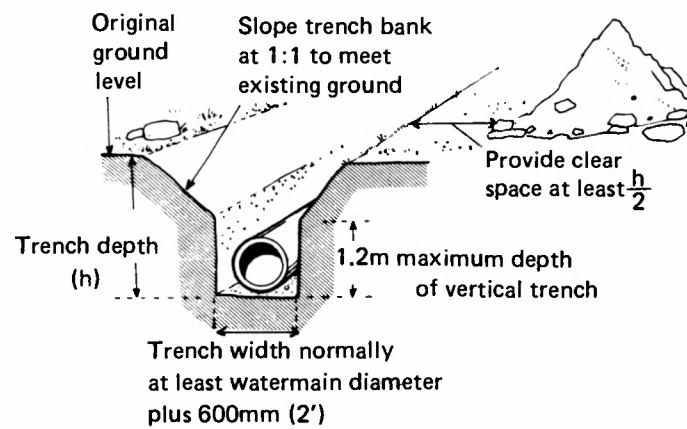


Fig. 3 Trench Excavation

3.3.2 Trench Width

The trench must be wide enough to permit proper laying and joining of the pipe. It is common practice to excavate the trench 300 mm (12 in.) wider than the water main on both sides to enable workers to compact the backfill under and around the pipe (see Figure 3).

In some soils the trench must be wider than normal, for example in sandy soils where the excavation embankments continually cave in and interfere with the placement of the water main.

Widening the trench in this manner places an additional load on the pipe. The designer must be aware of this in order to select the proper pipe strength.

3.3.3 Trench Wall Protection

3.3.3.1 Shoring

The maximum vertical unshored trench considered to be safe is about 1.2 m (4 ft.). For greater trench depths, shoring or sloping back the trench is required.

The type and amount of shoring depends upon the depth of the trench, the soil type, water conditions (for instance a high water table) and the location of the trench relative to existing buildings, roads, services etc. Figure 4 shows typical shoring methods; if more specific information is required, this can generally be obtained from provincial labour departments or construction safety associations.

When removing shoring materials from the trench, exercise care to prevent disturbance of the pipe. The shoring is sometimes left in place to prevent the formation of voids which would disturb supporting conditions of the backfill and result in pipe movement (see Figure 5).

3.3.3.2 Trench Box or Cage

This is a more common method of providing trench wall protection (see Figure 6). It consists of a

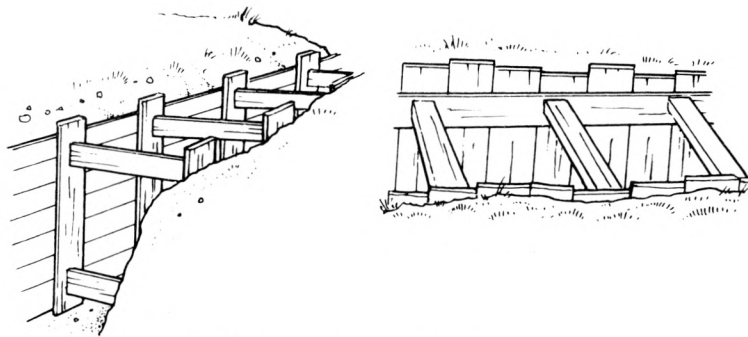
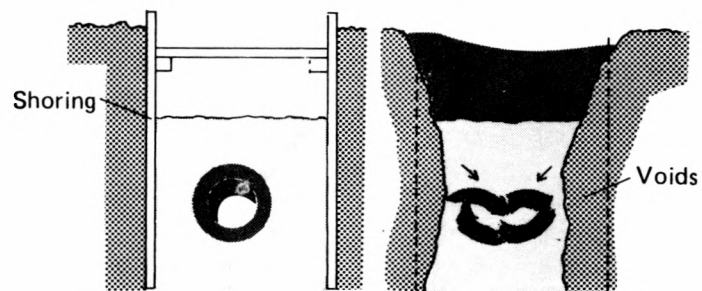


Fig. 4 Trench Shoring



Shoring in place — trench
partially backfilled

Shoring pulled out — voids
improperly filled and compacted
Trench backfill may settle
damaging pipe

Fig.5 Improper Removal of Shoring

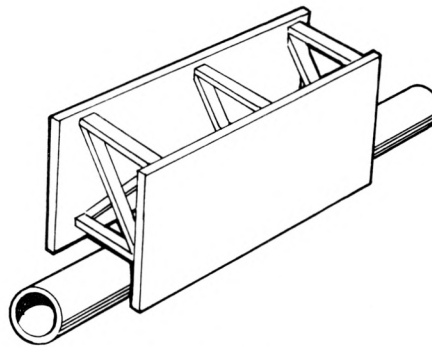


Fig. 6 Trench Box

prefabricated steel "box" that the contractor places in the trench and drags along (using a backhoe) as the work progresses. The workers can then work in safety in the trench box.

3.3.3.3 Sloping of Trench Walls

In areas where increasing trench width is acceptable, shoring requirements can be reduced or eliminated by sloping the trench walls outwards. The slope will depend upon the soil conditions, but usually a 1:1 slope is used (see Figure 3).

3.3.4 Trenching Safety Practices

Trenching operations are a major source of accidents on construction projects. The construction supervisor must ensure that the work is conducted in a safe manner and environment. It is his responsibility to bring unsafe practices to the attention of the person in charge of the construction crew and take whatever steps are necessary to correct the situation.

Some safety procedures to be followed during trenching operations are listed below:

- a. Where required, shore excavated areas or slope trench walls.
- b. Workers should never be left alone in a trench.
- c. Workers should attempt to face machinery while they are working, operators should avoid swinging machinery over the heads of workers.
- d. Do not keep tools, machinery, timber etc. adjacent to the trench, where they may fall in.
- e. Persons using explosives should be knowledgeable in their use.
- f. Never leave open trenches unbarricaded after completion of the day's work.

- g. The trench should be backfilled as soon as possible after the water main has been placed - normally, the maximum length of open trench is 60 m (200 ft.).
- h. Keep a safety ladder in the trench at all times.
- i. Do not leave dangerous materials such as boards with nails protruding, broken glass etc. lying around the construction site.
- j. Do not take unnecessary risks no matter how much time or labour might be saved.

3.3.5 Placement of Excavated Material

Place excavated material far enough from the edge of the trench to prevent the trench wall from caving in, due to the weight of the excavated soil, and to prevent excavated material washing back into the trench during rainfall (See Figure 3).

This area also provides a clear space for the movement of workers and equipment along the side of the trench. Where the trench walls are braced, a minimum distance of 1 m (3.3 ft.) should be provided from the edge of the trench to the toe of the excavated soil bank. When the trench walls are not braced, the minimum clear space between the trench edge and the toe of the soil bank should be equal to 1/2 the trench depth. For example, for a 6 m (20 ft.) deep trench with no bracing, provide a clear space of 3 m (10 ft.) between the trench edge and the toe of the soil bank (see Figure 3).

3.4 Bedding

3.4.1 Definition

Pipe bedding is the material (usually granular) on which the water main rests and which provides a firm and uniform support under the entire length of the pipe.

The bedding must be smooth and free from large or sharp edged rocks that could damage the pipe and must not contain construction material debris, large chunks of earth or frozen material.

If a pipe is set on a flat foundation without any bedding, there is a high load concentration at the bottom of the pipe. The pipe is able to support much more weight if bedding is placed beneath the pipe than if it is set on a flat foundation, because the load is spread out (see Figure 7).

3.4.2 Bedding Materials

The best bedding material is a well graded granular material with particle sizes up to 19 mm (3/4 in.), free from lumps or frozen material. (Well graded means a range of different particle sizes - materials consisting of similar particle size do not provide as much support because they are difficult to compact).

Granular materials such as gravel, crushed stone and sand are generally used for bedding. Whichever type of bedding material is selected, it must be well compacted to prevent movement of the pipe.

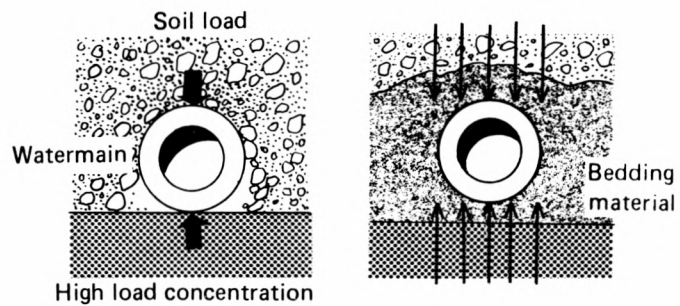
The existing soil may be used as a bedding material, when of acceptable quality. It must not, however, contain large stones, pieces of wood or top soil.

3.4.3 Bedding Preparation

The general procedures for placing pipe bedding are as follows:

Step 1 Excavate the trench to the depth or grade of the undisturbed soil on which the bedding is to be placed (meaning original or unexcavated soil).

Step 2 If the undisturbed soil at the trench bottom is acceptable, (firm and not wet or spongy), place the bedding material as described below. If the soil at the trench bottom is unacceptable, it will be



Pipe set on flat foundation without bedding results in high load concentration at the bottom of the pipe

Bedding material under watermain results in load under pipe being spread out. This gives the pipe more supporting strength.

Fig 7. Pipe Bedding — Reducing Load Concentration

necessary to excavate deeper to provide additional bedding - normally at least an extra 0.3 m (1 ft.). Generally when these type of wet conditions are encountered, crushed stone is used as a bedding material.

- Step 3 Place the bedding material in layers of about 150 mm (6 in.) on the trench bottom, and compact thoroughly. Best compaction results are obtained using vibratory mechanical equipment.
- Step 4 Check the bedding surface for high or low spots. Remove or add material as required to obtain a smooth uniform surface - the bedding must provide support for the entire length of the pipe barrel.
- Step 5 Dig holes in the bedding large enough to ensure proper joint making.
- Step 6 Place the pipe on the bedding ensuring that the entire pipe barrel is in contact with the bedding surface and that the pipe bells are NOT resting on the bedding surface (see Figure 8).

3.5 Pipelaying

When work is not in progress, trench water should always be kept out of the pipe and the pipe ends kept closed by means of a watertight plug.

Once the bedding has been prepared, ensure that any dirt or debris in the pipe has been removed, then lower the pipe into the trench - do not just roll it in. Smaller diameter pipe - up to 300 mm (12 in.) may be lowered into the trench by placing a turn of rope at each end of the pipe and simply letting the rope out until the pipe rests on the bottom of the trench.

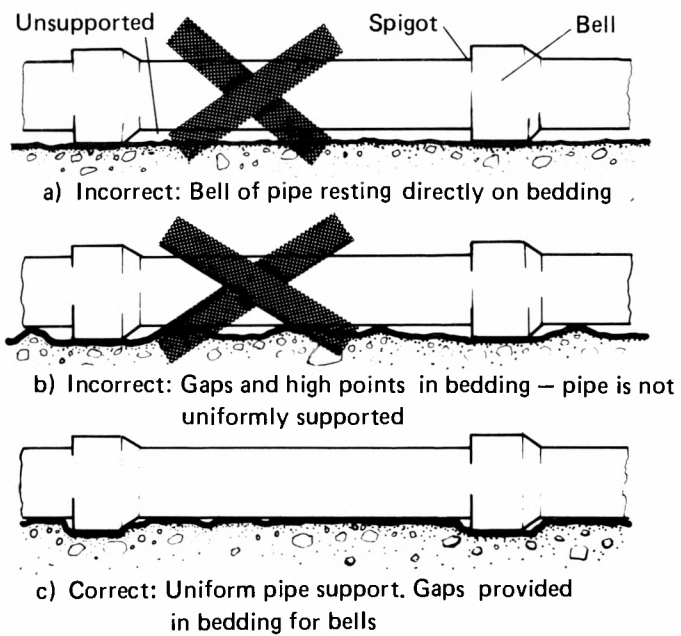


Fig 8.Placing Pipe Bedding — Proper Procedures

3.6 Materials and Jointing

3.6.1 General Remarks

Although there are many different pipe materials available for water main installation, only the most commonly used will be discussed.

The principles involved in the installation of these types also apply to other materials such as reinforced concrete and asbestos cement that are not so commonly used.

Note: when jointing a pipe, the main objective is to obtain a watertight seal. If water is going to leak from a water main, it will usually do so at a joint.

3.6.2 Ductile Iron

3.6.2.1 General Remarks

Ductile iron pipe has the same joints and dimensions as the previously used cast iron pipe, except for pipe wall thickness. Ductile means that when the pipe is placed under a great load or stress, it will bend or deform rather than break. A common problem with cast iron pipe is that it is very brittle and will break when heavily loaded.

Ductile iron pipe is also very strong and very resistant to shock or impact loading. All ductile iron pipes are finished with a protective coating of bituminous paint to protect them from corrosion and are generally cement lined.

3.6.2.2 Pipe Joints

The joint used with ductile iron pipe is a "tyton" type. This is a simple push on joint with a rubber gasket forming the seal (see Figure 9).

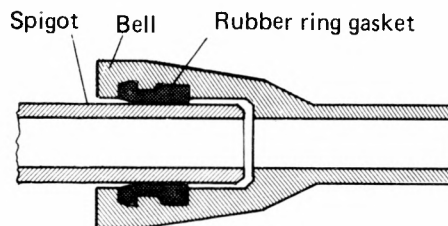


Fig. 9 Push-on Joint "Tyton"

21/10/83

The procedure for making the pipe joints is as follows:

- Step 1 Clean the gasket groove in the bell.
- Step 2 Install the rubber gasket.
- Step 3 Lubricate the gasket.
- Step 4 Push the spigot end into the bell until a reference point marked on the pipe is reached. This is called "pushing the pipe home" and the recommended method is with a bar and block (Figure 10). This method will provide enough force to bring the pipes together and will not damage the pipe.



Fig. 10 Bar-and-block Method

Step 5 If there is resistance to inserting the spigot end or the reference point is not reached, disassemble the joint and check the position of the rubber ring. If it is twisted or pushed out of its seat, clean the ring, bell and spigot ends and repeat the assembly procedure.

Note: When pushing the pipe home, never use a backhoe bucket. The bucket could damage the pipe and the large force that the bucket applies to the end of the pipe can push the pipe "home" overcoming the resistance of a twisted gasket. The construction crew would not realize there was a problem until the water main was tested and found to leak at the joints.

3.6.3 Polyvinyl Chloride Pipe (PVC)

3.6.3.1 General Remarks

This is the most popular plastic pipe used today. It is very light-weight, flexible, easy to handle and to cut and joint in the field, and is available in various strengths.

3.6.3.2 Jointing Method

The joint used with PVC pipe is similar to the "tyton" joint used with ductile iron pipe. The installation procedure is identical except that the spigot is lubricated instead of the rubber gasket.

3.6.4 Polyethylene Pipe (PE)

3.6.4.1 General Remarks

This plastic pipe is sometimes used in unstable ground conditions where an extremely flexible pipe is required.

PE pipe is also available in preinsulated heat traced pipe. This is especially suited to northern areas where frost penetration is deep. The pipe consists of a high density polyethylene inner pipe, factory

insulated with rigid polyurethane foam and electrically heat traced where necessary. A "jacket" made up of either polyethylene or metal (steel or aluminum are available) surrounds the insulation. The pipe, insulation and jacket are locked together as a single unit (see Figure 11).

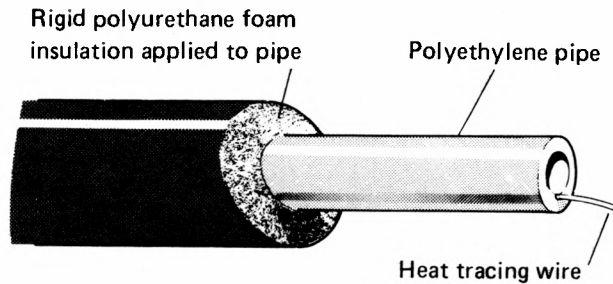


Fig. 11 Pre-insulated Heat Traced Pipe

The electrical heat tracing ensures that the water in the pipe does not freeze. It should be noted, however, that the heat trace method is not very cost effective. A more efficient method is to heat the water at the collection point (for example the pump house) before it is pumped into the mains. The heat tracing technique should be looked on as a means of thawing water mains that do freeze rather than as a preventive measure.

In other words, the water main system should be designed so that the heat tracing wires are not continually being heated electrically.

3.6.4.2 Jointing Method

Presently there is no conventional jointing technique for polyethylene pipe similar to that for ductile iron and PVC. A special butt fusion welding operation is used instead.

To join pipes in this manner, the pipe ends are cut precisely at right angles, "butted" up against each other and then melted using a type of "welding" machine. The melting of the pipe ends fuses the pipe together. When the pipe cools, a joint has been formed that is completely watertight.

This type of jointing is a specialist operation and this portion of the work often requires a special contract.

3.7 Thrust Blocking

Thrust blocking means providing restraint to any bends in the water main, either vertical or horizontal. This is necessary because the force developed by water under pressure at any change in direction of the water main (for instance a bend or hydrant connection) can force the joints apart.

In general, a block of concrete (called a thrust block) is placed at all changes in direction where tees or bends occur. Where possible, the concrete is poured up to the undisturbed trench walls.

3.8 Backfilling

Backfill is the material used to fill the trench once the water main has been placed. It extends from the top of the pipe bedding to the ground surface (see Figure 7). Generally the backfill extending up to 300 mm (12 in.) above the pipe is approved granular material. It is important that this material is well compacted as this helps the water main to support earth loads.

The balance of the backfill is not as critical as the 300 mm above the pipe in terms of supporting the pipe, however if the water main is under a roadway, the backfill must be well compacted in uniform lifts to prevent the roadway from settling. This is especially critical if the road is paved.

As mentioned under shoring, (see 3.3.3.1) the compaction method must ensure that all voids caused by removal of shoring are filled. Shoring which extends below the invert of the pipe cannot be withdrawn without disturbing the pipe bedding and should be cut off near the top of the pipe.

4.0 WATER MAIN APPURTENANCES

4.1 General Remarks

A water main system requires various devices to allow efficient operation or control. These are called appurtenances.

This section will discuss the most common of these appurtenances, their function and method of installation.

4.2 Gate Valves

4.2.1 General Remarks

There are many different types of valve available for a water system, performing many different functions. The most common one is a gate valve. This is a control valve, it is used to stop or start the flow of water in the water main. It is usually used in the fully open or fully closed position.

As you can see from Figure 12, the valve consists of a sliding flat metal disc slightly larger than the flow opening. The disc is moved by a screw operating stem which passes through a stuffing box or packing gland into the valve casing. When the stem is rotated, it lifts or lowers the gate mechanism.

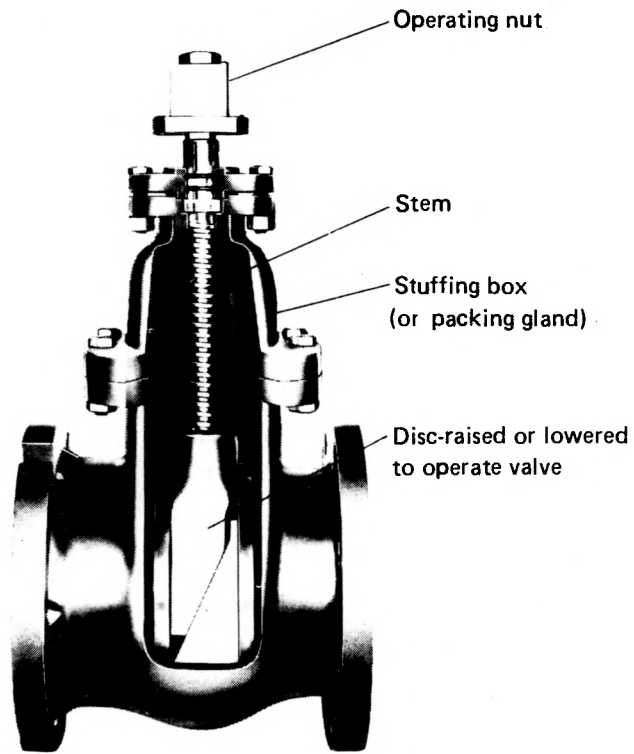


Fig. 12 Gate Valve

4.2.2 Installation Procedures

The installation procedure is as follows:

Step 1 When valves are received they should be handled carefully to avoid distortion, breakage and damage to the flanges and gaskets. Keep the valves in the closed position until it is time for installation and protect them from rain or snow.

21/10/83

- Step 2 Before installation clean any dirt or debris from the piping.
- Step 3 Install the valves in the line making sure that both pipe and valve are adequately supported so that any external pressures or forces are not transmitted to the valve body.
- Step 4 In the case of flange end valves, tighten the flange bolts uniformly and in stages. Pull up the bolts on opposite sides of the flange until they are all uniformly tight, and the joint gasket has sufficient compression to prevent leakage at the test pressure.

4.2.3 Valve Joint Types

4.2.3.1 Mechanical Joint

The mechanical joint is the most commonly used joint with both ductile iron and polyvinyl chloride pipe. As you can see from Figure 13, this joint is cast with a flange as part of the bell. A rubber gasket fits into a recess in the bell socket and a metal gland is bolted to the bell flange which compresses the gasket and seals the joint.

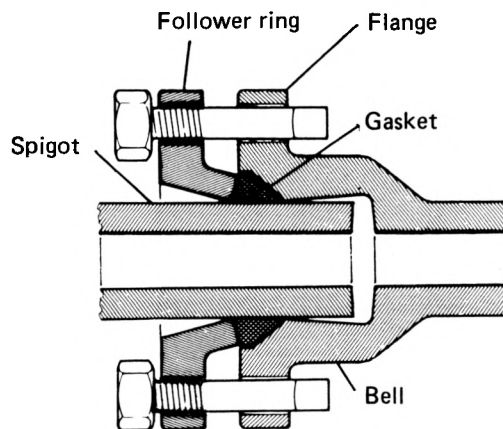


Fig. 13 Mechanical Joint

4.2.3.2 Flanged Joint

This type of joint is used with polyethylene pipe (see Figure 14).

The installation procedure is as follows:

Step 1 A stub end section is fused to the end of the pipe using the same method of pipe joints (See 3.6.4.2).

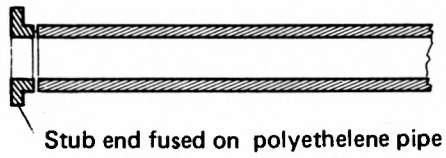
Step 2 A slip on metal flange, which presses against the stub end, is then bolted to the flange of the valve. This compresses a gasket which forms the seal.

4.2.4 Valve Boxes

The valve box provides access to the operating nut of the valve which is used to open and close the valve (see Figure 15).

The valve box is a hollow assembly fitting over the operating nut of the valve. The assembly comes in three standard sections. The bottom section fits directly over the valve operating nut with a guide plate to position the section correctly.

The middle section is an extension for valves buried too deep to reach using only the standard top and bottom sections. Extensions are added as required to give the required depth.



Valve flange Slip on metal flange

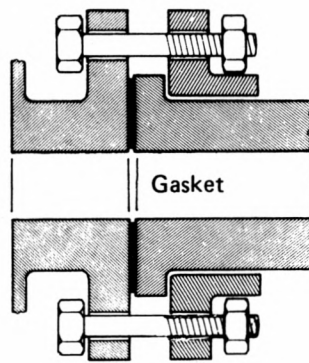


Fig. 14 Flanged Joint

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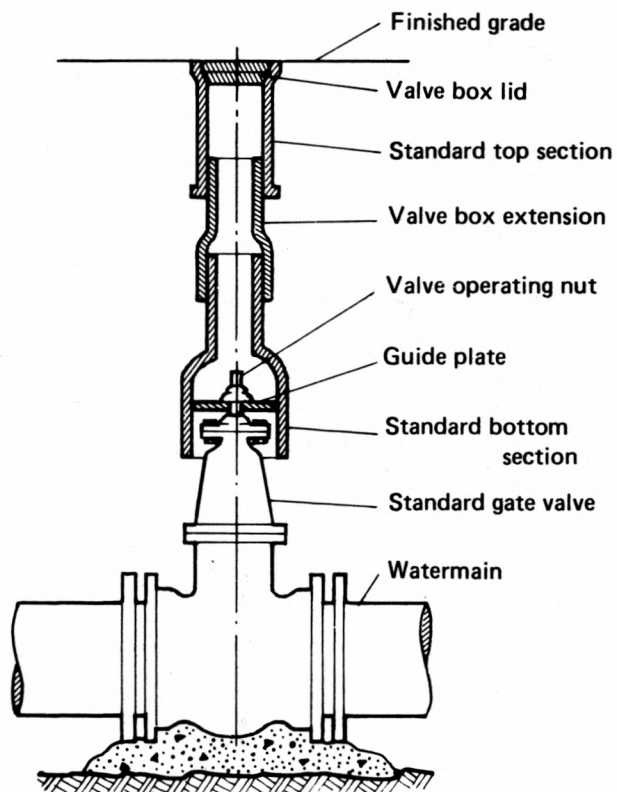


Fig. 15 Typical Valve Box Installation

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The top section has a lid at the top to fit flush or level with the ground surface. To operate the valve, remove the lid and insert a "key" down into the valve box to turn the operating nut.

4.2.5 Valve Chambers

4.2.5.1 General Remarks

A valve chamber is a chamber (similar to a sewer manhole) which permits easy access to the valve for operation, maintenance or removal. These chambers are normally only used on large valves (for water mains 300 mm (12 in.) or larger).

4.2.5.2 Installation Procedures

This section gives procedures for installing valve chambers constructed of precast concrete sections. As this is by far the most common material, it will be the only one discussed, however, procedures for installing valve chambers of other materials are similar.

Excavation, bedding and backfill procedures and principles are similar to those for constructing the water main (see 3.0).

As the water main excavation progresses, the trench is widened to provide sufficient working space to construct the valve chamber.

The procedure for installing precast valve chambers is as follows:

a. Place bedding material.

A 150 mm (6 in.) layer of crushed stone is normally placed on the bottom of the excavation as a foundation for the concrete base. As is the case with the water main, if the soil at the bottom of the excavation is wet or spongy, it should be removed and replaced with crushed stone. The foundation is very important since settlement of the valve chamber may cause the water main to break.

b. Place precast sections.

Once the crushed stone foundation material is in place, the concrete base slab is placed onto the foundation, and the precast sections placed in order onto the base. The precast sections are usually equipped with 2 lifting holes and the concrete base slab with 2 lifting rings. Lifting pins are placed into the holes or rings, and the sections lifted into place using a chain attached to a backhoe bucket.

It is important that these lifting holes be sealed using some type of nonshrink grout, before the valve chamber is backfilled. Similarly, nonshrink grout is placed between the concrete base and the first section.

Precast sections are manufactured so that standard neoprene (rubber) rings or gaskets fit between the sections to provide a watertight seal. Other forms of waterproofing such as cement mortar can also be used. The purpose of the waterproofing is to prevent the entry of groundwater into the valve chamber.

c. Backfilling.

As with the water main, the compaction of backfill is very important and must be carefully done in lifts. Too often the road surface settles around the valve chamber cover as traffic compacts the backfill.

In addition, ensure that the backfill is brought up evenly all around the valve chamber to prevent lateral displacement. In other words, if one side of the valve chamber is backfilled and compacted before the other side, this will displace the valve chamber sideways.

4.3 Fire Hydrants

4.3.1 General Remarks

A hydrant is basically a control valve in the water main system which allows water to be made available in large quantities. It is used mainly for firefighting.

As you can see from Figure 16, the hydrant consists of a cast iron bell with a flange fitting at the bottom to connect to a branch from the water main. At the bottom of the cast iron barrel there is a control valve operated by a long valve stem which is connected to a nut at the top of the hydrant. Water passes up the barrel when the valve is opened and passes to the fire hoses through two 2 1/2 in. hose outlets.

Hydrants are generally installed with a shut-off valve between the hydrant and the main. This permits maintenance and replacement of hydrants without disturbing the flow in the main.

4.3.2 Installation Procedures

The installation procedure is as follows:

- | | |
|---------------|---|
| <u>Step 1</u> | When hydrants are received they should be handled carefully to avoid breakage and damage to the flanges. Keep hydrants closed until they are installed and protect them from rain and snow. |
| <u>Step 2</u> | Before installation, clean the piping and drain ring. |
| <u>Step 3</u> | To prevent water freezing in the hydrant barrel, excavate around the hydrant drain ring and surround the base of the hydrant with clear stone to a level about 150 mm (6 in.) above the lower barrel flange. When the hydrant barrel drains through the drain hole at the bottom, the clear stone will soak up the water. |

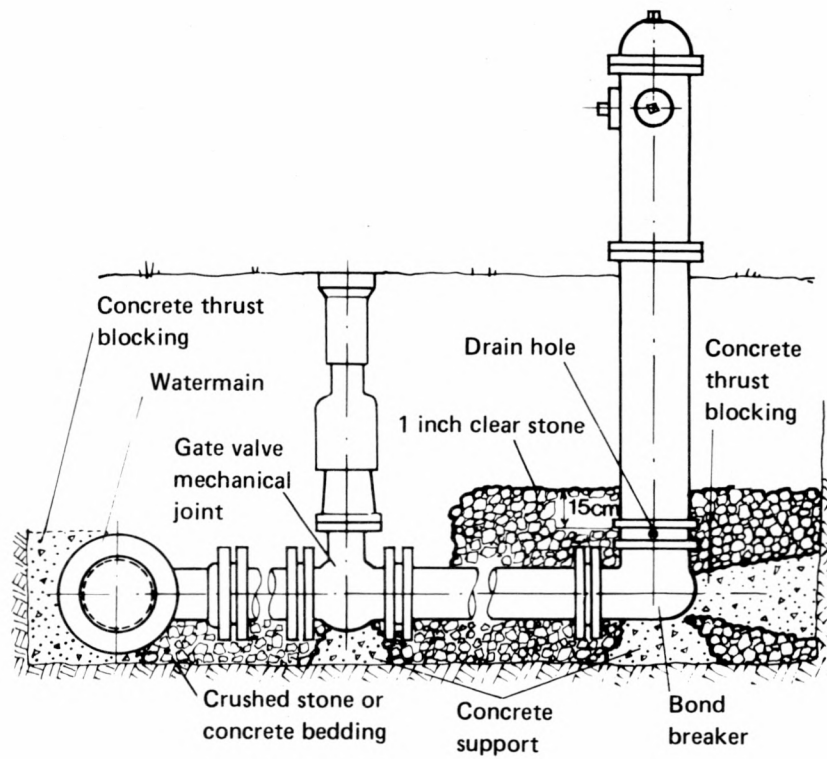


Fig. 16 Typical Hydrant Installation

- Step 4 In setting a hydrant in position, it is recommended that a firm support or footing be used, such as crushed stone or a concrete base on firm ground. This prevents settling of the hydrant and pressure on the lateral line joints.
- The hydrant should be anchored at both ends of its branch lateral by a thrust block arrangement. This is a concrete block set at the end of the lateral line which anchors the hydrant and helps to transfer the force of the moving water to the undisturbed soil, therefore minimizing the force on the pipe joints. Excessive force on the pipe joints could cause them to pull apart.
- Step 5 Hydrants should be visible and accessible but located far enough from the road to prevent damage from vehicles. The pumper outlet nozzle should face the street. Ensure that the outlet nozzles are high enough above the ground line for hose attachment and that there are no obstructions to prevent operation.
- Step 6 Compact both the drainage stone and the earth fill above the stone to give firm support to the hydrant barrel.
- Step 7 When first installed, operate the hydrant from the fully closed to the fully open position and back to make sure that there are no obstructions present.
- Step 8 After the hydrant has been installed and the line and hydrant pressure tested, (see 5.2) the hydrant should be flushed and then checked for proper drainage. This is done by removing the nozzle cap and placing the palm of the hand over the nozzle outlet. The drainage should be rapid enough to create suction which can be felt on the palm.

Step 9

The nozzle caps should be tightened and then backed off slightly so that they are just tight enough to prevent removal by hand.

4.4 Water Service Connections4.4.1 General Remarks

The water service connection is the piping which carries water from the water main to an individual building (see Figure 17).

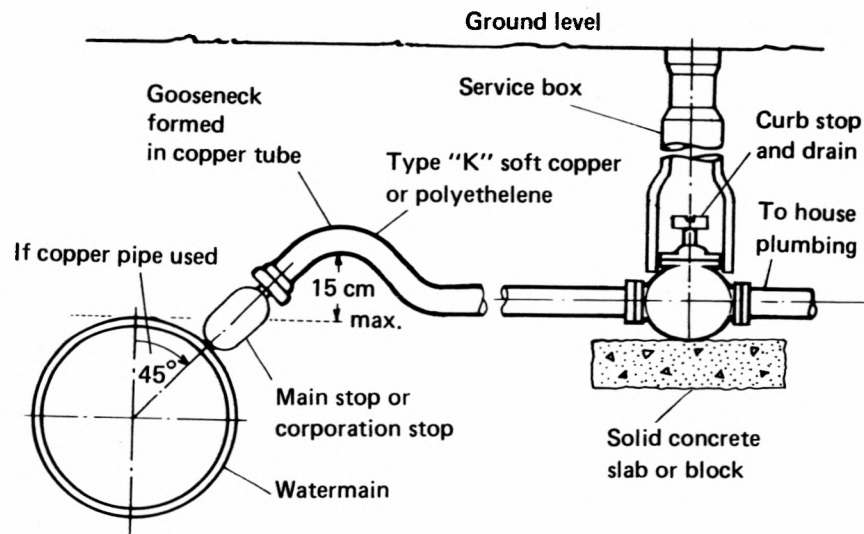


Fig. 17 Typical Water Service Connection

The usual sizes for an individual water service connection are 16 mm or 19 mm (5/8 in. or 3/4 in.).

The most common types of material used for service connections are copper type "K" and polyethylene.

As is the case with the water main, the service connection should be protected from freezing, and so the pipe is usually installed below the depth of frost penetration. In areas with very deep frost penetration this is sometimes impractical and so other methods must be used such as insulating the pipe or preheating the water (see also 3.6.4). The most practical method usually is to use polyethylene pre-insulated pipe (see Figure 11). If additional frost protection is required the polyethylene pre-insulated and heat traced pipe can be used.

4.4.2 Main Stop

4.4.2.1 General Remarks

This is the device used to connect smaller diameter service pipes into the water main (see Figure 18).

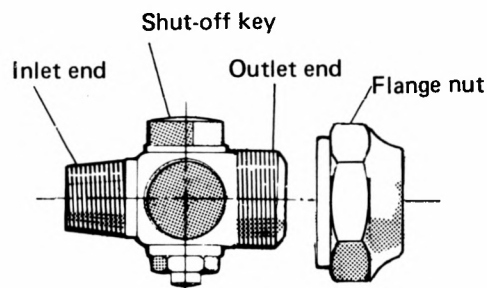


Fig. 18 Corporation or Main Stop

The main stop, sometimes called the corporation stop, is made of a brass alloy and consists of a body with an inlet and outlet. The body has a brass plug, known as a key, inserted through it. The key is tapered with a round hole through which the water flows. A 90° turn of the key opens or closes the stop and controls the flow of water from the water main. The key is secured through the body by means of a brass nut and washer.

The main stop is an additional valve in the service line between the water main and the building, however once the remainder of the connection to the building is completed, the main stop is left open usually for the life of the service. Once the service is backfilled, the main stop is no longer accessible.

It is recommended that, with copper service pipe, the main stop be installed at a 45° angle with the service pipe looped to allow for ground settling (see Figure 17). With plastic pipe, the main stop is inserted horizontally.

4.4.2.2 Installation

The connection to the main can be made when the main is dry, however, it is preferable to make it when the main is under pressure. An improper connection commonly creates leakage problems, and so by making it when the main is under pressure it can be determined immediately if there is leakage. Additional service connections to an existing main are usually made under pressure to avoid interrupting service to existing buildings.

4.4.2.3 Dry Connection

To make this type of connection, a tapping machine is used to thread a hole into the water main. The inlet end of the main stop is then simply threaded into the hole (see Figure 19).

Another type of dry connection makes use of a special saddle to secure the main stop to the water main (see Figure 20). A saddle connection is generally used on

polyethylene and some types of PVC pipe. It is best to seek advice from the manufacturer on which procedure they recommend for their pipe.

The procedure is to first drill a hole into the pipe using a brace and bit, carefully removing all of the cuttings. The saddle is then placed, carefully aligning the threaded hole in the saddle with the one in the water main.

The saddle is then tightened onto the main, a gasket on the saddle providing a seal. The main stop is then threaded into the saddle and the service pipe inserted into the outlet end of the main stop to complete the connection.

4.4.2.4 Wet Connection

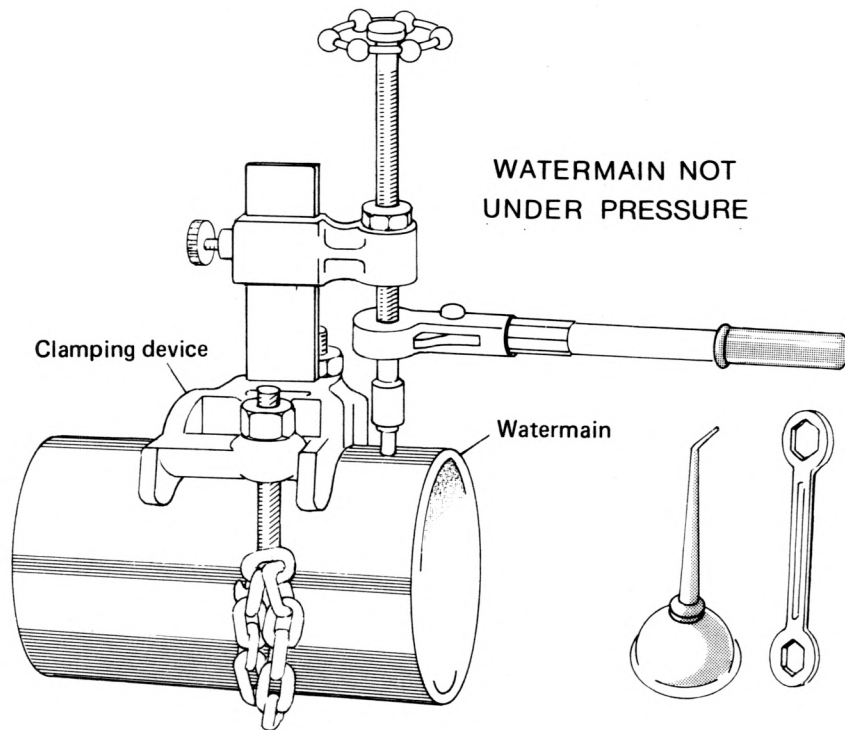
A type of tapping machine is used which enables the pipe to be tapped and the main stop installed while the main is still under pressure (see Figure 21).

There are numerous types of tapping machines available. They are such specialized equipment that operating instructions should be obtained from the manufacturer.

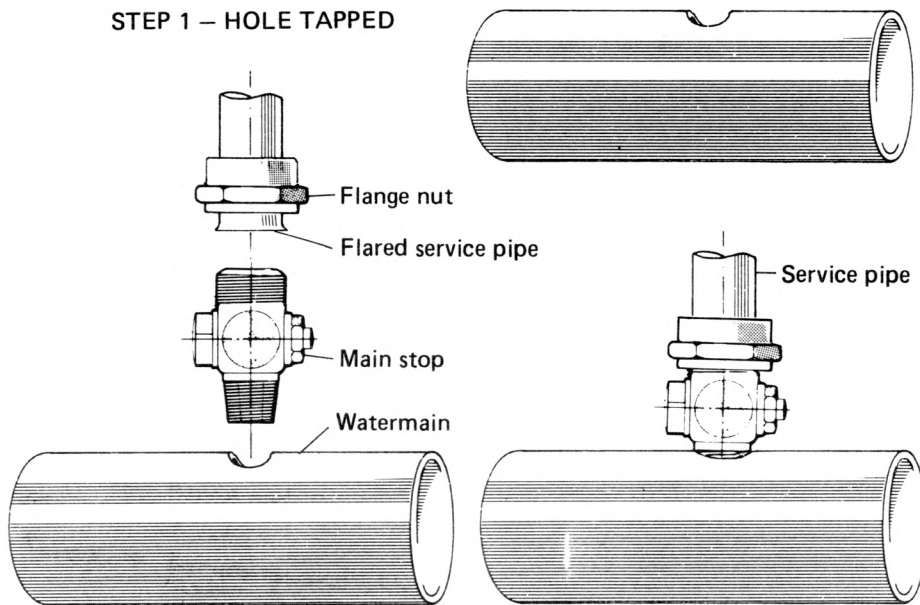
4.4.2.5 Outlet End of Main Stop

Once the inlet end of the main stop has been connected to the water main the service pipe can be connected to the outlet end. The most common type of outlet end is the flared connection.

See Figure 19, steps 2 and 3. When the flared pipe is inserted into the main stop, the curved surface in the flange nut opposes the convex surface on the body of the main stop. When the nut is tightened the two surfaces form a watertight seal. This type of connection also provides a great deal of resistance to the service pipe being pulled out of the stop.



STEP 1 – HOLE TAPPED

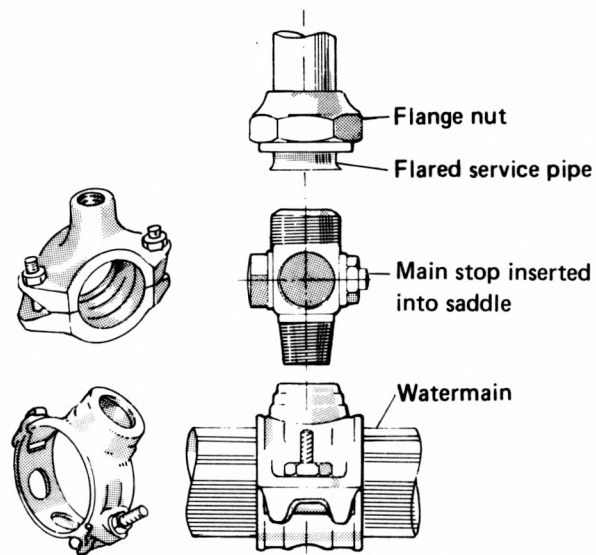


STEP 2 – MAIN STOP THREAD AND
FLARED SERVICE PIPE

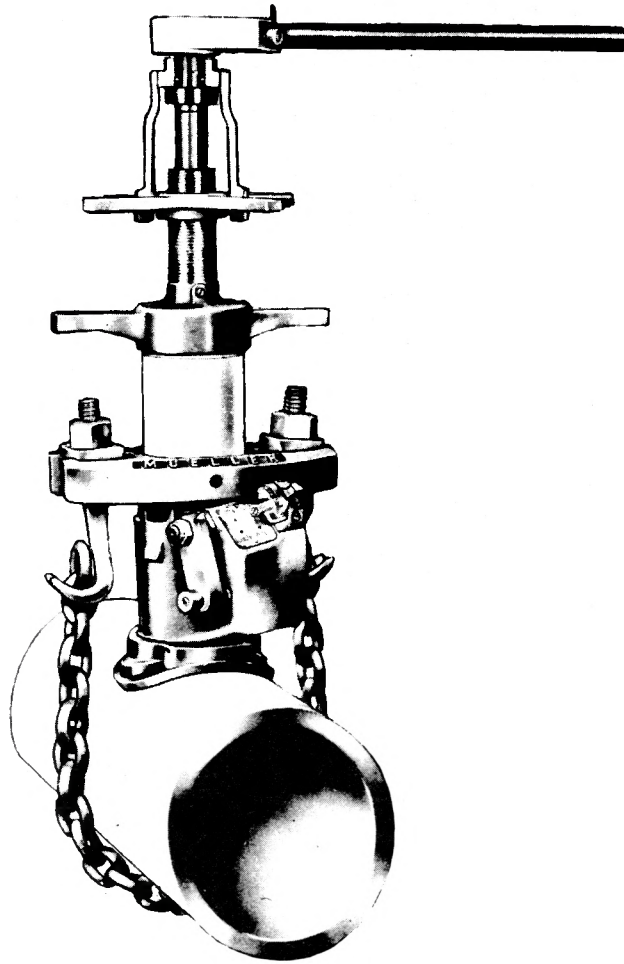
STEP 3 – CONNECTION COMPLETED

**Fig. 19 Service Connection Method,
(Watermain tapped directly)**

21/10/83



**Fig. 20 Service Connection Method
(using saddle)**



**Fig. 21 Wet Connection (Watermain
under pressure)**

21/10/83

There are various tools available to flare the end of the pipe, the most common being a flanging tool. The flanging tool is preformed to give the correct shape of flare. To use it, the end of the pipe is heated with a torch, and the flaring tool is oiled and then driven into the end of the pipe with a hammer (see Figure 22).

4.4.3 Curb Stop

This is a valve placed in the service line between the water main and the building it serves. Its purpose is to turn the flow of water on or off to individual buildings (see Figure 23).

Like the main stop, the curb stop has a brass plug, known as a key, inserted in the body. The key is turned through 90° to open or close the curb stop. The couplings for the inlet and outlet ends are similar to those for the main stop with the flared end most commonly used.

4.4.4 Service Box

The service box is a telescopic "box" that is located and installed above the curb stop (see Figure 23).

The purpose of the service box is to provide access from above ground to the curb stop buried below.

A rod extends through the box and is connected to the drilled key on the curb stop by a "U" shaped clip with two holes drilled to take a brass cotter pin. The cotter pin holds the rod in place over the drilled key.

The length of the service box is adjustable so that the top can fit flush with the ground. A lid on the service box prevents dirt falling in and jamming the rod.

To turn the curb stop on or off, remove the lid from the service box and insert a shut-off key into the box. A "U" shaped slot fits over the key on the end of the rod which will turn the curb stop below on or off.

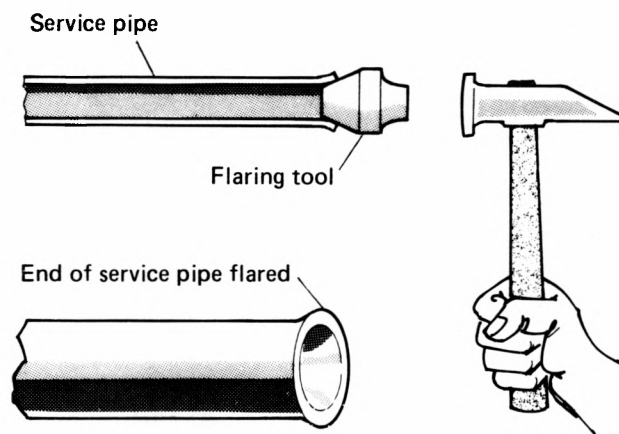


Fig. 22 Flaring End of Service Pipe

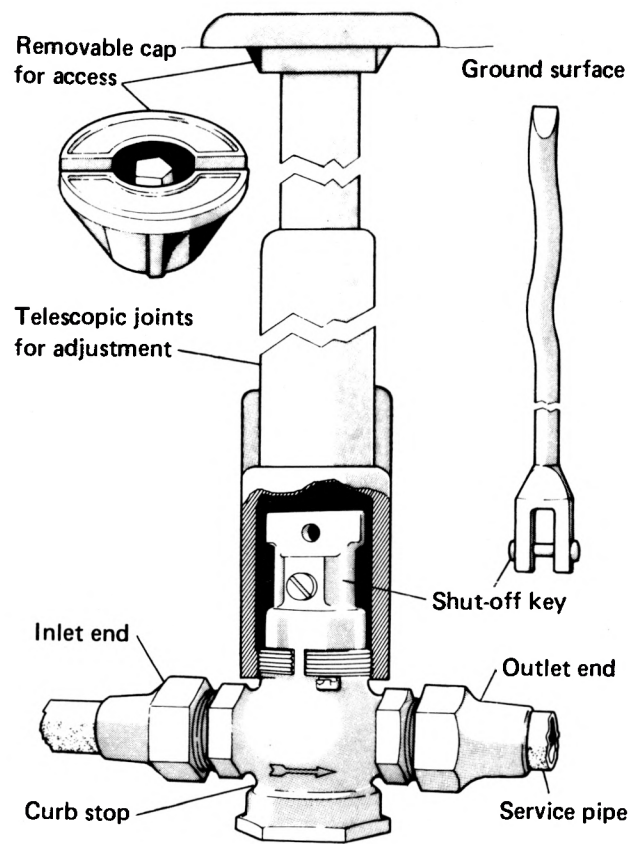


Fig. 23 Curb Stop and Service Pipe

21/10/83

When the service box is placed and backfilled it must be done carefully to ensure that dirt does not plug up the key on the curb stop. The box must be backfilled uniformly on all sides to ensure that it remains vertical.

5.0 TESTING AND DISINFECTION

5.1 General Remarks

Once the water main has been installed, there are a number of steps that must be taken before it is put into service. These steps are outlined in the following sections (see Figure 24).

5.2 Pressure Test

5.2.1 Procedure

Once the main has been installed, it must be tested to see if it is watertight. This gives an indication of the quality of workmanship and materials used in the construction. The object of the test is to determine how much the main leaks in one hour at a test pressure of 1.5 times the working pressure, which is normally about 400 kPa (60 psi). Basically, the procedure is to fill the test section with water and pump the section being tested up to the test pressure. By then checking to see how much the pressure drops, (as it will if water is leaking from the main) we have an indication as to how watertight the main is.

Use the following procedure for the test:

| | |
|---------------|--|
| <u>Step 1</u> | Make sure that all changes in horizontal and vertical alignment and dead ends are well braced to provide thrust restraint (see section 3.7). This is especially important during the pressure test since test pressures are normally much higher than normal water main pressures. |
|---------------|--|

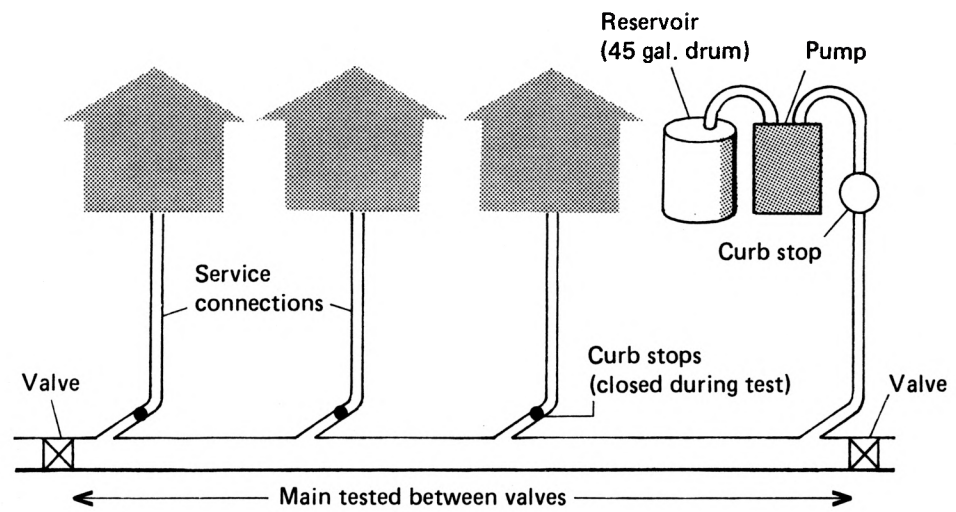


Fig. 24 Pressure Test

Step 2

Fill the test section with water. The most common method is to fill the main through a service connection at the end of the pipe. A convenient method is to install a service connection extending above ground near the end of the line. This is used only for the testing and is later abandoned.

Fill the test section by a pump with water from a small reservoir such as a 45 gallon drum. If a completely new system is being installed, a water truck is usually required to provide enough water. The water truck is used to keep the 45 gallon drum full as the main is being filled by the pump.

If the section of main being installed is connected to an existing distribution system, the main is filled by opening the valve connecting the two systems. The valve is then closed, isolating the section being tested.

Step 3

Pump water from the drum to reach the test pressure. Before the pressure reaches full test value, bleed off all the air in the mains by venting through hydrants, service connections etc. This is important because if there is too much air in the water main, it could escape during the test, lowering the pressure and giving false test results.

Step 4

Once the main is up to test pressure, fill the drum to the very top. Maintain the test pressure for 1 hour - if the pressure drops during the test, pump additional water from the reservoir into the main to bring the pressure back up to the test pressure. If the pressure does drop, it is because water is leaking from the main. By pumping water from the drum to

maintain test pressure - and later measuring the amount removed from the drum, we can find out exactly how much the main is leaking.

5.2.2 Example

Using a 45 gallon drum as the reservoir, 800 ft. of 6 in. main is being tested. During the 1 hour test, as the pump maintains the test pressure, the level in the drum drops 1 3/4 ins. The diameter of the drum is 2 ft.

$$\begin{aligned}\text{Volume of water leaked} &= \frac{\pi D^2}{4} \times \text{drop in water level} \\ &= \frac{\pi 2^2}{4} \times \frac{1 \frac{3}{4}}{12} \\ &= 0.46 \text{ ft.}^3 = 2.86 \text{ gallons}\end{aligned}$$

Actual leakage = 2.86 gallons

5.2.3 Allowable Leakage

This will depend on what the construction specifications call for. In the event that the allowable leakage is not specified, the allowable leakage is normally .90 gallons per inch of pipe diameter for each mile of pipe tested.

The corresponding figure in metric units is 0.1 L per mm of internal diameter for each km of pipe tested.

For our example, the allowable leakage is:

$$0.90 \text{ gallons} \times 6 \times \frac{800}{5280}$$

Allowable leakage = 0.82 gallons

Since the actual leakage exceeds the allowable, (2.86 gallons instead of 0.82 gallons) therefore the test has failed and it will be necessary to find the point or points where the leakage is taking place.

5.2.4 Procedure If Test Fails

Although the procedure to find the leak can be tedious and time consuming, there are some basic steps that can be taken that might give some indication where the leak is taking place.

The first step is to leave the main at normal operating pressure (50 - 60 psi) for a day or so and then repeat the test. If the leak is worse than the day before, then the leak is probably at a pipe joint. This is because a twisted gasket will usually dislodge even more if the pressure is maintained, causing more leakage when the test is repeated.

If the leak is at a faulty valve or service connection, the leakage will usually remain the same when the test is repeated. To check the service connection curb stops (a common leakage problem), insert the shut off key for the curb stop and place your ear against the key. Since the key will act like a stethoscope, it may be possible to hear the leak. It is preferable to have someone experienced to carry out this type of testing.

If no leaking curb stops are found, the valves at the ends of the section being tested should be checked to make sure they are not leaking. Opening and closing the end valves a few times will flush out any sand grains or other debris that may be preventing the valves from closing completely, causing slight leakage.

If the leak is still not found, it may be necessary to test the main in smaller sections to find the general location of the leak. Usually the valves in a water main are located approximately every 300 ft. and so the shorter sections between the valves can be tested separately. When the leaking section is determined, some sort of leak detection device such as a sensitive microphone with earphones may be required.

Unfortunately, there is no definite method by which a leak can be found. As previously mentioned, it is often a time consuming, tedious process that is dependent on trial and error and relies heavily on the

experience of those doing the testing. As a last resort, portions of the main may have to be reexcavated to check them.

5.3 Flushing

Flushing is carried out to remove any dirt or debris left in the water main after it has been installed. Any such material left in the main following construction could cause taste or odour problems and can also shield bacteria from disinfection. The most common method of flushing a main is to open up a hydrant near the end of the line.

5.4 Disinfection

5.4.1 General Remarks

Disinfection means the destruction of disease causing organisms. Before the water main is put into service it must be disinfected because it will have become contaminated during the transit and installation. Note that at this point, we are disinfecting the water main - when it is later put into service, we may disinfect the water before it is delivered to the users.

The water main is disinfected by filling it with highly chlorinated water and allowing it to stand for a period of time. This will kill any disease causing organisms.

Following the retention period, the highly chlorinated water must be removed by flushing and the system filled with potable water that has been proven through bacteriological testing to be free of contamination.

5.4.2 Procedure

5.4.2.1 Gas Chlorination

This is a complex method, requiring special equipment, which can be extremely dangerous. It is therefore not recommended.

5.4.2.2 Hypochlorination

Hypochlorination is the most common method of chlorinating a water main. A chlorine compound is added to water to form a solution. The water main is then filled with this solution which is allowed to stand, usually for 24 hours.

The most commonly available products which can be used for hypochlorination are as follows:

- a. Calcium hypochlorite (trade names - "HTH", "Perchloron") contains up to 70% available chlorine.
- b. Chlorinated lime or "bleaching powder" contains approximately 33% available chlorine.
- c. Sodium hypochlorite includes a variety of liquid solutions containing between 5% and 14% available chlorine.

All these compounds are commonly used for the disinfection of water mains because of the relative ease and safety with which they can be handled and applied. Calcium hypochlorite is the most commonly used. It is sold in powder form and has the strongest concentration of the three types listed. It is therefore the easiest and cheapest to transport.

The sodium hypochlorite is a weaker solution which comes pre-mixed in liquid form. Although it is very convenient to use, it is heavy and bulky to transport and for this reason is not frequently used in northern or remote areas.

5.4.2.3 Application (hypochlorination)

When the water main is first filled, the usual concentration of chlorine in the water is 50 mg/L which is equivalent to 50 parts per million (ppm). Stated another way, this means there are 50 parts of chlorine for every one million parts of water. During the 24 hours the chlorinated water stands in the main, the chlorine will react to neutralize any

contamination or bacteria. This will lower the concentration of chlorine in the water. The concentration at the end of the 24 hour period is called the chlorine residual. If it decreases to below 25 mg/L this indicates that there is excess contamination in the main and the process is repeated.

Examples of calculations for determining the amounts of the various chlorine compounds required to disinfect a main are given in Appendix 1.

Once the quantity of compound required to disinfect the main is determined, it is fed into the main through either a main or curb stop near the start point of the new line. At the same time, water from the distribution system (or other suitable source) is introduced into the main. The flow of the water and the chlorine must be fairly accurately measured to give the desired dosage of 50 mg/L.

Following the retention period, (usually 24 hours) the chlorinated water should be removed from the main by proper flushing and the main then filled with clean potable water.

Bacteriological Testing

After the water main has been adequately chlorinated, flushed and filled with clean water, a number of water samples should be collected from various locations (including the end of the line) and submitted to a laboratory for bacteriological testing.

The most important test to be carried out in a laboratory is the fecal coliform test. Fecal coliforms are a particular type of bacteria found in humans and animals. When this type of bacteria shows up in a water test, it indicates that the water is polluted from human or animal waste, and could mean that disease causing organisms are present.

When the laboratory report has confirmed that the water in the new main is safe, it may then be put into service. If the lab tests indicate there is possible contamination, then the disinfection must be

repeated. The main should never be put into service until all bacteriological tests indicate the water is safe.

When collecting samples, care should be taken to make certain that the sample is not contaminated by the use of unsanitary techniques. Both the chlorination of the new works and the collection and submission of samples should be carried out by adequately trained individuals. If these processes are done carelessly, this could result in a great loss of time on the project.

APPENDIX 1Sample Calculations for Pipeline Chlorination

The most common compounds used to provide chlorine for water main disinfection are: HTH (high test hypochlorite), sodium hypochlorite solution and javex.

The normal strength of water main disinfection is 50 mg/L for 24 hours leaving a chlorine residual of 25 mg/L. The amount of chlorine required is dependent on the following:

1. Diameter of the pipe.
2. Length of the pipe.
3. Percentage of available chlorine in the compound.
4. Dosage required.

To determine the amount of material required to give the required chlorination, use the following formulae:

Objective: to dose the water main at 50 mg/L chlorine

Data: diameter of the pipe in inches, d
length of pipe in feet, Y

Equation 1 Using HTH 70% available chlorine (pellets or powder)

$$\text{amount of HTH required (in lbs.)} = \frac{d^2 Y}{41,135}$$

Equation 2 Using sodium hypochlorite solution at 12% strength

$$\text{amount required (in gallons)} = \frac{d^2 Y}{70,518}$$

Equation 3 Using Javex solution at 6% available chlorine

$$\text{amount required (in gallons)} = \frac{d^2 Y}{35,259}$$

To correct the above equations for chlorine dosages different from 50 mg/L, multiply the above equations by:

$$(0.02 \times \text{required dosage in mg/L}).$$

To correct equation #2 for sodium hypochlorite concentration different from 12% multiply by:

$$\frac{12}{\text{actual \% chlorine}}$$

To correct equation #3 for a javex concentration different from 6%, multiply by:

$$\frac{6}{\text{actual \% chlorine}}$$

Example 1

Assume a 6 inch main, 2000 ft. long, strength required - 50 mg/L, calculate the amounts of HTH, sodium hypochlorite and javex that would be required to disinfect the main.

1. HTH required = $\frac{d^2 Y}{41,135} = \frac{6^2 \times 2000}{41,135} = \underline{1.75 \text{ lbs.}}$
(70% strength)
2. Sodium hypochlorite = $\frac{d^2 Y}{70,518} = \frac{6^2 \times 2000}{70,518} = \underline{1.02 \text{ gallons}}$
required
(12% strength)
3. Javex required = $\frac{d^2 Y}{35,259} = \frac{6^2 \times 2000}{35,259} = \underline{2.04 \text{ gallons}}$
(6% strength)

Example 2

Using the same data as Example 1, calculate the amounts of HTH, sodium hypochlorite and javex that would be required to disinfect the main to a dosage of 25 mg/L.

1. HTH required = $\frac{d^2 Y}{41,135} \times (0.02 \times 25) = \frac{6^2 \times 2000}{41,135} (0.02 \times 25)$
(70% strength)
 $= \underline{0.88 \text{ lbs.}}$

$$\begin{aligned}
 2. \text{ Sodium hypochlorite required (70\% strength)} &= \frac{d^2 Y}{70,518} \times (0.02 \times 25) \\
 &= \frac{6^2 \times 2000}{70,518} (0.02 \times 25) \\
 &= \underline{0.51 \text{ lbs.}}
 \end{aligned}$$

$$\begin{aligned}
 3. \text{ Javex required (6\% strength)} &= \frac{d^2 Y}{35,259} \times (0.02 \times 25) = \frac{6^2 \times 2000}{35,259} (0.02 \times 25) \\
 &= \underline{1.02 \text{ lbs.}}
 \end{aligned}$$

Example 3

Using the same data as Example 1, calculate the amount of sodium hypochlorite at 30% strength that would be required to disinfect the main.

$$\begin{aligned}
 \text{Sodium hypochlorite required (30\% strength)} &= \frac{d^2 Y}{70,518} \times \frac{12}{30} = \frac{6^2 \times 2000}{70,518} \times \frac{12}{30} \\
 &= \underline{0.41 \text{ lbs.}}
 \end{aligned}$$