CAPITAL DEVELOPMENT AUTHORITY

ISLAMIC REPUBLIC OF PAKISTAN

MANUAL OF WATER LEAKAGE CONTROL IN ISLAMABAD WATER SUPPLY

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Prepared for

OVERSEAS TECHNICAL COOPERATION AGENCY

GOVERNMENT OF JAPAN

by

JAPAN SURVEY TEAM FOR WATER SUPPLY

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PREFACE

The construction of Islamabad as the capital city for the nation of Pakistan commenced in October, 1961, and the water works began to supply water in 1963. Since then, the demand for water increased markedly with the increase in population. Thus, the sharply increased demand for water had to be met by building small head works, one after another, along small rivers and brooks which flow near the outskirts of the capital. Such addition of head works has never given a satisfactory solution to the problem of constant shortage of water supply. The shortage in volume of water supply itself coupled with the various problems set forth below have kept the capital in a chronic state of water shortage throughout the whole year as pointed out in the Pre-feasibility Report on Water Supply in Islamabad, prepared by Japanese Survey Team in October, 1970.

(a) Huge amount of water is wasted through leakage in transmission mains, distribution lines and broken valves.

(b) Imperfect distribution networks stand in the way to uniform supply of water to service areas.

(c) Metering of all home connections is not operated normally. To be more specific, water meters are installed only in some part of consumer connections and many of those installed are out of order.

Thus, the aforementioned Pre-feasibility Report points out that the following measures should be taken immediately to give an early solution to this serious situation of water shortage.

(1) Water leakage control

(2) Sound management of metering system

(3) Rearrangement of existing distribution networks to ensure uniform water distribution.

These are invariably the most basic works indispensable for the satisfactory maintenance and operation of water supply system.

The water works as an enterprise is to supply an ample amount of water with sufficient pressure hygienically and inexpensively to consumers. Water leakage and wastage proves to be a major loss in all aspects, namely, from the viewpoints of hygiene, quantity, pressure and economy. Water leaks occur in all the supply installations, particularly in pipe lines. In addition to the leakage to the ground surface, leakage can quite often occur under the ground. Water penetrates into the soil under the surface in some cases and it flows down and finds its way into the sewer in other cases. Such underground leakage sometimes escapes our observation. The latter leakage, if allowed to take its own course, will grow in quantity and eventually account for the greater part of water leakage. Therefore, a well-programmed work of survey is required to be continued against possible underground leakage.

The wastage of water should be prevented by providing individual consumers' service connections with water meters and establishing the metering system. This is important also from the standpoint of rational operation of water supply system as it will ensure collection of appropriate water charges. Thus, each water meter is expected to measure the flow of water correctly and, as a rule, has to have a diameter equalling that of the service pipe. The meter should be installed at such point in the premises that it permits easy meter reading and should be protected sufficiently against entry of filthy water, or breakage or deterioration due to damage or impact by hard objects. When the valid period of inspection has terminated, the meter should be inspected again.

Control of distribution and consumption forms the most fundamental problem from the standpoint of operation of water supply system and it is performed by using the accounted-for quantity as the yardstick. At the entrance of pipe system, the volume of supplied water is measured. At the terminal of pipe system, the volume of water used by consumer is measured. The ratio of accounted-for water is the percentage ratio of the latter volume to the former volume. This ratio ought to be 100% if supplied water is not lost en route somehow or other. Actually, however, the ratio is generally at a considerably low level because of leakage in the pipe system, wastage caused by the mechanical trouble or leak of water meter, etc.

This manual, therefore, aims to describe technical methods covering the water leakage control which is the simplest yet most important step in the management of water supply system.

Nihon Suido Consultants Co., Tokyo, who provided majority of the field survey team, was commissioned by Government of Japan through OTCA to prepare this manual.

Table of Contents

CHAPTER I

WATER LEAKAGE DETECTION

1-1 Waste Water

1-2 Prevention Methods of Waste

1-3 Water Leakage

1-4 Nature of Water Leakage Prevention Works

1-5 Terms Related to Leakage Prevention

1-6 Detection Method

1-6-1 Detailed Inspection

1-6-2 Leakage Survey

1-7 Desk Work for the Leakage Prevention

1-8 Organization of Survey Team

CHAPTER I. WATER LEAKAGE DETECTION

1-1 Waste Water

By "waste" is meant that portion of the total output of water which is not used by the consumers or in the operation of the water undertaking, or is used extravagantly.

Waste may be caused by the following: -

(i) Leakage from reservoirs, mains and other works of the undertaking, and from consumers' pipes and fittings, through: -

(A) apertures or porosity due to faulty materials or construction, or to corrosion or erosion;

(B) fractures in structures or plant caused by subsidence, shrinkage of soils (especially clamp), vibration, water hammer, temperature changes, or, in the case of mains in public roads, fractures caused by other road users;

(C) defective joints;

(D) faulty washers or seatings in draw-off fittings.

(ii) Bad design.

(iii) Failure, either wilful, careless or accidental, to turn off taps after use.

(iv) Undue consumption caused by drawing more water than is needed, either into utensils, or through hosepipes for garden watering or washing vehicles.

(v) Misuse of water, such as the wasteful employment of water for cooling purposes, or unauthorized use.

In all cases leakage is intensified by unduly pressures.

The aggregate amount of leakage, quite apart from misuse or undue consumption, may be from 10 to 25 per cent of the total output. Few

undertakers can seriously claim a figure of less than 10 per cent, whilst in some areas, where perhaps pressures are high or where insufficient staff is available to ensure efficient waste prevention, the wastage may amount to as much as 50 per cent. To give an idea of the losses which may take place from a pipe containing water at the comparatively low pressure of 45 lb/sq.in., 360 gal. daily will escape from an orifice only 1/16 in. in diameter, enough to supply four average households.

The most serious leaks are those which take place underground; they may persist for months or years without giving any surface indication. There is thus need for constant and unremitting efforts to discover these, and all other leaks, and there is room for improved methods throughout the whole field of waste prevention.

The result of waste is to require additional water resources, larger works and mains, additional labour and fuel for pumping, and extra staff for repair work. Furthermore, waste reduces the available pressure in water mains, perhaps to a seriously low figure. A gallon saved is a gallon gained, and money spent on efficient waste prevention may obviate the need for far greater expenditure on new supply works, particularly if all local resources of good quality have already been utilized.

1-2 Prevention Methods of Waste

Methods of reducing waste include the following: -

(i) propaganda and public instruction;

(ii) provision of a repair and rewashering service;

(iii) enforcement of by-laws and regulations to ensure the provision of high quality service pipes and fittings;

(iv) inspection of new, altered or repaired service pipes and fittings;

(v) surveys of all premises supplied;

(vi) *metering of supplies;*

(vii) reduction of pressure and establishment of zones of pressure;

(viii) improvements in materials, design, lay-out and construction of works and services; and

(ix) economy in use of water for scouring mains, back-washing filters, and other waterworks purposes.

(a) Propaganda

The importance of enlisting the help of the consumer in eliminating waste is now being increasingly recognized, and many authorities give much attention to the problem of educating the public, especially schoolchildren, in the need to use with care the supplies of pure water made available at great cost, and, in many cases, with increasing difficulty. Co-operative consumers are as valuable as waste inspectors, and they are on the spot all the time. Consumers' fittings and pipes are responsible for the majority of waste.

(b) Repairs Service

The provision by the water authority of facilities for the rewashering, renewal and adjustment of taps, and repairs to service pipes, at the lowest possible cost, undoubtedly encourages consumers to report leaks promptly.

(c) Bye-laws

The needs for sanctions to ensure the maintenance of reasonable standards for pipes and fittings has been recognized, granting the power to make bye-laws. Some authorities exercise statutory power to test all new fittings and stamp them if approved.

(d) Inspection of new work

It is necessary not only to make rules, but to ensure observance of them. All new work should be inspected and passed before permission is given to put it into use. Pipes should be examined to see if they are of correct weight or gauge. Fittings should be checked and the test marks found.

(e) Surveys

It may be as well to mention here the importance of making detailed inspections of all consumers' fittings every few years for, no matter how vigorous the system of initial inspection may be, there are always possibilities of evasion of regulations. The opportunity could then be taken of recording statistical information such as, for example, the number of people supplied in each house, so as to obtain an accurate figure of total population supplied.

(f) Metering

Industrial supplies and those afforded to hotels, schools and large institutions are almost invariably given by measure. In such cases it is easier to test for leaks and observe undue consumption. The metering is a logical way of detecting waste, and of discouraging excessive use of water.

(g) Zoning

Leakage from an orifice is proportional in quantity to the square root of the pressure of the water, so it is desirable to limit pressure to a reasonable figure, which is sometimes taken as 45 lb/sq.in. In hilly districts of Islamabad, considerable variations in pressure will necessarily arise, but these should be reduced to a minimum, as also should be the pressure fluctua-

tions brought about by small mains and their high frictional losses, by the provision of terminal storage or mains of adequate size. The area of supply should be divided into pressure zones, each controlled by service reservoirs or water towers. In many cases, booster pumps or pressure-reducing valves may be needed to increase or decrease pressures. When there are considerable changes in ground level, the feeder mains for some zones may cross other zones.

(h) Improvements in materials and design

There is also need for improvements of materials and designings employed for water supply. For instance, of all water fittings, the one responsible in the aggregate for the greatest amount of waste is the stop valve. It is therefore advisable for CDA to establish a standard for manufacturing fittings after careful studies of standards of Japan and other industrial countries.

1-3 Water Leakage

No matter how completely a water supply system has been planned, designed and constructed, this system cannot be said to be receiving proper maintenance and control if it suffers from constant leakage of large volumes of water. The water pressure decreases and the waste in the cost of water production at head works increases with the increasing volume of leakage. Wholesome operation of water works can hardly be hoped for under such conditions. When a distribution pipe line or service pipe line leaks and the supply of water through this line is suspended for repair works or some other purposes, filthy water from a nearby drainage or pool is suctioned through the point of leakage into the line. Thus, the water within is defiled. This may expose the consumer to serious danger. In the case of a system of deficient water

supply, effective prevention of leakage saves large volumes of water which would otherwise be lost through leakage and serves to mitigate shortage of supply to some extent. Thus, leak detection and repair plays an important part in the wholesome operation of financially strained water works business.

The most important things to be borne in mind for the water leakage prevention are:

- Full self-consciousness -

Every member of the water works personnel should fully appreciate the importance of his role in the water leakage prevention works, which are aimed at ensuring water quality, water volume and water pressure, rendering the operation economical, and eventually promoting the welfare of the general public.

- Kindness -

As a servant for all the consumers, every member should discharge his duty solely for the benefit of the general public. Even in the fulfillment of water leakage prevention works, he should conduct his duty while taking care to show kindness to and not to inconvenience citizens. He should deal with any citizen in a like manner.

- Responsibility -

Water leakage prevention works are not in the least attractive compared with some other works which are gay in outward appearance. These works are not achieved successfully unless every member engaging in the works assumes his responsibility for his duty and discharges the duty with full faith. He is required to exert all his ability to the work.

Leakage prevention works require the following organizations.

- Leakage prevention group -

The purpose of this group is to ensure proper and smooth performance of leakage prevention works. The group takes charge of planning leakage prevention, making necessary investigation, and collecting statistics on the survey of water pressure.

- Leakage prevention works' group -

This group is responsible for the execution of all field works which form the most important part of all leakage prevention works. No matter how rationally leakage prevention may be planned, the leakage prevention contemplated cannot be achieved unless field works are carried through to perfection.

- Meeting of persons in charge of leakage prevention -

Persons of supervising status responsible for leakage prevention meet once monthly toward the end of each month and discuss schedule of works and procedure of works for the next month. They also exchange views on problems relating to the performance of leakage prevention works so as to give solutions to problems and work out improvements wherever possible.

1-4 Nature of Water Leakage Prevention Works

Leakage prevention involves troublesome works of detecting hidden spots of leakage and giving necessary repairs to detected spots of leakage in the increasingly more complicated urban and traffic conditions. More hardships are experienced when much time is wasted in locating spots of leakage and desired results of work are not achieved than when works are progressing smoothly. Further, the task requires special techniques and skill in the use of such precision instruments as leak detector and pipe detector and in the detection of highly complicated distribution

pipes and service pipes. The members assigned to the leakage prevention works' group are required to be able to give necessary repairs not only to distribution pipes but also to service pipes. Thus, the leakage prevention workers must make efforts to improve skill, accumulate experience, and master technique day after day. If they deal with the works in any easy-going manner, they can hardly achieve the end of works. Even if individual workers are fully skilled, they cannot achieve desired results of work unless they combine their efforts to the fulfilment of works. This only ends up in waste of time and labor. Effective team work and sense of responsibility are preconditions for successful fulfilment of leakage prevention works.

1-5 Terms Related to Leakage Prevention

- o Water consumption - Of the water produced, that indicated on the water meter and water consumption not accounted-for.
- o Water loss - Of the water produced, that believed to be lost through leakage and other similar causes.
- o Water consumption paid-for - That water which is supplied to consumers and for which due charges can be collected.
- o Water consumption not accounted-for - That water used for washing pipes or for fire fighting and not indicated by the water meter, for which no charges can be collected.
- o Meter-insensible water - When the flow is very small, the passage of water through the meter is not reflected on the meter reading sometimes though not frequently. Meter-insensible water refers to the volume of water whose passage through the meter is not indicated on the meter.
- o Water production - That water forwarded from the water reservoir to the supply area. The water production is divided into the water

consumption and the water loss. The water consumption represents the volume of water used and the water loss represents the volume of water lost through leakage and other causes. Where there is a fair difference between the water production and the water consumption, the relationship between the two volumes must be reviewed. If the loss is large, leakage prevention works are executed as required, as a matter of course.

o Leakage and leakage ratio - Leakage is possible to occur throughout the entire water supply system. Leakage prevention works are particularly required for underground leakage which occurs predominantly on distribution pipes and service pipes. Since leakage increases or decreases in direct proportion to the square of water pressure exerted on distribution pipe in question, the pressure of water in the distribution pipe should be considered in comparing leakage. It is next to impossible to make a direct measurement of the aggregate volume of leakage occurring in the whole supply area. Thus, the aggregate volume of leakage may be estimated on the basis of the volume of leakage determined for smaller sectors through direct measurement in the course of leakage prevention works. The leakage ratio refers to the ratio of leakage to water production and serves as one yardstick to tell the condition of leakage.

1-6 Detection Method

Waste or leakage may take place from impounding reservoirs, aqueducts, service reservoirs, mains and services. A rough idea of the amount of leakage from a service reservoir and from the area it supplies may be obtained by measuring the quantity which has to be pumped or passed into the system to maintain the reservoir level during night hours, after allowing for the quantity being taken by factories on night work, etc. Reservoir may also be tested for leakage by shutting them off for

a time and measuring the reduction, if any, in water level.

To test trunk mains, the most efficient method is to install a meter (Master Meter) on the line into the isolated section. Valves are closed as may be needed in order to isolate various sections of the main, and the variations in reading show the losses between test points, all branches, of course, being shut off. Valves must be tested to see whether they cut off completely or not, and faulty valves should be replaced.

1-6-1 Detailed Inspection

The detection of individual leaks is carried out in various ways, and the method described here is one generally applied to most water works. The programme in any selected area where the master meter is in operation may be as follows: -

(i) Following examination of master meter records, a district will be selected where, after allowing for night consumption, if any, in factories, etc. the night flow is high. Fig. 1-1 shows a typical "open run" flow chart which indicate a minimum night flow of 2,000 g.p.h., as compared with an average flow of 3,250 g.p.h. Waste in this case is therefore 61.1/2 per cent of the total average flow, if no water is being used during the night hours.

Total day flow is obtained by adding the average hourly quantities, whilst the total day waste is estimated by multiplying the minimum night flow by 24. Where night pressures are higher than day pressures, this estimate will be on the high side.

(ii) A house-to-house inspection will be made so as to discover where taps need rewashing.

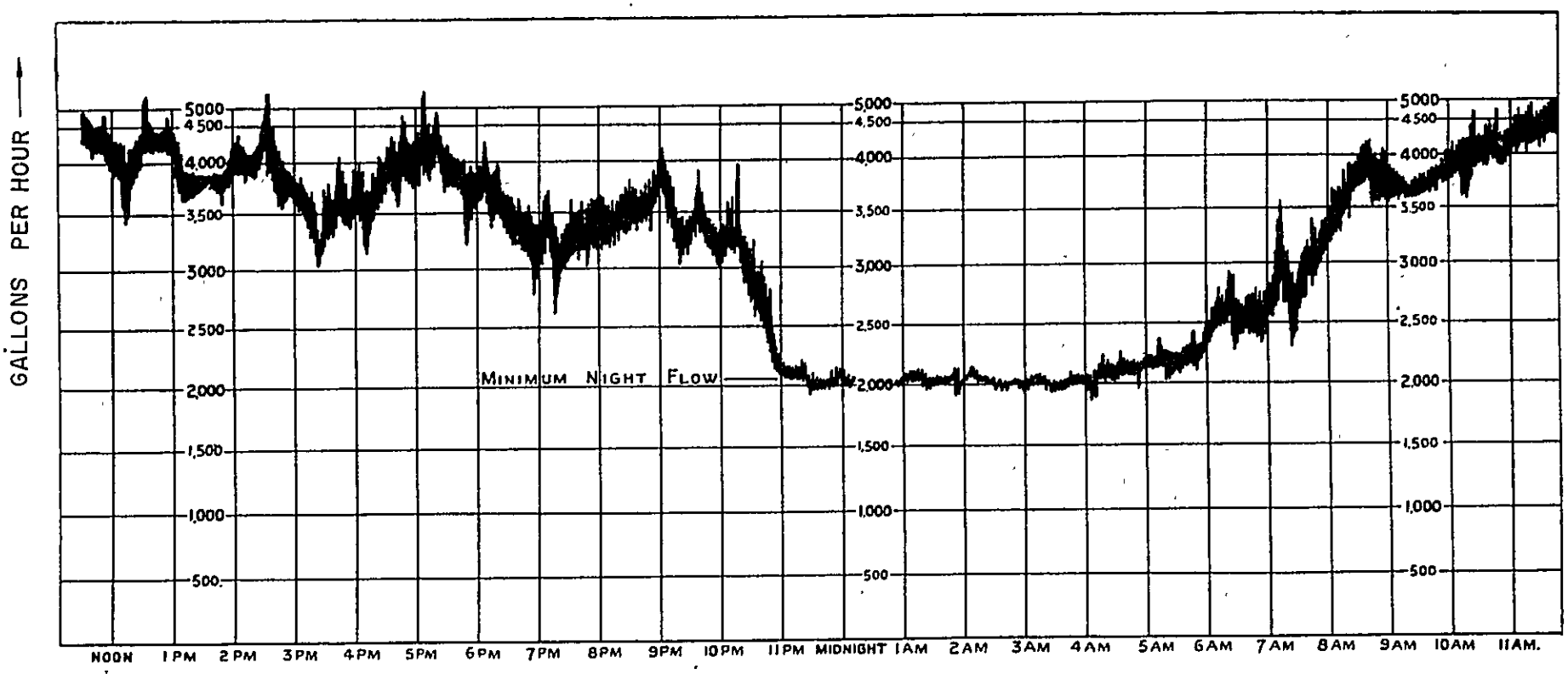


FIG. 1-1 TYPICAL FLOW CHART OF CONSUMPTION WATER.

(iii) A thorough waste water survey or valve inspection will be carried out, and this will give the amount of leakage and misuse in each branch main and the premises connected to it.

1-6-2 Leakage Survey

The service area is divided up into districts, each embracing from, say, 500 to 1,000 houses. The mains, connections and valves are arranged so as to permit each district, when required, to take the whole of its supply through one valve. The master meter test of open-run gives a chart showing the variation in the rate of flow into the whole district. Each district should be tested in this way at intervals of not more than two years or so. By conducting this scheduled work of maintenance, the condition of the pipe networks can be known and illegal connections may also be discovered.

This scheduled work for leakage survey gives emphasis on detection and repair of underground leakage of water. For detection of such leaks, an iron pipe detector, a leakage detector etc. are utilized. It is necessary to check to see whether the water leakage has been securely decreased down to a certain limit after the repair. Consequently, the work requires considerable labor and skill. It also requires a careful planning of the work on the part of the chief of field engineers and a strong spirit of responsibility and perseverence on the part of the working personnel as a whole.

An appropriate method for this scheduled work must be decided to meet the capacity of the water supply system, the type of pipe, the amount of leakage, the number of persons in a work force, etc. In the following, an outline of the method of work that can relatively easily be applied to a moderate size water supply system like as CDA is given.

A) Method

(i) Dividing the service area into districts -- the districts are to be determined according to the valves, which are unit districts for leakage survey work. The length of the pipes in each district should appropriately be from 1 KM to 2 KM or embrace from 500 to 1,000 houses in view of opening and closing operation of the valves. Consequently, it is necessary that valves may be added to shorten the length of the pipe lines. The amount of leakage is to be measured and the repair of the leaks is to be made district by district. If the resultant rate of leakage is within the allowable level, the survey way be considered completed. Fig. 1-2 shows an example of survey district.

(ii) Investigation and Repair of valves

The valves are most important in determining the district for water leakage survey. Those valves missed underground must be dug out beforehand, and faulty ones must be repaired or replaced to make all the valves in good condition to shut off the water flow completely. It is also important to raise the valve box, if there are any chance to have the valve buried.

The maintenance of the stop valve for each premises is an important part which influence the precision and speed of the leakage survey work. Many stop valve boxes are often found buried underground. For this reason, all the stop valves must be carefully located without any missing. Even a stop valves left unclosed can lead the measurement of the leakage to a failure, so sufficient care must be taken.

Stop valves whose locations are not clear or inappropriate

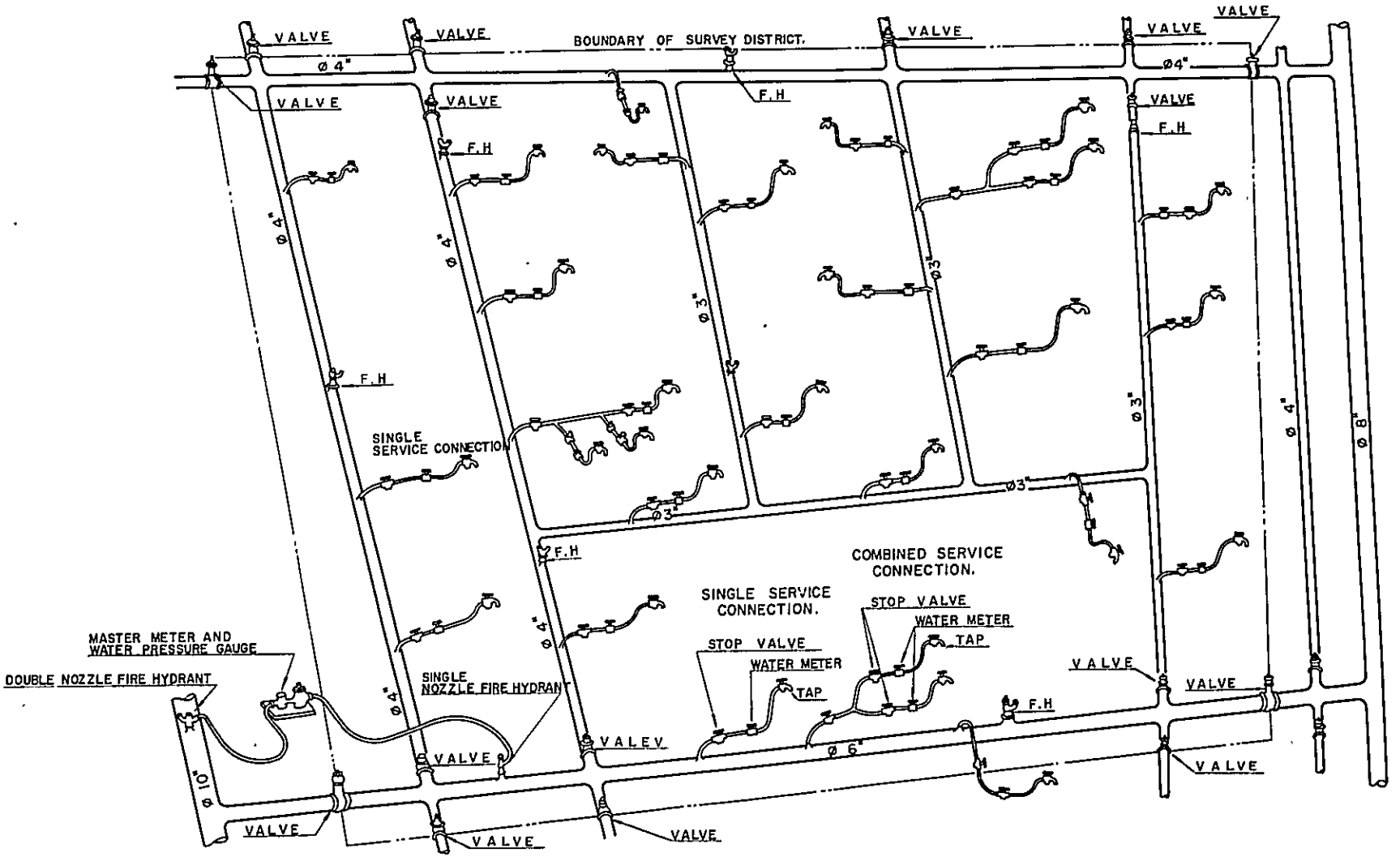


FIG.1-2 LEAKAGE SURVEY DISTRICT AND MEASUREMENT OF LEAKAGE.

must be placed in a proper place, and they must be maintained in good order.

(iii) Location of pipes

For the water leakage survey, the location of pipes and valves should be exactly checked using the pipe or valve locator. This is one of the main preparatory works to be conducted along with the shut-off of the valves. In this preparatory work, the length of the pipelines should be measured and recorded in the drawing of existing distribution pipe lines prepared by The Second Japan Survey Team of Water Supply in Islamabad.

(iv) Measurement of Leakage before Repair

One fire hydrant outside the district is connected with another in the district through a hose, and a water meter and a water pressure gauge each are installed in the middle of the hose. By feeding water from outside the district into the district, the water flow and pressure are measured. The diameter of the water meter is to be selected for the sensitivity of the meter depending upon the rate of leakage in the district. Initially when the leakage rate is not known, water meters of various sizes have to be prepared. However, when there is some guess about the rate of leakage, it is a good idea to combine two water meters, the one with a large diameter and the other with a small diameter, for convenient operation. For example, a wet type water meter of 50 mm dia. and of 20 mm dia. make a combination and when the rate of leakage is high, the one of 50 mm dia., is used and when the leak-

age is small, the other of 20 mm dia. is used.

Before beginning the measurement, it is necessary to make it sure that the valves in the district are all completely closed. If all the valves cannot be completely closed, the measurement should be stopped.

If the flow of water is measured when the stop valve for each consumer is closed, its value will show the leakage rate on the distribution pipe line and the service pipe upto the stop valve in the district.

If one district can be further divided into smaller districts, it would help to know the rate of leakage in each smaller district.

In the measurement of water flow, the indication of the water meter is read out every six minutes, and then the leakage amount for six minutes is obtained by getting the average of five readings, and this is multiplied by ten and the rate of leakage in the district for an hour can be obtained.

(v) Repairing Leaks on Ground

This work is to repair water leaks on ground after the measurement described in (iv). This work is to be done before the detection of underground water leakage. It is to avoid confusing the sound of water leakage on ground surface and underground at the time for detecting underground leakage.

(vi) Detection of Underground Leaks

This is the most important and difficult job in the scheduled work for leakage prevention. The engineers in

charge shall go around to investigate the entire pipe lines in the district with the meter reading of leakage in mind. Paying attention to the sunken surface of the ground and checking the quality and quantity and direction of flow in a sewer by opening manhole covers, underground leakage may be found.

If it is difficult to know whether water is from the distribution pipe into the sewer or another source, test the water by means of residual chlorine test. If some residual chlorine is detected, there is some water leaked from the distribution pipes.

Following the above procedure, a leak detector is used to know the exact point of leak. This device can catch even slight sounds of leak. For this reason, the detection of a leak is usually conducted in the quiet of night time.

A team of two workers shall go around the district with a sound bar and a valve opener, and check all the valves, fire hydrants, etc. by applying the sound bar to each of them to see whether there is any leak sound. For example, if a leak sound is detected at a valve, determine whether the leak is before or after the valve by opening and closing it. Namely if closing the valve makes the leak sound disappear, the leak is down-stream the valve. On the other hand, if the leak sound remains even after closing the valve, the leak is upstream the valve. Another team with a leak detector shall check the distribution pipe lines by placing the pickup of the detector with an interval of about 1 m on ground and when a leak is suspected the interval shall be shortened for careful examination. If a water leak is

detected by means of a sound bar, the exact spot of leak should be located. If the exact location could not be determined by a sound bar alone, the leak detector should be utilized to get its spot.

In using a water leak detector, only a skilled hand may get a leak sound from other noises. For this reason, it is important that the worker who uses a leak detector should familiarize himself with its use.

(vii) Repairing Leaking Spots

Leaking spots detected by spending much time, cost and trouble should be completely repaired without substituting it with a mere stopgap.

(viii) Measurement of Leakage After Repair

The measurement for the rate of leakage after the repair work has been completed must be conducted in the same method to the measurement before the repair work. The work for leakage prevention may be considered completed when the rate of leakage becomes within the permissible limit. The permissible limit, when it is taken too high, reduce the effects of the leakage prevention. On the other hand, when it is taken too low, it will require too much trouble to complete the leakage prevention. For this reason, this permissible limit must be determined appropriately depending upon the period given for the work, the degree of skills of the workers,, etc.

The permissible limit for the rate of water leakage in City A of Japan at its inception in 1949 was 1.5 m^3/hour per 1 km of the distribution pipes regardless of its diameter. It was changed since 1951 to 1.0 m^3/hour and is at

present 0.6 m^3/hour. The permissible limit for the water distribution pipes of 350 mm and less in diameter in City B of Japan is 1.0 m^3/hour per km when the water pressure is 2 kg/cm^2.

1-7 Desk Work for the Leakage Prevention

(i) Report of Results

The results of the leakage prevention should be written down in a report concerning the rate of leakage, repaired leaks such as the length of pipes by different diameters, the number and nature of repairs, valves and so on.

(ii) Completion Drawing

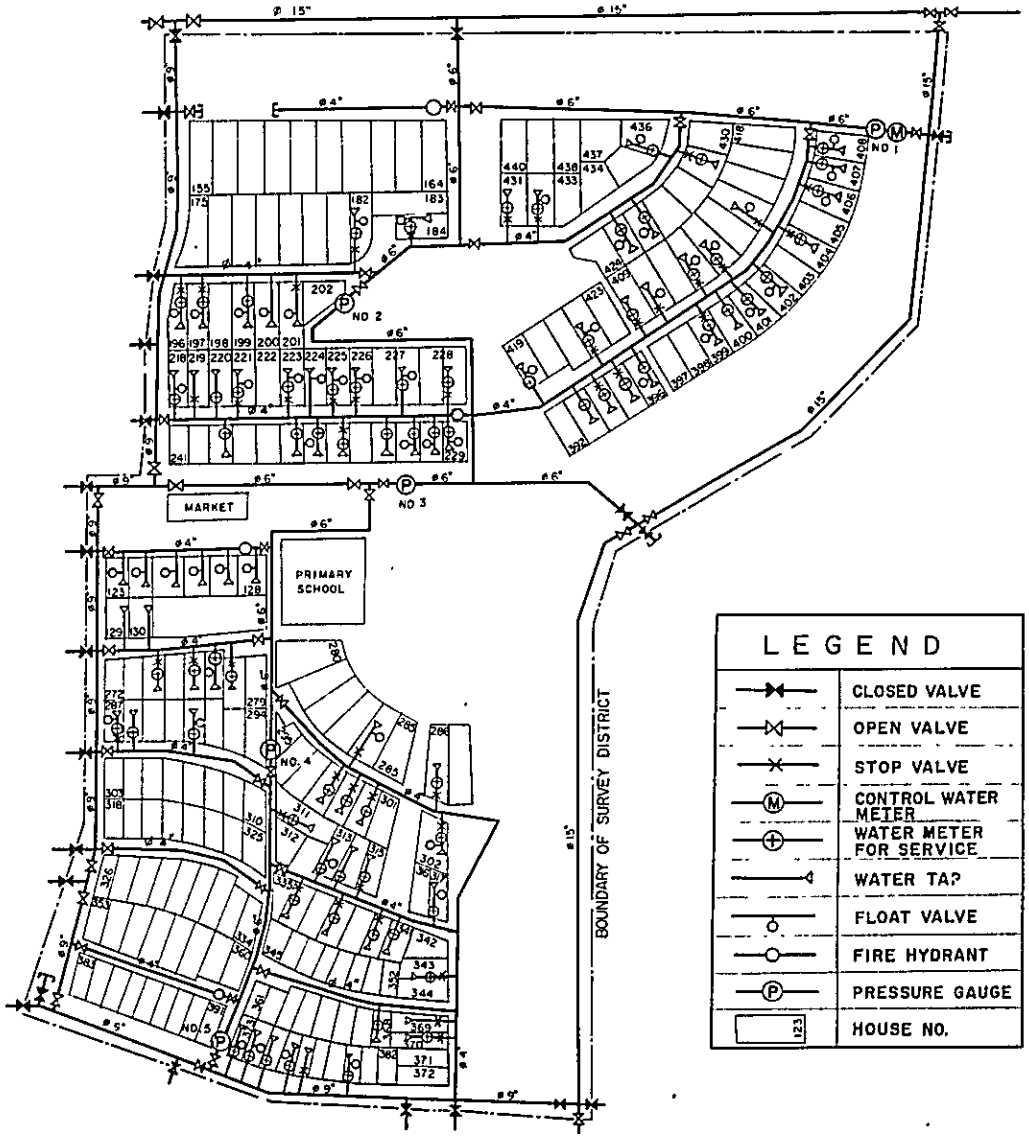
The distribution pipes, fire hydrants, valves, their diameter, length and the positions of valves, etc. should be plotted in the completion drawing. This completion drawing is made in a scale of about 1/1000 usually, and the completion drawing of CDA is in a scale of 1/1000 as the same of drawings of existing distribution pipes, cf. Fig. 1-3.

1-8 Organization of Survey Team

For CDA Water Works, it seems suitable that one team devoted to the survey of leakage within one district is composed of 7 to 9 members as follows:

Overseer one	Foreman	two
	Plumber	one
	Labourers	two to four
	Pick-up driver	one

This one team should be equipped with the following items:



LEGEND	
	CLOSED VALVE
	OPEN VALVE
	STOP VALVE
M	CONTROL WATER METER
	WATER METER FOR SERVICE
	WATER TAP
	FLOAT VALVE
	FIRE HYDRANT
P	PRESSURE GAUGE
123	HOUSE NO.

SURVEY DISTRICT	F-6/3
DISTRIBUTION PIPE	
ø 15"	3,900 FT
ø 9"	4,800
ø 6"	7,350
ø 4"	5,700
VALVE	
ø 15"	3 NOS
ø 9"	10
ø 6"	15
ø 4"	31
FIRE HYDRANT	4 NOS
SERVICE CONNECTION	94 NOS
LEAKAGE	
LEAKAGE BEFORE PROTECTION WORKS	
LEAKAGE AFTER PROTECTION WORKS	
AMMOUNT OF LEAK PREVENTION	

FIG.1-3 COMPLETION DRAWING OF LEAKAGE PROTECTION WORKS

1.	Pick-up	one
2.	Distribution pipe drawing	one set
3.	Pipe detector	two
4.	Leak detector	two
5.	Valve locator	one
6.	Sound bar	four
7.	Master water meter	two
8.	Pressure gauge	three
9.	Bicycle	three

The size of the master meter should be determined on the basis of the leakage rate. For example, a water meter of 75 mm is to be used first, and when leakage water is less, a water meter of 50 mm is used.

An iron pipe detector is an application of radar: its transmitter emits an electrical wave into ground and if there is any metal body underground the electrical wave gets reflected to cause resonance in the receiver of detector. These electrical waves have directivity, so the strength of the wave indicate the location of the metal body. Consequently, such metal body as water pipes, buried valves, etc. can be detected from above the ground to know their positions, directions, deflections, bends, branches, centres and depths, etc.

A leak detector catches with its pickup a sound vibration caused by the leak, amplifies it into an electrical vibration which is heard with its receiver to judge whether there is any leak.

A sound bar is a simple water leak detector. It is constructed by mounting a metal plate on the head of an iron bar and by making this plate into a receiver through putting it in a bakelite frame, etc. When the tip of the sound bar is directly put in contact with a valve or tap, etc., a leak in the pipe, if any, transmits its sound through

the iron bar. This sound bar is a convenient tool for detecting a leak in a corporation cock, stop valve, service pipe, etc.

CHAPTER 2

WATER LEAK REPAIR

CHAPTER 2

WATER LEAK REPAIR

2-1 General

1. The kinds of existing pipes (steel pipe, cast iron pipe, asbestos cement pipe, etc.), the pipe diameters and so on should be confirmed at the earliest possible date by checking them on the spot against the drawing.

Based on the data obtained consequently, arrangements shall be made for supply of pipes to be required for reinstatement.

2. The sheathing work at an excavated spot should be carried out in a more reinforced manner than that in an ordinary pipe-laying work, with sheet pipes placed more densely so as to endure the impulse from water which may spurt out of a pipe in trouble. In lifting or lowering a pipe, use of bracing materials or rigid stuba may be required. Thus, necessary materials for this purpose must be prepared in advance.

3. Where the ground at the site of work is particularly soft, it may prove to be more advantageous to place concrete on the bottom of excavation, allow the concrete to harden and start the work after the concrete has been hardened so as to facilitate the performance of work.

4. The time required for removal of defiled water affects most the schedule of work. So, it is advisable to determine the volume of water trickling into the excavation and the volume of water retained in the existing pipe in advance and install a discharge pump for ready use.

In consideration of possible pump trouble and deterioration of efficiency, it is wise to prepare a standby pump.

5. A robust crane should be used for lifting a pipe in trouble and lowering and setting in position a new pipe. The winch should be examined carefully to confirm safe working condition of brakes and holdfast. The size of wire rope, the number of wheels in the pulley and the bench rope should be checked to ascertain their safe working condition. Where a truck crane or similar article is used, a careful examination should be given to it in much the same way.

6. In lifting a faulty pipe and lowering and setting to position a new pipe, there must be prepared a perfect scaffolding, supports, foot-boards, sleepers for the pipe, packing and so on. The new pipe should be cleaned of foreign matter and then disinfected prior to installation. Meticulous care should be given to the handling of pipes particularly on rainy days or during night.

7. The foundation and the protection of pipes should be carried out by exercising the same precautions as in any ordinary pipe laying work. Where the work involves the use of a pipe of large diameter containing a bend of large angle, there should be provided protection sufficient to withstand the water pressure exerted while in service. A typical method is to immobilize the bent pipe against the calculated water pressure with the aid of permanent bracing materials or bracing rings.

8. The work of refilling and tamping of earth should be carried out by exercising the same precautions as in any ordinary pipe laying work. The work should be started after water has been passed on trial

through the newly laid pipe to confirm absence of irregularities.

9. When the work is protracted into night hours, sufficient illuminating facilities should be prepared and checked for safe working condition. Electric bulbs with holders and candles must also be prepared for ready use.

10. The names and quantities of tools, machines and necessary materials should be entered in a field record. Those which have already transported to the site of work should be checked against the record one by one so as to ensure smooth execution of work. When the work is continued throughout the night hours while the supply of water is discontinued, arrangements should be made for having a cargo truck kept near at hand if required.

Table of machines

Chain block, breaker, winch, air compressor, universal manual winch, diaphragm pump, lead melter, generator, welder, motor, powered discharge pump, chipping hammer, gasoline-driven pump, pipe cutter and powered hand grinder.

Table of tools

Tools for earth works, tents, tools for iron pipes, clips, valve openers and tools for asbestos cement pipes.

2-2 Cast Iron Pipe

1. In the case of leakage through the joint of a socket pipe, the leakage should be stopped by recaulking where there is allowance

for caulking. In the absence of caulking allowance, the socket pipe should be rejoined by first melting the old lead by the burner and then laying new molten lead along the seam.

2. In the case of leakage along the joint of a mechanical joint pipe, the leakage should be stopped by retightening the bolts.

3. In cutting a pipe, there should be used a pipe cutter. The cutting may be done manually under unavoidable circumstances. In the case of manual cutting, a standby pipe should be prepared in consideration of possible failure. Tools, particularly chisels and dias, are most susceptible to damage. So, they should be fully examined with respect to steel material and condition of hardening. It is also important that ample standbys are ready for use.

4. Prior to separating two adjoining pipes at the joint, the lead along the seam should be melted and removed.

5. In laying a new pipe with a part cut off, the length of pipe to be cut off should be determined by first finding the exact length of the part expected to be cut off and then deducting an allowance of length from the exact length.

6. In the case of a socket pipe, due precautions should be exercised to avoid making a mistake in the location of yarn in the circular joint.

7. Ample supply of lead and yarn should be prepared for the work of joining pipes. The laborer in charge of lead melting should keep constant attention to the progress of pipe installation work and regulate the melting of lead in accordance with the progress of work so as to avoid excessive or insufficient melting of lead.

8. Insertion of yarn and lead caulking should be carried out with the same precautions as in any ordinary pipe laying work. If the caulking work is protracted by some reason or other, extra laborers should stand by to relieve coworkers at suitable intervals.

2-3 Asbestos Cement Pipe

1. It is advantageous to use a motor-powered hand grinder for cutting a pipe. When a hand saw is used for cutting this pipe, precautions must be exercised lest the impulse exerted by the motion of hand saw should break the pipe.

2. Two adjoining pipes are joined in much the same manner as in any ordinary pipe laying work. When one cement pipe is to be joined with a pipe of different kind (cast iron pipe or steel pipe), the joining should be made by using a special fitting.

2-4 PVC Pipe

1. At the socket portion of the pipe being inserted, the length of pipe available for insertion should be indicated by inscribing a mark.

2. The inside wall of the socket of one pipe and the outside wall of the inserting end of the other pipe should be wiped clean with rag.

3. In cutting a pipe, precautions should be exercised so that the cut plane runs exactly perpendicularly to the length of pipe. This can be done by preparatorily inscribing a mark perpendicularly with reference to the axis of the pipe and cutting the pipe along this mark by a saw of fairly large width. Scratches or steps formed on the cut surface of pipe should be removed with a file. Then the

pipe should be cleaned of saw dust on both inside and outside.

4. In joining two pipe ends, the insertion of the end of one pipe into the socket of the other pipe should be completed quickly.

Excess adhesive agent which has cozed out of the joint should be removed quickly with a rag.

2-5 Steel Pipe

A minor repair may be accomplished by using a split joint ring or locally welding a spliced plate. Where the repair requires replacement of a part of pipe line, the faulty part of pipe line should be cut off by using a gas burner and replaced with a new pipe of same or other kind.

Where the steel pipe line is corroded over a considerable length, the affected pipes should be removed and replaced with new pipes of same or other kind. In making this replacement, the rules applicable to the pipes in question should be observed.

2-6 Plastic Steel A (Devcon A)*

Plastic Steel A is generally used for repairing broken machinery, pipe etc., for it has the consistency of putty and is as easy to use as modeling clay. It contains 80% steel and 20% epoxy materials with modifiers. Because of the large amount of steel present, its expansion and contraction are very close to iron, and therefore, a repair made with Devcon A is usually permanent. This material has excellent adhesion to iron, steel, and other metals as well as glass, wood and many other surface. It has good tensile and impact strength as well as outstanding chemical resistance. Plastic Steel A is easy to use. No heat, pressure or special equipment is necessary. Simply mix the hardening agent that is supplied with each container of the Devcon and apply to damaged area.

Plastic Steel A is used successfully throughout the world for repairing broken valves and cracked pipes.

As Plastic Steel A cannot be used effectively in the presence of water, the flow of water in the pipe must be stopped completely and the pipe dewatered.

The surface of the pipe including and surrounding the spot of repair is dried by blowing off water from the drain pipe or fire hydrants. The cracked portion and its immediate neighborhood are beated up by a torch lamp and scrapped with a file until the surface has been rubbed off completely. The Plastic Steel A is spread on the scrapped surface to cover up the crack. When a large hole is pitted through the wall of pipe, a metallic sheet is applied over the hole and the mixture of Plastic Steel A is spread over to fasten the sheet against the pipe surface while precautions are exercised not to allow excess mixture to enter into the interior of the hole.

After application of Plastic Steel A, the immediate neighborhood of the repaired portion with a raised surface is warmed up by a torch lamp. The plastic steel is hardened in approximately two hours of time. Then the pipe is ready for service.

* A proprietary name for plastic steel. This is handled in Japan by the following agent:

Kimmon Manufacturing Co., Ltd.
No. 2-3, Shimura 1-chome
Itabashi-ku, Tokyo
Japan

2-7 PRCC Pipe

In February, 1971, the Second Japan Survey Team for Water Supply in Islamabad conducted a water leakage survey at Sector F-6/3, selected as a district for the purpose of survey.

In the existing PRCC pipes, leak spots were detected nearly always at intervals of 10 to 20 feet by the leak detector. Since the situation

indicated replacement to be more economical than repairing, the existing PRCC pipes were dug out. Leakage was found to occur along joints as a matter of course. However, cracks were found to have developed near the center of most PRCC pipes in the circumferential direction. Leakage also occurred through these cracks. These PRCC pipes were manufactured by a local factory. An inspection of this factory revealed that no tension was applied to the steel wires incorporated in longitudinal direction. This has led to a conclusion that, after PRCC pipes had been laid under ground, there occurred uneven settlement which consequently exerted bending moment at the center of each pipe and that the pipe strength was not sufficient to withstand the resultant tension. As an immediate measure for the protection of PRCC pipes against leakage, blocks made of fast-hardening concrete incorporating a quick-setting admixture were used to cover up cracks or leak spots on pipes or to enclose the pipes completely.

At any rate, it is evident that the abnormally large quantity of leakage experienced by CDA Water Supply System is ascribable predominantly to the inferior performance of the existing PRCC pipes. It is, therefore, highly advisable to replace all PRCC pipes with DCIP, SP or asbestos cement pipes before starting the scheduled water leakage control programme. In the future water works, use of PRCC pipes in distribution line should be avoided by all means.

CHAPTER 3.

WATER METER REPAIR

3-1 General

3-2 Disassembling and Cleaning

3-3 Repair and Change of Parts

3-4 Assembling

3-5 Adjustment and Testing of Meter Accuracy

3-6 Painting

CHAPTER 3

WATER METER REPAIR

3-1 General

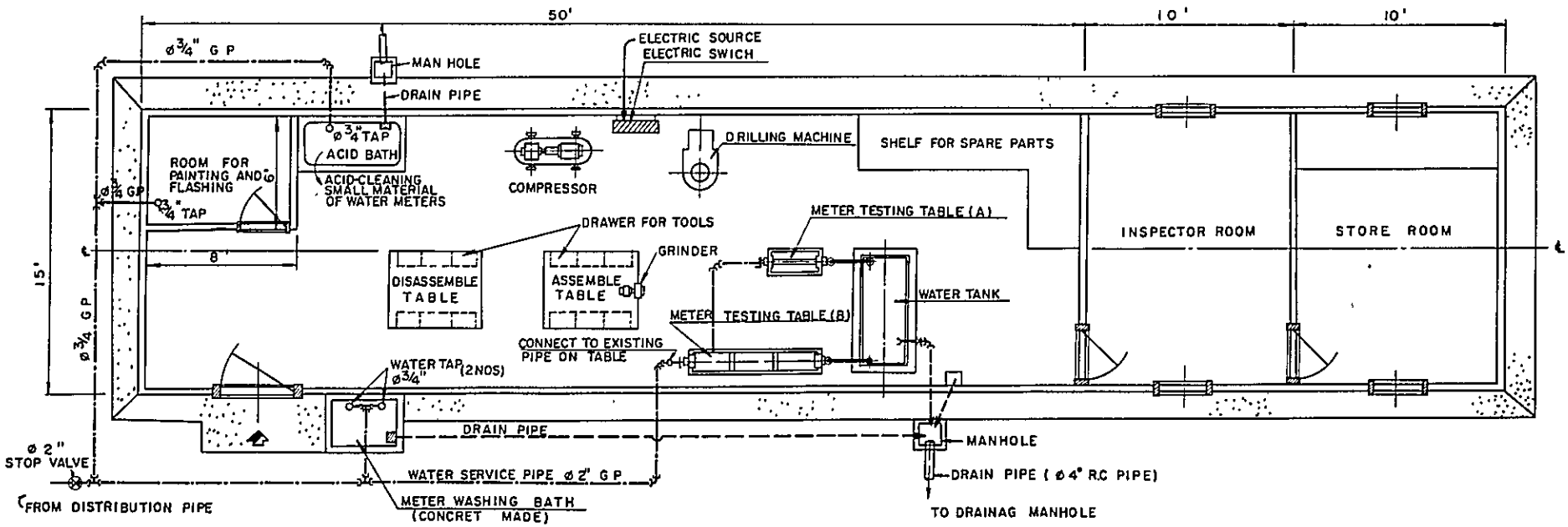
3-1-1 This Chapter is intended for use and guidance of the supervising staff in charge of the newly established water meter workshop, cf. Fig. 3-1, in Islamabad under Capital Development Authority. It describes various operations of repairing work in the order of sequence as per Japanese practice. This does not include water meter accuracy test which should be carried out on everyone of the meters installed after every four or five years as an overall maintenance programme, but various aspects of water meter repairing work are covered, taking into consideration of the local condition of Islamabad water supply.

3-1-2 The following is the procedure of the water meter repair in general.

1. Disassembling and cleaning
2. Repair and change of parts
3. Assembling
4. Adjusting of meter accuracy and testing
5. Painting

3-1-3 The Polish water meters have been used extensibly in Islamabad but are giving trouble in its gear mechanism on greasing of the spindles and work of the non return valves. In Japan, non return valves are not normally used, and, due to the fact that they are causing troubles in their functioning, their necessity must be reviewed carefully. As to

FIG. 3-1 C.D.A WATER METER REPAIR SHOP



greasing, due to prolonged storage and because of hot weather, the grease of most of spindles are often dried up and this workshop should therefore be fully geared to regrease all meter spindles at least once a year.

3-2 Disassembling and Cleaning

Almost all the meters taken away from service for repair are dirty with dirty water and mud, and so the surface of the meter must be cleaned with water, without giving the damage of the meter spuds. Then, the register case is taken out and the parts disassembled without giving any damage on them, and the water cleaning or acid-cleaning of all the meter parts is done. Water-cleaning must be done carefully with wirebrush, though it takes a little long time. But water-cleaning keeps the meter durable, and therefore it is better to avoid acid-cleaning as much as possible.

In case of water cleaning, the meter, which was taken out for repair and left for a long time in the air, should be disassembled and the inner mechanism should be taken out and soaked in the water for approx. 24 hours so that the dusts in the meters might swell and the parts might be easy for cleaning.

If the parts are very dirty, acid-cleaning is to be applied. The procedure of acid-cleaning and precautions of the mixing of the chemicals are described in the other paragraph. But it must be kept in mind that if complete water-cleaning is neglected, metal itself will be corroded and the parts cannot readily be in service.

<u>The procedure of acid-cleaning</u>

i) Disassemble and soak in the water for approx. 24 hours.

ii) Acid cleaning of metal parts

Mix 40% of nitric acid, 60% of sulfuric acid and a little

bit of hydrochloric acid. Put the parts in the acid-cleaning basket, soak it in the mixed acid for 2 or 3 minutes and shake slowly. In this case, every part should be disassembled so that acid might not stay in the joints of the parts.

iii) Acid cleaning of plastic parts

Put the parts in the plastic acid cleaning basket, soak it in the hydrochloric acid for 20 seconds and shake vertically and horizontally. In this case industrial hydrochloric acid (35-37%), which is in the market, can be used as it is.

iv) Water-cleaning in the running water

In order to remove the acid, the parts must be completely cleaned in the strong running water.

v) Soaking in the caustic soda solution

Dissolve 50 gram of caustic soda in one liter of water and soak in it for approx. one minute. In this case, caustic soda in large quantity should not be dissolved at one time, or else heat is generated and is dangerous.

This procedure aims at the removal of acid remaining in acid cleaning and at neutralization, which is a very important procedure. Shake the basket slowly for approx. one minute.

vi) Water-finish-cleaning in the running water

In order to remove the caustic soda it is needed to clean in the strong running water for considerable period of time.

Precautions in general

The surface of the parts should be wet from the beginning to the end of the cleaning procedure.

In case of interrupting the work on the way, keep the parts in the water but the parts soaked in chemicals must be dried completely beforehand. As acid is harmful, it is recommended to wear rubber gloves in case of washing.

3-3 Repair and Replacement of Parts

After the cleaning, the damaged parts must be replaced with new parts. It is sometimes difficult to decide whether the damaged parts are needed to be replaced with new parts, but it is always preferable to give up old parts wherever they are damaged.

Precautions are as follows:-

i) The holes of register plate and reduction plate must be cleaned with reamer, because the water-cleaning only is not enough. If the holes of register and reduction plate are too big by abrasion, the plates must be replaced with new ones.

ii) The gears teeth of which are damaged or worn out must be replaced.

iii) In case of straight reading register, pinions, pinion driving wheel and number wheels must be checked, and if these assembly will not work well, replace the parts. Especially, it must be checked and confirmed that the operating torque of the register will not increase suddenly when the next number wheel of the register is driven. (For example, in case of 00099 - 00100, 00999 - 01000 etc.) This should be kept in mind because this will influence directly the accuracy of the meter.

iv) Before assembling the gears, the clearance between gear shaft and the holes of register plate and reduction plate must be checked. The clearance between them is desirable to be 0.05 - 0.15 mm.

v) The mortar-shaped sapphire, which is inserted into the bottom of fan wheel spindle, must be carefully checked to see if it is worn out.

vi) If the point of pivot is worn out, it must be ground with the oil stone and reshaped. If it is badly worn out, it must be replaced with a new one.

vii) The clearance between pivot and the lower hole of fan wheel for pivot is desirable to be 0.5 - 1 mm. Therefore if the point of pivot is one-sidedly worn out or the lower hole of fan wheel becomes large, they must be replaced. If these parts are not good, the fan wheel will revolve eccentrically by water flow and the fan wheel will touch fan wheel casing, or the mesh between No.1 reduction gear (pinion) and No.2 reduction gear will go out of order, which will influence the meter accuracy.

viii) When fan wheel and fan wheel spindle are assembled, they are tightened with spindle nut so that each center of them will meet together. After assembly, it must be checked with fan wheel examination jig if the fan wheel revolves eccentrically.

ix) If the nozzle of fan wheel casing is worn out by water flow and becomes large, the fan wheel casing must be replaced because it influences the meter accuracy.

x) Replace the stuffing box and the reduction gear which is fixed to the stuffing box at the same time. Replace the packing at least even when the box and gear are not replaced. Fill up the box with the unmelting oil to prevent the water leakage and to smooth the revolution of gear shaft.

3-4 Assembling

Assembling is just the opposite procedure of the disassembling. The parts of other meters should not be used because every part of the meters has been working together smoothly.

i) After the assembling of straight reading register and reduction gear is finished, confirm what is described in the clause 3.3 iii). And then check if No.3 or No.4 reduction gear can be revolved lightly with the finger. In case the revolution is not smooth, it is caused by the wiring mesh of the gears or deformed teeth of gear.

ii) Careful attention must be paid to the assembling of the stuffing box and gear fixed to the stuffing box. After changing the packing, and fitting well, fill the high quality grease such as the silicon grease in the plate of the upper side of the gear.

iii) Check the vertical clearance of the fan wheel with fan wheel examination rod (repair tool) through the nozzle of fan wheel casing when the assembling of the inner mechanism is done. The clearance of approx. 0.5 mm is desirable. If it is small, the fan wheel will not revolve smoothly, and if it is large, the fan wheel in revolution is unstable because of lift by water flow and the accuracy of the meter is also affected.

iv) After the assembling of the inner mechanism, blow softly through the nozzles of fan wheel casing and after checking that fan wheel revolve smoothly, put inner mechanism in the meter casing. In case the fan wheel stops suddenly, check the following points:

- o If the centers of the pivot, fan wheel spindle, and spindle bearing are not met together.
- o If the clearance between the pivot and fan wheel lower hole is too big.
- o If the mesh of the gears is

3-5 Adjustment and Testing of Meter Accuracy

This procedure is to adjust the repaired meters and test them so that the meters are accurate when they are put to use.

In order to make the adjustment easier, record the total height of fan wheel, fan wheel spindle and pivot, and the location of regulater when the meters disassembled. Assemble them in accordance with the recorded dimension.

Precautions in adjusting water meters

i) Test of the meters starts at the maximum rate of flow and proceeds to the intermediate rate of flow. Testing is repeated until the meter accuracy comes within the expected error. An example of meter testing is shown in Fig. 3-2 and Fig. 3-3.

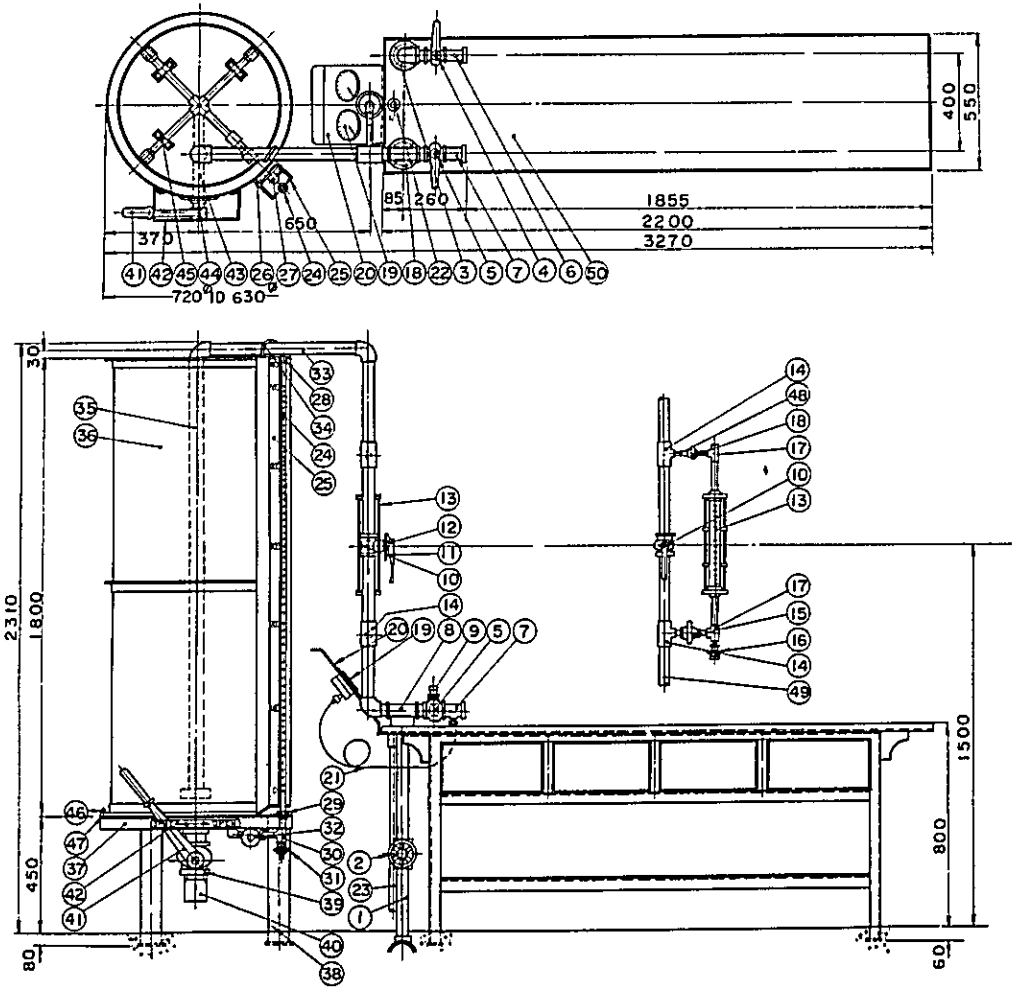
ii) The method of adjusting the meter accuracy is made by taking off the bolt at the inlet side of the meter casing and turning the regulator at the split of the regulator head. (See the Attached Drawing Fig. 3-4, and in Fig. 3-4 those three sub figures show the openings of the by-path hole.)

iii) In case of the error adjustment made by the regulator shifting is not enough, but also shift the fan wheel vertically. Investigate the relationship between fan wheel shifting and adjustment of error percentage, because it differs according to the meter type. If the fan wheel is moved downward, the meter goes fast and if it is moved upward, the meter goes slow. In this case, be careful for the fan wheel not to touch upper side or bottom side of casing.

iv) Adjust the meter error mainly by moving the regulator and make up for the rest of adjustment by moving the fan wheel. However, if the difference between the test results at maximum rate of flow and at intermediate rate of flow is big,

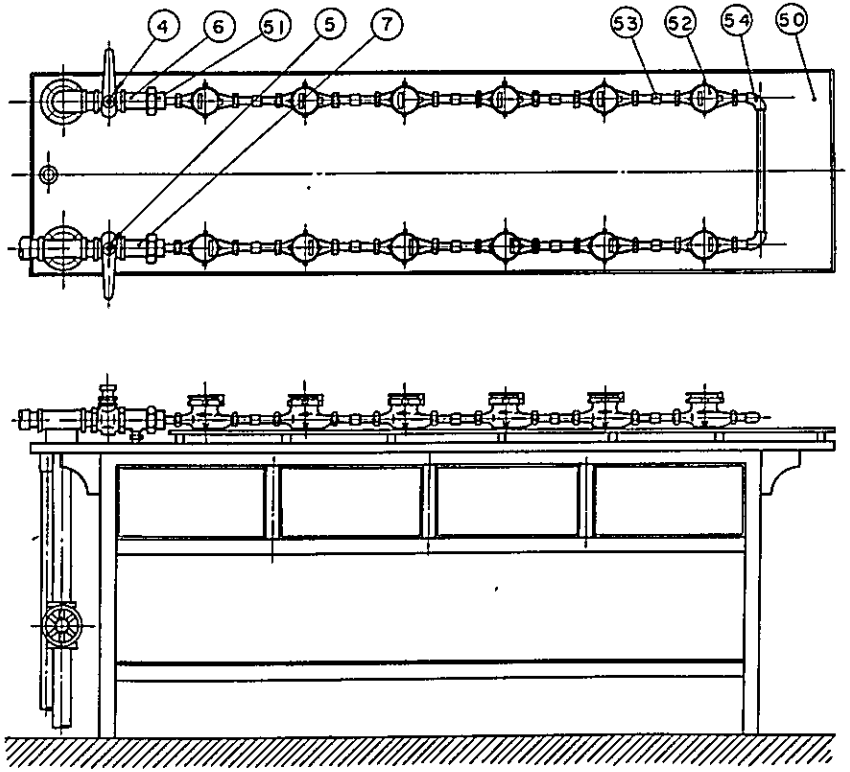
FIG. 3-2 TESTING TANK APPARATUS (CAPACITY 500ℓ TANK)

(UNIT IN mm)



NO	NAME OF PARTS	REMARKS
1	WATER SUPPLY PIPE	40 ø
2	SLUICE VAILE	40 ø
3	WASHER BASED ELBOW	
4	INLET COCK	40 ø
5	OUTLET COCK	40 ø
6	INLET JOINT	40 ø
7	OUTLET JOINT	
8	WASHER BASED TEE	
9	COCK HANDLE	
10	LARGE FLOW CONTROL VALVE	40 ø
11	LARGE FLOW CONTROL DIAL PLATE	90 ø
12	LARGE FLOW CONTROL HANDLE	
13	SMALL FLOW CONTROL METER	
14	BYE-PATH TEE	1/2" x 1/2" x 1/2"
15	SMALL FLOW CONTROL VALVE	1/2"
16	SMALL FLOW CONTROL DRAIN VALVE	1/2"
17	TEE	1/2"
18	UNION	1/2"
19	PRESSURE GAUGE	100² x 10 kg/cm²
20	PRESSURE GAUGE SET PLATE	
21	PRESSURE GAUGE COPPER TUBE	5"
22	TESTING STAND DRAIN SOCKET	3/4"
23	TESTING STAND DRAIN PIPE	3/4"
24	GAUGE GLASS	180 x 220 x 1800
25	AUXILIARIES SCALE PLATE	
26	AUXILIARIES SCALE FIXTURE	
27	SEEK LIGHT	
28	GAUGE HOLDER BAND	
29	GAUGE GLASS FIXTURE	
30	CONDUCT PIPE TEE	3/4"
31	DRAIN GAUGE PIPE	3/4"
32	INTERMEDIATE VALVE-GAUGE PIPE	3/4"
33	STAND PIPE	1 1/2"
34	FIXING BAND-STAND PIPE	6 ø
35	IMPREGNATION PIPE	
36	LEVEL TANK	630ø x 1800ℓ 30¹
37	TANK BED	L6 x 75
38	TANK BASE	100 x 50 x 6
39	DRAIN VALVE	2 1/2"
40	SHORT PIPE-DRAIN VALVE	2 1/2"
41	DRAIN HANDLE	
42	STOPPER	
43	DRAIN VALVE SHAFT	
44	DRAIN VALVE BRACKET	
45	MENISCUS SHAKING STOPPER	
46	TANK SET FIXING BOLT	
47	WATER LEVEL CONTROL SCREW	
48	BYE-PATH	1/2"
49	MAIN PIPE	1/2"
50	TESTING TABLE	

FIG.3-3 JOINTING OF TESTED METER



No	NAME OF PARTS	REMARK
51	TESTING BASES JOINT	
52	METER	
53	TESTING METER JOINT	
54	TESTING U JOINT	
4	INLET COCK	40$^{\phi}$
5	OUTLET COCK	40$^{\phi}$
6	INLET JOINT	40$^{\phi}$
7	OUTLET JOINT	
50	TESTING TABLE	

FIG 1.  BY-PATH HOLE IS FULLY OPENED

FIG 2.  BY-PATH HOLE IS HALF OPENED

FIG 3.  BY-PATH HOLE IS CLOSED COMPLETELY

ABOVE ARE SEEN FROM ARROW SIDE

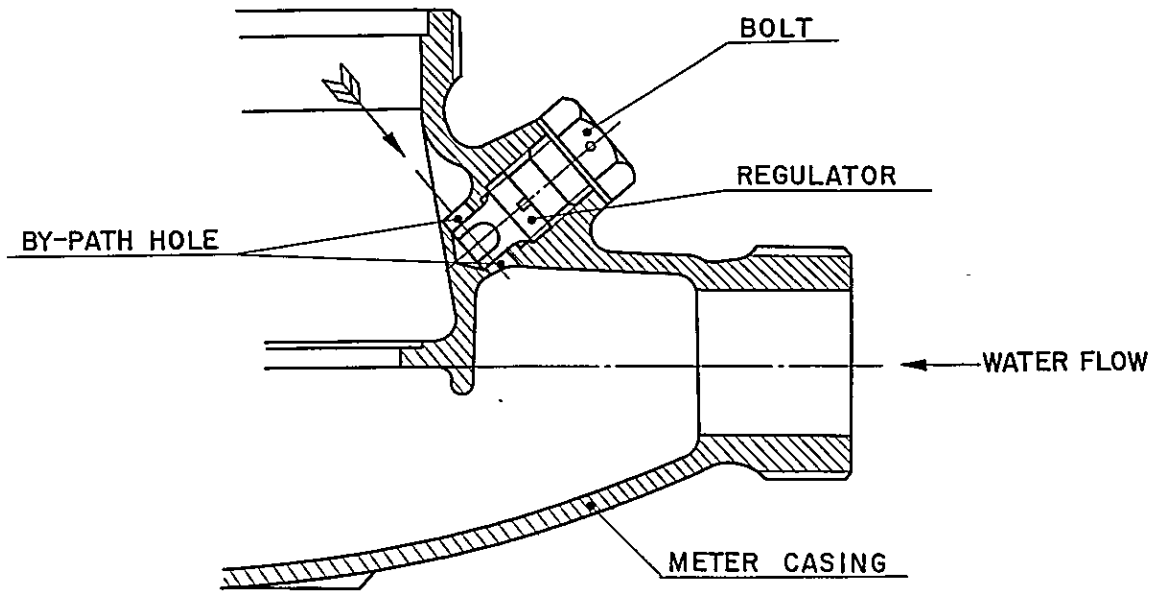


FIG.3-4 ADJUSTING OF METER ACCURACY

adjust the error by using both methods at the same time.

v) The big difference between the test results at maximum rate of flow and intermediate rate of flow may be caused by the wrong mesh of gears, the bending of pivot, or the unsmooth revolution of fan wheel, etc., and the causes must be traced.

3-6 Painting

When the meter testing is finished, paint the outer casing by diluting the paints with solvent.

CHAPTER 4

REPLACEMENT OF EXISTING PIPE

4-1. Ductile Iron Pipe

4-1-1 Installation

4-1-2 Pipe Cutting

4-1-3 Thrust Blocking of Bend

4-1-4 Retaining Joint

4-1-5 Cement Mortar Lining

4-2. Asbestos Cement Pipe

4-2-1 Handling

4-2-2 Jointing

4-2-3 Cutting and Machining

4-2-4 Thrust Blocks

4-3. PVC Pipe

4-3-1 Basic Processing and Connection Procedure

4-3-2 Piping

4-1 Ductile Iron Pipe

4-1-1 Installation

(i) Handling of Ductile Iron Pipe

Ductile Iron Pipe has enough strength to endure the ordinary handling but careful handling will be helpful to prevent the trouble. In unloading, mechanical equipment should be used whenever possible. Dropping pipe to the ground from railroad cars or trucks are apt to cause damage which may not show up until after the pipe is installed.

Pipe should be tied along the route with the bells facing in the direction in which the work is to proceed. Careful inspection should be done to find any damage of pipes.

Additional general precautions are as follows:

(1) As Ductile Iron Pipe is cement mortar lined, if dropped or knocked against other objects, the mortar may be peeled off or the pipe may be distorted and the spigot end is prone to cracking. It must therefore be handled with particular care.

(2) As Ductile Iron Pipe rolls easily, loose pipes must be chock blocked without fail, to keep them under control when handling.

(3) The safe limit of wire rope lifting capacity must be observed on loading and unloading.

(4) Workers should wear helmet and shoes at all times.

(ii) Earth Excavation

The width of trench for various sizes of pipes is determined by the type of soil, the depth of laying, the type of

excavation equipment and the space required to allow the ample room to thoroughly backfill around and under the pipeline.

Table 4-1 shows examples of trench width.

The bottom of the trench should be cut through and even, so that the barrel of the pipe will have a bearing along its full length.

(iii) Unloading Pipe

Pipe up to 250 mm in diameter may be lowered into the trench by taking a turn of rope around each end of the pipe. Large diameter pipe is best handled by means of mechanical equipment.

(iv) Jointing of Mechanical Joint

The main points of jointing are as follows:

(1) Lower the pipe to the fixed spot. Do not give shocks. If the positions of bolt holes are parted evenly from the center, screening becomes easier.

(2) Remove cross shape wood carefully from spigot.

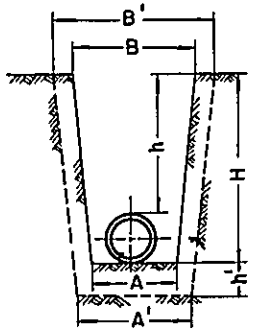
(3) Cleanse completely oil, sand, and other foreign stickings attached to spigot outside of socket for the width of approx. 40 mm from the end and bolt holes.

(4) Put gland on spigot. Cleanse completely sand and other foreign matters attached to gland outside and inside bolt holes. Face the side to be in contact with gasket to socket. Gentle revolving will make the work easier.

(5) Coat spigot outside and socket inside with soap

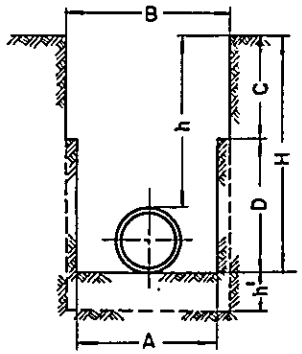
TABLE.4-1 SUGGESTED TRENCH SHAPE FOR DUCTILE IRON PIPE

WHEN SHEET PILE IS NOT USED



DIA (mm)	BARREL (m)				BELL HOLE (m)			
	A	B	h	H	A'	B'	h'	L※
75Ø	0.50	0.76	1.20	1.29	0.70	1.00	0.20	0.70
100	0.50	0.76	1.20	1.32	0.70	1.00	0.20	0.70
150	0.50	0.76	1.20	1.37	0.80	1.12	0.25	0.80
200	0.60	0.88	1.20	1.45	0.90	1.23	0.25	0.80
250	0.60	0.89	1.20	1.45	1.00	1.35	0.30	0.80
300	0.60	0.90	1.20	1.52	1.10	1.46	0.30	0.90
350	0.70	1.01	1.20	1.57	1.20	1.58	0.35	0.90
400	0.80	1.15	1.30	1.73	1.30	1.75	0.50	1.00
450	0.90	1.26	1.30	1.78	1.40	1.86	0.50	1.00
500	1.10	1.47	1.30	1.83	1.60	2.07	0.50	1.00
600	1.30	1.73	1.50	2.13	1.80	2.33	0.50	1.00
700	1.50	1.95	1.50	2.23	2.00	2.55	0.50	1.00
800	1.70	2.17	1.50	2.34	2.20	2.77	0.50	1.00
900	1.90	2.39	1.50	2.44	2.40	2.98	0.50	1.00

WHEN SHEET PILE IS USED



DIA (mm)	BARREL (m)						BELL HOLE (m)	
	A	B	h	H	C	D	h'	L※
600	1.40	1.90	2.10	2.73	1.23	1.50	0.50	1.00
700	1.50	2.00	2.10	2.83	1.33	1.50	0.50	1.00
800	1.70	2.20	2.10	2.94	1.44	1.50	0.50	1.00
900	1.90	2.40	2.10	3.04	1.54	1.50	0.50	1.20
1000	2.00	2.50	2.10	3.14	0.74	2.40	0.60	1.20
1100	2.10	2.60	2.10	3.24	0.84	2.40	0.60	1.30
1200	2.20	2.70	2.10	3.35	0.95	2.40	0.60	1.30
1350	2.30	2.80	2.10	3.50	1.10	2.40	0.60	1.40
1500	2.50	3.00	2.10	3.65	1.25	2.40	0.60	1.40

L※ : LENGTH OF BELL HOLE

water. (30 cc power soap is dissolved in 1 liter water.) Coating will protect rubber gasket from being scratched, will make surface smooth and processing will become easier.

(6) Coat rubber gasket with soap water and slip it on spigot. Place rubber gasket 120 - 150 mm from spigot end.

(7) Insert spigot into socket. Insert slowly avoiding shock. Leave a clearance between two pipes, allowing for future flexibility of pipe.

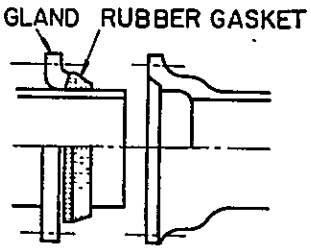


Fig. 4-1

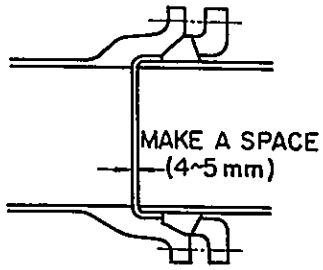


Fig. 4-2

(8) Maintain a clearance evenly between spigot outside and socket inside, and then push the rubber gasket into the fixed position of the socket inside. Unless both centers of spigot and socket of pipes are in correct alignment, the rubber gasket may get twisted or it may not adhere to the pipes; this will cause breaking of gland during bolting, which leads to leakage.

Even in the case when insertion is difficult, the rubber gasket should not be forced by the gland but, after being coated with soap water, it could be tapped softly with a stick.

(9) Slide the gland and line up the centers of the pipe

bolt holes with those of the gland. Make a space equally with the aid of a wedge between the gland and the outside surface spigot. If both bolt holes do not line up, it may lead to failure of bolt or flange.

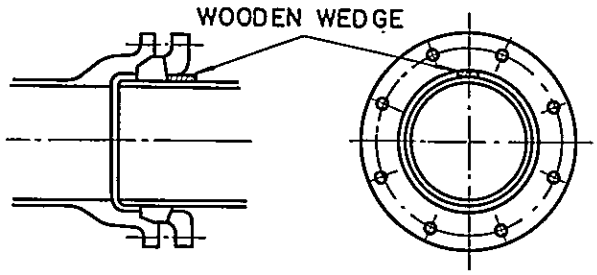


Fig. 4-3

(10) Clean up bolts and nuts.

(11) At first bolts should be inserted into four bolt holes: top, bottom, right and left holes, and gently bolted.

(12) Then remaining bolts should be put into all other holes. Check whether all bolt holes are filled by bolts and nuts, since there is a tendency to forget to fill all bolt holes when there are a large number of bolt holes.

(13) Tighten symmetrically and by degrees - that is, above and below at first, then to the right and to the legt and so on — using a ratchet wrench or a spanner.

Do not tighten at once. Tighten all bolts one by one degree. Finally tighten all bolts upto necessary torque. Do not tighten down a particular bolt excessively, as this may cause gland to be

broken.

(14) Check the nuts and bolts one by one once more to make sure all nuts have the necessary torque. Even if a bolt was tightened under the necessary torque it can become loose again after the next one has been bolted. Therefore, repeat tightening of all bolts and nuts uniformly several times.

(15) Proper tightening torques are shown as per the Table below.

Table 4-2 Tightening Torques for Mechanical Joint

Size of bolt	Torque (Kg-m)	Diameter of pipe (mm ϕ)	Length of arm of wrench which is suitable for bolting in needed torque for an ordinary worker (cm)
M20	10	200 - 600	25
M24	14	700 - 800	35
M30	17	900 - 1,200	40
M30	20	1,350 - 1,500	45

Bolting by a ratchet wrench is much efficient and easier than by a spanner.

(16) Permissible degree of bend in the case of bending piping at a joint is shown as per a Table.

Table 4-3 Maximum Permissible Deflection in Laying Mechanical Joint (A.K.-type)

Pipe dia. (mm)	Defective length permissible to a pipe (-cm) effective length of a pipe		Permissible deflection angle
	4 m	6 m	
75	35	-	5°00'
100	35	-	5°00'
150	44 (5m)	-	5°00'
200	35	-	5°00'
250	35	-	5°00'
300	23	35	3°20'
350	34	50	4°50'
400	29	43	4°10'
450	27	40	3°50'
500	23	35	3°20'
600	19	29	2°50'
700	17	26	2°30'
800	15	22	2°10'
900	14	21	2°00'
1,000	13	19	1°50'
1,100	11	17	1°40'
1,200	10	15	1°30'
1,350	9	14	1°00'
1,500	8	12	1°10'
1,600	10	15	1°30'
1,650	10	15	1°30'
1,800	10	15	1°30'
2,000	10	15	1°30'
2,200	10	15	1°30'
2,400	10	15	1°30'

Arrange the pipes in a straight line at the beginning of the jointing work. Set the rubber gasket at the correct position and screw nuts loosely. Then incline the pipe. Finally tighten up the bolts

to necessary torque. Consequently, in this case, a trench should be dug out of considerable width at the place where pipe laying is to be curved. The curve should be as slight as possible and enough elasticity kept at the jointing part.

(17) If the rubber gasket does not fit smoothly, it should not be forced by bolting but should be removed and cleaned once more.

(v) Jointing of Tyton Joint

This type of joint has many advantages. It has only one accessory - a rubber gasket, ease of installation, time and labor saving, economical, joint tight, self-centering, ample deflections.

Joint is simple provided the following instructions are followed precisely. Careless handling may lead to troubles.

(1) Cleaning the socket

Move the pipe to the required position and clean the inner surface of the socket. Take care not to leave foreign matter in it.

(2) Inserting the rubber gasket

Cleaning the rubber gasket, insert it carefully into the socket with the valve set to the interior part. Make sure that the groove of the rubber gasket is completely and accurately fitted over to the bead in the inner surface.

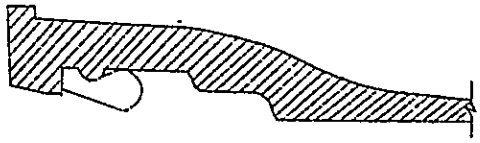


Fig. 4-4 Rubber gasket inserted into the socket

(3) Keeping the socket clean

When the trench side crumbles easily and sand or pebbles may enter the socket, clean the socket and the rubber gasket on the ground; setting the rubber gasket to the socket, move it down carefully without soiling it.

(4) Cleaning the spigot

Wipe the spigot with cloth. If earth and sand are on the surface of the spigot, joint assembly will become very difficult and cause a leak.

(5) Applying Lubricant

Use only lubricant supplied by the pipe manufacturers. Apply lubricant to the spigot and the rubber gasket. Spread it uniformly and entirely on the outer surface of the spigot for 3 - 4 cm from the end. (to about 8 cm ahead of the end in the case of a cut pipe.) Be sure to apply it to the lower part of the pipe.

Apply lubricant to the inner part of the rubber gasket, but take care not to allow it to flow on the internal groove of socket, or the rubber gasket may slip out from accurate position. As lubricant plays an important role in jointing, do not use oils such as grease etc., which have adverse effect.

(6) Setting the spigot

Set normally the inclined part of the end of the spigot to the inclined part of the inner surface of the rubber gasket. If care is taken, even piping bent within 5° can be installed.

(7) In case of pipes up to 200 mmϕ

When a wire rope is wound around the inserting pipe as shown in Fig. 4-5 (1) and the other end of the rope bending from the hook in the lower part of the fork is pulled, the pipe slides easily into the socket. The fork operation can be done by one person. The construction will be more completely finished if another person lightly presses the pipe end to prevent the pipe from rising.

(8) In case of pipes over 250 mmϕ

Fix a jack on the socket as shown in Fig. 4-5 (2) and wind a wire rope around a pipe to be inserted. Hang the rope end on the hook in the top of the jack and operate the jack to combine pipes easily.

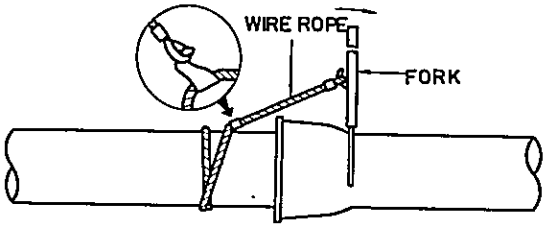
(9) Checking the insertion

After insertion, confirm that the spigot is correctly inserted into the socket. Joint is proper if the painted stripe near the pipe end among the two white stripes marked on the spigot is not visible but hidden inside the socket and only the outer stripe is visible, cf. Fig. 4-5 (3).

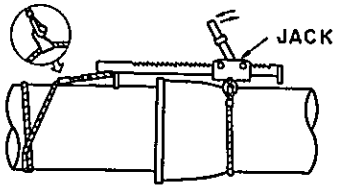
(10) Positioning the rubber gasket

Confirm that the rubber gasket is laid in the proper position beside the state of insertion. This may be determined by inserting a wire or thin steel plate into the whole circumference.

(1) Insertion with a fork



(2) Insertion with a jack



(3) Completion of insertion

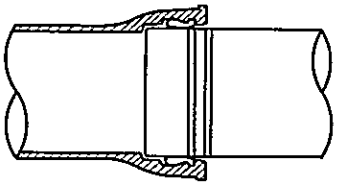


Fig. 4-5 Jointing tyton joint

(vi) Jointing of U-type Inside Joint

U-type Joint is especially designed to joint pipes from inside the pipe for the pipeline in tunnel or pipeline which must be laid in very narrow ditch, that does not allow to

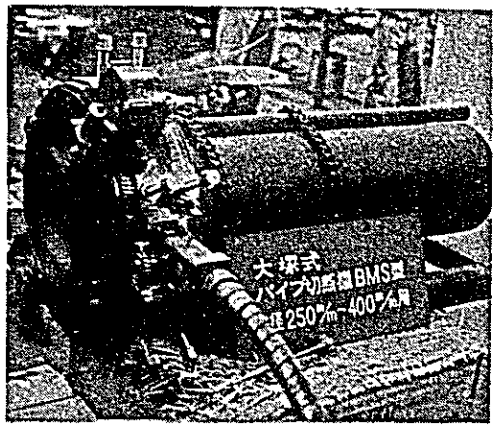
assemble joint from outside.

Following picture in Fig. 4-6 will show how to joint U-type joint pipes.

4-1-2 Pipe Cutting

As Ductile Iron Pipe is tough, it is time consumming to cut pipes with a chisel. It is advisable to use a hand operated or mechanical pipe cutter, or oxyacetylen gas.

(1) Disk Engine Cutter



(2) BMS-Type Pipe Cutter
Apply for φ250mm - φ400mm

4-1-3 Thrust Blocking of Bend

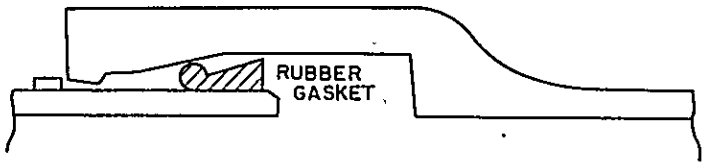
a) Force applied to bend pipe

Unbalance force by water pressure

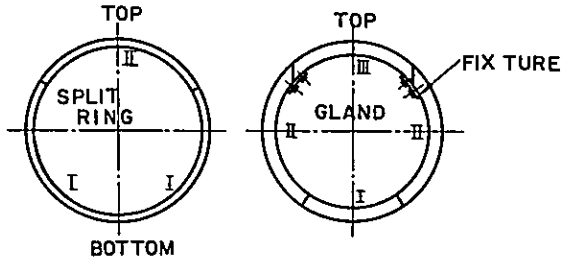
$$R = 2.P.A.\sin \theta/2$$

Where;

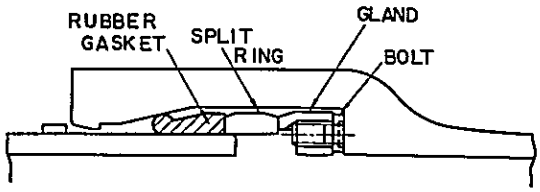
P: Internal pressure = Static pressure + Dynamic pressure



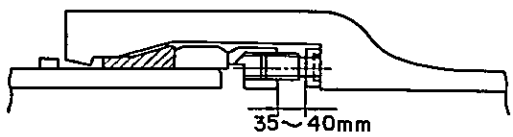
STAGE.1
INSERTION OF RUBBER GASKET.



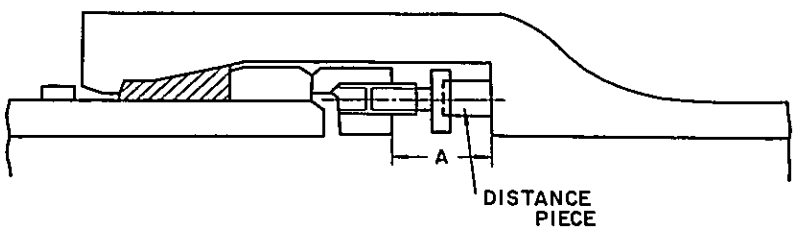
STAGE.2
INSERTION OF SPLIT RINGS AND SETTING GLANDS.



STAGE.3
SCREWING THE BOLTS.



STAGE.3'



STAGE.4
COMPLETION OF JOINT.

FIG.4-6 JOINTING U-TYPE INSIDE JOINT

A: Sectional area of pipe

θ: Bending angle of pipe

Centrifugal force caused by bending

$$R' = \frac{2W}{g} v' \sin \frac{\theta}{2}$$

Where;

W: Weight of water inside the pipe

g: Acceleration of gravity

v: Maximum flow rate in pipe

R' is relatively small comparing with R and considered negligible.

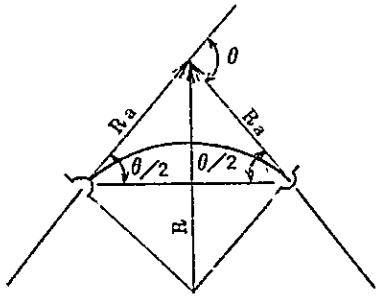


Fig. 4-7

b) Protection with concrete block

(i) Horizontal bend

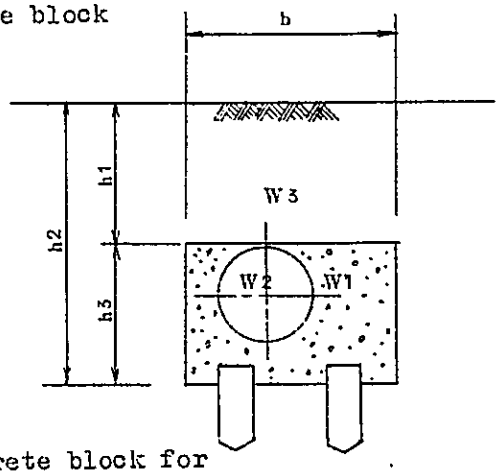


Fig. 4-8 Concrete block for Horizontal Bend

In Fig. 4-8

W_1: Weight of concrete block (Specific weight of concrete block is 2.3 ton/m^3)

W_2: Weight of pipe and water

W_3: Vertical load of soil (Specific weight of soil is 1.6 ton/m^3)

ΣW: Total load applied to the bottom of the concrete block = $W_1 + W_2 + W_3$

$\mu\Sigma W$: Friction resistance between sand and concrete

μ: Friction coefficient = 0.5

E: Passive earth pressure = $\frac{1}{2}$ Ce' $(h_2^2 - h_1^2)_L$

Ce': Coefficient of passive earth pressure = $\tan^2 (45^\circ + \frac{\varphi}{2})$

φ: Angle of internal friction of soil (Generally 25 degrees)

r: Unit weight of soil

h_2: Depth to the bottom of block

h_1: Depth to the top of block

L: Average width

When

$\mu\Sigma W + E_p > R$ is satisfied, the block is regarded safe.

For bearing capacity of earth

$$\Sigma W / a < \sigma$$

a: Bottom area of block

σ: Safe supporting force of sand

(ii) Vertical Bend

In Fig. 27

Rx = Horizontal partial force

When

$Rx < (\Sigma W - Ry) + Ep$ is satisfied, the block is regarded safe.

For Ry: Vertical Partial force = $R \cos \theta/2$

Ea: Resistance force by side active earth pressure

$= \frac{1}{2} Ce. r (h_2^2 - h_1^2) . 2. (b + L). \mu$

Ce: Coefficient of active earth pressure

$= \tan^2 (45^\circ - \frac{\phi}{2})$

When

$Ry < \Sigma W + \Sigma Ea$ is satisfied, the block is safe.

For bearing capacity of earth

$\Sigma W / bL < \sigma$ must be satisfied.

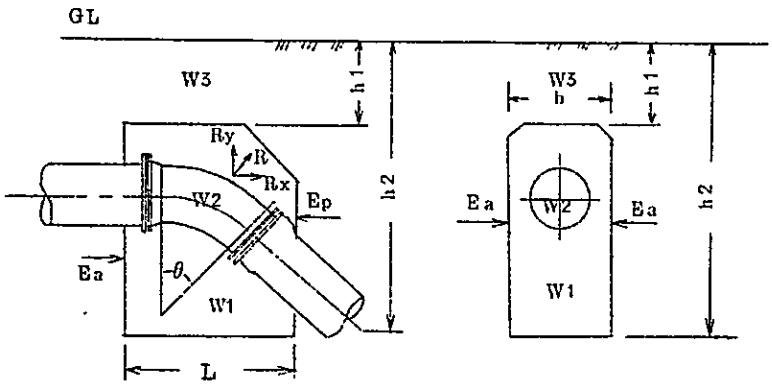
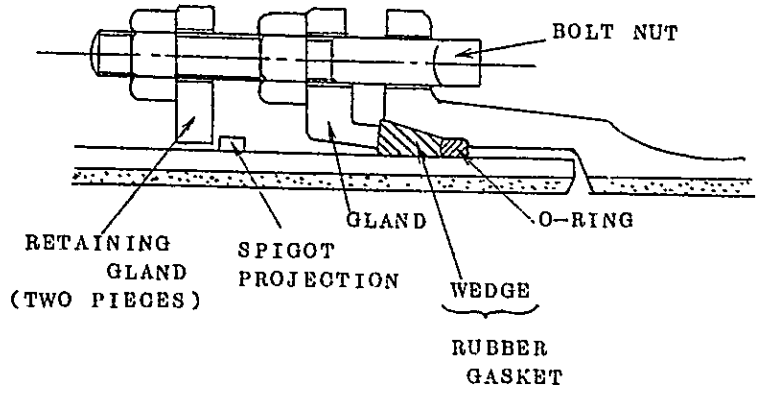


Fig. 4-9 Concrete Block for Vertical Bend.

4-1-4 Retaining Joint

For the protection of a bend pipe, a concrete block is effective but there are still uncertainty of the quality of back fill possibility of digging out, and problem of too big block in large diameter pipe.

To solve these problems, retaining joints are divised. Retaining joints generally used are shown in Fig. 4-10.



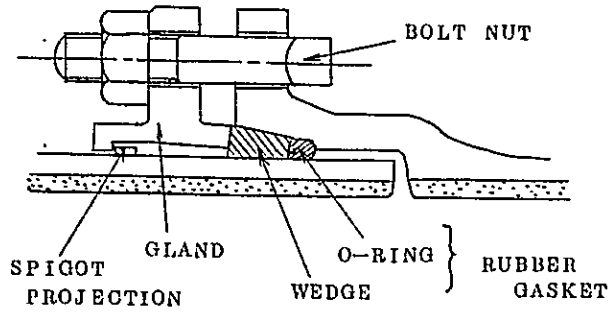


Fig. 4-10 Retaining Joint

4-1-5 Cement Mortar Lining

As a rule, cement mortar lining is applied inside ductile iron pipes to prevent the decrease of water flow efficiency owing to tuberculati These are shown in Fig. 4-11 and Table 4-4.

Rich mortar (cement/sand = 1/1.5 - 2.2) is inserted into a pipe and lined inside by centrifugal force, vapor cured, sprayed with water for four days and seal coated.

The thickness of lining is shown in Table 4-5. Seal coat of cement mortar lining serve to prevent moisture evaporation from mortar and leading of calcium ion into water. Fig. 4-5 shows effect of seal coat on the water quality.

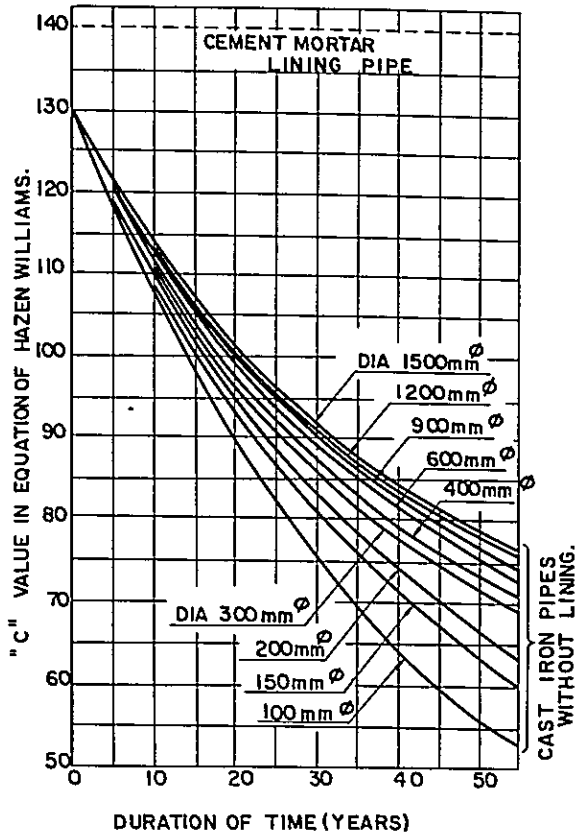


Fig. 4-11 Change in "C"

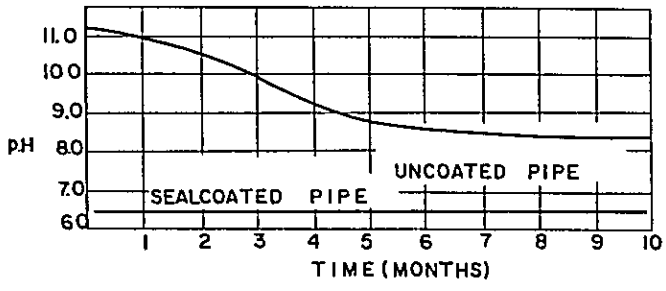


Fig. 4-12 Change of pH of seal coated and uncoated Cement Mortal Lining Pipe

Table 4-4 Flow Test of Cement-Lined Cast Iron Pipe

After Extended Periods of Service

Location	Size (in.)	Seal Coated	Nominal Minimum Lining Thickness (in.)	Length (ft)	Year installed	Test Age (years)	C Value
Birmingham, Ala.	6	yes	1/16	433	1940	1	148
						6	141
						12	138
						17	133
Catshill, N.Y.	16	no	1/8	30,825	1932	25	136
Champaign, Ill.	16	no	3/16	3,920	1928	13	137
						22	139
						28	145
						36	130
Charlston, S.C.	5.78			300	1941	new	145
						12	146
						16	143
	12		1/8	500	1932	15	145
						25	136
Chicago, Ill.	36	yes	1/8	7,200	1945	1	147
						12	151
Concord, N.H.	12	no	1/16	500	1928	13	143
						29	140
						36	140
Danvers, Mass.	20	no	1/16	500	1926	31	135
						38	133
Greenville, S.C.	30		1/8	87,400	1944	13	148
	30	yes	1/8	50,700	1939	19	148
						25	146
Greenville, Tenn.	12	no	1/16	500	1928	13	134
						29	137
						36	146
Knexville, Tenn.	10		1/16	500	1925	16	134
						32	135
						39	138
Manchester, N.H.	12	yes		500	1936	5	151
						19	132
						26	140
Safford, Ariz.	10	no	1/8		1941	16	144
Watertown, N.Y.	10	no	1/16	500	1927	14	151
						28	132
						37	125

Table 4-5 Dimensions and Weight of Ductile Iron Pipe

(JWWA and JCPA)

Nominal Dia. (mm)	Wall Thickness, T (mm) Class 1st	2nd	3rd	4th	Thickness of Lining (mm)	Outside Diameter D' (mm)	Working Length (mm)	Socket Weight (kg)	Weight (Kg) Barrel (Weight for 1 meter) Class 1st	2nd	3rd	4th	Lining	Total Weight for 1 Working Length Class 1st	2nd	3rd	4th	Lining
75 ϕ	7.5	-	6.0	-	4	93.0	4000	5.08	14.4	-	11.7	-	2.23	62.7	-	51.9	-	8.93
100	7.5	-	6.0	-	4	118.0	4000	6.53	18.6	-	15.1	-	2.98	80.9	-	66.9	-	11.9
150	7.5	-	6.0	-	4	169.0	5000	9.01	27.2	-	22.0	-	4.52	145	-	119	-	22.6
200	7.5	-	6.0	-	4	220.0	5000	11.7	35.8	-	28.8	-	6.06	191	-	156	-	30.3
250	7.5	-	6.0	-	4	271.6	5000	14.6	44.5	-	35.8	-	7.62	237	-	194	-	38.1
300	7.5	-	6.5	-	6	322.8	6000	17.8	53.1	-	46.2	-	14.85	336	-	295	-	81.9
350	7.5	-	6.5	-	6	374.0	6000	25.6	61.7	-	53.7	-	15.97	396	-	348	-	95.8
400	8.5	7.5	7.0	-	6	425.6	6000	34.4	79.64	70.44	65.22	-	18.21	512	457	429	-	109
450	9.0	8.0	7.5	-	6	476.8	6000	39.5	94.57	84.24	79.06	-	20.48	607	545	514	-	123
500	9.5	8.5	8.0	-	6	528.0	6000	45.7	110.64	99.19	93.44	-	22.76	710	641	606	-	137
600	11.0	10.0	9.0	8.5	6	620.8	6000	57.4	153.14	139.45	125.70	118.82	27.27	976	894	812	770	164
700	12.0	11.0	10.0	9.0	8	733.0	6000	74.9	190.35	178.40	162.40	146.37	42.28	1240	11150	1050	853	254
800	13.5	12.0	11.0	10.0	8	836.0	6000	90.6	249.42	222.11	203.85	185.54	48.32	1590	1420	1310	1200	290
900	15.0	13.0	12.0	11.0	8	939.0	6000	112	311.33	270.40	249.87	229.30	54.35	1980	1730	1610	1490	326
1000	16.5	14.5	13.0	12.0	10	1041.0	6000	139	379.71	334.34	300.19	277.37	75.25	2420	2150	1940	1800	452
1100	18.0	15.5	14.0	13.0	10	1144.0	6000	162	455.27	392.91	355.36	330.27	82.79	2890	2520	2290	2140	497
1200	19.5	17.0	15.0	13.5	10	1246.0	6000	186	537.23	469.31	414.77	373.75	90.85	3410	3000	2670	2430	542
1350	21.5	18.5	16.5	15.0	12	1400.0	6000	231	665.74	574.09	512.77	466.66	121.69	4230	3680	3310	3030	730
1500	23.5	20.5	18.0	16.5	12	1554.0	6000	279	807.90	706.15	621.04	569.84	135.26	5130	4520	4010	3700	812
1600	25.0	22.0	19.0	17.5	15	1650.0	4000	325	912.54	804.51	696.09	641.72	179.26	3980	3540	3110	2890	717
1650	25.5	22.5	19.5	18.0	15	1701.0	4000	360	959.71	848.32	736.53	680.48	184.91	4200	3750	3310	3080	740
1800	28.0	24.0	21.0	19.5	15	1848.0	4000	427	1144.69	983.32	861.82	800.92	200.97	5010	4360	3870	3630	804
2000	30.5	26.5	23.5	21.0	15	2061.0	4000	534	1391.10	1211.05	1075.53	962.28	224.50	6100	5380	4850	4380	898
2100	32.0	28.0	24.5	22.0	15	2164.0	4000	596	1532.48	1343.43	1177.43	1058.52	235.81	6730	5970	5310	4830	963
2200	33.5	29.0	25.5	23.0	15	2280.0	4000	659	1690.47	1466.33	1291.36	1166.05	248.59	7420	6520	5820	5320	994
2400	36.5	331.5	27.5	25.0	15	2458.0	4000	803	1985.34	1716.91	1501.36	1366.28	268.04	8740	7670	6810	6270	1070

*Socket Weight & Total Weight for one Working Length Stand for { A -type mechanical joint: Upto 350mmϕ. K -type mechanical joint: Upto 400mmϕ.

4-2 Asbestos Cement Pipe

4-2-1 Handling

Do not open the trench too far ahead of the pipe laying. This will help avoid accidents such as cave-ins, flooding, and it eliminates expensive operations such as pumping and working with sheeting. Ease of handling Asbestos Cement Pipe (ACP) and the simple assembly of couplings for AC pipe make it possible to lay the pipe rapidly as the trench is excavated.

(i) Width of the trench

If the trench is too wide at pipe level, it will increase the earth load on the pipe. If it is too narrow, it will slow down the installation of the pipe and make it difficult if not impossible. The trench width at the top of pipe should be within the limits shown on the following table.

Recommended trench width at the top pipe:

Pipe size	Minimum trench width	Maximum trench width
3 and 4 inch	18 inch	28 inch
6 and 8	20	32
10 and 12	24	36
14 and 16	30	42

(ii) Depth of the trench

Depth is normally specified in the blueprints. If not, depth is determined with local conditions such as permissible surface loads and earth loads. The bottom of the trench should follow the specified grade and depth and should be levelled so that it will support the pipe along its full length.

(iii) Line of the trench

Couplings for AC pipe allow some deflection. Long curves can be followed even with straight pipe sections.

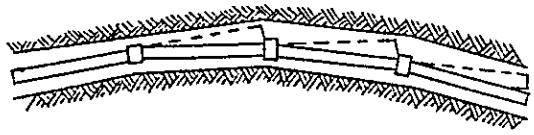


Fig. 4-13

Maximum recommended deflection of couplings for AC pipe.

Pipe size	Maximum recommended deflection
3 to 12 inches	5°

Offset required for various pipe length and angles of deflection

Angle of deflection	Offset per pipe length		
	3'3" length	6'6" length	13' length
1°	0.7"	1.4"	2.8"
2°	1.4	2.7	5.5
3°	2.0	4.1	8.2
4°	2.7	5.4	11.0
5°	3.4	6.8	13.7

(iv) Method of supporting pipe

Method of pipe supporting in the trench depends largely on the soil conditions, If the soil is stable, the bottom of the trench is simply levelled by hand and the pipe is laid directly on the trench bottom. If this method is used, holes should be dug where couplings are located. These holes keep the pipe from resting on the couplings. The trench bottom must be levelled carefully so that the full weight of a pipe

and its earth load are not concentrated on one high spot. In unstable soil and in rock excavation, it will be necessary to dig deeper than pipe grade and refill with tamped, selected material such as sand, until pipe grade is reached.

Coupling holes should be left deep enough to provide minimum clearance of 2" below the coupling.

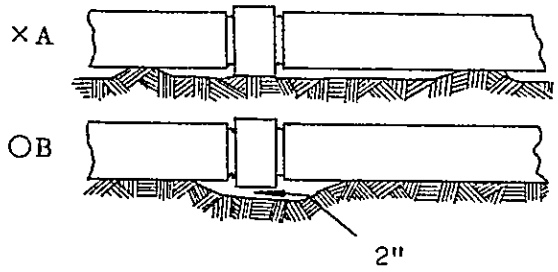


Fig. 4-14

(v) Lowering pipe into trench

When the trench is not too deep, trench walls are straight and stable, and when pipe weight is not over 140 lbs. per length, the pipe can be lowered manually from the ground surface into the trench.

4-2-2 Jointing

(1) Jointing with AC couplings

Coupling for asbestos cement pipe joint is used for straight pipeline jointing. In the coupling, the tow pipe end slides under the ring and automatically stop in the correct position as the stop ring comes in contact with the edge of the pipe end.

The stop ring keeps the pipe ends properly separated in the coupling, to allow for expansion and flexibility

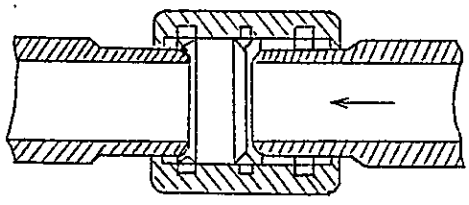


Fig. 4-15

(i) Lubricating pipe ends

Lubricant should be applied just before couplings are assembled. Clean the ends of the pipe with a cloth. Apply lubricant with a glove or with a brush over the entire end of the pipe and all around it..... as far back as 3" from the pipe end. It is also recommended to lubricate the exposed surface of the rubber rings inside the coupling.

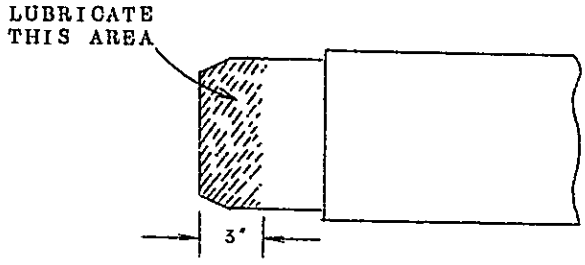


Fig. 4-16

(ii) Assembling pipe and coupling

Clean and lubricate the end of the pipe. Place the coupling over this end and, in one quick motion, push it until the pipe end meets the stop ring. This operation can easily be done by hand in pipe size up to 8 inches.

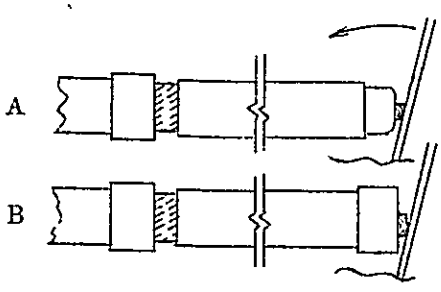


Fig. 4-17 A - Pushing Pipe into Coupling

B - Pushing Belled Pipe into Coupling

For 10 inches and larger pipe, use a bar as a lever to push coupling on to the pipe end. Put a wood block between the bar and the coupling to prevent damage. Push until pipe end is against stop ring.

Clean and lubricate the end of the next pipe to be laid. Line it up with the laid section and start the end into the coupling. Push the pipe into the coupling with hands or with a bar until stop ring is against pipe end. When assembling 3", 4" and 6" pipe, each joint can be made in one "push". First, align the new section to be laid with the section in place. Slide the new pipe back enough to make room for the coupling. Clean and lubricate the pipe ends. Place the coupling between the pipe ends and pull the new section up until both ends are started inside the sealing rings.

Then, using a bar as a lever, push the complete unit together.

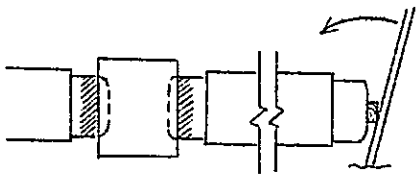


Fig. 4-18 Assembling 3", 4" or 6" Pipe Joint with One Push

If the trench bottom is soft and sticky and the pipe does not slide easily, lift it slightly off the ground, by hand or with the hoisting equipment, and push the pipe into the coupling.

A standard puller can also be used.

(iii) Making closures or replacing a section of pipe

When tow crews meet, when a section is to be replaced, or when tying into a fixed fitting, a closure must be made between tow installed pipe ends. Tow methods are used.

The conventional method of making a closure is to lay sections in place in the usual manner until only one piece, cut to exact length, is to be inserted. A machined- over-all piece is used. Both couplings are mounted on this piece and pushed completely past the couplings are slid back into place. Short lengths are normally used to make a closure.

Short lengths are available in 3'3" (Quarter) lengths machined over all and in 6'6" (half) lengths machined each end.

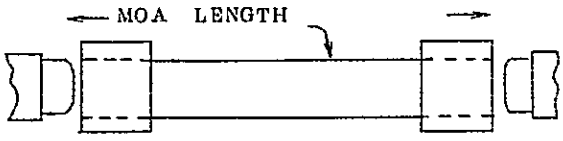


Fig. 4-19

One method is to use two or three full lengths, assemble them loosely with the center couplings in the air, then push the pipe downward into place.

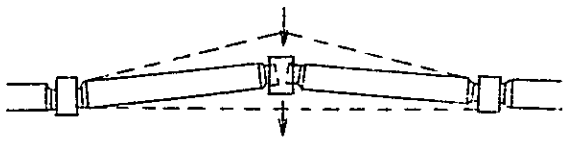


Fig. 4-20

And alternate is to use one 6'6" length and tow 3'3" length.

(2) Jointing with CI couplings

CI coupling, grey cast iron joint, is used for assembling with specials or pipes of other kind of materials. It is composed of joint sleeve, rubber ring and flange with bolts and nuts, as follows:

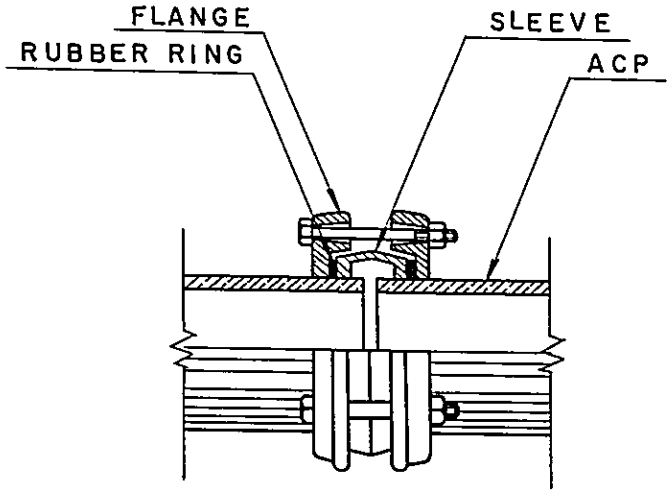
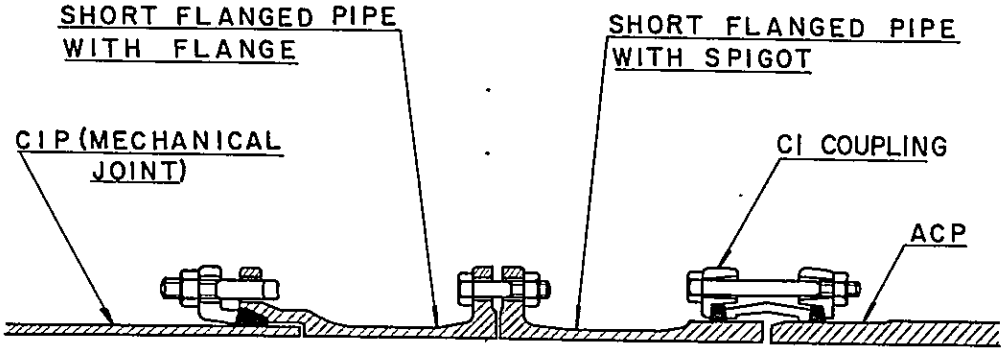
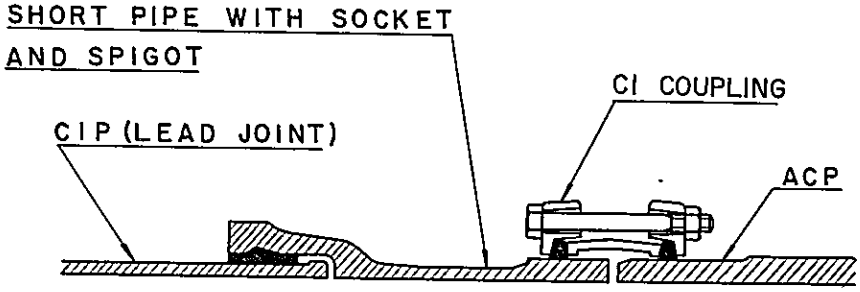


Fig. 4 - 21

Examples of jointing with other pipes are shown in Fig. 4-22.



(1)



(2)

FIG. 4 — 22

4-2-3 Cutting and machining

AC pipe can be cut with hand saws, abrasive wheels or power-driven pipe cutters. Pipe cutters are recommended for speed and clean accurate cutting, cf. paragraph 4-1-2.

4-2-4 Trench blocks

Whenever a pipe line comes to a dead end or its direction or size changes, the fluid pressure will cause side or end thrust.

To prevent these thrust from moving the line, thrust blocks, usually of concrete, are poured in position where they will resist thrust force.

The total thrust on any particular block is calculated from the following tables.

Thrust at fittings in pounds at 100 pounds per square inch of water pressure

Size	Tees and plain end	90° bend	45° bend	22 1/2° bend	Per deg. of deflection
3"	1,100	1,560	840	430	19.2
4"	1,690	2,400	1,300	660	29.5
6"	3,510	5,000	2,690	1,370	61.2
8"	6,090	8,700	4,570	2,370	106.0
10"	9,330	13,200	7,150	3,630	162.0
12"	13,250	18,700	10,200	5,150	231.0
14"	17,800	25,200	13,600	6,930	310.0
16"	23,100	33,000	17,700	9,000	408.0

Various arrangements for thrust blocks are illustrated in Fig. 4-23.

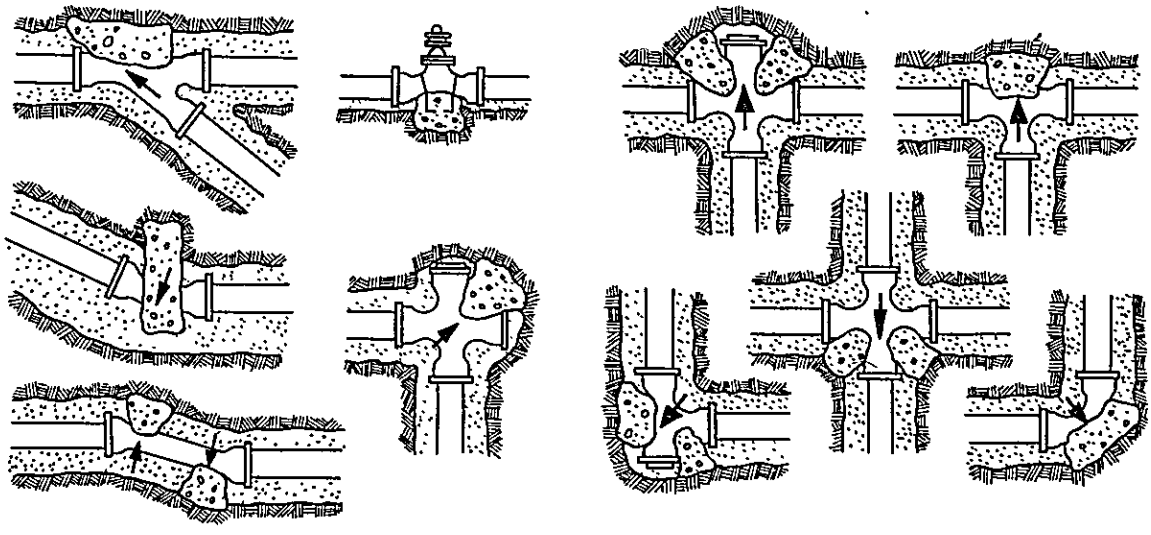


FIG. 4-23

EXAMPLES OF THRUST BLOCKS

4-3 PVC Pipe

4-3-1 Basic Processing and Connection Procedure

How to cut the pipe

1) Use a saw for metal cutting and cut the pipe at right angle to the axial direction of the pipe

When the diameter is large, put a red mark on the outer surface of the pipe using a paper ruler, and saw along this mark completely around the circle until it cuts about half of the pipe's thickness. This method will achieve the correct cutting angle.

2) A difference in cutting angle, or a slanted cutting angle, will adversely influence the strength of the connected part, particularly for connections. Therefore, an irregularly cut face must be corrected by filling.

3) For large size pipe (more than 8 inches), the outside edge must be bevelled.

4) The residue from sawing inside the pipe must be completely cleaned away

How to bend the pipe

Pipe 2-1/2 inches or larger in diameter is bent by filling with sand and using a wooden guide.

1) Cut the pipe in suitable length for making bend.
2) Fill the pipe with heated sand upto approx. 130°C. Use sand as fine and dry as possible. The sand should not be overheated. The filling should be done tightly, in

the same manner as for metal pipe, tapping the pipe with a wooden hammer.

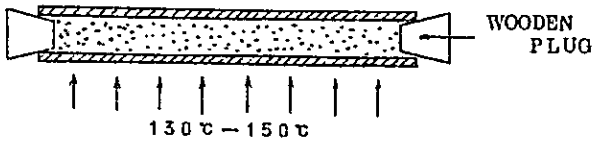


Fig. 4 - 24

3) The heat is applied to the place to be bent, utilizing radiant heat of approx. 130°C. Heating can be done by electricity, or by simply inserting the pipe into heated sand sand (about 130°C), for the purpose of softening the pipe with the surrounding sand.

4) Bend the softened pipe as required
The guide (wood, etc.) is preferably prepared beforehand for better finishing. The bending radius (R) should be 3-4 times the outside diameter of the pipe.

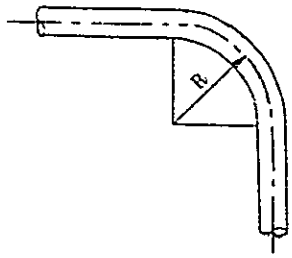


Fig. 4-25

5) Remarks

a. Since the thermal expansion of PVC pipe is large, the inside volume will be increased as the heat rises for further softening of pipe. Therefore, sand must be added once or twice during heating in order to keep an even sand pressure.

b. The sand temperature must be kept as uniform as possible. Never overheat the pipe, because a crack might be caused inside the pipe if the temperature rises to more than 150°C.

c. The bending angle must be made precisely and solidified for fixing immediately after the bending processing by applying cool water.

How to connect the pipe with solvent cement

TS connection method

No heating is required for this method and the pipe is connected simply by use of solvent cement alone. This method can be used for all pipes up to 350 mm ϕ.

Connection method

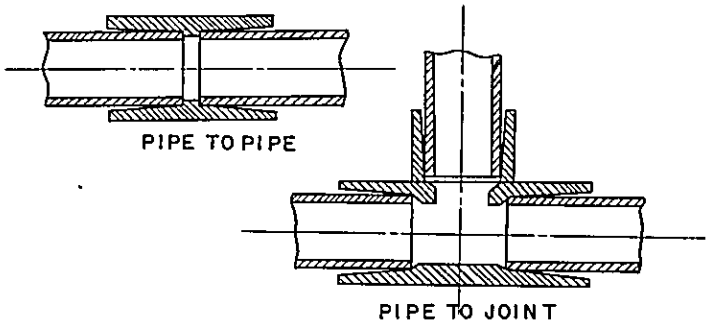
1) The pipe end must be cut at a right angle. Outside bevelling is to be done on pipes with a diameter of more than 200 mmϕ.
2) Clean the connection place and mark the insertion length on the pipe.
3) Apply a thin and even layer of solvent cement to the inside of fitting part and to the outside of the pipe to be inserted.
4) Promptly insert the pipe while the solvent cement is wet, and adjust so that the pipe centers are on the same axis.
5) Do not release the pressure too soon. Otherwise the pipe may be loosened and leakage may be caused. Hold it for 20-30 seconds and remove hand after confirming that the pipe is firmly fixed.

6) Wipe off completely any solvent cement which seeped out.

Remarks

1) Since both pipe and joint inlet have some manufacturing tolerance, not all pipe can be inserted to the fullest extent. When the pipe axis is on the same line, the pipe can be inserted for a substantial distance. Do not try to insert with undue force, because stress will remain at the connection.

2) Connection can be made by hand for pipe up to 100 mm. For pipe with a diameter of more than 150 mm, it is easy and safe to use an inserting tool such as a chill hole, lever block, puller, etc.



NOMINAL DIAMETER (mm)	13	16	20	25	28	30	35	40	50	65	75	100	125	150	200	250	300	350	400	450
INSERTION DEPTH (mm)	26	30	35	40	40	44	44	55	63	69	72	92	112	140	215	275	300	350	380	

Fig. 4 - 26

How to connect the pipe with flange

This connection method is solely for PVC pipe and is used for the part where the pipe must be taken away or for the part where a valve flange or metal pipe is connected with PVC pipe.

Table 4 - 6

Item / Kind	Flexible flange method	Flange adapter method
Applicable diameter	50 - 350 mm	75, 100, 150 mm
Ease of connection	Simply inserted the pipe into flange	Simply press the pipe to the TS Faucet
Resistance to Vibration and bending	good	normal
Resistance to water pressure	normal	normal
Material	Body and flange; Cast iron	Body: PVC Flange; Cast iron
Application	Buried	Buried or exposed

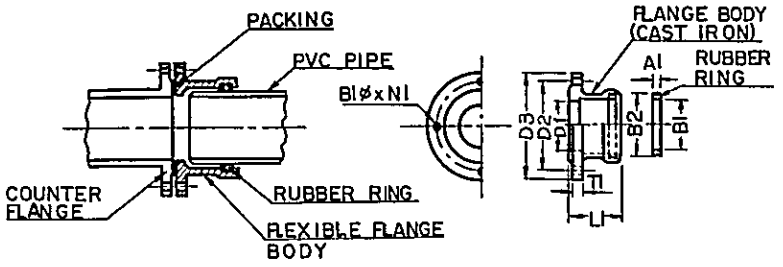
1. Flexible flange method

Features

1) As opposed to the conventional joint, no difficult technique is required for flange fitting work. Connection is made simply by applying a soap solution and inserting the pipe.
2) Since it has flexibility, it can be also used as expansion pipe.
3) This method can be used conveniently for the repair and replacement of pipe.

Structure

(1) 150mm OR LESS



(2) 200mm OR MORE

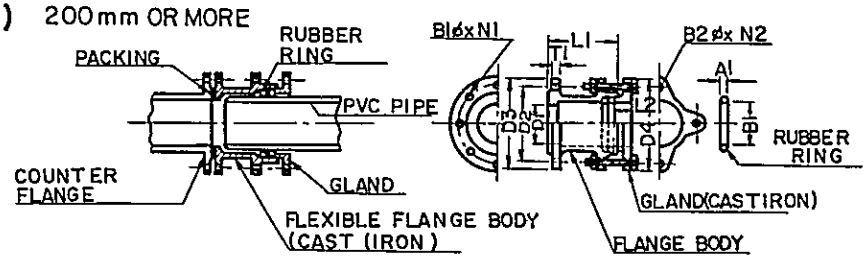


Fig. 4 - 27

2. Flange Adapter Method

Features

1) Since it is a PVC molded product, it has corrosion-resistance.

2) Connection with PVC pipe is easy and surely made by TS connection.

3) It can be also used for exposed piping.

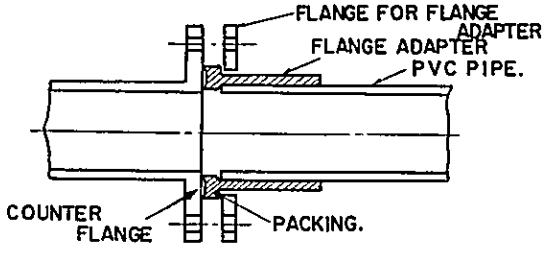


FIG. 4-28

(mm)

NOMINAL DIAMETER \ MARK	T CAST IRON	T CAST STEEL	D1	d1	BOLT HOLE D2	BOLT HOLE d	BOLT HOLE NUMBER	BOLT DIAMETER
75	19	15	211	104	168	18	4	M16
100	19	15	238	133	195	18	4	M16
150	20	17	290	190	247	18	6	M16

REMARK:
(1) THE MATERIAL IS AS FOLLTOWS:
CAST IRON CONFORMING TO JIS G 5521
CAST STEEL CONFORMING TO JIS G 5101
CLASS 1.
(2) ALTHOUGH THESE DIMENSIONS MEET WATER SERVICE SPECIFICATIONS, FLANGES FOR JIS 5 Kg/cm² AND 10 Kg/cm² FLANGE ADAPTER ARE ALSO AVAILABLE.

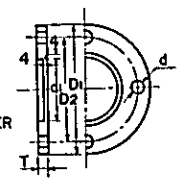


FIG.4-29

NOMINAL DIAMETER \ MARK	D	D1	d (mm)	T	L
75	101	125	77.4	12	90
100	129	152	100	12	110
150	185	208	146	15	165

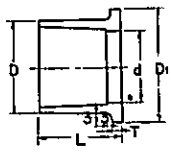


FIG.4-30

4-3-2 Piping (up to 100 mm in diameter)

Distribution

1) Distribution pipe lines are laid in a network, avoiding closed points. In unavoidable circumstances, a hydrant is installed at the end of a closed pipe.

2) In order to take out the water services pipe from the distribution pipe line without shutting off the line, a distribution branch line may be installed, if necessary.

3) For the purpose of minimizing the area of water supply failure, a sluice valve should be installed at both ends of such hazardous places as overhead traversing and traversing under a railway.

4) A hydrant should be installed at the crossing of streets so that fire fighting activities can be conveniently carried out. For this, a pipe with a nominal diameter of 75, 100mm has a single mouth hydrant, while a pipe of 150 mm or more has a twin-mouth hydrant.

5) An air relief valve and blow off branch are installed at the elevated and lowered parts respectively, as the case may be.

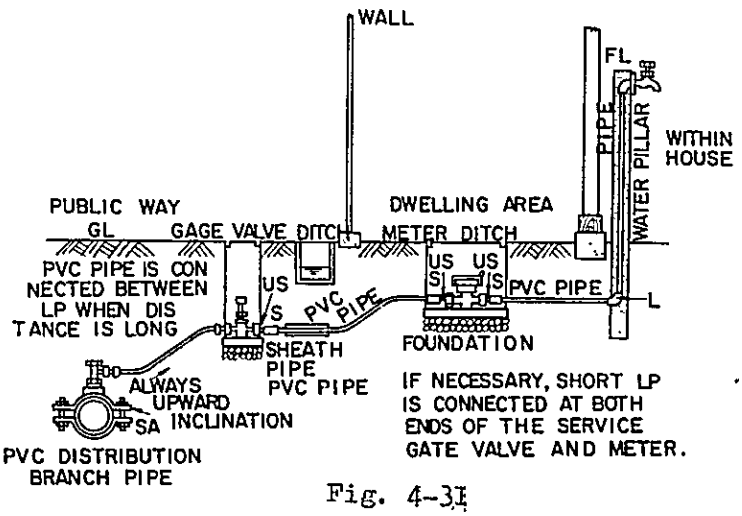


Fig. 4-31

Conversion Tables

Chemical doses

Milligram per litre (mg/l)	= 1 part per million (p.p.m.)
Gram per cubic metre (g/m^3)	= 1 p.p.m.

Unit of length

in	inch	= 0.0254 in
ft	foot (12 in)	= 0.3048 m
yd	Yard (3 ft)	= 0.9144 m
	Mile (1760 Yd)	= 1,609.344 m
		= 1.6 km
m	Metre	= 1.093 Yd
		= 39.37 in
		= 3.281 ft

Unit of area

in^2	square inch	= 6.4516 cm^2
ft^2	square foot (144 in^2)	= 0.0929 m^2
Yd^2	square yard (9 ft^2)	= 0.83613 m^2
sq. mile	square mile (640 acres)	= 2.5899 km^2
	acre (4840 yd^2)	= 4,046.8 m^2
m^2	square metre	= 1.196 yd^2
ha	hectare = 10,000 m^2	= 0.3861 sq. miles

Unit of weight

oz	ounce	= 28.344 g
lb	pound (16 oz)	= 453.592 g
ton	long ton (UK 2240 lb)	= 1.016 t
kg	kilogram	= 35.2736 oz

Unit of volume

in^3	cubic inch	= 16.387 cm^3
gal (UK)	Imperial gallon	= 4.546 ℓ
ft^3	cubic foot	= 28.316 ℓ
ℓ	litre	= 0.220 gal (UK)
		= 0.03531 ft^3
m^3	cubic metre	= 1.3079 yd^3