The Design Criteria for Water Supply Facilities

2012

Chapter 4. Raw Water Transmission Facilities

Chapter 6. Treated Water Transmission Facilities

Chapter 7 Distribution Facilities

Chapter 9. Water Service Fittings

（The Excerpt）

Ministry of Health, Labour and Welfare

Chapter 4. Raw Water Transmission Facilities

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Chapter 7 Distribution Facilities

Chapter 9. Water Service Fittings

These criteria are the extracts from “Design Criteria for Water Supply Facilities 2012”, Japan Water Works Association:

4. Raw Water Transmission Facilities
6. Treated Water Transmission Facilities
7 Distribution Facilities
9. Water Service Fittings

【Table of contents】

4. Raw Water Transmission Facilities 1
4.1 General 1
4.1.1 Basic Items 1
4.1.2 Design Flow of Raw Water Transmission 1
4.1.3 Type of Raw Water Transmission 2
4.1.4 Route of Transmission 3
4.2 Raw Water Transmission Mains 4
4.2.1 General 4
4.2.2 Pipe Material 4
4.2.3 Pipe Diameter 4
4.2.4 Flow Velocity 6
4.2.5 Location and Depth of Pipe Laying 6
4.2.6 Pipe Laying in the Unstable Soil 7
4.2.7 Junction Well 7
4.2.8 Ancillary Facilities 8
4.2.9 Water Mains Protection Facilities 8
4.2.10 Expansion Joints 9
4.2.11 Foundation of the Water Main 9
4.2.12 Protection of Special Fittings 9
4.2.13 Erosion Prevention of Outside Wall of the Water Main 9
4.2.14 Water Pressure Test 9
4.2.15 Water Main Bridge and Bridge-Piggybacked Water Main 9
4.2.16 Inverted Siphon 9
4.2.17 Pipe Jacking Method 9
4.2.18 Shield Driving Method 10
4.2.19 Pump Facilities 10
4.3 Raw Water Transmission Channel 11
4.3.1 General 11
4.3.2 Type and Structure 11
4.3.3 Flow Velocity 12
4.3.4 Junction Well 13
4.3.5 Ancillary Facilities 13
4.3.6 Raw Water Transmission Tunnel 14
4.3.7 Aqueduct Bridge 14
4.4 Raw Water Regulating Reservoir 17
6. Treated Water Transmission Facilities 19
6.1 General 19

6.1.1 Basic Items 19
6.1.2 Design Treated Water Transmission Flow 20
6.1.3 Type of Treated Water Transmission 20
6.2 Treated Water Transmission Main 21
6.2.1 General 21
6.2.2 Pipe Material 21
6.2.3 Pipe Diameter 21
6.2.4 Flow Velocity 21
6.2.5 Location and Depth of Pipe Laying 21
6.2.6 Pipe Laying in Unstable Soil 21
6.2.7 Ancillary Facilities 21
6.2.8 Water Mains Protection Facilities 22
6.2.9 Expansion Joints 22
6.2.10 Foundation of the Water Main 22
6.2.11 Protection of Special Fittings 22
6.2.12 Erosion prevention of Outside Wall of the Water Main 22
6.2.13 Water Pressure Test 22
6.2.14 Water Main Bridge and Bridge-Piggybacked Water Main 23
6.2.15 Inverted Siphon 23
6.2.16 Treated Water Transmission Main on Sea Bed 23
6.2.17 Pipe Jacking Method 23
6.2.18 Shield Driving Method 23
6.2.19 Pump Facilities 23
6.3 Regulating Reservoir 25
7. Distribution Facilities 26
7.1 General 26
7.1.1 Basic Items 26
7.1.2 Setting of the Service Area 29
7.1.3 Design Distribution Flow 31
7.1.4 Time Coefficient 32
7.1.5 Firefighting Water Flow 35
7.1.6 Layout of Distribution Facilities 38
7.1.7 Selection of the Type of Water Distribution 40
7.1.8 Renovation and Replacement of Distribution Facilities 41
7.1.9 Water Mains Replacement Plan 41
7.1.10 Direct Connection Water Service 42
7.2 Service Reservoir 43
7.2.1 General 43

7.2.2 Structure and Type 45
7.2.3 Capacity 47
7.2.4 Effective depth 51
7.2.5 Inlet pipe, outlet pipe and bypass pipe 52
7.2.6 Overflow and drainage facilities 53
7.2.7 Ventilation equipment, manholes and sampling holes 53
7.2.8 Level gauge, sampling apparatus etc. 53
7.2.9 Supplementary chlorination facilities 54
7.3 Standpipe and Elevated Reservoir 55
7.3.1 General 55
7.3.2 Structure 57
7.3.3 Capacity 58
7.3.4 Water depth 59
7.3.5 Foundation and supporting pillars 60
7.3.6 Inlet pipe, outlet pipe and bypass pipe 61
7.3.7 Overflow and drainage facilities 61
7.3.8 Ventilation equipment, manholes and sampling holes 61
7.3.9 Level gauge, sampling apparatus etc. 61
7.5 Distribution Mains 62
7.5.1 General 62
7.5.2 Procedure of the design of distribution mains 62
7.5.3 Pipe material 65
7.5.4 Water pressure 67
7.5.5 Pipe diameter 68
7.5.6 Location and depth of laying 71
7.5.7 Expansion joints 74
7.5.8 Foundation of the water main 79
7.5.9 Protection of special fittings 81
7.5.10 Labeling of water mains 83
7.5.11 Corrosion prevention of the outside wall of water mains 84
7.5.12 Water pressure test 88
7.5.13 Laying of distribution mains 89
7.5.14 Water main bridge and bridge-piggybacked water main 90
7.5.15 Inverted siphon 92
7.5.16 Pipe jacking method 92
7.5.17 Shield driving method 93
7.5.19 Construction method with uninterrupted water service 94
7.5.20 Pipe laying method inside the existing water main 94

7.5.21 Pipe rehabilitation method ... 95
7.6 Ancillary Facilities ... 96
7.6.1 General ... 96
7.6.2 Closure valve and control valve ... 97
7.6.3 Air valve ... 99
7.6.4 Hydrant ... 100
7.6.5 Pressure reducing valve ... 103
7.6.6 Flow meter and water pressure gauge ... 104
7.6.7 Drainage facilities ... 105
7.6.8 Manhole ... 107
7.7 Pump Facilities ... 107
9. Water Service Fittings ... 108
9.1 General ... 108
9.1.1 Basic items ... 108
9.1.2 Type of water service ... 110
9.1.3 Structure and material of water service fittings ... 115
9.1.4 Installation of water service fittings ... 115
9.2 Service Pipe ... 117
9.2.1 General ... 117
9.2.2 Design volume of water use ... 117
9.2.3 Pipe diameter ... 124
9.2.4 Pipe material ... 129
9.2.5 Branching of the service pipe from the distribution main ... 130
9.2.6 Pipe laying ... 132
9.3 Water service devices ... 135
9.3.1 General ... 135
9.4 Water meter ... 136
9.4.1 General ... 136
9.5 Hygienic safety measures ... 137
9.5.1 General ... 137
9.5.2 Selection of materials and equipment in consideration of water quality ... 137
9.5.3 Prevention of backflow ... 141

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4. Raw Water Transmission Facilities

4.1 General

4.1.1 Basic Items

1. Roles and Components of Raw Water Transmission Facilities

Raw water transmission facilities are facilities for transmitting raw water, which is abstracted from a water intake facility, and composed of a raw water transmission main, a raw water transmission conduit, pumping facilities etc.

It is desirable to provide, if needed, a raw water regulating reservoir so as to temporarily store raw water so that a certain quantity of water is secured to cope with such an emergency as restricted raw water abstraction at a time of draught, suspension of raw water intake due to water pollution accidents and so forth.

2. Considerations to be practiced for the construction of raw water transmission facilities.

Raw water transmission facilities are required to have a capacity for transmitting the necessary quantity of water without fail, and possess high functional reliability since there is a risk in that the failure of raw water transmission facilities by an accident will widely affect the operation of water supply due to suspension of water transmission or reduction in the volume of water to be transmitted. As such, pluralization of water sources, doubling of raw water transmission mains, mutual connections and the provision of allowance in capacity of facilities shall be exercised to secure backup capability of the water supply system. At the planning stage, the existence of alternative facilities, the capacity of water sources, which can be secured, and so forth shall be examined; and effective measures for provision of facilities shall be selected in consideration of efficient usage of the existing facilities, means to prolong their economic lives, and their cost-effectiveness.

At the stage of the design of raw water transmission facilities, the selection of suitable routes of laying of transmission mains, provision of anti-earthquake property and the durability, prevention of water pollution in the transmission mains, the ease of maintenance, economic benefits, energy efficiency etc. shall be studied.

3. Rational maintenance

To rationally carry out maintenance, the structure of the facilities shall be so designed that their inspection is easy; and a remote monitoring apparatus shall be provided to regularly watch water level, pressure, transmission flow etc.

4.1.2 Design Flow of Raw Water Transmission

> The design flow of raw water transmission facilities shall be based on the design flow of raw water intake.

[Interpretation]

Although the design flow of raw water transmission shall primarily be based on the design flow of raw water intake, it shall be determined in consideration of the trend of water demand in accordance with its forecast.

4.1.3 Type of Raw Water Transmission

> The type of raw water transmission shall be determined in consideration of the difference in elevation between the raw water intake facilities and the water treatment facilities, the design flow of raw water transmission, geographical condition of the transmission route, construction cost, the cost of operation and maintenance etc.

[Interpretation]

1. Type of Raw Water Transmission

The types of raw water transmission include the gravity flow type, pumping type and their combination in accordance with the difference in elevation between its beginning point, i.e., the raw water intake facilities and its terminal point, i.e., the water treatment facilities, topography and geography of the transmission route and so on.

2. Type of Water Conduit

The type of water conduit is classified into the pipe and the open channel. The pipe conduit is generally used in the case of the pumping system; and the open channel type is employed in the case of the gravity flow system in consideration to topography and geography of the transmission route, the ease (difficulty) of land acquisition, the ease of construction, merits in operation and maintenance, economic advantage, the environmental concerns etc.

For the selection of the route of transmission, even for the open channel type, the pipe type, e.g., water main bridge, tunnel and inverted siphon may be used together with the open channel in case the route crosses a river, mountain, valley, railway, road etc. in accordance with the topography and geography of the transmission route. (See Figure 4.1.1)

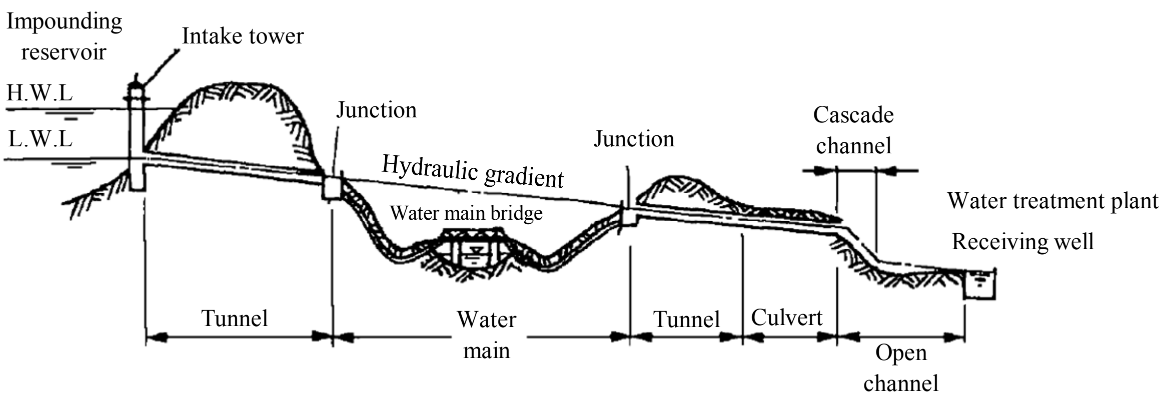


Figure 4.1.1 Profile of raw water transmission mains route

4.1.4 Route of Transmission

The selection of the route of raw water transmission shall be in conformity with the following:

1. The route shall be determined in synthetic consideration of the economic benefits such as construction cost, anti-earthquake property, ease of construction work, ease of operation and maintenance etc. after their comparative studies based on several alternative routes.
2. The land to be used for laying raw water transmission mains shall principally be a public road or the property owned by the water utility.
3. The route of raw water transmission mains shall basically be positioned lower than the minimum hydraulic gradient.

[Interpretation]

On the item 1.;

For the selection of the raw water transmission route, the alternative routes shall be examined on the map at first, and then a reconnaissance survey shall be conducted to study on the points which may cause a trouble at the design stage.

In the case of an open channel, a study is needed on the possibility to obtain land, which will realize the uniform and gentle water surface gradient, ease and cost of construction work for tunnels, water main bridges, inverted siphons etc. in case the route crosses a hill, river and valley. As for the sections of the tunnel and siphon, a study on soil condition shall be conducted; loose soil, active faults etc. shall be avoided; and sound ground shall be selected.

On the item 3.;

In case the raw water transmission main is located above the hydraulic gradient, the flow of water is hindered due to the separation and detention of air in the water main as the inside pressure becomes lower than the atmospheric pressure. In addition, if there are loose joints or cracks on the pipe body, hygienic concerns are caused as rain water or dirty water may be sucked into the water mains. Hence, the design elevations of the route of raw water transmission mains shall always be placed lower than the hydraulic gradient between the beginning and terminal points of the routes.

4.2 Raw Water Transmission Mains

4.2.1 General

The pipe type raw water transmission conduit is in general a facility, which is intended to transmit water under pressure, and composed of main pipe body, pumping facilities, and such ancillary facilities as stop and control valves, and air valves. (See Figure 4.2.1)

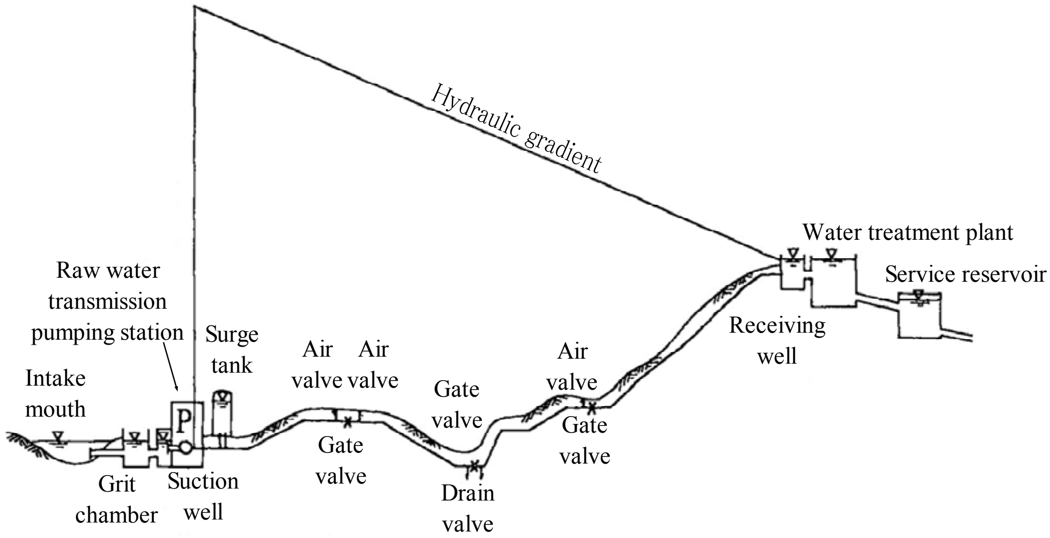


Figure 4.2.1 Schematic of a raw water transmission main

For the selection of pipe material, a material shall be chosen, which is safe for the internal and external pressure; possesses high anti-earthquake property; and suitable for laying underground.

For arranging the ancillary facilities, those which are suitable under the hydraulic condition as a water main; and favorable for their operation and maintenance shall be selected and arranged in suitable locations.

The route of raw water transmission mains shall be designed to always remain below the hydraulic gradient so that negative pressure is avoided.

4.2.2 Pipe Material

The material of the raw water transmission main shall be in conformity with 7.5.3 Pipe Material.

4.2.3 Pipe Diameter

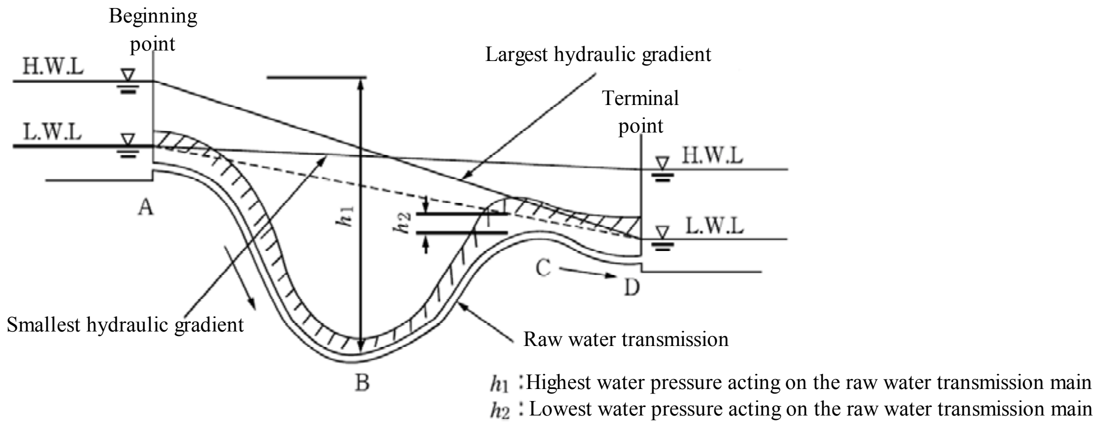
The diameter of the raw water transmission main shall be determined as follows:

1. The diameter of the raw water transmission main shall be computed based on the low water level as the water level at the beginning point of the raw water transmission main; and the design water level as its terminal level.
2. In the case of raw water transmission by pumping, the pipe diameter shall be determined in consideration of the correlation between the pipe diameter and the annual cost.

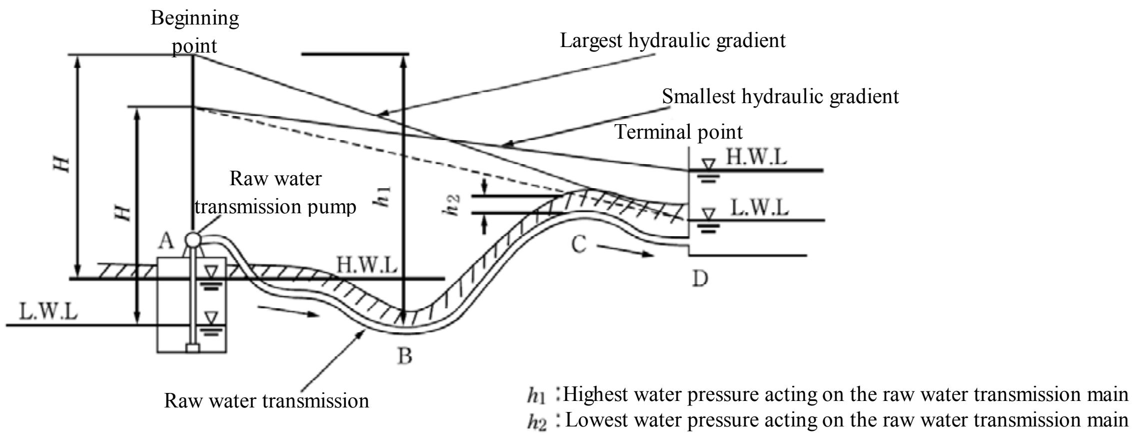
[Interpretation]

On the item 1.;

It is required for the raw water transmission main to convey the design flow of water without fail. To this end, it is safe to design the pipe diameter using the smallest probable hydraulic gradient.



(1) Raw water transmission main by gravity flow



(2) Raw water transmission main by pumping

Figure 4.2.4 Hydraulic gradient of raw water transmission main

On the item 2.;

In the case of raw water transmission by pumping, although, if the small pipe diameter is used, the pipe laying cost will be low, the lift of pumping will become large. As a result, the pumping facilities will become expensive; and the power cost of pumping will then become high, which will bring about economic disadvantage.

On the other hand, although the pump-related cost (cost of pump facilities, energy cost etc.) will be small in case the pipe diameter is set large, the cost of pipe laying will become large resulting in economic disadvantage.

Therefore, the combined annual cost of pipe laying and pump facilities and their operating expenses (the total of interests on the construction cost, depreciation of facilities and cost of operation and maintenance) is the function of pipe diameter, by which the most economical pipe diameter can be found with the lowest total costs with respect to the design raw water flow. (See Figure 4.2.5)

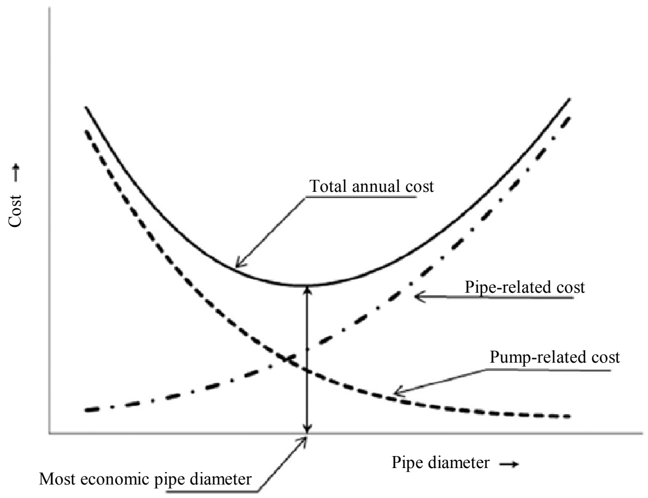


Figure 4.2.5 An Example of the relationship between the pipe diameter and the annual cost (in case the water flow is constant)

4.2.4 Flow Velocity

The flow velocity to be used for the design of a raw water transmission main shall be determined as follows:

1. In the case of the gravity flow type, the maximum flow velocity shall be 3.0 m/s or so.
2. In the case of the pumping type, the flow velocity shall be the most economic velocity.

4.2.5 Location and Depth of Pipe Laying

The location and depth of pipe laying shall be in conformity with 7.5.6 Location and Depth of Pipe Laying.

4.2.6 Pipe Laying in the Unstable Soil

1. Slope protection measures shall be undertaken for the slope shoulder, slope edge and slope surface of mountain ridge; and the drainage of surface water, seepage water and groundwater shall be considered so as to prevent the erosion and collapse of the slope.
2. In case pipe laying is carried out in sloping ground such as a steeply inclined road or slope, concrete blocks or a shielding wall shall be provided to prevent the moving of the pipe and the wash-away of soil.
3. In case pipe laying is undertaken where the topography or the nature of soil is abruptly changes, in embankment or in soft ground, pipe material and joint, with which uneven sinking of soil can be dealt with, shall be selected. In addition, measures for the improvement of soil to restrain the subsidence of pipe shall be implemented if required.
4. Appropriate pipe materials and joints shall be selected in the soil, in which liquefaction can be expected, and, what is more, improvement of soil shall be undertaken.

4.2.7 Junction Well

The junction well of the raw water transmission main shall be in conformity with the following:

1. The junction well shall have a safe structure as well as enough water-tightness, resistance to earthquake and durability; and retention time of more than 1.5 minutes equivalent of the design raw water transmission flow.
2. In case the influent velocity is excessively high, an overflow weir shall be installed; or, in case the influent water pressure is excessively high, a pressure control valve shall be installed if required.
3. The elevation of the center of the outlet mouth shall be twice the outlet pipe diameter lower than the low water level.
4. Such ancillary facilities as overflow pipe etc shall be installed if required.

[Interpretation]

On the item 1.;

The primary purpose of the junction well, which is built on the route of the water main, is to control the water pressure in the main. Hence its location shall be determined in synthetic consideration of the water pressure acting on the water main and other hydraulic conditions. A drainage channel shall be provided for the junction well.

The volume of the junction well shall be 1.5 minutes equivalent of the design raw water transmission flow so as to control the water pressure and absorb the fluctuation of water surface for smooth water transmission. It is desirable that its water depth is 3.0 to 5.0 m. The minimum water surface of the well shall be 10 m2 or so since the water surface becomes small when the design raw water transmission flow is small, so it cannot absorb the water surface fluctuation.

On the item 3.;

When the outlet mouth is close to the low water level, air is drawn to the water main, which will reduce the transmission capacity of the water main, to prevent such a situation, the center of the outlet mouth shall be set twice the outlet pipe diameter lower than the low water level.

4.2.8 Ancillary Facilities

The ancillary facilities of the raw water transmission main shall be in conformity with the following:

1. Valves shall be installed at the beginning, terminal and other necessary points on the raw water transmission main.
2. Air valves shall be in conformity with 7.6.3 Air Valves.
3. Drainage facilities shall be in conformity with 7.6.7 Drainage Facilities.
4. Manholes for inspection shall be provided on the water main according to the need.

[Interpretation]

On the item 1.;

Valves shall be installed at the beginning and terminal points of the water main, at the junction well, both ends of inverted siphon, water main bridge etc.; and it is desirable to install them every 1 km to 3 km on the water main in the case of a long water main.

On the item 2.;

The dynamic water pressure at the air valve shall be higher than 0.05 MPa.

4.2.9 Water Mains Protection Facilities

The protection facilities of the raw water transmission main against water hummer shall be in conformity with 8.2.8 Water Hummer.

8.2.8 Water Hummer

The following points shall be considered regarding water hummer occurring in a pumping facility:

1. It shall be examined whether or not water hummer occurs at the time of abrupt stop of a pump.
2. Countermeasures shall be provided against water hummer if there is a risk of water hummer to occur.

4.2.10 Expansion Joints

The expansion joints of the raw water transmission main shall be in conformity with 7.5.7 Expansion Joints.

4.2.11 Foundation of the Water Main

Foundation of the raw water transmission main shall be in conformity with 7.5.8 Foundation of Water Mains.

4.2.12 Protection of Special Fittings

The protection of special fittings shall be in conformity with 7.5.9 Protection of Special Fittings.

4.2.13 Erosion Prevention of Outside Wall of the Water Main

Erosion prevention of the outside wall of the raw water transmission main shall be in conformity with 7.5.11 Erosion Prevention of Outside Wall of the Water Main.

4.2.14 Water Pressure Test

Water pressure test of the raw water transmission main shall be carried out in accordance with 7.5.12 Water Pressure Test.

4.2.15 Water Main Bridge and Bridge-Piggybacked Water Main

The water main bridge and bridge-piggybacked water main shall be in conformity with 7.5.14 Water Main Bridge and Bridge-Piggybacked Water Main

4.2.16 Inverted Siphon

Inverted siphons of the raw water transmission main shall be in conformity with 7.5.15 Inverted Siphon.

4.2.17 Pipe Jacking Method

The pipe jacking method of the raw water transmission main shall be in conformity with 7.5.16 Pipe Jacking Method.

4.2.18 Shield Driving Method

The shield driving method of the raw water transmission main shall be in conformity with 7.5.17 Shield Driving Method.

4.2.19 Pump Facilities

Pump facilities of the raw water transmission main shall be in conformity with 8.2 Pump Facilities.

4.3 Raw Water Transmission Channel

4.3.1 General

The raw water transmission channel is defined as a facility which conveys water from the water intake facilities to the water treatment facilities.

There are an open channel, culvert, tunnel etc. as the structure of the raw water transmission channel, which convey s water by a certain hydraulic gradient (1/1,000 – 1/3,000).

The raw water transmission channel shall be able to safely convey the required quantity of raw water. Besides, to convey the design raw water transmission flow, its shape and structure shall be designed taking into account topography, geography and soil condition after synthetically judging from the economic benefits based on land cost, construction cost, the ease of operation and maintenance, and the safety against disasters.

4.3.2 Type and Structure

The type and structure of the raw water transmission channel shall be in conformity with the following:

1. The raw water transmission channel shall be structurally safe, and possess sufficient water-tightness, resistance to earthquakes, and durability.
2. The raw water transmission channel may be a culvert depending on the needs. In case it is unavoidably shaped as an open channel due to a large cross section is required or the like, measures for the prevention of pollution and safety shall be undertaken.
3. Expansion joints shall be installed every 20 m to 30 m or so along the open channel and culvert.
4. At points where ground formation changes, and both ends of a water main bridge, weir, gate etc. expansion joints with flexibility shall be provided.
5. Ventilation holes shall be provided for the culvert.

[Interpretation]

The raw water transmission channels are classified as shown in Figure 4.3.1 according to the quantity of raw water transmission.

Figure 4.3.1 (1) indicates a common type of a raw water transmission channel in case the raw water transmission flow is small.

Figure 4.3.1 (2) shows a common type of a small raw water transmission channel in case there is a low risk of collapse of soil from the sides of the channel and pollution.

Figure 4.3.1 (3) denotes a raw water transmission channel with twin cross sections in consideration of operation and maintenance and structural condition. The type is advantageous when one of the pair is inspected and so forth while the other one is in use.

Figure 4.3.1 (4) represents a type which has a hydraulic advantage. It is commonly employed in case the raw water transmission flow is large.

Figure 4.3.1 (5) stands for a common cross section of a tunnel. The horse shoe type section is generally used for a free-surface tunnel. Since the larger the radius of the tunnel side wall, the easier the construction work, the wall may be shaped vertical or in a nearly vertical radius.

Figure 4.3.1 (6) is a cross section of a shield tunnel.

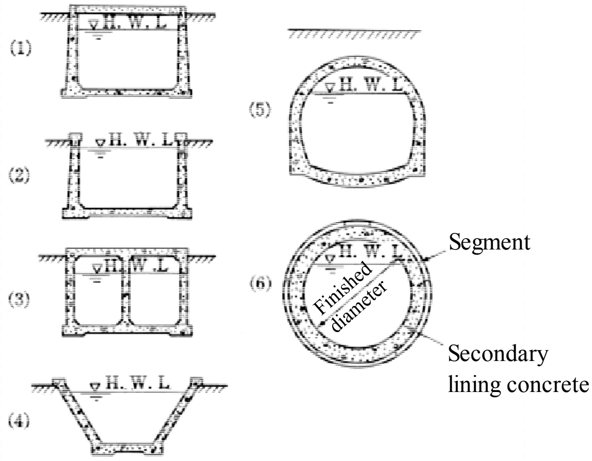


Figure 4.3.1 Types of cross section of raw water transmission channels

On the item 1.;

The open channel or culvert shall be structured by reinforced concrete or plain concrete so that smooth water flow, prevention of turbidity and avoidance of scouring of the inside wall of the channel are secured.

4.3.3 Flow Velocity

The maximum allowable average flow velocity in the raw water transmission channel shall be 3.0 m/s or so and its minimum limit shall be 0.3 m/s or so.

[Interpretation]

Since the raw water transmission channel is in general made of concrete, the maximum allowable average flow velocity in it is set at 3.0 m/s or so taking into consideration the attrition of the inside wall of the channel by flowing sand based on the past experiences. On the other hand, the minimum flow velocity is set at about 0.3 m/s so that small grains of sand would not settle in the channel.

The average flow velocity is defined as follows:

$$\text{Average flow velocity} = \frac{\text{Design raw water transmission flow}}{\text{Water cross section of the channel}}$$

4.3.4 Junction Well

The junction well of the raw water transmission channel shall be in conformity with the following:

1. The junction well shall be structurally safe, and possess sufficient water-tightness, resistance to earthquake, durability, and volume with which flow of the design raw water transmission flow is not hindered.
2. The junction well shall be installed at the point where the structure of the raw water transmission channel changes such as a point where an open channel is connected to a culvert and so forth.
3. Ancillary facilities such as a spillway shall be provided if needed.

[Interpretation]

The junction well of the raw water transmission channel shall be installed at a point where the channel changes structurally so that it absorbs fluctuation of water level, and makes the flow smooth and its structure shall not cause excessive swirling currents or short-circuiting currents.

On the item 1.;

The junction well shall be structurally safe, and possess sufficient water-tightness, resistance to earthquake, durability, and volume with which flow of the design raw water transmission flow is not hindered; and its size shall be determined based on the size of the channel, to which the junction well is connected, the ease of access by man, and the type of the spillway which is installed on the channel.

4.3.5 Ancillary Facilities

Ancillary facilities of the raw water transmission channel shall be installed in accordance with the following:

1. Gates or flashboards and a manhole shall be provided at the beginning and terminal points and other necessary points of the raw water transmission channel.
2. Spillways shall be provided along the raw water transmission channel if needed.
3. In the case of the open channel, inspection paths shall be provided in the premises of the channel etc.
4. In the case of the open channel, screens shall be installed to prevent the transportation of fallen leaves etc. through the channel.

[Interpretation]

On the item 1.;

At the required locations such as the beginning and terminal points of the raw water transmission channel, a long tunnel, an inverted siphon etc. gates and/or flashboards shall be provided; and large enough manholes shall be provided on culverts for the purposes of inspection, repair, cleaning etc.

The gate shall be strong and durable; and its operation shall be motorized or manually handled at the time of power failure and so forth.

On the item 2.;

To secure the safety of the raw water transmission channel, such a spillway as the lateral overflow weir will drain surplus water to suppress the rise in the water level in the channel at the times when an excessive amount of water temporarily flows in due to heavy rain, and when the gate is closed because of an accident etc. which would occur downstream of the channel.

4.3.6 Raw Water Transmission Tunnel

The raw water transmission tunnel shall be in conformity with the following:

1. Design of a tunnel through a mountain range shall be in conformity with the STANDARD SPECIFICATIONS FOR TUNNELING -2006: Mountain Tunnels, the Japan Society of Civil Engineers.
2. Design of a shield tunnel shall be in conformity with STANDARD SPECIFICATIONS FOR TUNNELING -2006: Shield Tunnels, the Japan Society of Civil Engineers, and 7.5.17 Shield Driving Method.

4.3.7 Aqueduct Bridge

The aqueduct bridge shall be in conformity with the following:

1. The aqueduct bridge shall be structurally safe; and the aqueduct shall possess sufficient water-tightness, resistance to earthquake and durability.
2. Effective expansion joints shall be provided so as to cope with relative displacements which would be caused by the change in temperature, uneven subsidence, earthquake etc.
3. The clearance beneath the girders shall be determined according to the clearance limit rule and other related laws.

[Interpretation]

On the item 1.;

In case the raw water transmission channel crosses a deep valley or a river, a bridge may be constructed to piggyback a channel to convey water.

The structure of the bridge is to be reinforced concrete, steel or prestressed concrete etc. The channel shall have water-tightness, resistance to earthquake and durability.

The type of the structure of the bridge may be simple girder, rahmen, continuous beam etc. The channel is in general considered a bridge girder.

When planning and designing an aqueduct bridge, its harmony with the landscape and environment shall also be taken into account.

Figure 4.3.3 shows an example of the aqueduct bridge.

The aqueduct bridge shall be safe against such load as its dead weight, weight of water, wind pressure, earthquake etc. It is safer for the bridge to possess shorter trave (span) of girders than the road bridge or the railway bridge since the weight of water acts on the bridge as dead weight for a long time.

On the item 2.;

Water-tight expansion joints shall be fit in the vicinity of the jointing points of the aqueduct bridge with the channel, and movable supports to absorb various relative displacements caused by temperature changes, uneven subsidence and earthquake.

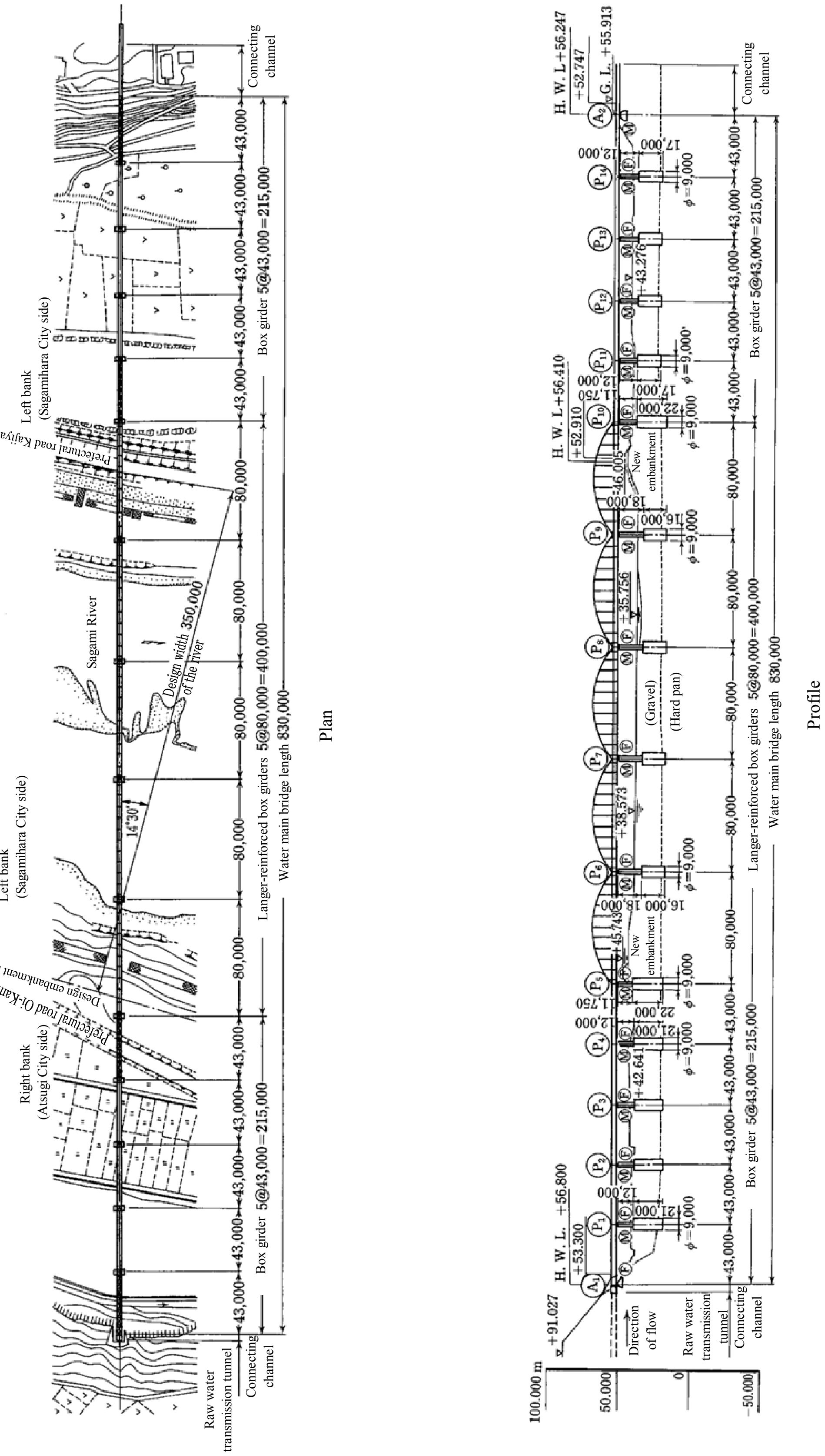


Figure 4.3.3 An example of the aqueduct bridge (Sagamigawa Aqueduct Bridge, Kanagawa Prefectural Water Authority) (Unit: mm)

4.4 Raw Water Regulating Reservoir

When building a raw water regulating reservoir, the following points shall be taken into account:

1. The raw water regulating reservoir shall be installed in-between the water intake facilities and the water treatment facilities.
2. Its capacity shall be appropriate in consideration of draughts, accidents related to water quality etc.
3. Such ancillary facilities as pumps etc. shall be installed if required.
4. Measures against water pollution and prevention of hazards shall be undertaken if required.

[Interpretation]

In accordance with the nature of the city and characteristics of the region, the raw water regulating reservoir is built as part of the raw water transmission facilities in order to mitigate as much as possible the effect of suspension and restriction of water service at the times of suspension or restricted raw water abstraction in the case of draught or an accident related to water quality, repair of the water intake facilities etc.

Specifically speaking, raw water is stored in a raw water regulating reservoir as the difference between the water demand and the allowable intake quantity depending on the season or meteorological conditions, and the water is released to make up the shortage only at the times of draught or water pollution as a measure for better water service management.

As examples of the provision of the raw water regulating reservoir, the outline of its facilities, the purpose of installation and its effects are illustrated in Table 4.4.1.

Table 4.4.1 Examples of the Raw Water Regulating Reservoir

Name of water utility	Name of facility	Outline of facility	Purpose and result
Tokyo Metropolis	Mitake-san raw water regulating reservoir	○Design intake flow: 277m^3/day ○Effective capacity: 1,000 m^3 (equivalent to 13 days of flow) ○Structure: Half-buried, fabricated with pre-cast panels	(Purpose) The water source in this area is heavily dependent on precipitation. Water production is affluent in summer while it is short in winter (Dec. – Mar.) when rainfall is small. The demand peak coincides with the high demand by tourism as the characteristic of the area. Thus an increase in water demand is expected in future with respect to the development of the area. To this end the raw water regulating reservoir was built to secure reliable water service throughout the year including the winter season. (Effectiveness) Reliable water service has become available.
Takamatsu City	Goten reservoir	○Design intake flow: 2,000m^3/day ○Effective capacity 524,000 m^3 (equivalent to 19 days of flow) ○Structure: Earth dam with a center core	(Purpose) To cope with the water shortage for the Goten water treatment plant, it stores, as raw water regulating reservoir, infiltrated raw water from Katou River (built in 1954). (Effectiveness) It is always used as the water source for the Goten water treatment plant, and plays a role of a raw water regulating reservoir to secure reliable distribution flow in the period when the yield from Katou River becomes short and during drought.
Kitami City	Kitami City Hirosato water treatment plant retention reservoir	○Design intake flow: 67,580m^3/day ○Effective capacity 28,000 m^3 (equivalent to 14 hours of flow) ○Structure: PC	(Purpose) It enhances the treatment efficiency when treating raw water of unstable quality, and makes it possible to avoid suspension of operation even at the time of high raw water turbidity. (Effectiveness) As the retention reservoir secures 14 hours of allowance for raw water intake, it is possible to set the maximum limit of turbidity low (presently 200 turbidity units). Reliable water service has become possible with proper allowance even at the time of high turbidity, and degraded water quality caused by ammonia, oil etc.

6. Treated Water Transmission Facilities

6.1 General

6.1.1 Basic Items

1. Role of the Treated Water Transmission Facilities and their Structure

The treated water transmission facilities are the facilities which convey water from the water treatment plant to the service reservoir, and consist of the treated water transmission main, the transmission pump, the regulating reservoir, such ancillary facilities as valves etc. As a general rule, the treated water transmission facilities shall be composed of pipe for the safety of treated water.

There are three types of the treated water transmission, namely, the gravity flow type, the pumped type and the combined type depending on the difference between the elevations of the water treatment facilities and that of the distribution facilities, and the topography and geography between them.

The treated water transmission facilities are required to be reliable enough so that lives of consumers shall not be severely threatened not only at normal times but even in such an emergency as accidents, droughts and so forth.

Therefore, their location and structure shall be chosen based on a careful study on topography and soil condition, after due consideration of elevations of water supply facilities situated upstream and downstream of them, the treated water transmission method suitable for the required transmission flow, assurance of safety against earthquake, wind- and flood-related damages etc. and so forth.

2. Points of Attention for the Improvement of Facilities

In case there is only a single system from the water treatment plant to the service reservoir, the reliability of the facilities shall be enhanced by such a measure as doubling the transmission mains and so forth taking into account their future replacement, the influence of an accident etc.

In case there are more than two service reservoirs, interconnecting mains shall be laid between them, and the transmission flow and the diameter of each transmission main, the flow in the interconnecting mains and their diameters shall properly be determined in preparation for accidents of the treated water transmission mains.

3. Considerations to Operation and Maintenance

For design of the treated water transmission facilities, considerations are required to not only safe and sound construction work but also the ease of operation and maintenance of facilities after their completion.

(1). In case there is a plan on a multi-purpose utility tunnel which is to cross a river, railway etc., participation to the plan shall be considered.

(2). Risk distribution shall be considered by doubling of water mains.

(3). Such ancillary facilities as valves, air valves, drainage pipe etc. shall be provided so as to make operation and maintenance easy.

(4). Manholes shall be installed at both ends of the inverted siphon for a treated water transmission main with a diameter of 800 mm or larger. The installation of manholes shall be in conformity with 7.6.8 Manholes.

6.1.2 Design Treated Water Transmission Flow

As a general rule, the design treated water transmission flow shall be based on the design maximum daily supply.

[Interpretation]

The design treated water transmission flow shall be set in accordance with the following:

1) The design treated water transmission flow shall be set as the design maximum daily supply in the design year under the master plan.

2) In case there are more than two water treatment plants and service reservoirs, the design flow in each treated water transmission main shall be set so that the rational management of water supply becomes possible in the entire service area.

3) In case there are more than two service reservoirs, the design treated water transmission flow shall be able to not only cope with the design treated water transmission flow to be handled by the transmission main of the respective system, but be able to supply water to other systems in an emergency.

6.1.3 Type of Treated Water Transmission

The most desirable type of treated water transmission shall be chosen after comparison of the difference between the elevations of water treatment plant and the service reservoir, the design treated water transmission flow and the geographical situation of the route of the transmission main.

[Interpretation]

The types of treated water transmission include the gravity flow type, pumping type and their combination in accordance with the difference in elevations between the water treatment plant and the service reservoir.

In case difference in elevations between the water treatment plant and the service reservoir is sufficient to convey water, the gravity flow type is in general employed because of its high reliability, the ease of operation and maintenance, no need of energy cost etc.

In case the water treatment plant is situated at lower elevation than the service reservoir, or the difference in elevations is insufficient, the pumping type shall be employed. In either case, it shall be practiced to always avoid negative pressure in the treated water transmission main.

6.2 Treated Water Transmission Main

6.2.1 General

When planning the treated water transmission main, a pipe material shall be selected, which is safe against load of water pressure, earth load at normal times and at a time of earthquake, or deformation caused thereby, and fits the buried environment; and a location with good quality of soil shall be chosen for its laying. In order to save energy, a route of the transmission main, which will make gravity flow possible, and with which the elevation of the main will be lower than the minimum hydraulic gradient, shall be selected as much as possible.

6.2.2 Pipe Material

The material of the treated water transmission main shall be in conformity with 7.5.3 Pipe Material.

6.2.3 Pipe Diameter

The diameter of the treated water transmission main shall be in conformity with 4.2.3 Pipe Diameter.

6.2.4 Flow Velocity

The flow velocity in the treated water transmission main shall be in conformity with 4.2.4 Flow Velocity.

6.2.5 Location and Depth of Pipe Laying

The location and depth of pipe laying shall be in conformity with 7.5.6 Location and Depth of Pipe Laying.

6.2.6 Pipe Laying in Unstable Soil

Laying of the treated water transmission main in unstable soil shall be in conformity with 4.2.6 Pipe Laying in Unstable Soil.

6.2.7 Ancillary Facilities

Ancillary facilities of the treated water transmission main shall be in conformity with 7.6 Ancillary Facilities.

6.2.8 Water Mains Protection Facilities

The protection facilities of the treated water transmission main shall be in conformity with 8.2.8 Water Hummer.

8.2.8 Water Hummer

As to water hummer of the pump system, the following points shall be taken into consideration:

1. It shall be examined whether or not water hummer occurs at the time of abrupt stop of a pump.
2. Where water hummer is expected to occur, measures for its reduction shall be considered.

6.2.9 Expansion Joints

The expansion joints of the treated water transmission main shall be in conformity with 7.5.7 Expansion Joints.

6.2.10 Foundation of the Water Main

Foundation of the treated water transmission main shall be in conformity with 7.5.8 Foundation of the Water Main.

6.2.11 Protection of Special Fittings

The protection of special fittings shall be in conformity with 7.5.9 Protection of Special Fittings.

6.2.12 Erosion prevention of Outside Wall of the Water Main

Erosion prevention of outside wall of the treated water transmission main shall be in conformity with 7.5.11 Erosion Prevention of the Outside Wall of the Water Main.

6.2.13 Water Pressure Test

Water pressure test of the treated water transmission main shall be carried out in accordance with 7.5.12 Water Pressure Test.

6.2.14 Water Main Bridge and Bridge-Piggybacked Water Main

The water main bridge and bridge-piggybacked water main of the treated water transmission main shall be in conformity with 7.5.14 Water Main Bridge and Bridge-piggybacked Water Main.

6.2.15 Inverted Siphon

Inverted siphons of the treated water transmission main shall be in conformity with 7.5.15 Inverted Siphon.

6.2.16 Treated Water Transmission Main on Sea Bed

The treated water transmission main on the sea bed shall be in conformity with the following:

1. The selection of the location of the treated water transmission main on the sea bed shall be based on the result of a preliminary study on the entire area of mains laying.
2. The pipe shall possess a structure, which is safe against the load expected at the time of laying, various loads after laying, lifting pressure and buoyancy, and have sufficient strength.
3. As a general rule, it shall be buried under the sea bed, and protected by such a cover as concrete blocks if needed.

6.2.17 Pipe Jacking Method

The pipe jacking method of the treated water transmission main shall be in conformity with 7.5.16 Pipe Jacking Method.

6.2.18 Shield Driving Method

The shield driving method of the treated water transmission main shall be in conformity with 7.5.17 Shield Driving Method.

6.2.19 Pump Facilities

Pump facilities of the treated water transmission main shall be in conformity with 8.2 Pump Facilities.

[Interpretation]

The pump facilities, which convey water from the water treatment plant to the service reservoir, shall cope with the varying quantity of the treated water transmission flow. In addition, measures against water hummer such as a surge tank to prevent the damage to the mains at the time of sudden stop of pumps shall be provided if needed.

The pump well shall have enough capacity to provide sufficient thrusting and suction heads based on careful examination of the pumping flow and the inflow into the well. Besides, the well can be divided into two or more sections in consideration of the ease of such operation and maintenance work as cleaning, repair etc.

6.3 Regulating Reservoir

It is desirable for the bulk water supplier to provide a regulating reservoir with an appropriate volume based on consultation with its customers on the situation related to their provision of service reservoirs and their future development plans.

[Interpretation]

The regulating reservoir denotes a reservoir built by the bulk water supplier within the treated water transmission facilities or at the end thereof to store water and regulate the operation of water transmission or cope with the need in an emergency.

In order to reliably transmit water at normal times, the regulating reservoir shall possess a sufficient volume with which the bulk water supplier can cope with the fluctuation of demand by its customers; and to deal with an emergency, the storage of the regulating reservoir shall have enough capacity so that the quantity of water transmission can be sustained even at the times of drought, water pollution at the source, power failure and so forth.

Although the volume of the regulating reservoir is in the range of 1 to 10 hours or so of the design water transmission flow by experience, it shall be determined with certain allowance in consideration of the volume of service reservoirs of the customers, and their future development plans in addition to hourly fluctuation of transmission water flow, the operation in an emergency etc.

7. Distribution Facilities

7.1 General

7.1.1 Basic Items

The distribution facilities have functions of the storage, transmission, distribution and supply of treated water, and are composed of the service reservoir, stand pipe, elevated reservoir (hereinafter the service reservoir etc.), distribution mains, pump, valve, and other ancillary facilities.

The distribution facilities need to be laid out in accordance with a rational plan, can continuously and reliably supply water, of which demand fluctuates over time, under appropriate pressure; and their operation and maintenance shall be efficient and easy. What is more, due consideration is required to maintain the quality of treated water so as to avoid its pollution or a change in its quality. Besides, a layout of the distribution facilities in consideration of water supply for firefighting is also important.

Since the distribution facilities are laid out over an especially wide area among water supply facilities, and are under complex and versatile natural environment; the safety of water service needs to be strengthened through their renovation and replacement as planned because frequent failures and accidents shall be expected due to a change in their function and capacity as they age.

The outline of basic items for planning and design of the distribution facilities are as follows:

1. Security against the earthquake

2. Provision of service reservoir etc.

The service reservoir possesses the function to absorb the hourly fluctuation in distribution flow, and plays a large role to eliminate or reduce the influence of an emergency to consumers utilizing its storage. Given this, the service reservoir etc. shall properly be constructed after studying on their layout, capacity, structure and so forth from view points of not only reliable water service at normal times but in an emergency.

1) The selection of the layout of the service reservoir etc. shall be made in or in the vicinity of the service area on an elevated location which is advantageous for distribution.

2) The standard volume of the service reservoir etc. shall be 12 hours equivalent of the design maximum daily supply in consideration of the volume needed for adjusting the hourly fluctuation in demand, the quantity required to cope with an emergency, and the amount necessary for firefighting.

3) The structure of the service reservoir etc. shall be selected taking into account the assurance of durability, resistance to earthquake, water-tightness and so on. Solid foundation shall be chosen for their construction as much as possible.

3. Laying of Distribution Mains

It is required for the distribution mains to have the function of conveying, distributing and serving treated water; reliably supply water under appropriate water pressure at normal times; and be capable of continuing supply even in an emergency. Since the large portion of the distribution facilities are composed of distribution mains laid out as a reticulation, it is important for them to be so laid and structured that their operation and maintenance are easy and that the quality of water in the mains is well maintained.

The distribution mains are classified into the distribution trunk main and the distribution submain. The distribution trunk main has the function to convey water to distribution submains, and is not fit with service connections whereas the distribution submain plays the role of serving water to the customers through service connections branching from it.

The items to be considered when laying distribution mains are the following:

1) General Items

[1] Necessary measures shall be provided so that negative pressure is not caused inside the distribution main.

[2] Earthquake-resistant pipe material and joints shall be selected; and anti-corrosion measures shall be provided if required.

[3] Valves etc. shall be installed so that the influence of the suspension of service etc. in an emergency can be restricted to as a small area as possible.

[4] In consideration of direct connection service etc., which is becoming popular, the minimum water pressure shall be determined in accordance with the characteristics of the community to be served. The datum line for the water pressure is to be set at the ground level.

[5] As for shallow-ground pipe laying, the ease of operation and maintenance, the reduction in laying cost and the policy for environmental protection shall be considered.

2) Distribution Trunk Mains

[1] Distribution trunk mains shall not be laid in a treelike form, but structured as reticulations interconnected each other as much as possible.

[2] The distribution mains shall have not only the capacity of distribution to cope with the water demand of the incumbent service area, but also certain surplus capacity to supply water to the adjoining community, and be able to backup the other area, of which trunk mains are under replacement work.

[3] It is desirable that interconnection is available with the trunk distribution mains of the other service area or a block of thereof at normal and emergency times.

[4] It is desirable that such measures be provided as double-lined principal trunk distribution mains so as to increase their reliability.

3) Distribution Submains

[1] The distribution submains shall be suitable to the topography and geography of the service area and in charge of an appropriate size of service block which forms a pipe network. Besides, layout of submains such as cul-de-sac mains etc., which cause dead water, should be avoided.

[2] Valves shall be fit on distribution submains, which connect neighboring distribution submains blocks, so that cutoff and mutual supply can be made.

[3] The appropriate minimum dynamic water pressure in the distribution mains shall be maintained at higher than 0.15 MPa at the point of tapping for service pipes. However, this condition may not apply to the case the submains are so laid that no trouble can be caused for water service even if the pressure locally falls lower than this value due to geographical characteristics. Negative pressure in the submains shall be avoided at the time of discharging water from fire hydrants. In addition, it is ideal for the minimum dynamic water pressure of 0.1 MPa or so is maintained even at the time of firefighting in consideration of the direct connection water service, which is becoming popular, and the prevention of backflow.

[4] The maximum water pressure in the submain at the point of branching of a service pipe shall not exceed 0.7 MPa. However, this condition may not apply if the service pipes are so installed that no trouble may be caused for water service even if the water pressure locally exceeds the value.

4. Provision of Ancillary Facilities

Ancillary facilities (cutoff valve, control valve, air valve, reducer valve, drainage facility, fire hydrant, flow meter, water pressure gauge etc.) shall be installed so that the distribution mains can effectively perform their function, and that their operation and maintenance can be carried out efficiently and easily.

5. Installation of Pump Facilities

Pump facilities are used in case water is distributed by pumping; water is conveyed by pumping to a service reservoir, stand pipe, elevated reservoir etc.; water is distributed by boosting the water pressure in part of the service area and so forth.

The items of consideration when installing pump facilities are as follows:

1) The capacity, number of units, type of the pumps shall be adequate for reliable distribution in accordance with hourly fluctuation of demand and operational conditions.

2) Standby units shall be provided for the pump facilities. However, this rule may not apply in case water service is not interrupted at the time of suspension of pumping.

3) In case there is a risk of water hummer to be caused by sudden stop of pumping, necessary measures shall be undertaken to abate the effect of water hummer.

6. Protection of Water Quality

The water produced in the water treatment facilities is conveyed to the taps of consumers through the distribution facilities. Therefore, although it is a matter of course to prevent the pollution from outside of the facilities, the deterioration of water quality within the facilities shall also be averted.

Water sampling points shall be provided at important locations in the distribution facilities so that inspection can be performed whether or not the treated water quality meets the water quality standards; and if the residual chlorine is in the prescribed range.

In case the reduction in the residual chlorine is anticipated, additional dosing of chlorine is needed by providing disinfection facilities at the service reservoir or in the distribution mains and so on.

The items of consideration for the protection of water quality are as follows:

1) Service Reservoir etc.

[1] An appropriate volume of the service reservoir shall be set so as to avoid excessively long retention time. Since water quality may get deteriorated; or disinfection byproducts such as trihalomethanes etc. may increase due to long retention time, the service reservoir shall have an appropriate volume in accordance with the size of the service area and the condition of water mains reticulation.

[2] Locations of the inlet and outlet mouths of the service reservoir shall be determined so as not to cause dead water and short-circuiting; and partition walls and/or guide walls etc. shall be provided if needed.

[3] Material and coating of pipes and such ancillary facilities as hardware, which come in contact with treated water, shall be in conformity with the elution standard prescribed in the Ordinance to

provide Technical Guidelines for Water Supply Facilities (Ministry of Health, Labor and Welfare Ordinance No. 15, [2001]) (hereinafter The ordinance to provide technical guidelines), and shall not cause adverse effects to water quality.

[4] In case coating for water proofing and corrosion control of the inside wall of the service reservoir is needed, materials for such work, which do not give adverse effects to water quality, shall be used.

2) Distribution Mains

[1] Appropriate diameters of distribution mains shall be used so that excessively long retention time in the mains is avoided.

[2] A drain facility shall be provided at the cul-de-sac submain, which does not form a reticulation since it may cause deterioration in water quality.

[3] Distribution mains, of which inside wall is not lined, or coating and lining have been deteriorated due to superannuation, shall be rehabilitated or replaced on schedule since they will cause red water due to rust etc.

[4] Drainage facilities shall be provided so that cleaning of the distribution main by flashing and drainage can be carried out at such a suitable location as the vicinity of a river etc. Careful enough laying of distribution mains shall be undertaken to avoid the contamination of the mains with soil etc.

7. Management of Data and Information

Management of data and information shall be provided by a system with which accurate and speedy data processing can be carried out; addition and collection of data can be made, and long-term and reliable storage of data is possible.

Commonly used methods of management of data and information include management drawings, information register, computerized mapping system and so on.

7.1.2 Setting of the Service Area

The service area shall be set in consideration of such natural conditions as topography and geography and social requirements so that rational and economic operation and maintenance of the facilities can be carried out.

[Interpretation]

The service area is in general formed mainly based on the service reservoir, distribution mains network etc.

As the principle of setting a service area, continuous and reliable water service can be assured under appropriate water pressure corresponding to the variation of demand in normal times; and the effect to water service is kept to a minimum even in an emergency. To this end, the service area shall be divided into subareas with appropriate sizes. When setting a service area, such a social condition as actual water demand etc., such natural conditions as topography and geography, locations of water sources and the water treatment plant and so forth shall be taken into account; and rational and economic management of water and facilities can be made mutually between service areas. Division of service area into the high zone, low zone etc. may be needed according to the elevation of the respective areas in case there is a lot of undulation in the service area.

Since the service area may still be pretty large in many cases even setting it in consideration of various conditions, it may unavoidably have subareas situated at different elevations. For that reason, such problems may tend to accrue as operation and maintenance of water mains may be complex; adequate operation cannot be undertaken in an emergency; appropriate integration of the existing facilities with the new ones cannot be insured at the time of development planning and so forth.

To solve such issues, it is useful to further divide the service area into small blocks and operate them block by block. In general the block includes the distribution block, which is formed with distribution trunk mains by dividing the service area horizontally and vertically; and the distribution submains network blocks. (See Figure 7.1.1)

The merits of division of the service area in blocks are as follows:

1. Easy recognition of the present condition

1) Appropriate installation of monitoring devices is possible; and acquisition of data and information on water management (flow, water pressure, flow direction, water quality etc.) is easy. In addition, collection, management and analysis of data and information will become easy.

2) The fluctuation of water demand can be recognized block by block, which makes estimate of the demand easy.

3) Laying of distribution mains under a new, improvement or replacement scheme can be undertaken rationally on schedule.

2. Improvement in distribution management and operation and maintenance at normal times

1) Control of water pressure, water flow management and water quality control will become easy,

2) Water pressure reduction and increase in respective service subareas can rationally be set; facilities for such operation can efficiently be used; and energy saving in operation can be achieved.

3) Locations and quantities of water leakage can easily be grasped; and water leakage detection will be performed efficiently. Especially, the area, in which water service is suspended at the time of repair of leaks, can be minimized.

3. Improved operation in an emergency

1) By means of mutual water supply between the blocks, operation to cope with disasters and accidents will become easy.

2) Close identification of the area of the disaster and accident and its understanding can be made. Furthermore, estimate in advance of the effect of the disaster and accident can be made.

3) Quick restoration after the disaster and accident can be undertaken.

4. Others

1) Since adequate control of water pressure and quantity can be made, it will become easy to introduce and expand the area for direct connection water service.

2) By understanding the quantity of water consumption block by block, analyses of quantity of distribution will efficiently be made.

When planning and implementing the block system, attention shall be paid to such issues and problems to be addressed as the occurrence of dead water and drop in residual chlorine at the boundaries of the blocks; occurrence of red water at the time of setting blocks; expenses for laying of water mains network and installation of monitoring devices and so on.

The number of points of inlet to the block shall be 1 to 3 or so in consideration of the size of the block, operation required in an emergency etc. so that control of water quantity, pressure and quality is sound and easy.

In the cases of small water supplies and simple distribution reticulations, such operation is often more rational than dividing the distribution submains network into small blocks as setting the block in accordance with elevations, or setting small blocks where water pressure boosting or reduction are locally made.

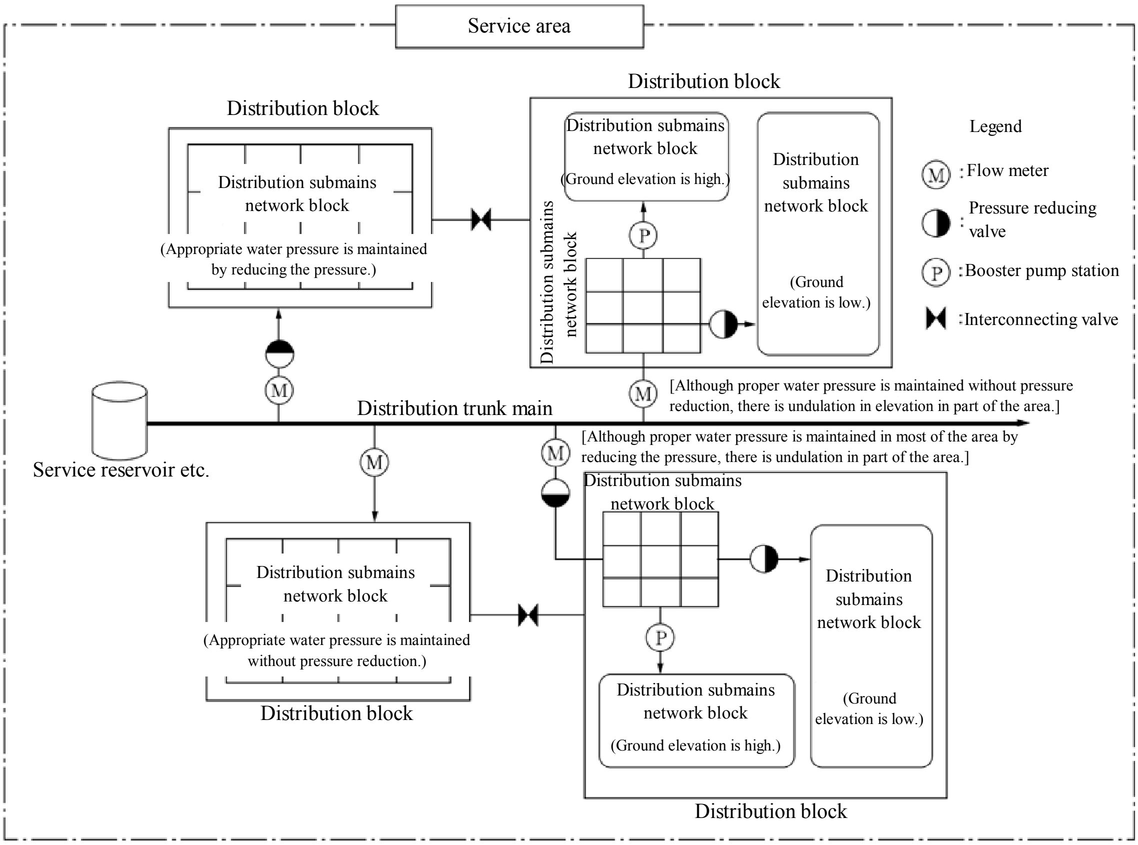


Figure 7.1.1 Illustrated Concept of Division of Service Area into Blocks

7.1.3 Design Distribution Flow

The design distribution flow shall as the general rule be the design maximum hourly distribution flow in the service area in question.

[Interpretation]

The design distribution flow is presented by the water flow per hour, and corresponds to the maximum hourly distribution flow in the day with the maximum daily distribution flow in the design service area to be assigned to the respective distribution main.

The design maximum hourly distribution flow is determined as the average hourly distribution flow in the day with the maximum daily distribution flow multiplied by a time coefficient assuming that the design population served in the service area uses the maximum quantity of water in the time zone in question.

The formula to compute the design maximum hourly distribution flow is the following:

$$q = K \times \frac{Q}{24}$$

Where

q: Design maximum hourly distribution flow (m^3/hr)

Q: Design maximum daily distribution flow (m^3/day)

$\frac{Q}{24}$: Average hourly distribution flow (m^3/hr)

K: Time coefficient (The ratio of the design maximum hourly distribution flow to the average hourly flow. See 7.1.4 Time Coefficient)

The design maximum hourly distribution flow is the base for determining the diameter of the distribution main, by which hydraulic calculation is carried out; and the diameter is calculated in consideration that appropriate dynamic water pressure is maintained; that distribution of water pressure in the main is as uniform as possible; and that flow velocity in the main is suitable.

It is required for the dynamic water pressure at the point, where tapping for service pipes is made, to be higher than 0.15 MPa; and, in case direct connection water service for houses of more than three stories is implemented, higher dynamic water pressure in the main than this is required.

The effect of the firefighting water flow is large in the cases of a small water supply and an area where the quantity of distribution is small, the diameter of distribution mains is, in a case, determined by the distribution flow at the time of firefighting. See 7.1.5 "Water Quantity for Firefighting" as to design of distribution mains in consideration of water flow for firefighting.

7.1.4 Time Coefficient

The time coefficient as the base of the design maximum hourly distribution flow is determined with reference to the experiences or the condition in the region with similar characteristics.

[Interpretation]

According to the experience, the time coefficient varies in regard to the fluctuation of population at day and night, demand patterns of factories, businesses etc., and has the tendency to become small as the maximum daily water supply becomes large.

Figure 7.1.2 (1) – (5) indicates the experience (in summer of 2008) with the relationship between the quantity of distribution in 411 distribution areas in the service areas of 46 water supplies and the time coefficient (K).

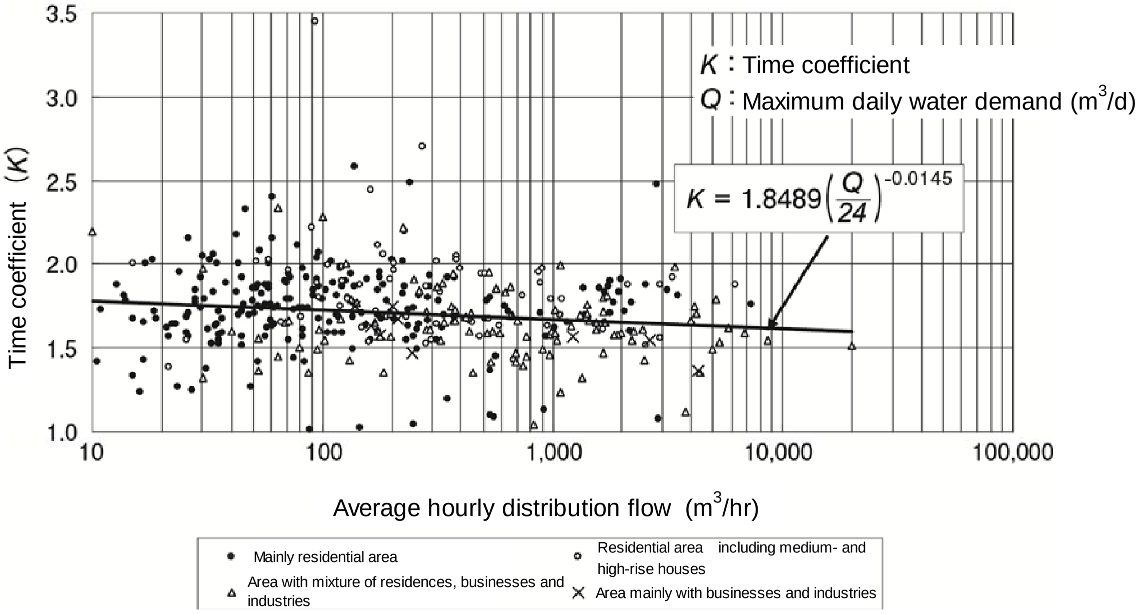


Figure 7.1.2 (1) Average hourly distribution flow and time coefficient (in 411 service areas of 46 cities)

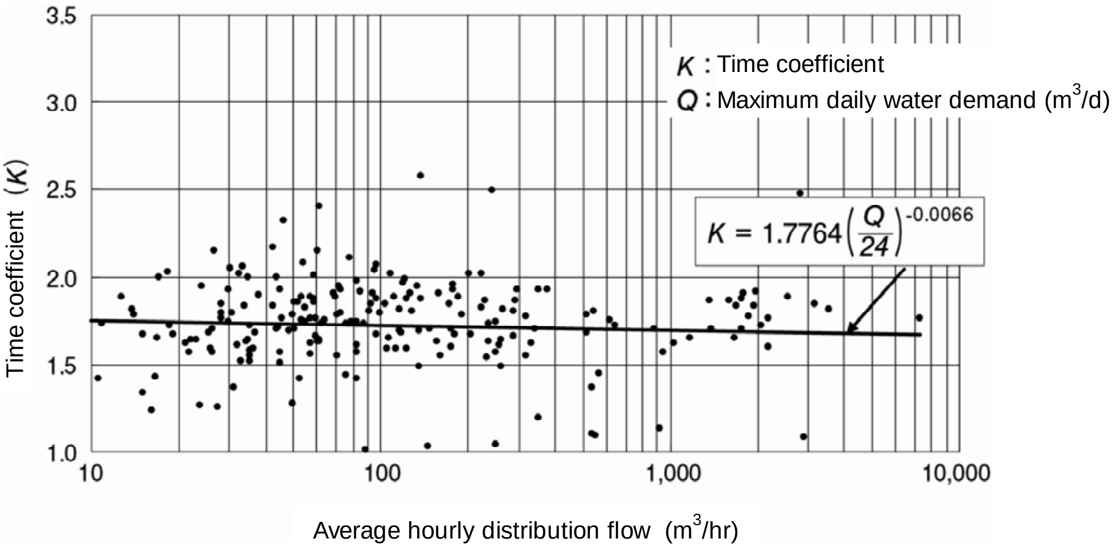


Figure 7.1.2 (2) Average hourly distribution flow mainly in a residential area and the time coefficient (in 227 service areas of 32 cities)

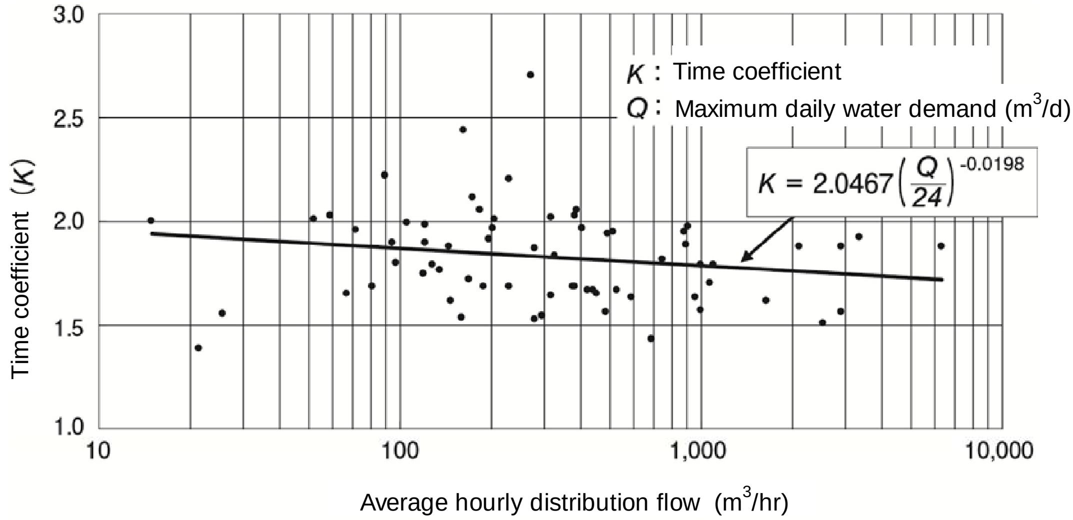


Figure 7.1.2 (3) Average hourly distribution flow in a residential area including medium- and high rise houses and the time coefficient (in 68 service areas of 13 cities

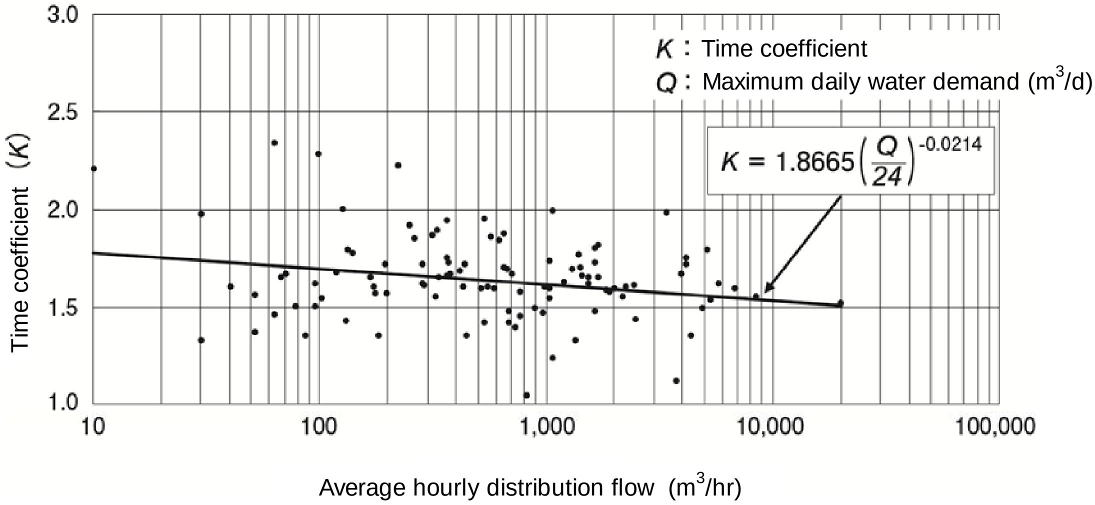


Figure 7.1.2 (4) Average hourly distribution flow in an area with mixture of residences, businesses and industries and the time coefficient (in 106 service areas of 38 cities)

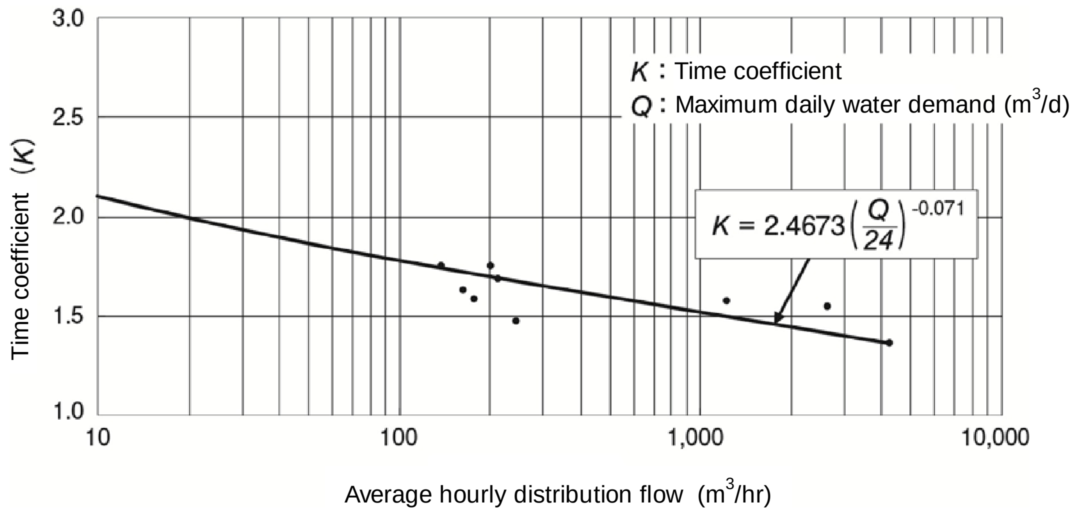


Figure 7.1.2 (5) Average hourly distribution flow in an area mainly with businesses and industries and the time coefficient (in 10 service areas of 6 cities)

Besides, the relationship between the population served and the time coefficient (K) in small water supplies is shown in Figure 7.1.3 as the standard.

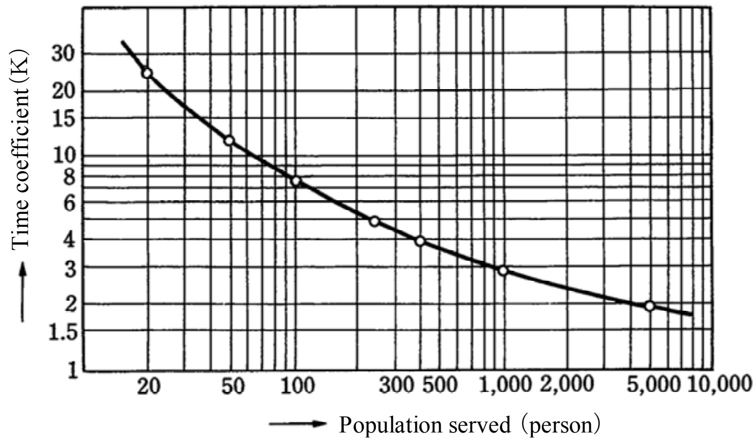


Figure 7.1.3 Population served and the time coefficient (Guidelines for Facilities for such projects as small water utilities to be subsidized by the National Treasury: Ministry of Health and Welfare)

7.1.5 Firefighting Water Flow

The firefighting water volume shall be determined as follows:

1. As a general rule, for designing the volume of a service reservoir, the firefighting water volume shall be added in the case of a service reservoir for a service area with a design population served of less than 50,000 persons.
2. As a general rule, for designing the diameter of the distribution main, firefighting water flow shall be added in the case of a distribution main for a service area with a design population served of less than 100,000 persons.
3. The firefighting water volume at the time of fire shall be determined by the discharging capacity of a hydrant and the number of hydrants to be engaged at the same time.

[Interpretation]

In small water supplies or the region with a small distribution flow, if the facilities are designed as per this standard, the diameter of distribution mains will be too big and so uneconomical, and there will be a risk of water quality deterioration due to an excessively low flow velocity. As such, fire hydrants shall be installed synthetically considering the situation with such firefighting facilities as fire cisterns, rivers, lakes, wells etc.

Since the firefighting water flow varies depending on the population, meteorological condition, building-to-land ratio, structure of building etc., it shall separately be computed by the urban area, semi-urban area, area other than the urban area and semi-urban area; and special consideration shall be taken for an area with a large number of hotels, Ryokan etc.

On the item 1.;

Since the ratio of firefighting water flow to the general distribution flow is large in small water supplies, and firefighting water flow will affect the operation of distribution in case water is used for firefighting, the volume of water needed for firefighting shall be added to the capacity of the service reservoir for the service area with population of less than 50,000 persons. Table 7.1.1 presents the water volume to be added to the capacity of the service reservoir, which is equivalent to about one hour of firefighting water flow indicated in Table 7.1.2. However, it will not apply to the case where other firefighting facility than hydrants is available.

Table 7.1.1 Firefighting water volume by population to be added to the volume of the service reservoir

Population (10,000 persons)	Firefighting water volume (m^3)
1	100
2	200
3	300
4	350
5	400

Notes: The population denotes the figure obtained by rounding off the fraction, which is smaller than 10,000, of the population concerned.

Table 7.1.2 Firefighting water volume by population to be added to the maximum daily water demand

Population (10,000 persons)	Firefighting water volume (m^3/min)
0.5 or smaller	1 or larger
1	2
2	4
3	5
4	6
5	7
6	8
7	8
8	9
9	9
10	10

Note Excluding population smaller than 5,000 persons

On the item 2.;

The distribution flow at the time of fire shall be obtained by the average hourly flow on the day of the design maximum daily supply with the addition of the firefighting water volume. In general, the design maximum hourly distribution flow is larger than the distribution flow at the time of fire on the distribution main which serves the design population served of more than 100,000 persons. On the other hand, the diameter of the distribution main shall be determined by the flow of the sum of the average hourly flow on the day of the design maximum daily supply and the firefighting flow that is given in Table 7.1.2. The table presents the standard firefighting flow which is considered appropriate from the relationship between the number of hydrants to be activated at the same time and the population.

The firefighting flow need to be specially augmented in the case of a building for which excessively large amount of firefighting water is required, or for an area where the average size of buildings is large.

In the case of a small water supply etc., the standard practice is to assume that the discharge from a hydrant is to be 1 m^3/min; and that the number of the hydrants to be engaged at the same time is set at 1 (one). Nonetheless, the firefighting flow and the number of hydrants to be engaged at the same time may be determined in accordance with Table 7.1.3 in consideration of the degree of congestion of houses, meteorological condition, availability of other firefighting facilities than water supply, and the capacity of fire engines, with which it is not required for the above standard practices to be observed.

On the item 3.;

In accordance with Table 7.1.2, the number of hydrants to be engaged at the same time in a built-up area shall be determined based on the discharge flow from a hydrant to be set at 1 m^3/min. The number of hydrants to be engaged at the same time per fire point shall be set at 5; and the fire points shall be considered to be distributed over separate sections in the case of a service area with a population of more than 40,000 persons.

The number of hydrants to be engaged at the same time may be set at 3 or so in case the capacity of discharge flow from hydrants exceeds 2 m^3/min. There is a case it is more advantageous to secure double the discharge flow per hydrant than to secure two hydrants with a capacity of 1 m^3/min.

The dynamic distribution water pressure at the time of fire shall be maintained not to be negative at the fire point (in principle at the point of the furthest hydrant) even in case fire engines are used; and in addition, it shall be held positive uniformly in the distribution mains.

Table 7.1.3 Type of hydrants and its flow to be used in small water supplies

Hydrant to be used (mm)	Discharge flow rate （m^3/min）
Single-jet hydrant 65	0.50
Small-sized hydrant 50	0.26
Small-sized hydrant 40	0.13

Facility standards for small water supply projects under financing with national subsidy (Ministry of Health and Welfare)

[Computation example] An example of a distribution flow in consideration of a firefighting flow at the time of fire

1. **Assumption: Design population served: 15,000 persons; design per-capita maximum daily demand; 0.5 m^3/day**

   Assuming the population served in the design year at 15,000 persons, and the design per-capita maximum daily demand at 0.5 m^3/day, the firefighting flow to be added is found to be at 4 m^3/min as per Table 7.1.2.

   The result of computation based on the above assumptions is as follows:

   Design maximum daily demand = 0.5 m^3 × 15,000 persons = 7,500 m^3/day

   Average hourly water demand = 7,500 m^3/day ÷ 24 hr ≒312 m^3/hr

   Distribution flow at the time of fire = 312 m^3/hr + (4 m^3/min ×60) = 552 m^3/hr

   Besides, comparison can be made on the design maximum hourly distribution flow assuming the time coefficient at 1.7 as follows:

   Maximum hourly distribution flow = 312 m^3/hr ×1.7 = 530 m^3/hr

According to the above computation example, if the distribution flow at the time of fire is employed for the design of the diameter of the distribution main, the purpose of firefighting is fully accomplished even at the time of fire during the maximum hourly distribution flow in summer, when the maximum distribution flow often occur, even though the distribution is affected only a little.

2. **Assumption: Design population served: 2,000 persons; design per-capita maximum daily demand; 0.5 m^3/day**

Assuming the population served at the design year at 2,000 persons, and the design per-capita maximum daily demand at 0.5 m^3/day, the firefighting flow to be added is found as 1 m^3/min

The distribution flow based on the above assumptions is computed as follows:

Design maximum daily demand = 0.5 m^3 × 2,000 persons = 1,000 m^3/day

Average hourly water demand = 1,000 m^3/day ÷ 24 hr ≒ 42 m^3/hr

Distribution flow at the time of fire = 42 m^3/hr + (1 m^3/min × 60) = 102 m^3/hr

Furthermore, the design maximum hourly distribution flow is computed as a comparison assuming the time coefficient at 2.4 as follows:

Maximum hourly distribution flow = 42 m^3/hr × 2.4 = 100.8 m^3/hr

Therefore, the larger figure 102 m^3/hr of distribution flow at the time of fire shall be employed for the design of the diameter of the distribution main.

7.1.6 Layout of Distribution Facilities

The layout of distribution facilities shall be in conformity with the following:

1. The layout shall be suitable for the topography and geography of the service area.
2. Distribution mains shall be laid out so that they form a reticulation.
3. The layout shall bring about rational and economical operation of the facilities.
4. Operation and maintenance shall be easy and maintenance cost shall be economical.

[Interpretation]

On the item 1.;

It is the most ideal for the layout of distribution facilities if the potential energy of water is utilized to its maximum, and if energy-saving is realized with the reduction in the power cost etc. Moreover, the shorter the distance of distribution, the smaller the diameter of distribution mains required for the same amount of water to be distributed.

As such, if there is an elevated point in the vicinity of the service area or in or around its center, it is rational to place the service reservoir etc. there and distribute water by gravity. When designing the layout of the distribution facilities, coordination shall be made with long-term development plans of water utilities concerned; and the layout shall as much as possible incorporate the topography and geography of the service area with due consideration of the future of the distribution facilities.

On the item 2.;

The distribution mains shall be laid out so that they can convey a necessary quantity of water to the service area under appropriate pressure, and that they are rationally connected to distribution submains networks.

1) Distribution Trunk Main

The distribution trunk mains shall basically form main reticulations with trunk lines laid along roads vertically or horizontally crossing the proximity of the center of the service area, which make the transportation and distribution of water advantageous; and other trunk mains are drawn from the trunk mains, which are assigned to serve the respective distribution blocks.

Since the trunk mains reticulations are as such the core of the distribution facilities, they should possess high reliability by means of employing earthquake-resistant pipe materials and fittings as well as making loop connections between them. What is more, it is desirable that their layout in loose or unstable ground is avoided as much as possible.

Connection with the neighboring service areas shall be provided even at normal times so that mutual supply of water and adjustment of water pressure between service areas become possible in an emergency; in other words, connecting valves shall be installed on the connecting mains so that water flow and pressure can be regulated in an emergency. At the same time, such ancillary facilities as valves, pressure reducing valves, flow meters etc. shall be installed in appropriate locations in the service area so that distribution can rationally be carried out.

2) Distribution Submains

Distribution submains reticulations are composed of water mains branching from the distribution trunk mains forming networks; and serve water directly to consumers in the service area of the submains networks through service connections. Therefore, diameters and pipe materials of the mains, which form the networks, shall rationally be designed and such ancillary facilities as valves, hydrants, blow-off pipes, flow meters etc. shall be installed in proper locations so that appropriate water volume, pressure and quality are secured. The same consideration of durability, resistance to earthquakes etc. of distribution trunk mains shall also apply to the submains, which constitute the framework of the submains reticulations.

The ancillary facilities, which possess the most proper functions in accordance with 7.6 Ancillary Facilities, shall be installed in appropriate locations according to the hydraulic condition, topography, geography etc. of the trunk mains reticulations and submains networks.

On the item 3.;

The distribution facilities are laid out so that the mutual water use between service areas is rationally and economically made in accordance with the water demand of the respective service areas at normal times. On the other hand, it is very important that water service is restored in such an emergency as burst of water mains etc. as the damage caused by such an accident is repaired as quickly as possible. To make this possible, flow meters, pressure gauges, valves etc. shall properly be installed so that information on water flows and pressure in distribution mains is always obtained and can properly be reflected to the management of water use.

For functional water use management, an information acquisition and control system to be made at one single facility, a remote operating facility for valves, a telemeter system for information collection etc. are needed. The scope of provision of such facilities shall be determined in consideration of the size of water supply facilities etc.

On the item 4.;

It is natural enough that the distribution facilities shall be located in consideration of their relative positions with the water treatment and water transmission facilities, and the ease of the control of water flows, pressure etc. What is more, distribution facilities shall be laid out in order for them to be safely and smoothly operated after the management system, personnel, technical standards, working condition etc. for operation and maintenance of service reservoirs, stand pipes, elevated reservoirs, distribution pumps and water mains are examined.

Besides, distribution facilities shall be laid out to save the power cost utilizing potential energy of water by taking topographical and geographical advantage as much as possible; and, at the same time, to take the expansion of the area for direct connection water service into consideration.

7.1.7 Selection of the Type of Water Distribution

> The type of water distribution shall be determined in consideration of elevations of water supply facilities situated upstream of the present facilities and the service area, the volume of water distribution, characteristics of the service area etc.

[Interpretation]

The types of water distribution are classified into the gravity flow type, the pumping type, and their combination.

The gravity flow type is employed in case there is a proper elevated point within or in its vicinity of the service area; and the pumping type is otherwise employed (Figure 7.1.4).

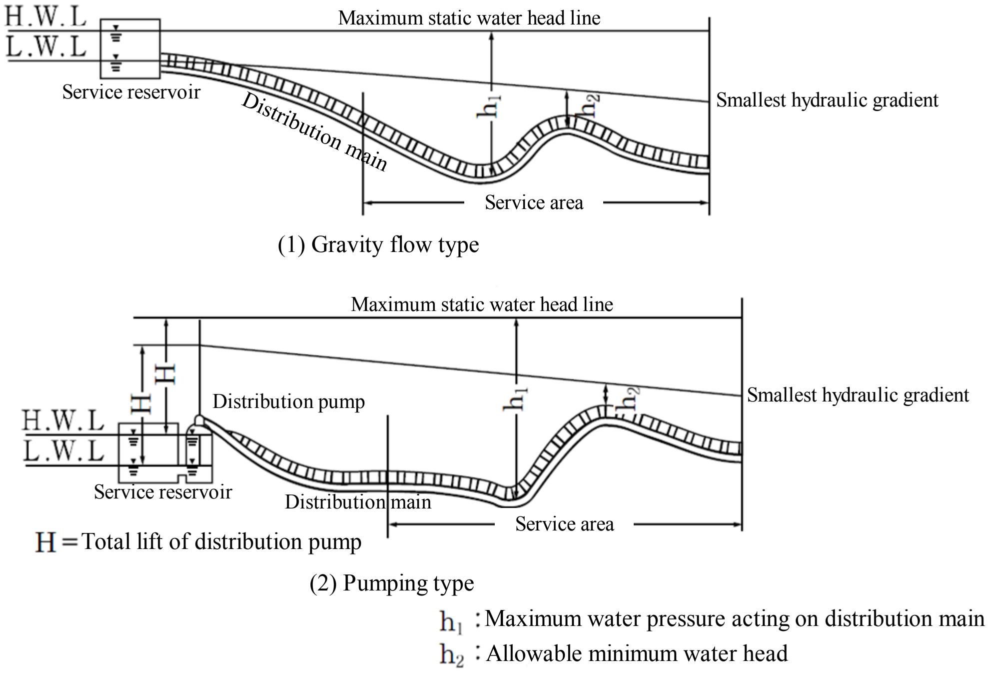


Figure 7.1.4 Types of Water Distribution

1. Gravity flow type

The gravity flow type has an advantage over other types since it is not affected by power outage and its operation is reliable. Therefore, it is a general rule to employ the gravity flow type in case a proper elevated point is secured within or in the vicinity of the service area in economic consideration of the construction cost and operation and maintenance expenses.

However, such a proper measure as emergency isolation valves etc. shall be provided since there is a risk that the necessary water quantity in the service reservoir may become short as a result of the damaged distribution trunk main and the delay of its restoration, or there may be a lateral damage to houses situated along the trunk main.

2. Pumping type

Under pumping type distribution, although control of water flow and pressure is possible in accordance with the changes in water demand in the service area, the provision of power generators is required to cope with a case of power failure.

Irrespective of the type of distribution, namely, the gravity or pumping types, it is a useful measure to separately provide booster pumps for limited elevated points in the service area.

On the other hand, since the water pressure may be excessively high in low-lying areas, and there may be a lot of cases of damage on water mains or leakage due to the high pressure, the method to control the water pressure by installing pressure reducing valves etc. will be effective.

3. Combined type

Under the combined type of distribution, the gravity type shall be employed for the section of the area where the potential energy of water can be utilized as per topographical characteristics; and the pumping type shall be adopted for the another section, where the water pressure is insufficient, by installing pump facilities at the service reservoir etc. Even under the pumping type, the gravity flow type distribution may be possible in some cases during the night when water demand is low.

7.1.8 Renovation and Replacement of Distribution Facilities

Renovation and replacement of distribution facilities shall be undertaken on the designed schedule in consideration of available technologies and funds after precisely evaluating and judging the functions and capacity of the existing facilities.

7.1.9 Water Mains Replacement Plan

In order to replace the very large length of distribution mains, replacement work shall be carried out after establishing a replacement plan suitable to the respective water utilities by means of such a method as asset management etc. so as to introduce the notions of leveling and efficiency to the water utility.

[Interpretation]

Superannuated distribution mains shall be replaced without delay so as to realize reliable water service while preventing the burst of the mains and water leakage. It is desirable to make a water mains replacement plan with the introduction of the method of asset management after evaluating the urgency of the replacement work, the importance of the water mains etc. The following items shall be examined for the provision of the replacement plan.

1. Identification of the present status

2. Evaluation of the urgency of the replacement work

3. Evaluation of the importance of the water mains

4. Provision of the planning framework

7.1.10 Direct Connection Water Service

It is desirable to introduce direct connection water service in consideration of the distribution of medium-rise buildings in the service area, the characteristics of the community, the layout of the distribution facilities, their capacity, the type of distribution and so forth.

[Interpretation]

There is a tendency that the receiving cistern type water service is being replaced by the direct connection type water service as a means to improve the quality of water service since such regular maintenance work as inspection, cleaning etc. is needed for the former; and hygienic problems may arise if maintenance is inadequate.

There are two methods of direct connection water service: (1) the direct connection direct pressure water service in which water is served directly from a distribution main; and (2) the direct connection boosted-pressure water service for which water pressure of the distribution main is increased by a booster pump facility.

To serve water to a medium rise building by the direct connection direct pressure, the minimum water pressure at the tapping points on the distribution main as described in 7.5.4 Water Pressure shall be secured.

Due to the condition of the minimum water pressure, direct connection water service may be introduced zone by zone or step by step in case overall unconditional introduction of direct connection water service to the entire service area is difficult. Therefore, it is important for the water utility to make efforts for the improvement of the distribution networks etc. with due regard to the fairness of water service.

7.2 Service Reservoir

7.2.1 General

1. Role of the Service Reservoir

The service reservoir is a basin to store treated water for the purposes of receiving water transmitted from the water treatment plant and distributing the water to the service area according to its demand; and possesses the function not only to regulate the hourly fluctuation of distribution flows but to be able to supply water in required quantity under necessary pressure for a certain period of time even in an emergency.

The service reservoir etc. shall be built in the vicinity of the service area at a safe location taking into account the geographic and geological features. Distribution by gravity flow can be made if the service reservoir is properly situated at a high elevation; and distribution will be undertaken by pumping if the location is low. For an example of useful application of the potential energy of water, water is distributed by the boosted-pressure by a pump utilizing residual pressure available at the receiving point of the reservoir.

In many cases it is often difficult for a single one service reservoir to distribute water to the service area under proper and uniform water pressure in regard to particular topographic and geographical conditions; and it may be difficult to carry out required operation in an emergency. It is also necessary to provide more than two service reservoirs dispersed in the service area taking into consideration the characteristics of the community and the composition of the distribution mains networks.

2. Forms of Construction of Service Reservoir and Points of Attention

There are three forms of construction of the service reservoir: (1) ground level setting; (2) underground setting; and (3) semibasement setting.

3. Location and Structure of the Service Reservoir

It is a general rule to choose foundation with good soil for the construction of the service reservoir. However, such appropriate measures as foundation piles shall be provided in case the foundation is placed on weak soil if there is no other choice. The service reservoir shall possess structure which not only provides sufficient earthquake resistance, durability, and water-tightness but also prevents the formation of dead water (See Figure 7.2.2).

The service reservoir shall be structured with reinforced concrete (RC), prestressed concrete (PC), fiber reinforced plastic (FRP), or steel plates (steel, stainless steel etc.), and its shape shall generally be rectangular, cylindrical etc. in consideration of dynamic characteristics, capacity, economic benefits, the ease of construction etc.

There shall be more than two service reservoirs (or a reservoir to have two sections divided by a partition); and it is desirable for them to be fitted with emergency isolation valves to prevent emptying of the service reservoir due to such an accident as the burst of a distribution main.

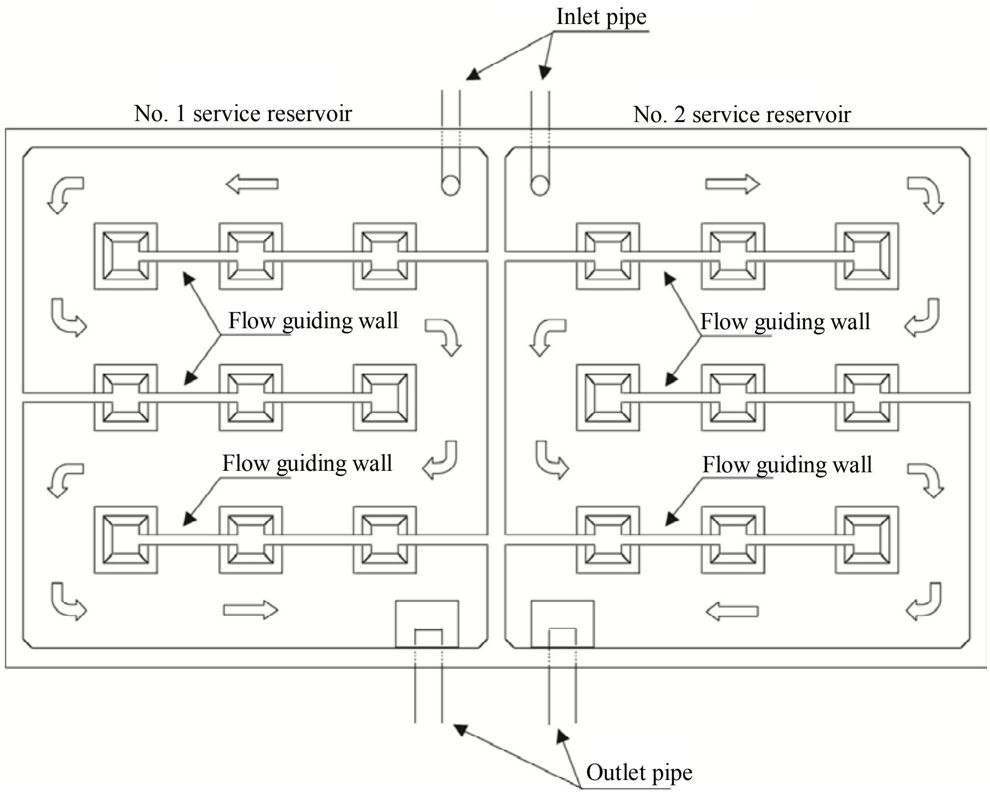


Figure 7.2.2 Example of the structure of the service reservoir to prevent dead water

4. Measures as an emergency water service point

The service reservoir shall be equipped with such emergency water service facilities as power generators, submerged-motor pumps etc. with due regard to its function as the emergency water service point at the time of such a disaster as a great earthquake etc. Given this, the service reservoir shall be structured so that handling of water feeding to a tank truck and so on can easily be undertaken.

5. Anti-corrosion measures for the service reservoir

The anti-corrosion measures for a service reservoir to be built newly are (1) application of anti-corrosion coating on inside walls of the reservoir; and (2) uncoated concrete wall with thick cover of reinforcement.

Although the service reservoir fabricated with steel (SS) plates by welding possesses high water tightness and earthquake resistance, corrosion control measures are needed on both inside and outer walls. The paint for coating the inside wall shall be selected in conformity with the “Ministry of Health, Labor and Welfare Ordinance for establishing technical standards” since the inside wall comes in contact with treated water. The solvent-less epoxy resin paint for water supply (JWWA K157:2010), which is one of paints in conformity with the above ordinance, has the characteristics that its adverse effects to the work place environment are small since it does not contain solvent and does not emit a solvent odor.

7.2.2 Structure and Type

Function, outlook, the ease of construction, economic benefits etc. shall synthetically be evaluated when selecting the structure and type of the service reservoir.

[Interpretation]

The general items for the structure and type of the service reservoir shall be in conformity with "5.9.2 Structure".

The structure and type of the service reservoir shall be selected after synthetically evaluating applicability, economic benefits etc. based on such basic elements as the planned service area, distribution method, effective capacity of the reservoir, water level and so forth (See Figure 7.2.3). As for the evaluation of the applicability and economic benefits etc., economic benefits shall be considered after synthetically evaluating such a function as the form of installation etc., the harmony with the surroundings, the ease of construction based on the term of construction work etc. construction cost and maintenance expenses and so on.

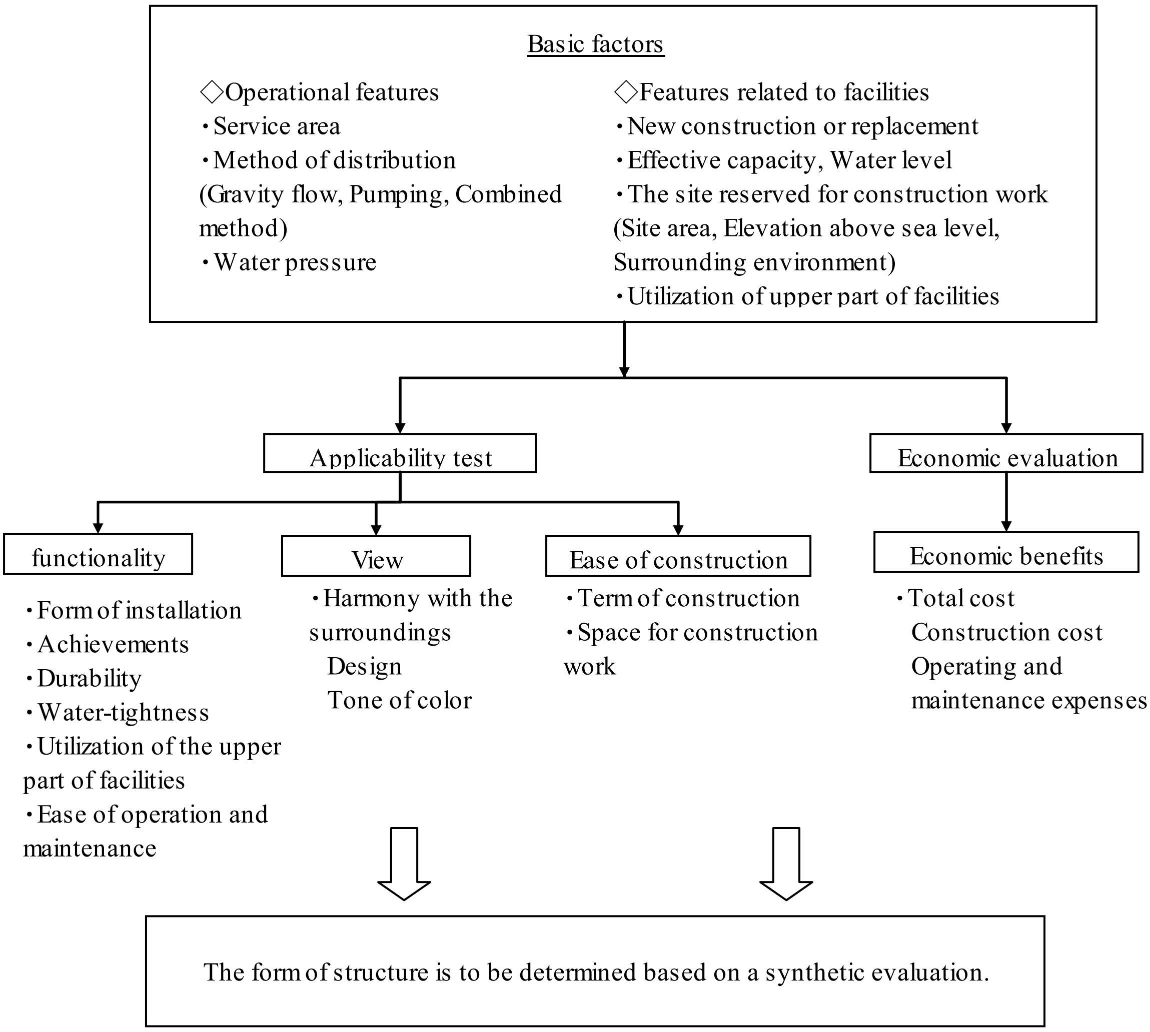


Figure 7.2.3 Examination procedure of the structure and type of the service reservoir

Table7.2.1 Characteristics of the structure and type of the service reservoir

Structure		Characteristics
Reinforced concrete structure (RC structure)		・Mainly a beam and pillar structure, or flat slab structure. Although its rigidity is high, its dead weight is the heaviest. ・In general, the shape is rectangular, and it is built on the ground, underground or semibasement. ・Curing time is needed for concrete to get its prescribed strength.
Prestressted concrete structure (PC structure)	Spot-poured concrete	・As formed as a one body, it possesses relatively high rigidity. ・Its wall thickness is smaller than the PC structure. ・Mainly cylindrically shaped and placed on the ground. ・Its capacity is mostly small to medium. Some ones have a capacity exceeding 10,000 m^3. ・To enhance anti-corrosiveness, the management of inside wall coating is needed. ・Curing time is needed for concrete to get its prescribed strength.
	Precast	・As formed as a one body, it possesses relatively high rigidity. ・Precast members, which are manufactured in a factory, are fabricated on site, and formed in one body by means of prestressing. ・As concrete with higher strength than spot-poured one, its wall can be thin. ・Mainly cylindrically shaped and placed on the ground. ・Its capacity is mostly small to medium. ・To enhance anti-corrosiveness, the management of inside wall coating is needed. ・The term of construction can be shorter than the spot-poured concrete type.
Ordinary structural steel plate structure (SS structure)		・High rigidity and water-tightness can be obtained owing to fabrication as one body by welding. ・Structured by jointing steel members (bottom plate, wall plate, roof plate etc.), which are manufactured and processed in a factory) by welding. ・Although in general cylindrically shaped, the shape can relatively freely be chosen. ・Anti-corrosion coating is necessary both for inside and outside walls.
Stainless steel plate structure (SUS structure)	Cylindrical structure	・High rigidity and water-tightness can be obtained owing to fabrication as one body by welding. ・Structured by jointing steel members (bottom plate, wall plate, roof plate etc.), which are manufactured and processed in a factory) by welding. Some ones have a capacity exceeding 20,000 m^3. ・Although in general cylindrically shaped, the shape can relatively freely be chosen. ・Although the construction cost is high, a comparative study on the life cycle cost is necessary since no anti-corrosion coating is required. ・Rational corrosion control can be achieved by selectively applying stainless material depending on the environment (gaseous phase and liquid phase sections). ・Reflection of sun light from SUS plates may be hazardous depending on the method of finishing their surface.
	Rectangular structure	・Since there are the double side welding type, one-side welding type (panel type) and bolting type fabrication, a proper type of structure shall be chosen with respect to the size, importance etc. of the facility. ・The limit for its height is smaller than the cylindrical type. for structural reason. ・Its capacity is small to medium; so the maximum size will be 10,000 m^3 or so. ・Although the construction cost is high, a comparative study on the life cycle cost is necessary since no anti-corrosion coating is required. ・Rational corrosion control can be achieved by selectively applying stainless material depending on the environment (gaseous phase and liquid phase sections). ・Reflection of sun light from SUS plates may be hazardous depending on the method of finishing their surface.

7.2.3 Capacity

The capacity of the service reservoir shall be in conformity with the following:

1. The standard capacity of the service reservoir shall be 12 hours equivalent of the maximum daily supply of the service area; and it is desirable to augment this figure to a certain extent in consideration of the reliability of the water supply system.
2. The firefighting water to be added to the above capacity shall be in conformity with 7.1.5 Firefighting Water (1).

[Interpretation]

It is required for the service reservoir to be able to regulate the fluctuation of water demand with respect to the transmitted quantity; and, furthermore, it shall possess the function to supply water for a certain period of time even in an emergency.

Therefore, the standard effective capacity of the service reservoir is set at 12 hours equivalent of the maximum daily supply of the service area with due regard to not only the volume required for regulating the fluctuation of water demand but also the water volume necessary for coping with such an emergency as what is needed upstream of the reservoir (drought, water pollution, damage in facilities etc.), and what is needed downstream thereof (emergency water service, damage in facilities etc.) as well as firefighting water.

However, although the firefighting water is in general included in the standard 12-hour volume, the capacity of the service reservoir for a population served of less than 50,000 persons shall as a general rule be determined based on the above 12-hour volume plus the firefighting water since the ratio of firefighting water volume to the ordinary water demand is large in small water supplies as described in “7.1.5 Firefighting water”.

1) Volume required for regulating hourly fluctuation

The basic function of the service reservoir is the regulation between the water treatment flow or water transmission flow and the distribution flow.

A constant quantity of water is transmitted from the water treatment facilities to the service reservoir since the water treatment facilities are operated based on the design maximum daily water supply. On the other hand, balancing of demand and supply is achieved in that, since there is hourly fluctuation in distribution flow, the transmission water volume in excess of the hourly distribution flow is stored during the night when the demand is low; and water is fed from the reservoir in excess of the transmission water volume during the day when the demand increases.

As such, the effective capacity of the service reservoir needed for the regulation of hourly fluctuation shall be obtained by summing up water volume hour by hour, which exceeds the average hourly distribution flow on a day of the maximum daily supply.

Although the area method, mass curve method etc. are used for computing the effective capacity of the service reservoir required for the regulation of fluctuation of hourly distribution flow, the capacity of a new service reservoir shall be determined with reference to the past experience or that of water utilities which have similar facilities. “Reference 7.2” presents an annotation on the area method and mass curve method; and “Reference 7.3” shows an example of computing the capacity required for regulating hourly fluctuation.

2) Capacity required for an emergency

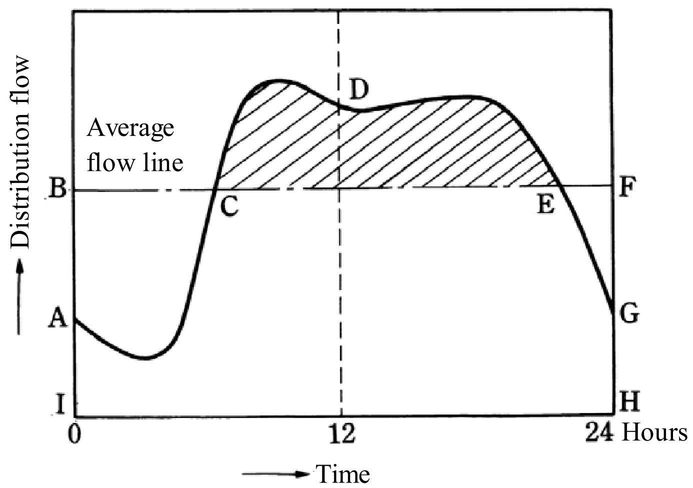
The capacity for coping with an emergency is that for emergency water service to be provided for a certain period of time in such occasions as drought, water pollution, accident of facilities, disaster of earthquake etc. However, the storage capacity of the water supply system as a whole shall in advance be augmented including the raw water regulating reservoir and the service reservoir according to the need since there may be a case when it is difficult to carry out measures against such disasters depending on the frequency and scale of their occurrence.

[Reference 7.2] Area method and mass curve method

1. Area method

As shown in Reference Figure 7.2.1, the distribution curve is drawn through points ACDEG setting the hourly distribution flow at the time of the design maximum daily demand on the axis of ordinate, and time on the axis of abscissa. The area enclosed by the points ACDEGHIA denotes the maximum daily water demand; and the vertical axis IB is the average hourly distribution flow which is equivalent to the transmission water flow.

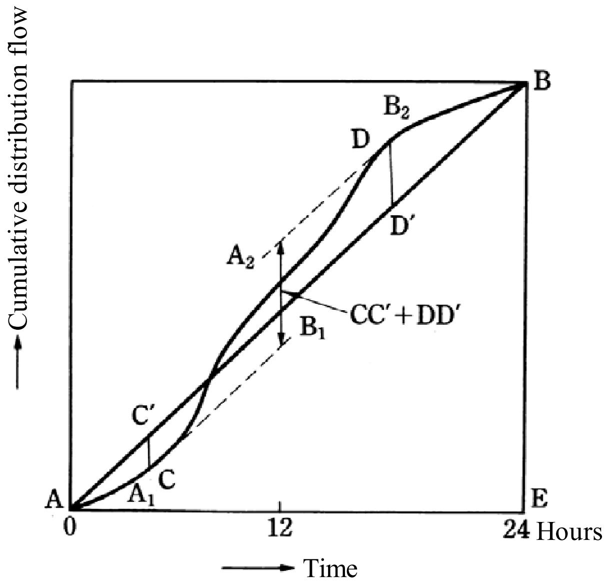
Given this, the area ACDEGHIA = the area BFHIB, and the capacity needed for regulating the hourly fluctuation is formed by the area CDEC (hatched area) which exceeds the average flow line. In other words, assuming that treated water is constantly produced at the average flow and transmitted to the service reservoir, the area above the average flow line (hatched area) stands for the reduced quantity of water in the service reservoir, and the area under the line (BCAB + EFGE) means the increased quantity in it.



Reference Figure 7.2.1 Area method

2. Mass curve method

As illustrated in Reference Figure 7.2.2, setting cumulative distribution flow on the axis of ordinate, and time on the axis of abscissa, the mass curve of distribution flow ACDB is obtained. BE denotes the design maximum daily water supply; and AB means the cumulative water transmission flow to the service reservoir, and it is a straight line if the transmission flow is constant every hour. The point C indicates the point when the volume in the service reservoir has increased; and the point D stands for the point when the volume has decreased. Therefore, CC'+DD' equals the quantity required for regulating the hourly fluctuation.



Reference Figure 7.2.2 Mass curve

(Source: Water Supply Technology, Nihon Suido Shimbun, Supervised by Hikoichi Senda)

[Reference 7.3] An example of computation of the capacity required for regulating hourly fluctuation of distribution flow

1. Outline

Assuming that a service reservoir is newly built in a city;

Setting the following factors,

Design population served 15,000 persons

Design per-capita maximum daily water demand 0.5 m^3/day

The result will be the following:

Design maximum daily water demand = 0.5 m^3/day-capita × 15,000 persons =7,500 m^3

Average hourly distribution flow =7,500 m^3 ÷24=312.5 m^3

2. Capacity required for regulating hourly fluctuation

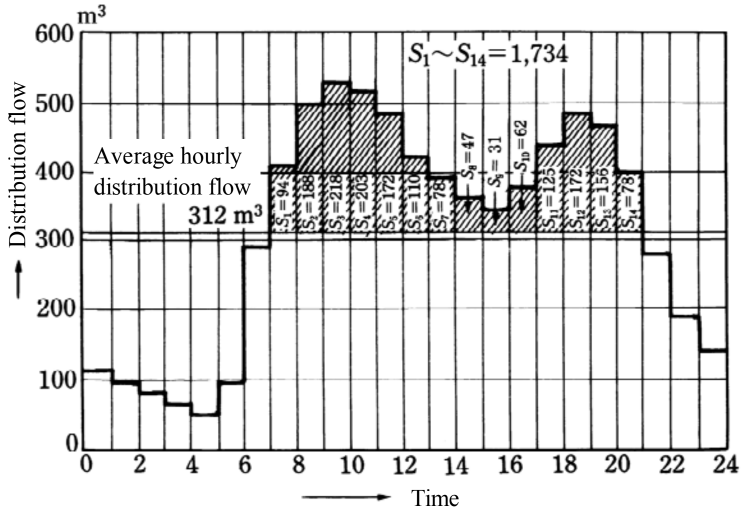
The following factor needs to be known when determining the capacity of the service reservoir:

$$\text{Rate of hourly change in distribution flow} = \frac{\text{Distribution volume in each hour}}{\text{Average hourly distribution flow}}$$

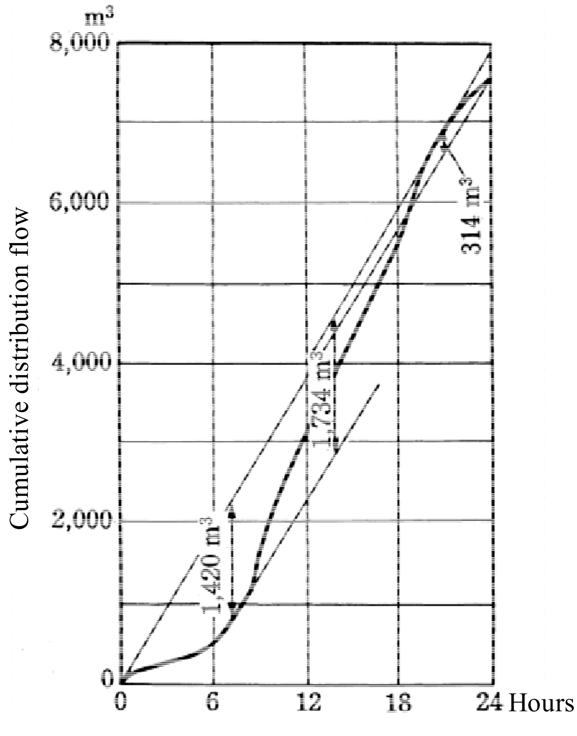
And, after referring to the experience of other water utilities, of which facilities are similar to those of the present utility, the flow in each hour and the cumulative distribution quantity are estimated referring to Reference Table 7.3.1.

In the case of the computation of the capacity by the area method, since the graph of hourly fluctuation of distribution is drawn as shown in Reference Figure 7.3.1, and the average hourly distribution volume is 312 m^3, the water volume larger than this figure, namely, the distribution flow S1 through S14 totals 1,734 m^3 as the capacity required.

In the case of the computation of the capacity by the mass curve method, since the graph of hour-cumulative curve of distribution flow is drawn as shown in Reference Figure 7.3.2, the vertical distances between the tangent lines of the cumulative curve of inlet flow into the service reservoir and the cumulative curve of the distribution flow are 1,420 m^3 at the lower side of the former curve, and 314 m^3 at the upper side thereof, totaling 1,734 m^3.



Reference Figure 7.3.1 Capacity required for regulation of hourly fluctuation the area meth



Reference Figure 7.3.2 Capacity required for regulation of hourly fluctuation by the mass curve method (Source: Water Supply Technology, Nihon Suido Shimbun, Supervised by Hikoichi Senda)

Reference Table 7.3.1 Hourly change rate by hour and distribution volume

Hours	Rate of hourly change	Water volume (m^3)	Cumulative distribution volume (m^3)	Hours	Rate of hourly change	Water volume (m^3)	Cumulative distribution volume (m^3)
0-1	0.35	110	110	12-13	1.35	422	3,643
1-2	0.30	94	204	13-14	1.25	390	4,033
2-3	0.25	79	283	14-15	1.15	359	4,392
3-4	0.20	63	346	15-16	1.10	344	4,736
4-5	0.15	48	394	16-17	1.20	374	5,110
5-6	0.30	95	489	17-18	1.40	437	5,597
6-7	0.95	297	786	18-19	1.55	484	6,031
7-8	1.30	406	1,147	19-20	1.50	468	6,499
8-9	1.60	500	1,692	20-21	1.25	390	6,889
9-10	1.70	530	2,222	21-22	0.90	282	7,171
10-11	1.65	515	2,732	22-23	0.60	188	7,359
11-12	1.55	484	3,221	23-24	0.45	141	7,500

7.2.4 Effective depth

The standard effective depth of the service reservoir shall be 3 m to 6 m or so.

[Interpretation]

The effective depth of the service reservoir is defined as the depth between the high water level (H.W.L.) and the low water level (L.W.L.). If it is too shallow, a large water surface is needed for a required volume; whereas, although if it is too deep, a small water surface will suffice, it may cause problems related to its structure or construction such as earthquake resistance and waterproofing. For that reason, the standard depth is empirically set at around 3 to 6 m.

In the case of distribution by gravity flow, the L.W.L. of the service reservoir shall be determined so that the minimum dynamic pressure on distribution mains in the service area does not fall below the limit prescribed by the water utility in question even at the time of the design maximum hourly distribution flow.

Likewise, the H.W.L. of the service reservoir shall be determined so that the maximum static pressure on distribution mains does not exceed the maximum standard usable pressure for the respective pipe material.

In case the effective water depth of the service reservoir is large, the dynamic water pressure on the distribution mains shall be controlled by a control valve so as to keep the pressure within the proper range.

In the case of distribution by pumping, there is no definite relationship between the effective depth of the service reservoir and the required dynamic distribution pressure since the dynamic pressure can be regulated by throttling the delivery pressure on the pumps. The required lift of pumping shall be determined so that the dynamic water pressure on distribution mains falls in the prescribed pressure at the fringe of the service area based on the L.W.L. of the service reservoir.

7.2.5 Inlet pipe, outlet pipe and bypass pipe

The inlet pipe, outlet pipe and bypass pipe of the service reservoir shall be in conformity with the following:

1. The installation of the inlet pipe and outlet pipe shall be in conformity with 5.9.5 Inlet pipe, outlet pipe and bypass pipe.
2. At the inlet end of the service reservoir, an inlet weir shall be provided; the water shall freely fall from the inlet pipe; or a non-return valve shall be installed on the inlet pipe. An emergency isolation valve shall be provided on the outlet pipe as required.
3. In case the flow in the inlet and outlet pipes is to be regulated, a flow control valve shall be installed on them.
4. The bypass pipe should always be provided and an isolation valve shall be furnished on it.

[Interpretation]

On the item 2.;

In general, an overflow weir is provided at the inlet end of the service reservoir to reduce the force of the inlet current and prevent the backflow of the water stored in the reservoir. In case an overflow weir is not provided, the water shall freely fall from the inlet pipe; or a non-return valve shall otherwise be installed.

In the case of distribution by gravity flow, a device for emergency isolation etc. shall be equipped on the outlet pipe to minimize the loss of water from the reservoir at the time of the burst of a distribution main and so on; prevent a lateral disaster due to the discharge of water; and, furthermore, secure water for emergency water service at the time of such a disaster as an earthquake.

On the item 3.;

Since the diameters of the inlet and outlet pipes are determined based on the design maximum daily water supply and the design maximum hourly distribution flow respectively in the design year, a flow control valve needs to be installed to regulate the inlet or outlet flow in the period before the design year when the distribution flow is small. When selecting a flow control valve, a valve possessing good control and cavitation characteristics shall be used with reference to “8.4 Valves” and the Handbook of Valves for Water Supply (Japan Water Works Association).

On the item 4.;

When the service reservoir cannot be used for a prolonged period of time due to its repair and so forth, it is needed for water to directly be distributed bypassing the reservoir. Therefore, a bypass pipe and an isolation valve shall always be installed.

Under the pumping distribution regime, during such a time zone as the night when distribution flow is low and the residual water pressure in the inlet pipe is high, the operation can be made economic by stopping the pumps and distributing water by gravity via the bypass pipe.

To directly distribute water using the bypass pipe, a non-return valve needs to be installed on the bypass line as illustrated in Figure 7.2.4.

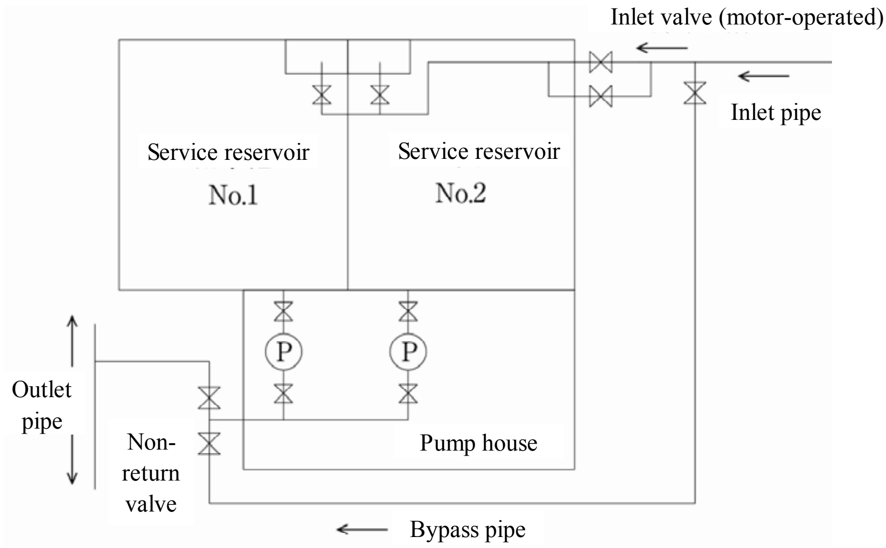


Figure 7.2.4 A layout example of the bypass pipe

7.2.6 Overflow and drainage facilities

The overflow and drainage facilities of the service reservoir shall be in conformity with 5.9.6 Overflow and drainage facilities.

7.2.7 Ventilation equipment, manholes and sampling holes

The ventilation equipment, manholes and sampling holes of the service reservoir shall be in conformity with 5.9.7 Ventilation equipment.

□ **5.9.7 Ventilation equipment (Excerpt from 5. Water Treatment Facilities)**

The ventilation equipment shall be in conformity with the following:

1. The ventilation equipment is to be installed at an inspection chamber etc.
2. A cross section equivalent to that of the outlet pipe, through which as much air as the fluctuating quantity of distributed water can freely pass, is needed for the ventilation equipment.
3. The ventilation equipment shall be so formed that rain water, dust, small animals etc. will not intrude from outside.

7.2.8 Level gauge, sampling apparatus etc.

The level gauge, sampling apparatus etc. of the service reservoir shall be in conformity with 5.9.8 Level gauge etc.

[Interpretation]

Since the retention time in the service reservoir is relatively large, sometimes there may be differences between the water temperature, pH, residual chlorine etc. at the inlet side and those at the outlet side. As such, water quality shall be monitored installing sampling apparatus at or in the vicinity of the inlet and outlet points.

□ **5.9.8 Level gauge etc. (Excerpt from 5. Water Treatment Facilities)**

Level gauges, sampling apparatus and water analyzing equipment shall be installed in the clear water well. Flow meters shall also be installed as required.

7.2.9 Supplementary chlorination facilities

Supplementary chlorination facilities to be installed at the service reservoir or halfway on the distribution main shall be in conformity with 5.10.2 Types, dosage and dosing point of chlorine agents.

[Interpretation]

In the distribution facilities the residual chlorine concentration shall be maintained at the standard level at the tap of consumers at the fringe of the distribution network.

Supplementary chlorination facilities need to be installed at the service reservoir or halfway on the distribution main in case the residual chlorine concentration is expected to markedly reduce due to long detention time in relation to the length of water transmission and distribution mains and the volume of the service reservoir. What is more, the above measure is also useful to make the residual chlorine uniform at consumers' taps in case the residual chlorine concentration becomes uneven at the taps depending on the distance from the chlorination facilities to the taps.

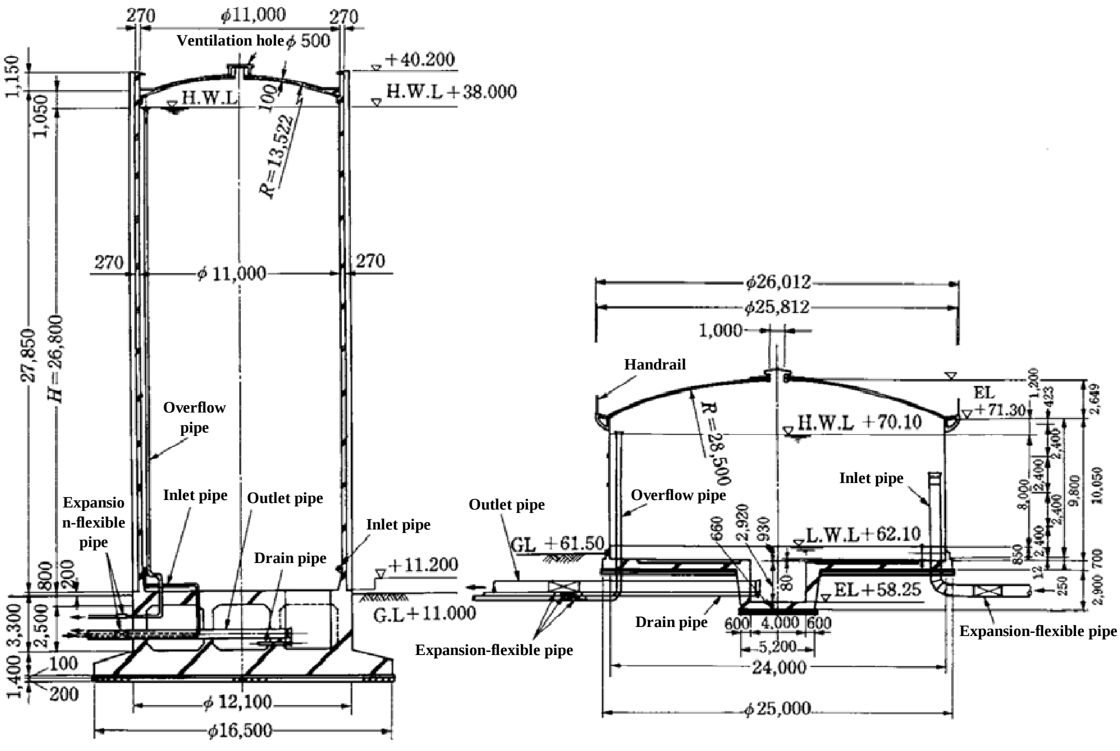
It is desirable to use sodium hypochlorite solution among various chlorine agents for disinfection since from the hazard prevention point of view and the ease of handling since the service reservoir and distribution mains are generally often situated close to residences.

7.3 Standpipe and Elevated Reservoir

7.3.1 General

1. Role

The standpipe and the elevated reservoir are treated water storage basins built on the ground to regulate the distribution flow or control water pressure in a service area served by pumping in case a proper elevated location is unavailable for building a service reservoir. The whole body of the standpipe is filled with water whereas the elevated reservoir is a water tank supported by pillars or walls (See Figure 7.3.1 and Figure 7.3.2).



(1) Prestressed concrete structure (2) Steel or stainless steel structure

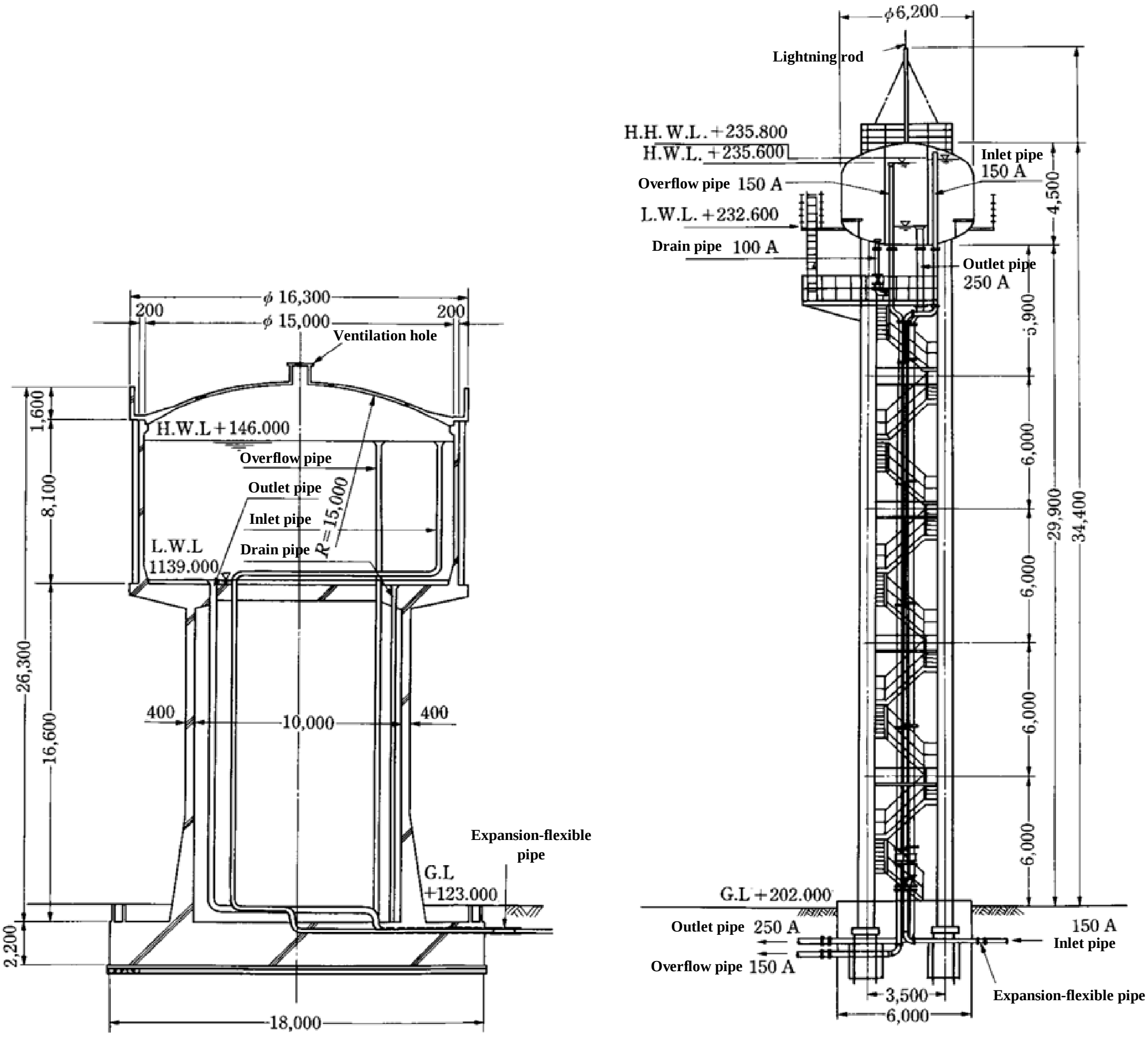
Figure 7.3.1 Examples of structure of the standpipe (Unit: mm)

2. Material and Structure

The standpipe and the elevated reservoir are built with reinforced concrete, prestressed concrete or steel plate s (steel structure or stainless steel structure), and their shape is mostly cylindrical. Irrespective of their material and shape, since they rise high above the ground, considered shall be not only their physical sturdiness but wind force when they are empty, earthquake force when they are full, ground bearing capacity, water-proofing, corrosion control, lightning prevention, electric wave interference, appearance etc.

3. Effective capacity

The effective capacity of the standpipe and the elevated reservoir shall be in conformity with the service reservoir since they possess as same function as the service reservoir built at an elevated location in case they are used to regulate the distribution flow. The effective capacity can be smaller in case they are used to regulate the distribution flow for a service area served by pumping since another reservoir with proper effective capacity is separately provided.



(1) Prestressed concrete structure **(2) Steel or stainless steel structure**

Figure 7.3.2 Examples of the structure of elevated reservoirs (Unit: mm)

4. Location of construction

The location of the standpipe or the elevated reservoir is selected near the center of the service area. However, it is located close to the fringe of the service area in case the service area is very large, and the length of distribution mains is markedly long; and sometimes, while storing water during the night, water is fed from it in addition to the direct water supply in such a period as daytime when the distribution flow increases, and at the time of fire.

7.3.2 Structure

The structure of the standpipe and the elevated reservoir shall be in conformity with the following:

1. The structure shall secure hygienic safety, sufficient durability and water-tightness.
2. Structural safety against wind force when it is empty and earthquake force when it is full shall be secured.
3. A proper heating and insulation device shall be provided in a cold district if needed.
4. The freeboard shall be determined based on a hydraulic analysis.

[Interpretation]

On the item 1.;

The standpipe and the elevated reservoir need to be safe in terms of their structure and hygienic property, and possess sufficient durability, earthquake resistance and water-proofing property. For that reason, they are in general structured with reinforced concrete, precast concrete or steel plates.

As they rise high above ground, such influence to the surroundings as their appearance and electric wave interference etc. shall also be taken into consideration.

Inside wall coating may be required for some types of standpipes and elevated reservoirs of concrete structure for the purposes of water-proofing, the prevention of degradation of concrete due to chlorine, and maintenance of water quality. Coating on both inside and outside walls is generally applied for corrosion control for the steel structure standpipe and the elevated reservoir. Coating materials, which have been certified for their hygienic safety and absence of adverse effects to water quality, shall be employed for inside wall coating.

Epoxy resin paints, FRP lining etc. are used for water-proofing and corrosion control for inside walls of the concrete structure.

It is desirable for the surface of roofs to be applied with a whitish paint, asphalt water-proofing, urethane water-proofing and so on to prevent expansion and contraction by radiant heat.

An epoxy resin paint is applied for the inside walls of the steel reservoir, and an epoxy resin paint, an urethane resin paint or a fluororesin paint etc. is used for their outside wall. Weather resistant steel material, for which outside wall coating is unnecessary, is used in some installations.

On the item 2.;

Standpipes and elevated reservoirs shall be so designed that they are dynamically safe against wind force, when they are empty, and earthquake force, when they are full, in consideration to the most dangerous condition they face under such circumstances. Furthermore, localized damage to structural members or ancillary facilities, overflow etc. to be caused by the sloshing phenomenon at the time of an earthquake shall also be examined.

A cylindrical shape is generally employed for reinforce concrete and prestressed concrete reservoirs.

A cylindrical, spherical, rotating oval shape etc. is dynamically advantageous in the case of the steel structure.

On the item 4.;

The upper part of the standpipe and the elevated reservoir shall be structured in consideration of the rise in water surface to be caused by the sloshing phenomenon at the time of an earthquake in addition to the ordinary freeboard.

7.3.3 Capacity

The capacity of the standpipe and the elevated reservoir shall in general be in conformity with 7.2.3 Capacity.

[Interpretation]

The examples of the purposes of the installation of the standpipe and the elevated reservoir are tabulated in (1) to (3) below:

(1) In a case to install it for the regulation of distribution flow

(2) In a case to install it for the regulation of water pressure in a service area served by pumping

(3) In a case to combine the above (1) and (2).

In the case (1), the capacity shall as a general rule be in conformity with the case of the service reservoir prescribed in 7.2.3 Capacity.

In the case (2), a service reservoir is normally separately provided, and the distribution pressure is regulated by means of controlling pumps or inlet valves in relation to the water depth in the standpipe and the elevated reservoir. For that reason, their capacity can be made small compared with the case of the service reservoir. An effective capacity equal to 30 minutes of the design maximum hourly distribution flow is the standard for small-scale water supplies.

In the case of the pressurized service reservoir, its standard effective capacity is equivalent to 10 minutes of the design maximum hourly distribution flow.

In the case (3), the capacity shall be determined in consideration of the size of the water supply system, the condition of the service area, the situation of the site of installation, the ease of operation and maintenance, economic condition etc. The capacity shall normally be set at equivalent to 1 to 3 hours or so of the maximum daily water supply; and, if the capacity is insufficient to regulate the distribution flow, hourly fluctuation is regulated by means of transmitting water from a service reservoir, which is to be built in the vicinity of the standpipe or the elevated reservoir.

In the case (1), the hourly discharge rate of pumping facility, as transmission pumps, for transmitting water to the standpipe or the elevated reservoir can be one hour equivalent of the design maximum daily supply. In the case (2), it needs to be equal to the design maximum hourly distribution flow or the distribution flow at the time of fire as distribution pumps.

Likewise, as the capacity of the standpipe or the elevated reservoir almost becomes as large as that of the service reservoir, the nature of pumps, which feed water to the standpipe or the elevated reservoir, will gradually change from that of distribution pumps to that of transmission pumps, and their discharge rate accordingly becomes small. However, in case the capacity of the standpipe or the elevated reservoir is equal to 1 hour or so of the design maximum daily water supply, it is not recommended to forcefully reduce the size of the pumping facility with respect to the firefighting water and reliability of distribution.

7.3.4 Water depth

The water depth of the standpipe and the elevated reservoir shall be in conformity with the following:

1. The total depth of the standpipe shall be determined taking its structure, construction and economic benefits into account.
2. The effective depth shall be determined in consideration of condition for installation, the characteristics of the distribution networks, the required water pressure and so forth.

[Interpretation]

On the item 1.;

In some cases, the 1/3 to 1/2 portion of the water in the standpipe cannot be utilized at normal times in relationship with the required water pressure in the distribution mains. Therefore, when building the standpipe, efforts shall be made to select the site for its construction so as to minimize the dead water portion as much as possible and effectively utilize the water depth.

The maximum limit of the total depth of the standpipe has been considered to be about 20 m according to the experience. The reason is that, as the standpipe becomes tall, the center of gravity becomes high, and the structure gets dynamically unstable, which requires its foundation to be large and strong enough.

On the item 2.;

Although it has been considered that the effective depth of the standpipe and the elevated reservoir is to be around 3 m to 6 m in accordance with that of the service reservoir, it is mostly 4 to 8 m according to the experience, and there are many examples of 10 to 15 m of the effective depth for the standpipe.

The effective depth is determined in consideration of the required water pressure related to the location of the standpipe and the elevated reservoir, the relationship between their elevation and that of other facilities, the ease of construction and the ease of operation and maintenance, economic condition etc.

In the case of the standpipe, it is desirable for the lower portion of water, which cannot be used in ordinary operation, to be utilized as the emergency water to be reserved for the need at the time of such a disaster as earthquake etc.

7.3.5 Foundation and supporting pillars

The foundation and supporting pillars of the standpipe and the elevated reservoir shall be in conformity with the following:

1. The foundation shall be placed in good and sound ground, which has the required bearing force, and possesses sufficient stability.
2. In case they are obliged to be placed in such an unfavorable location as loose soil etc., such an appropriate measure as a foundation construction method or a soil improvement method etc., which is the most suitable for the soil condition, shall be applied.
3. The supporting pillars of the elevated reservoir shall be fabricated with steel or reinforced concrete, and firmly joined to the foundation.
4. The water tank part of the elevated reservoir and the base on the supporting pillars shall firmly be joined.

[Interpretation]

On the item 1.;

The standpipe and the elevated reservoir are dynamically unstable structures since they rise high above ground. As such, firm ground shall be selected for their foundation; and such measures as foundation piles shall be applied so that the foundation can fully bear the load of the upper structure.

A careful study shall be undertaken on foundation soil; and soil boring, test piling or soil bearing tests shall be carried out to identify the condition of the soil, stability of the ground, bearing force of the ground, groundwater and so on. Such a sufficiently stable foundation structure as foundation piling shall be selected based on the result of the above study.

Even in case direct foundation is chosen owing to relatively good soil, it is desirable for the foundation to be placed as deep as possible; and even in case separate foundations are provided for respective pillars of a multi-pillared support structure, the foundations shall be connected as one by underground beams.

On the item 2,;

The ground at the foot of a hill, a boundary of different soil formations, loose soil, reclaimed land etc. will cause adverse effects to the facilities since it will move in complicated ways; for example, it may greatly get deformed at the time of an earthquake or unevenly subside. On a sloped ground, the risk of the collapse of the slope is high. The bearing force of sandy ground, in case it is fluidized, will drastically be reduced.

Therefore, it is the best way to avoid weak ground for the foundation. In case it is obliged to place the foundation in loose ground, however, a type of structure and a method of construction suitable for the soil condition shall be employed. Soil improvement work is undertaken in some cases.

On the item 3. and 4.;

Since the supporting pillars are an important component of the elevated reservoir to bear the load of the water tank mounted on them, and safely deliver the load to the foundation, they shall be structured as one body firmly bound together with the tank so that safety against earthquake and wind forces is secured. The upper elevated structure shall be firmly fixed with the lower structure so that they are not dislodged since such large horizontal force as inertial force and dynamic water pressure are caused by an earthquake and wind. Since the rigidity of the elevated tank and that of the base are different from each other, sufficient reinforcement shall be applied; and, in case the base directly supports the side walls and the bottom slab, a thick material for the side walls or stiffener plates shall be used to strengthen them as extremely large localized stress will be caused.

7.3.6 Inlet pipe, outlet pipe and bypass pipe

> The inlet pipe, outlet pipe and bypass pipe of the standpipe and the elevated reservoir shall be in conformity with 5.9.5 Inlet pipe, outlet pipe and bypass pipe.

[Interpretation]

Although the inlet pipe, outlet pipe and bypass pipe shall be in conformity with 5.9.5 Inlet pipe, outlet pipe and bypass pipe, in some cases, only one pipe as inlet cum outlet pipe is installed. In this case, a control valve etc. shall be installed, as required, and operated in regard to the water level. Furthermore, an emergency insulation valve shall be installed if necessary.

Uneven subsidence tends to occur due to the difference in the condition of foundations in case pipes penetrate the concrete portion of the foundation of the standpipe or the elevated reservoir. Hence, an expansion-flexible joint shall be fit at the interface between the pipes and the concrete structure. Besides, proper anti-corrosion measure shall be applied on the pipes in soil close to the concrete body where there is a risk of macro cell corrosion to occur (See 7.5.1 Corrosion control on the outside pipe wall).

7.3.7 Overflow and drainage facilities

> The facilities for overflow and drain of the standpipe and the elevated reservoir shall be in conformity with 5.9.6 Overflow and drainage facilities.

7.3.8 Ventilation equipment, manholes and sampling holes

> The ventilation equipment, manholes and sampling holes of the standpipe and the elevated reservoir shall be in conformity with 5.9.7 Ventilation equipment.

□ **See 7.2.7 Ventilation equipment, manholes and sampling holes.**

7.3.9 Level gauge, sampling apparatus etc.

> The level gauge, sampling apparatus etc. of the standpipe and the elevated reservoir shall be in conformity with 5.9.8 Level gauge etc.

[Interpretation]

The capacity of the standpipe and the elevated reservoir ranges from 10 minutes or so even to several hours equivalent of the maximum daily water supply.

For that reason, as same as in the case of the service reservoir, sampling apparatus needs to be installed to monitor water quality for them of which retention time is long.

□ **See 7.2.8 Level gauge, sampling apparatus etc.**

7.5 Distribution Mains

7.5.1 General

1. Pipe material and joint

As pipe materials for the distribution mains, there are ductile iron pipe, steel pipe, stainless steel pipe, hard PVC pipe, polyethylene pipe for water supply etc.; and a proper pipe material shall be selected in consideration of their conformity with the elution standards prescribed in the "Ordinance to provide Technical Guidelines for Water Supply Facilities" as well as safety against external pressure, environmental condition and condition related to laying.

Since safety is solely affected by water pressure and external loads, a pipe material and a joint, which can withstand such forces, shall be selected. As to water pressure, the surging pressure as well as the maximum static pressure shall be taken into consideration; and as to the external force, earth load, road live load, earthquake force etc. shall be taken into account.

2. Laying method

The soil condition of the location for pipe laying is an environmental condition. Depending on the soil condition, specially designed joint or laying method may have to be examined; or protection of special fittings and anti-corrosion coating of outside wall of the pipe shall be considered.

Condition of buried objects in the surroundings, road traffic etc. are the condition for pipe laying. Although laying of distribution mains is in general carried out by the open cut method, the pipe jacking method, shield driving method and pipe-in-pipe method are in some cases employed from the view points of prevention of traffic congestion, avoidance of such public nuisance as noise and vibration etc. in addition to such physical obstacles as congested buried objects.

3. Improvement and replacement of distribution mains

There are a considerable number of distribution mains among ones aged for long years since their laying, for which improvement and replacement are needed due to their degradation. Although temporary repair is required for the distribution mains, which have been damaged by accidents or superannuation, replacement by new pipes, and such additional function as further improvement by earthquake resistance are important to secure safety of the distribution mains for the future as well. Even if various methods of construction for improvement and replacement of distribution mains have been developed, their applicability with respect to the environmental condition and the situation of the construction site as well as suitability to the future development plan in consideration of the purpose of improvement and replacement, life cycle cost and so forth shall be examined, and the most suitable method shall be selected.

7.5.2 Procedure of the design of distribution mains

Detailed design of distribution mains shall be in conformity with the following:

1. Design shall be based on the latest technical standards etc. while identifying the purpose of laying the distribution mains.
2. A reconnaissance and survey of buried objects of the site shall be undertaken prior to detailed design, and a safe and reliable construction method shall be adopted.

[Interpretation]

On the item 1.;

When carrying out detailed design of distribution mains laying, their role in the entire development plan and other related project schemes shall be recognized. Either for new installation or replacement of distribution mains, their diameters shall be determined by hydraulic analyses, as the basic practice, after setting flow and pressure in the mains according to the plan for distribution. Hydraulic examinations are desirable even for the replacement of distribution submains since such a condition as the surroundings of the site may largely have changed compared with ones at the time of the laying of the existing mains. Technical standards for design shall be in conformity with the “Ordinance to provide Technical Guidelines for Water Supply Facilities” and these guidelines.

On the item 2.;

The general procedure of design is illustrated in Figure 7.5.1

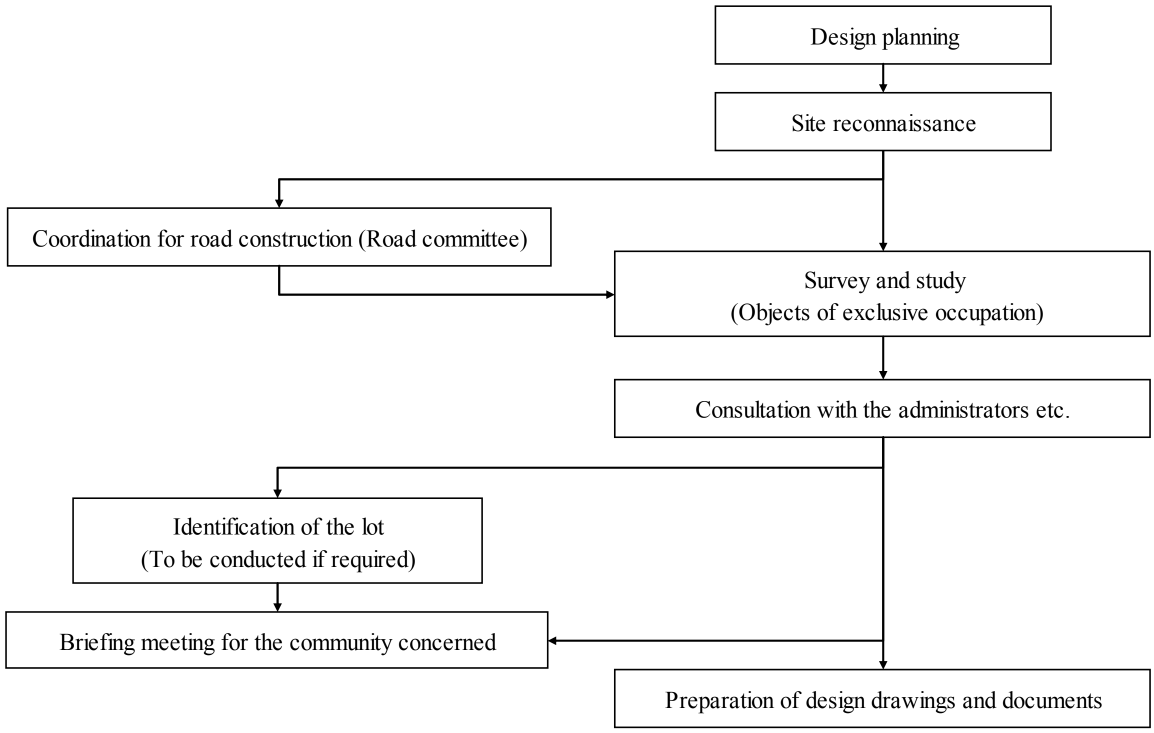


Figure 7.5.1 Procedure of the design of distribution mains

1) Site reconnaissance

Sufficient site reconnaissance of the route of pipe laying as the object of design shall be conducted prior to design work so as to identify the existence of obstacles and the surroundings in connection with pipe laying work.

2) Coordination with road construction work

In case a coordination committee for road construction has been established with the administrator of roads, that of traffic and the exclusive users of the road, coordination by the committee shall be made on the timing of pipe laying and road construction, the possibility of their execution concurrent with the work of other enterprises, other construction work to be carried out in a nearby site and so on; and efforts shall be made to undertake the present work rationally and smoothly. In case such a coordination committee has not been set up, coordination shall be made through coordination directly with those administrators.

3) Survey and study

A route survey, geotechnical survey, traffic survey and environmental study shall be conducted as required.

4) Survey of buried objects

Locations of buried objects (for water supply, industrial water supply, sewerage, power supply, communications, multipurpose underground utility conduit etc.), their shape, dimensions, materials, earth cover, year of burial and so forth shall be identified. The condition of buried objects shall be recognized by conducting test excavation according to the need.

5) Coordination with administrators

When executing a construction work exclusively occupying the road, coordination with the administrator of the road shall be made. In case there is an interaction with such other work as road improvement, coordination shall also be made with the incumbent section responsible for such work.

Coordination with the administrator of the river shall be made in case a river is to be exclusively occupied for the construction work. Besides, coordination with administrators of railway, public transportation, parks, ports etc. is needed in some cases.

In case regulation of traffic is necessary, coordination shall be made with the administrator of the department in charge of traffic on the date of construction, the time zone of the work, the means of traffic regulation, arrangement of traffic control conductors etc. In case hydrants are newly installed, moved or removed, coordination shall be made with the fire department in advance.

6) Identification of lot

Distribution mains are in general laid in such a public lot as roads. It is desirable to purchase a lot or set surface rights in case they are unavoidably laid in a private lot. In the case of leased land, written consent of the owner shall be obtained.

7) Briefing to the community concerned

In case briefing is required due to large scale construction work, advanced briefing to the community concerned shall be conducted so that the residents of the community understand the purpose of the work.

8) Preparation of design drawings and documents

Design drawings, detailed technical specifications, implementation plan, quantity surveys, estimates of construction cost etc. shall be prepared for detailed design of distribution mains.

Such design conditions as pipe material, diameter, the beginning and terminal points of construction, locations of exclusive occupation shall clearly be described when preparing the design drawings. Above all, it is important to fix the locations of exclusive occupation through coordination with the administrator etc. of the road based on site reconnaissance, survey of buried objects and so on.

7.5.3 Pipe material

Pipe material of distribution mains shall basically be in conformity with the following: 1. Pipe material, with which no risk of water contamination is brought about 2. It is safe against inside pressure and external forces. 3. It conforms to the burial condition. 4. It possesses good property of laying which conforms to the environment of burial.

[Interpretation]

As pipe material for distribution mains, there are ductile iron pipe, steel pipe, stainless steel pipe, hard PVC pipe, polyethylene pipe for water supply etc.

They are different from each other in terms of material, method of manufacture, standard dimensions, strength, coating on inside and outside walls etc. Therefore, the most suitable material shall be selected in consideration of hygienic property, compatibility, resistance to earthquake, ease of maintenance etc. The characteristics of common pipe materials used for distribution mains are shown in Table 7.5.1.

On the item 1.;

Pipe, of which material does not bring about the risk of water contamination, and which meets the elution standard prescribed in the Ordinance to provide Technical Guidelines for Water Supply Facilities, and with which safety has been confirmed, shall be selected and used.

On the item 2.;

The pipe shall possess the strength to bear the inside water pressure and external forces. As the inside water pressure, the maximum static pressure plus the surging pressure of distribution mains actually used shall be taken into consideration. As for the surging pressure, a value of 0.45 MPa to 0.5 MPa shall be anticipated for the ductile iron pipe and the stainless steel pipe; and a value of 0.25 MPa shall be accounted for the hard PVC pipe and polyethylene pipe for water supply since their Young's modulus is smaller than the above two materials.

Earth force, live load from the road, earthquake force etc. shall be taken into account as the external forces.

On the item 3.;

The most suitable pipe material shall be selected giving consideration to the conditions of the site for pipe laying, i.e., geotechnical property, situation of groundwater, existence of other buried objects, live load of the road etc.

Proper corrosion control measures shall be applied where soil of high corrosiveness and groundwater are anticipated. The use of the hard PVC pipe and polyethylene pipe for water supply shall be avoided where there exists an influence of organic solvents (gasoline, kerosene, toluene etc.).

On the item 4.;

Since the structures of joints are different among pipe materials, which will become a big factor to control the ease of construction, pipe material shall be selected taking into account the ease of construction which depends on the structure of the joint in case the other buried objects resting in congestion, or quick backfilling is needed. Furthermore, the employment of expansion joint (pipe) with flexibility needs to be considered depending on the environment of burial.

Table 7.5.1 Characteristics of main pipe materials used for distribution mains

Pipe material	Advantage	Disadvantage
Ductile iron pipe	(1) Pipe body is strong, high in ductility and can withstand strong impact. (2) High durability (3) Such flexible joints as K, T, U type etc. can deal with deformation of soil owing to their ability to expand and bend. (4) Such rigid joints as NS, S, SII etc. can deal with bigger expansion and contraction than the flexible joints; and furthermore can cope with bigger deformation of soil as they possess dislodge-resistant joint. (5) Easy handling	(1) Relatively heavy (2) Protection of special fittings is needed depending on the type of material. (3) Easily corroded if the protection coating of the inside or outside wall is damaged. (4) The K, T, U type etc. joint may slip off if the degree of expansion exceeds the prescribed limit due to fluidization or cracking of the soil at the time of an earthquake.
Steel pipe	(1) Pipe body is strong, high in ductility and can withstand strong impact. (2) High durability (3) Can be composed as one body by welding, and able to deal with movement of soil by strength of its body and ability to transform. Where soil movement is large, expansion joint or thicker pipe wall can be applied. (4) Easy handling for construction (5) Pipe coated with corrosion-proof material (polyurethane or polyethylene) is available.	(1) Although professional skill is required for the welding joint, automatic welding is available. (2) Protection against electrolytic corrosion shall be taken into account. (3) Easily corroded if the protection coating of the inside or outside wall is damaged.
Stainless steel pipe	(1) Pipe body is strong, high in ductility and can withstand strong impact. (2) High durability (3) Excellent corrosion resistance (4) No lining or painting is needed	(1) The joint welding work is time-consuming (2) Means of isolation from other metal material is needed.
Hard PVC pipe	(1) Excellent corrosion resistance (2) Handling is easy owing to its light weight (3) Roughness of the inside wall does not change. (4) The RR long joint is superior than the RR joint in terms of expandability.	(1) Body strength is smaller than metal materials. Resistance to the impact reduces in low temperatures. (2) Vulnerable to heat and UV ray (3) Softened by such organic solvent as thinner (4) Protection of special fittings is needed depending on the type of material. (5) Sufficient examination prior to its use is required for the RR long joint for its resistance to an earthquake since it has only a little experience to deal with a disaster because of its short application history.
Polyethylene pipe for water supply	(1) Excellent corrosion resistance (2) Handling is easy owing to its light weight (3) Pipe can be made one body by butt fusion welding and electrofusion welding, and so can deal with movement of soil. (5) Roughness of the inside wall does not change.	(1) Body strength is smaller than metal materials. (2) Vulnerable to heat and UV ray (3) Caution shall be paid for its permeability to organic solvents. (4) Pipe laying under rainy condition or where water springs out is difficult in the case of the butt fusion welding method. (5) Such special tools as the controller is needed in the case of the butt fusion welding method. (6) Sufficient examination on earthquake resistance prior to its use is required since it has no disaster experience in weak soil.

7.5.4 Water pressure

Water pressure of distribution mains is prescribed in the Ordinance to provide Technical Guidelines for Water Supply Facilities and shall be in conformity with the following:

1. The minimum dynamic water pressure at the tapping points on the distribution main for branching of service connections shall be more than 150 kPa (0.15 MPa).
2. The maximum static water pressure at the tapping points on the distribution main for branching of service connections shall be less than 740 kPa (0.74 MPa).

[Interpretation]

On the item 1.;

To enable direct connection water service to two-story buildings, the standard minimum dynamic water pressure in distribution mains shall be 0.15 to 0.2 MPa. What is more, when expanding the area for direct connection water service, to deal with hygienic problems of receiving cisterns and effectively use the potential energy of water, the water utility shall set up the area for such purpose, and determine the minimum dynamic water pressure in distribution mains in consideration of the distribution of buildings in the service area and its characteristics. For reference, the standard minimum dynamic water pressures for direct connection water service to 3-story, 4-story and 5-story buildings are 0.20 to 0.25, 0.25 to 0.30 and 0.3 to 0.35 MPa respectively.

Although, to secure direct connection direct pressure water service for two-story buildings, the minimum level of service in terms of water pressure at the tapping points on the distribution main for branching of service connections to be insured by the water utility for the moment is set at 0.15 MPa, this rule may be evaded if measures to assure uninterrupted water service have been provided even if water pressure becomes lower than 0.15 MPa in localized areas due to a geographical condition. Besides, although, in case hydrants are used for firefighting, it is needed for the water pressure in the distribution mains not to be negative irrespective of the above requirements, it is ideal if the minimum dynamic pressure can be maintained at about 0.1 MPa. even at the time of fire.

Since the rise in dynamic water pressure may bring about the risk of the occurrence of accidents and the increase in water leakage in case aged pipes are intermingled within the distribution network, improvement of distribution mains shall steadily be undertaken; and, while implementing the improvement of water service connections, it is required to reform or replace the entire distribution system so as to withstand the high water pressure.

On the item 2.;

As pipe materials used for the distribution mains, there are ductile iron pipe, steel pipe, stainless steel pipe, hard PVC pipe, polyethylene pipe for water supply etc. As for the ductile iron pipe, steel pipe and stainless steel pipe, the maximum usable water pressure for these pipes is 1.00 MPa in the case of the lowest rank of them; and 0.75 MPa for the hard PVC pipe and polyethylene pipe.

Since these pipe materials are intermingled in the distribution network, the maximum static pressure is set at 0.7 MPa as the allowable value from the view point of protection of water service connections.

However, this standard may not be observed even if the pressure exceeds in localized areas due to geographical condition if measures are provided so that water service is not interrupted. The use of ductile iron pipe or steel pipe etc. shall be considered in such a case.

As to the maximum dynamic water pressure, it is desirable to set it at 0.5 MPa or so in consideration of the rise in the minimum dynamic pressure as a result of the expansion of the service area for direct connection water service.

7.5.5 Pipe diameter

The diameter of distribution mains shall be determined based on the following:

1. The dynamic water pressure in the distribution mains at normal times shall be so determined that it is higher than the minimum dynamic pressure required in the area in question; and that the distribution of the water pressure becomes as uniform as possible.
2. The low water level of the service reservoir, standpipe or elevated reservoir shall be the datum level for the computation of the diameter of distribution mains.

[Interpretation]

On the items 1. and 2.;

The minimum dynamic water pressure in the distribution mains at normal times shall be planned according to the characteristics of the community concerned; and it shall be so planned that it does not become negative even at the time of fire, and that remarkable drawdown in water pressure does not occur in other areas.

For computation of the diameter of distribution mains, reference shall be made to "7.1.3 Design distribution flow"; hydraulic analyses shall be carried out for normal times; and the diameter, with which minimum dynamic water pressure will not become lower than the design minimum dynamic pressure prescribed in "7.5.4 Water pressure", shall be obtained. Then, hydraulic analyses shall be carried out for the time of fire so that the minimum dynamic pressure at the time of fire is confirmed not to become negative. Although it is the principle to plan for the distribution of dynamic water pressure to becomes as uniform as possible in the service area, caution shall be given that the minimum dynamic pressure does not become lower than the design minimum dynamic pressure after a careful survey of ground elevations where the land highly undulate. Moreover, attention shall be paid to the flow velocity in the distribution mains in consideration of such an aspect related to maintenance as deterioration in water quality in the mains.

As a general rule, distribution mains shall be so planned that they are interconnected from each other to form reticulations; and diameters of the respective mains shall be obtained by means of hydraulic calculations as pipe networks. The low water level of the service reservoir etc. shall be the datum for computing dynamic water pressure.

The water flow formulae commonly used in Japan are the Hazen-Williams formula, the Ganguilet-Kutter formula and the Ikeda formula. The Hazen-Williams formula, which is the most popular, is presented below.

$$H = 10.666 \cdot C^{-1.85} \cdot D^{-4.87} \cdot Q^{1.85} \cdot L$$

where,

H: friction head loss (m)

C: velocity coefficient

D: inside diameter (m)

Q: flow rate (m^3/s)

L: length (m)

The C value of the pipe changes depending on the roughness of the inside wall of the pipe, and the number of bends, branches etc. in the pipe. It is appropriated to use the C value of 110 in case designing a water main using new pipe including head losses of bends etc. for the entire water main; and 130 in case computing the head loss for the straight sections only (Head losses of beds etc. are computed separately). On the other hand, it is sometimes needed to know the C value in a case of the improvement or replacement of existing water mains. In this case a study shall be conducted since it will be markedly different with the influence of years of use and water quality.

A computation chart of the Hazen-Williams formula with C= 110 is illustrated in Figure 7.5.2.

The methods of hydraulic computation of a pipe network are roughly divided into the flow method and the potential method. For the flow method, flow values are set as the parameters to realize the balance of water pressure; and, adjusting the flow, the balance of water pressure is obtained. The Hardy-Cross method is the representative one of such methods. For the potential method, the flow values in the distribution mains are obtained assuming the pressures at the nodes of the network; and the node potential method is common.

The procedure of computation is presented as follows:

1) Flow computation at normal times

(1). The locations and pipe diameters of the pipe network are assumed.

(2). The service area is appropriately divided in accordance with the blocks, elevations of the ground, the distribution of population densities etc.; and the sections to be assigned to respective mains are assumed.

(3). The design maximum hourly distribution flow to be assigned to the respective sections of the mains is determined. Besides, computation is simplified assuming that the distribution flow is halved and concentrated on both ends of the main to discharge.

(4). When it is expected that there is a consumer which uses a large quantity of water, the quantity shall matter of course be taken into account, and it is rational to fix a point where the quantity is discharged.

(5). The flow values and the loss of heads shall be obtained by hydraulic analyses of the pipe network, from which the effective dynamic heads are computed.

(6). The smaller the number of the grids in the network, the simpler the computation. In case the number of grids is large, it is a convenient way to carry out calculation combining thin pipes with thick ones, or omitting the thin ones and forming a skeleton network only with thick ones.

Friction losses may only be considered for computation of head losses of distribution mains.

2) Computation of flow at the time of fire

(1). As there is sufficient allowance in the design maximum hourly distribution flow in the case of the design population served of more than 100,000 persons, the flow in the network can be computed in the same way as normal times.

(2). It is desirable to set the flow in the respective pipe as the total of the design maximum hourly distribution flow and the firefighting flow in the case of the population of smaller than 100,000 persons.

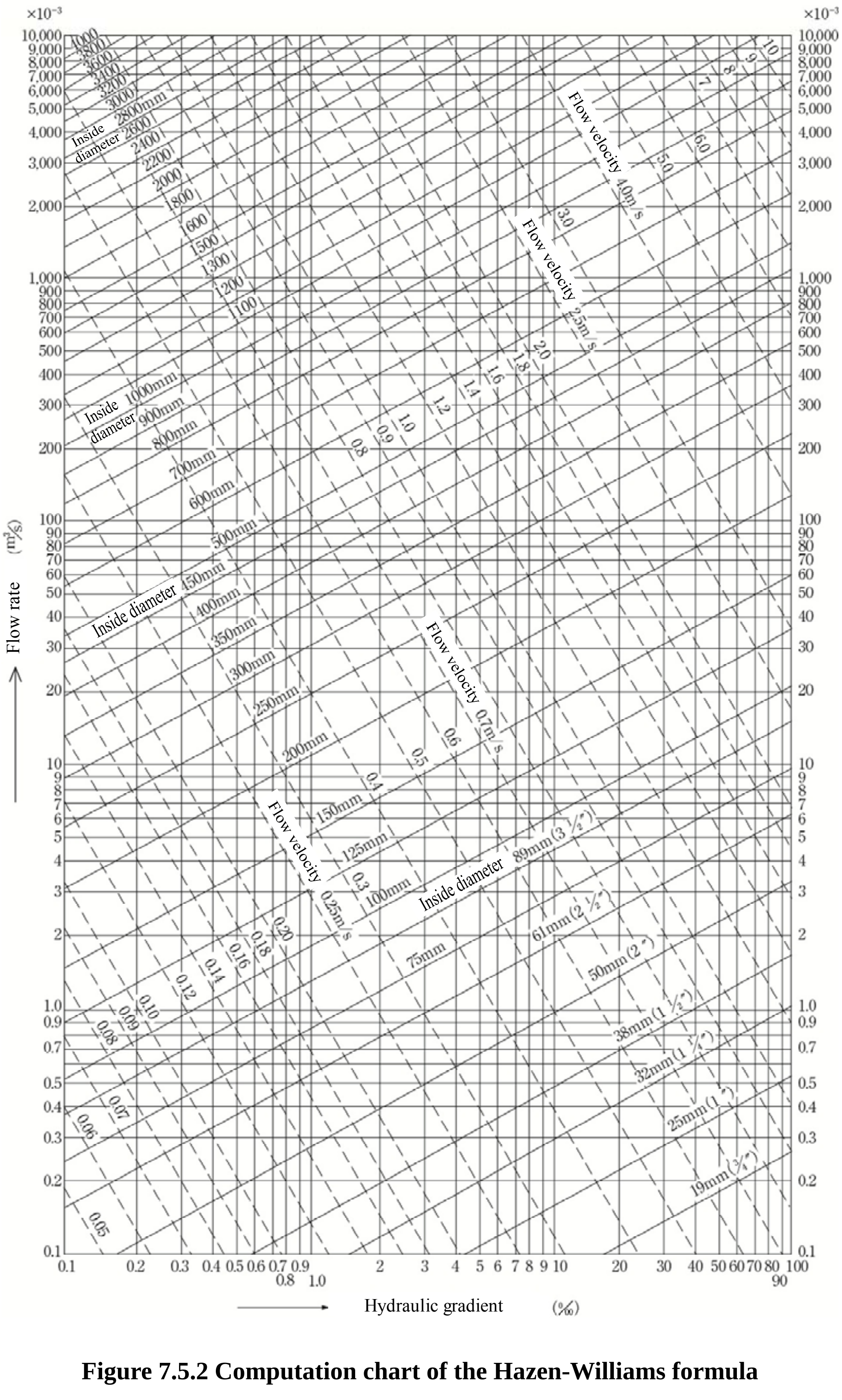


Figure 7.5.2 Computation chart of the Hazen-Williams formula

Furthermore, the same procedure can apply to the case the service area is divided into blocks. The discharge point of firefighting water shall be placed at the area where the condition is the worst; and, in case only one discharge point is considered insufficient, hydraulic analyses shall be carried out setting points of fire in other areas as well. The area of bad condition means the location which is situated far from the service reservoir, or of which elevation is high, and urbanized or congested area with low distribution pressure even as a result of hydraulic analyses at the normal times. Computation shall be conducted assuming firefighting water is discharged at the number of hydrants to be engaged simultaneously as prescribed in 2. and 3. of 7.1.5 Firefighting water.

For pipe network hydraulic analyses both at normal times and the time of fire, the water flow and pressure to the distribution mains, which branch off from the main distribution network and are not its components, shall always be taken into account.

7.5.6 Location and depth of laying

The location and depth of laying of distribution mains shall be in conformity with the following:

1. In case distribution mains are laid in the public road, the location and depth of laying shall be in conformity with the Road Law and the related regulations, and subject to coordination with the administrator of the road. Also in case distribution mains are laid in land other than public roads, consent of the administrator for the use of such land shall be obtained.
2. In case distribution mains are laid across or in the vicinity of other buried objects, more than 0.3 m of space shall be provided between them.
3. Anti-floating measures shall be provided where the groundwater level is high or expected to become high.
4. The depth of laying in a cold region shall be deeper than the frost depth.

[Interpretation]

On the item 1.;

Distribution mains shall as a general rule be laid in (public) roads in consideration of the ease of maintenance. In this instance, it is recommended for the trunk mains to be laid around the center of the road whereas the lateral mains (submains) shall be laid as close to the side of the road as possible for the purpose of branching of service connections. In case the width of the road is small, the submains may be laid only on one side of the road; whereas, in case the road is broad enough, the submains shall be laid in both sidewalks or on both sides of the roadway so as to facilitate the work of branching of service connections; and avoid service pipe laying across the broad road.

In regard to the location and depth of buried objects, they are in many cases set by the type of the road through coordination between the administrator of the road and such entities, which occupy the road, as water supply, industrial water supply, sewerage, gas, telegraph, power supply, telephone etc. An example of the layout standards for objects buried in the road are illustrated in Figure 7.5.3.

When laying water mains in a river basin, premises of railway or private land, consent of the administrators of the premises or the owner of the land shall be obtained through coordination with them.

Although under "the enforcement ordinance of the Road Law" (Government Ordinance No. 479 [1952]), the earth cover is set at 1.2 m, it can be reduced to 0.6 m in case the prescribed earth cover cannot be realized with regard to the relationship with the crossing of the water main through the embankment at the end of a water main bridge, intersection with other buried objects and so forth through coordination with the administrator of the road or that of the river.

As for shallow laying of water mains of the steel pipe (JIS G3443) with diameter of smaller than 300 mm, the ductile iron pipe (JIS G5526), the hard PVC pipe (JIS K6742), and the polyethylene pipe for water supply with diameter of smaller than 200 mm and the outside diameter/wall thickness=11 (yielding tensile strength of higher than 204 kgf/cm2), the depth of burial can be set in conformity with the application rule: “the space between the top of the water main and the road surface shall not be less than the thickness of the pavement plus 0.3 m (0.6 m in case the value is smaller than 0.6 m)”.

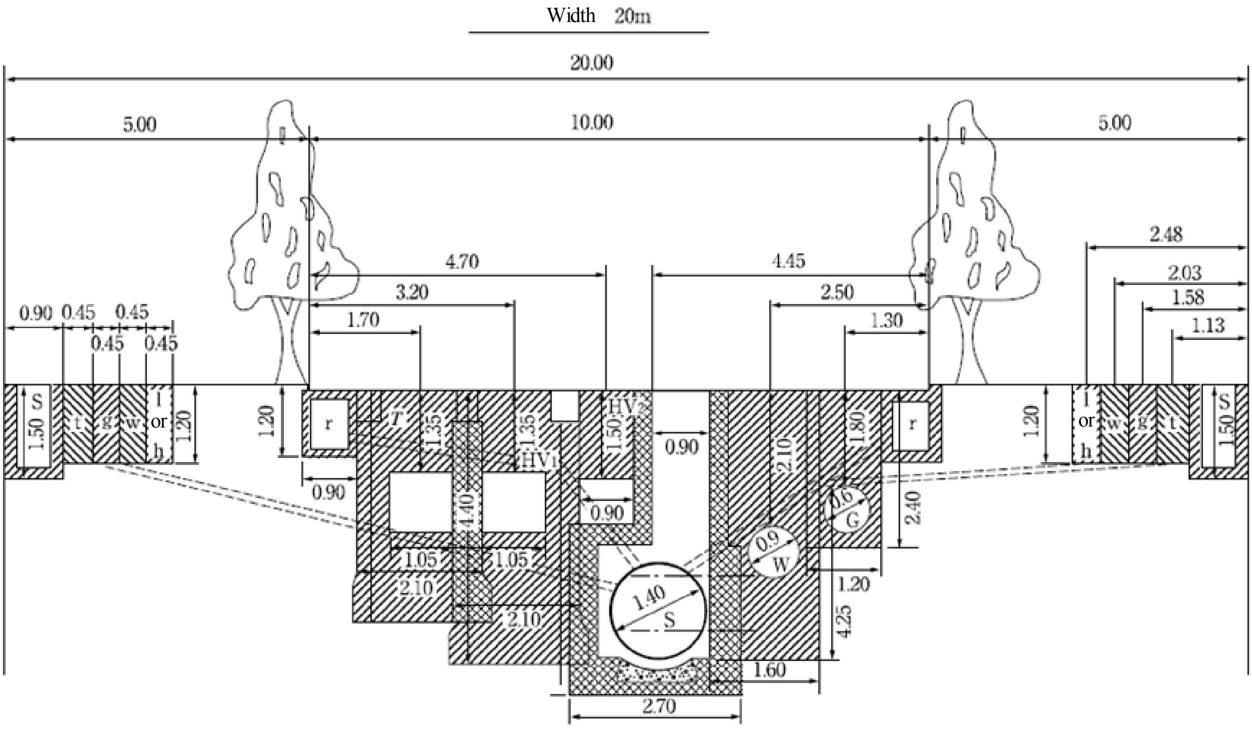


Figure 7.5.3 Example of the standard layout illustration of buried objects in the road (Fukuyama city) (Unit: m)

1. The scale in the example in this figure is 1:100.
2. This example shall actually apply to the northwestern or western section in usual cases.
3. The symbols for the conduits and pipes under the road are presented in the table below.

Legend				
Type of conduit under the road	Main line		Lateral line	Note
Telecommunication lines	*T*		*t*	
High tension line	HV_1	HV_2	*h*	HV_1 is duct type. HV_2 is trough type.
Low tension line for electric lights			*l*	
Water main	*W*		*w*	
Sewer	*S*		*s*	*s* is sewage pit. *r* is rainwater pit.
Gas main	*G*		*g*	

On the item 2.;

Maintenance and repair work is difficult unless there is some space between the distribution main and other buried objects. In addition, there is a risk of accidents caused by water leakage. In regard to such conditions, the minimum space for laying is set at more than 0.3 m. Sand erosion (sandblast) unlikely occurs if the space larger than 0.3 m is provided. Sand erosion stands for a phenomenon caused by a gush of water like leakage from a water main, which entrains the surrounding soil and sand, forming currents of the mix of water and soil, which continuously collide with such a pipe body as gas mains, abrade it and bore holes on it.

On the item 3.;

In case the level of groundwater is high or expected to become high, it is needed to prevent floating of the main when it is empty. Examples of the minimum earth cover for the prevention of floating of the main is presented in Table 7.5.5; and the dangerous water levels, with which the main will become afloat, are shown in Table7.5.6.

Table 7.5.5 Minimum earth cover for the prevention of floating of the main

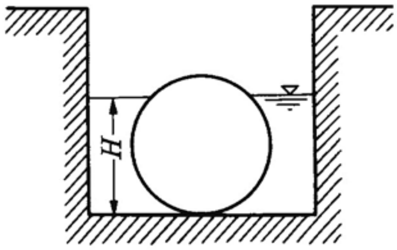
Nominal diameter	Steel pipe		Ductile iron pipe (Class 3 pipe)		Hard PVC pipe		Polyethylene pipe for water distribution	
(mm)	Wall thickness (mm)	Minimum earth cover (m)	Wall thickness (mm)	Minimum earth cover (m)	Wall thickness (mm)	Minimum earth cover (m)	Wall thickness (mm)	Minimum earth cover (m)
50	-	-	-	-	4.5	0.05	5.8	0.05
75	-	-	6.0	-	5.9	0.08	8.2	0.08
100	4.5	-	6.0	-	7.1	0.10	11.4	0.11
150	5.0	0.02	6.0	0.01	9.6	0.15	16.4	0.16
200	5.8	0.04	6.0	0.07	11.5	0.20	22.7	0.22
500	6.0	0.32	8.0	0.36	-	-	-	-
1000	9.0	0.72	13.0	0.80	-	-	-	-
1500	14.0	1.07	18.0	1.25	-	-	-	-
2000	18.0	1.45	23.5	1.68	-	-	-	-
2400	22.0	1.73	27.5	2.03	-	-	-	-
2600	24.0	1.86	29.5	2.05	-	-	-	-

Notes. 1. Computation is made assuming the soil on the pipe is submerged in water, and the weight of the filling soil to be (18-10=8KN/m^3).
2. As for the ductile iron pipe, the weight of its cement lining is accounted for.

Table 7.5.6 Dangerous water levels for floating of water mains

Nominal diameter (mm)	Steel pipe		Wuctile iron pipe; ()is for Class 1, others are for Class 3	
	Wall thickness (mm)	Water level H(m)	Wall thickness (mm)	Water level H(m)
100	4.5	-	(7.5) 6.0	(-) -
150	5.0	0.14	(7.5) 6.0	(-) -
200	5.8	0.17	(7.5) 6.0	(-) 0.19
500	6.0	0.20	(9.5) 8.0	(0.31) 0.27
1000	9.0	0.33	(16.5) 13.0	(0.54) 0.47
1500	14.0	0.50	(23.5) 18.0	(0.76) 0.64
2000	18.0	0.65	(30.5) 23.5	(0.99) 0.84
2400	22.0	0.79	(36.5) 27.5	(1.17) 0.97
2600	24.0	0.86	(39.5) 29.5	(1.26) 1.04

Note. As for the ductile iron pipe, the weight of its cement lining is accounted for.



7.5.7 Expansion joints

The expansion joints shall be in conformity with the following:

1. An expansion joint with flexibility shall be fit at such a location as loose ground, the interface of pipe with a structure etc. where uneven subsidence likely occurs.
2. Expansion joints shall be installed at a 20 m to 30 m interval on the sections of water mains which are laid with non-expandable joints, and exposed in the open air.
3. In case steel water mains with welded joints, expansion joints shall be installed if required.
4. It is desirable for trunk water mains to be fit with expansion joints with the function of anchoring (anti-escapement).

[Interpretation]

Expansion joints are installed to absorb expansion and contraction caused by change in temperature, uneven subsidence of ground, displacement of soil brought about by an earthquake and so on, and to prevent unintended force to be caused by such movements on the water mains.

Expansion joints are classified into the expansion-flexible pipe and the expansion-flexible joint. The expansion-flexible pipe, which is suitable for the environment of its installation, and possesses function required since it is subject to displacement in angle and expansion and contraction, and torsion at the same time in some cases, shall be selected. Examples of the expansion-flexible pipe are presented in Figure 7.5.6; and expansion joints for the hard PVC pipe are shown in Figure 7.5.7.

Since there are cases of water leakage from expansion-flexible pipes etc. due to their degradation over time and unexpected uneven soil subsidence, it is needed to carefully examine the durability of the materials and expected displacement of soil when selecting them (See Figure 7.5.5).

The expansion-flexible joint denotes a joint used to minimize the displacement stress of the water main caused by soil subsidence, soil movements due to an earthquake etc. so that the safety of the water mains is improved. Such joints as S type, NS type etc., which possess resistance to the earthquake as well as expandability, flexibility and even the function of anti-escapement, are commonly used in the recent years. Examples of earthquake-resistant joints for ductile iron pipes are presented in Figure 7.5.8.

On the item 1.;

Expansion-flexible joints with resistance to the earthquake shall be used for the entire water mains where the occurrence of uneven subsidence in a large area is expected. In case expansion joints with flexibility are used at the interface with such a structure as a water main bridge and siphon, the most suitable one shall be chosen examining not only their flexibility to absorb the expected value of subsidence but also the safety against inside and outside pressures, durability and water-tightness.

On the item 2.;

Expansion joints shall be inserted in the section of water mains laid on a water main bridge etc. since the expansion and contraction of the pipe body caused by the change in temperature are large.

On the item 3.;

Although, laying of steel water mains by jointing by means of welding is designed almost without expansion joints in some cases, expansion joints shall be inserted on both sides of valves as required. In this case a means of the prevention of escape of the joint is needed against one-sided pressure.

At the last point of laying steel water mains by welding, an expansion joint shall be installed so as to lessen the thermal stress caused by welding as required.

On the item 4.;

As the expansion joints for trunk water mains, ones with a structure, which possesses to absorb not only expansion and contraction at normal times but also displacement at the time of an earthquake, shall be selected. Especially for buried water mains, it is desirable to choose expansion joints with an anti-escapement function since regular monitoring of displacement is difficult.

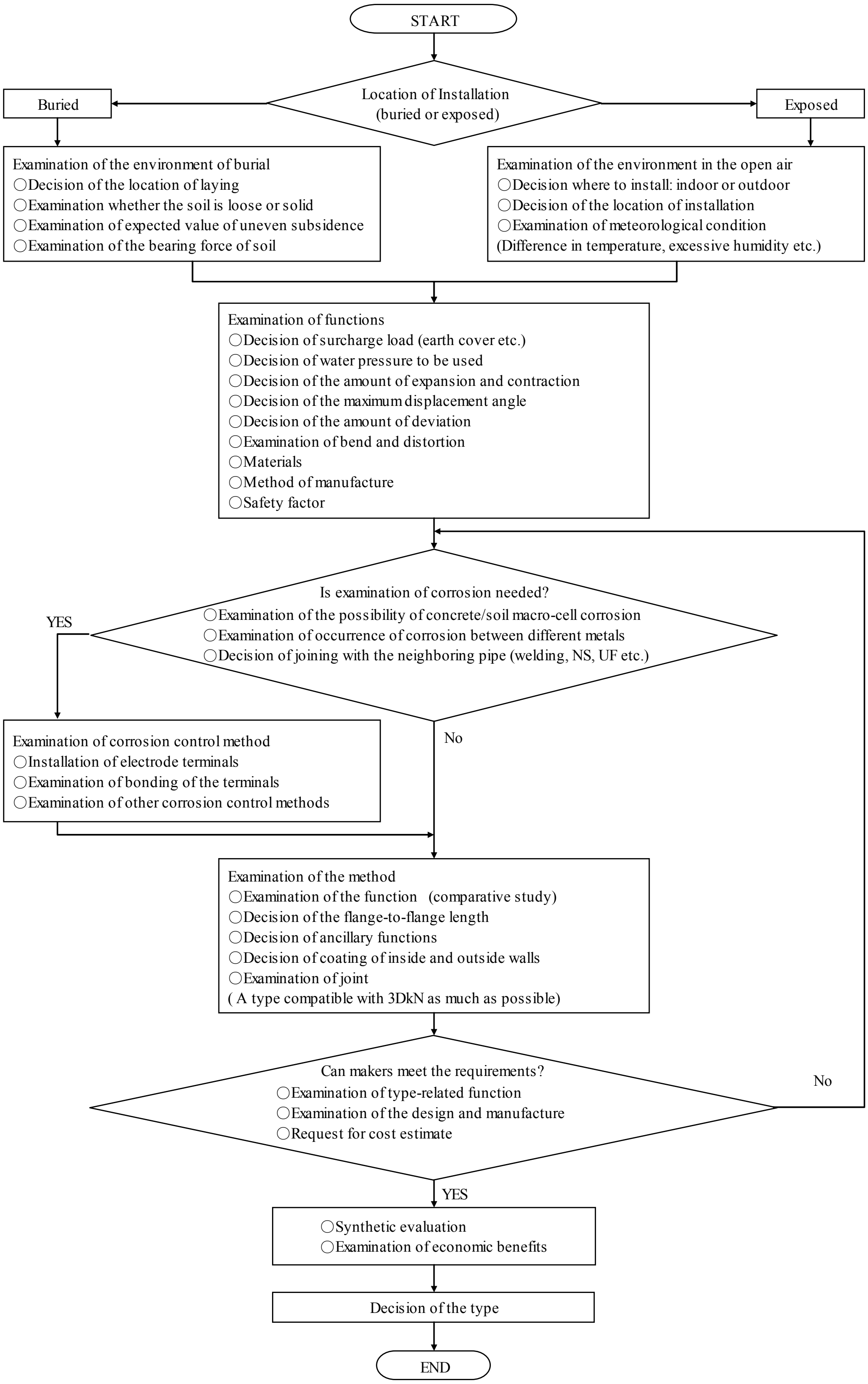


Figure 7.5.5 Flow diagram for the selection of expansion-flexible joints

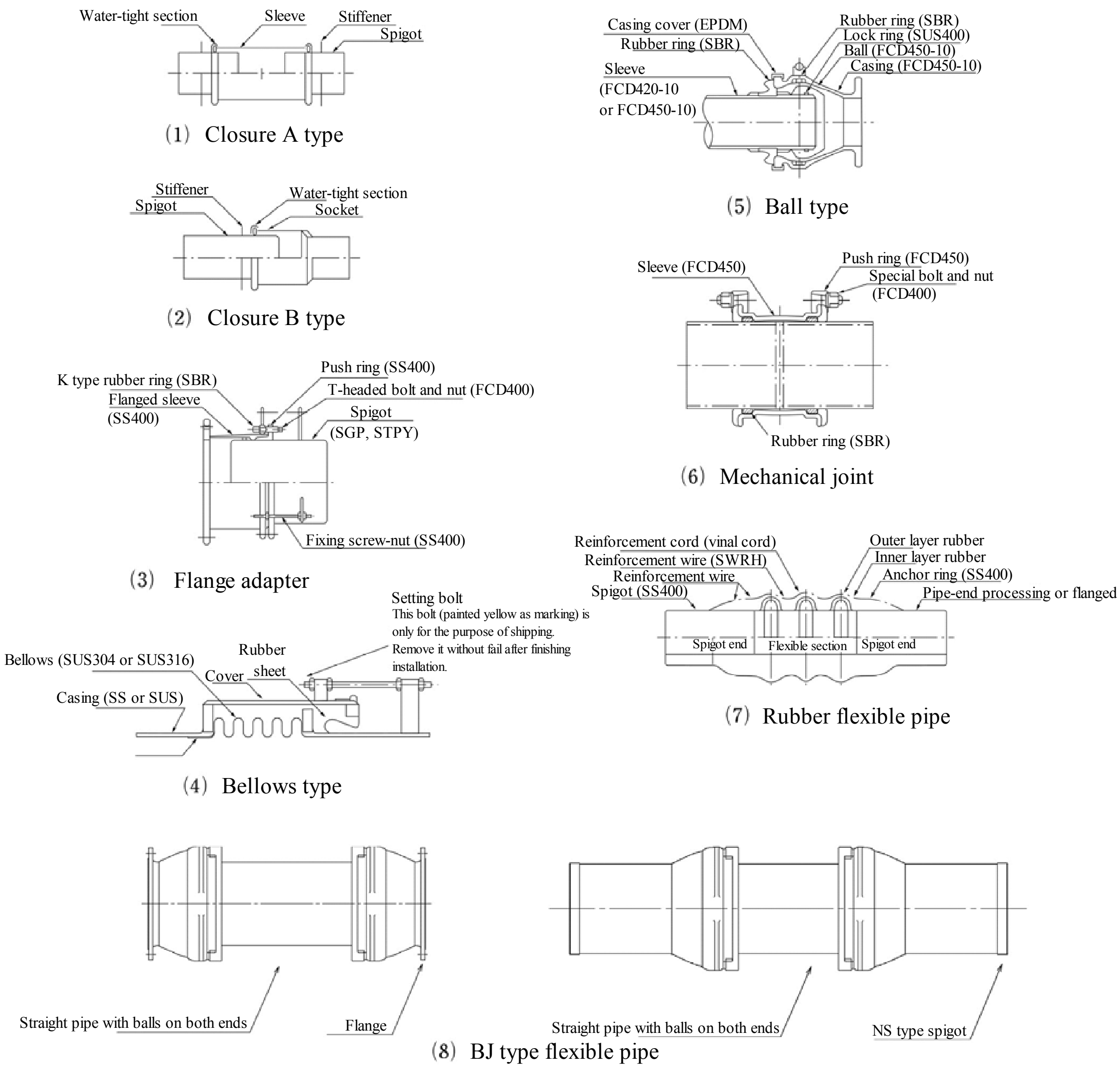


Figure 7.5.6 Examples of expansion-flexible pipes

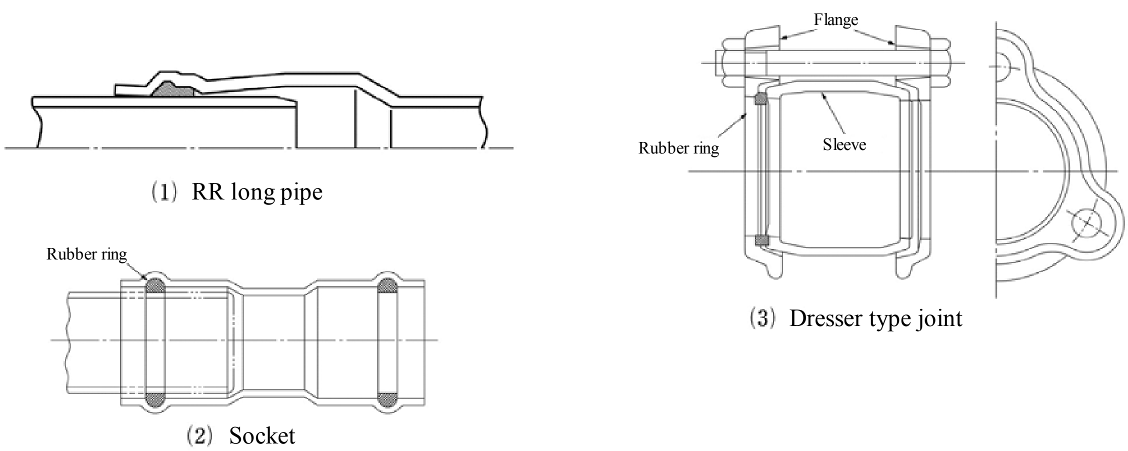
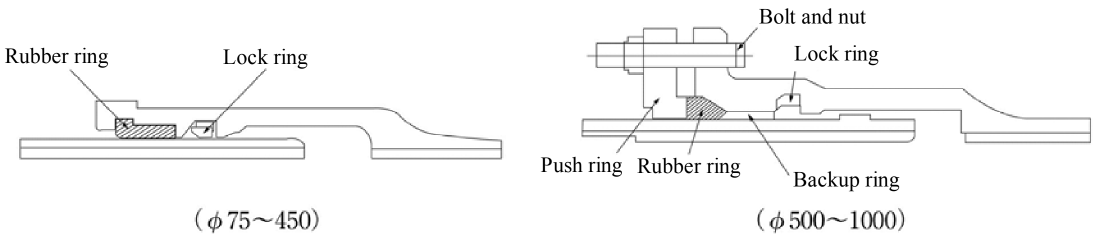
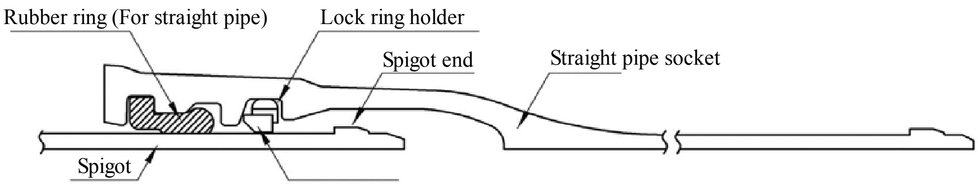


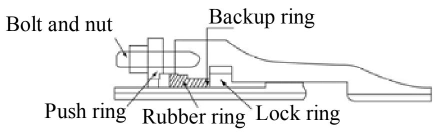
Figure 7.5.7 Examples of hard PVC pipe expansion joints



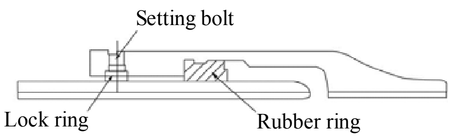
(1) NS type



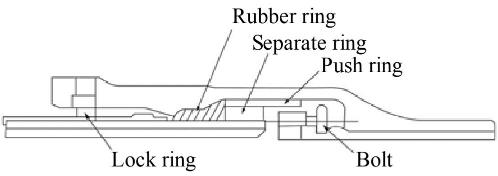
(2) GX type (φ75～250)



(3) S type (φ500－2600)



(4) PN type (φ300～1500)



(5) US type (φ800～2600)

Figure 7.5.8 Examples of ductile iron earthquake-resistant joints

7.5.8 Foundation of the water main

The design of the foundation etc. of buried water mains shall be in conformity with the following:

1. The foundation etc. of buried water mains shall be designed taking into consideration the condition of the soil, loads on the mains and the characteristics of the pipe material used.
2. Soil for backfilling shall be selected so that compaction of soil for backfilling can be carried out properly.
3. In case water mains are laid in loose soil etc., the condition of the ground and the magnitude of subsidence of the mains shall be examined; and then the suitable laying method, pipe material and joints shall be chosen.

[Interpretation]

On the item 1.;

The foundation of buried water mains shall be designed taking into consideration the condition of the soil, loads on the mains and the characteristics of the pipe materials used.

1) Shape of the foundation

The foundation for ductile iron water mains can as a general rule be flat-bottomed trench, for which no special foundation is needed. Although no special foundation is required for steel water mains in the case of the normal soil and earth cover, sand bed is used so as to abate the sectional stress and strain of the mains in case the bottom of the trench contains hard rock, boulders etc. Sand or soil of good property in the thickness of more than 0.1 m shall be placed on the bottom of the trench for hard PVC pipe and polyethylene pipe for water supply.

2) Pipe bottom support angle (design support angle)

The pipe bottom support angle to be used for the calculation etc. of pipe wall thickness shall be determined taking into account the property of soil, the type of the backfill and the support angle of the foundation. Examples of pipe bottom support angles for the ductile iron pipes are presented in Table 7.5.7.

Table 7.5.7 Pipe bottom support angles by each condition of burial

Category	Condition of burial	Support angle
A	In the case of common ground	60°
	In case sand is placed on the trench bottom as the bottom is hard.	
	In case the backfill is replaced with sand as the bottom is solid.	
B	In case the bottom is solid.	40°

As to the steel pipe and the stainless steel pipe, the pipe bottom support angle of 90° is generally used whereas a support angle of foundation of 60° to 150° is prescribed under the standards of the Japan Water Steel Pipe Association. The foundation of the steel pipe shall be made of sand or soil of good nature so compacted as to give the above design support angle. Unless sufficient compaction is not provided, there is a risk that the anticipated design support angle is not obtained, so the safety of the water mains is not secured.

On the item 2.;

The quality of the backfill not only influences the ease of the work of backfilling and compaction of the soil, but affects the safety of the water mains. Especially, the backfill shall not contain boulders, rocks etc. which may damage the body of the steel pipe, hard PVC pipe and the polyethylene pipe for water supply. Sand or soil of good quality shall be used for backfilling in case good quality of soil, which can meet the requirements for design, cannot be provided only with the excavated soil.

Supervision of construction work shall be made so that proper compaction and consolidation of the backfill are carried out to prevent uneven subsidence around the water mains and so on.

On the item 3.;

In such loose ground as an alluvium, there is a risk of not only the difficulty in laying of water mains but uneven subsidence to be caused in future. In case water mains are laid in loose ground, a proper pipe material, joint and method of construction shall be employed based on the examination of the ground condition and the magnitude of subsidence of the mains.

In case water mains are laid in a shallow loose formation, safety measures shall be provided in consideration of the weight of the mains, the weight of water in the mains, the earth load of the backfill etc. based on computation of additional earth force at the bottom of the mains and so forth and due identification of the properties of the pipe material and the joint as regards the estimate of the degree of subsidence.

It is desirable to replace the depth of 1/5 to 1/2 or so (0.15 m at minimum) of the pipe diameter below the pipe bottom with sand or soil of good nature.

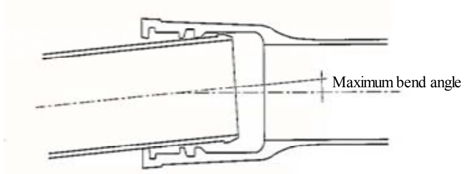
As the flexibility of the respective joints for the ductile iron pipe is given in Table 7.5.8, the water mains fit with the joint can withstand the soil subsidence if the magnitude of bend of the mains is within the angle given in the table.

Table 7.5.8 Flexibility of the joint for the ductile iron pipe (Allowable bend angle)

Nominal diameter (mm)	K type				T type				U type				NS type				S type				US type				PII type,PN type			Nominal diameter (mm)
	Bend angle θ	Allowable displacement per pipe δ (m)			Bend angle θ	Allowable displacement per pipe δ (m)			Bend angle θ	Allowable displacement per pipe δ (m)			Bend angle θ	Allowable displacement per pipe δ (m)			Bend angle θ	Allowable displacement per pipe δ (m)			Bend angle θ	Allowable displacement per pipe δ (m)			Bend angle θ	Allowable displacement per pipe δ (m)		
		4m	5m	6m		4m	5m	6m		4m	5m	6m		4m	5m	6m		4m	5m	6m		4m	5m	6m		4m	6m	
75	5° 00'	0.35	-	-	5° 00'	0.35	-	-	-	-	-	-	4° 00'	0.28	-	-	-	-	-	-	-	-	-	-	-	-	-	75
100	5° 00'	0.35	-	-	5° 00'	0.35	-	-	-	-	-	-	4° 00'	0.28	-	-	-	-	-	-	-	-	-	-	-	-	-	100
150	5° 00'	-	0.44	-	5° 00'	-	0.44	-	-	-	-	-	4° 00'	-	0.35	-	-	-	-	-	-	-	-	-	-	-	-	150
200	5° 00'	-	0.44	-	5° 00'	-	0.44	-	-	-	-	-	4° 00'	-	0.35	-	-	-	-	-	-	-	-	-	-	-	-	200
250	4° 00'	-	0.35	-	5° 00'	-	0.44	-	-	-	-	-	4° 00'	-	0.35	-	-	-	-	-	-	-	-	-	-	-	-	250
300	3° 20'	-	-	0.35	4° 00'	-	-	0.42	-	-	-	-	3° 00'	-	-	0.31	-	-	-	-	-	-	-	-	4° 00'	0.28	0.42	300
350	4° 50'	-	-	0.50	4° 00'	-	-	0.42	-	-	-	-	3° 00'	-	-	0.31	-	-	-	-	-	-	-	-	4° 00'	0.28	0.42	350
400	4° 10'	-	-	0.43	3° 30'	-	-	0.37	-	-	-	-	3° 00'	-	-	0.31	-	-	-	-	-	-	-	-	4° 00'	0.28	0.42	400
450	3° 50'	-	-	0.40	3° 00'	-	-	0.31	-	-	-	-	3° 00'	-	-	0.31	-	-	-	-	-	-	-	-	4° 00'	0.28	0.42	450
500	3° 20'	-	-	0.35	3° 00'	-	-	0.31	-	-	-	-	3° 20'	-	-	0.35	3° 20'	-	-	0.35	-	-	-	-	4° 00'	0.28	0.42	500
600	2° 50'	-	-	0.29	3° 00'	-	-	0.31	-	-	-	-	2° 50'	-	-	0.29	2° 50'	-	-	0.29	-	-	-	-	4° 00'	0.28	0.42	600
700	2° 30'	-	-	0.26	2° 30'	-	-	0.26	2° 30'	-	-	0.26	2° 30'	-	-	0.26	2° 30'	-	-	0.26	-	-	-	-	3° 00'	0.21	0.31	700
800	2° 10'	-	-	0.22	2° 30'	-	-	0.26	2° 10'	-	-	0.22	2° 10'	-	-	0.22	2° 10'	-	-	0.22	2° 10'	0.15	-	0.22	3° 00'	0.21	0.31	800
900	2° 00'	-	-	0.21	2° 30'	-	-	0.26	2° 00'	-	-	0.21	2° 00'	-	-	0.21	2° 00'	-	-	0.21	2° 00'	0.14	-	0.21	3° 00'	0.21	0.31	900
1000	1° 50'	-	-	0.19	2° 00'	-	-	0.21	1° 50'	-	-	0.19	1° 50'	-	-	0.19	1° 50'	-	-	0.19	1° 50'	0.13	-	0.19	3° 00'	0.21	0.31	1000
1100	1° 40'	-	-	0.17	2° 00'	-	-	0.21	1° 40'	-	-	0.17	-	-	-	-	1° 40'	-	-	0.17	1° 40'	0.12	-	0.17	2° 45'	0.19	0.29	1100
1200	1° 30'	-	-	0.15	2° 00'	-	-	0.21	1° 30'	-	-	0.15	-	-	-	-	1° 30'	-	-	0.15	1° 30'	0.10	-	0.15	2° 45'	0.19	0.29	1200

1350	1°30'	-	-	0.14	2°00'	-	-	0.21	1°30'	-	-	0.15	-	-	-	-	1°30'	-	-	0.15	1°30'	0.10	-	0.15	2°30'	0.17	0.26	1350
1500	1°30'	-	-	0.12	2°00'	-	-	0.21	1°30'	-	-	0.15	-	-	-	-	1°30'	-	-	0.15	1°30'	0.10	-	0.15	-	-	-	1500
1600	1°30'	0.10	0.13	-	2°00'	0.14	0.18	-	1°10'	0.08	0.10	-	-	-	-	-	1°30'	0.10	0.13	-	1°10'	0.08	0.10	-	-	-	-	1600
1650	1°30'	0.10	0.13	-	2°00'	0.14	0.18	-	1°05'	0.07	0.09	-	-	-	-	-	1°30'	0.10	0.13	-	1°05'	0.07	0.09	-	-	-	-	1650
1800	1°30'	0.10	0.13	-	2°00'	0.14	0.18	-	1°00'	0.07	0.09	-	-	-	-	-	1°30'	0.10	0.13	-	1°00'	0.07	0.09	-	-	-	-	1800
2000	1°30'	0.10	0.13	-	2°00'	0.14	0.18	-	1°00'	0.07	0.09	-	-	-	-	-	1°30'	0.10	0.13	-	1°00'	0.07	0.09	-	-	-	-	2000
2100	1°30'	0.10	0.13	-	-	-	-	-	1°00'	0.07	0.09	-	-	-	-	-	1°30'	0.10	0.13	-	1°00'	0.07	0.09	-	-	-	-	2100
2200	1°30'	0.10	0.13	-	-	-	-	-	1°00'	0.07	0.09	-	-	-	-	-	1°30'	0.10	0.13	-	1°00'	0.07	0.09	-	-	-	-	2200
2400	1°30'	0.10	-	-	-	-	-	-	1°00'	0.07	-	-	-	-	-	-	1°30'	0.10	-	-	1°00'	0.07	-	-	-	-	-	2400

Notes. 1) The allowable bend angle for the SII type joint is as same as the NSII joint.
2) The allowable bend angle stands for the maximum bend angle at the time of jointing water mains as illustrated in the figure below.



Such soil improvement work as chemical injection, the sand-drain method etc. is needed in case the loose formation is deep, or the soil is too soft for heavy construction vehicles to enter for pipe laying. Foundation for water mains, the soil at the bottom of the trench for a depth of 1/3 to 1/1 of the pipe diameter (0.5 m at minimum) shall be replaced with sand or soil of good quality, and backfilling around the pipe shall also be made with the similar material.

In case water mains are laid in deep loose soil, in which the subsidence is expected to be large, it is desirable to install joints in appropriate locations with the function of anti-escapement as well as large allowable expansion and bend (S type, NS type joint and so on for the ductile iron pipe).

7.5.9 Protection of special fittings

Protection of special fittings shall be in conformity with the following:

1. The maximum water pressure shall be the total of the maximum static water pressure and the surging water pressure in consideration of safety.
2. Protection of special fittings for the ductile iron pipe and the hard PVC pipe shall as a general rule be made by concrete blocks or anti-escapement joints. However, fixtures for the prevention of escape can be used for small size water mains in case sufficient binding force of surrounding soil can be expected.
3. The requirement for the protection of special fittings can be reduced or omitted for the welded steel pipe, the stainless steel pipe and the polyethylene pipe with fusion joints. However, protection with concrete blocks etc. shall be made in case expansion joints are installed within the effective distance for the joints to suppress the imbalanced stress.

[Interpretation]

The special fittings for bends, tees, reducers etc. receive horizontal and vertical imbalanced forces due to water pressure in the water main; and the larger the water pressure, diameter and angle of bend, the larger the force.

Protection of special fittings is needed as they are pushed out sideways due to the force, and there is a risk that the joints are dislodged.

On the item 1.;

The maximum water pressure for protection of special fittings shall be the total of the maximum static water pressure and the surging water pressure.

When determining the size of protection measure, it is decided by the condition of pipe joints and the environment of the buried water mains whether or not to consider the resisting strength against the imbalanced forces caused by water pressure in the water main, i.e., weight of backfill, resistance by earth force and resistance by friction with surroundings of the main. In case there is a possibility that the ground behind the protection block is excavated in an urbanized area where buried objects are congested, such effect shall be taken into account.

On the item 2.;

1) Protection by concrete blocks

The basic concept is that total of the following forces can withstand the imbalanced forces, which act on the special fittings: the weight of earth cover, the weight of water main, the weight of water, friction force to be generated by the weight of the concrete block and earth, and the resistance force of the passive (active) earth pressure behind the concrete block. Part of such resistance forces (e.g., resistance to active earth pressure) can be omitted in some cases.

2) Protection by the anti-escapement joint

The anti-escapement joint is used in case the soil is loose or the space for installing the concrete block is restricted.

There are the UF type and the NS type as anti-escapement joints for large diameter ductile iron pipe; and the length of water mains consolidated as one body is computed in accordance with the imbalanced forces and the soil condition.

The use of the concrete blocks together with the anti-escapement joints is desirable in the case of high pressure water mains and where there is a possibility of excavation in the vicinity of the block.

3) Protection by fixtures for anti-escapement

The water mains may be consolidated as one body by the use of the fixtures for anti-escapement in case the water mains are small in diameter; the soil is not corrosive; and the gripping force of surrounding soil is expected to be sufficient. There are fixtures for anti-escapement for the K type, T type etc. for the ductile iron pipe; and there are ones for the RR type joint and the special fitting embodied with a built-in anti-escapement device for the hard PVC pipe. (See Figure 7.5.10 and Figure 7.5.11).

Either of the above fixtures shall be used only for water mains of which water pressure is less than the total of the allowable water pressure set for the anti-escapement fixture, and the water pressure with enough safety factor in accordance with the imbalanced forces and the soil condition. What is more, such complete means of anti-corrosion as the polyethylene sleeve shall be provided in case the anti-escapement fixture is unavoidably used in corrosive soil.

On the item 3.;

Protection of special fittings for water mains of steel pipe and stainless steel pipe with welded joints and polyethylene pipe with butt fusion joints can be abated or omitted since the mains are made in one body and the imbalanced forces due to the inside pressure will be absorbed by the strength of the pipe body itself.

Protection of special fittings with concrete blocks shall be used in case the length to exert binding force is insufficient as expansion joints etc. are installed on the water mains.

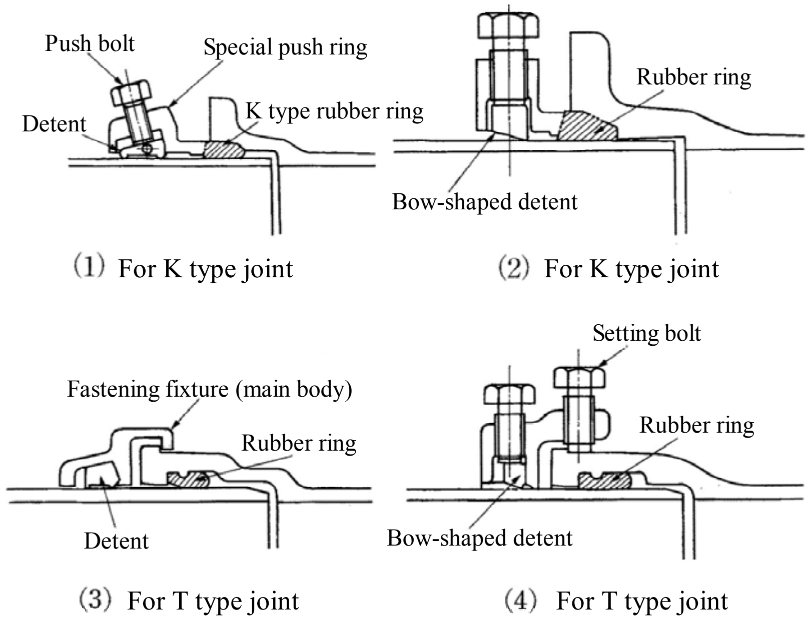


Figure 7.5.10 Examples of anti-escapement fixture (for ductile iron pipe)

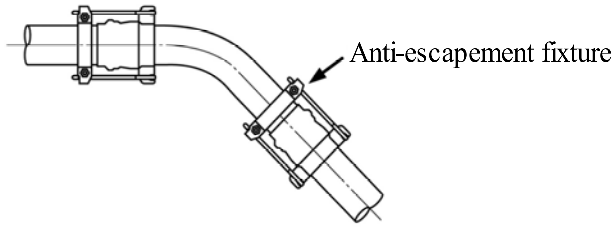


Figure 7.5.11 Example of anti-escapement fixture (for RR pipe of hard PVC pipe)

7.5.10 Labeling of water mains

As a general rule, tape bearing the name of utility, the date of laying, the type of industry etc. shall be stuck on buried water mains so that they are not mistaken for other pipelines.

[Interpretation]

Due to congestion of buried objects, exclusive buried objects shall be labeled with the name of the object, the name of its administrator, the year of its installation and so on so as to avoid an accident on an occasion of excavation of the road.

(An example of labeling)

	○○City Water Department 2002		2002 ○○City

Furthermore, there are cases where a labeling sheet, in addition to a labeling tape, is placed in the ground above the water main at the time of backfilling so that the location of the main can be recognized to avoid damage which may be caused by other construction work (See Figure 7.5.13).

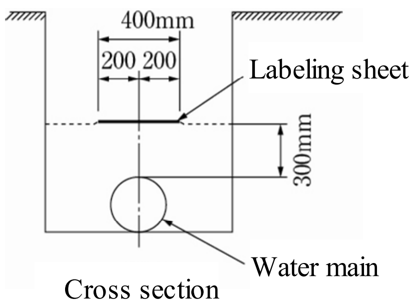


Figure 7.5.13 Example of labeling sheet

7.5.11 Corrosion prevention of the outside wall of water mains

Corrosion prevention of the outside wall of water mains shall be in conformity with the following:

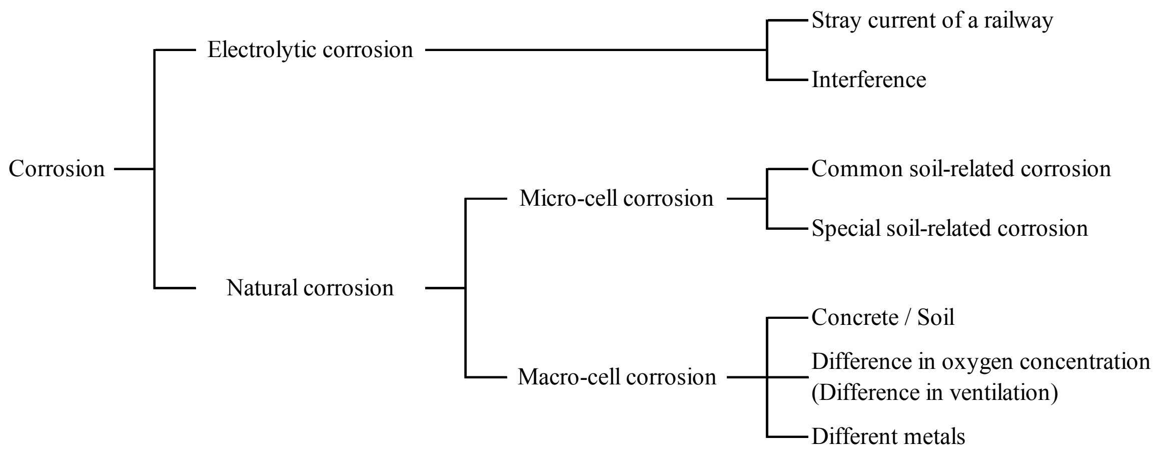
1. Proper measures for corrosion prevention shall be provided in advance based on a study on the situation in case metal water mains are unavoidably laid in the vicinity of a railway or another facility of corrosion control.
2. Such proper measures as corrosion prevention coating shall be provided when water mains are laid in an area with highly corrosive soil or a region where there is a risk of salt water intrusion and so forth.
3. Proper measures for the prevention of macro-cell corrosion shall be provided for a pipe at the points where it pierces through concrete; it is laid in the interface of different soil formations; and different metals come in contact.
4. After the implementation of cathodic protection, it is desirable to regularly check its effectiveness for management of the protection system.

[Interpretation]

The phenomena of corrosion of the outside wall of the metal pipe are roughly divided into electrolytic corrosion and natural corrosion. Electrolytic corrosion means the corrosion caused by stray current from the electric railway, and that brought about by the current for a cathodic protection facility.

Natural corrosion is classified into micro-cell corrosion and macro-cell corrosion depending on the situation of the formation of corrosion cells. The micro-cell corrosion is caused by localized microscopic cell action on the surface of the metal pipe body. The macro-cell corrosion is caused when a large corrosion cell is formed by part of the pipe body as anode and other object situated near the pipe as cathode due to the difference in environment and that in material.

The location and the scale of the anode and the cathode of the macro cell (a large corrosion cell) can generally be distinguished by measurements etc. The classification of corrosion of metal pipes is presented in Figure 7.5.14.



Stray currents of an electric railway	Corrosion which occurs where a direct current railway runs parallel with a water main.
Interference	Corrosion occurring in the vicinity of a direct current railway where electric grounding is made for other buried objects.
Common soil-related corrosion	Corrosion occurring in a place with such relatively corrosive soil as the one containing much quantity of salt in the seashore, reclaimed land etc., humus, clayey soil and so on
Special soil-related corrosion	Corrosion occurring in a place of marine clay with very high corrosiveness by the activity of sulfate reducing bacteria
Concrete/soil	Corrosion occurring due to the difference in electric potential between metal objects due to different pH values of concrete and soil. Especially, corrosion gets accelerated where the pipe comes in contact with reinforcing rods in concrete through which the pipe is laid.
Difference in oxygen concentration (difference in ventilation)	Corrosion occurring on pipe laid in well-ventilated soil (or low humidity) and another poorly-ventilated (or high humidity) soil next to the former.
Different metals	Corrosion occurring in case different metal objects (steel, stainless steel etc.) are connected, of which electric potentials are different.

Figure 7.5.14 Classification of corrosion of metal pipe

On the item 1.;

As the rails of a direct current railway are used as the return line for the electric current for the train, part of the current returning to the substation through the rails also flows through the ground. In case water mains, gas mains, ducts for communication lines, power lines etc. are laid in such ground, the current tends to conduct these metal pipes, whose electric resistance is relatively small, and return to the substation. Electrolytic corrosion occurs on the location on the pipe body where the current comes out (See Figure 7.5.15).

Given this, in case water mains are unavoidably laid close to, in parallel with or crossing an electric railway, proper preventive measures against electrolytic corrosion shall be provided in advance based on a survey of potential gradient etc.

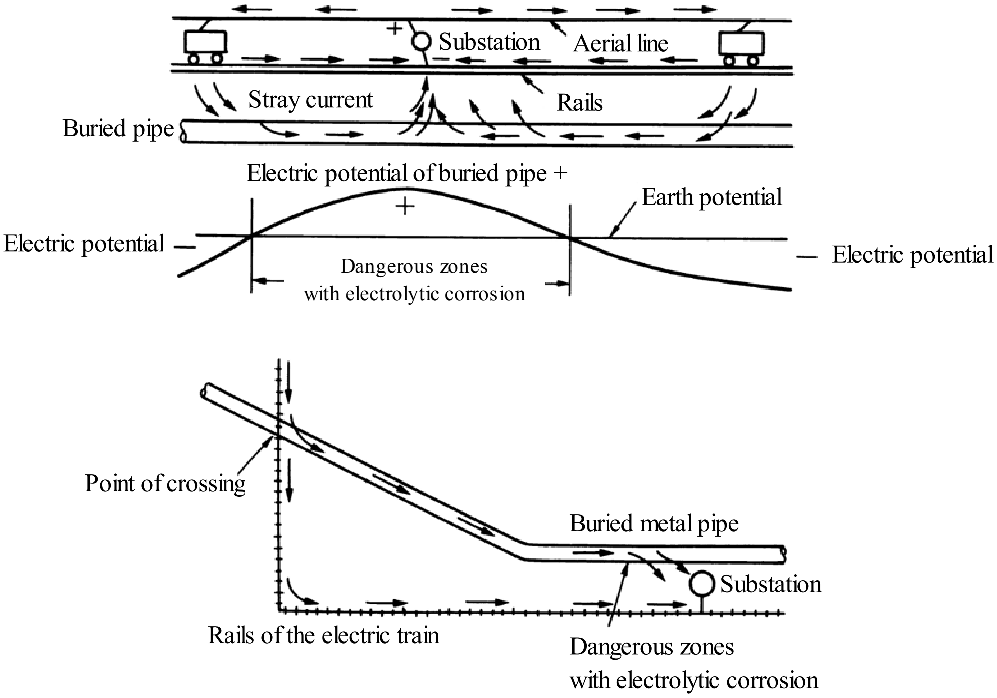


Figure 7.5.15 Dangerous zones with stray currents

On the item 2.;

It is desirable to study on the corrosiveness related to the quality of soil and groundwater prior to laying of water mains.

In case water mains are laid in the soil contaminated with acidic wastewater from a factory, in the place groundwater containing a lot of salt in a seashore region, in the embankment of cinder with a content of sulfur, in a peat region and other reclaimed land filled with waste, measures for protection of the outside wall of the water mains suitable to the respective environment shall be provided such as shrouding by concrete, wrapping with corrosion-resistant tape, covering with polyethylene sleeves etc. or coating with polyurethane or polyethylene material or anti-corrosion plating with zinc alloy and so forth.

As for bolts and nuts for pipe joints, those of stainless steel or ductile iron coated with oxide film shall be used; and the joint section shall, before burial, be wrapped with a polyethylene sleeve together with the pipe itself.

For laying hard PVC pipe or polyethylene pipe for water supply, it is desirable to avoid locations where there is leak of such organic solvent as gasoline; there is influence of UV ray; or there are high temperatures or excessively low temperatures.

On the item 3.;

Macro-cell corrosion is caused by huge corrosion cells which are formed due to the potential difference depending on the surroundings or that of metals themselves. Concrete examples of macro-cell corrosion are presented below (See Figure 7.5.20 to Figure 7.5.23):

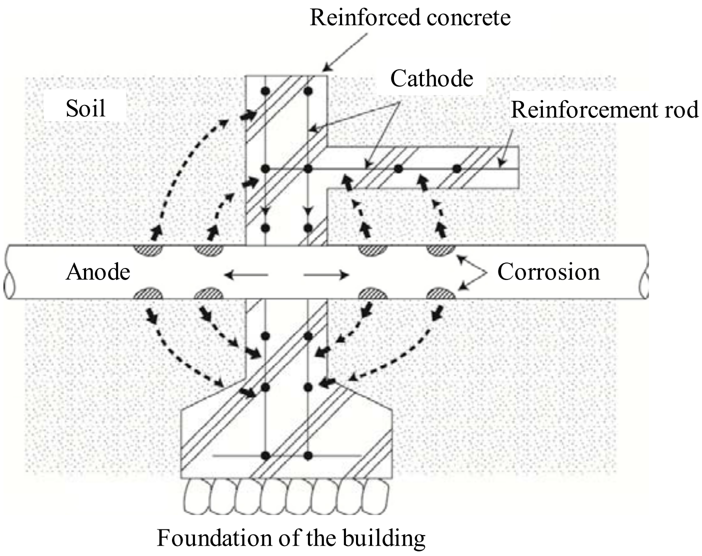


Figure 7.5.20 Corrosion in case pipe and reinforcement rods in concrete come in contact

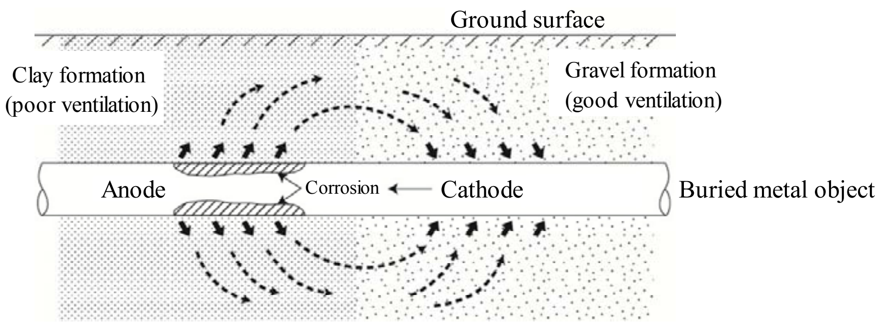


Figure 7.5.21 Corrosion caused by the difference in soil quality

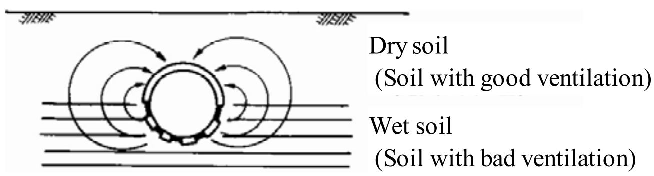


Figure 7.5.22 Corrosion caused by different soils with high and low moisture

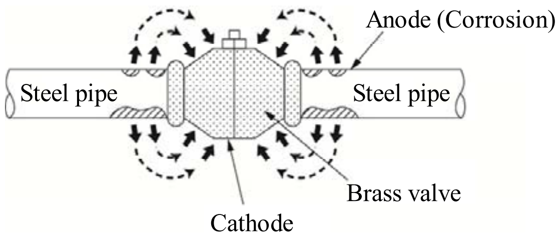


Figure 7.5.23 Corrosion caused by contact between different metals

7.5.12 Water pressure test

Water pressure test shall be undertaken in conformity with the following:

1. After laying water mains, the water-tightness and safety shall in principle be confirmed by means of a pressure test.
2. Proper measures shall be provided based on the result of the test.
3. Tests using air pressure shall not be employed.

[Interpretation]

On the items 1., 2., and 3.;

Water-tightness and pressure resistance of the pipe itself have been certified by a water pressure test etc. at the factory. However, after finishing jointing water mains, fixing ancillary facilities, installing concrete blocks for special fitting protection and so on, water pressure tests shall be carried out on the entire water mains laid to confirm their water-tightness and pressure resistance. Nonetheless, this procedure may be omitted if there exist such restrictions as conditions for construction work. In addition, tests of water mains using air, of which rate of expansion is large, shall not be performed because it may bring about such a hazard to the construction work as the dangers of blowing-off of the testing apparatus, damage of ancillary facilities etc.

For the water pressure test, air contained inside the water mains shall completely be discharged from air valves, hydrants etc. so that the mains are not broken due to rapid pressurization, so water shall gradually be introduced into the mains.

What is more, an appropriate measure shall be applied on the end of the water mains so that the mains are not detached.

It is desirable for the pressure test to be undertaken one day or so after filling the water mains with water. The test shall first be carried out at the pressure lower than the design pressure, and then, while holding the pressure for a certain period of time after raising the pressure up to the design pressure, the existence of leak from the mains and the change in pressure shall be studied during such time. Proper values of the testing pressure, the holding time and allowable drawdown of the pressure shall be set in consideration of the operational water pressure, the pipe material, the type of joints, the length of the mains, condition of the ancillary facilities, requirements for construction and so on.

7.5.13 Laying of distribution mains

Attention shall be paid to the following items for the laying of distribution mains:

1. Based on the design drawings and related documents, a plan for the laying of distribution mains shall be established, and the laying shall be carried out efficiently and reliably.
2. Such a laying method shall, as much as possible, be selected that does not require the suspension of water service with the provision of a temporary interconnection main. In this case, measures to avoid interference to the laying of such an interconnection main shall be practiced. Even if water service is suspended, public relations activities shall be conducted so as to make its influence to a minimum.
3. Removal of existing water mains shall properly be carried out after confirming that they are really the ones to be removed judging from their location of laying, pipe material, diameter etc.
4. Water mains shall always be furnished with a plug or cap at their ends; and they shall properly be protected.
5. In case a pipe of different material is connected with the present water mains, a proper measure shall be provided so that corrosion caused by the contact between different metals does not occur.
6. The distribution mains shall not be connected with facilities of another water provider.

7.5.14 Water main bridge and bridge-piggybacked water main

The water main bridge and bridge-piggybacked water main shall be in conformity with the following:

1. Water main bridge

1) The most proper type and structure shall be selected in consideration of the diameter, the trave, the geographical condition and the harmony with the view of the surroundings.

2) The water main bridge shall be safe against dead weight, water pressure, earthquake force, wind force, snow load etc.

3) The support structure of the water mains shall be safe against water pressure, earthquake force and the change in temperature.

4) Expansion joints with flexibility shall be installed on water mains buried close to the bridge abutments; and protection measures shall be provided for the bend sections of the mains.

5) Protection measures shall be provided for the bridge piers against collision with objects if needed.

6) Air valves shall be provided at the highest point of the bridge. Proper insulation shall be provided in a cold region. Moreover, a walkway shall be provided for inspection as required.

7) The water main bridge shall be provided with a proper measure to prevent the fall of the water mains.

8) Proper corrosion-preventive measures shall be provided for the water main bridge.

2. Bridge-piggybacked water main

1) Expansion joints shall be set at the sliding end of the bridge as required.

2) Expansion joints with flexibility shall be installed on water mains buried close to the bridge abutments; and protection measures shall be provided for the bend sections of the mains.

3) Air valves shall be set at the highest point of the main. Proper insulation shall be provided in a cold region.

4) Proper corrosion-preventive measures shall be provided for the bridge-piggybacked water main.

3. Ductile iron water main bridge and bridge-piggybacked ductile iron water main

Although their basic functions shall be in conformity with 1. Water main bridge, and 2. Bridge-piggybacked water main, the following aspects are different:

1) The structure of the water main bridge

2) The displacement caused by the load to be considered for design

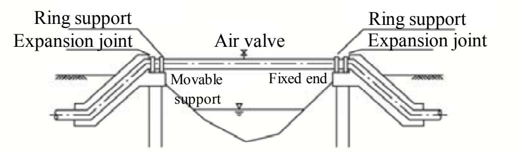
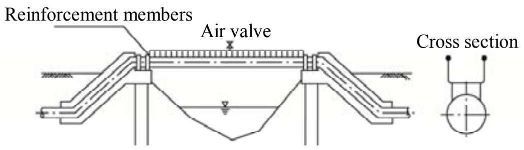
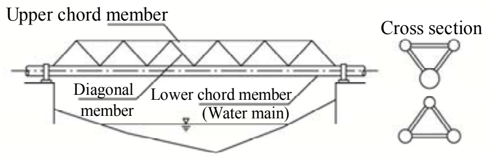
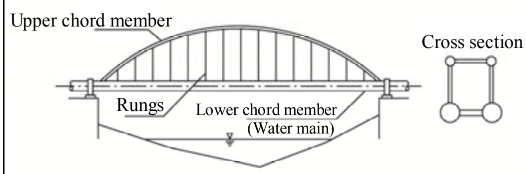
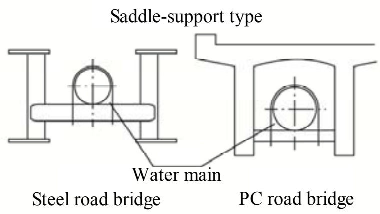
3) The structure of buried water mains in the vicinity of the abutments of the bridge

4) The coating method for the exposed surface of the water main

[Interpretation]

As the methods for crossing rivers, roads, railways etc., there are the water main bridge and the bridge-piggybacked water main.

Figure 7.5.32 Type and structure of steel water main bridge

<table>
<tr><th colspan="2">Type</th><th>Structure</th><th>Outline description</th></tr>
<tr><td>Pipe beam type</td><td>Simple beam (simply supported)</td><td>
</td><td>Water mains are supported by ring supports and support saddles. The expansion joint and saddle absorb the angular displacement and expansion/ contraction. As similar type and structures, there are the one-end-free one-end-fixed type; continuous support type; both ends fixed type etc.</td></tr>
<tr><td rowspan="3">Reinforcement type</td><td>Flange-reinforced</td><td>
</td><td>The rigidity of water mains is reinforced by T type or π type flanges set on the pipe body. The position of the flanges is commonly the top of the pipe, and the bottom of the pipe in some cases.</td></tr>
<tr><td>Truss-reinforced</td><td>
</td><td>Water mains are used as upper and lower chord members of the truss: The property of water mains is effectively applied. There are the triangle type truss, and box type truss etc.</td></tr>
<tr><td>Langer-reinforced</td><td>
</td><td>The water mains, which form the lower members, are hung by rungs hanging from the arching upper members. It is a rational type as the respective members are decided mainly by tensile stresses.</td></tr>
<tr><td>Bridge-piggyback type</td><td>Steel road bridge
PC road bridge</td><td>
</td><td>Structurally speaking, it is a pipe beam type.
Construction cost and space can be saved by the use of the road bridge. Examination is needed on measures against relative displacements between the water main and the road bridge, sufficient strength of the support at the time of an earthquake, ancillary facilities and methods of their installation.</td></tr>
</table>

7.5.15 Inverted siphon

The inverted siphon shall be in conformity with the following:

1. Access pipes at the ends of a siphon shall be laid on a gentle slope, and their bending sections shall be fixed on concrete bases as required.
2. Foundation for the siphon shall be determined taking into consideration the nature of the foundation ground, condition of loads etc.
3. A mark showing the location of the siphon shall be planted on the embankment and so forth.
4. Important water mains shall be laid as siphons in a coastal region, where damage by tsunami is expected.

[Interpretation]

Siphon is a method of laying the water main by means of lowering the line of the main to cross a river, canal, railway, road, buried obstacles etc. underneath them.

7.5.16 Pipe jacking method

The pipe jacking method shall be in conformity with the following:

1. An appropriate method shall be selected synthetically examining the safety and soundness of the construction work based on a survey in advance on geotechnical quality, obstacles, environment etc. and prior consultation with the concerned authorities.
2. The pipe material, which is suitable for the required diameter, the length, the depth and method of laying, shall be selected for pipe jacking in consideration of its strength, durability and the ease of construction.
3. The guide pipe shall have the structure suitable for the diameter of the jacking pipe, geotechnical quality, and the construction method.

[Interpretation]

There are cases where the pipe laying by the open cut method in urbanized areas is difficult from the view point of assurance for smooth traffic and the prevention of hazards caused by construction work; and so implementation by a non-open cut method is increasing in number.

Non-open cut methods are roughly classified into the jacking method and the shield driving method. The jacking method is commonly used in case crossing a railway, river, trunk road etc., and the length of its execution is in general 50 m to 100 m or so. The shield driving method is, in turn, employed in the cases of large-scale work for water mains with a large diameter and length.

By the jacking method, a leading head is attached on the head of pipe; excavation is operated from a jacking shaft etc.; the excavated soil is carried out; and one span of the pipe is laid.

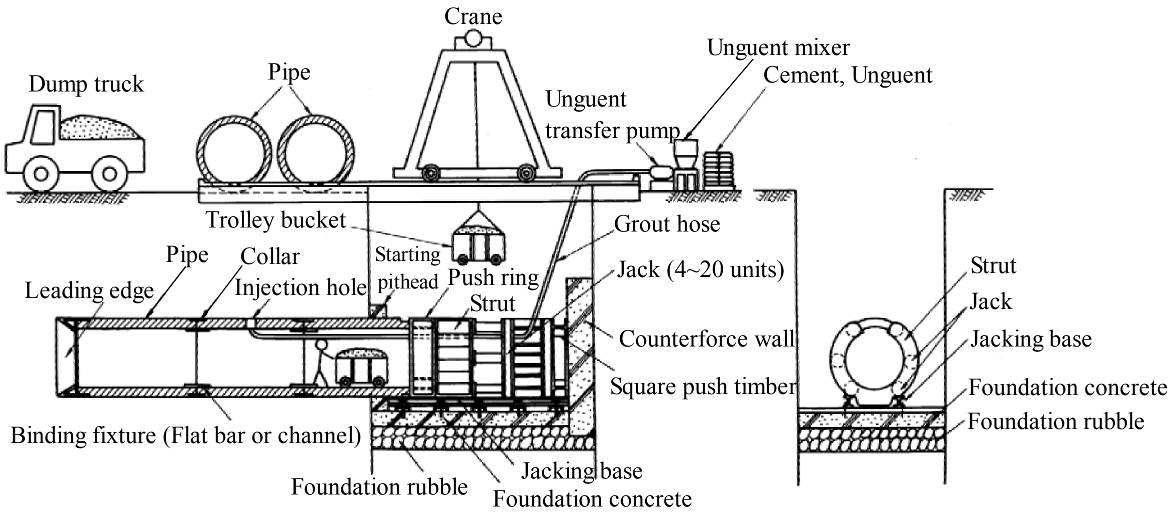


Figure 7.5.42 Example of the lead-pipe jacking method

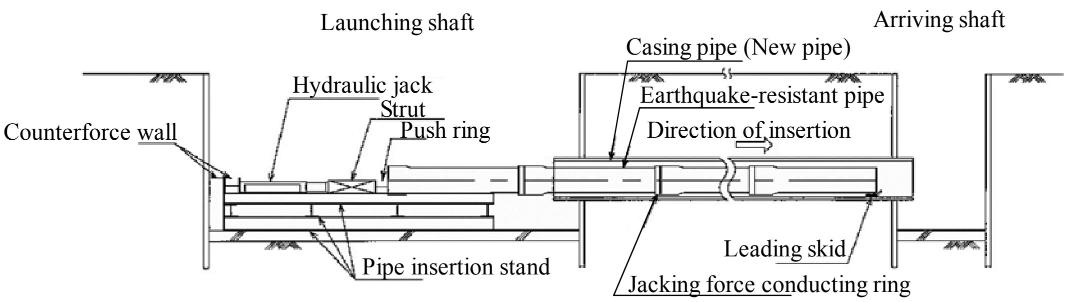


Figure 7.5.43 Example of casing pipe jacking method

7.5.17 Shield driving method

The shield driving method shall be in conformity with the following:

1. Studies shall be conducted on the site condition, obstacles, geography, geotechnical property, environmental protection while examining the laws and their contents to be abided by, and required procedures and measures for them.
2. The section of the tunnel shall be determined taking into account the safety and efficiency of construction while the sectional area required for the method of construction, diameter etc. is secured.
3. A straight or gently curving line shall be employed for tunneling, and the earth cover shall be determined in consideration of the condition of the ground surface and buried structures, the condition of the natural ground and requirements for construction.

[Interpretation]

The shield driving method is a tunneling method by a shield. The shield is mainly composed of cylindrical skin plate made of steel, and a built-in jack. The earth is excavated at the working face at the head of the shield; segments are assembled inside the shield for the primary lining; and the shield is thrust forward by the counterforce produced from the segments by the jacks set behind the shield. As the skin plate holds the natural earth from collapse, the tunnel is constructed under such protection.

The shield driving method is employed for a large construction work compared with the pipe jacking method, and the standard scale of the work by the method is for more than 1,000 mm of inside diameter and the tunneling length of 500 m to 1,000 m. Correction of meandering is easy with the method; and horizontal curving and vertical sloping can be made to a certain extent..

7.5.19 Construction method with uninterrupted water service

The installation of branching work and valves under the method with uninterrupted water service shall be undertaken based on the following:

1. A method with a structure and material with sufficient strength, durability and water-tightness shall be selected for the method with uninterrupted water service.
2. When employing the method with uninterrupted water service, a study shall be conducted, by test excavation etc., to identify the pipe material of the existing water main, its outside diameter, circularity, space for setting of drill etc.
3. Drilling shall be performed after fitting a separate tee on the existing water main and confirming that there is no water leakage based on a prescribed water pressure test.
4. When undertaking a method with uninterrupted water service in loose soil, sufficiently sound foundation shall be provided; or expansion joints with flexibility, which can cope with uneven subsidence of the ground, shall be used.

[Interpretation]

As methods with uninterrupted water service, there are the branching method with uninterrupted water service, and the method of installing a valve with uninterrupted water service. The branching method with uninterrupted water service is a method to provide a branch pipe from the existing water main by means of setting a separate tee for branching. The method of installing a valve with uninterrupted water service is a method to install a gate valve or cock at any point on the existing water main with the same diameter as the main.

7.5.20 Pipe laying method inside the existing water main

Improvement or replacement of a water main shall be in conformity with the following:

1. A sufficient study is needed on the condition of the site, situation of the existing water main and so forth when selecting the method.
2. A pipe material shall be selected to be used in the existing water main, which possesses water-tightness, durability and the ease of construction; and it can secure the required pipe diameter.
3. The interstice between the casing pipe and the new one inside the former shall as a principle be filled with cement mortar etc. to form a layered structure.

[Interpretation]

While minimizing excavation of road and making good use of the existing water main, there are a pipe insertion method to improve or replace the existing water main by means of laying a new pipe inside the existing one; a method to apply lining of the inside wall of the existing water main for the same purpose and so on.

7.5.21 Pipe rehabilitation method

Rehabilitation of water mains shall be in conformity with the following:

1. A method, with which the strength of the existing mains can be expected, shall be employed. When selecting the method, sufficient study shall be carried out on the condition of the existing water mains and so on.
2. For cleaning of the inside of a water main, an appropriate method shall be used depending on such condition as the pipe diameter, the length of implementation and the method of work etc.

[Interpretation]

The pipe rehabilitation method is to intend the restoration of transmission capacity of the existing water mains and the prevention of “red water” using various types of machinery and materials by means of removing incrustation deposited or large tubercles inside the mains which reduces transmission capacity thereof. The object of the method is cast iron pipe, steel pipe etc.

7.6 Ancillary Facilities

7.6.1 General

1. Types and roles of ancillary facilities

Ancillary facilities of distribution mains are classified into closure valves, control valves, air valves, pressure reducing valves, hydrants, drainage facilities, flow meters, pressure gauges, automatic water quality analyzers etc. It is required for them to be able to properly secure the water flow, water pressure and water quality working together with the distribution mains in accordance with the water demand of the service area. The hydrants shall be able to properly cope with for water flow at the time of fire.

2. Standards etc. of materials used

Although the ancillary facilities have respective materials, method of manufacture, standard size and inside coating, those, which fall in conformity with the Ordinance to provide Technical Guidelines for Water Supply Facilities, shall be used as same as distribution mains. Although such an apparatus as hydrants, which come in contact with water on very small surface, are excluded from the application of the elution standards of the Guidelines, it is desirable to use those which meet the elution standards.

Main standards for ancillary facilities are presented in Table 7.6.1.

Table 7.6.1 A table of main ancillary facilities (for reference)

	Name	Standard	Diameter (mm)	Note
Valve and faucet	Gate valve for water supply (W.S.)	JIS B 2062	50-1,200	Vertical, flanged, mechanical
	(do)	(do)	400-1,500	Horizontal, flanged
	Soft-seal gate valve for W.S.	JWWA B 120	50-500	Flanged, NS
	Ductile iron gate valve for W.S.	JWWA B 122	50-500	Flanged
	Butterfly valve for W.S.	JWWA B 138	200-1,500	Vertical, horizontal, flanged,
	Large-size butterfly valve for W.S.	JWWA B 121	1,600-2,600	Flanged
	Rapid-action air valve for W.S.	JWWA B 137	25	Screw
	(do)	(do)	75,100,150,200	Flanged
	Underground hydrant for W.S.	JWWA B 103	75	Single-jet, flanged
	(do)	(do)	100	Double-jet, flanged
	Ball type single-jet hydrant for W.S.	JWWA B 135	75	Flanged
	Repair valve for W.S.	JWWA B 126	75,100	Ball valve, butterfly valve, flanged
	Gate valves with gears for W.S.	JWWA B 131	600-1,200	Vertical, flanged
	(do)	(do)	400-1,500	Horizontal, flanged
Lid and box	Cap for valve for W.S.	JWWA Z 103		
	Round iron lid for W.S.	JWWA B 132		
	Square iron lid for W.S.	JWWA B 133		
	Screwed valve box for W.S.	JWWA B 110		
	Resin-concrete box for W.S.	JWWA K 148		

7.6.2 Closure valve and control valve

The installation of isolation valves and control valves shall be in conformity with the following:

1. Isolation valves and control valves shall possess functions compatible with the hydraulic condition of water mains, the purpose of installation and so on.
2. They shall be installed where they are needed for the operation of water distribution and the maintenance of water mains.
3. They shall not adversely affect the water quality.
4. Valve with diameter of more than 400 mm shall be fit with a bypass valve or have the function to fill water in itself.
5. The valve box shall be of a strong structure, and will not cause any obstruction for the operation and inspection of the valve.
6. The stability of the water main shall be maintained on both sides of the valve.

[Interpretation]

Gate valves and butterfly valves are used in many cases as valves for closure; and butterfly valves and cone valves as the valves for control of flow and pressure.

On the item 1.;

The valves for closure act to close or open the flow in the water main at the full-open position or complete-shut position. Valves, which can reliably work, shall be used in case such operation as closure of flow is needed due to a change in the service area or its subdivisions; laying of distribution mains; operation in an emergency and so forth.

The control valves shall be able to properly regulate the water flow and pressure by adjustment of its opening so that the dynamic water pressure in the service area is maintained constant as much as possible; and that the necessary quantity of water is distributed depending on demand in relationship with the land elevations in the service area, characteristics of the community such as the size of buildings, and the layout of the trunk and sub- distribution mains.

On the item 2.;

Valves (closure valve and control valve) shall be installed in appropriate locations taking into consideration the composition of the trunk mains network and the submains networks and the geographical condition so that leveling of dynamic water pressure, rational water use management, maintenance of distribution mains etc. can properly be undertaken. Control valves shall be installed at important locations for water use management at normal times and in an emergency.

Examples of the location of valves are tabulated as follows:

1) Distribution trunk mains

(1). Valves shall be installed at the beginning point, branching point, crossing section of water mains, both ends of a water main bridge and a siphon, near the branching point for drainage pipe, and at 1 km to 3 km interval in the case of a long water main.

(2). Valves shall always be installed at the upper and lower ends of a long slope with a large difference in elevations.

2) Distribution submains

Valves shall always be installed at the branching points from trunk mains, both ends of a water main bridge and a siphon, near branching points for drainage pipe; and they shall be installed at branching points and intersections of submains depending on the composition of the submains network.

On the item 3.;

Both closure valves and control valves will gather rust due to deterioration of paint in the valve casing and on the valve disc after a long period of use, which will cause “red water” or make their operation difficult.

There are epoxy resin powder painting for water supply, solventless epoxy painting for water supply and so on as paint for valves.

On the item 4.;

The torque of the closure valve becomes large at the moments of opening from the complete closure and right before closing to a complete closure. The higher the water pressure working on the valve disc, the bigger the torque; and the bigger the pipe diameter, the larger the torque.

Therefore, for valves of diameter of larger than 400 mm with water pressure of more than 0.4 MPa, it is needed to attach a valve of much smaller diameter to the main valve; or install a valve with a built-in sub-valve so as to open the smaller valve prior to the operation of the main valve to send water to the downstream side of the main so that the pressure difference between both sides is reduced; and that the operation of the main valve become easier.

On the item 5.;

Valve boxes are provided for valves on trunk distribution mains of a diameter larger than 400 mm. In case the boxes are installed under a road with busy traffic of automobiles, the boxes shall have a sturdy structure which can withstand such a condition.

The valve box shall be so designed that the replacement of the valve can be made. Step irons with strong resistance to corrosion shall be planted inside the box so that safe access to the valve can be secured for inspection and maintenance.

Round valve boxes are used for valves of a diameter smaller than 350 mm. Foundation with crushed stones is provided; the box is placed on it and sufficient compaction of backfill shall be made so that the operation of the valve is not hindered due to its leaning. An example of the round valve box is sown in Figure 7.6.1.

On the item 6.;

Since the water mains around the valve box move in different ways from the box at the times of uneven ground subsidence and liquefaction of the ground, and so there is high possibility of accidents, appropriate measures shall be made to secure the stability of the mains.

An example of the valve box is presented in Figure 7.6.2.

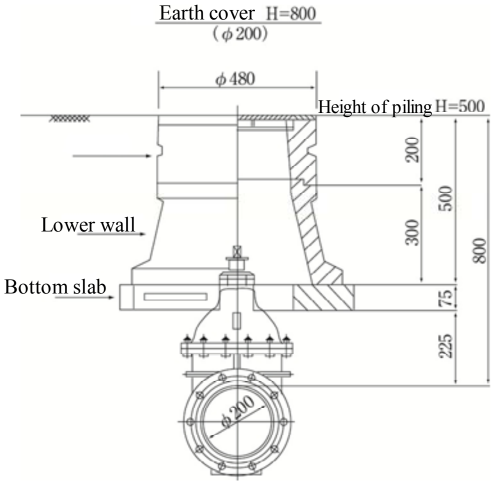


Figure 7.6.1 Example of installation of a round valve box

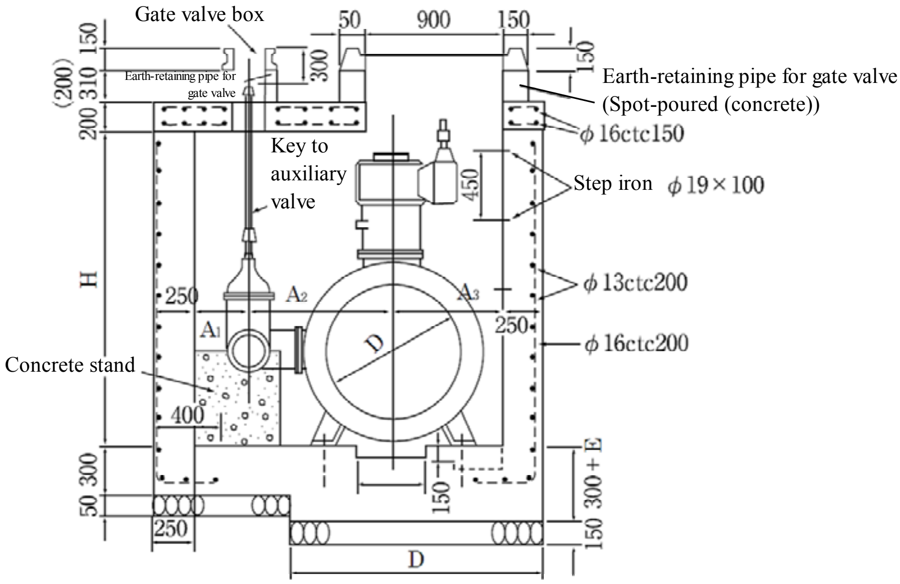


Figure 7.6.2 Example of installation of a valve box

7.6.3 Air valve

Installation of air valves shall be in conformity with the following:

1. Air valves shall be installed at convex (elevated) points or other suitable points of water mains.
2. Rapid-action air valves with an appropriate diameter shall be selected.
3. An auxiliary valve shall be fit on the air valve.
4. The air valve box shall have a sturdy structure, and so maintenance of the valve shall be easy.
5. Proper insulation against frost shall be provided in a cold region.

[Interpretation]

On the item 1.;

The air valve is an ancillary facility to discharge air, which separates from water, and inhale air into the water main when water is drained from it. For this reason, the air valve is indispensable to be installed at convex points of water mains where air accumulates the most easily. The convex point of the water main, in this case, denotes a convex point in the profile of the water main, of which example is the crest of a water main bridge.

The air valve is also needed when filling and draining water in and from the water main. In case the length of the water main is large and there are no convex points along the main, air valves are installed to properly regulate time required for filling and draining water. Since valves are installed at a 1 to 3 km interval in case the water main is long, air valves shall always be installed in-between the valves. In this instance, it is convenient to install the air valve close to the valve at the highest point of the water main in case the main is vertically inclined only to one direction.

As service pipes are connected to the distribution submains, air in the mains is discharged from the tap in some cases. Hydrants can also be used for inhaling and exhausting air when the water main is filled with water, or water is discharged from it. For this reason, there is no need to install air valves in-between valves on distribution submains; and it is a common practice to install them at the water main bridge, bridge-piggybacked water main, and at locations where air tends to accumulate.

7.6.4 Hydrant

Hydrants shall be installed on distribution submains, of which installation shall be in conformity with the following:

1. Hydrants shall be installed at an interval of 100 m to 200 m in consideration of the situation of buildings etc. along the distribution submains.
2. The single-jet hydrant shall be mounted on a distribution main with a diameter of larger than 150 mm; the double-jet hydrant on a distribution main with a diameter of larger than 300 mm.
3. The hydrant shall be provided with an auxiliary valve.
4. The non-freeze type ground hydrant shall be used in a cold or snowy region. Anti-frost measures shall be provided in case the underground type hydrant is employed.
5. The diameter of the hydrant shall as a general rule be 65 mm.

[Interpretation]

On the item 1.;

In accordance with the standard for firefighting water supply, the distance from an object of firefighting in an urbanized or congested area to a firefighting facility is prescribed in Table 7.6.2.

Hydrants shall in general be installed at an interval of 100 m to 200 m in consideration of the distribution of buildings, the limitation from the maximum length of the fire hose used etc.

It is desirable for hydrants to be properly installed in locations where feeding and draining of water in and from the water main are made; for the purposes of inhalation and discharge of air; and at the convex and concave points in the profile of the water mains for maintaining water quality in addition to the locations required for water supply for firefighting. On the rough estimates of volume of water to be discharged from a hydrant, see Table 7.6.3.

Table 7.6.2 Distance from an object of firefighting in urbanized or congested area to a firefighting facility (Unit: m)

Average wind speed / Land use zone	Yearly average wind speed is less than 4 m/s	Yearly average wind speed is more than 4 m/s
Neighborhood commercial zone Commercial zone Industrial zone Exclusive industrial zone	100	80
Other use zones and other zones where uses are not established	120	100

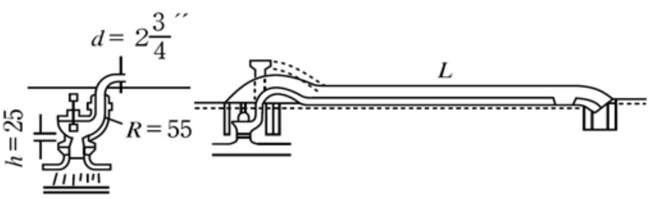
Note
The division of use zones shall be based on the regulation established under Article 8, Clause 1, Subclause 1 of the City Planning Law (Law No. 100 [1968])

Other firefighting facilities may not have to be provided within 140 m from a firefighting facility which possesses more than 10 times the licensed water volume*; and more than five fire engines can be deployed for the intake of water. (*The storage in normal times of more than 40 m^3 of water for firefighting, or the capacity for intake rate of more than 1 m^3/min, and the capacity to feed water for more than 40 min.)

Table 7.6.3 Rough estimates of volume of water to be discharged from a hydrant

(Unit : m^3/min)

Water pressure of trunk water main (MPa)	Length of hose L(m)						
	6	8	10	12	14	16	20
0.05	0.90	0.82	0.76	0.72	0.67	0.64	0.59
0.07	1.06	0.97	0.90	0.85	0.80	0.76	0.70
0.10	1.26	1.16	1.03	1.01	0.95	0.90	0.83
0.12	1.39	1.27	1.19	1.11	1.05	0.99	0.91
0.15	1.55	1.42	1.32	1.24	1.17	1.11	1.02
0.175	1.68	1.53	1.43	1.35	1.26	1.20	1.10
0.20	1.79	1.64	1.52	1.43	1.35	1.25	1.17
0.25	2.00	1.83	1.70	1.60	1.51	1.43	1.31
0.30	2.20	2.00	1.87	1.75	1.65	1.56	1.44
0.40	2.78	2.55	2.38	2.22	2.08	1.97	1.82



Diameter of hose $2\frac{3''}{4}$ = 69.8mm Velocity V

Diameter of trunk main 100mm Velocity V_0

Assumptions made for computation

f : Friction coefficient of the hose 0.042

f_0 : Inlet 0.5

f_b : Bend 0.3

f_v : Head loss coefficient of the valve 4.5,

$$V_0 = \frac{d^2}{D^2} V = 0.49$$

$$\text{Total head losses H} = (f_0 + f_v)\frac{V_0^{\ 2}}{2g} + (2f_b + f\frac{L}{d})\frac{V^2}{2g} + \frac{V^2}{19.6}$$

$$= (0.4 + 4.5)\frac{(0.49V)^2}{19.6} + (0.6 + 0.042\frac{L}{0.0698} + 1)\frac{V^2}{19.6}$$

On the item 2.;

The minimum diameter of distribution submains, on which a hydrant is to be mounted, shall as a principle be 150 mm; and a single-jet hydrant shall be installed.

The double-jet hydrant shall be installed on a water main of a diameter of larger than 300 mm, of which water conducting capacity is large, so as to enable double-jet discharging of water (See Figure 7.6.4 and Figure 7.6.5).

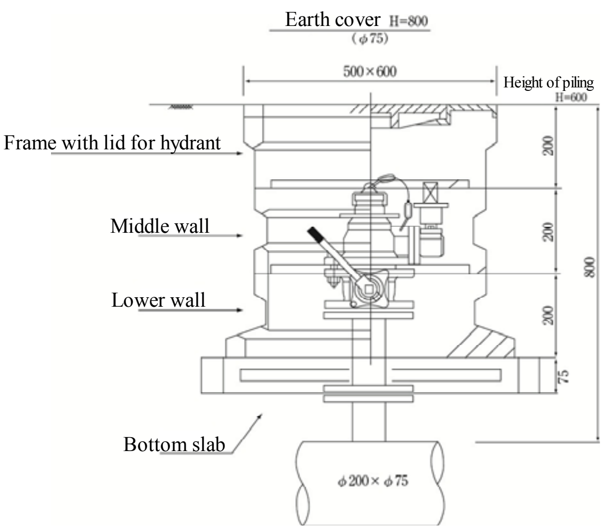


Figure 7.6.4 Example of installation of a box for the single-jet hydrant

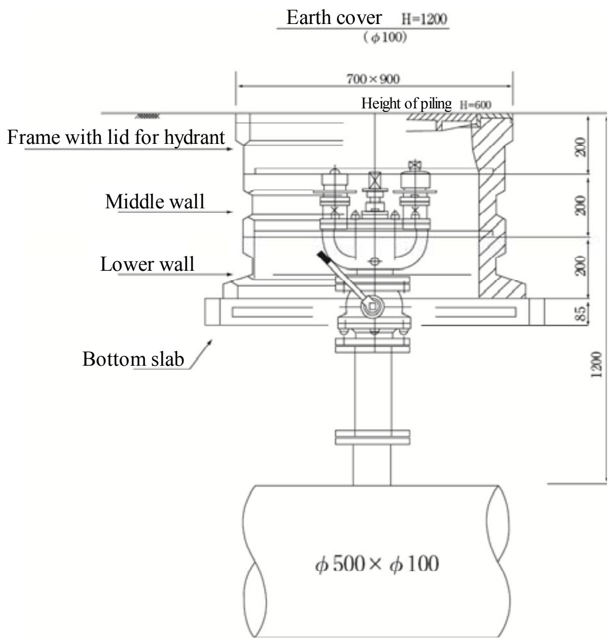


Figure 7.6.5 Example of installation of a box for the double-jet hydrant

On the item 5.;

Since the fire engine can be connected to a hydrant of the diameter of 65 mm, hydrants with the diameter of 65 mm shall as a general rule be installed as the standard.

7.6.5 Pressure reducing valve

The pressure reducing valve shall be installed in conformity with the following:

1. It shall possess functions suitable to the condition for water pressure reduction.
2. It shall be installed depending on the topography and geography where it is the most suitable for controlling the reduction in water pressure at the normal times and controlling the water pressure at the time of drought etc.
3. A bypass pipe of the same diameter as the pressure reducing valve shall be installed in parallel with it.
4. The valve box for it shall be in conformity with the item 5 of 7.6.2 Closure valves and control valves

[Interpretation]

When improving the distribution mains, it is fundamental that the diameters of the mains shall be so determined that the dynamic water pressure in the service area becomes as uniform as possible for the maximum hourly distribution flow in the design year. To this end, the water pressure shall be controlled by valves, which possess the ability to regulate water pressure at an appropriate level at the outset point and optional points in the distribution network.

On the other hand, however, it is also expected that water pressure exceeds the appropriate dynamic water pressure level in an area due to the topography and geography.

Given this, it is the role of the pressure reducing valve to reduce the water pressure, which exceeds the controllable range of the pressure control valve, so that appropriate water pressure is maintained in the service area.

On the item 2.;

Examples of the concrete installation of the pressure reducing valve are tabulated below:

1) Distribution trunk mains

(1). At the very upstream point of the service area where the difference in ground elevation is large and the dynamic water pressure is excessively high.

(2). At the point where the dynamic water pressure becomes excessively high in such a time zone as nighttime.

(3). At the points where interconnections are made with another system.

2) Distribution submains

(1). At branching points from the trunk mains

(2). At the entrance to a distribution block

7.6.6 Flow meter and water pressure gauge

The installation of the flow meter and the water pressure gauge shall be in conformity with the following:

1. They shall be installed at the beginning point of the distribution main, principal branching pints from it etc.
2. It is desirable to set up a facility to control the data and information on the flow and water pressure.

[Interpretation]

To properly control the flow and the water pressure in accordance with the change in water demand in the service area, the flow meters and the pressure gauges shall be installed at principal points in distribution network to precisely know the values of flow and dynamic water pressure in the service area.

The electromagnetic flow meter, ultrasonic flow meter and Venturi flow meter are used as the flow meter. There are the electronic pressure gauge and the mechanical Bourdon pressure gauge as the pressure gauge. For the purpose of measuring water pressure in a small section of a service area, the portable self-registering pressure gauge is available.

On the item 1.;

The locations of the flow meter and the water pressure gauge shall be selected to precisely know the trend of the maximum demand, the hourly, seasonal, and yearly changes of dynamic water pressure in the service area. Examples of their installation are given as follows:

1) Location of installation of the flow meter

(1). Beginning point and principal branching points of the trunk distribution main

(2). Entrance points to distribution blocks

(3). Interconnecting points with other service area and distribution blocks

2) Location of installation of the pressure gauge

(1). The same location as for the flow meter

(2). High and low points in elevation

(3). Other location needed for the control of water pressure

On the item 2.;

It is desirable to set up information management facilities, in addition to the usual operation, by means of telemetering of water flow and pressure, computerized data processing and so forth so as to prevent the spread of damage by detecting the breakage of distribution mains and discharge of water at the time of an accident or disaster, and carrying out measures against such events.

7.6.7 Drainage facilities

Drainage facilities shall be in conformity with the following:

1. Drainage facilities shall be provided in the neighborhood of a river, irrigation canal, a sewer etc. (hereinafter “canal etc.”) at a concave point of the distribution main.
2. They shall be installed selecting an appropriate location in the distribution submains network.

[Interpretation]

Drainage facilities are provided to discharge foreign matters from the water mains at the time of laying them, drain turbid water from the mains, and discharge water from them at the time of construction, in an emergency of an accident and so on.

On the item 1.;

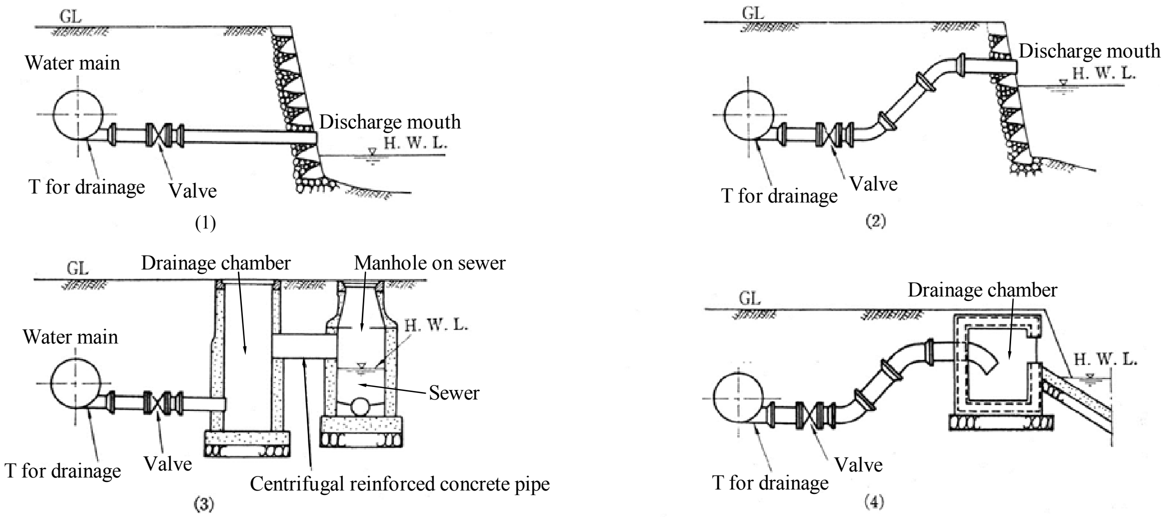
It is desirable to install drainage facilities in concave sections of the water main in the vicinity of a canal etc.

Furthermore, to facilitate efficient drainage, a valve shall be fit at an appropriate location near the point where the drainage pipe branches off.

Installation examples of drainage facilities are presented in Figures 7.6.6 (1) to (4), and rough estimates of discharging capacity by respective drainage scenarios are given in Table 7.6.4.

On the item 2.;

In case there is a site for drainage in the distribution mains network, the drainage facilities shall be installed near there.



Figures 7.6.6 Installation examples of drainage facilities

Table 7.6.4 Rough estimates of discharging capacity by respective drainage scenarios

In the case of L=50m (Unit : m^3/min)

φ100		1/8	2/8	3/8	4/8	5/8	6/8	Full open
Degree of opening		1/8	2/8	3/8	4/8	5/8	6/8	Full open
Opening area (m^2)		0.0009	0.0027	0.0034	0.0046	0.0057	0.0067	0.0079
Number of spindle rotations		1.7	3.5	5.2	7.0	8.6	10.4	13.8
Water pressure of trunk water main (MPa)	0.05	0.44	0.74	0.85	0.91	0.93	0.95	0.95
	0.10	0.63	1.05	1.21	1.29	1.31	1.33	1.35
	0.15	0.76	1.27	1.48	1.57	1.61	1.63	1.65
	0.20	0.87	1.48	1.70	1.82	1.86	1.90	1.90
	0.25	0.97	1.65	1.91	2.05	2.09	2.11	2.12
	0.30	1.06	1.80	2.11	2.24	2.27	2.31	2.33
	0.35	1.16	1.95	2.26	2.39	2.46	2.48	2.52
	0.40	1.57	2.09	2.43	2.56	2.63	2.67	2.69

φ250		1/8	2/8	3/8	4/8	5/8	6/8	Full open
Degree of opening		1/8	2/8	3/8	4/8	5/8	6/8	Full open
Opening area (m^2)		0.0062	0.0142	0.0226	0.0291	0.0358	0.0416	0.0491
Number of spindle rotations		3.1	6.7	9.2	12.3	15.4	18.2	24.6
Water pressure of trunk water main (MPa)	0.05	2.9	6.0	8.0	9.2	9.8	10.2	10.5
	0.10	4.2	8.4	11.3	13.0	13.9	14.4	14.8
	0.15	5.1	10.3	13.9	15.9	17.0	17.7	18.1
	0.20	5.9	12.0	16.1	18.5	20.1	20.6	21.2
	0.25	6.6	13.4	18.0	20.7	22.4	23.0	23.7
	0.30	7.3	14.7	19.7	22.7	24.5	25.2	26.0
	0.35	7.5	15.9	21.3	24.5	26.5	27.3	28.1
	0.40	8.3	17.0	22.7	25.2	28.3	29.4	30.0

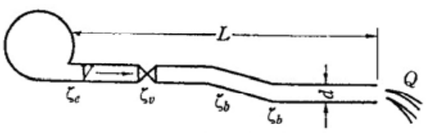
φ150		1/8	2/8	3/8	4/8	5/8	6/8	Full open
Degree of opening		1/8	2/8	3/8	4/8	5/8	6/8	Full open
Opening area (m^2)		0.0021	0.0050	0.0077	0.0091	0.0127	0.0149	0.0177
Number of spindle rotations		2.2	4.4	6.5	8.9	11.1	13.3	17.7
Water pressure of trunk water main (MPa)	0.05	1.0	1.9	2.3	2.5	2.6	2.7	2.7
	0.10	1.5	2.7	3.3	3.6	3.7	3.8	3.9
	0.15	1.8	3.3	4.0	4.4	4.6	4.6	4.7
	0.20	2.0	3.8	4.7	5.1	5.3	5.4	5.4
	0.25	2.3	4.2	5.2	5.6	5.9	6.0	6.1
	0.30	2.5	4.6	5.7	6.2	6.4	6.6	6.6
	0.35	2.7	5.0	6.1	6.7	7.0	7.1	7.2
	0.40	2.9	5.3	6.6	7.1	7.4	7.6	7.7

φ300		1/8	2/8	3/8	4/8	5/8	6/8	Full open
Degree of opening		1/8	2/8	3/8	4/8	5/8	6/8	Full open
Opening area (m^2)		0.0094	0.0173	0.0315	0.0420	0.0516	0.0601	0.0707
Number of spindle rotations		3.7	7.4	11.1	14.8	18.4	22.1	29.5
Water pressure of trunk water main (MPa)	0.05	4.3	8.9	12.3	14.5	15.7	16.5	17.0
	0.10	6.0	12.7	17.4	20.5	22.2	23.3	24.0
	0.15	7.4	15.5	21.3	25.0	27.2	28.6	29.4
	0.20	8.6	17.9	24.7	29.0	31.5	32.9	34.0
	0.25	9.6	20.0	27.6	32.4	35.3	36.8	38.0
	0.30	10.5	21.9	30.2	35.5	38.6	40.3	41.6
	0.35	11.3	23.7	32.6	38.3	41.6	43.5	45.0
	0.40	12.1	25.3	34.9	41.0	44.5	46.7	48.0

φ200		1/8	2/8	3/8	4/8	5/8	6/8	Full open
Degree of opening		1/8	2/8	3/8	4/8	5/8	6/8	Full open
Opening area (m^2)		0.0040	0.0090	0.0137	0.0186	0.0228	0.0267	0.0314
Number of spindle rotations		3.0	5.9	8.9	11.8	14.7	17.7	23.6
Water pressure of trunk water main (MPa)	0.05	1.9	3.6	4.5	5.2	5.5	6.0	6.1
	0.10	2.6	5.1	6.3	7.4	7.8	8.0	8.1
	0.15	3.2	6.3	7.7	9.0	9.5	9.8	10.0
	0.20	3.7	7.3	9.0	10.4	11.0	11.3	11.5
	0.25	4.2	8.1	9.9	11.6	12.3	12.6	12.8
	0.30	4.6	8.9	10.9	12.7	13.4	13.8	14.1
	0.35	4.9	9.6	11.8	13.8	14.5	14.9	15.2
	0.40	5.3	10.2	12.6	14.7	15.5	15.9	16.3

φ400		1/8	2/8	3/8	4/8	5/8	6/8	Full open
Degree of opening		1/8	2/8	3/8	4/8	5/8	6/8	Full open
Opening area (m^2)		0.0168	0.0368	0.0564	0.0749	0.0920	0.1070	0.1256
Number of spindle rotations		4.3	8.6	12.9	17.2	21.5	25.9	34.5
Water pressure of trunk water main (MPa)	0.05	7.7	16.4	23.5	28.4	31.6	33.4	34.8
	0.10	10.9	23.3	33.3	40.1	44.6	47.3	49.2
	0.15	13.3	28.5	40.8	49.1	54.7	58.0	60.2
	0.20	15.4	32.9	47.0	56.7	63.2	66.8	69.5
	0.25	17.2	36.8	52.7	63.4	70.6	74.8	77.7
	0.30	18.8	40.3	57.6	69.5	77.3	81.8	85.1
	0.35	20.3	43.6	62.3	70.1	83.5	88.5	92.0
	0.40	21.7	46.6	66.6	80.2	89.2	94.5	98.3

(Assumptions for computation)



$$H=\left(\zeta_c+\zeta_v+2\zeta_b+\lambda\frac{L}{d}+1\right)\frac{v^2}{2g}$$

$$=\left(1.6+\zeta_v+\lambda\frac{L}{d}\right)\frac{v^2}{2g}$$

$$\therefore v=\frac{4.43}{\sqrt{1.6+\zeta_v+\lambda\frac{L}{d}}}\sqrt{H}$$

Flow rate $Q=\frac{\pi}{4}d^2v$

$$=\frac{\pi}{4}d^2\frac{4.43}{\sqrt{1.6+\zeta_v+\lambda\frac{L}{d}}}\sqrt{H}\ (m^3/s)$$

where,

H : Water pressure of water main

L : Length of drainage pipe

d : Diameter of drainage pipe

ζ_I : Inlet head loss coefficient

ζ_b : Bend head loss coefficient

ζ_v : Valve head loss coefficient

λ : Friction head loss coefficient of drainage pipe

(New pipe, with no lining)

Relationship between degree of valve opening and ζ_v

Degree of opening	1/8	2/8	3/8	4/8	5/8	6/8	Full open
ζ_v	90	16	5.5	2.3	1.0	0.385	0

Relationship between pipe diameter and λ

Pipe diameter	100	150	200	250	300	400
λ	0.045	0.040	0.036	0.031	0.027	0.024

7.6.8 Manhole

Manholes shall be provided on water mains of diameter of larger than 800 mm at important locations in regard to construction and maintenance.

7.7 Pump Facilities

Pump facilities of distribution facilities shall be in conformity with 8.2 Pump Facilities.

9. Water Service Fittings

9.1 General

9.1.1 Basic items

1. Legislative grounds of water service fittings and the role of water utilities

1) Legislative grounds of water service fittings

Water service fittings are the concept peculiar to water utilities, and defined as “the water service pipe installed on a branch from a distribution main provided by a water utility and apparatus directly connected to the service pipe for serving water to consumers” under the Waterworks Law (Law No. 177 [1957]). In this definition, “apparatus directly connected” means such fittings as water taps etc. which are connected to the service pipe as a structure, which cannot easily be detached, and with which water service can be made under pressure. Therefore, such fittings as a hose, which can easily be detached, are not included. Given this, in case water is once received in a cistern for a building etc. and water is served from there, the apparatus from the branch on the water main to the inlet fitting of the cistern (a ball-tap etc.) is the “water service fittings”, and the apparatus downstream of the cistern is not. “Standards for material and structure of water service fittings” are established for service pipe etc. used as water service fittings under Article 5 of the Ordinance under the Waterworks Law (Ordinance No. 336 [1957]).

The water service fittings in general consist of service pipe, water service apparatus and water meter. Although water meters are the property of the water utility, they are understood as falling under the category of water service fittings from the view point of the water service system.

2) Role of water utilities

The water service fittings are the property of customers to be installed by them, and so not categorized as the facilities to be managed by the water utility. However, the water utility is responsible for the quality of water to be served from a device set at the end of the fittings in accordance with the water quality standards prescribed under Article 4 of the Waterworks Law. What is more, as to such water service devices as water heaters, water filters etc., by which consumption of residual chlorine and a change in water quality are anticipated, the water utility is considered to be exempted from the responsibility for water quality of such water.

On the other hand, in accordance with the diversification of life style and the purposes of water use, water utility’s guidance is required for technology improvement in manufacture of water service fittings and their installation in consideration of measures to insure the reliable water service with the quantity and quality of water required by customers, prevention of water pollution by backflow from water service fittings and the expansion of direct connection water service and so forth

2. Planning of water service fittings

Prior to the design of water service fittings, decision shall be made on identification of the site and purpose of installation, the design water supply, identification of water mains, on which branching of service connections can be made, and its minimum dynamic water pressure, type of water service and the diameter of service pipe for it. It is the most important factor to determine whether or not the water service fittings achieve their purposes, and exert their functions. In Japan, the preparation of the plan for water service fittings is in general the duty of the chief engineer for installation of the water service fittings.

Meanwhile, to reliably supply clean water, water utilities as well shall instruct and give guidance on the type of water service for the appropriate locations on distribution mains, where branching is possible, and their dynamic water pressure, and, furthermore, the purpose and elevation of water service after identifying the site of construction, purpose of use, and the quantity of water use. Therefore, it is desirable for water utilities to determine the standards required for planning of water service fittings based on the project plan related to such water supply and water service as the improvement of distribution mains, expansion of direct connection water service, measures against damages by a disaster and so on.

3. Design of water service fittings

The design of water service fittings stands for the selection and installation method of service pipe and other fittings to be used based on a plan, and is also the duty of the chief engineer for the installation of the water service fittings in Japan as same as their planning.

It is essential for the selection of service pipe and other fittings to be in conformity with the standards for the structure and material of water service fittings.

Besides, considered shall be such environment as water pressure, quality of soil, climate, direct sun ray etc. to which the water service fittings are exposed after installation. For example, on the water service fittings, which branch from a distribution main with high water pressure, flow velocity in them is excessively large, and there is a risk to cause water hummer and damage to water meters; so such a measure as the installation of a pressure reducing valve etc. is required from the view point of assurance for proper water pressure. Besides, the type of water meters and the type of bolts used for them are different among water utilities. Therefore, it is desirable for water utilities to give notice to licensed contractors for the installation of water meters on their handling.

For designation of the method of construction for the facilities from the branch on the water main to the water meter by water utilities shall be in conformity with 9.1.4 Installation of water service fittings and 9.2.6 Pipe laying.

4. Implementation of installation of water service fittings

Although in Japan water utilities or licensed contractors for installation of water service fittings shall carry out the installation of water service fittings under the Waterworks Law (revised in 1996), the latter generally undertake the work. The licensed contractors for installation of water service fittings can be given designation by any water utility insofar as they possess certain qualification, and the chief engineer for installation of the water service fittings, which is a national license, has been allowed to do the installation of the water service fittings anywhere in Japan.

On the other hand, they are required by consumers to install the water service fittings requested by them as a proper system for water service.

Under the circumstances, it is desirable for water utilities to establish standards for the installation of the water service fittings, and present them to entities concerned with the installation of water service fittings for the aim of their smooth installation suitable for the community concerned. Moreover, the installation standards shall bear, within the power of the law, such aspect required for the installation of water service fittings as the scope of work to be undertaken by licensed contractors for their installation, the system of water service fittings suitable to the community concerned etc., the procedures of application for the their installation and the inspection method of completed work, procedures of application for excavation of public roads and exclusive occupation of public roads related to the installation of water service fittings, the method of the repair of the road, the location of the installation of the water meter, the safety measures at the time of work in the road and so forth in addition to the above-stated items related to the planning and design of water service fittings.

9.1.2 Type of water service

As the type of water service, there are the direct pressure type, the receiving cistern type and the combination type with the direct water pressure and the cistern methods, and the actual type shall be determined in consideration of the height of taps, volume of water used, purpose of water use, maintenance, demand of customers, condition of distribution mains etc.

1. As the direct connection water service type, there are the type of direct connection direct pressure water service, which serves water by the water pressure of the distribution main; and the type of direct connection boosted-pressure water service by booster pump facility (hereunder boosted-pressure water service facility) installed halfway in the service pipe.
2. In the receiving cistern type, water is once received in a receiving cistern from the distribution main, and served from it.
3. In the combination type, both direct pressure water service and receiving cistern type water service are used in a building.

- Types of water service
  - Direct connection type
    - Direct pressure type
    - Boosted-pressure type
  - Receiving cistern type
  - Combination type

[Interpretation]

As the types of water service, there are the direct connection type which branches from the distribution main and directly serves water; the receiving cistern type which once receives water from a branch on the distribution main and serves water from it; and the combination type with the above both types.

In water supplies in Japan, water service for buildings with more than three stories has been practiced with the receiving cistern type since the standard minimum water pressure in distribution mains has been set at 150 kPa to 200 kPa (0.15 MPa to 0.2 MPa) historically reflecting the social situation in its stage of development. However, since under the revised Building Standards Law (1987), the construction of a three-story wooden building became possible even in semi-fireproof districts, water utilities have been intending to expand the area for direct connection direct pressure water service. Adoption of direct connection water service to middle- and high-rise buildings is also increasing as the means to solve the hygienic problems of the receiving cistern systems as well as a useful measure from the energy-saving point of view.

1. Direct connection type

1) Direct connection direct pressure type

The direct connection direct pressure type is a type to directly serve water by the dynamic water pressure in the distribution main. An example of water service by this type to a three-story house is shown in Figure 9.1.1. This type is employed for the purpose of improving the quality of service by water utilities to successively expand the area as the object of the type while coordinating with such present capacity as the water pressure etc. of the distribution mains and the improvement plan for them; and there are some water utilities which are expanding the objective area for the type also to five-story buildings or taller.

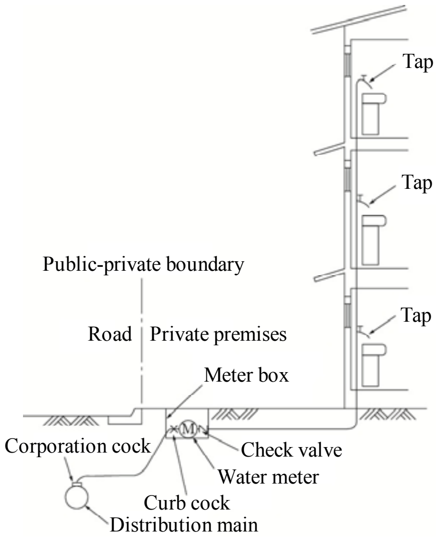


Figure 9.1.1 Example of direct connection direct pressure type (for a 3-story house)

2) Direct connection boosted-pressure type

The direct connection boosted-pressure type is a type to serve water by direct connection with boosted-pressure by a pressure boosting facility mounted along the service pipe. With this type, the quality of water service can be improved since water is served by direct connection, which is made by fitting a pressure boosting facility connected directly to the service pipe, and boosting the water pressure without affecting the water pressure in the distribution mains, and can solve hygienic problems of the receiving cistern, promote the energy saving, save the space for the cistern and so on.

Nonetheless, as this type has no storage of water, the adoption of the type shall be avoided for a building which may face a trouble when water supply is suspended or reduced in quantity. Therefore, sufficient consideration is required for the method of substituting the stock capacity of the cistern which is unavailable with the type in an emergency; the method of maintenance of the pressure boosting facility; selection of the method to compute the flow for simultaneous water uses; measures for the prevention of backflow; and issues related to meter reading, adjustment of water volume actually used, collection of fees etc. depending on the water utility.

Water service for each house under the direct connection boosted-pressure type is in general carried out up to the tap by direct feeding (See Figure 9.1.2). However, in case the existing system is converted to a direct connection boosted-pressure type, a type is adopted in some instances, which receives water directly at the elevated reservoir, and serves water by gravity from it to taps through the existing water service fittings in consideration of their deterioration due to aging (See Figure 9.1.3). Furthermore, as an advanced example, practical examples of a direct connection multistage type and a direct connection parallel type, by which direct connection water service for high-rise buildings and large-scale condominiums, for which direct connection water service has been unavailable, becomes possible, are presented in Figure 9.1.4 and Figure 9.1.5. By the direct connection multistage type, booster pumps are directly connected to serve water, which enables direct connection water service to higher floors than the standard direct connection boosted-pressure type; and the direct connection parallel type is a type to install booster pumps in parallel to serve water, by which direct connection boosted-pressure water service can be made to a larger apartment building than the standard type.

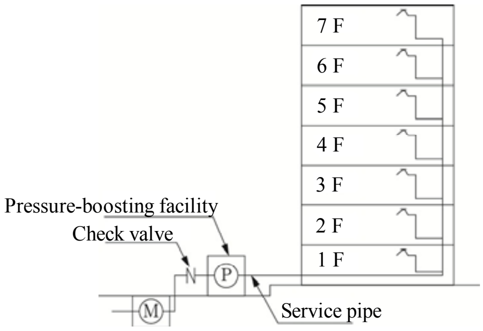


Figure 9.1.2 Example of direct connection boosted-pressure type （Direct pumping type）

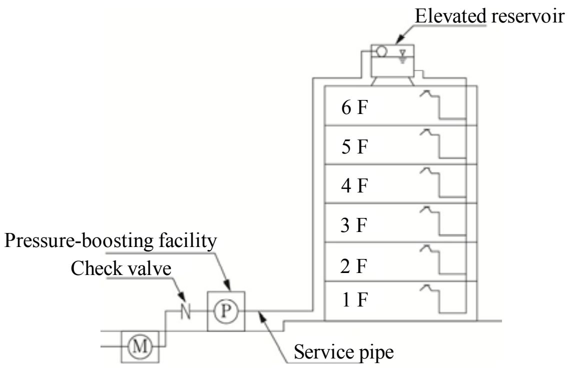


Figure 9.1.3 Example of direct connection boosted-pressure type (Elevated reservoir type)

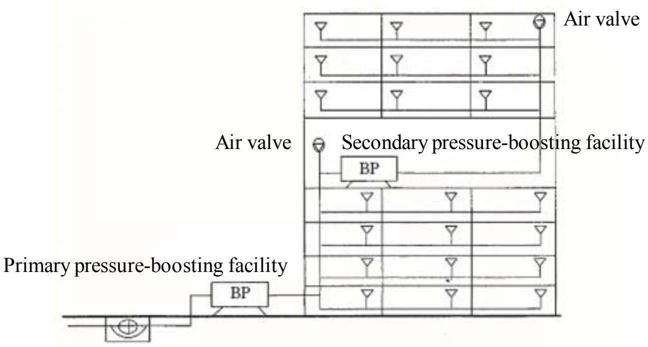


Figure 9.1.4 Example of direct connection multistage type

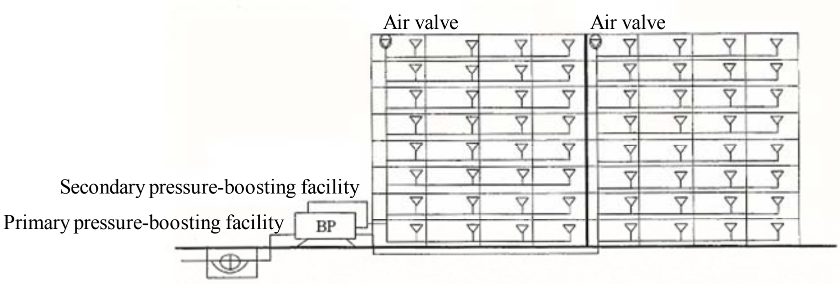


Figure 9.1.5 Example of direct connection parallel type

3) Points of consideration to expansion of direct connection water service

(1). Measures for prevention of back-flow etc.

Since the expansion of direct connection water service will bring about cases where the position of water service becomes high compared with the traditional water service fittings; the pressure from the water service side becomes high at the time of suspension of water supply; reverse pressure may act when the pressure of water supply gets reduced; there are a number of water service devices with diverse usage thereof and so on, such more careful backflow prevention measures as a decompression type check valve shall be provided along the service pipe between the branch on the distribution main and the building. In case a backflow prevention device, of which workings can be inspected, is installed, space for its inspection shall be provided. Besides, since the inside of some types of backflow prevention devices becomes open to the ambient atmosphere when they work, there is a risk for foreign water to get in the device if it has been submerged due to the failure of another apparatus. Therefore, measures to prevent such submergence shall be provided. Since these aspects are important from the water quality assurance point of view, it is desirable for the water utility to establish an implementation standards related to such measures.

2. Receiving cistern type

The receiving cistern type is a type that once receives water in a cistern, and serves water from it; can, as a merit, maintain water service pressure and volume constant downstream of the cistern; can feed a large quantity of water at a time; can secure water even at the times of suspension of water supply and a disaster and so forth. On the other hand, it needs such proper management as regular inspection and cleaning, and water temperature goes up in summer, which are the factors to give consumers anxiety about water quality.

1) The receiving cistern type shall be adopted in case water is served to such facilities and buildings as the following:

(1). Facilities and buildings, which use a large amount of water at a time, or of which water use greatly fluctuates; and there is a risk that such condition causes the decrease in water pressure in the distribution main.

(2). Factories, businesses, laboratories etc., which handle such dangerous chemicals as poisonous substances, powerful medicines and drugs etc., manufacture, process or store them.

Examples: facilities which operate such a business as laundry and cleaning, photo processing and printing, plate making, handling of petroleum products, dyeing, plating etc.

(3). Facilities for which a certain amount of water is needed even at the time of suspension of water supply due to a disaster or an accident

Example: Cases where water is served to such facilities as hospital, department store etc. and as cooling water for food freezing and computers and so forth.

(4). In case a certain amount and pressure of water is needed irrespective of the fluctuation in the water pressure in the distribution main.

2) Main receiving cistern types are the following:

(1). Elevated reservoir type

By this type, water received at a cistern situated at the ground level is pumped up to the elevated reservoir placed on the rooftop, and served from it by gravity, which has generally been used as in the past. Although this type has a merit that water can be served in constant pressure, and for a certain length of time even when the pump stops by power failure owing to its storage of water, it has a demerit that it causes problems about sunshine and appearance. The situation with low water pressure at the floor right beneath the elevated reservoir is also a drawback. The elevated reservoir shall regularly be cleaned like the receiving cistern; otherwise there is a risk of water pollution (See Figure 9.1.6 (1)). Since there is a limit in the height to which water can be served in appropriate pressure from an elevated reservoir, elevated reservoirs and pressure reducing valves are arranged in stages in accordance with the height in high-rise buildings (See Figure 9.1.6 (2)).

(2). Pressure tank type

Water is pumped into a pressure tank and stored; and served by the inside pressure of the tank up to the taps of consumers. By this type, the tank is always pressurized; the pump is actuated when the pressure goes down due to water demand; the pressure gradually rises as the demand decreases; and the pump eventually stops (See Figure 9.1.6 (3)).

(3). Direct pumping type

Water received at the receiving cistern is directly pumped to taps of consumers while the water pressure is maintained constant irrespective of the change in water demand by means of regulating the motor speed etc. Especially, in case the nighttime demand is small, water service can be made with provision of a small pressure tank without operating the pump (See Figure 9.1.6 (4)).

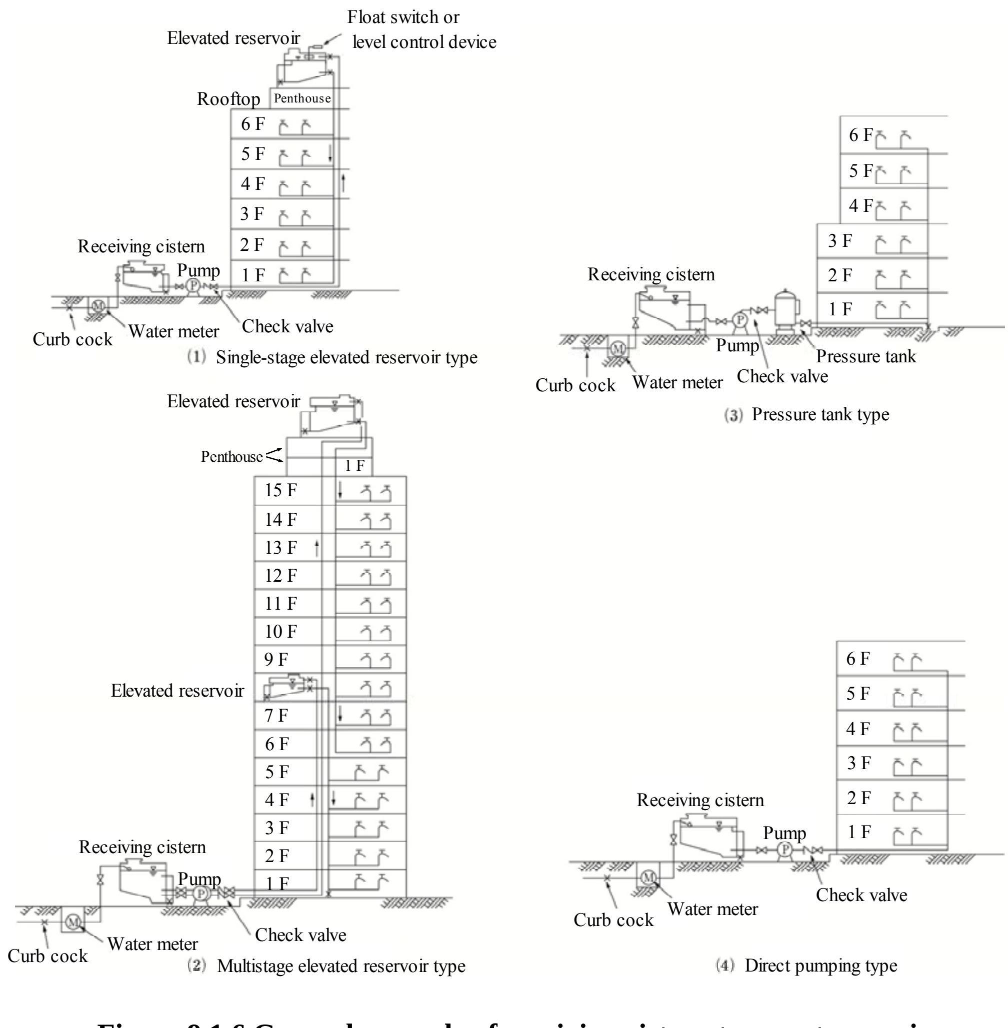


Figure 9.1.6 General example of receiving cistern type water service

3) Capacity of receiving cistern and receiving type

The capacity of receiving cistern shall be determined by the design daily water demand.

In case the volume of receiving water per hour is large compared with the capacity of the distribution main, the water pressure in the main will decrease, which may cause trouble for water service in the surrounding area. In such a case, such a flow regulating valve as the constant flow valve shall be installed; or in some cases water is received only during the time zone when the pressure is high by means of the installation of a motorized valve with a timer switch.

3. Combination type with direct connection and receiving cistern

By this type, both the direct connection type and the receiving cistern type are used for a building.

9.1.3 Structure and material of water service fittings

1. The structure and material of water service fittings shall be in conformity with the "Ministry Ordinance on the Standards for Structure and Material of Water Service Fittings" (Ministry of Health and Welfare Ordinance No. 14 [1997]) based on Article 5, Clause 1 and Clause 2 of the Enforcement Ordinance under the Waterworks Law.
2. The confirmation of conformity with the standards can be made by the selection of products with self-certification or certification by the third party organization, and the product standards which meet the above "Standards".

9.1.4 Installation of water service fittings

The installation of water service fittings shall be inconformity with the following:

1. The installation of water service fittings stands for setting or alteration of water service fittings.
2. The water utility can designate those who can properly undertake the installation of water service fittings so as to secure the compatibility of the structure and material of the fittings of the user of water to be served by the said utility to the standards prescribed under the Ordinance. In this instance, the water utility can, in accordance with its water service code, set a condition for water service to the water user that his (her) water service fittings are installed by the said utility or those who possess such designation (licensed contractor for water service fittings). In the case of the installation of water service fittings carried out by other person than one with such designation, the utility can reject the application for water service or suspend the service in accordance with its service code.
3. The water utility can impose the above conditions as the method of installation, the term of the work etc. for water service fittings from the branching point on the distribution main to the water meter.

[Interpretation]

On the item 2.;

This item annotates on the main entity who conducts the installation of water service fittings and related procedures prescribed in Article 16, Clause 2 of the Waterworks Law (Installation of water service fittings). The water utility should designate those who meet the following qualification as a licensed contractor for water service fittings on his (her) application for it if he (she):

(1). Instates the chief engineer for the installation of water service fittings in its every office.

(2). Possesses machines and tools prescribed under the Ministry of Health, Labor and Welfare Ordinance.

(3). Is not falling in a reason for disqualification.

In this instance, the duties of the chef engineer for installation of water service fittings to be posted in each of such offices are the following:

(1). Technical management of the installation of water service fittings

(2). Guidance and supervision of those who are engaged in the installation of water service fittings

(3). Confirmation that the structure and material of water service fittings conform to the standards prescribed under the Ordinance based on Article 16 of the Waterworks Law

(4). Other duties prescribed under the Ministry of Health, Labor and Welfare Ordinance

The chief engineer for the installation of water service fittings is responsible to secure the conformity of the structure and material of water service fittings to the above standards in a series of the work from a preliminary survey to the inspection of the completed work related to the installation of water service fittings.

On the item 3.;

Conditions for the method, the term etc. of installation work mean the specification of the method for tapping a branch on a distribution main suitable for its pipe material; designation of materials and the installation method from the view points of smooth and efficient execution of urgent work from the distribution main to the water meter for the prevention of such a disaster as an earthquake, water leakage or at the time of calamity; setting of the term of work from the view point to prevent the suspension of water service; execution of the work in the presence of the staff of the water utility and so forth.

In this instance, the designation of service pipe and other fittings does not come under the exercise of such power of refusal etc. of water service by the water utility under Article 16 of the Waterworks Law. Besides, this designation does not apply to the fittings downstream of the water meter.

9.2 Service Pipe

9.2.1 General

The service pipe shall be in conformity with the standards for the structure and material of water service fittings (hereinafter, standards for structure and material).

When installing water service fittings, the estimate of the design volume of water use and ensuing decision of the diameter of the service pipe will determine whether or not the water service fittings can perform their function. In addition, as there are various service pipes and joints, their selection and installation shall be made in consideration of their conformity with the above standards, geotechnical quality, climate and the condition related to pipe laying inside as well as outside of the house, the ease of installation work, and, furthermore, their maintenance.

In this chapter, mainly service pipes and joints of the diameter of smaller than 50 mm are described.

9.2.2 Design volume of water use

The design volume of water use is the base for planning such main parameters as the diameter of the service pipe and the capacity of the receiving cistern etc., so shall be determined taking into account the use and floor area of the building, the purpose of water use, the number of residents, the number of taps etc.

The method of computation of the design volume of water use shall be selected in accordance with the actual situation of water use based on the examination of characteristics of various methods of computation.

[Interpretation]

The method of computation of the design volume of water use is shown below:

1. Design volume of water use in the type of direct connection water service

1) Design volume of water use

The design volume of water use under the direct connection type water service shall be set at the volume of water which reflects the actual situation of water use in consideration of the percentage of taps used simultaneously etc. The general method of computing the water volume by taps in simultaneous use is presented below. The unit of water volume for simultaneous use is L/min.

(1). In the case of a detached house

(i). The method to compute the water use assuming water service devices to be used at the same time

In this method, obtaining water service devices to be used at the same time from Table 9.2.1, assuming any of them to be used simultaneously, and summing up the discharging volume of respective devices, the volume of simultaneous water use is found. Although the setting in accordance with actual situation of water use is possible, as calculations with different combinations of types of water use is needed to cope with all the cases of variation since the use pattern changes in many ways, consideration shall be practiced to set the parameters including water service devices (kitchen, wash basin etc) with a high frequency of use and so on.

In such cases as schools and railway stations where the rate of simultaneous use is high, the discharge volumes of hand wash basins, urinals, toilet bowls etc. shall be totaled based on Table 9.2.1.

The discharge volumes by category of general water service devices are given in Table 9.2.2. Furthermore, there also is a method which treats all devices with the same discharge volume depending on their diameter irrespective of their category (See Table 9.2.3).

(ii). Method to determine the simultaneous-use volume by the standardized volume

In this method, the simultaneous-use volume is determined based on the standardized volume to be found according to the relationship between the number of water service devices and the simultaneous-use volume. The simultaneous-use volume is obtained by summing up the water volumes used by all the respective water service devices divided by the total number of the devices, and multiplied by the rate of simultaneous use (Table 9.2.4).

Simultaneous-use volume = Total volume used by all the water service devices
÷total number of devices ×rate of simultaneous use

(2). In the case of apartment houses

(i). Method to use an equation to estimate the simultaneous-use volume by the number of houses

Simultaneous-use volume $=42\times(\text{number of houses})^{0.33}$ [less than 10 houses]

(do) $=19\times(\text{number of houses})^{0.67}$ [10 houses to less than 600 houses]

(ii). Method to use an equation to estimate the simultaneous-use volume by the number of residents

Simultaneous-use volume =26×(number of residents)0.36 [less than 30 persons]

(do) =13×(number of residents)0.56 [31 persons to less than 200 persons]

(do) =6.9×(number of residents)0.6 [201 persons to less than 2000 persons]

(iii). Method to use an equation to estimate the simultaneous-use volume by the number of residents (A new method which was recommended in a research)

Simultaneous-use volume =26×(number of residents)0.36 [less than 30 persons]

(do) =15.2×(number of residents)0.51 [more than 31 persons]

(iv). Method to estimate by the unit load of water service devices

This method is used for office buildings, apartment houses etc. which possess more than a certain number of water service devices

The unit load of water service devices is a normalized water use flow applying a load factor in consideration of the frequency of the use of the devices by their type, duration of the use, and simultaneous use of a number of devices. The simultaneous-use volume is obtained by summing up the unit loads of the respective types of water service devices (Table 9.2.5) multiplied by the number of devices, and using the chart of the simultaneous-use volume (Figure 9.2.1).

(v). Method to apply water use of each house and the rate of houses using water simultaneously

The water use of a house is first obtained by a method using Table 9.2.1 and Table 9.2.2, and the simultaneous-use volume is computed by determining the number of houses using water service devices simultaneously with the application of the number of houses served and the rate of houses using water simultaneously (Table 9.2.6). This method is not commonly used since the water volume becomes excessively large compared with other methods.

Table 9.2.1 Number of water service devices when considering their simultaneous use

Total number of water service devices	Number of devices when considering their simultaneous use
1	1
2-4	2
5-10	3
11-15	4
15-20	5
21-30	6

Table 9.2.2 Discharging volume by category and corresponding diameter of water service device

Use	Volume used (L/min)	Corresponding diameter of device (mm)	Note
Kitchen sink	12-40	13-20	
Laundry sink	12-40	13-20	
Wash basin	8-15	13	
Bath tab (Japanese style)	20-40	13-20	*Water discharged per
Bath tab (Western style)	3-60	20-25	use (4-6 sec.) =2-3L
Shower	8-15	13	
Urinal (wash cistern)	12-20	13	** Water discharged per
Urinal (flash valve) *	15-30	13	use (8-12 sec.)
Toilet bowl (wash cistern)	12-20	13	=13.5-16.5L
Toilet bowl(flash valve)**	70-130	25	
Hand wash basin	5-10	13	
Hydrant (small)	130-260	40-50	
Sprinkling	15-40	13-20	
Car wash	35-65	20-25	Business use

Table 9.2.3 Standard volume used by water service device

Diameter of water service device (mm)	13	20	25
Standard volume used (L/min)	17	40	65

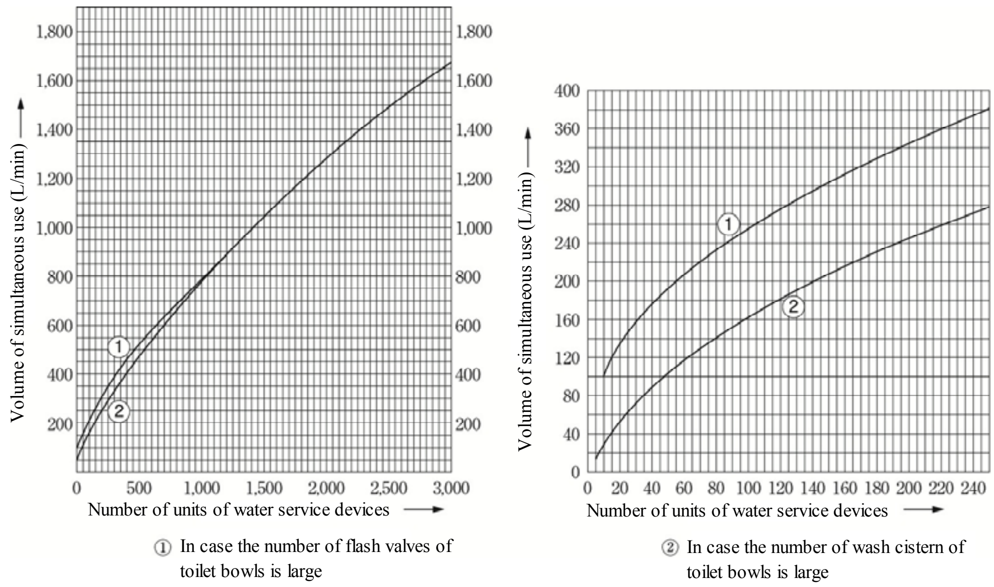


Figure 9.2.1 Chart of the simultaneous-use volume (Source: Practical water service and drainage facilities in architecture)

Table 9.2.4 Number of water service devices and rate of volume simultaneously used

Total number of water service devices	1	2	3	4	5	6	7
Rate of volume simultaneously used	1	1.4	1.7	2.0	2.2	2.4	2.6
Total number of water service devices	8	9	10	15	20	30	
Rate of volume simultaneously used	2.8	2.9	3.0	3.5	4.0	5.0	

Table 9.2.5 Unit load of water service devices

Name of device	Faucet	Water service device unit load	
		Public use	Private use
Toilet bowl	Flash valve	10	6
Toilet bowl	Wash cistern	5	3
Urinal	Flash valve	5	
Urinal	Wash cistern	3	
Wash basin	Faucet	2	1
Hand wash basin	Faucet	1	0.5
Clinical wash basin	Faucet	3	
Sink for office	Faucet	3	
Kitchen sink	Faucet		3
Sink for cookroom	Faucet	4	2
Sink for cookroom	Mixing faucet	3	
Dish wash sink	Faucet	5	
Combined sink	Faucet		3
Face wash sink (per faucet)	Faucet	2	
Sink for cleaning	Faucet	4	3
Bath tab	Faucet	4	2
Shower	Mixing faucet	4	2
Bath room & toilet combined	Toilet bowl with flash valve		8
(do)	Toilet bowl with wash cistern		6
Water fountain	Faucet for drinking	2	1
Water heater	Ball-tap	2	
Water spraying, garage	Faucet	5	

Note; In the case of the faucet for warm water used together, the unit load per faucet will be 3/4 of the above values.
(Source) The Society of Heating, Air-conditioning and Sanitary Engineering of Japan; Guidebook of Heating, Air-conditioning and Sanitary Engineering, 14th Edition, Volume 4, p. 116 (2010)

Table 9.2.6 Number of houses served and rate of houses using water simultaneously

Total number of houses	1～3	4～10	11～20	21～30	31～40	41～60	61～80	81～100
Rate of houses using water simultaneously (%)	100	90	80	70	65	60	55	50

[Reference 9.2] Computation example of simultaneous-use water volume

Examples of computation by various methods of simultaneous-use water volume for apartment houses:

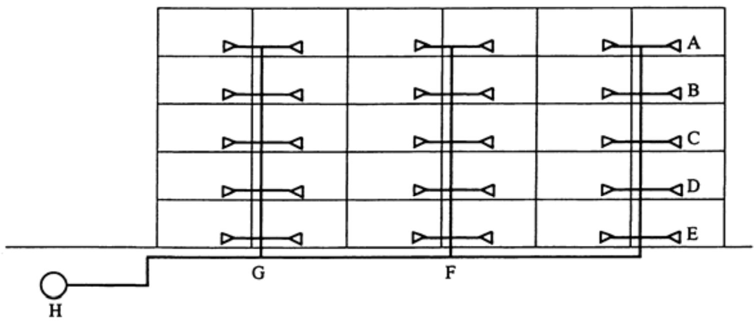
(1). Condition of the building (See Reference Figure 9.2.1)

(i). A 5-story apartment building with 30 houses

(ii). Water service devices of each house are composed of five of them: kitchen sink, wash basin, bath tab, shower, and toilet bowl with cistern.

(iii). The design number of residents per house: 4

(2). Computation method and parameters used for the computation example (See Reference Table 9.2.1)



Reference Figure 9.2.1 Outline concept of the building

Reference Table 9.2.1 Method of computation and parameters for computation

<table>
<tr><th>Method</th><th>Method of computation</th><th colspan="2">Parameters for computation</th><th>Note</th></tr>
<tr><td>(1)</td><td>Method to use the formula to estimate simultaneous-use volume by the number of houses</td><td colspan="2">less than 10 houses: 42×(number of houses)$^{0.33}$
10 houses to less than 600 houses:19×(number of houses)$^{0.67}$</td><td></td></tr>
<tr><td>(2)</td><td>Method to use the formula to estimate simultaneous-use volume by the number of residents</td><td colspan="2">less than 30 persons: 26×(number of residents)$^{0.36}$
31 persons to less than 200 persons: 13×(number of residents)$^{0.6}$</td><td></td></tr>
<tr><td>(3)</td><td>Method to use the formula to estimate simultaneous-use volume by the number of residents (A new method which was recommended in a research)</td><td colspan="2">less than 30 persons: 26×(number of residents)$^{0.36}$
more than 31 persons: 15.2 × (number of residents)$^{0.51}$</td><td></td></tr>
<tr><td>(4)</td><td>Method to estimate by unit load of water service devices</td><td>・Kitchen sink :
・Wash basin
・Bath tab
・Shower
・Toilet bowl wash cistern</td><td>Total 11 units</td><td>Table9.2.5 (for a private room)</td></tr>
</table>

(5)	Method to apply water use of each house and the rate of houses using water simultaneously	・Kitchen sink ・Wash basin ・Bath tab ・Shower ・Toilet bowl wash cistern	:12L/min(※) : 8L/min :20L/min(※) : 8L/min :12L/min(※)	(※)Designed as devices used simultaneously Total 32L/min	Table9.2.1 Table9.2.2 Table9.2.6

(3). Computation of simultaneous-use volume (See Reference Table 9.2.2)

Reference Table 9.2.2 Result of computation of simultaneous-use volume

Method / Section	(1)	(2)	(3)	(4)	(5)
A-B	$42\times2^{0.33}$	$26\times(4\times2)^{0.36}$	$26\times(4\times2)^{0.36}$	11×2＝22	32×2×1.0
	53	55	55	58	64
B-C	$42\times4^{0.33}$	$26\times(4\times4)^{0.36}$	$26\times(4\times4)^{0.36}$	11×4＝44	32×4×0.9
	66	71	71	98	115
C-D	$42\times6^{0.33}$	$26\times(4\times6)^{0.36}$	$26\times(4\times6)^{0.36}$	11×6＝66	32×6×0.9
	76	82	82	128	173
D-E	$42\times8^{0.33}$	$13\times(4\times8)^{0.56}$	$15.2\times(4\times8)^{0.51}$	11×8＝88	32×8×0.9
	83	91	89	154	230
E-F	$19\times10^{0.67}$	$13\times(4\times10)^{0.56}$	$15.2\times(4\times10)^{0.51}$	11×10＝110	32×10×0.9
	89	103	100	175	288
F-G	$19\times20^{0.67}$	$13\times(4\times20)^{0.56}$	$15.2\times(4\times20)^{0.51}$	11×20＝220	32×20×0.8
	141	151	142	263	512
G-H	$19\times30^{0.67}$	$13\times(4\times30)^{0.56}$	$15.2\times(4\times30)^{0.51}$	11×30＝330	32×30×0.7
	186	190	175	350	672

Notes
1. The formula (except (4)) at the top of the line, the simultaneous-use volume at the bottom.
2. The top of lines of column 4 is the units of water service devices, with which simultaneous-use volume is obtained according to Figure 9.2.1.
3. In method of (5), Table 9.2.1 and Table 9.2.2 are used.

2) Design water use in direct connection boosted-pressure type water service

When implementing direct connection boosted-pressure type water service, it is indispensable to properly set the simultaneous-use volume for the determination of appropriate diameter of service pipe and the proper capacity of a boosted-pressure water service facility. If failing in such setting, such a trouble may be caused as the installation of excessively large facility, inefficient use of energy, shortage in water service capacity etc.

As the methods for computing simultaneous-use volume, there are such methods as the one which computes with reference to Table 9.2.7, one which calculates based on the rate of simultaneous-use volume and the unit load of water service devices, and one which estimates from the use of the devices in addition to the above method. Eventually, a method suitable to the actual situation shall be selected based on good understanding of the methods.

On the occasion to introduce direct connection boosted-pressure type water service, it is desirable for the water utility to include the method for determining the simultaneous-use volume in their standards for construction work.

2. Design water use in the receiving cistern type water service

The water volume received in receiving cistern type water service is determined in consideration of the capacity of the receiving cistern and the hourly change in the water use volume. The per-hour water volume received in the receiving cistern is in general equal to the design water use per day (the design daily water use) divided by 24.

The design daily water use shall be set not only referring to the unit water use by category of buildings, time of use, the number of persons who use water (Table 9.2.7) but also taking into enough consideration the size and property of the facility in question, the situation of water uses by other users in the same service area and so forth.

Table 9.2.7 Unit water use by category of buildings, time of use, and number of persons who use water

Category of building	Unit volume served (per day)	Time of use (hr/day)	Annotation	Number of persons per effective area	Note
Detached house	200-400L/person	10	Per resident	0.16 persons/m^2	
Apartment house	200-350L/person	15	Per resident	0.16 persons/m^2	
Dormitory for single persons	400-600L/person	10	Per resident		
Government buildings and offices	60-100L/person	9	Per worker on duty	0.2 persons/ m^2	Men 50L/person Women 100L/person Additional volume to be added for company canteen, tenants etc.
Factory	60-100L/person	Work hour +1	Per worker on duty	Seated work 0.3 person/m^2 Standing work 0.1 person/m^2	Men 50L/person Women 100L/person Water for canteen, shower etc. added separately
General hospital	1500-3500L/floor 30-60L/m^2	16	Per m^2 of total floor area		Shall be studied in detail depending on the composition of facilities
Entire hotel	500-6000L/floor	12			(do)
Guest room sections	350-450L/floor	12			Only guest rooms
Sanitarium	500-800L/person	10			
Tearoom	20-35L/guest 55-130L/shop floor(m^2)	10		Shop floor area includes that for kitchen	Only for water for kitchen Toilet flash water added separately
Restaurant	55-130L/guest 110-530L/shop floor(m^2)	10		(do)	(do) Qualitatively, more cases in light meal, soba, Japanese food, western food, Chinese food,
Canteen	25-50L/set of meal 80-140L/floor(m^2)	10		(do)	(do)
Feeding facility	20-30L/set of meal	10			(do)
Dept. store, supermarket	15-30L/m^2	10	Per m^2 of total floor area		Including water for employees, and air-conditioning
Primary, middle, general high school	70-100L/person	9	Per person (students+staff)		Including teachers & staff. Water for swimming pool added separately
Lecture house of university	2-4L/m^2	9	Per m^2 of total floor area		Water for experiments and research added separately
Theater, movie theater	25-40L/m^2 0.2-0.3L/person	14	Per m^2 of total floor area Per visitor		Including water for employees, and air-conditioning

Terminal station	10L/1000persons	16	Per 1000 passengers		Water for trains and car washing added separately
Ordinary station	10L/1000persons	16	(do)		Water for employee and some tenants included
Temples & churches	10L/person	2	Per attendee		Water for residents and full-time worker added separately
Library	25L/person	6	Per visitor	0.4person/m^2	Water for full-time worker added separately

(Source) The Society of Heating, Air-conditioning and Sanitary Engineering of Japan; Guidebook of Heating, Air-conditioning and Sanitary Engineering, 11th Edition, Volume 3, p. III-80

Note: 1) The unit water use is the design water use, but not the (yearly) daily average water use.
2) Without a particular note, water for air-conditioning, freezer, experiment & research, processing, swimming pool & sauna etc. shall separately be added.
3) This table was prepared based on judgment of the writer of the table after referring to a number of bibliographies.

For the computation of design daily water use, there are the following methods:

(1). Water use per capita per day × number of users (or number of persons per floor area × total floor area)

(2). Water use per unit floor area of a building × total floor area

(3). Other methods in accordance with the experience in water use

As for businesses not clearly indicated in Table 9.2.7, water use shall be computed based on a study on the actual condition of water use of the present building, the water use experienced by similar businesses and so on. For example, the water use can also be determined by summing up water use volume of each water service device in use.

The standard capacity of receiving cistern is 4/10 to 6/10 or so of the design daily water use.

9.2.3 Pipe diameter

> The diameter of water service pipe shall be the one that can serve the design water use at the time of the design minimum dynamic pressure of the distribution main.

[Interpretation]

1. Standard for the decision of the pipe diameter

The diameter of water service pipe shall be one that can adequately serve the design water use at the time of the design minimum dynamic pressure of the distribution main, and that is economically advantageous.

The pipe diameter is determined so that the sum of the height of the water service device and the total head loss of the pipe for the design water use falls less than the design dynamic head of the distribution main from which the service pipe branches (See Figure 9.2.2). However, certain allowance of the head shall be secured in consideration of the increase in water demand, change in the pressure of the distribution main in future etc.

Although 3 m to 5 m of head shall be secured where water service devices are connected, the minimum required head shall be maintained at the tap of a water heater, a shower head etc. in case there is a water service device, which needs the minimum working pressure, and the tubing for the top-end cock type gas water heater is long etc.

2. Head loss

As head loss, there are head loss at the inlet and outlet ends of a pipe, friction head loss of the pipe, those which occurs at water meter, water service devices, pipe joints, bends of pipe, branching points, change in diameter etc. Since, among them, main ones are friction head loss of the pipe, and head losses of the water meter, water service devices and pipe joints, there will be little effect even if other losses are omitted in the process of computation.

1) Friction loss of water service pipe

The Weston formula shall be employed for computation of friction loss of the water service pipe in the case of pipe diameter of smaller than 50 mm. Computation for pipe with a diameter of larger than 75 mm shall be in conformity with 7.5.5 Pipe diameter.

Weston formula

$$h = (0.0126 + \frac{0.01739 - 0.1087d}{\sqrt{V}}) \cdot \frac{l}{d} \cdot \frac{V^2}{2g}$$

$$Q = \frac{\pi d^2}{4} \cdot V$$

where,

h: friction loss of the pipe (m)

v: average flow velocity in the pipe (m/s)

l: pipe length (m)

d: actual inside diameter of the pipe (m)

g: gravity constant (9.8 m/s^2)

Q: flow rate (m^3/s)

A chart of flow rate by the Weston formula is given in Figure 9.2.3.

2) Head losses by various types of water service devices and sections of pipe joint

Charts of head losses by faucets, water meters and joints in relation to flow rates are presented in Figure 9.2.4 to Figure 9.2.6.

Head losses by water service devices, which are not shown in the charts, shall be determined with reference to the documents etc. supplied by their manufacturer.

3) Equivalent pipe length of head losses of water service devices etc.

The equivalent (converted) pipe length is the length of a straight pipe, which generates equivalent head losses of water service devices, water meters, joints etc. If the converted length of straight pipe of various water service devices is computed in accordance with the standard water use in advance, these head losses can be obtained from the friction loss formula of the pipe. The method of finding the converted length of straight pipe is presented below:

(1). Head loss (h) of various water service devices corresponding to their standard water use shall be found applying Figure 9.2.4 to Figure 9.2.6 etc.

(2). The hydraulic gradient (I) corresponding to their standard water use shall be found applying the chart of flow rate by the Weston formula (Figure 9.2.3)

(3). The converted length of straight pipe (L) is: L=(h/I)×1,000

3. Method to determine the pipe diameter

Although the pipe diameter required to conduct the design water use can be obtained by the flow rate formula, an example of the method to find it with the application of flow rate chart is presented.

What is more, there is another practical method to find the approximate diameter of the pipe in that (1) the effective head is found as the balance of the design minimum dynamic pressure in the distribution main less the rising height of the device; (2) the hydraulic gradient is obtained by the effective head and the largest length of the pipe; and (3) the diameter will be determined by the Weston formula flow chart (Figure 9.2.3) using the hydraulic gradient and the design water use in consideration of the rate of simultaneous use.

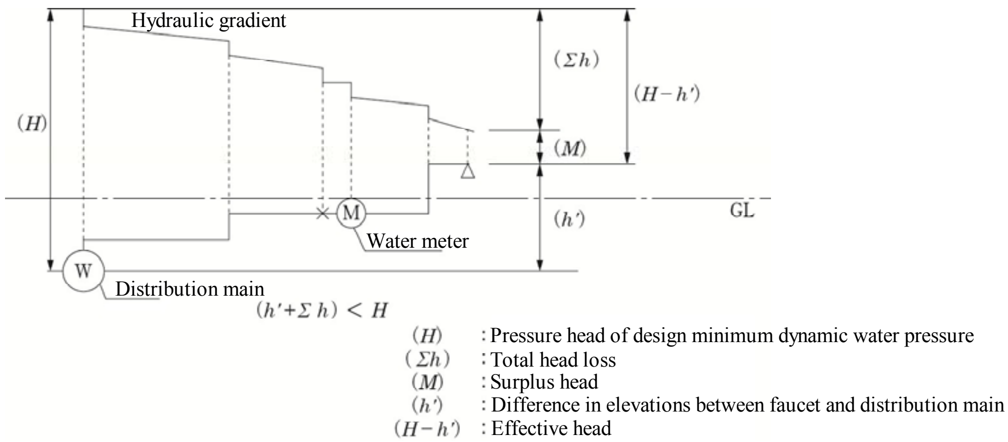


Figure 9.2.2 Diagram of hydraulic gradient

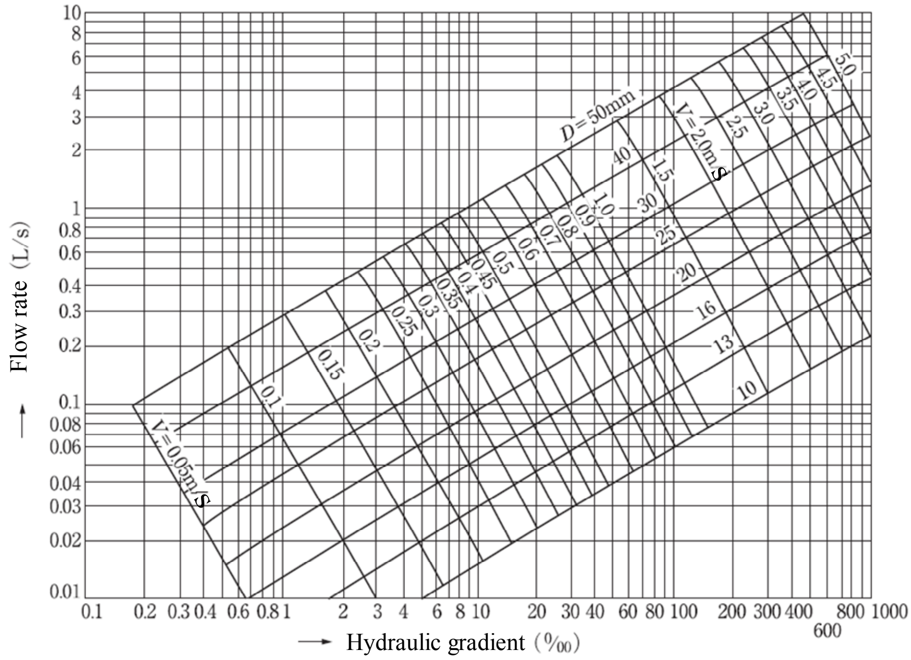
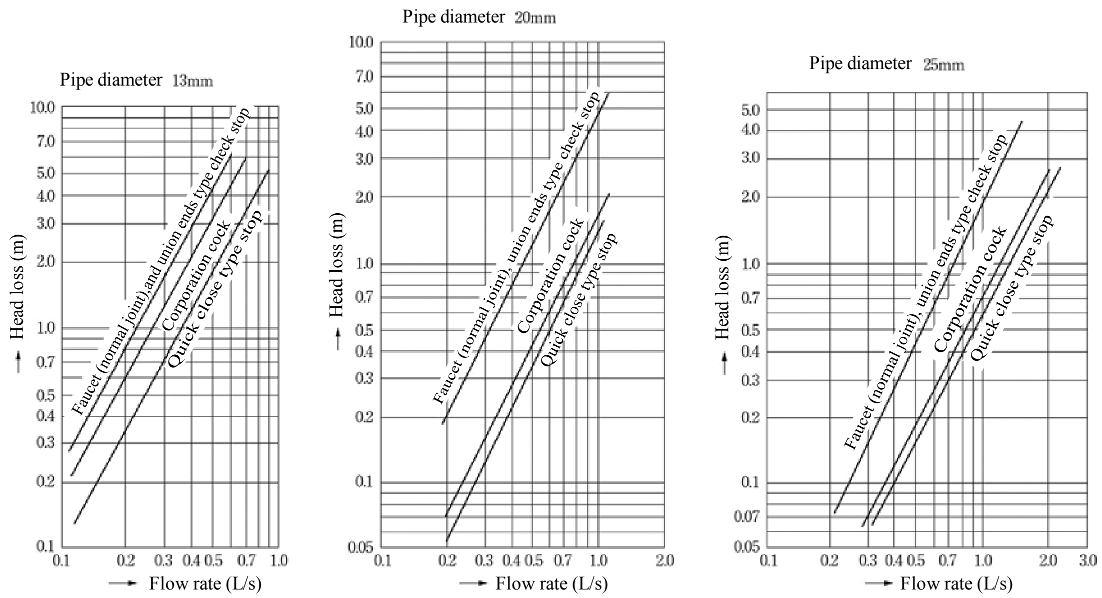
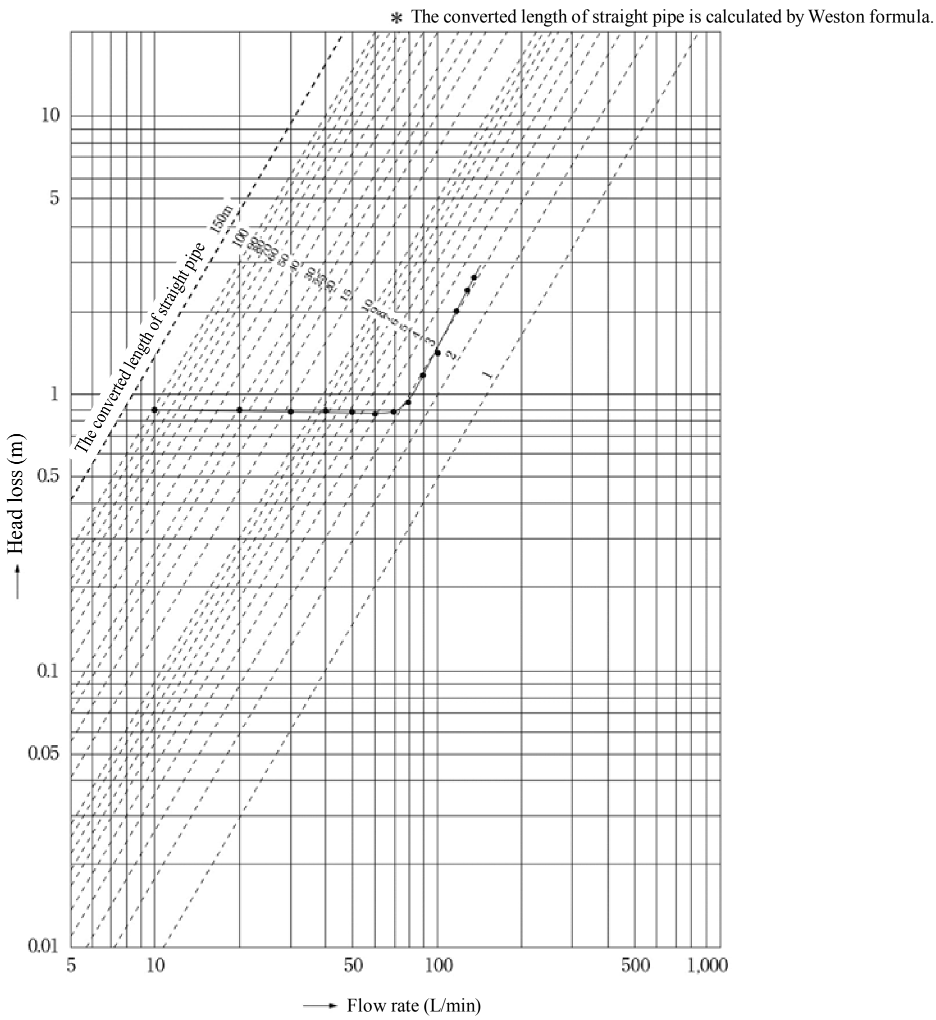


Figure 9.2.3 Flow chart by Weston formula



(Faucet, Stop valve, Corporation cock)



(Nominal diameter 25 Check valve)

Figure 9.2.4 Examples of head loss of faucets

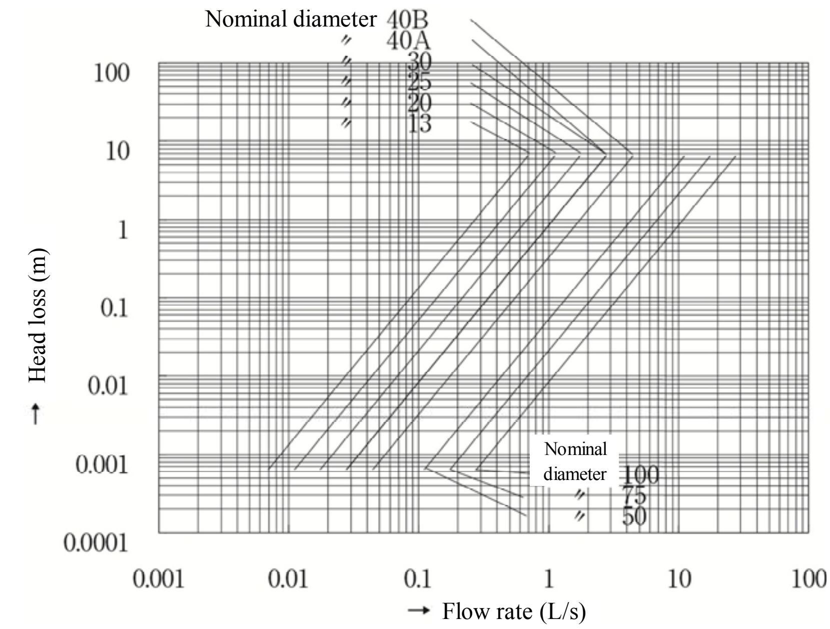


Figure 9.2.5 Examples of head loss of water meters

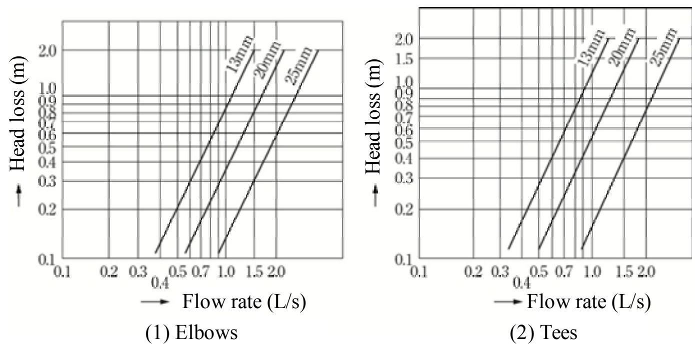


Figure 9.2.6 Examples of head loss of pipe joint sections

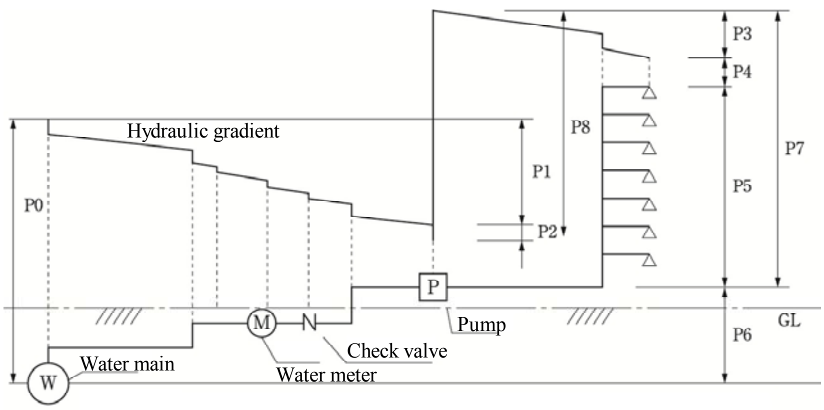
2) Direct connection boosted-pressure type water service

When determining the pipe diameter in direct connection boosted-pressure type water service, the design water use shall be obtained after precisely knowing the simultaneous-use water volume based on the actual situation of water consumption in the building in question since the capacity of the boosted-pressure water service facility and the feeding capacity of the pipe branching from the distribution main will be mutually influenced by the water use of the building. In addition, a boosted-pressure water service facility shall be selected, which possesses the capacity to meet the above water flow; and the diameter of the branching pipe shall be determined according to the flow.

As the methods of hydraulic calculation to decide the pipe diameter, one of them is the method to employ the Weston formula for pipe with a diameter of smaller than 50 mm, the Hazen-Williams formula for pipe with a diameter of larger than 75 mm: and another method is the equivalent friction resistance method in design of architectural facilities. Given this, it is desirable for the water utilities to decide the method to be used after comparative studies on them so that it is included in the standards for construction work.

In this occasion, the output pressure of the booster facility shall be adequate for the use of the water service device situated at the highest end. The value set for the output pressure of the booster facility shall be the sum of the head loss of the service pipe and the water service devices situated downstream of the booster facility, the pressure head needed to use the water service device situated at the highest point, and the elevation difference between the booster facility and the device at the highest point.

The chart of the hydraulic gradient in direct connection boosted-pressure water service is shown in Figure 9.2.9.



P0 : Water pressure of distribution main (pressure head);
P1 : Head loss of service pipe and water service devices situated upstream of the booster facility
P2 : Head loss of the booster facility
P3 : Head loss of service pipe and water service devices situated downstream of the booster facility
P4 : Pressure needed to use the water service device situated at the highest point (pressure head)
P5 : Elevation difference between the booster facility and the water service device situated at the highest point
P6 : Elevation difference between the booster facility and the distribution main
P7 : Delivery pressure of the booster facility (pressure head)
P8 : Total lift of the booster facility
Delivery pressure of booster facility (pressure head)(P7) shall be computed by the following formula.
P7=P3+P4+P5

Figure 9.2.9 Chart of the hydraulic gradient in direct connection boosted-pressure water service

9.2.4 Pipe material

The service pipe shall be in conformity with the quality standards of the standards for structure and material. Besides, when laying it, the pipe material shall not only be conformity with the standards for water service fittings system of the standards for structure and material but also the most suitable to the geotechnical property of the site, the external force acting on the pipe, climate, characteristics of the pipe, its maintenance after laying etc.

[Interpretation]

As service pipe, there are ductile iron pipe, steel pipe, stainless steel pipe, hard PVC pipe, polyethylene pipe, copper pipe etc.; and they shall meet the quality standards of the standards for their structure and material. The service pipe, which possesses good durability and strength, and does not adversely affect the water quality, shall be used. Especially, the pipe joint shall have a simple and reliable structure and function since it tends to become the most vulnerable part.

9.2.5 Branching of the service pipe from the distribution main

It is desirable for water utilities to incorporate the method of branching of the service pipe from the distribution main and its implementation in the standards for construction work etc.

Branching of the service pipe shall be undertaken as follows:

1. Tapping on the distribution main by drilling shall not cause adverse effects to the strength of the pipe and its inside coating.
2. For the purpose of branching of the service pipe from the distribution main, the corporation cock, the corporation cock with saddle, the plastic tee fitting (for hard PVC or polyethylene main), the tee fitting or the separate tee fitting for other pipe materials in accordance with the pipe material and diameter of the distribution main and the diameter of the service pipe.
3. In case taping is made using a corporation cock or a corporation cock with saddle, the interval of tapping shall be more than 30 cm.
4. For making a branch for service pipe using a plastic tee fitting, a tee fitting or a separate tee fitting for other pipe materials, its size shall not be larger than the diameter of the distribution main.

[Interpretation]

When making a branch for a water service pipe from a distribution main, the right main shall carefully be identified according to the marking tape, the location of hydrants and valves, sounding by flow noise etc. so that no cross connection should be made with such other pipe than drinking water main as a gas main, a water main for industrial water supply and so on.

Furthermore, confirmation of the buried objects shall be made based on their drawings together with the administrator of the objects; and site inspection by the presence of the officers of the water utility and the administrator.

Since it is prescribed in Article 36, Clause 1, Section 3 of the Ordinance under the Waterworks Law that the branching of a service pipe shall be carried out in accordance with the method of laying and the condition for the laying work approved in advance by the water utility concerned, it is recommended for the utility to incorporate such method and condition in its standards for the construction work.

On the item 1.;

For drilling tapping holes on the distribution main, the interval of the holes and their diameter shall carefully be chosen so that the strength of the main is not reduced.

A drill bit suitable for the coating on the inside wall of the main shall be used so that the coating is not peeled off; and such a measure as a sealing core shall be applied on the drilled holes to protect the cut surface from corrosion.

On the item2.;

In case a branch is made from the distribution main for a service pipe, a corporation cock or a corporation cock with saddle shall be used for a service pipe of a diameter of smaller than 50 mm.

A plastic tee fitting can also be used in case the pipe material of the distribution main is hard PVC pipe or polyethylene pipe.

In case the diameter of the service pipe is larger than 75 mm, a plastic tee fitting, a separate tee fitting or a tee fitting, which is placed after cutting and removing a section of the water main, shall be used for branching from the main in accordance with the pipe material, diameter, depth of burial of the distribution main, property of soil at the point of branching of the service pipe, and the material of the service pipe.

No corporation cock shall be tapped on special fittings. When tapping a corporation cock near a pipe joint, a space of more than 30 cm shall be provided from the joint in consideration of maintenance work.

More than three threads of the screw-cock for tapping shall be provided so that the resistance of the cock against external forces is not impaired; and that water leakage is prevented. Since more than three threads cannot be provided for the 25-mm corporation cock depending on the diameter of the distribution main, the corporation cock with saddle shall be adopted. A saddle shall be used for tapping a corporation cock on a hard PVC pipe to prevent the accident of its snapping.

On the item 3.;

In case making a branch from a distribution main by means of the corporation cock, it is prescribed under the Ordinance of the Waterworks Law that more than 30cm of space between two cocks shall be maintained to prevent the impairment in pipe strength caused by drilling holes; avoid the adverse influence to the flow of one tap to be caused by that of another tap; and make maintenance easy.

On the item 4.;

In case making a branch by means of the plastic tee fitting (for hard PVC or polyethylene main), the tee fitting or the separate tee fitting for other pipe materials, the diameter of such service pipe shall as a general rule be one size smaller than the main so that water service to other houses in the surroundings shall not be affected.

9.2.6 Pipe laying

Laying of the service pipe shall be undertaken in accordance with the standards for the water service fitting system of the standards for the structure and material. Since the water utility can specify the laying method of water service pipe from the tapping on the distribution main to the water meter, it is desirable to incorporate such a method in the standards of service pipe laying. The pipe laying shall be in conformity with the following:

1. When laying a water service pipe in a road, the location and the depth of exclusive occupation of the pipe shall not be mistaken. Besides, more than 30 cm of space shall be maintained between the pipe and other buried objects.
2. Backfilling shall be made with soil of good quality or sand; and the backfill shall properly be compacted to protect the pipe.
3. In case the pipe is laid in the premises of a house, the location of the curb cock and the water meter shall be selected to facilitate their maintenance; and the pipe shall be laid in a straight line as much as possible even in the premises.
4. In case the pipe laid on the ground floor or the second or higher floor, stop valves etc. shall be fit at each floor; and its sections, which are laid vertically or horizontally and exposed, shall be fastened to the building at an appropriate interval.
5. In case there is a risk of freeze or condensation at exposed sections of the pipe, proper measures shall be provided for the prevention of freeze and condensation.
6. In the occasion of crossing an open channel, the pipe shall be laid underneath the channel as much as possible.
7. For the selection of the method for pipe laying inside a medium- to high rise building under direct connection water service, and specification for a pressure boosting facility, maintenance, hygienic management, the influence to distribution mains, reliable water service etc. shall be taken into consideration.
8. In case the pipe is laid in reclaimed land or soil of high corrosiveness, resistance against an earthquake and protection from corrosion shall adequately be considered.

[Interpretation]

On the item 1.;

In the occasion of laying a service pipe crossing a public road, the exclusive location of the pipe, which is instructed by the administrator of the road, shall not be mistaken in consideration of its relationship with gas mains, telephone cables, sewers and other buried objects. In addition, if the pipe is laid close to other buried objects, there is a risk of damaging them by its concentrated load at the neighboring point or sandblast caused by water leaking from it. Given this, the pipe shall be laid with a space of more than 30 cm at the minimum to prevent such an accident and in consideration to repair work.

If the pipe is laid in a diagonal line to the distribution main, since maintenance work may be troubled, the pipe shall be laid square to the distribution main. An example of branching from the distribution main and pipe laying is presented in Figure 9.2.14.

On the item 3.;

The curb cock and water meter shall be installed in locations, with which no trouble for maintenance is caused in future, and the water service pipe shall be laid in a straight line as much as possible. In case there is such an object as a sewage box in the halfway of the pipe, since there is a risk of contamination in an occasion of breakage of the pipe, the pipe shall be laid far enough from the object to avoid its influence.

It is desirable for the curb cock and its box to be placed close to the public-private boundary of the road inside the house premises avoiding locations where such external load as automobiles is imposed; an obstacle is placed; or its burial is made. It is important for them to be located at a location where they can be operated even at the time of the collapse of the house taking into account the early restoration in an occasion of an earthquake and other disasters.

In case the valve and its box are placed in a road, since water leakage, breakage of the box, its burial etc. may be caused in many cases by such an external force as road construction, traffic loads and so on, and emergency operation will be hindered, attention shall be paid to avoid such events to occur.

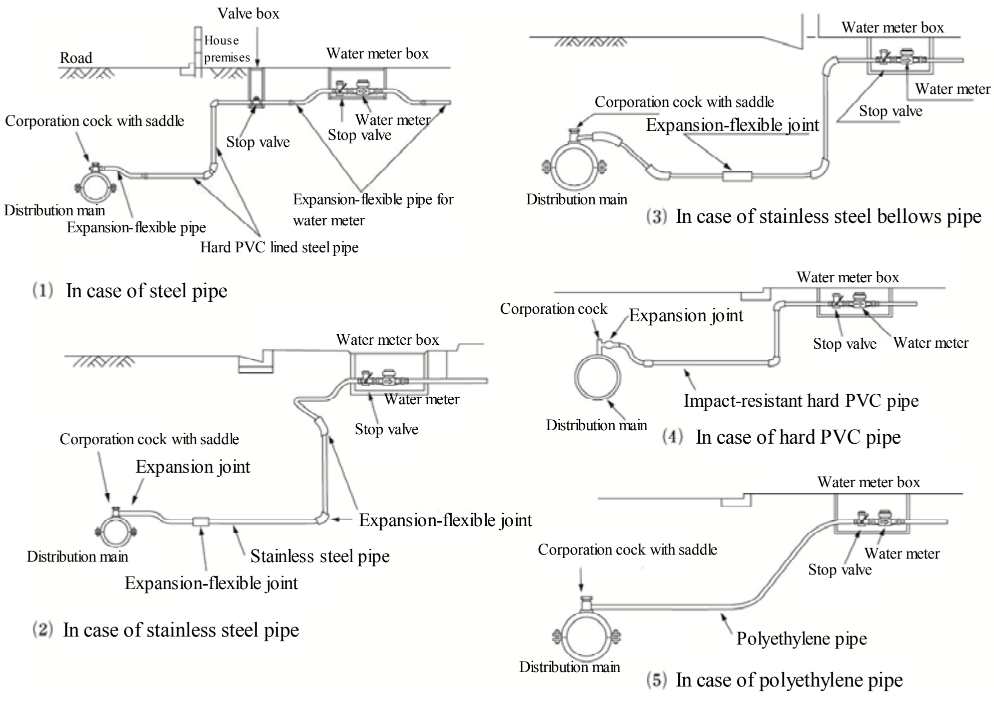


Figure 9.2.14 Example of branching from the distribution main and pipe laying

On the item 4.;

On the pipe laid on the ground floor or the second or higher floor, stop valves shall be fit at each floor as provision for repair or reform work. Besides, its sections, which are laid vertically or horizontally and exposed, shall be fastened to the building with such fixtures as grips at an interval of 1 m to 2 m since it is easily damaged by vibration and flexion caused by external forces, dead load, water pressure etc.

The section of the pipe where a faucet is fit shall firmly be fastened since such portion is especially easily damaged.

Inside a house (apartment house etc.) to avoid pipe joints, which becomes the cause of water leakage, there is header type pipe laying. In this type of pipe laying, a pipe is individually laid from the header to each water service device, and the crosslinked polyethylene pipe, polybutane pipe etc.

are used as the pipe material for this purpose. In this method, a sleeve pipe or a header pipe is generally used to facilitate future replacement of pipes inside of the house.

On the item 6.;

In the occasion of crossing a gutter or an open channel, the pipe shall be laid inside a sleeve of steel pipe placed underneath the channel etc. as much as possible. If such a measure is impossible, the pipe shall be laid above the high water level.

9.3 Water service devices

9.3.1 General

Water service devices stand for corporation cocks, curb cocks, faucets, valves, apparatus etc. which are directly connected to the service pipe and form the water service fittings together with the pipe.

Water service devices shall be in conformity with the function standards prescribed under the standards for structure and material.

As the water service devices which are in conformity with the standards for structure and material, there are the Japan Industrial Standards products (JIS products), Japan Water Works Association Standards products, self-certified products, third-party certified products etc.

What is more, the figures presented in this chapter are examples. Such devices as the toilet bowl, flash valve, dish washer etc., for which special attention shall be paid for the prevention of backflow, shall be in conformity with the standards related to the prevention of backflow under the standards for structure and material.

9.4 Water meter

9.4.1 General

1. Role and state of water meters

The water meter (hereinafter "meter") is a device, which is installed in the water service fittings to measure customer's water use by integrating and scaling, of which volume is the base for the management of water use by determining the water charge, the ratio of revenue water etc. As precise measurement is required, for the selection and use of the meter, taken into consideration shall be that the meter has passed the tests for specific measurement devices prescribed in the Measurement Law (Law No. 51 [1992]); that it is within the validity term of the tests; and its other properties.

As the application of direct connection water service is expanding, and water service devices of small head loss is in demand, the type and performance of the meter shall be selected in accordance with the actual condition of use so as to achieve reduction in its head loss.

It is desirable for the water utility to specify the types of the meters to be adopted by it in its standards for installation of water service fittings; and to prescribe the location and method of their installation.

2. International coordination of accreditation of standards and establishment of the JIS Standards

Since, as international coordination of the standards accreditation system in the field of legal measurement, coordination of the recommendations of the OIML (International Organization of Legal Metrology), which are international technical standards, and the ISO (International Organization for Standardization) with the technical standards of Japan had been demanded, the Ministry of Economy, Trade and Industry established the Japanese Industrial Standards (JIS) so that "the rule for testing and authorization of specific measurement devices " (Ministry of Economy, Trade and Industry Ordinance No. 70 [1993]) under the Measurement Law should be ruled by the JIS.

Although the rule for testing and authorization of specific measurement devices was revised on 30 March 2005, certain transitional measures for its implementation were provided. Although the starting date of certification of the JIS meters is 1 October 2005, the terminal date for manufacture of old JIS meters was 31 March 2011; and the terminal date for their use is 31 March 2019.

Accordingly new JIS meters will fully be manufactured from April 2019.

9.5 Hygienic safety measures

9.5.1 General

Unlike water supply facilities, although the water service fittings are the property of individual customers, and its management is their responsibility, they constitute the water supply system together with distribution mains.

Therefore, water quality shall not be impaired by the water service fittings; or the water in the distribution main shall not be polluted by backflow from the water service fittings. Article 16 of the Waterworks Law (Structure and material of water service fittings) prescribes that the water utility is entitled to refuse the application for the contract for water service to an individual or suspend, according to its water service code, its water service to a customer whose water service fittings are not in conformity with the standards stipulated in the Ordinance in terms of their structure and material until his (her) water service fittings become to meet the standards.

The water service devices shall carefully be chosen from those which are in conformity with the performance standards prescribed in the standards for structure and material in adequate consideration of their characteristics and condition of their use etc. and suitable for the particular location for its installation.

As such, it is important that the customers shall be enlightened and educated for proper use of water service fittings.

9.5.2 Selection of materials and equipment in consideration of water quality

To secure the water quality the following aspects shall be taken into consideration:

1. Pipe material, which does not give an adverse effect on water quality, shall be selected.
2. A drainage facility shall be provided according to needs.
3. For pipe laying, appropriate and careful work shall be conducted.

[Interpretation]

On the item 1.;

With respect to abnormal water quality in water service fittings, there are a large number of reports on incidences of water pollution due to deterioration of the aged service pipe, and wrong material chosen for it. They are classified into the one that is related to the material and its quality, and the other one that is caused by the installation of the water service fittings. Their causes and countermeasures are presented in Table 9.5.1.

When designing the installation or alteration of the water service fittings, such a water service pipe shall be selected that matches the treated water quality and the surroundings of the laid pipe, and that possesses corrosion resistance, or anti-corrosion coating on its inside wall in reference to the "table of the cases of abnormal water quality of tap water" in Table 9.5.1 and so forth; and proper measures needs to be put into practice so that no abnormal water quality is brought about in future.

Such troubles related to water quality as white water, red water, blue water, foreign matters, odor etc. may be caused by certain types of pipe material.

Table 9.5.1 Cases of abnormal water quality of tap water (caused by water service fittings)

Type of phenomena	Situation	Cause		Countermeasure
Color, odor etc. of tap water	1. Tap water is colored red or brown	Caused by the material and quality of water service fittings	Pipe, of which inside wall is corroded, is used: cast iron pipe without lining, galvanized steel pipe or joints of such material.	Water detained in service pipe is to be used for other purpose than drinking. As such trouble is caused by corrosion of the inside of the pipe, its replacement is needed to other pipe material (hard PVC lined steel pipe, hard PVC pipe etc.). Pipe rehabilitation, measures to suppress red water etc. are also useful depending on the condition.
	2. Tap water is colored white.		Pipe, of which material [galvanized steel] elutes, is used.	(1) Zinc eluting from galvanized steel pipe is the cause; and red water is produced when corrosion further progresses. Replacement of the service pipe is needed. (2) Water retained for a long time shall be used for cleaning or watering the garden etc., wasted for some time and used for other purposes.
	3. Tap water is colored blue.		Pipe, of which material [copper pipe] elutes, is used.	Although small amount of eluting copper forms blue colored “copper soap” in reaction with fatty acid of soap, it causes no effect on human body, so the colored portion shall be cleaned well. Elution of copper tends to occur when the pipe is relatively new.
	4. Odor of solvents or oil is smelled from water.		Pipe (hard PVC pipe, polyethylene pipe etc.), in which organic solvents, kerosene etc. tend to permeate, is used.	Since there is a possibility that the pipe is invaded by such organic solvents as thinner, kerosene etc. by some reasons, a survey shall be conducted by excavation. In case the soil is contaminated by solvents, kerosene etc., the soil shall be replaced with new soil or the pipe be changed into a pipe of solvent-resistant material.
	5. Tap water contains small black fragments.		Rubber gaskets etc. of curb cocks and faucets have been degraded.	The rubber gaskets in question shall be replaced.
	6. Tap water becomes turbid in white.	Caused by pipe laying work	Air is entrained in water.	If the water becomes clear in a bowl in several minutes, air is the cause. Discharge water containing air.
	7. Odor of oil etc is smelled from water.		Lubrication oil agents for threading, sealants, solvents etc. are used for pipe laying.	Since lubricants for threading of lined steel pipes, sealants for setting of joints, and adhesives for jointing hard PVC pipes are the main causes, water shall be wasted at the beginning when water is used. In several days, the problem will be gone.
	8. Foreign matters are contained in water.		Sand, iron fragments, machining dust, sealants for joints are left in the pipe at the time of laying.	Since contamination with sand etc. at the time of laying work, discharge water for a while, and use it for drinking. Cleaning of filters fit in water service devices shall be carried out according to the situation.

	Situation	Cause
Others	1. Small holes are bored on the surface of aluminum pans, kettles etc.	A particular point on such utensils is intensively corroded by chlorine ion and small amount of copper ion eluting from a copper pipe, and a hole is bored.
	2.White, fibrous, or needlelike glittering matters are contained in water of such a glassware as a vacuum bottle, a coffee siphon etc.	The silicon, which comes off glass as a result of collapse of its composition, or substance formed by reaction of magnesium with silicate of glass (flakes phenomenon)

1) Abnormal water quality caused by steel pipe and cast iron pipe

"Red water" is a main incidence of abnormal water quality. Red water is produced when the inside lining of steel pipe by galvanization is degraded by aging; the iron metal directly contacts the water; and the metal gathers rust. Since the same phenomenon occurs at such locations as the threaded joint, the end of pipe etc. which are vulnerable to rusting even in the case of the lined pipe, such proper anti-corrosion measures as a joint with corrosion resistant pipe ends and corrosion resistant cores on pipe ends shall be applied to prevent corrosion. Besides, water gets colored white in case zinc elutes. Since the conventionally used galvanized steel pipe easily gets corroded; accumulates scales; and becomes the cause of red water, it was eliminated for water supply from the scope of use under the standards since September 1997. What is more, composite steel pipes with various types of inside lining have been standardized. Furthermore, since there are cases where red water is caused by detachment of coating on the tapping hole or inside of the pipe, such measures as careful drilling of holes for corporation cocks, applying anti-corrosion cores etc. shall be carried out.

2) Elution of lead from lead pipe

Lead pipe has been used for branching from the distribution main, piping around the water meter etc. because of its property of excellent flexibility. However, some of them causes contents of lead in water retained in lead pipe in excess of the water quality standards even though the contents of lead in water does not exceed the water quality standards under the normal condition of water use.

The water quality standard for lead was intensified down to 0.05 mg/L or less in 1993, 0.01 mg/L in 2003; and the lead pipe without lining, and the polyethylene-lead composite pipe (lining lead pipe) were eliminated from the JIS standards in 1993 and 2004 respectively.

Furthermore, the Ministry of Health and Welfare issued a notice "On hygienic measures concerned with water service pipe etc." (Notice No. 177 [27 June 1989]), which stipulated that the pipe material, which caused no problem of the elution of lead, should be used when newly laying a water service pipe.

3) Abnormal water quality caused by copper pipe

Small amount of copper tends to elute from a copper pipe in the case of water containing a lot of free carbon dioxide. It is said that water containing a small amount of copper adversely affects its taste.

In case copper pipe used as water service pipe etc., although toilet appliances, tiles of the bath room etc. are gradually colored blue-green in some occasions after a long time, it is unlikely that water itself is clearly colored blue.

4) Abnormal water quality caused by such a plastic pipe as the hard PVC pipe, the polyethylene pipe etc.

In case such a plastic pipe as the hard PVC pipe, the polyethylene pipe etc. are laid where soil is contaminated with gasoline, thinner, kerosene etc. or where such a substance permeates later on, water is at times tainted with oily odor etc. by permeation of such solvents.

It is predicted that various types of other plastic pipes will be developed in future.

As for these new pipes, it is important for the prevention of problems related with water quality that the environment of pipe laying etc. shall be studied; and that they shall be selected in consideration of their chemical resistance and so on.

On the item 2.;

In the case of the water service fittings temporarily or seasonally used in such an institution as a school, water is at times retained in the pipe for a long time. As such water is hygienically unfavorable, such a device as a drainage facility shall properly be provided so that such water can easily be drained.

On the item 3.;

As for adhesives, lubrication oil for cutting, sealants etc. used for jointing pipes in installation work of water service fittings, those which do not give adverse effects to water quality shall be adopted.

For instance, if the adhesive for the TS type joint of hard PVC pipe is used in an excessively large quantity, it will be pushed inside the pipe. In addition, in case threading of hard PVC lined steel pipe is carried out, the lubrication oil or the sealant will be squeezed into the pipe if the lubrication oil remains stuck inside the pipe, or too much sealant is applied.

In case the adhesive, lubrication oil, sealant etc. are inappropriately used, oily odor, chemical smell etc. may be caused. Therefore, processing of the joint section, and jointing of pipes shall properly and carefully be carried out so that water is not tainted with unusual odor and taste.

Besides, there are cases where sand, iron fragments etc. are coming out together with water. Since such an incidence mostly occurs due to such matters to be introduced in the pipe at the time of laying work, they shall be removed from the pipe by flashing water out.

[Reference 9.6] On the hygienic measures related to water service pipe etc.

(Notice No. 177 dated 27 June 1989 of Manager, Water Supply Section, Water Supply and Environment Division, Department of Living and Sanitation, Bureau of Living and Hygienic Safety, the Ministry of Health and Welfare addressed to the respective directors of Departments of Prefectures in charge of the administration of water supply activities)

On the captioned subject, the Ministry of Health and Welfare established in November 1988 a review meeting on the hygienic issues of water service pipe etc. aiming at surveying and reviewing the issue of the elution of lead in water. The review had been concluded, of which report was issued as attached separately.

As it is considered appropriate to undertake the following actions based on this report, it is appreciated if you would notify and guide the water utilities etc. under your administration.

Notice

1. Selection of material of water service pipe

The pipe material, which causes no problem of the elution of lead, shall be used when newly laying a water service pipe.

2. Replacement of lead pipe

When replacing an existing distribution main to which a lead service pipe is connected or in a similar occasion, efforts shall be made to use the pipe material, which causes no problem of the elution of lead.

3. Improvement in pH value

Since the lower the pH of tap water, the more the elution of lead from the lead pipe, efforts shall be made to improve the pH of tap water in the water supply of which water has low pH.

4. Implementation of Public Relations activities

The aspect, which causes a problem of elution of lead, is the first portion of water coming from a tap when it is open; and it is desirable for the water to be used for other purposes than drinking, so public relations activities shall be mounted in that effect.

In addition to the above, there are such notices on the elution of lead as follows. See the Homepage of the Ministry of Health, Labor and Welfare for more detail.

- "On the hygienic measures related to water service pipe etc." (Notice No. 57 dated 6 July 2001)
- "On Partial revision of the Ministry of Health, Labor and Welfare Ordinance on Water Quality Standards" (Notice No. 0327003 dated 27 March 2002)
- "On the proper measures for water service lead pipe" (Notice No. 1221001 dated 21 December 2007)

9.5.3 Prevention of backflow

To prevent accidents caused by backflow in water service fittings, such proper measures as the following shall be implemented:

1. The service pipe shall not be directly cross-connected with other pipe, machine, facilities etc. than the present water service fittings.
2. In case water is fed to a water tank, sink or other container, a required air gap between the overflow level of the tank etc. and the mouth of the tap shall be secured.
3. A water service device with the prescribed function shall be installed at an appropriate location to prevent backflow.

[Interpretation]

On the item 1.;

Direct connection of the service pipe with other water pipe, machine, facilities etc. than the present water service fittings must absolutely be avoided to secure safe water quality.

Even assuming that a backflow prevention device is set at the interconnecting point between the present service pipe and other facilities, hygienically big peril to customers will be brought about by backflow caused by mishandling or failure of the device.

In case the service pipe and pipes of other purposes are laid closely side by side, their identification will be difficult by their appearance in some cases. As such, the pipe shall be so marked on its body that its use is recognized to prevent the cross-connection.

1) **Examples of pipe with which connection with water service pipe tends to be made (See Figure 9.5.1 and Reference 9.7)**

(1) Pipe for well water, industrial water supply, reclaimed water supply

(2) Piping downstream of the receiving cistern

(3) Circulation piping for a swimming pool, a public bath etc.

(4) Hot water dispensing pipe other than the present water service pipe

(5) Piping for water sprinkling

(6) Piping for priming of a pump

(7) Rainwater pipe

(8) Cooling water piping for freezer

(9) Other drain pipe

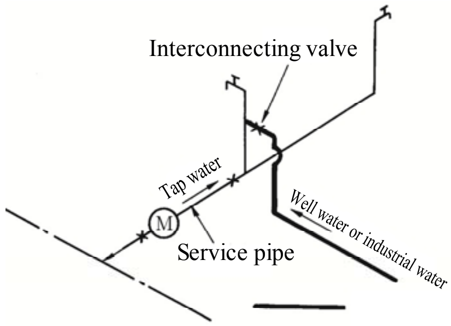
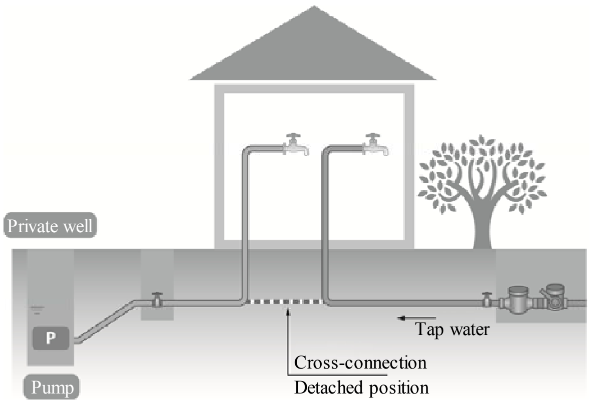


Figure 9.5.1 An example of piping to which connection of water service pipe not to be made

[Reference 9.7] An example of accident due to connection with piping for private-use well

Connection was made (by the house owner himself) between the pipe for a private well and the water service pipe; the check valve built-in the pump was damaged after use for a long time; and tap water was flowing into the well. At a time of meter reading, the fact was noticed, the owner requested the water utility for a leakage study. As a result, separation of the well pipe from the service pipe was made.



2) **Examples of machines, facilities etc. with which connection with water service pipe tends to be made (See Figure 9.5.2)**

(1) Rice washing machine
(2) Boiler (except for storage type water heater), water chiller
(3) Dry cleaning machine
(4) Pure water filter, water softener
(5) Air cleaner, water-jet washer
(6) Bottle washer
(7) Automatic mat washer, car-washing machine
(8) Bath boiler cleaner
(9) Simple shower set, pump for bailing water from bath tab
(10) Hair washer

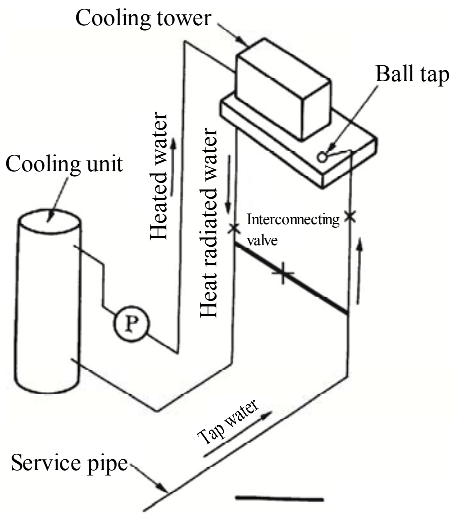


Figure 9.5.2 An example of facility to which connection of water service pipe not to be made

On the item 2.;

In case water is fed to a receiving cistern, sink, wash basin, bath tab etc. a required air gap between the overflow level of the tank etc. and the mouth of the faucet shall be secured (See Figure 9.5.3).

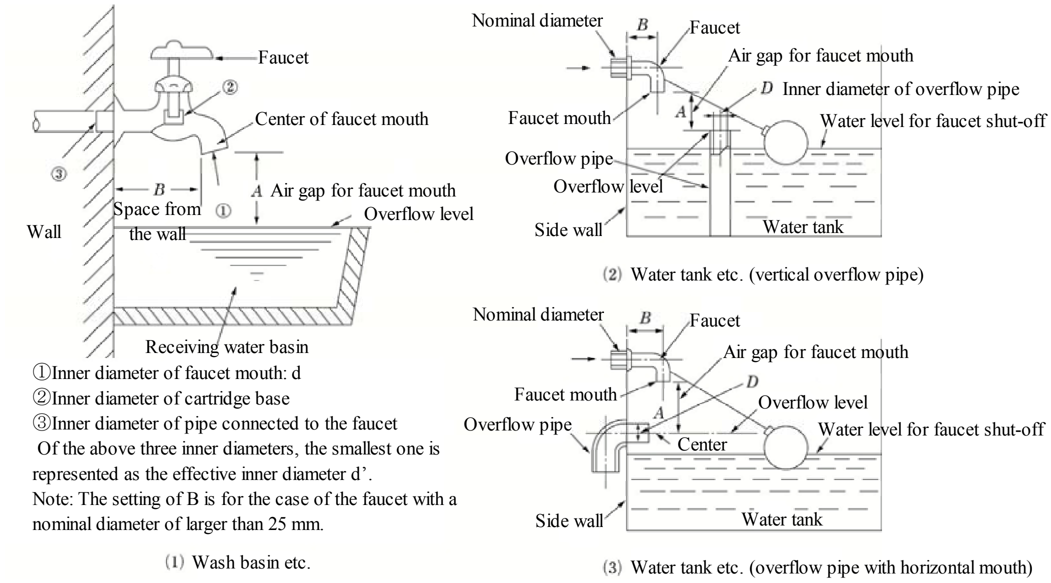


Figure 9.5.3 Air gap for faucet mouth

The air gap for faucet mouth is the most common and reliable method for backflow prevention; and the air gap for faucet mouth shall be secured as indicated in Table 9.5.2 and Table 9.5.3 when feeding water to a receiving cistern, bath tab, swimming pool etc. (See Reference 9.8).

Table 9.5.2 Air gap for faucet mouth with nominal diameter of smaller than 25

Nominal diameter	Horizontal distance from nearest wall to the center of faucet mouth B	Vertical distance from the overflow level to the center of faucet mouth A
Smaller than 13	More than 25 mm	More than 25 mm
Larger than 13 but smaller than 20	More than 40 mm	More than 40 mm
Larger than 20 but smaller than 25	More than 50 mm	More than 50 mm

Note

1. In case feeding water to a bath tab, the vertical distance from the overflow level to the center of faucet mouth shall not be less than 50 mm.
2. In case feeding water to such a water tank as swimming pool, where waves easily rise, and a water tank or container, in which detergents or chemicals are used in business activities, the vertical distance from the overflow level to the center of faucet mouth shall not be less than 200 mm.
3. The rules in above 1. and 2. do not apply to the air gap for faucet mouth inside the water service devices.

Table 9.5.3 Air gap for faucet mouth with nominal diameter of larger than 25

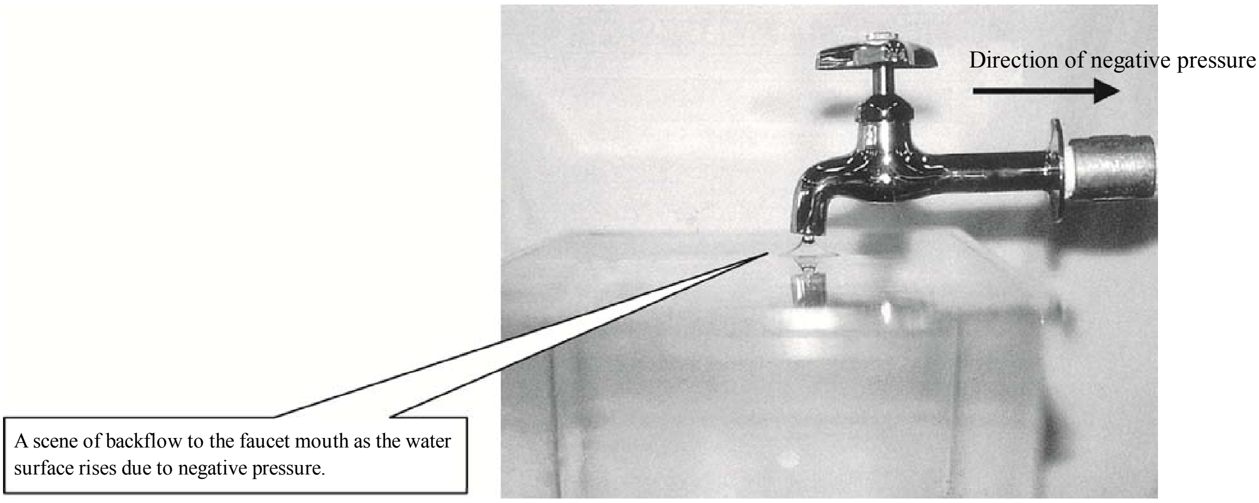
Case		Distance from wall	Vertical distance from overflow level to lowest position of faucet mouth A
In case influence of neighboring wall is weak			≥ 1.7d’+5 mm
In case there is influence of neighboring wall	There is only one wall.	≤ 3d	≥ 3.0d’
		> 3d, but ≤ 5d	≥ 2.0d’+ 5 mm
		> 5d	≥ 1.7d’+5 mm
	There are two walls	≤ 4d	≥ 3.5d’
		> 4d, but ≤ 6d	≥ 3.0d’
		> 6d, but ≤ 7d	≥ 2.0d’+5 mm
		> 7d	≥ 1.7d’+5 mm

Note

1. d: Inner diameter of faucet mouth (mm) d’: diameter of effective opening (mm)
2. In case the cross section of the mouth is rectangular, the long side is d.
3. In case there is a wall, which is higher than the overflow level, it shall be the neighboring wall.
4. In case feeding to a bath tab, vertical distance from overflow level to lowest position of faucet mouth shall not be less than 50 mm.
5. In case such a water tank as swimming pool, where waves easily rise and a water tank or container, in which detergents or chemicals are used in business activities, the vertical distance from the overflow level to the center of faucet mouth shall not be less than 200 mm.
6. The rules in above 4. and 5. do not apply to the air gap for faucet mouth inside the water service devices.

[Reference 9.8] An example of an experiment on backflow due to insufficient air gap for faucet mouth

A scene of backflow from a faucet when negative pressure is forcibly imposed by a vacuum pump. Although unless sufficient air gap for faucet mouth is provided, sucking will occur as shown in this photo, backflow can be prevented with the provision of a proper air gap even if such negative pressure occurs.



Water Service Construction Technical Promotion Foundation; Technical Guidelines for Water Service Construction, 2nd Edition, p.15

Although an overflow pipe and a drain pipe are provided in the receiving cistern etc., if they are directly connected to a sewage box or other sewer, there is a risk of backflow from them to the cistern etc. in case such an incidence as clogging of the sewer system occurs. Therefore, the connection of such pipelines shall indirectly be made to the receiving facility so as to secure an air gap for the drain pipe and overflow pipe (See Figure 9.5.4).

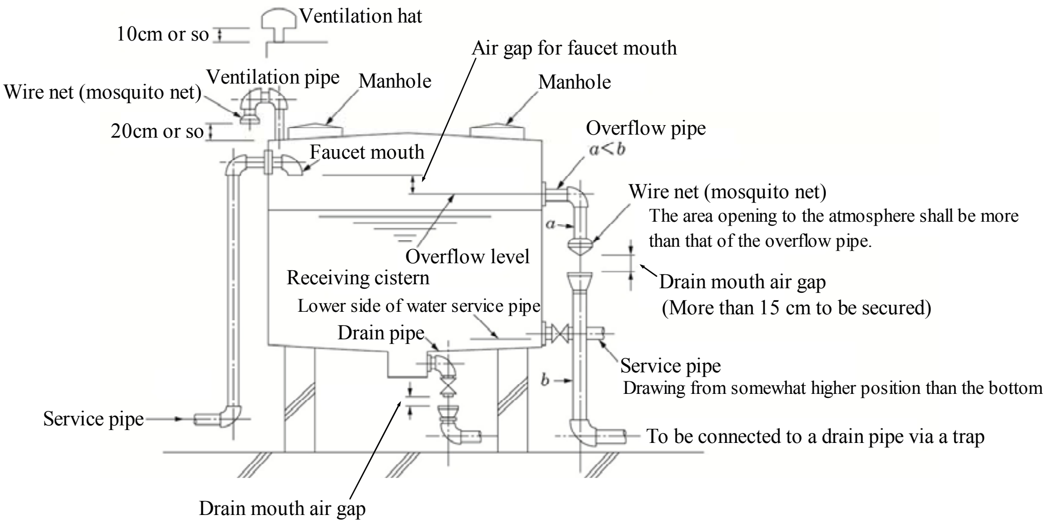


Figure 9.5.4 Example of air gap for drainage pipe of a receiving cistern etc.

(Source: Technical Standards for Water Service and Drainage Facilities: and their Annotation 2006, Japan Center for Architecture)

On the item 3.;

Even if appropriate water service devices are in use, there is a risk of backflow depending on the manner of their use in case it is difficult to secure the air gap for faucet mouth, or a hose is connected to the faucet etc. Given this, such devices with the effective function for backflow prevention as a vacuum breaker, check valve etc. shall be installed.

Appropriate devices with the function for backflow prevention shall be used in accordance with the magnitude of the risk to be caused depending on the type of water service and the method of use.

1) Flash valve etc.

In case the flash valve for a toilet bowl directly connected to the service pipe, there is a risk of backflow of sewage if the toilet bowl is clogged, sewage collects above the flash jet mouth, and negative pressure is introduced in the service pipe.

As a countermeasure to this case, a flash valve with a vacuum breaker shall be fit to prevent backflow.

Since there are various types of vacuum breakers to be combined with the toilet bowl, effective one shall be adopted after adequately studying their functions when they are selected.

In addition, as washing devices for toilet utensils, although the urinal wash valve and the urinal wash cock are directly connected, a check valve or vacuum breaker shall be fit on the urinal wash cock, of which operation is entrusted to the user, as provision for an accident at the time when negative pressure is generated in the service pipe.

2) Faucet etc. to which a hose is connected

As devices, with which there is a risk of backflow to occur depending on their function or manner of use, there are bidet, faucet with hand shower (excluding one with vacuum breaker), faucet with coupling to be used with a hose, water spraying faucet, chemical faucet and so forth.