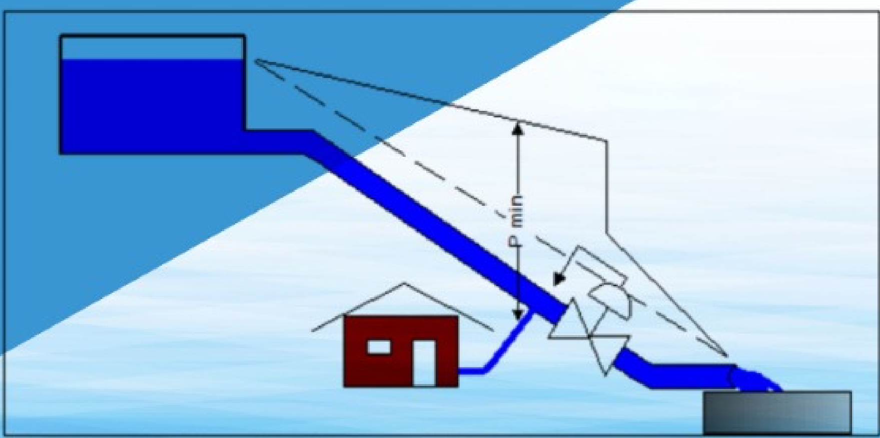
Ministry of Housing and Urban Affairs
Government of India

ADVISORY ON

CONTROL VALVES FOR WATER SUPPLY SYSTEMS



CENTRAL PUBLIC HEALTH AND ENVIRONMENTAL ENGINEERING ORGANISATION

MINISTRY OF HOUSING AND URBAN AFFAIRS

APRIL
2020

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Government of India
Ministry of Housing and Urban Affairs
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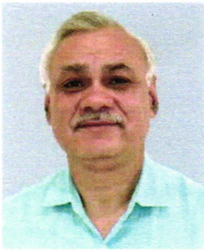
सत्यमेव जयते

स्वच्छ भारत
एक कदम स्वच्छता की ओर



FOREWORD

The Ministry of Housing and Urban Affairs has constituted an Expert Committee under the chairmanship of Adviser (PHEE), CPHEEO to prepare various advisories on Latest Technologies in Water & Wastewater, Integrated Urban Water Resource Management Plan, 24x7 Water Supply towards Equity, Quality and Sustainability, GIS Mapping of Water Supply and Sewerage Infrastructure, Pipe Materials & Other Appurtenances used in Urban Water Sector, Institutional Strengthening and Capacity Building, Planning and Design aspects of Regional Water Supply Schemes etc. to facilitate implementation of Jal Jeevan Missions for both urban and rural areas.

Water has the innate quality to move towards the hydraulically favourable areas like low elevated areas or nearby delivery locations. As a result, complaints regarding Non-Revenue Water (NRW), untimely and irregular filling of Elevated Service Reservoirs (ESRs) situated at tail ends or higher elevation and more water being drawn by the consumers living near the source or at lower elevations are very common. Water being a limited resource, the aforesaid problems result in some areas getting more water whereas other areas are deprived.

In the past, manually operated valves such as sluice valves, gate valves or butterfly valves were used for regulating the flow of water in water transmission systems. This was a cumbersome exercise with low level of accuracy. Subsequently, the manual operations were replaced by electrical actuators. Although human intervention got reduced, the operational cost due to power consumption was increased and the valves were unable to function in case of power failure.

With the advent of modern technology, the control valves were introduced and they act as panacea for such situations. Control valves are smart valves used to control the hydraulic parameter (flow & pressure) at varying degrees between minimal flow and full capacity in response to command from a control device. With control valves, high degree of perfection, precision and accuracy can be attained. Till date, no Indian standards have been framed for these valves.

This advisory provides details of various types of control valves and their specifications. I believe that this advisory will guide and empower the Urban Local Bodies (ULBs), State Authorities and concerned stakeholders to appropriately select and procure control valves for implementation of water supply schemes.

I congratulate all the concerned officers of the Ministry, CPHEEO and the Members of the Expert Committee, who were involved in the preparation of this advisory.

(Durga Shanker Mishra)

New Delhi
24 April, 2020

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सत्यमेव जयते

भारत सरकार
आवासन और शहरी कार्य मंत्रालय
GOVERNMENT OF INDIA
MINISTRY OF HOUSING AND URBAN AFFAIRS

अमृत
Atal Mission for Rejuvenation and Urban Transformation

PREFACE

A well planned water distribution system should deliver water to all the consumers with adequate quality, quantity and required pressure in an equitable manner and facilitate its ease of operation and maintenance. This requires a comprehensive system of head works, pumping systems, service reservoirs, distribution lines, hydrants, valves, meters, house service connections and related appurtenances.

A control valve is used to control flow of water by varying the size of the flow passage and enables the direct control of flow rate and the consequential control of hydraulic parameters, which proves to be useful for regulating the flow and pressure in municipal water supply systems. Maintaining such type of systems in balanced condition helps to reduce the loss of potable water.

The standards and specifications of different types of valves for procurement by the State Departments/Parastatals/ULBs are yet to be brought by BIS. Therefore, the Advisory on Control Valves for Water Supply Systems is brought out to provide technical details including specifications, general requirements, advantages, limitations, applications etc. of various types of control valves depending on the design and functions to be performed.

I hope that all the concerned stakeholders will make use of this Advisory for appropriate selection and suitable use of Control Valves in Water Supply System.

I take this opportunity to congratulate the Chairman and the Members of Expert Committee in bringing out this Advisory on Control Valves for Water Supply System.

(D. Thara)

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सत्यमेव जयते

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MINISTRY OF HOUSING AND URBAN AFFAIRS
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EXECUTIVE SUMMARY

Management of flow and pressure with control valves enables balancing of the water supply system thereby increasing the design life of the infrastructure. Depending on the function to be performed, control valves are available in the following types: (a) Flow Control Valve (b) Pressure Reducing Valve (c) Level Control Valve (d) Flow Control Valves with Timer (e) Flow Control with Level Control (f) Pressure Reducing with Flow Control (g) Pressure Sustaining and Relief Valve (h) Surge Anticipation Valve and (i) Pump Control Valve.

All the above mentioned valves are available in two types of design, which are Diaphragm Actuated Control Valve and Plunger Type Control Valve. Diaphragm Actuated Control valves are further classified as Globe type control valves and Weir type Control valves. In Globe pattern valves, all the functions *viz.,* the opening, closing and regulation are done by stem assembly actuated by diaphragm. This is a robust valve and can handle high pressure differentials in the water network. In weir type of valves, all the functions viz., opening, closing and regulation are done by diaphragm.

Both globe type and weir type valves are again available in three types (a) Hydraulically pilot operated control valve (b) Hydraulically pilot operated with single solenoid and (c) Electronically (dual solenoid) controlled. The hydraulic engineer should understand the technical comparison between these types of valves before selecting the appropriate control valve as per the required hydraulic parameters. The plunger type of valves can perform the functions similar to diaphragm actuated control valves. This type of valve requires gear box and actuators for its operation. Since it requires continuous power consumption, the same is not preferred.

The application of different types of control valves and their specifications are provided in the Advisory, which will be helpful for the State Public Health Engineering Departments (PHEDs)/Parastatals/Boards/Urban Local Bodies (ULBs) etc. to select appropriate control valves suiting to the field conditions and use the specifications of different types of valves for procurement purpose till the standards and specifications are brought out by BIS.

I would like to convey my gratitude to Dr. (Ms.) Shweta S. Banerjee, Superintending Engineer (PHE), Nagpur Municipal Corporation, Nagpur & Member of the Expert Committee for providing technical support in preparation of the Advisory. I would also like to extend my sincere thanks to the Members of the Expert Committee and the Officers of CPHEEO for reviewing the Advisory and supporting staff for their effective coordination in completing the task.

(Dr. M. Dhinadhayalan)
Adviser (PHEE) & Chairman of the Expert Committee

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CONTENTS

1. BACKGROUND

The Hydraulic Engineers were using sluice valves, gate valves or butterfly valves from years together, not only for isolation but also for regulating the flow of water on ground. It was a regular practice to throttle the valves by adjusting the threads to control the flow. This adjustment was completely dependent on the years of experience of the valve person. Even though regulation of flow to some extent could be achieved still the lacuna of accuracy existed.

With the advent of modern technology, the manual adjustment by means of throttling was replaced by electrical actuators. Although human intervention got reduced, but the operation cost due to power consumption increased. Also the valves were unable to function in case of power failure.

To isolate and drain pipe sections for test, installation, cleaning and repairs, a number of appurtenances or auxiliaries are generally installed in the line like line valves, scour valves, air valves, kinetic air valves, pressure relief valves, check valves and the details may be referred in the Manual on Water Supply and Treatment, 1999 and Manual on Operation and Maintenance of Water Supply System, 2005, published by Central Public Health and Environmental Engineering Organization (CPHEEO), Ministry of Housing and Urban Affairs, Govt. of India.

To overcome all the difficulties faced due to the aforesaid valves, concept of control valves was introduced. Precision in controlling flow, pressure and other hydraulic parameters could now be achieved. Human intervention has been reduced and the Hydraulic Engineer got an option to select between hydraulically and electrically operated valves or electronic valves depending on the geographic conditions of the service area in the cities/towns. The Control valves discussed in the subsequent sections may be used in water supply systems.

2. INTRODUCTION

Control valves are smart valves used to control the hydraulic parameter (flow/pressure) at varying degrees between minimal flow and full capacity in response to command from a control device. The hydraulic parameter is controlled by varying the size of flow passage as regulated by the control device. This also enables consequential steering of combination of hydraulic parameters. Every Water Engineer comes across problems related to management of water in highly elevated areas, distant service reservoirs, untimely filling of reservoirs, uncontrolled water supply (pressure, flow and level management in distribution network) and reduction in Non-Revenue Water (NRW). Water being a limited resource, the aforesaid problems result in unequal distribution of water in the service areas. If control valves used smartly, it shall resolve most of the hydraulic issues as mentioned above.

Sizing of these types of valves should be decided on the basis of required hydraulic applications.

In order to procure the optimal size and to ensure no cavitation, the following information must be provided in tabular form for each main valve size required in the project:

a) Upstream pressure available
b) Maximum flow rate
c) Minimum flow rate
d) Residual pressure at the control valve
e) Maximum level of reservoir (in case of elevated service reservoir management).

3. FUNCTIONS OF CONTROL VALVES AND ITS TYPES

Depending on the purpose of its service, control valves may be classified as under:

3.1 Flow Control Valve: The valve sets a fixed flow at the downstream. An adjustable differential pilot valve, sensing the pressures across the orifice plate, is set to maintain a preset differential, hence the flow rate. The pilot opens the main valve if the flow is below the required value or closes it when the flow exceeds the desired rate. (Please refer Section 8, Case 1 / Case 2 / Case 3 / Case 4 / Case 5 for better understanding of its installation)

3.2 Pressure Reducing Valve: The valve sets a fixed pressure at the downstream when opened. An adjustable pilot valve, sensing the pressures downstream of the valve, is set to maintain a preset pressure regardless of fluctuations upstream. (Note: The calculated cavitation factor[1] of valve should be higher than that claimed by the manufacturer. Else anti-cavitation kit or step reduction of pressure by installing multiple pressure reducing valve should be deployed.) (Please refer Section 8, Case 6 for better understanding of where to install).

3.3 Pressure Reducing Valve with Flow Control: The valve sets a combination of fixed pressure at the downstream when opened or the fixed flow rate at the downstream when opened regardless of fluctuations in the values of upstream pressure and demand.

3.4 Level Control Valve (Float type or Altitude type): Altitude pilot located at the valve and float pilot is located in the tank, at the intended maximal level. It is connected to the main valve by control tubes, which convey the inlet pressure of the valve to the control chamber when the level reaches the maximal point, thus

[1] Cavitation factor $\sigma_c = (P_1 - P_v) / (P_1 - P_2)$ where P_1 = upstream pressure, P_2 = downstream pressure, P_v = Vapour pressure

closing the valve and preventing overflow. When the water level drops, due to demand from the tank, the altitude/float pilot opens the top of the control tube that connects to the control chamber, allowing the water in it to drain and the main valve to open. (Please refer Section 8, Case 1 / Case 2 / Case 3 / Case 5 for better understanding of where to install).

3.5 Flow Control Valve with Timer: This is a flow control valve with timer controller to set the times of operation without any external energy. (Please refer Section 8, Case 1/ Case 2 / Case 3 / Case 4 / Case 5 for better understanding of where to install).

3.6 Flow Control Valve with Level Control: This is a flow control valve with capability to control level. When the level is high, valve closes and when level reaches the set point it opens. The valve sets a fixed flow at the downstream when opened. (Please refer Section 8, Case 2 / Case 3 / Case 4/ Case 5 for better understanding of where to install).

3.7 Pressure Sustaining and Relief Valve: The valve maintains upstream pressure, regardless of flow-rate variations. The valve will be in the “closed” position if the upstream pressure drops below the set-point and will fully open when the upstream pressure exceeds the set-point. (Please refer Section 8, Case 7 for better understanding of where to install).

3.8 Surge Anticipation Valve: The valve is installed on a tee junction on the discharge manifold or the main pipeline, downstream of the check valves of pumping station. The valve opens instantly when the pressure at site drops below the static value due to initial low-pressure wave generated by the pump stoppage. The valve stays in “opened” position until the returning flow arrives to the station, and will be sized to allow draining of part of it, so the velocity change of the returning flow, when stopped by the already-closed check valves, will not generate excessive transient pressures. When the pressure rises above the opening point, the valve starts closing gradually at adjustable pace. In case of too-fast closure, that may cause pressure surge, the valve will function as a relief valve, re-opening slightly to increase the released flow rate thus preventing over-pressure in the pump site.

The above listed functions are controlled by hydro-mechanical pilot valves - low-pressure pilot that opens the valve through the low-pressure wave, and high-pressure pilot which opens the valve in case the pressure exceeds the allowed maximum. Both pilots are adjustable by the operator. A simulating assembly, containing a pressure gauge, should be a part of the control circuit. It allows adjustment of the low pressure pilot to the designed opening point, without stopping the pumps.

A drain pipe should be assembled at the outlet of the surge anticipation valve to transport the drained water back to the pumps suction pit or to another location, where the high-velocity flow will not cause flood damage. To cease high hydraulic resistance and excessive side-stress in elbows, the drainage pipe should be sized to avoid excessive velocity. In most of the cases, the drainage pipes are larger than the control valves. (Please refer Section 8, Case 1/ Case 2 / Case 3 / Case 4 / Case 5for better understanding of where to install).

3.9 **Pump Control Valve:** A pump control valve automatically regulates the pump start-up and shut-down in a time controlled to minimize system hydraulic surges. The pump control valve is electrically interfaced with the pump motor, the Pump Control Valve “opens” and “closes” at an adjustable speed, providing a smooth, predictable transition of pump discharge flow into the system. The valve is installed at the outlet of pump discharge. The valve is controlled by an electric solenoid valve. The pump control valve automatically adjusts to provide constant pressure at different flows and works with any pump. (Please refer Section 8, Case 1 / Case 2 / Case 3 / Case 4 / Case 5 for better understanding of where to install) (Note: However, the utilization of these valves is neither mandatory nor limited to the applications cited above. The engineer can use the control valves as per his discretion after verification of the hydraulic conditions of the site.)

4. DESIGN

All the above mentioned control valves from 3.1 to 3.9 are available in two types of design which are Diaphragm Actuated Control valve and Plunger Type Control Valve. These are explained in following sections.

4.1 DIAPHRAGM ACTUATED CONTROL VALVE

This type of valve can further be classified into following categories:

4.1.1 **Globe Type Control Valve** – All the functions viz. opening, closing and regulation is done by stem assembly actuated by diaphragm. It contains many parts like stem, seat, diaphragm, centering guide, etc. When the ratio of upstream and downstream pressure is more than 3:1, Globe type valve can be used with anti-cavitation kit. This is robust valve and can handle high pressure differentials in the water network. Such Valve can also be used as Check valve. Although the diaphragm in this type of valve requires replacement once in 7 years. The dynamic O-ring can get worn off if there is problem in water quality and thereby leading to internal leakage. Since it involves so many parts, this valve is comparatively heavy.

4.1.2 **Weir Type Control Valve** – All the functions viz. opening, closing and regulation is performed by the diaphragm. The diaphragm and the spring are the only moving parts, thereby making it lighter and easier to repair. The diaphragm needs replacement once in 5 years. When the ratio of upstream and downstream pressure is more than 3:1, Weir type valve can be used in step down manner implying utilization of two or more valves and thereby leading to an increase in capital cost.

Both the Globe type and Weir type valves are again available in the following three types such as (i) Hydraulically Pilot Operated Control Valve, (ii) Hydraulically Pilot Operated Control Valve with Single Solenoid and (iii) Electronic (Dual Solenoid) Control Valve.

- **Hydraulically Pilot Operated Control Valve** – This is pilot operated valve. Number of pilots is dependent on the application, such that the control parameters are not hydraulically contradictory. This pilot will be a direct-acting adjustable spring device, maintaining any set point as the prescribed value, regardless of flow or upstream pressure variations. If the valve has to perform the function of both, level and flow control, there would be 2 pilots – one for flow and the other for level. The pilot governing the closure would be considered as master pilot. For example, in case of pressure reducing cum flow control valve, if the fixed and set pressure of 45m attains prior to attaining the set flow rate of 50 cum/hr., the pilot designated for pressure would dictate the closure of the valve and would be called the Master Pilot. This type of valve does not require electricity and should be preferred where the set points are fixed.

- **Hydraulically Pilot Operated Control Valve with Single Solenoid** –This is hydraulically control valve by SCADA or local PLC with provision of an additional Solenoid in the control loop for facilitating the function of On/Off. It is suitable in the condition where necessary switch on/off the valves are required through SCADA system with fixed set point control.

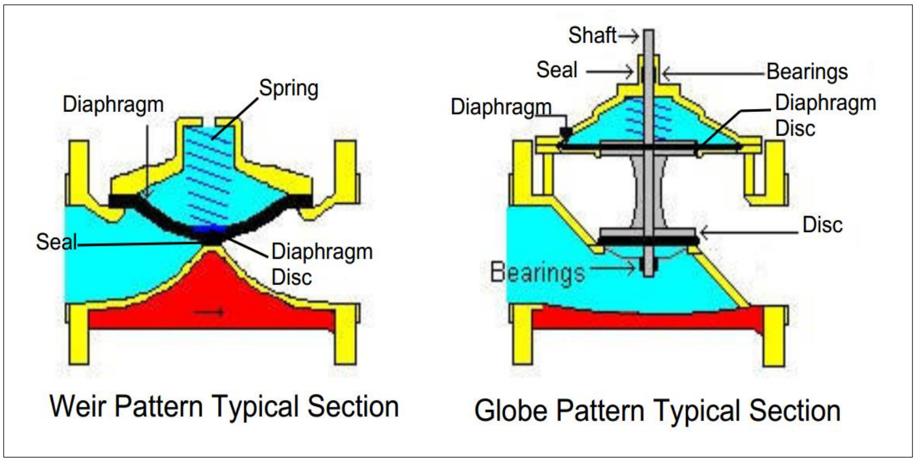
- **Electronic (Dual Solenoid) Control Valve** – There is no pilot required in this type of valve. This is dual solenoid operated valve and the performance is governed by a controlling device that can be PLC, RTU or preferably inbuilt controller. The controller should enable to receive an input either pulse/volume contact-input or 4-20mA analogue signal. The flow/pressure set-value may be modified automatically on time basis, or by a pre-defined relation to pressure or another measured parameters. This should also be operated by smart Android phone or local HMI screen for change of parameters and to avoid compatibility with the systems.

  (Note: The performance of the Electronic (dual solenoid) control valve for flow control application depends on the performance of flow meter. Hence, selection of flow meter should be done as per flow meter manufacturers' guidelines.)

Technical comparison of all aforesaid three types of valves has been represented below:

S. No.	Features	Hydraulically Pilot Operated Control Valve	Hydraulically Pilot Operated Control valve with Single Solenoid	Electronic (dual solenoid) Control Valve
1	Material	Ductile Iron one piece cast body	Ductile Iron one piece cast body	Ductile Iron one piece cast body
2	Flow/Pressure control	Yes	Yes	Yes
3	Level Control	Yes	Yes	Yes
4	Manual On/off	Yes	Yes	Yes
5	Flow Meter	Not required	Not required	Yes
6	Level Transmitter	Not required	Not required	Yes
7	Power Required	No	Battery operated	Solar/Grid energy
8	SCADA operation	Not possible	Yes for on/off purpose	Yes
9	O&M Cost	Minimal	Only to change AAA batteries	Maintenance of solar panels, battery replacement
10	Requirement of external devices	None	None	Flow meter / level transmitter / pressure transmitter to control flow / level and pressure respectively
11	Failure	Low	Low	Failure in case of no power supply or failure of flow meter or level transmitter
12	Set Points	Fixed set point	Fixed set point	Variable set points
13	Controller/RTU/PLC and Communication	Not required	Required	Required
14	Suitability	Urban, Rural.	Urban, Rural.	More suitable to urban given the power dependency and more sophisticated instruments involved
15	Manp Power	Not required	Not required	Not required
16	Vertical operation	Any Position	Any Position	Any Position
17	Programming	NA	Minimal	Programming knowledge is required for third party controller. Not required for inbuilt controller.
18	Recurring cost	None	None	SIM card charges for communication
19	Main line strainer	Not required	Not required	Not required

Thus, the both valves, Globe type and Weir type, are diaphragm operated valves performing the same function with only difference in design.



Schematic representation of Weir type and Globe Type Control Valve

4.2 PLUNGER TYPE

This type of valve can also perform the functions of regulating hydraulic parameters (flow, pressure and level) like diaphragm actuated control valve. This type of valve requires gear box and actuators for its operation. Since it requires continuous power consumption, the same is not preferred. Although, this valve can perform all functions of valves mentioned in Section 3, at present this type of valve is not much in vogue.

The Hydraulic Engineers have to first define the purpose of installation of valves before its selection. After which, depending on the geographical/ site situation, these may be chosen amongst the options available in Diaphragm and Plunger type valves.

5 SPECIFICATIONS

5.1 GENERAL REQUIREMENTS

The control valve shall be designed and hydro tested for the 1.6 times the rated pressure of the control valve i.e. PN16 rated valve should be tested for pressure of 25 kg/cm^2. The control valves shall be designed to cause minimum head loss in fully opened condition. Flange ends should be as per IS-1538/ISO16/ ANSI B-16.5, Class 150 and Class 300/EN-1092-2or any other National/ International Standards. The material of all components of valve / internal working parts shall be corrosion resistant in case of chlorinated water. The epoxy coating (both external and internal) should be fusion bonded, food grade of minimum 250microns (NSF / FDA / WRAS approved).

According to water network technology's advancement and evolution, the valve may be upgraded on site i.e. Hydraulic valve to Electronic (dual solenoid) control valve or flow control valve to pressure reducing valve by just changing the control trim. More specifically, function of the valve may evolve towards other standards of control in terms of hydraulic or electronic modulation.

A control valve must demonstrate the following main features:

- **Sensitivity** (ability to respond to the smallest change of the controlled variables);
- **Accuracy** over time within the prescribed operating range;
- **Stability** within the prescribed operating range; for the low demand conditions, must be specified for the lower limits/worst conditions below which the valve may unable to operate at full stability.

The manufacturer may indicate a simple rate of flow, or a formula allowing for its calculation, and accounting for the pressure differential through the valve. The accuracy of control valve is very important. The regulating valve shall warranty the highest ranges of accuracy when required and same must be checked before approving the control valves during inspection of the project, which should be indicated in absolute value, according to the following table:

Downstream Pressure Control	Downstream pressure not more (or less) than ±1m of Water Column of set value
Upstream Pressure Control	Upstream pressure not more (or less) than ±1m of Water Column of Set value
ON-OFF altitude level control	Maximum reservoir level not more than ±0.10m of Water Column of Set value
Flow control	Downstream flow not more (or less) than ±5% of defined flow rate.

The Manufacturer may specify and describe:

- The recommended operating range of the regulating valve by indicating clearly its extreme limits;
- The design features allowing for a precise and stable operation of the valve within this range; and
- The way of setting the operating speed of the valve.

5.2 DETAILED SPECIFICATIONS

5.2.1 Hydraulically Operated, Diaphragm Type Control Valve with Globe Pattern: The detailed specification of a hydraulically operated, diaphragm type control valve with globe pattern is as under.

Main Valve

The valve should be preferably single chamber/double chamber, straight / oblique pattern hydraulically operated, direct diaphragm actuated stem guided Globe type. The main valve consists of three major parts: body, cover, internal trim assembly. The only moving part is the internal trim, which is guided in two ends. The stem should be fully guided at both ends by a dismountable stainless steel bearing in the main valve cover. Bottom guided is sliding within the valve seat, in order to be in balance along its full lift for limiting excessive friction, thus increasing its ability to react when performing a correction. This is the recommended solution however slotted disc guide is acceptable.

The main valve should be suitable for low flow conditions and capable of operating in unsteady flow conditions. No supplementary mechanical device may be allowed for achieving stable operation at near zero flows. The diaphragm assembly should be the only moving part and should form a sealed chamber in the upper portion of the valve, separating the operating pressure from line pressure. Packing glands and/or stuffing boxes technology should not be permitted and there should be no piston operating the main valve.

Material of Construction for PN10, PN16 and PN25 rated Control Valves with Globe Pattern

Body& cover	Ductile iron ASTM A536or equivalent
Circuit fittings	Brass EN12164/SST316 (corrosion proof)
Diaphragm	Nylon reinforced rubber/ EPDM/Buna-N (FDA / WRAS Approved)
Control tubes	High pressure polypropylene/Copper/SST316
Pilot and relay	BrassEN12164/SST316/ SS AISI-304/CF8 or Bronze
Surface protection	Epoxy coating min. 250 microns Fusion Bonded, Food grade (NSF/FDA/WRAS approved)
Operation	Automatic, manual override enabled
Seat ring	Stainless steel AISI- 304/316, raised (if applicable), Bronze replaceable inline or onsite, ASTM-A351 GR CF8M
Stem	Stainless Steel AISI-304/316 (replaceable inline & onsite)
Spring and bearing bush	Stainless Steel AISI-302/304/316
Disc guide, disc retainer & Diaphragm washer	Cast steel, Stainless Steel AISI – 304/316, Bronze & Coated Steel or equivalent
Seal	Synthetic rubber-Buna-N /EPDM (if applicable)(FDA/ WRAS approved)
Self-cleaning filter	Stainless Steel 316
Solenoid valve (if applicable)	IP68 for underground condition and IP65 if vertical installation on ESR (Brass, SST 316 base). IP68 solenoids must be warranted for infinite time under 1m submerged condition.
Throttling plug	To have the linear flow (non-turbulent flow), if required, V-shaped or U-shaped throttling plug may be provided
Nut-bolts and studs	Stainless steel AISI-304/ASTM A 193 B7

Manufacturer must provide the Kv value of each diameter of the valve for selection of valves. The standard valve model fits all control operations (pressure reducing, level, flow control or combination of parameters. Disassembly and reassembly of all the valve's components shall be made possible on site, without having to remove the valve from the line. The valve's pilot control loop should include a low maintenance, inline self-cleaning control-filter. The valve should also be suitable for vertical assembly wherever required. Oblique/Y-shaped valves over 200 mm diameter should not be preferred due to dismantling difficulties. Double chamber valve should be selected where external pressure is required to open the valve. The valve shall include a low friction trim. No O-ring sealing is permitted on the valve stem. The valve should require low maintenance.

Maintenance

- The bidder should propose a recommended five year set of spare parts per a batch of 5 valves of the same diameter;
- The valve should be built in a way that enables all future maintenance action to be performed in situ without having to take the valve body of the line;
- The typical weight of internal assembly, regardless of valve diameter, should not exceed the permitted lifting weight for a single person as defined in the regulations; and
- Disassembly should not require usage of sophisticated, heavy lifting devices such as cranes of any type. These are to be provided and installed at the assembly site by the supplier.

5.2.2 Hydraulically Operated, Diaphragm Type Control Valve with Weir Pattern: The detailed specification of a hydraulically operated, diaphragm type control valve with weir pattern is as under.

Main Valve

Valve should bea single chamber hydraulically operated weir type control valve. Manufacturer must provide the Kv value of each diameter of the valve. The valve should consist of three major components: the body, cover and the diaphragm assembly. The diaphragm-trim with a stainless-steel spring should be the only moving part. The diaphragm should form a sealed chamber in the upper portion of the valve, separating operating pressure from line pressure. The standard valve model fits all control operations (pressure reducing, level, flow control or combination of parameters). The diaphragm of the weir-type valves should not be guided by any shafts or bearings and should not be in close contact with other valve parts except for its sealing surface. A compressing spring at the top side of the diaphragm is essential to a reliable closure.

Disassembly and reassembly of all the valve's components should be made possible on site, without having to remove the valve from the line. The valve should also be suitable for vertical assembly wherever required. The main valve should be suitable for low flow conditions and capable of operating in unsteady flow conditions. No supplementary mechanical device may be allowed for achieving stable operation at near zero flows. The selection of valve may ensure a positive drip tight shut off. The valves must pass hydro-test or 1.6 times the rated pressure of the control valve.

Material of Construction for PN10, PN16 and PN25 rated Control Valves with Weir Pattern

Body& cover	Ductile iron ASTM A536 or equivalent
Circuit fittings	Brass EN12164/SST316
Diaphragm	Nylon reinforced rubber/ EPDM/Buna-N (FDA /WRAS Approved)
Control tubes	High pressure polypropylene/Copper/SST316
Pilot and relay	BrassEN12164/SST316
Surface Protection	Epoxy coating min. 250 microns, color RAL 5005 Blue
Operation	Automatic, manual override enabled
Spring and Bearing Bush	Stainless Steel AISI – 302/304/316 (if applicable)
Seal	Synthetic rubber-Buna-N /EPDM (if applicable)
Self-Cleaning filter	Stainless Steel 316
Solenoid Valve (if applicable)	IP68 solenoid for underground condition and IP65solenoid if vertical installation on ESR (Brass, SST 316 base). IP68 solenoids must be warranted for infinite time under 1m submerged condition.

Maintenance

- The bidder should propose a recommended five year set of spare parts per a batch of 5 valves of the same diameter;
- The valve should require low maintenance. No set periodic packing or parts replacement should be required;
- The valve's pilot control loop should include a low maintenance, inline "self-cleaning" control-filter;
- The typical weight of internal assembly, regardless of valve diameter, shall not exceed the permitted lifting weight for a single person as defined in the regulations. Disassembly should not require usage of sophisticated, heavy lifting devices such as cranes of any type. These are to be provided and installed at the assembly site by the supplier.

5.2.3 Hydraulically Operated (with Single Solenoid), Diaphragm Type Control Valve: This is also hydraulically operated control valve with an additional solenoid for on / off purpose through SCADA or local PLC / RTU. Solenoid should be IP68 solenoid for underground condition and IP65solenoid for vertical installation on ESR (Brass, SST AISI 316 base). IP68 solenoids must be warranted for 10 years under 1m submerged condition.

5.2.4 Dual Solenoid Operated, Diaphragm Type Control Valve: There are no pilots for this type of valve. This is dual solenoid operated valve, performance of which should be governed by a controlling device through PLC, RTU or preferably inbuilt controller. In other words, an Electronic (dual solenoid) control valve should be controlled by an electronic-controller, which enables control of the requested flow rate or pressure as per need and demand.

A controller designed for the control of hydraulic control valves with the support of two continuous operation solenoid valves and / or two latching type solenoid valves. The configuration should enable high regulation accuracy as well as energy efficient operation. The controller must have inbuilt battery to run the controller for minimum 1 week during no-power condition. Accordingly, it should also log the data during no-power condition. The controller should enable selection amongst the solenoid valves' types: normally-open and\or normally-closed. It should allow user to set the variable set points in a time table as required during supply hours (peak, normal hours). Set-values are modifiable with the help of remote communication or an analogue signal. In case of disconnected control-signal, the controller would be able to continue to regulate per pre-set internal values. The controller must have 4 digital inputs, 4 analogue inputs and01 RS-485 connection. The user should be able to allocate control inputs and outputs, as per the used control-functions so that each input can be used for one or more control functions. The control function should be user-configurable and\or pre-configurable by the manufacturer/ supplier. The function should include but not be limited to ‘Pressure-Reducing’, ‘Pressure-Sustaining’, ‘Flow control’, ‘Water-Level control’, ‘Pressure-Relief’ and combination of these parameters.

The change in requirement (pressure to flow control) should not require change in any hardware or software of the systems. Combination of two or more of these control function should be possible without any restriction, as long as this combination is not logically-contradicting and sufficient number of inputs are free. The user may not be required to have preliminary programming knowledge or have other special expertise. To avoid issues in compatibility, the controller and the control valve should be preferred of the same manufacturers/ suppliers. The size of the controller should be compact in order to avoid operational difficulties.

5.2.5 Electrically Operated Plunger Type Valves: Plunger valve should be provided with electrical actuators having the control facility for intermediate valve positioning by connecting external signal. The electric actuators should be designed to provide the required torque for operations in the flow and pressure conditions of the water transfer system. Gear assembly should be provided as necessary. The flow path with annual flow cross-section in any open position should be rotationally symmetric. The movement of plunger / piston by means of crank / shaft / spindle drives should be axial / linear. A handle wheel should be provided for plunger valves so that operations of the valve can be carried out when the power supply of valve is failed. The torque requirements at the hand wheel should be such that one person can operate the valve. Hand wheel should be positioned to give access for operational personnel. It should be provided with integral locking device to prevent operation by unauthorized persons. A selector switch should be provided on the actuator for remote/local/hand operation of the valve. Valve /profile sealing seat should be preferably in the no-flow zone. The O-ring seal should envisage the double sealing effect between the body and the plunger. There should not be any obstruction in the main flow passage except the plunger and attached control cylinders.

Material of Construction Electrically Operated Plunger Type Valves

Body	Ductile iron ASTM A536 /DI (GJS 500-7)
Plunger/Piston	Stainless steel AISI -304/Gr 1.4301
Piston Guide	Bronze welded overlay / SS
Shaft Crank/Spindle	Stainless Steel AISI-420 / Gr 1.4021
Seat Ring	Stainless Steel AISI-316 / Bronze
Seal (O-ring)	Synthetic rubber-Buna-N /EPDM (FDA/WRAS approved)
Bearing Bush	Bronze
Bolts	Stainless Steel (A4)
Eye Bolt for Lifting	Galvanized steel
Slotted cylinder / Strainer	Stainless Steel
Coating (Both inside & outside)	Epoxy coating min. 250 microns, Fusion Bonded, Food Grade (NSF/FDA/WRAS approved)

The hydraulic engineer, when opting for diaphragm actuated control valves, can include both the specifications of globe pattern and weir pattern for procurement purpose. Bureau of Indian Standards (BIS) may also be followed, if available for these types of valves.

6 ADVANTAGES

The degree of perfection, precision and accuracy which can be attained with respect to regulation by using control valves can hardly be achieved manually or by using actuators. The valves can reduce utilization of manpower without demanding extra maintenance cost. They can also help in controlling Non Revenue Water (NRW). As a result, the benefits of these valves are too many and to be analyzed based on cost benefit ratio. Yet one can find out the savings in workforce and other indirect expenditures as under: -

S. No	Particulars	Amount (Rs.)	Remarks
Total Cost incurred prior to installation of Control Valves			
1	Expenditure incurred towards establishment of employees who are needed for operation of valves		
2	Indirect Losses – Cost of NRW		Total Water Lost (MLD) x Cost of treated water Rs/MLD x 365
	Total Cost:		**(A)**
Total Cost to be incurred after installation of Control Valves			
1	Expenditure to be incurred towards establishment of employees who are needed for operation of valves		
2	Indirect Losses – Cost of NRW		NRW will not be nil.
	Total Cost:		**(B)**
Saving: (A) – (B)			

However, it is suggested that procurement of valves like flow control, pressure reducing, pressure sustaining and surge anticipation shouldn't be decided on the basis of savings in cost alone, it should also be decided on cost benefit ratio and life cycle cost assessment.

7 LIMITATIONS

Control valves are viewed as a threat by the ground level staff because of the opinion of ground staff that the workforce shall be curtailed. Control valves may also control the tampering of the valves because of its availability for different hydraulic conditions. In absence of technical knowledge of the working of the control valves, it is not utilized to the best of its potential thereby leading to unfruitful expenditure. Hence, prior to installation of valves, the staff of Urban Local Bodies should be given technical training and build the capacity to implement the same at ground level.

The hydraulic diaphragm type control valves require minimum hydraulic pressure between 5m and 12m (varying from manufacturer to manufacturer) for its operation in water supply systems. It is the duty of the Hydraulic/ Environmental Engineer to ensure that there is some residual head as specified by the manufacturer for flow control and pressure reducing applications. From the maintenance point of view, it is recommended to install isolation valves as per the requirements.

8 APPLICATIONS OF CONTROL VALVES

The Hydraulic/Environmental Engineer can use the above mentioned control valves in the following scenarios:

Case 1: The entire demand of the city is catered through only one ESR (Please Refer Sketch 1)

Depending on the requirement, the Hydraulic/Environmental Engineer can effectively use either one or all the valves suggested in the sketch or in combination. If the supply is through pumping, Surge Anticipation Valve (Section 3.8) can be installed for surge protection and water hammer. The Level Control Valve (Section 3.4) at the inlet of ESR can be used for reducing human intervention and NRW. For intermittent supply, Hydraulic/Environmental Engineer can install a Flow Control Valve with Timer (Section 3.5) whereas the same can be replaced by an Electronic (dual solenoid) Control Valve (Section 4.1) in case of continuous supply. The workforce saved by adopting this method can be used for other activities.

Case 2: There are two or more ESRs in the system (Please refer Sketch 2)

Same as above. Depending on the difference in ground levels of the ESRs, the level control valves at the inlets of ESRs can be replaced by a flow with level control valve (Section 3.6) for equitable distribution of water.

Case 3: Water is supplied to the ESRs through a Master Balancing Reservoir (MBR) (Please refer Sketch 3)

Same as Case 2.

Case 4: City is big and there are multiple District Metering Areas (DMAs) under each ESR (Please refer Sketch 4)

Same as Case 3. For equitable distribution of water beyond ESR, flow control valve (Section 3.1) should be installed at the entrance of each DMA.

Case 5: City is huge and there are multiple sub-zones in each DMA (Please refer Sketch 5)

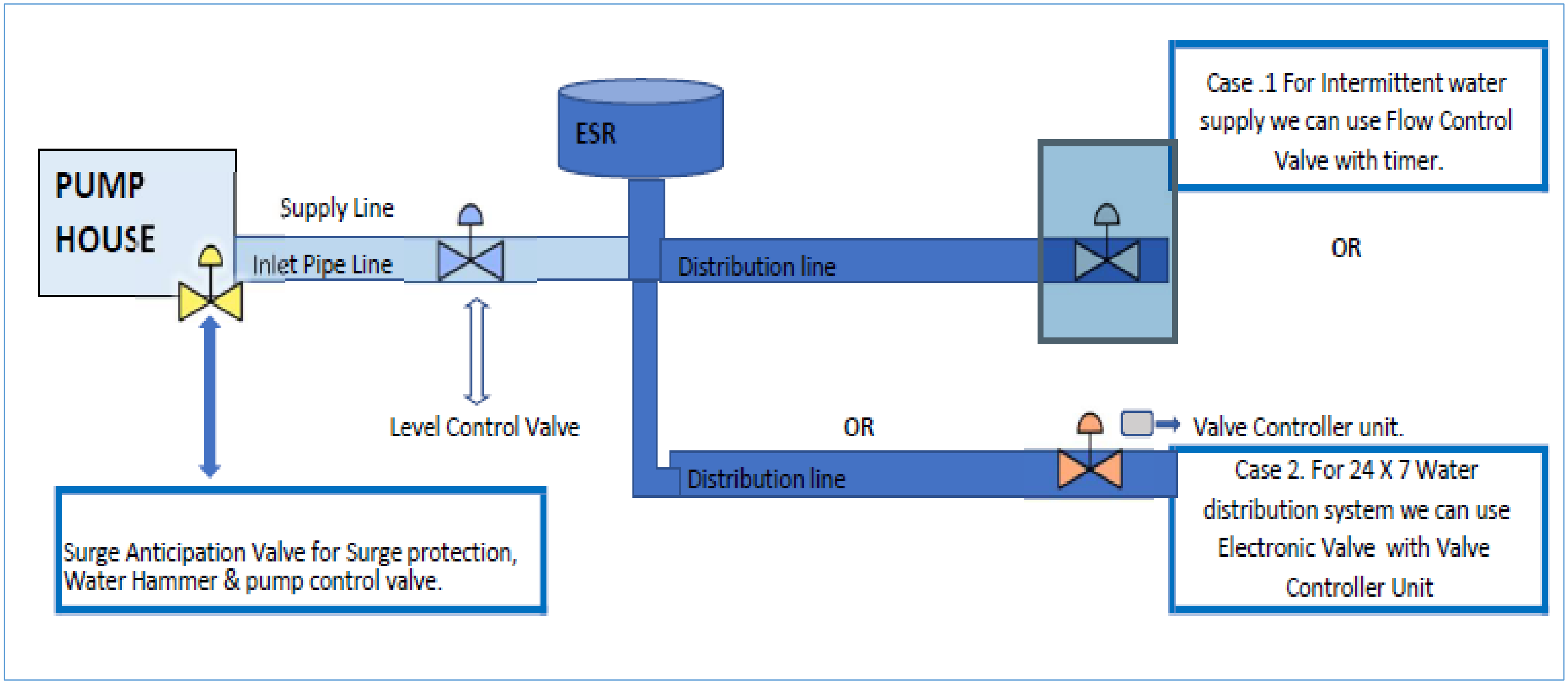
Same as Case 4. In addition, there is flow control valve (Section 3.1) at the entrance of each sub-zone. This will exert better control, reduce human intervention considerably and also NRW.

Case 6: In Hilly areas (Please refer Sketch 6)

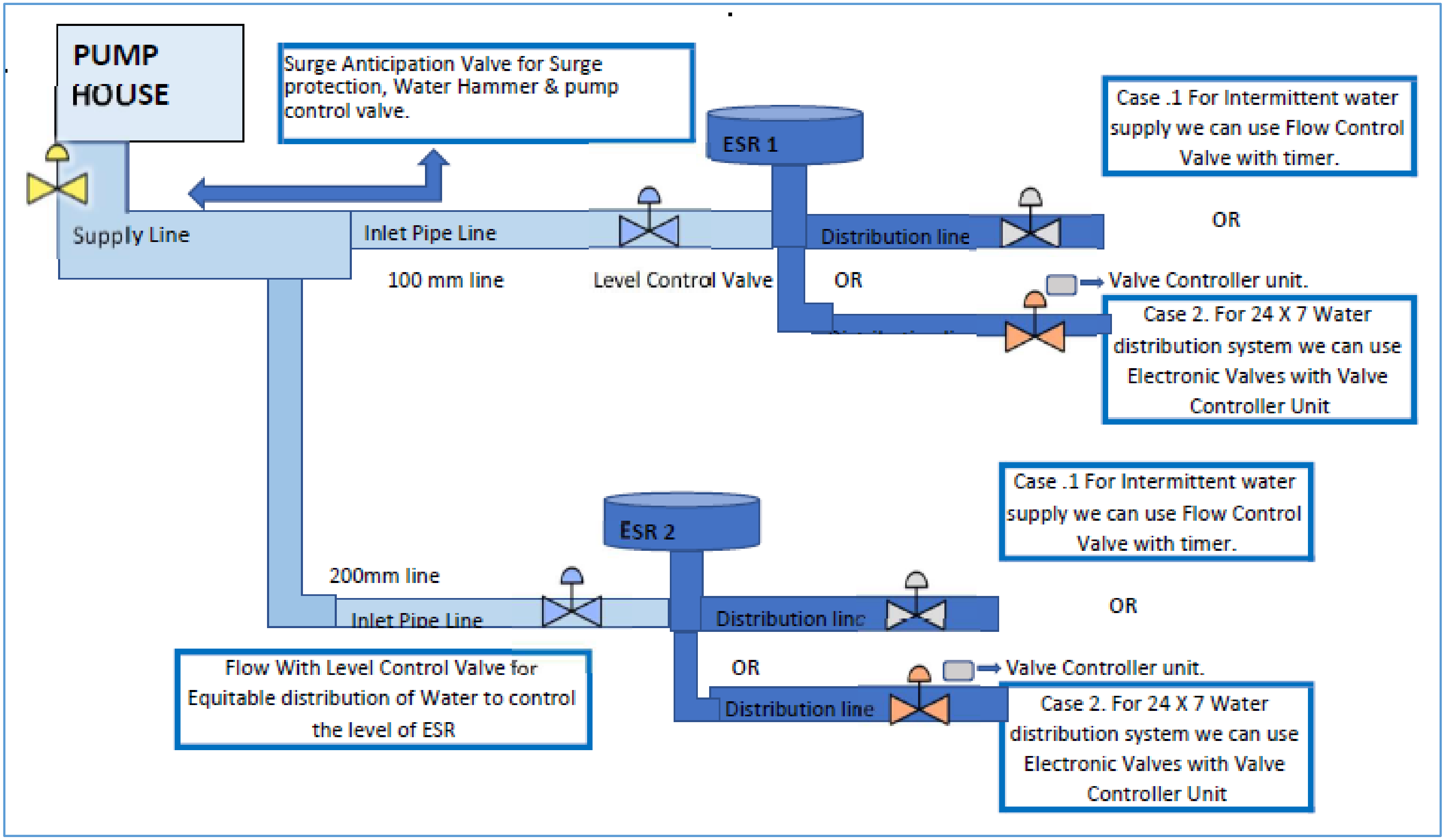
In hilly areas, bursting of pipelines due to high pressure is very common. To counter such type of problems like the name suggests, pressure reducing valves (Section 3.2) should be installed.

Case 7: When it is mandatory to maintain certain minimum pressure in the pipeline (Please refer Sketch 7)

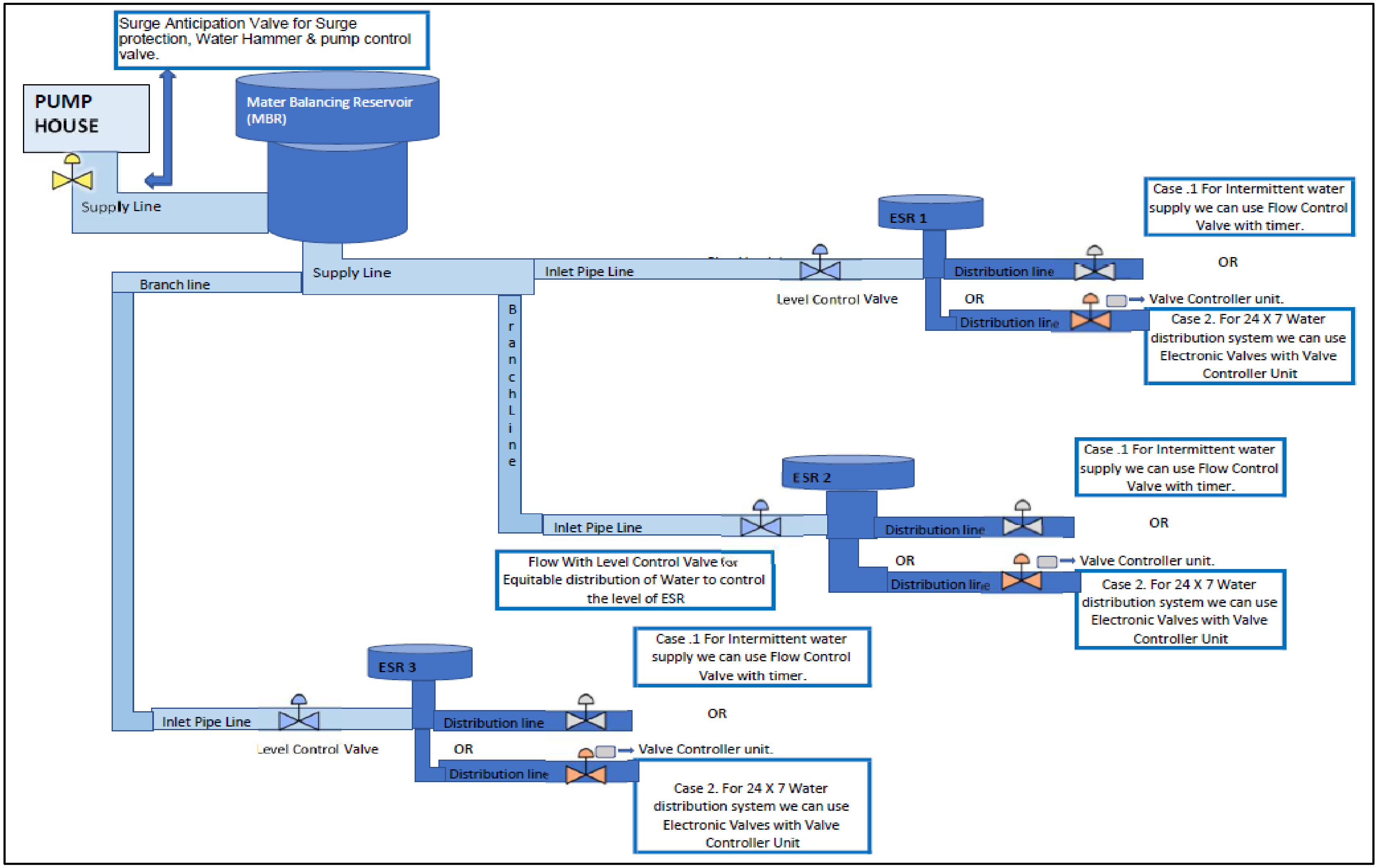
When it is mandatory to maintain a certain minimum pressure on the upstream side of a particular location, pressure sustaining valve (Section 3.7) should be installed at such location.



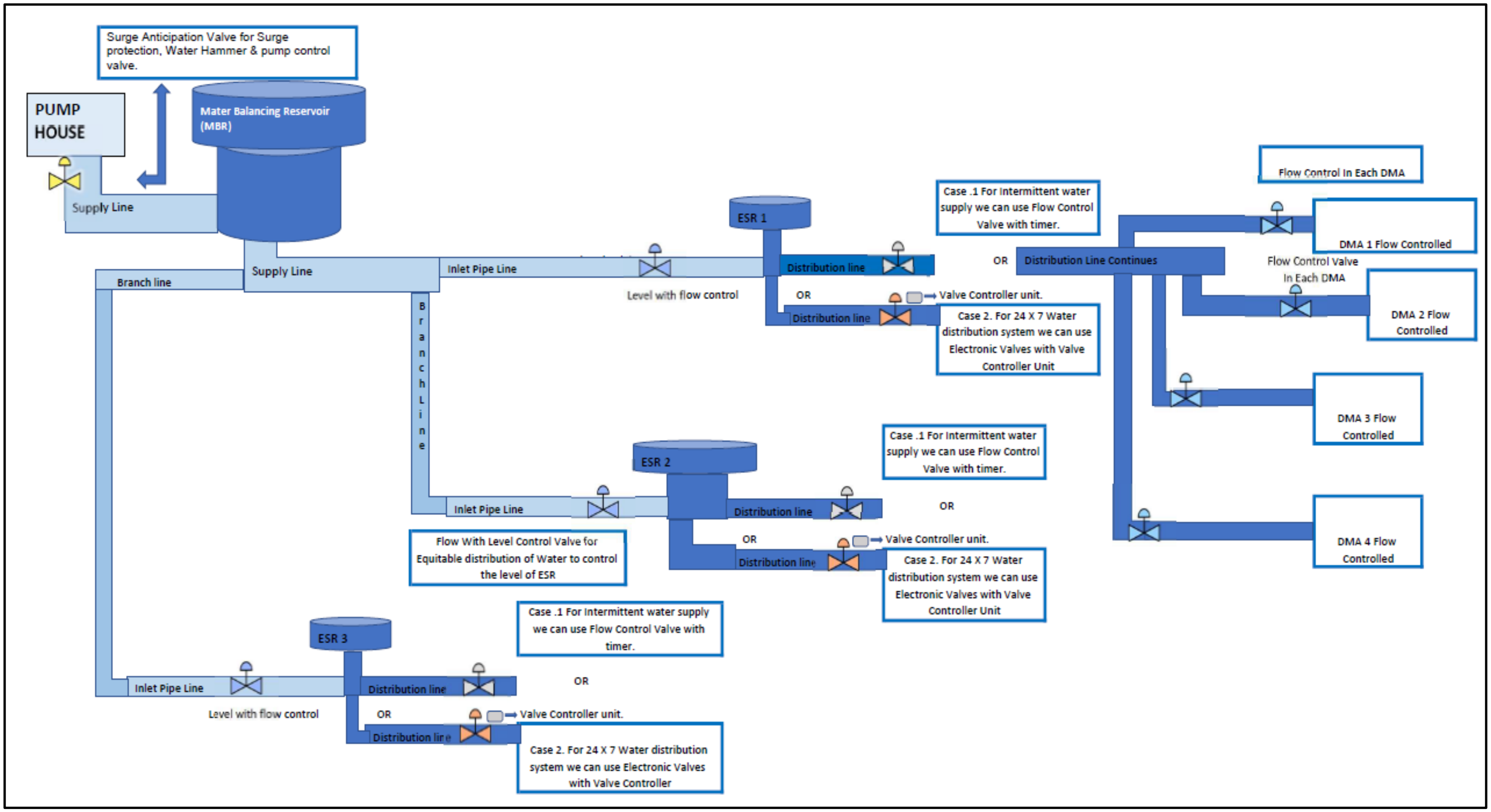
(The figures mentioned above are for representation purpose only)
Sketch 1



(The figures mentioned above are for representation purpose only)
Sketch 2

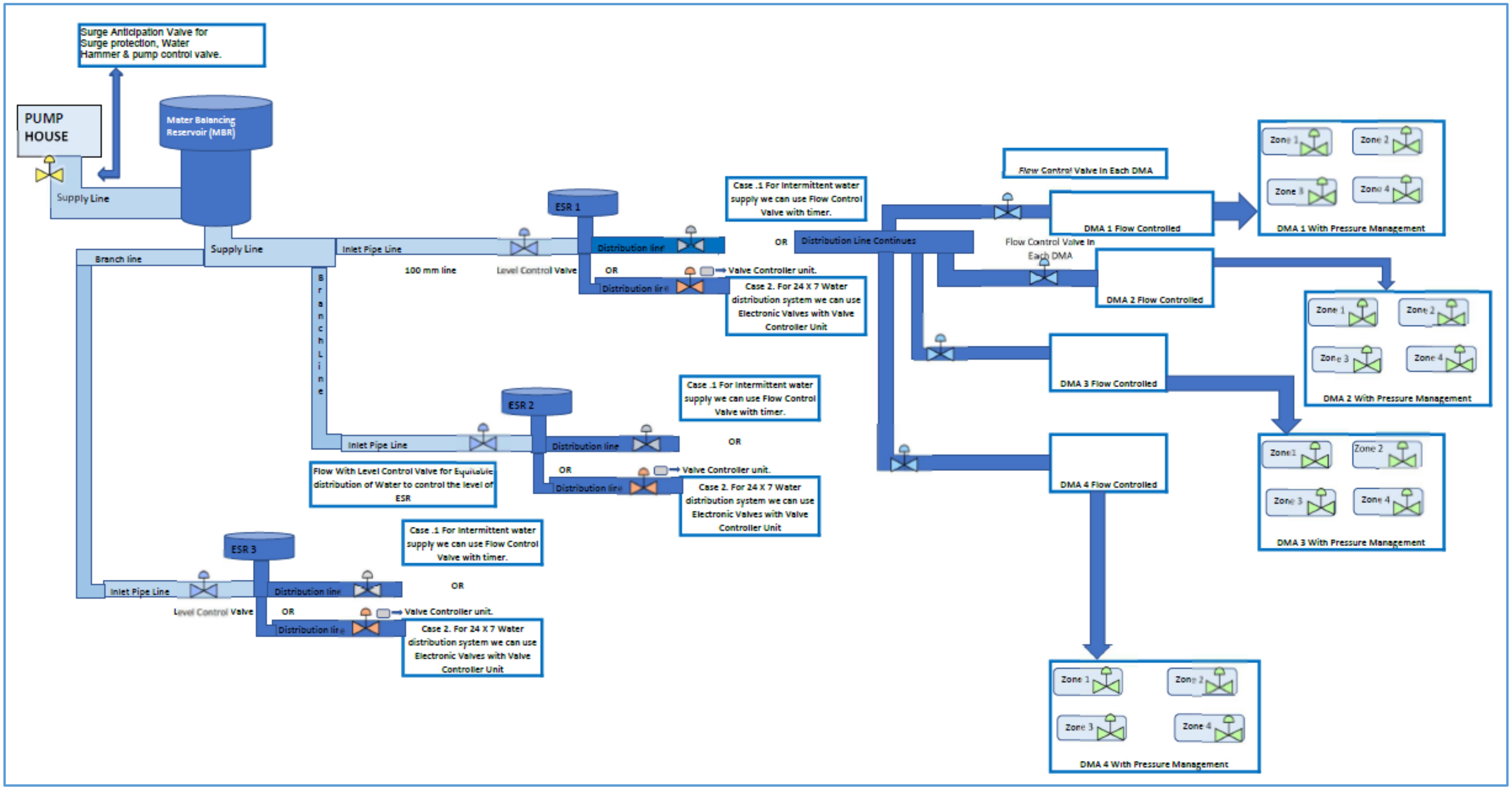


(The figures mentioned above are for representation purpose only)
Sketch 3

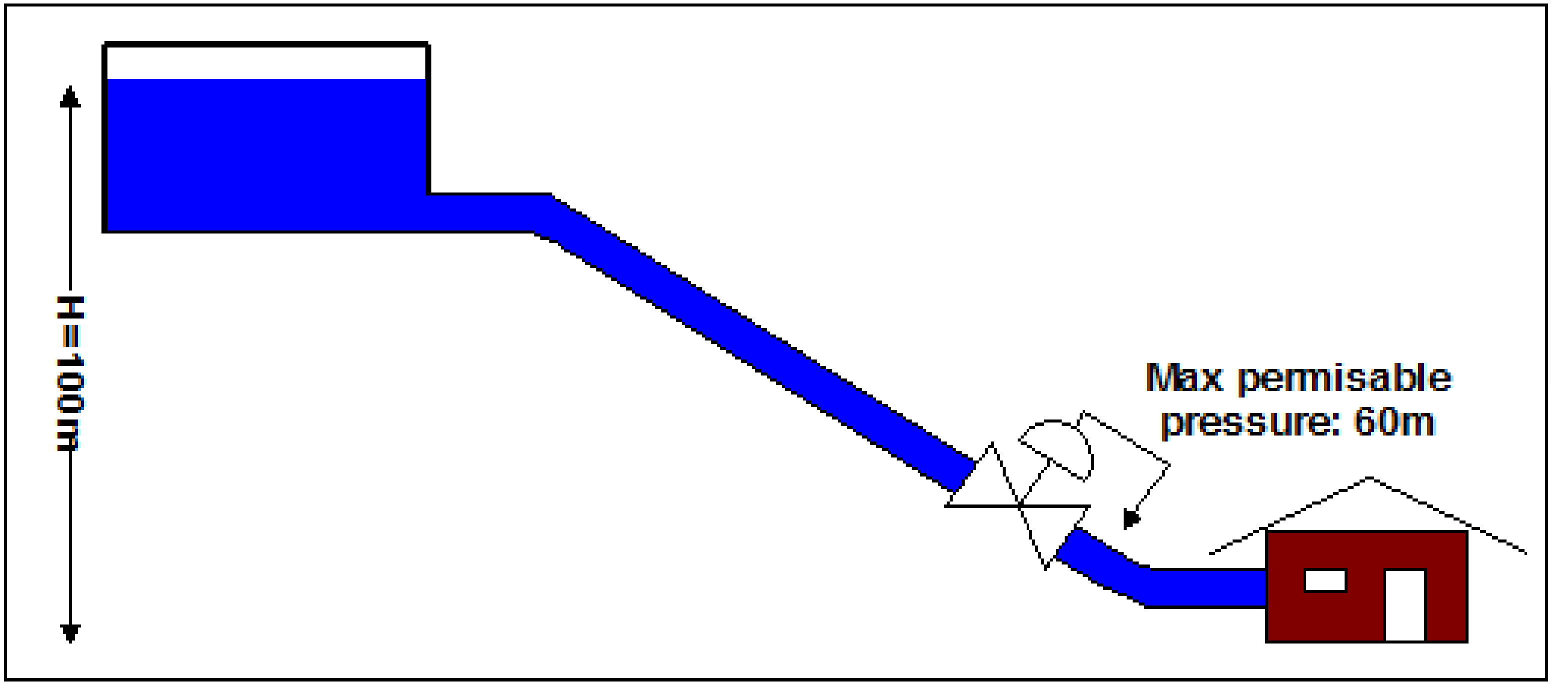


(The figures mentioned above are for representation purpose only)

Sketch 4

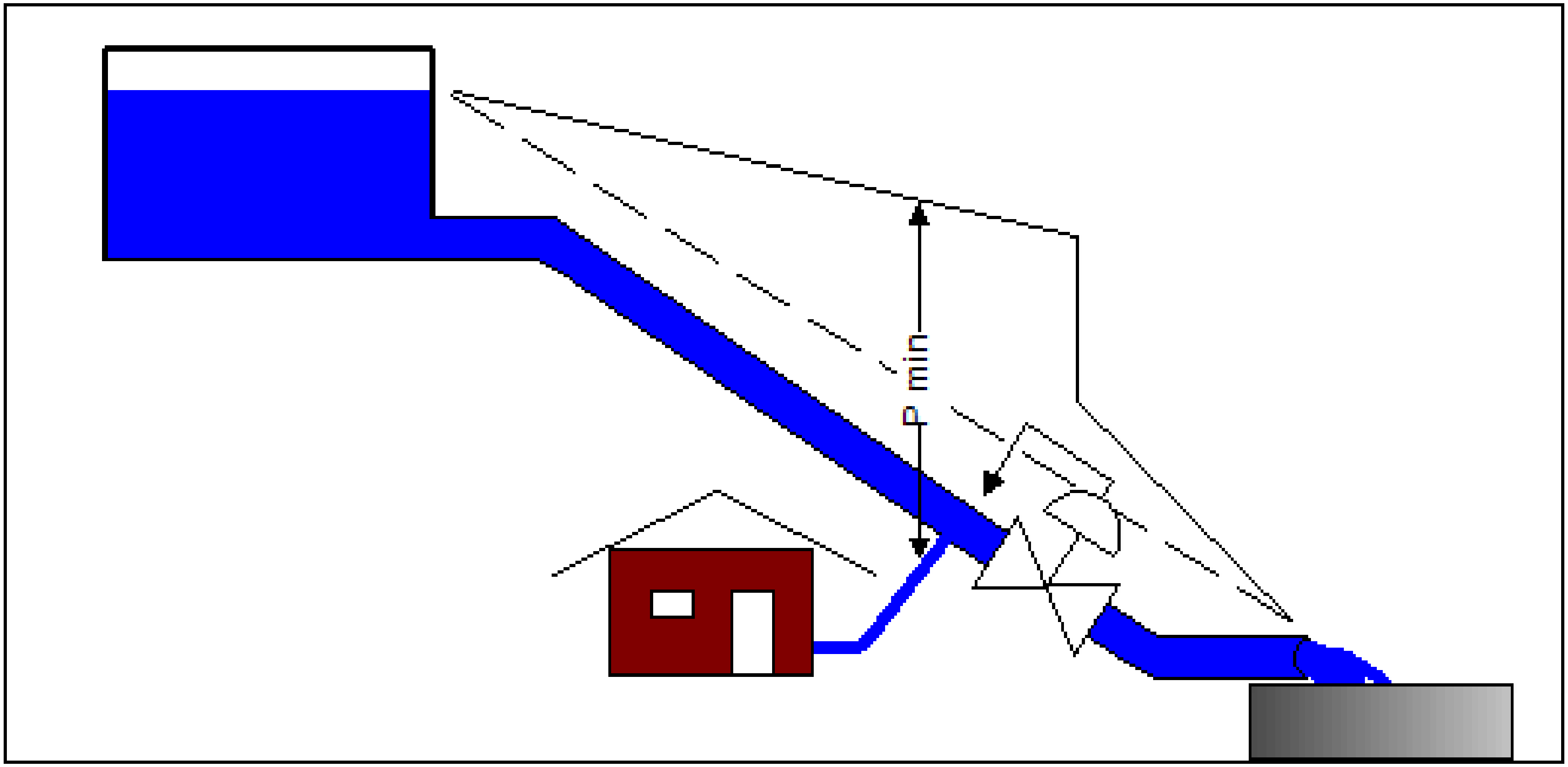


(The figures mentioned above are for representation purpose only)
Sketch 5



(The figures mentioned above are for representation purpose only)

Sketch 6



(The figures mentioned above are for representation purpose only)

Sketch 7

9 CONCLUSION

There are very few water supply schemes which are running on cost recovery concept or even at break-even point. The reason for the same is non-recovery of operation and maintenance cost. Recovery of water tax is dependent on two major aspects viz: willingness to pay and ability to pay. Water being a fundamental necessity of humankind, stringent actions against defaulters becomes difficult to be implemented. So the only way to find respite from the loss is by reducing the cost of production of potable water. Major portion of expenditure on operation and maintenance of any scheme is incurred on electricity and establishment charges. It is advisable to encourage solar energy based water supply schemes (depending on availability of area/space) or gravity based schemes (depending on topography), in order to reduce the expenditure on electricity charges, thereby reducing the cost of production of potable water. While complete automation of water supply systems requires substantial expenditure, installation of control valves can prove to be the first step towards reducing establishment charges and conservation of potable water by reducing NRW.

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सत्यमेव जयते

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