Examination of Direct Booster Water Supply System in Japan

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Abstract

This paper reports on Direct Booster Water Supply (DBWS) system adopted in Japan. The DBWS system is a method to connect a booster pump to the water service pipe that diverged from a distributing water pipe. In some countries this system has already been adopted quite a long time ago in order to supply water to buildings. This system was introduced for middle scale buildings in Japan about 10 years ago. The main reason this system was not adopted earlier in Japan is that of a legal issue. On the other hand, there have been no legal regulations on maintenance of small capacity receiving tanks (less than capacity of 10 m^3). As a result, degradation of water quality in receiving tanks has been continuously pointed out. To solve this problem, various examinations have been performed for an extensive period of time. This resulted in the introduction of the DBWS system to Japan ten years ago.

This paper illustrates the introduction process of the system to Japan, current trends, related criterion and the decision method of booster pumps.

Keywords
Direct Booster Water Supply (DBWS) system, Waterworks, Booster Pump Unit, Estimated Terminal Pressure Peak Flow Rate,

1 Introduction

Since the adoption of European and US technology, Japanese plumbing system has advanced to the state of today. On-site and buildings' water supply system can be classified into two types of system, the direct supply system and the receiving tank system, as shown in Figure 1. Until recently, the former method that utilizes the

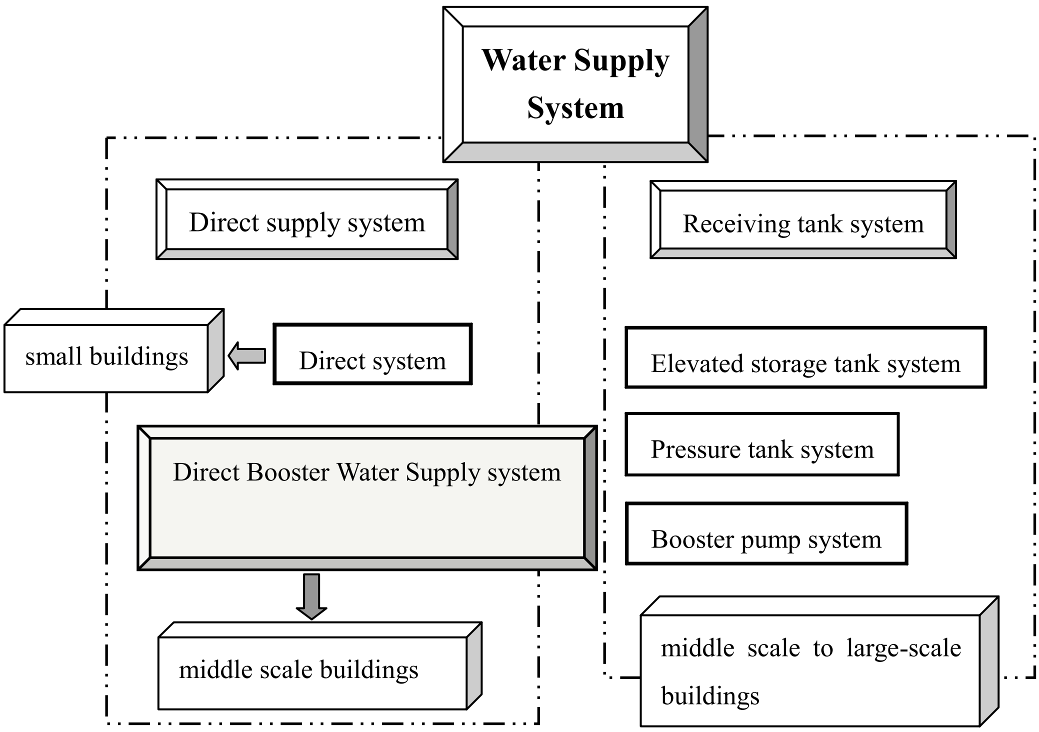

Figure 1 Type of water supply system in buildings

pressure from the distributing water pipe has been used for houses and small scale-low rise buildings. The latter method which first stores water in a tank and after distributes on demand has been adopted in middle to large-scale buildings. However, the collaborative works among the public, private and academic sectors with various perspectives resulted in the implementation of the DBWS system for middle scale buildings in Japan. Since the beginning of the implementation, Ichikawa and Kiya have led and planned projects to implement the DBWS system.

2 Implementation Process

2.1 The Japanese policy on implementing the DBWS system

An announcement of 'Long-term goal of water supply improvement towards the 21st century' by Ministry of Health, Labour and Welfare (MHLW) in 1991 gave opportunity to implement the DBWS system. MHLW is one of the Japanese government administration offices that deal with the public health & sanitation, labor and aging population issues, and also devise the standards for quality of potable water.

(A) MHLW directive basic policies

a) Waterworks accessible by all people
b) High safety level waterworks
c) Safe waterworks

(B) Detailed objectives for waterworks improvement

Seven items have been selected as the detailed objectives for the waterworks improvements. The following is one of the items expansion of subject for the direct water supply system.

a) With the long run perspective, promote the implementation of direct water supply on 3 stories to 5 story buildings and execute the required facility improvement. Moreover, enhance the service level of water supply and solve the sanitary issues of small size receiving tanks.

(C) Background of detailed objectives

a) To resolve the sanitary issue of under 10m^3 receiving tanks that are exempted from the regulation.
b) To further expand the range of direct water supply system.
c) Other

2.2 Details and progress of DBWS system implementation

The method of raising the pressure level of a water supply can generally be classified into two types; one where a supplier raises the pressure of the entire water supply area, and the other where users of individual buildings can increase the pressure by directly connecting a booster pump onto a water service pipe that has branched off from the distributing water pipe. The former has been used by water suppliers until now. The latter is the DBWS system that has recently become popular in Japan.
The DBWS system has been adopted in Europe and US since the 1960s. The reason for Japan's late implementation of the system is that a pump that could affect a distributing

pipe should not be connected to a water service pipe according to the Water Works Law of Japan. In other words, without even evaluating whether the pump would affect the main pipe, a notion of “a pump should not have a direct connection” delayed an adaptation of the system.

Figure 2 shows the flow of DBWS system from introduction phase to present day. In Japan as mentioned above, the MHLW’s guideline of 1991 that directs ‘improvement on facilities to expand the direct water supply’ has been the start of DBWS system implementation. Today, 79 local governments have approved the implementation.

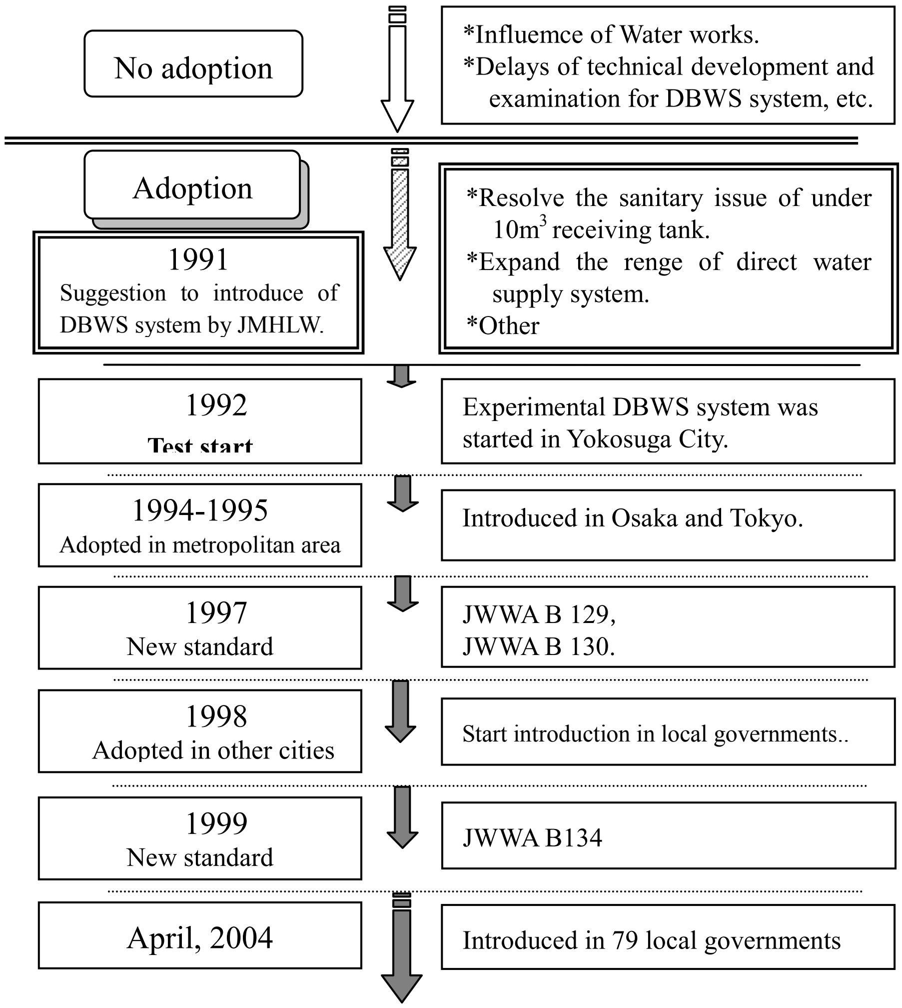

Figure 2 Flow of adopt DBWS system in Japan

Figure 4 illustrates detailed implementation results of Tokyo Metropolitan Government. Meanwhile, new technological standards have been set to date. Examples of such new standards are JWWA(Japan Water Works Association) -B-130 ”Pressure booster for direct water supply”(1997), and JWWA-B-134 “Reduced pressure principle backflow preventers for water supply (BFP)”(1999).

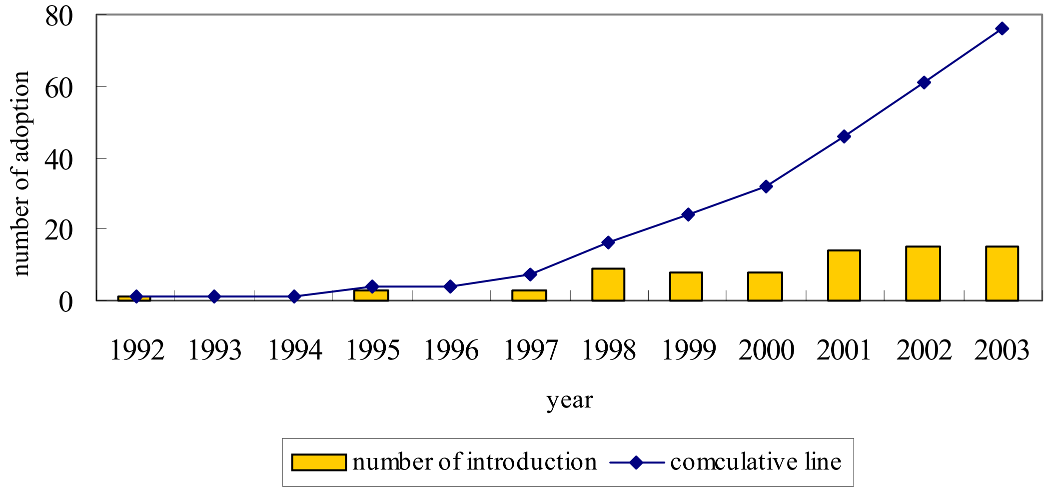

Figure 3　Transition of introduce DBWS system in local governments

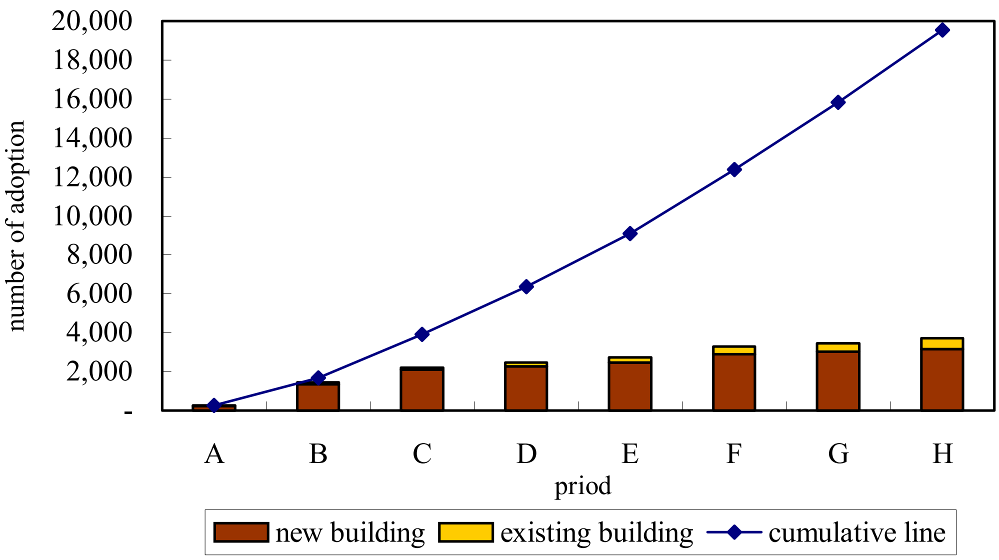

Figure 4　Transition of adopt DBWS system in Tokyo

3 DBWS system outline

3.1 DBWS system configuration

Figure 5 shows an outline of the DBWS system. Figure 5 (a) is a general system, and figure 5 (b) explains the method to apply the system to an existing building equipped with an elevated storage tank. Figure 5 (b), however, should only be considered as a temporary scheme. Installation of the BFP on the suction side of the booster pump is mandatory. The parts that were used as a reduced pressure principle backflow preventer in Japan for a short

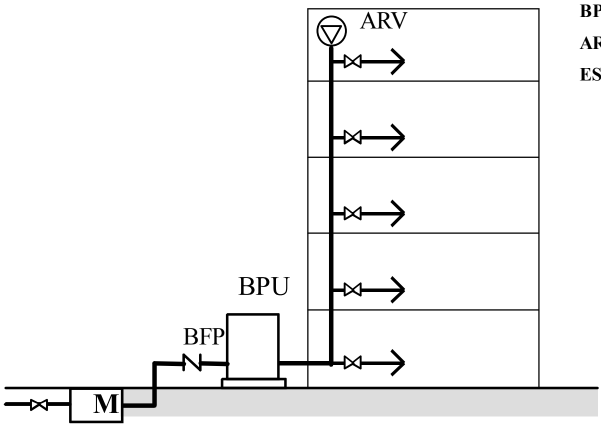

Figure 5 (a) DBWS System

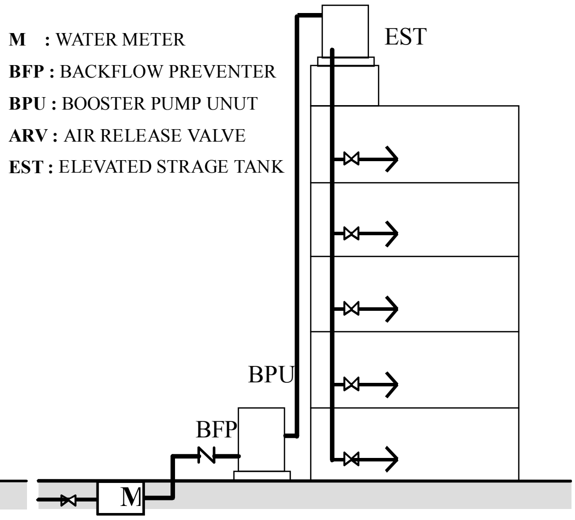

Figure 5 (b) Application to existing elevated tank

period of time from 1992 had been all imported goods. However, since an establishment of a new set of standards in 1999, domestic products (Picture 1) have been in use. Also in Tokyo Metropolitan Government, installation of a Meter Bypass Unit such as Picture 2 is obligatory in respect of periodical replacement of water meters.

Picture 1 Backflow preventer
(JWWA B 134) / by QSO[*1)]

Picture 2 Meter bypass unit
/ by QSO[*1)]

3.2 Booster Pump Unit

Main contents of JWWA B 130 “Pressure booster for direct water supply” is as follows

a) Applied of usage: Under 50A in nominal sieve size of unit. Under 0.75MPa discharge pressure.
b) Number of pumps: Install over 2 pumps per unit.
c) Discharge pressure:
   * Discharge pressure change tolerance level at the change of flow rate and suction pressure fluctuation is within 5% differential of target pressure.
   * Pressure change tolerance level when start and stop of pump is within 30%

differential of target pressure.

* Pressure change tolerance level when replacing pump is within 30% differential of target pressure and under 0.07MPa.

d) Suction pressure:
  * When the pump starts, drop of a suction pressure is within 25% of the previous pressure and under 0.05MPa.
  * When the pump stops, increase of suction pressure is under 0.1MPa of the pressure from the stopping point.

e) Others

3.3 Control of booster pump unit

Figure 6 shows the composition of a direct booster pump unit, and Figure 7 illustrates the concept of control flow of pump operation. These two pumps take turns operating, and are typically managed by a control method of *estimated terminal pressure at a constant* (a).

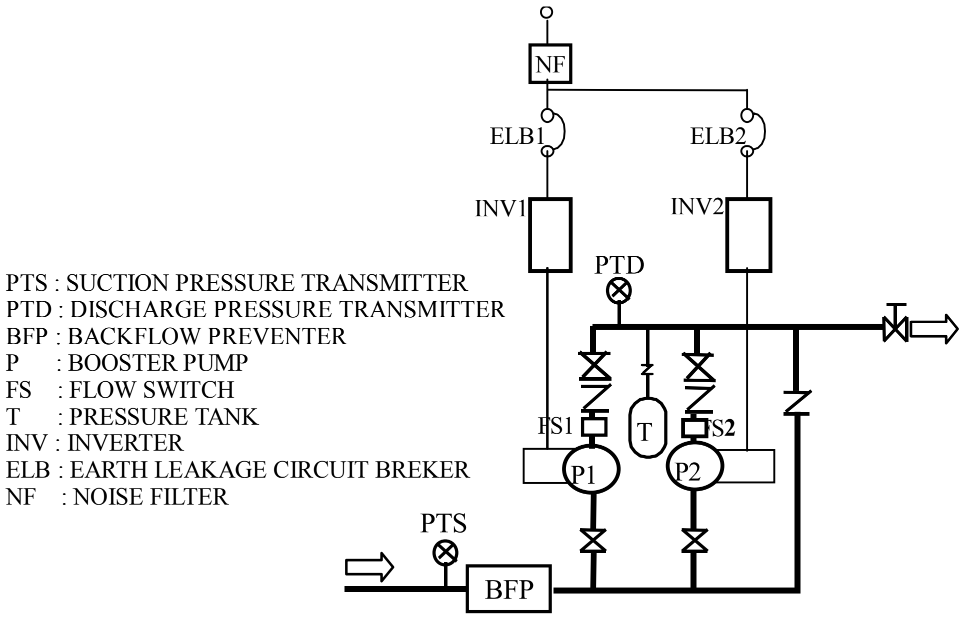

Figure 6 Composition of booster pump unit

This control method enables a steady pressure at the terminal by estimating the resistance of distributing water pipe relative to the amount of water used with readings from pressure transmitter of discharge side(PTD), pressure transmitter of suction side(PTS), pump rotation signals and etc(a). Flow switch(FS1 or FS2) detects the decrease in amount of water used(b). The pressure accumulation of the pressure tank(T), resulting from the increase in the discharge pressure of the pump, stops the pump(c). While the pump has stopped, pressure of discharging side is monitored by pressure transmitter(PTD)(d). If the use of water is confirmed, pressure tank(T) will supply water. At this point, if the discharge pressure drops lower than the set pressure (start pressure of pump) then water is supplied by activating a pump (P1 or P2). Perform control of estimated terminal pressure at a constant via pump operation (a).

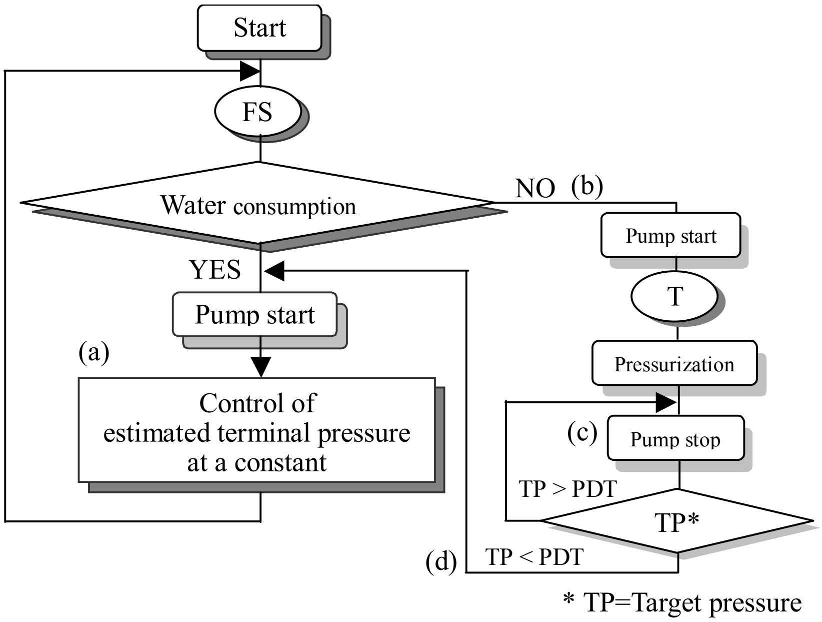

Figure 7 Flow of control for booster pump unit

4 Selection of applicable building and pump

4.1 Applicable Building

Table 1 shows the use of buildings currently using DBWS system. Generally, it is adopt the system for multiple dwelling house and office buildings. In respect to safety concerns on backflow, it is impossible to implement this system at factories and facilities that operate chemicals, medicines substances (toxic, poison, etc). Also, hospitals, schools and hotels are considered inappropriate due to the reservoir capability and other reasons.

Table 1 Applicable Buildings

	Buildings
Impossible	Factories and facilities that operate chemicals, medicines (toxic, poison, etc).
Unsuitable	Hospital, School, Hotel
Applicable	Multiple dwelling House, Office Buildings
Height	30m + less than 4 stories

If the DBWS system is to be used, the height of a building is automatically limited from the fact that discharge water pressure be under 0.75MPa, as stated in JWWA B 130. Normally, it is known that the limit for the height of a building is 30m + 4 stories considering the various resistance and minimum required pressure. In reality, many local governments set the limit to 10 story buildings.

4.2 Peak flow rate of water supply and the diameter of booster pump unit

4.2.1 Identifying peak flow rate of water supply

In order to select a booster pump unit, a peak flow rate of water supply needs to be clearly identified. The calculation method for this rate is described in SHASE (The Society Heating, Air-Conditioning and Sanitary Engineers of Japan). It is defined this calculation method especially for multiple dwelling houses by Better Living, Urban Development Corporation and local government. The following is an example of Tokyo metropolitan government.

* Formula to estimate a peak flow rate of water supply Q [L/min] by the number in residents P [persons]

$P = 1 - 30 : Q = 26.0\ P^{0.36}$

$P = 31 - 200 : Q = 13.0\ P^{0.56}$

$P = 201 - 2000 : Q = 6.9\ P^{0.67}$

4.2.2 Setup of the diameter of booster pump unit and discharge water pressure

Figure 8 shows the relationship between the peak flow rate of water supply that is calculated through the formula above and the number of dwelling units (a family of 4 and 3). This shows the result according to the diameter of the booster pump unit when a flow speed of discharging side is 2.0m/s. As in Figure 8, a 50A diameter booster pump unit will be able supply water to 46 units with a family of 4 or 61 units with a family of 3. Figure 9 shows the concept to set the discharge water pressure of the booster pump unit. This is generally the same as calculating the needed pressure.

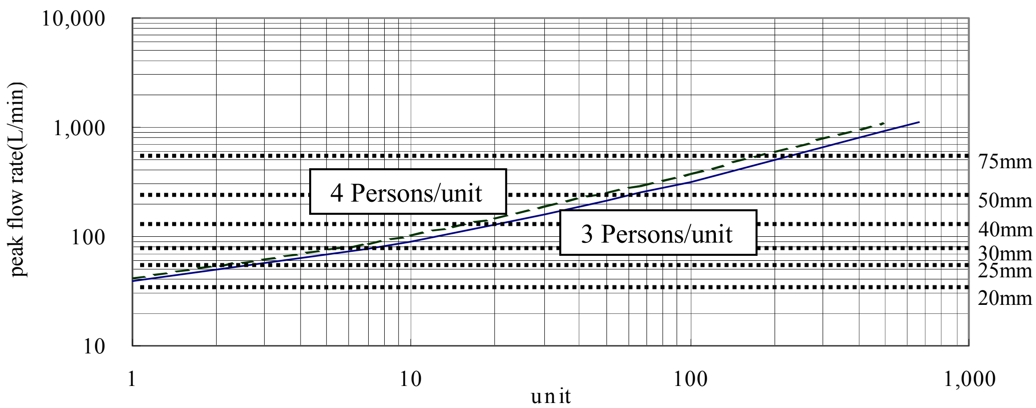

Figure 8 Relation of peak flow rate and number of unit

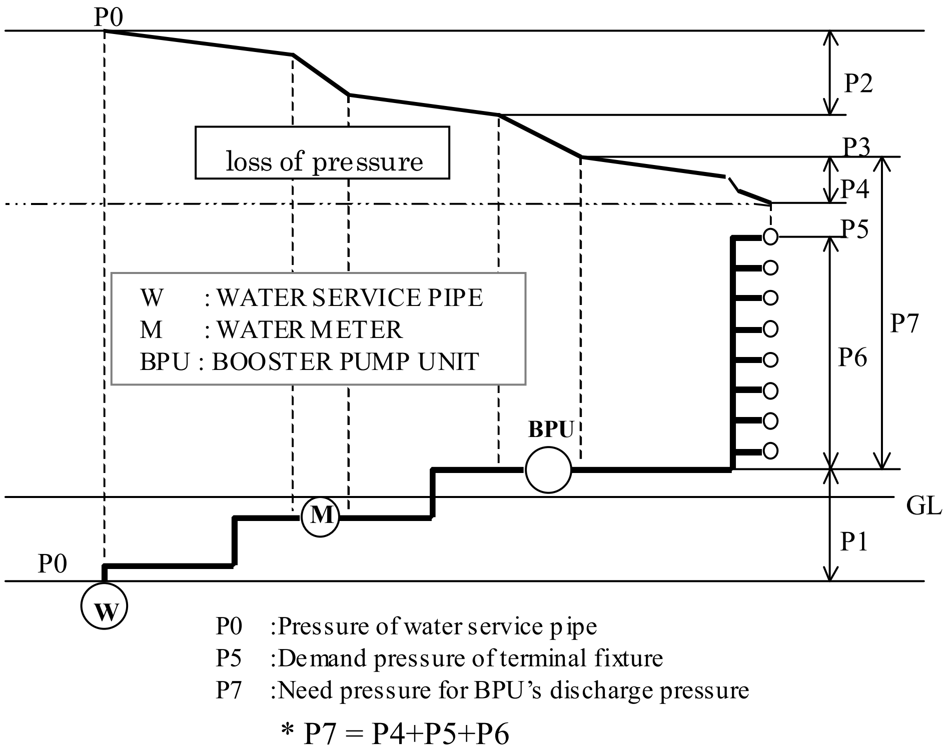

Figure 9 Scheme to need pressure for BPU's discharge pressure

5 Energy consumption

The DBWS system can efficiently use the retained energy of distributing water pipe. Table 2 shows an example of a pump's power consumption amount of the booster pump in the receiving tank system, which has been widely used, and of the DBWS system. At a few existing buildings, the authors are conducting field studies on the amount of power consumed in cases where a receiving tank system has been modified to a direct booster system. The authors believe that the power consumption per unit water consumption can be reduced by approximately more than 40%.

Table 2 Energy Consumption

	Pressure [MPa]		**Consumption**		
	start	stop	electricity [kWH]	water [m^3]	unit of electricity [kWH/ m^3]
Receiving tank *1)	0.24	0.43	120	163	0.74
DBWS system *2)	0.26	0.31	59	155	0.38

*1) booster pump system, *2) Control of estimated terminal pressure at a constant

6 Movement toward to the expansion of range of water supply for the future

Bureau of Waterworks in Tokyo Metropolitan Government (BWTMG) has a significant amount of influence in the waterworks of Japan. In Tokyo Metropolitan Government, DBWS system (under 50A in meter diameter) has been implemented since October of 1995. Due to the many advantages of the system, investigations for implementing the system on large-scale buildings are being performed. For example, Ichikawa has led the researches such as "Technological examination of DBWS system expansion[4),5)]" for 2 years since 1999. In this project, research on the peak flow rate, field study on existing high-rise buildings, various tests on a high-rise (100m), evaluation of management conditions etc.

On the basis of these results, BWTMG approved the diameter of booster pump unit up to 75A (80A) in June 2004. As results, the range of a number of units (160, 220 units (a family of 4, a family of 3)) with accessible water supply in the house complex has broadened in using DBWS system with 75A diameter(Figure 8). In future, BWTMG's this policy to expand the range of water supply may largely influence other local self-governing bodies in Japan.

7 Conclusion

About 10 years has past since the initial implementation of DBWS system in Japan, and the new expansion of water supply range is in progress. Hereafter, The authors predict a nationwide increase in installation of 75A diameter DBWS systems in Japan. The authors plan to further continue our research focusing on the following items.

* Continue understanding of current situation after implementing the DBWS system.
* Research and investigation on leak water.
* Development and investigation of related equipment and system control.
* Effect on distributing water pipe with an implementation of multiple DBWS systems.
* Examination of system implementation in super-high-rise buildings.
* Economic comparison with receiving tank system.
* Investigation of energy conservation considering environmental load.
* Investigation of performance evaluation and maintenance of backflow prevention devices.
* Others

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9 References

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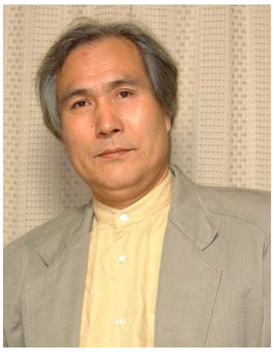
10 Presentation of author



Dr. Noriyoshi Ichikawa is professor at the Tokyo Metropolitan College. The Tokyo metropolitan government plans to combine four existing colleges into the New Tokyo Metropolitan University in April of 2005. As a result he will become a professor of the New TMU starting next April. He is conducting various researches on his major field of study of water supply and drainage system in buildings. He is also actively involved in governmental and academic institutions and committees related to his field of study as chief coordinator and board member.