Reinforcement of Earthquake-Resistance of Air Valves

M. Ishii*

*Bureau of Waterworks, Tokyo Metropolitan Government, 1-19-1 Tamagawa-den'enchofu, Setagaya-Ku, Tokyo, Jp ,
ishii-masanori@waterworks.metro.tokyo.jp

INTRODOUCTION

- The Great East Japan Earthquake (2011) was recorded with a seismic intensity of "strong 5"even in Tokyo.
- In particular, the number of cases of water leakage from dual-mouth air valves (Picture 1) was overwhelmingly larger than that from pipelines.
- The Bureau of Waterworks, Tokyo Metropolitan Government has been adopting dual-mouth air valves for pipelines with a diameter of 400 mm or more.
- However, it became clear that dual-mouth air valves caused water leakage since it was subject to the effect of the earthquake tremor, due to their heavy weight with a high center of gravity.
- Therefore, the Tokyo Waterworks developed small and light quick air valves to replace the existing dual-mouth air-valves.

<Air Valves>
Air-valves are indispensable equipment for water pipelines, with an outlet function to release air in pipelines and an air inlet function to prevent negative pressure in pipelines.
They are installed in high places at crossings over rivers, railway tracks and road bridges, as well as raised portions of the bedrock or underground pipelines (Figure 1).

Picture 1.
Dual Mouth Air-Valve

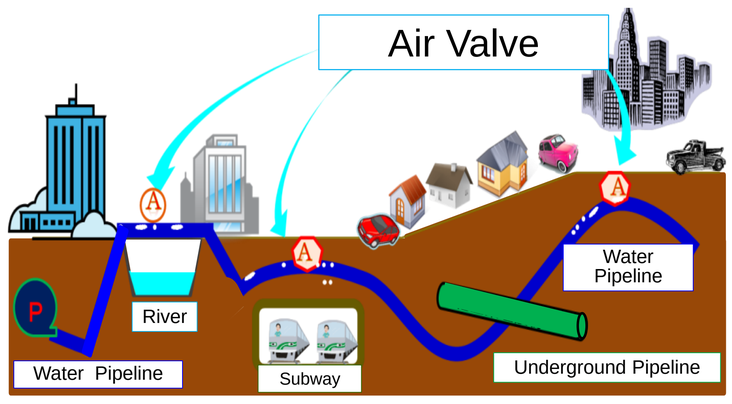


Figure 1.
Conceptual image of air valve installation

Air Valve Damages（Great East Japan Earthquake 2011）

1. Dual mouth air valve damages in Tokyo

- The number of water leakage from air valves was overwhelmingly larger compared to that from pipelines, fire hydrants and water control valves.
- Furthermore, most dual-mouth air valve damages were caused by position shift of floating balls in air valves due to the tremor of the earthquake. (Table 1, Figure 2, Picture 2)

Waterworks Facility	Pipelines	Air-Valves	Control Valves	Fire Hydrants	Total
Instances of Damage	22 (19%)	80 (70%)	5 (4%)	8 (7%)	115 (100%)

Table 1. Damage overview in Tokyo Waterworks Facilities

2. Damages to quick air-valves in the Tohoku Region

- Quick air-valves were also damaged in the Tohoku Region.
- There was little damage from floating balls, but much damage and deformation of internal parts.(Pictures 3 and 4)

The Tokyo Waterworks has decided to handle seismic retrofitting of air-valves as an urgent challenge.

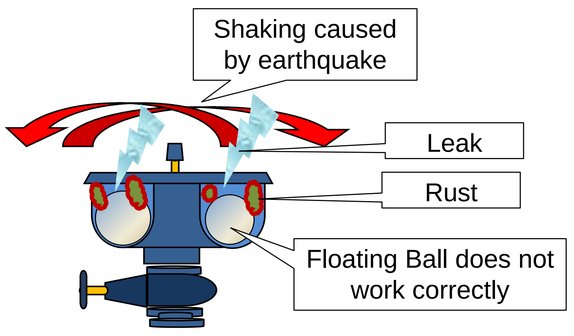
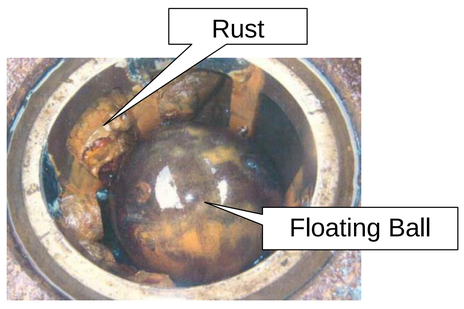
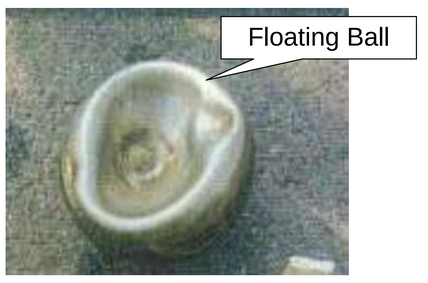
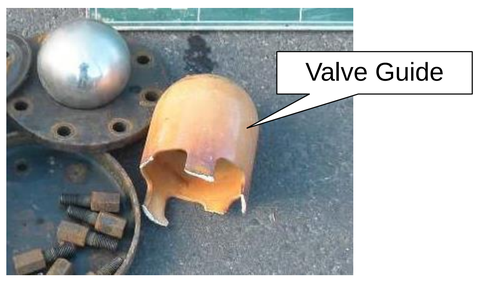


Figure 2.
Conceptual image of leak caused by a quake



Picture 2.
Floating ball shifting





Pictures 3 and 4.
Damage to a quick air-valve in the Tohoku Region

Development of Quick Air Valves of Highly seismic resistant

Advantages of development (Goals)

- Lightened air-valves
- Selection of highly seismic resistant materials
- Greater ease closing valves

1. Lightened air-valves

- Quick air-valves(Picture5) weigh less than half as much as dual mouth air-valves (Table 2).

2. Changed materials and dimensions

- The floating ball uses expanded ebonite for its core, making it more resistant to compression than hollow stainless steel. (Figure 3)
- The free-moving valve body and valve guide use ABS resin, polyethylene resin, rigid PVC resin and so on, which are highly resistant to compression. (Figure 3)
- Dimensions of the top of the air-valve were set so that a ball pusher can be installed, making it easier to suspend water. (Picture 6)

Picture 5. Quick Air-Valve

	Dual Mouth Air-Valve	Quick Air-Valve
75 mm Diameter	65 kg	25 kg
150 mm Diameter	140 kg	70 kg

Table 2. Weight comparison of dual mouth air-valves and quick air-valves

3. Reinforcement of flanges and improved ease of closing valves

- Flange welds are reinforced with flange reinforcement brackets, making them stronger against earthquakes.
- To make closing valves easier, a cap isolating valve was installed the under the air-valve, in addition to the conventional flange gate valve. (Figure 4, Picture 7)

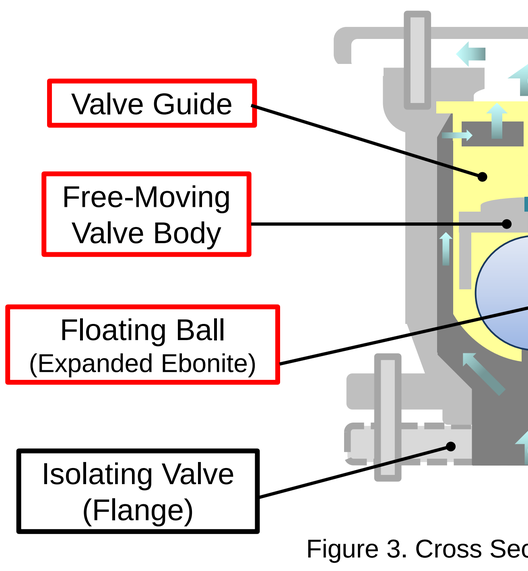


Figure 3. Cross Section of Quick Air-Valve

Picture 6. With a ball pusher installed

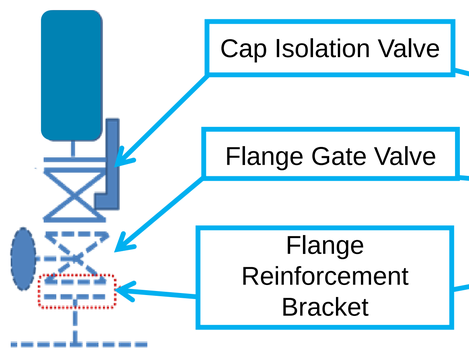
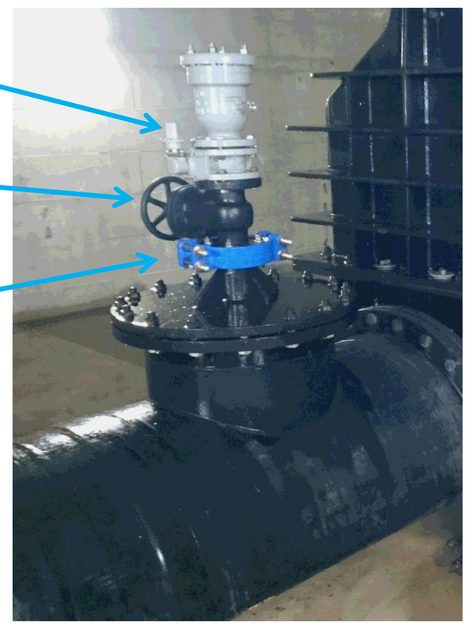


Figure 4.
Conceptual image of flange reinforcement
Cap isolation valve



Picture 7.
With Quick Air-Valve installed

Project to Reinforce Earthquake Resistance of Air Valves

Learning from lessons of the Great East Japan Earthquake and the imminence of a potential epicentral earthquake in Tokyo are, the Tokyo Metropolitan Government has started and implemented the "Project to Reinforce Earthquake Resistance of Air Valves" since 2013, making steady progress since then.
This includes replacement of all dual-mouth air valves, which are installed in approximately 9,000 locations in Tokyo.