Report of the Investigation on Wall-Mounted Dispensers (Dispenser)

1. Background

1.1 In accordance with Reg24 of Waterworks Regulation (WWR) (Cap 102A), permission of Water Authority (WA) has to be sought for any installation of wall-mounted dispenser (dispenser) connected to inside service. This is to ensure no backflow of water from the dispenser causing potential contamination of the inside service. If necessary, WA may require the installation of a non-return valve upstream of the dispenser or it be supplied by a separate storage cistern to prevent backflow. Dispensers however are not fittings of the inside service and WA does not issue acceptance letters for them.

1.2 Water Supplies Department (WSD) has been assisting the Education Bureau and Social Welfare Department in the sampling testing of lead content in drinking water in kindergartens and welfare units respectively since 10 September 2015. Up to 30 November 2015, a total of 1,542 drinking water samples taken from the inside service of 772 kindergartens and 205 welfare units have been tested and they all complied with the Provisional Guideline Value (PGV) of 10μg/L for lead content specified in the "Guidelines for Drinking-water Quality" published by the World Health Organisation (WHO) in 2011 (WHO 2011 Guidelines). Besides, 366 drinking water samples taken from the outlet taps of dispensers in the kindergartens and welfare units have been tested and 10 samples (each for a dispenser) in 8 kindergartens had lead content exceeding the PGV in the WHO 2011 Guidelines (excess lead).

1.3 Preliminary investigations were conducted jointly by departments including Electrical and Mechanical Services Department (EMSD), Government Laboratory (GL) and WSD for the 10 dispensers with excess lead in the drinking water samples taken from their outlet taps (failed dispensers). In the preliminary investigations, additional drinking water samples were taken at the inlets of these failed dispensers and the test results showed that they all complied with the PGV of lead content in the WHO 2011 Guidelines. This confirmed that the excess lead in the drinking water samples should be caused by the dispensers themselves. Besides, X-ray fluorescence (XRF) spectrometer was used for testing the presence of lead in the components inside the dispensers. The results indicated the soldering material at the inlets inside the dispensers as well as their copper alloy components contained lead.

1.4 WSD has commissioned the Hong Kong Productivity Council (HKPC) to conduct an investigation on dispensers to:

(a) identify the causes of excess lead in the drinking water in the failed dispensers;
(b) investigate the lead content in drinking water of dispensers on the market;
(c) recommend requirements for new dispensers; and
(d) provide advice on the use of existing dispensers.

1.5 This report summarises the findings and recommendations of the investigation.

2. Investigation on Dispensers

2.1 The investigation tested 6 dispensers including:

(a) Two used and failed dispensers; and
(b) Four new dispensers of different brands procured from retail shops at Yau Ma Tei, Kowloon.

2.2 <u>Dispensers</u>

2.2.1 The details of the 6 dispensers tested are as follows:

Dispensers	New/ Used	Nominal Size (litres)
WD 1	Used	25
WD 2	Used	100
WD 3	New	20
WD 4	New	25
WD 5	New	30
WD 6	New	40

2.2.2 All the above dispensers were of similar design with details as shown in **Appendix A**. Such design is commonly adopted in the dispensers used in Hong Kong. Drinking water entering the dispenser will feed a cold water tank at the upper part of the dispenser. There is a float valve in the cold water tank for stopping the inflow when it is full. The lower part of the dispenser is the hot water tank where the heating element with jacket is installed. When hot water is consumed, cold water will flow by gravity from the upper cold water tank into the lower hot water tank through a hole on the partition plate between the tanks. As the water level in the cold water tank drops, the float valve will open to allow inflow for topping up the cold water tank. When the temperature of the water in the hot water tank drops to a certain level, it will be heated up again automatically until boiling (automatic heating).

2.2.3 Dispensers are basically constructed of stainless steel sheets. However, some of their components in contact with cold and hot water are made of copper alloy including the float valve in the cold water tank, outlet tap, heating element jacket, etc. Besides, soldering is used for sealing around the components such as the inlet, outlet tap, etc. for ensuring water tightness. The copper alloy components and the typical locations of the soldering points are also shown in **Appendix A**.

2.2.4 The heating element jackets in some dispensers are made of stainless steel instead of copper alloy. In the 6 dispensers tested in the investigation, WD1, WD3, WD4 had stainless steel heating element jackets while WD2, WD5, WD6 had copper alloy heating element jackets. Besides, the copper alloy holder nuts of the level indicators in WD5 and WD6 were installed inside the dispensers and the bottom nuts were in contact with the hot water. .

2.2.5 Among the copper alloy components in the dispensers tested, the outlet tap, bottom holder nut of the level indicator (in WD5 and WD6 only) and heating element jacket (in WD2, WD5 and WD6 only) had much larger water contacting area and were in contact with hot water which would significantly increase their lead leaching rate. The investigation therefore focused on these components in respect of lead leaching from copper alloy components inside the dispensers.

2.3 Testing of dispensers

Various tests were conducted for the dispensers and their components in the WSD Mechanical and Electrical (M&E) Workshop and HKPC as detailed below. The 4 new dispensers (WD3, WD4, WD5 and WD6) had only been briefly cleaned before testing to avoid disturbance to their condition.

2.3.1 *Boiling test for dispensers*

(a) Tap water sample in the WSD M&E Workshop was tested for lead content for control purposes.

(b) Each of the dispensers was filled with tap water which was then boiled and a water sample was taken at the outlet tap. The hot water in the dispensers was kept under automatic heating at 100 ºC. Water samples were then taken at 2-hour interval until 24 hours. All water samples were tested for lead content after they had cooled down. This testing arrangement was based on the Australian/New Zealand Standard (AS/NZS 4020:2005) "Testing of products for use in contact with drinking water".

2.3.2 *Testing of lead content in copper alloy components and soldering material*

(a) The 6 dispensers were disassembled and tests were conducted using XRF to determine the presence of lead in the major components inside the dispensers including copper alloy components and soldering material.

2.3.3 *Boiling tests for copper alloy components*

(a) In the testing for presence of lead in paragraph 2.3.2 above, the soldering materials in 3 new dispensers (WD3, WD4, WD5) were found not containing lead. However, the lead contents in the drinking water samples in the boiling tests for the 3 new dispensers in paragraph 2.3.1 above differed significantly. Boiling tests were therefore conducted for their copper alloy components including level indicator holder nut (for WD5 only), heating element jacket (for WD5 only) and outlet taps to determine their contribution to the lead content in the drinking water in the dispenser.

(b) Tap water sample in HKPC was tested for lead content for control purposes.

(c) Each component was put in a beaker with about 0.7 litre of tap water for 6 hours at room temperature. The water was then tested for lead content.

(d) The water in the beaker was then replaced by fresh tap water (about 0.7 litre) which was boiled and maintained at 100 ºC for 6 hours. The water was then tested for lead content. Each component was tested for three boiling cycles with the water in the beaker replaced by fresh tap water in each boiling cycle.

(e) For comparison purposes, boiling test was also conducted for the outlet tap of the failed dispenser (WD1) which had been used for about 8 years. However, it was only tested for one boiling cycle.

2.4 Test results

2.4.1 *Summary of boiling test results for dispensers*

Tap water sample at WSD M&E Workshop was less than 1 μg/L.

Dispensers	Lead Content in Drinking Water Samples at Outlet Taps (μg/L)	Compliance with the PGV in WHO 2011 (10μg/L)
WD 1	37 – 85	No
WD 2	35 – 58	No
WD 3	10 – 16	No
WD 4	1 – 6	**Yes**
WD 5	21 – 33	No
WD 6	23 – 120	No

The full test results are shown in the graphs at **Appendix B**.

2.4.2 *Summary of XRF test results of lead content in copper alloy components and soldering materials in the dispensers :*

Dispensers	Lead Content of Soldering Material (%)	Lead Content of Copper Alloy Components in Contact with Hot Water			Lead Content of Copper Alloy Components in Contact with
		Outlet Tap	Level Indicator Holder Nut	Heating Element	

				Jacket	Cold Water
WD 1	29 – 51%	3.0%	NA	Nil	2.3 – 3.6%
WD 2	30 – 42%	2.4%	NA	0.1%	1.7 – 5.5%
WD 3	Nil	3.2%	NA	Nil	2.1 – 3.3%
WD 4	Nil	1%	NA	Nil	2 – 3.8%
WD 5	Nil	3.1%	3.4%	0.1%	3.6%
WD 6	22 – 55%	2.3%	3.4%	0.1%	2.5 – 4.3%

Note: WD1, WD3 and WD4 had stainless steel heating element jacket.

2.4.3 *Summary of boiling test results for the copper alloy components of WD3, WD4 and WD5.*

Tap water sample at HKPC was less than 1 μg/L.

The amounts of lead leached in water of the copper alloy components during each boiling cycle are shown in **Appendix C**.

2.4.4 Lead laden deposit with lead content of about 15% was found on the tank bottom of the failed dispenser WD2 which had been used for more than 10 years. Lack of regular cleaning was probably the cause of the lead laden deposit. Trial use of mild fruit acid (citric acid) was found to be effective in removing the lead laden deposit.

2.5 Analysis of test results

2.5.1 Both of the two used and failed dispensers WD1 and WD2 had leaded soldering material. The maximum lead contents in their drinking water samples were 85μg/L and 58μg/L respectively.

2.5.2 The new dispenser WD3 without leaded soldering material failed marginally with a maximum lead content of 16μg/L in its drinking water sample. It had a stainless steel heating element jacket. There was significant lead leaching from the outlet tap with lead content of 3.2% in the initial boiling cycles. It should be the major source of lead in the drinking water in the dispenser.

2.5.3 The new dispenser WD4 without leaded soldering material did not fail with a maximum lead content of 6μg/L in its drinking water sample. It had a stainless steel heating element jacket. The lead leaching from the outlet tap with lead content of 1% was mild even in the initial boiling cycles.

2.5.4 The new dispenser WD5 without leaded soldering material failed mildly with a maximum lead content of 33µg/L in its drinking water sample. The lead leaching from the heating element jacket with lead content of 0.1% was insignificant. There was significant lead leaching from the copper alloy outlet tap and level indicator holder nut with lead content of 3.1% and 3.4% respectively in the initial boiling cycles. They should be the major sources of lead in the drinking water in the dispenser.

2.5.5 The new dispenser WD6 with leaded soldering material failed seriously with maximum lead content of 120µg/L in its drinking water sample.

2.5.6 The amounts of lead leached from new copper alloy components reduced drastically with more boiling cycles. The amounts of lead leached in the 3rd boiling cycle were only about one-fourth to one-third of those in the 1st boiling cycle. Based on the above test results, the amount of lead leached from the copper alloy components after the 3rd boiling cycle should not cause excess lead in the drinking water in the dispensers WD3, WD4 and WD5 which did not have leaded soldering material. The estimated lead contents in drinking water in WD3, WD4, WD5 and WD1 for each boiling cycle are shown in **Appendix C**.

2.5.7 The amount of lead leached from the old copper alloy outlet tap of WD1 (which had been used for 8 years) after one boiling cycle was of similar order to those of the new copper alloy outlet taps of WD3 and WD5 in the 3rd boiling cycles. The lead contents of the copper alloy outlet taps of WD1, WD3 and WD5 were also of similar order of about 3%.

2.5.8 As observed from the 6 dispensers, soldering material of the same type (i.e. leaded or lead free) are used for the whole dispenser in both the cold water tank and hot water tank. This is believed to be a normal manufacturing practice.

2.5.9 Lead laden deposit would accumulate at the tank bottom of the dispenser with leaded soldering material or copper alloy components with relatively high lead content (say 3-6%) after it has been used for a long time without regular cleaning. The deposit may leach lead into the drinking water in the dispenser. Mild fruit acid (citric acid) is effective in removing the lead laden deposit.

3. Conclusions

3.1 Based on the testing results and the analysis, it is concluded that:

(a) Leaded soldering material is the major source of lead leading to excess lead in drinking water in dispensers after boiling, which is consistent with the results of the preliminary investigations for the 10 failed dispensers in kindergartens. Leaded soldering material should not be used in the fabrication of dispensers.

(b) Normally, if leaded soldering material is used at the inlet inside the dispenser, leaded soldering material will also be used in other parts of the dispenser. Therefore, checking the lead content in the soldering material at the inlet inside the dispenser will serve as a good indicator whether leaded soldering material has been used in the dispenser.

(c) Copper alloy outlet tap and level indicator holder nut (if in contact with hot water) normally leach much more lead than the other copper alloy components in the dispenser because of large contact surface area with hot water. Even the dispenser does not have leaded soldering material, copper alloy components in new dispensers will leach comparatively high level of lead in drinking water in the dispenser after boiling. However, the amount of lead leached from the new copper alloy components will reduce after a few boiling cycles and become stable. Therefore, the copper alloy components will not cause excess lead in the drinking water in the dispenser after it has been used for boiling water for a few times (say 4 times).

(d) **Based on (a), (b) and (c) above, if a dispenser has been used for some time (say over 4 times) and it does not have leaded soldering material detected at the inlet inside the dispenser, the risk of having excess lead in the drinking water in the dispenser should be low.**

(e) To avoid the risk of excess lead in drinking water in the dispenser, the soldering material used should be lead free. Besides, the components in the dispenser particularly those in contact with hot water should have low lead content (say not exceeding 1%).

(f) Usage pattern will have bearing on the amount of lead leached into the drinking water in dispensers because the amount of lead leached will increase with temperature and contact time with leaded material. As a result, prolonged boiling without consumption (and hence no replenishment of water) in dispensers should be avoided.

(g) Under normal usage with short boiling cycles (say 1 to 2 hours with replenishment), the lead content in the drinking water in new dispensers should be lower than the testing results in this investigation which were based on 24-hour boiling without replenishment.

(h) If dispensers are not cleaned regularly and they contain leaded material / components, lead laden deposit could accumulate in the dispensers which may leach lead into the drinking water in the dispensers.

4. Recommendations on New Dispensers

4.1 To avoid excess lead in the drinking water in dispensers, it is recommended to purchase products with international certification which normally includes testing of product safety such as those certified by the WaterMark of Australia, NSF/ANSI of the USA or the Water Regulations Advisory Scheme (WRAS) of the UK.

4.2 For dispensers without international certification, it is recommended that they should undergo type test by laboratories accredited by the Hong Kong Laboratory Accreditation Scheme (HOKLAS) in accordance with the procedures below.

Supplier / manufacturer of the dispenser shall submit the following to the HOKLAS accredited laboratories

(a) Certificate of the soldering material used in the dispenser to prove that it is lead free; and

(b) A sample of the model of the dispenser for testing by the laboratory.

The laboratory shall:

(a) Conduct test on the lead content in the drinking water in the dispenser after the water has been boiled and maintained at 100 ºC for 24 hours. The lead content shall comply with the PGV in WHO 2011 Guidelines. If testing of the contents of other heavy metals like nickel, chromium and cadmium in water is conducted in association with the above 24-hour boiling test, they should comply with the respective guideline values in WHO 2011 Guidelines.

If the product satisfies the above requirements, the HOKLAS accredited laboratory shall issue a type test report to the supplier / manufacturer.

4.3 Suppliers / manufacturers are encouraged to use components of low lead content (say not exceeding 1%) inside the dispensers.

4.4 Suppliers / manufacturers are recommended to display the type test report showing the compliance of lead content in water issued by the HOKLAS accredited laboratories for the dispenser and the supplementary information on the lead contents of the soldering material and components inside the dispenser at sale points for the information of the customers. The public are advised to purchase dispensers with type test reports issued by HOKLAS accredited laboratory and for prudence reason to check the supplementary information on lead free soldering material and components of low lead content (say not exceeding 1%) inside the dispensers, as these dispensers will have lower risk of excess lead in its drinking water.

(Note: If the suppliers / manufacturers provide false information on the lead contents of the soldering material and components inside the dispensers, they may contravene the Trade Descriptions Ordinance (Cap 362) for false trade description.)

4.5 The above proposal has been discussed with the HOKLAS accredited laboratories and major local suppliers and they are generally supportive of the proposal. The local HOKLAS accredited laboratories will require about one month for setting up for the type test for dispensers.

4.6 To ensure proper installation, it is recommended that a licensed plumber should be engaged to install the dispenser. A lead check should be conducted on the soldering material at the inlet inside the dispenser to confirm that it is lead free before the installation to further safeguard the water quality of the dispenser.

(Note: Lead check is a simple method to test the presence of lead on metal, wood or paint by using lead test swabs or papers. Different kinds of lead testing kits are available for sale at some hardware stores.)

4.7 It is recommended that new dispensers should be cleaned thoroughly with water and undergo a few times (say 4 times) of boiling with one-third full of fresh tap water every time before it is used for drinking purposes.

5. Advice to the Public on the Use of Existing Dispensers

5.1 If the owners of existing dispensers would like to make sure that the dispensers are lead-free, they should conduct a lead check for the soldering material at the inlet inside the dispenser or arrange to take boiled water sample from the outlet tap of the dispenser for testing for lead content by a HOKLAS accredited laboratory. If the lead check confirms that soldering material contains lead or lead in water exceeding the WHO Guidelines is confirmed, the dispenser should be replaced.

5.2 If the lead check confirms that the soldering material does not contain lead and the dispenser has been used for some time (say over 4 times), the risk of having excess lead in the drinking water in the dispenser should be low.

5.3 The following procedures for taking boiled water sample from the outlet tap of the dispenser should be followed:

(a) Take a water sample only after the water inside the dispenser has been cooled down naturally;
(b) Fill the water into a polyethylene sample bottle (250ml) prepared by a HOKLAS accredited laboratory and do it carefully to prevent overflow;
(c) Put the cap back on the sample bottle, ensure that it is tightly closed, and put on labels (with sampling location, date and time); and
(d) Store the water sample in an icebox with freezer packs and deliver it to the laboratory on the same day.

6. Good Practices in Using Dispensers

6.1 For dispensers without international certification, they should be cleaned regularly say every 6 months to prevent accumulation of dirt or other impurities according to the procedures below:
(a) Ensure that nobody takes water from the dispenser during the cleaning for drinking;
(b) Top up the dispenser and boil the water;

(c) Isolate the power supply and add small amount of mild fruit acid (citric acid) in powder form (about 20 grams for a 20L dispenser) into the dispenser;

(d) Keep the water in the dispenser for about 1 hour;

(e) Start the draining cycle by closing the inlet valve and then drain away the water inside the dispenser;

(f) Commence another draining cycle by opening the inlet valve for about 1 minute and then drain away the water in the dispenser again;

(g) After 4 or 5 draining cycles, fully open the inlet valve and resume the power supply when the tank is full.

6.2 It is recommended to switch off the power of the dispenser every night and during long holidays to avoid continuous automatic heating, which may increase the amount of lead leached into the water in the dispenser if it contains leaded material / components.

6.3 It is also recommended to drain away the water in the dispenser every morning. The drained water can be stored for non-drinking purposes.

Water Supplies Department
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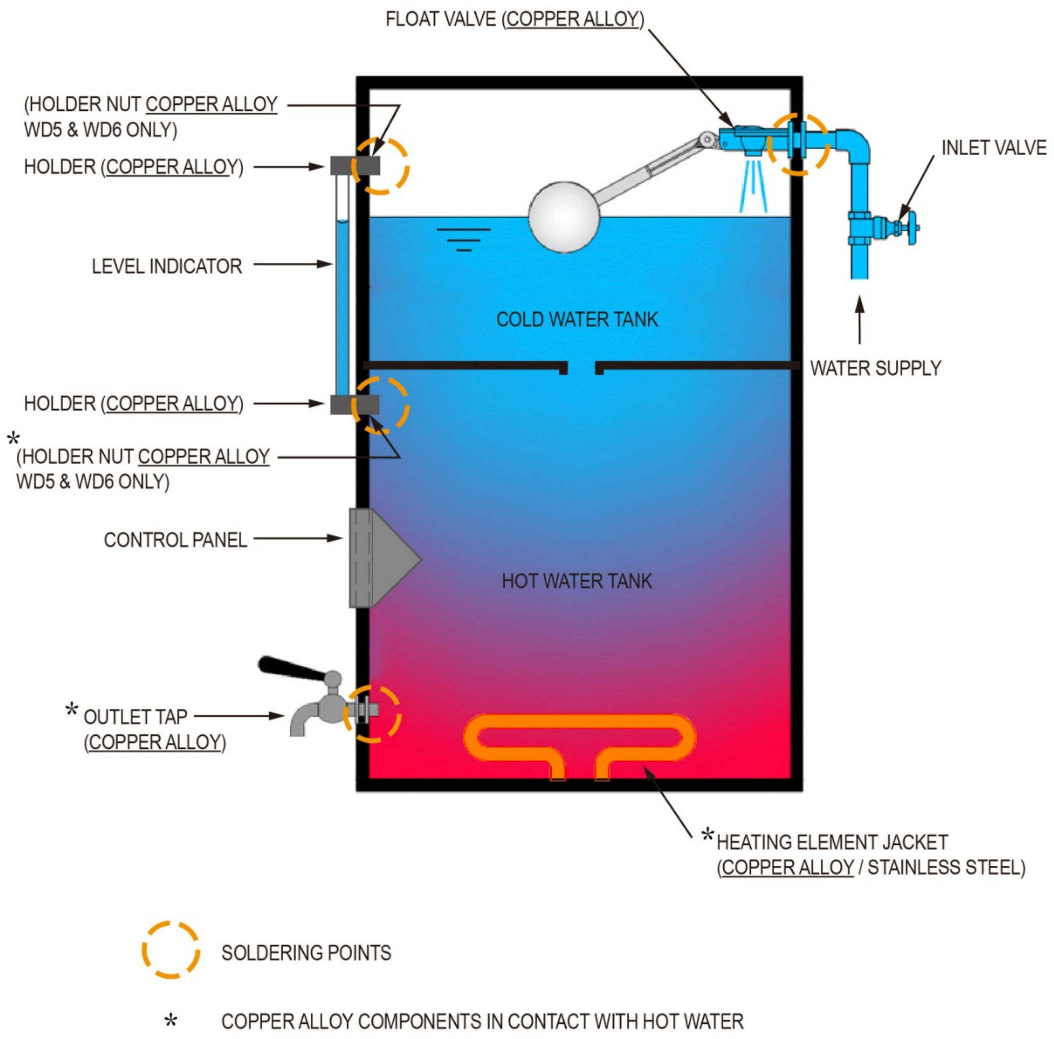
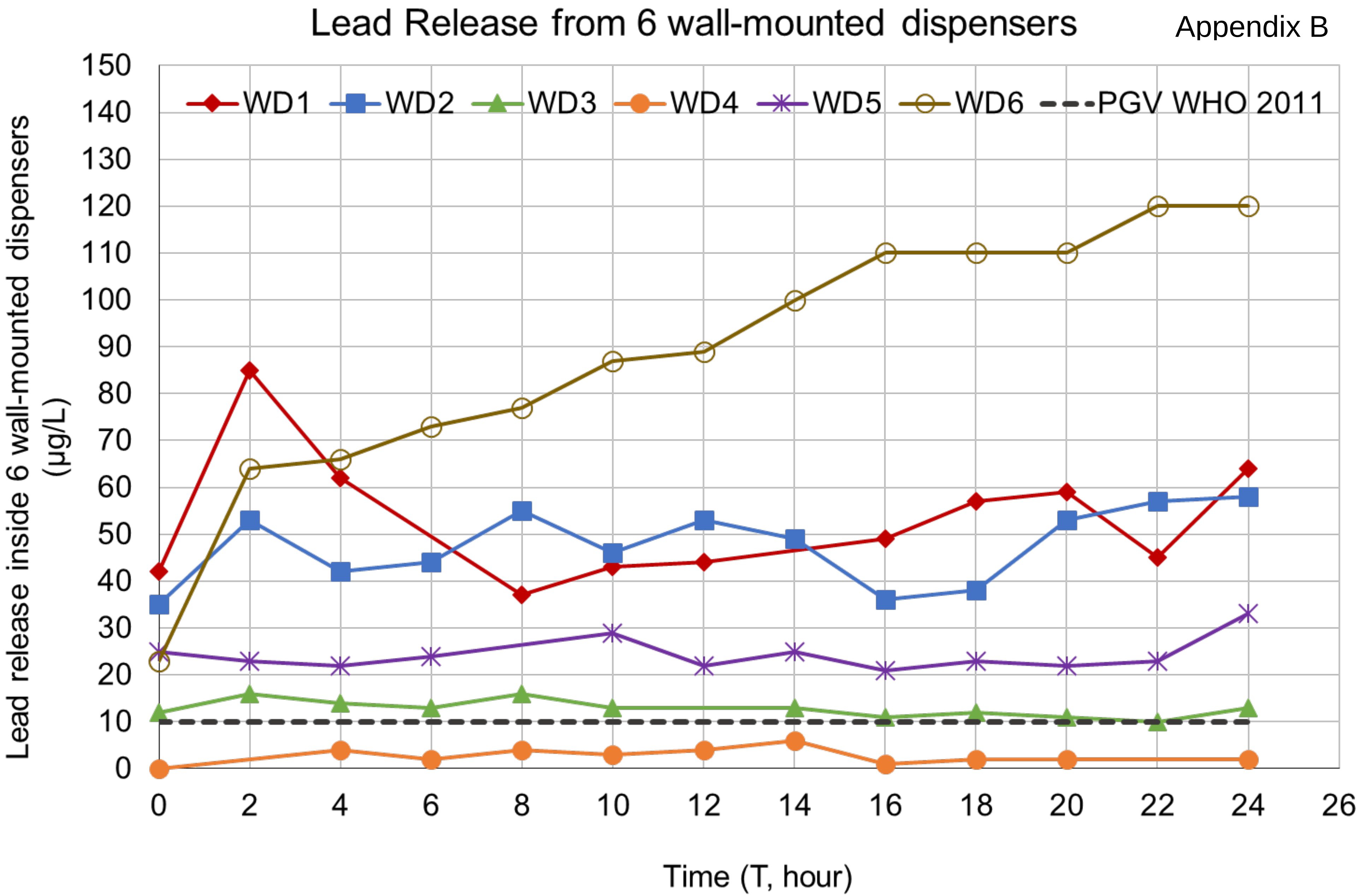
Appendix A

Typical Design of Wall-mounted Dispenser





Lead Release from 6 wall-mounted dispensers
Appendix B
WD1
WD2
WD3
WD4
WD5
WD6
PGV WHO 2011
Lead release inside 6 wall-mounted dispensers (µg/L)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
0
2
4
6
8
10
12
14
16
18
20
22
24
26
Time (T, hour)

Appendix C

Results of Boiling Tests for Copper Alloy Components

Dispensers	Nominal Size (Litres)	Lead Content in Drinking Water Samples at Outlet Taps (μg/L)	Key Copper Alloy Components (Lead Content)	Lead Content in Drinking Water in Each Boiling Cycle (μg/L)) (Amount of Lead Leached in Water in μg)		
				First Cycle	Second Cycle	Third Cycle
WD 3	20	10 – 16	Outlet tap (3.2 %)	12.4 (579μg)	11.8 (549μg)	3.4 (159μg)
WD 4	25	1 – 6	Outlet tap (1 %)	1.8 (56μg)	1.5 (47μg)	0.6 (19μg)
WD 5	30	21 – 33	Outlet tap (3.1 %)	10.1 (433μg)	9.8 (418μg)	3.7 (158μg)
			Heating element jacket (0.1 %)	0.1 (2μg)	0.2 (4μg)	0.1 (2μg)
			Level Indicator holder nut (3.4 %)	12.2 (262μg)	10.8 (232μg)	3.1 (67μg)
			Total	22.4	20.8	6.9
WD1	25	37 – 85	Outlet tap (3 %)	3.1 (151μg)		
			PGV in WHO 2011 for Lead Content	10μg/L		

Note:

- Lead content in drinking water = Amount of lead leached / Volume of hot water tank
- Volume of hot water tank for WD3, WD4, WD5 and WD1 are taken as 14 litres, 17 litres, 15 litres and 17 litres respectively.

As the whole outlet taps were immersed in the boiling test but the actual water contacting area for WD3, WD4, WD5 and WD1 were only about 30%, 55%, 35% and 35% of their total surface area respectively, the amounts of lead leached for outlet taps were therefore taken as 30%, 55%, 35% and 35% of the test results given in the above table respectively. For the copper alloy level indicator holder nut, since the nut was fixed on the stainless steel plate, only about 70% of total surface area was in contact with hot water and the amount of lead leached was taken as 70% of the test result given in the above table. For the heating element jacket, since it was fully immersed in hot water, the amount of lead leached was therefore taken as 100% of the test result given in the above table.