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DRINKING WATER SAFETY ADVISORY COMMITTEE

Findings of the Consultancy Study on Detachment of Internal Bitumen Lining in Fresh Water Mains

PURPOSE

1. This paper briefs members on the key findings of an ongoing study on Detachment of Internal Bitumen Lining in Fresh Water Mains ("the Study") commissioned by the Water Supplies Department ("WSD").

BACKGROUND

2. In the past, bitumen was generally used as the internal protection material for steel pipes. The bitumen had to comply with British Standard BS4147 "Specification for Bitumen Based Hot Applied Coating Materials for Protecting Iron and Steel, including Suitable Primers where required". According to this Standard, compliant bitumen lining of water mains shall be free from toxic hazard to drinking water supply. Owing to ageing, the linings of some of the steel fresh water mains in Hong Kong are found peeling off, resulting filing of complaints by members of the public. Since 2005, WSD has switched to the use of epoxy, which has stronger adhesion to steel pipes, in lieu of bitumen as the internal protection material for steel water mains, and yet there are about 700 km of steel fresh water mains with internal bitumen lining (hereafter referred to as "lining") in Hong Kong.

3. In February 2019, WSD commissioned a consultant to carry out the Study with the following key objectives:-

(a) to identify the mechanism of detachment of lining in steel fresh water mains;
(b) to assess the potential health risk(s) associated with consuming drinking water with bitumen particles coming from the detached lining;
(c) to assess the condition of the lining of the existing steel fresh water mains in Hong Kong; and
(d) to propose remedial measures and formulate strategy to tackle the issue of lining detachment as mentioned above.

ASSESSMENT OF HEALTH RISK CAUSED BY BITUMEN IN DRINKING WATER FROM DETACHED LINING

4. For task 3(b) above, after a comprehensive review of the international experience and practices including those of the World Health Organization ("WHO") and various jurisdictions[1], the Water Research Centre ("WRc") of the United Kingdom (one of the specialists of the consultant) advised that :-

(a) benzo(a)pyrene, which could be released from bitumen, should be the parameter for assessing the health risk(s); and

(b) the guideline value of 0.0007 mg/L (0.7 μg/L) for benzo(a)pyrene in the Guidelines for Drinking-water Quality of the WHO ("WHO Guidelines"), which is also the current standard value adopted in the Hong Kong Drinking Water Standard ("HKDWS"), should be used for the health risk assessment purpose.

The above advice of WRc is agreeable to Professor Doctor WONG Tze Wai[2] who is another specialist of the consultant.

5. Under the Study, the following drinking water samples have been tested in an accredited independent laboratory: -

(a) Without bitumen particle;
(b) With bitumen particles[3] of 1 gram and 10 grams[4] respectively soaked in the drinking water samples for at least 200 minutes;
(c) Without bitumen particle and boiled for 5 minutes; and
(d) With bitumen particles[3] of 1 gram and 10 grams respectively soaked in the drinking water samples for at least 200 minutes and boiled for 5 minutes.

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1 The jurisdictions included Scientific Committee on Food (European Commission), European Food Safety Authority (European Union), Drinking Water Inspectorate (United Kingdom), Drinking Water Quality Regulator for Scotland, United States Environmental Protection Agency, Health Canada, National Health and Medical Research Council (Australia), The New Zealand Ministry of Health, Singapore Food Agency, The Health Council of the Netherlands and International Agency for Research on Cancer.

2 Professor Doctor WONG Tze Wai is the Adjunct Professor of the Hong Kong Jockey Club School of Public Health and Primary Care, Faculty of Medicine, The Chinese University of Hong Kong.

3 The bitumen particles come from detached lining.

4 1 gram and 10 grams bitumen particles respectively from detached lining were added to the drinking water samples (each 3 litres (equivalent to 0.003m^3) in volume) to simulate extremely high concentration of bitumen in drinking water. This assumption was verified by the Fire Hydrant Flushing Survey (see below) conducted in existing steel fresh water mains with complaints of bitumen particles in drinking water that the average weight of bitumen particles collected was 1.2 grams per 100m^3 water flushed.

6. The bitumen particles used for preparing the above drinking water samples come from detached lining collected at strainers installed in the existing distribution networks with previous complaints of bitumen particles in drinking water. Detailed methodology and approach for the laboratory testing are documented in **Annex 1**.

7. The test results show that all the drinking water samples have undetectable benzo(a)pyrene content[5]. The Study therefore concludes that **the health risk caused by the presence of bitumen, detached from the water main lining, in drinking water is negligible**. In addition, the two specialists involved in the Study have agreed that no adverse health or toxicological effect is expected even if there is accidental ingestion of the bitumen particles due to the chemical inertness of bitumen.

8. Nonetheless, the presence of bitumen particles in drinking water could cause objectionable aesthetic effects that may undermine the confidence of consumers on the drinking water quality and will probably lead to complaints. Therefore, it is necessary to formulate a proper strategy to tackle the issue of lining detachment in steel fresh water mains in Hong Kong.

CONDITION ASSESSMENT ON DETACHMENT OF LINING IN STEEL FRESH WATER MAINS

9. For task 3(c) above, based on a desktop study and some site trials, the consultant has devised a Fire Hydrant Flushing ("FHF") Survey through which bitumen particles, if any, in the drinking water are collected from the discharge of a fire hydrant connected with some steel fresh water mains being surveyed. If bitumen particles are collected in the FHF Survey, it should reflect that the corresponding steel fresh water mains have the problem of lining detachment. As compared with other more sophisticated investigation methods, such as CCTV inspection, the FHF Survey will cause the least disruption to water supply and is therefore considered as an effective and practicable method for the purpose of the Study.

10. The FHF Survey, which will cover all the existing steel fresh water mains with lining in Hong Kong, is in progress and scheduled for completion in December 2020. Based on the survey results obtained so far, bitumen particles

[5] The detection limit of the testing equipment for benzo(a)pyrene is 0.05μg/L which is far below the guideline value and standard value of 0.7μg/L of the WHO Guidelines and HKDWS respectively.

have been captured at fire hydrants connected to steel fresh water mains supplying potable water to buildings which filed complaints on presence of bitumen particles in drinking water previously.

STRATEGY TO TACKLE LINING DETACHMENT IN STEEL FRESH WATER MAINS

11. For task 3(d) above, the following long and short term measures have been formulated under the Study:

LONG TERM MEASURES

12. Most of the steel fresh water mains with lining are large diameter (600 mm or above) water mains which are normally trunk mains or primary distribution mains. If they are to be replaced or rehabilitated in one go, it would definitely cause many impacts to the community (e.g. traffic impact, noise and dust nuisance, etc.), not to mention the huge funding requirement. Therefore, it is necessary to prioritise the replacement / rehabilitation works ("improvement works") of these steel fresh water mains based on the severity of the lining detachment as well as the level of consequence[6] of the lining detachment, which are elaborated in **Annex 2.** Accordingly, the replacement / rehabilitation works for the steel fresh water mains with lining in Hong Kong can be ranked as high, medium, medium-low and low priority. Besides, the steel fresh water mains with previous complaints of bitumen in drinking water will be assigned high priority for improvement works.

13. For effective implementation of the improvement works, the steel fresh water mains with high priority may be further packaged with due consideration of various relevant factors after further investigation. Such factors include the acceptable impacts to the community with respect to the scale of the proposed improvement works, the operational constraints of the water mains and relevant waterworks facilities, etc. Similar packaging can also be carried out in due course for the water mains with lower priorities.

14. For the water mains with medium priority and below, the Study recommended WSD conducting regular FHF Survey on them, either annually or bi-annually depending on the level of consequence of their lining detachment.

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[6] The level of consequence can be inferred based on the size, type and characteristic of consumers served by the steel fresh water mains i.e. the size of population served and whether the mains serve for essential installation(s) such as hospital without alternative source of supply.

This will enable continuous monitoring of any change in the severity of the lining detachment so that re-assessing of the priority for improvement works can be carried out if necessary.

SHORT TERM MEASURES

15. As mentioned in the paragraph 12 above, the improvement works for the steel fresh water mains concerned will take considerable time to implement. As such, strainers should be installed at strategic locations, where bitumen particles are found in the FHF Survey, as an interim precautionary measure to prevent bitumen particles of the detached lining from entering into the inside services. Regular cleansing of the installed strainers and regular flushing at fire hydrants connected to the steel fresh water mains with lining should also be conducted.

16. Where there are complaints of bitumen particles in drinking water, diversion works should also be considered, if feasible, by supplying water through water mains without the problem of detached lining to the affected population.

17. Based on our experience, implementation of the above interim measures is effective to minimize the occurrence of bitumen particles in drinking water.

Development Bureau
Water Supplies Department
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Annex 1

Methodology and Approach for the Laboratory Test on Health Risk of Bitumen in Drinking Water from Detached Lining

1. The methodology and approach for collection and preparation of bitumen samples and drinking water samples for the laboratory test on health risk caused by bitumen in drinking water from detached lining are as below.

2. Collection and Preparation of Bitumen Samples

- Bitumen samples were taken in early 2020 from detached lining collected at strainers installed in existing distribution networks with previous complaints of bitumen particles in drinking water.

- The bitumen samples were put inside a new sampling bag and were crushed into particles using a hammer. The sampling bag was chemically inert and abrasion resistant to ensure that no contamination would be caused by the sampling bag to the bitumen samples.

- A clean and chemically inert sieve was used to select the crushed bitumen particles with sizes of 3 mm and below for use in the test.

3. Collection and Preparation of Drinking Water Samples

- A bulk drinking water sample (treated water) was collected from Sha Tin Water Treatment Works by the accredited independent laboratory with assistance and supervision of WSD and the consultant. The sampling bottle for collection of the bulk drinking water sample was pre-cleansed and provided by the accredited independent laboratory.

- The collected bulk drinking water sample was divided into 8 drinking water samples (each 3 litres in volume). The crushed bitumen particles were added and soaked in the drinking water samples for at least 200 minutes as follows:

1.	Drinking water sample + 1 gram ("g") of bitumen particles
2.	Drinking water sample + 1g of bitumen particles (duplicate)
3.	Drinking water sample + 1g of bitumen particles; boiled for 5 minutes
4.	Drinking water sample + 1g of bitumen particles; boiled for 5 minutes (duplicate)
5.	Drinking water sample + 10g of bitumen particles
6.	Drinking water sample + 10g of bitumen particles (duplicate)
7.	Drinking water sample + 10g of bitumen particles; boiled for 5 minutes
8.	Drinking water sample + 10g of bitumen particles; boiled for 5 minutes (duplicate)

- The accredited independent laboratory also prepared the following "blank" drinking water samples (each 3 litres in volume) for control:

9.	Blank drinking water sample
10.	Blank drinking water sample; boiled for 5 minutes

- For the drinking water samples 1 to 8, they were filtered to remove the bitumen particles before the chemical analysis. The blank drinking water samples 9 and 10 underwent the same procedure before the chemical analysis. Equipment used for filtering was chemically inert to ensure no contamination to the drinking water samples.

- For drinking water samples that required boiling, they were continuously stirred during the boiling. The equipment for boiling the drinking water samples was chemically inert (e.g. a glass beaker) and properly covered during the boiling.

4. Testing of the Drinking Water Samples

- The drinking water samples were tested for the parameter with the detection limit of testing equipment as listed in the following table:

Parameter(s)		**Detection Limit**
Polycyclic Aromatic Hydrocarbons		
-	Benzo(a)pyrene	0.05 µg/L

Annex 2

Ranking Mechanism for the Priority of Improvement Works for Steel Fresh Water Mains with Internal Bitumen Lining

1. A matrix for ranking the priority of improvement works for steel fresh water mains with internal bitumen lining based on the "Presence of Bitumen in FHF survey" and "Level of Consequence" is shown in the table below.

		Level of Consequence (Population Affected, Y)		
		Significant ($Y \geq 20,000$ and/or fresh water supply to essential installation(s) such as hospital without alternative source of supply)	Moderate ($0 < Y < 20,000$)	Insignificant^ ($Y = 0$)
Presence of Bitumen in FHF Survey	Yes	High priority (including problematic mains)	Medium priority	Low priority
	No	Medium priority	Medium-Low priority	Low priority

Remarks:

^ Steel fresh water mains with "Insignificant" "Level of Consequence" are trunk mains for transferring fresh water between water treatment works, primary service reservoirs ("PSRs") and secondary service reservoirs ("SSRs"). Bitumen from detached lining of these water mains will normally be trapped in the PSRs or SSRs without affecting the consumers.