

Report

Study of

Lead in Drinking Water

in

Public Housing Estates

2 November 2015

**Task Force on Episode of Lead Residue Found in Tap Water
The Hong Kong Institution of Engineers**

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Taskforce Members

Steering

Chair Task Force	<i>Ir Peter Y WONG</i>	FHKIE FCIBSE FIET
Chair-HKIE BSD	<i>Ir K T CHEUK</i>	FHKIE FCIBSE FIMechE
Chair-CIBSE HKB	<i>Ir C M CHUNG</i>	MHKIE MCIBSE MIMechE
Chair-Research	<i>Ir Andrew M W WONG</i>	FHKIE FCIBSE FIMechE FIEAust MIFireE
Chair-Editorial	<i>Ir Dr P L YUEN</i>	FHKIE FCIBSE FIHEEM

Editorial

Chair	<i>Ir Dr P L YUEN</i>	FHKIE FCIBSE FIHEEM
	<i>Ir CM CHUNG</i>	MHKIE MCIBSE MIMechE
	<i>Ir Carrie CHEUNG</i>	MHKIE MICE
	<i>Mr Patrick W W LEE</i>	AMHKIE MCIBSE

Research

Chair	<i>Ir Andrew M W WONG</i>	FHKIE FCIBSE FIMechE FIEAust MIFireE
	<i>Ir K T CHEUK</i>	FHKIE FCIBSE FIMechE
	<i>Ir Dr Wai Ling LEE</i>	FHKIE FCIBSE
	<i>Ir Franky W L SHUM</i>	MHKIE MCIBSE MIMechE
	<i>Dr Benjamin P L HO</i>	Affiliate HKIE

Acknowledgement

Ir Raymond K S CHAN FHKIE	Ir Harry LEE MHKIE MICHEM	
Ir Jonathan M Y CHAN MHKIE MCIBSE	Ir Alan K M LEE MHKIE	
Ir T C Chan MHKIE MCIBSE	Ir K K LI FHKIE FCIBSE	
Ir Lawrence W C CHAN FHKIE FIMechE	Ir Joseph Y C LO MHKIE MCIBSE MIMechE	
Ir Kevin S N CHENG FHKIE FCIBSE MIMechE	Ir Clarence Y F MAK FHKIE FCIBSE MIFireE	
Mr Tommy T C LEUNG MCIBSE	Mr Derek L Y MAN AMHKIE	
Ir K K CHOY FHKIE FIMechE MICE	Mr Paul NG Graduate HKIE	
Ir Y M FAN MHKIE MIET	Mr Brian TAM MIMechE	
Ir C S HO MHKIE FCIBSE	Mr Ronne C C TANG	
Ir Dora HO MHKIE MCIBSE	Mr Raymond TO	
Ir Billy K L HO MHKIE MCIBSE	Ir Edward H L TSANG MHKIE MIET	
Ir Thomas O S HO FHKIE FICE FCIQB	Ir Jacky M K TSUI MHKIE MCIBSE MIMechE	
Mr H S KUOK	Ir Hyvan T Y WONG MHKIE MCIBSE MIMechE	
Mr Ivan KWAN	Ir K F YEE MHKIE FCIBSE FIET	
Ir Keith K F LAM MHKIE MIMechE	Mr K C YEUNG Graduate HKIE MSOE	
Ir Gilbert LAW FHKIE FCIBSE	Ir Mai YEUNG FHKIE	
Ir Brian LEE MHKIE	Ir Jeffrey YUNG MHKIE FCIBSE HonFSOE	
HKIE Australian Chapter	HKIE Canadian Chapter	HKIE UK Chapter
HKIE Building Services Division		
CIBSE Hong Kong Branch		

Special Acknowledgement

Mr Nick MEAD FCIBSE FIMechE

President 2014/15 - The Chartered Institution of Building Services Engineers, UK

Mr Chris NORTHEY MCIBSE FIHEEM FCIPHE MIET

President 2014/16 - The Institute of Healthcare Engineering and Estate Management, UK

Preface

October 2011 - HKSAR

In a paper submitted to HKSAR Legislative Council on the “Progress of Ten Major Infrastructure Projects”, an estimated cost-in-progress of over HK\$ 300 billion for seven projects was reported.

Circa 2011/2012 – Iran

The U.S. and allied nations had imposed embargoes. Iran was facing declining income from energy sales from international sanctions. Iran's rial currency fell to a new record low against the US dollar, having lost about 80% of its value since 2011.

September 2012 – Isfahan, Iran

Isfahan Petrochemical Co. halted operations because of insufficient funds to buy feedstock, pay wages and settle overdue debt. (MEHR News Agency, 2 Sept)

Isfahan Oil Refining Co. stopped supplying feedstock to Isfahan Petrochemical Co after outstanding accounts rose to more than 2.4 trillion rials (US\$ 196 million). (Bloomberg, 17 Sept).

October 2012 – Isfahan, Iran

Isfahan Water and Wastewater Co. issued a report¹ with the following mission quoted in the Abstract. (22 Oct):-

“Lead poisoning is an important water quality parameter. The variety of adverse health effects caused by lead accumulation in the human body warrants the investigation of lead concentrations in drinking water.”

¹ *“Release of Lead to Drinking Water from Water Services Connection Valves”, P. Bohlooli & S. Shamsaee, Isfahan Water and Wastewater Co., Isfahan, Iran [Report was originally written in Arabic; the quote was obtained from the English Abstract]*

Report on Study of Lead in Drinking Water in Public Housing Estates

I. BACKGROUND

The Hong Kong Institution of Engineers (**HKIE**) noted incidents of lead contaminant in drinking water initially found in one public housing estate spread continually fueling wide media coverages and causing uncertainties, worries and unnecessary panics to many in the whole summer. Crossed incubated with other isolated incidents, the HKIE was of the opinion that some of the contents of the later spree and reactions could be either taken out of context or bordering on misguided perception.

2. As the only institution by statute representing the engineering profession in HKSAR, the HKIE undertook the obligation of setting up a dedicated taskforce (**TF**) to look at this episode with the aim that the general public should be better and more accurately informed on the engineering aspect of this issue. This is in line with the pledge of the HKIE that the wellbeing of the public health is always a paramount factor for the engineering professionals to take note.

3. First and foremost, within the sphere of engineering practice plumbing is a very small part of the building services (**BS**) discipline.
4. However tiny, the intricacy of the system design is still complex and the implications of latent faults bringing risks to health cannot be undermined.
5. As such, even engineers proficient in disciplines¹ other than that of building services would not profess themselves being equally qualified to address the installations of plumbing systems, unless they were so specifically exposed.
6. It follows that the membership of the TF was largely drawn from the building services discipline. It was also a joint effort of the Building Services Division of the HKIE and the HK Branch of the Chartered Institution of Building Services Engineers, UK. In addition, the Australian Chapter, the Canadian Chapter and the UK Chapter of the HKIE had assisted in clarifying respective measures taken in overseas.
7. With this statement the HKIE hopes the authority of the engineer profession in offering confirmation of, comments to and clarifications on observations, worries, or propositions broadcast by other entities would be appreciated with due deserved acknowledgement.

¹ Before the recognition of building services as one of the qualified disciplines for employment within the grades of professional engineer by the Administration, engineers in mechanical engineering discipline were, and many still are, responsible for the design, supervision and commissioning of plumbing and drainage installations.

II. INTRODUCTION

8. Water quality at the tap is affected by both the distribution system fed from the water treatment plants to discharge points before entry to premises and the construction work of plumbing systems installed inside superstructures and buildings².

9. There are many contaminants in drinking water that would degrade the quality. One of the important factors influencing the quality of water supplied to tenants is the effect of various materials that come into contact with the water as it passes through the system.

10. The study carried out for this report was focused on the metal lead, the residue of which could critically affect one's health in long term.

11. This report is not meant to be exhaustive. The scope of the study is confined to the installations of plumbing systems using copper pipes and copper and copper alloy fittings in the public housing estates.

12. The distribution side was not investigated not only due to limitation of time and other constraints, but also the HKIE was quite confident that the water quality of the distribution system under the ambit of Water Supplies Department (**WSD**) has always been in good order as demonstrated by track records validated by information collected from our members working in the Department and other organisations³

² Plumbing system installed inside buildings is defined as “Inside Service” under Cap 102

³ The Audit Commission had submitted a report in 1999 had similar conclusion

carrying out periodic monitoring and researches for WSD throughout the years.

13. In essence, the TF was to assess how the plumbing work was carried out in the public housing estates in the light of the requirements of the ordinance and regulations and whether the quality of drinking water was diligently safeguarded, and, if not any plausible causes. The TF would limit the coverage of the plumbing part of fire services in this report as much as possible.

14. The HKIE wished to reiterate that without details on how contracts were implemented in any specific project, observations and conclusions made in this report were at the system and structural level and not whether any specific contracting parties were responsible for deficiency found, if any.

15. The HKIE also wished to add that apart from the impact to health due to heavy metals, other concerns - bacterium like Legionella Pneumophila just to name one - in drinking water are equally paramount. The HKIE would leave the impacts from such on health for other professionals to address.

16. Nonetheless, it would be an opportune juncture to carry out a holistic and system-wise review of our drinking water supplies at the tap in public housings.

17. The TF was of the view the following scope of coverage for study should be adequate for the purpose of this report:-

- a. governing ordinances and regulations in term of licensing of plumbers, equipment standards, control & monitoring sequence on installations, and overseas trend and experience
- b. public housing estates plumbing contract format, procurement, work supervision and the underlying structure of engineering engagement
- c. observations
- d. recommendations

III. THE STUDY

PART I

Ordinance and Regulations

18. The primary instruments governing the provision of safe drinking water are the Waterworks Ordinance (**Cap 102**) and the sub-legislature Waterworks Regulations (**Cap 102A**) under the Water Authority (**Authority**) delegated to WSD for enforcement.

Provisions

19. The TF considered the following provisions in Cap 102 were relevant for this report:-

S2 – Interpretation

“Licensed Plumber” is defined as a person licensed under this ordinance to construct, install, maintain, alter, repair or remove fire services or inside services.

“Inside Service” is defined as the pipes and fittings in premises, and any pipes and fittings between the premises and a connection to the main, (other than the pipes and fittings forming part of a fire service) which are used or are intended to be used for the purpose of a supply.

s15(1) - Subject to subsection (2), no fire service or inside service shall be constructed, installed, maintained, altered, repaired or removed by a person other than a licensed plumber...

s15(2) - Alteration or repairs to a fire service or inside service which are, in the opinion of the Water Authority, of a minor nature, or the rewashing of a tap, may be carried out by a person other than a licensed plumber...

s16(1) - The Water Authority may, if he is satisfied that a fire service or inside service-

- a. *is in such a condition that waste or pollution of a supply has occurred or is likely to be caused thereby,*
- b. *– (not relevant for this report) –*
- c. *does not comply with the provisions of this Ordinance, by notice require the consumer to carry out the repairs or other works specified in the notice to the fire service or inside service.*

s34(1)(a) - In any civil or criminal proceedings it shall be presumed, until the contrary is proved, that in the case of any alteration or repairs to a fire service or inside service (other than a communal service), the consumer has caused or permitted the alteration or repairs.

20. By examining the format of applications and approval process of plumbing work, the TF now turns to assess how the authority vested under Cap 102 and Cap 102A was implemented at the working level by WSD.

Form WWO 46 (6/2012a)

21. The form itself was intended to cover both new installation and alteration work. This arrangement does cause some confusion that would be covered in paragraphs that follow.

New Installation

22. For new building project installations, the appointed Authorized Person (**AP**) was required to signify their approval or endorsement by signing Parts I & IV. Likewise the applicant was required to signify the same by signing Parts II & IV.

23. The TF believed that the reason for the applicants being specifically required signing Part II *alone* is to ensure the applicants were

duly put on notice for their endorsement of information contained in the Part I.

24. Getting down to the fine prints, in Part I, it stated:-

“A set of duly completed Annex to this Form is attached to show details of pipes and fittings installed / intended to be installed at the above premises”.

25. In the appended Notes, item 5 stated:-

“A copy of the form will be returned to the Licensed Plumber with signature of staff of the Water Authority in Part III and/or Part V or where appropriate.”

26. Item (II)(iii) of Completion of Plumbing Works under the accompanied guidance notes to licensed plumber for submission stated:-

“On completion of the inspection works, Licensed Plumber will receive Part V of the Form. A copy of Parts I, II, III and IV of the Form will also be returned to Licensed Plumber.”

27. With new installations, the Licensed Plumber (LP) is not obliged to turn over copies of all parts of Form WWO 46 together with relevant drawings to the APs and the applicants.

28. From Part IV itself, it appears the role of the AP is to ascertain the position of meter installation and nothing else on completion whilst the AP had to endorse the installation details contained in Part I.

29. By virtue of Part I, there was no provision that AP would be subsequently, let alone timely, informed on any communications between WSD and LP including those necessitating changes of the installation albeit AP was one of the parties jointly and severally responsible for the technical submission of the project.

Alteration & Minor Repairs

30. For alteration and repairs, as gathered from the format of Form WWO 46, both the AP and the applicant would not be involved. The LP would deal directly with WSD via Parts I, III, IV & V. The LP is also not obliged to hand over the same details to the applicant for record.

31. From the Form WWO 46 alone, the TF could not find clear indication of what would constitute as a minor work nature, except rewashering of a tap as previously stated under s15(2).

32. The uncertainty was further complicated by the provision that “*a person other than a LP*” could carry out such alteration or repairs of a minor nature under the same s15(2).

33. Unless there was a separate application form unbeknown, the TF could only presume Part I would be the instrument to be submitted for the Authority to consider whether the scope of work was of a minor nature that “*a person other than a LP*” could carry out.

34. Since Part 1 would require his signature, a LP must first file the application for the kind of work that “*a person other than a LP*” could perform.

35. If affirmative, the TF presumed Part III would be returned to the LP with due decision from the Authority that paradoxically his possession of a LP license was not necessary in carrying out the submitted scope of work, if indeed it turned out to be the case.

36. The TF would not speculate the root that caused this paradox but would conclude the setting out of Form WWO 46 was not capable to take into account of s15(2) causing further confusion, as claimed by the trade, when the class Grade II of LP was repealed in October 1992.

37. The TF could only note that the consumer would not be in a position to know if the alteration or repairs works were carried out by an individual, “*whether a person other than a LP*” or in fact a LP, for exemption under s15(2) unless the record kept at WSD was true and accurate, and free of omissions and errors, as per the state on completion, if any record was so submitted *ab initio*.

38. That is, if the LP did not submit application of alteration and repairs work under the Form WWO 046, obviously such kind of work would not reach the stage of Part V and no record would be stored at the WSD computer.

39. The implication to consumers under s34(1)(a) in this circumstance is hence anybody’s imagination. This should be an area that further clarification is required.

40. The ultimate position is that the applicants should receive a copy of the completed job in full details for record, even involving the changing a faucet, to run their own verifications of equipment brands and/or models as installed on completion up front and assist their defence of s34(1)(a) if it ever comes to that at a later stage.

Annex to Form WWO 046

41. The TF found the annex table “*PIPES AND FITTINGS*” was in good order. It is not known how frequent “*Testing of Samples*” would be carried out.

42. The TF noted only three of those British Standards specified for products compliance in Note 7(i) was still valid and the rest were outdated. A comparison for those outdated is listed below:-

Specified	Current Standards
BS 1010	BS EN 200:2008
BS 1387	BS EN 10255:2004
BS 1415	BS EN 1286:1999 & BS EN 1287:1999
BS 3505	BS EN ISO 1452-1:2009, 1452-2:2009, 1452-3:2010, 1452-4:2009, & 1452-5:2009
BS 4127	BS EN 10312:2002
BS 4622	Withdrawn in 2013 ⁴
BS 4772	BS EN 598:2007+A1:2009, BS EN 545:2010, & BS EN 969:2009
BS 5154	BS EN 12288:2010
BS 6572	BS EN 12201-1:2011, 12201-2+A1:2013, 12201-3+A1:2012, 12201-4:2012, & 12201-5:2011
BS 6730	BS EN 12201-1:2011, 12201-2:2011+A1:2013 & 12201-5:2011
BS 7291	Part 4 withdrawn in 2013

43. For engineering specifications it is imperative to ensure that obsolete standards shall not be specified.

⁴ Broken down and now covered under many different standards, BSI was kind enough to provide a specific link covering “*iron pipe and fitting*” for ease of reference <http://shop.bsigroup.com/SearchResults/?q=iron%20pipes%20and%20fittings>

44. When a particular standard was under reviewed or to be withdrawn or repealed by revisions or a new one, ample time was allowed for the changes by the promulgating authority allowing the manufacturers, the designers and the industry to cope in order to minimise disarray and assist smooth transitions.

45. The TF considered the lapse of WSD failing to replace those obsolete specifications by current standards was a very serious matter, considering a few of them had already expired for over a decade. An updated list of relevant British Standards is attached. [**Appendix A**]

46. It was plausible that there were no dedicated personnel or an engineering section to monitor the plumbing installations even though this should be a part of WSD's responsibility. The TF would further examine this in later paragraphs.

47. Under Note 7(ii) four categories of fittings for compliance were listed.

48. Category A bears the "*British Standards Kitemark*". Category B relied on approval from a UK Regulation and Category C under the Authority's own approval arrangement. Under Category D, WSD would put its own departmental stamp on the fittings, typically the valves, but for a long period it was no longer exercised.

49. The Kitemark[®] specified under Category A is a quality assurance scheme. The TF was informed that most of the fittings submitted to

WSD for approval were on the strength of laboratory type-test reports, usually under Category C.

50. Unless WSD had exercised the same measures ensuring fittings submitted for approval under Categories B & C were also of an equivalent quality monitoring scheme as Kitemark[®] in Category A, there might not be incentive for LP seeking products manufactured with similar quality assurance certification.

51. The TF believed that it is important to require copper pipes and fittings installed in the potable system with quality assurance scheme certification to lend proper protection to public health.

Licensed Plumber

52. WSD on behalf of the Authority issues licenses for plumbers. As from October 1992, only Grade I class would be issued with Grade II to be faded out.

53. The TF had no evidence to ascertain whether this decision was to group new construction and alteration work under the same control mechanism or whether the aim was to lessen the burden of monitoring those minor alteration and repairs.

Qualification

54. Application for Grade I Plumber's License is by Form WWO 495 (9/2014). By Regulation 33, for registration as a LP, a plumbing worker should have completed the 3-year Craft Certificate in Plumbing and

Pipefitting program⁵ or other accepted equivalent training plus a pass in the 39-hour Certificate in Plumbing Service (Hong Kong)⁶. The latter included both written and practical tests⁷.

55. The TF opined the arrangement for LP to be solely responsible for all scopes of work is no longer adequate.

WSD Supervision on LP

56. As noted the class Grade II LP meant to carry out alteration work was repealed in October 1992. The TF appreciated the burden to monitor minor repairs work was insurmountable.

57. Equally for new construction work, the TF was also informed by the trade WSD was not that ‘vigorous’ in inspecting plumbing installations, or the “inside service” as defined in Cap 102, of new premises, comparing to the attention given on the meter locations.

58. The TF would leave this to WSD to further investigate whether our intelligence gathered from the industry for above was correct.

⁵ Regulation 33(1)(a), Program 53776 or 55776 offered by the VTC.

⁶ Regulation 33(1)(b), Program 56767 offered by the VTC

⁷ Passing rates of Course 56767 conducted by the VTC were less than 40% which is about the same as that of Registered Electrical Workers. A Pass in Course 56767 requires satisfactory results of both written test on the knowledge of Cap 102A and a practical skill test including joint soldering. The statistic showed those have been engaged in the trade (after taking prerequisite Program 53776 or 55776) had a higher passing rate in the practical test but lower in the written one. It was the contrary for those who were exempted from taking the prerequisite programs for straight admission to Course 56767.

59. But the TF did note in Part IV the LP, the applicant and the AP were only required to confirm “*the correctness of the meter positions*” as indicated by the LP and nothing more or anything related to other details of the installations.

60. The TF understood save a separate electrical & mechanical section undertaking work on the distribution system, WSD has no independent building services section to cover, *inter alia*, the demanding workload of inspecting plumbing installations in new buildings. If indeed the case this deficiency must be addressed.

61. The TF considered setting up a strata system of a responsible parties and personnel to cover various aspects of the construction side would be in order and conducive for WSD enforcing the regulations.

[Appendix B]

Credit Due

62. In fairness the TF noted the Consumer section of WSD has received wide acclaim. The publication of LP contacts by districts for the consumers' ease of reference and the readiness to assist can be summarised by the exemplary remark "*the phone was always answered by a person at the other end*" picked up in one of the interviews conducted. No mean feat.

63. In appreciation the TF noted the water quality on the distribution side has been kept at a world class standard, and it is just across the building boundaries where the scope and scale of monitoring should demand added attention, perhaps, by a different and dedicated engineering team or a section.

PART I (continued)

Contamination

64. In a drinking water distribution, corrosion of metal and metal alloy from reactions with the running water and the environment could cause a leach of contaminant in the system.

65. Broadly speaking there are two sectors that the quality of water should be put under surveillance. The supply side, from sources, reservoirs, treatment plants, ducts to discharge tanks and connection points before entry to tenancy.

66. The other sector is where the occupants would find from the tap, after the distribution through the plumbing installations in the premises. Here is where the TF found WSD has room to improve, putting it mildly.

67. Different from other chemicals, lead found in drinking water mostly arises from the plumbing installations in buildings. This section will delineate what could have caused the lead contamination found in the plumbing installations.

68. The followings are a brief coverage of the various contributing factors:

Metal and Metal Alloy

69. Metal dissolved in water in a rate depending on the type of metal and metal alloy and the circumstances under which the metal and metal alloy were exposed.

70. This is a very complicated topic and constantly subject to researches across the globe. As stated this report would limit to copper and copper alloy within the areas that were of immediate interest.

Copper Pipes

71. Copper pipes are now commonly used in the domestic plumbing installations in Hong Kong. Copper, in contact with water running through it would develop a protective layer of copper oxides and copper carbonates on the inner sides limiting the amount of copper that can dissolve into the water at values usually well below the maximum allowance. Impurities, depending on the types, inside the copper pipes would react differently.

72. Copper pipes complying with BS EN 1057 are of minimum 99.9% copper content (including silver). Unless substandard copper pipes were used, lead contamination from the copper pipes as a source could be negligible.

Copper Alloy Fittings

73. Fittings and accessories are either of copper with the same material of copper pipes or of brass and bronze. In plumbing installations of residential developments, brass is used in domestic fittings and bronze in valves.

74. Brass is the generic name for alloys made primarily from copper and zinc with some impurities including lead. These fittings are often chromium-nickel coated. The lead content in brass is between 2% to 8%. The proportion of zinc is in the range of 30-40% but can be lower.

75. Bronze is an alloy basically of copper and tin; and lead is usually added for manufacturing processing. During the casting process of fittings, the lead in these alloys with lower melting temperature would solidify last to fill in any 'pore-holes'. Bronze is stronger than brass and hence more suitable for manufacturing valves.

Lead leaching from copper alloy

76. Lead may leach into the potable water system from meters, pipes, brass fittings, bronzes fittings, solder joints, faucets, shower heads and goose necks.

77. The TF found the study report⁸ published by UK Water Industry Research Limited on brass fitting could serve some insights on the leaching behavior of lead and is summarized below:-

The leaching characteristics of brass fittings⁹ would depend on individual make and lead could leach throughout their lifetimes. Concentration would fall off over time after levelling off in a few weeks to a few months.

Lead concentration increase with increasing stagnation time but the most substantial increase generally occurs during the first few hours. The characteristic of the water in supply, in particular the hardness would affect the leaching trend - higher in soft waters.

78. The leaching trend also depends on the manufacturing technique, the alloy grades used as well as the surface areas in contact.

79. Again, unless substandard fittings were installed in the first place or actual causes were found, replacing brass taps fittings is no guarantee of reducing observed lead concentrations.

Soldering

80. Connection of pipes by soldering is quite numerous but not a big part of the whole plumbing installation. With the attention it received

⁸ *Brass fitting – A source of Lead in Drinking Water?*, Report No. 14/DW/04/14, UK Water Industry Research Limited

⁹ Brass fittings contain less content of lead than that made of Bronzes. Due to the softer nature of the former, if dezincification occurs, leaching of lead could be more likely than that of the latter which is more resistant to corrosion.

throughout the episode, the TF felt it should deserve its own heading in this study.

81. There are actually two types of soldering materials, viz. in the trade they are usually called as tin-solder or soft soldering and silver brazing or hard soldering.

82. With advancement in extrusion technology copper pipes can be manufactured in thinner thickness. Consequently jointing of pipes, in particular those of smaller diameters used in the plumbing installations are now by soldering instead of threaded connection which is still used in steel conduit and pipes installations, as in fire services.

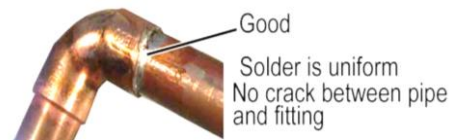
83. For the soldering method, capillary fittings formed from copper tubes or copper alloys made by pressing or stamping process would be used.

84. The physical work of using solder joining pipes with capillary fittings is a handy one requiring attention, care, patience and steady hands.

85. The demanding part is the experience to note the moment of reaching the desired temperature and the dexterity of filling a right amount of solder to end-feed the narrow gap between the fittings and the pipes. Propane tank and blowtorch are needed to heat up the assembly.

86. The skill required is relatively straight forward (even implicitly advertised as being so)¹⁰ but surprisingly it appears it was not mastered that well for some who intended to be qualified as LP in Hong Kong¹¹.

87. With the right amount of flux and at the right temperature, by the effect of capillarity a skilled plumber can let the solder self-feeding like a melting butter to make the assembly water-tight.

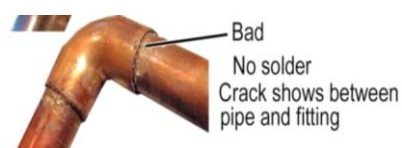


<http://waterheatertimer.org/How-to-solder-pipes.html>

88. Impatient is often one of the causes of poorly made joint. Substandard fittings or pipes not manufactured at proper tolerance could make the gap larger rendering it difficult to do a good connection.

Tin Solder

89. Lead-free tin solder was stipulated and had been used in overseas for over two decades and that lead contamination from solder was not a common cause due to the ban since. Tin soldering as one of the approved materials for joining the copper pipes was specified by WSD. It was to be “lead-free”.



<http://waterheatertimer.org/How-to-solder-pipes.html>

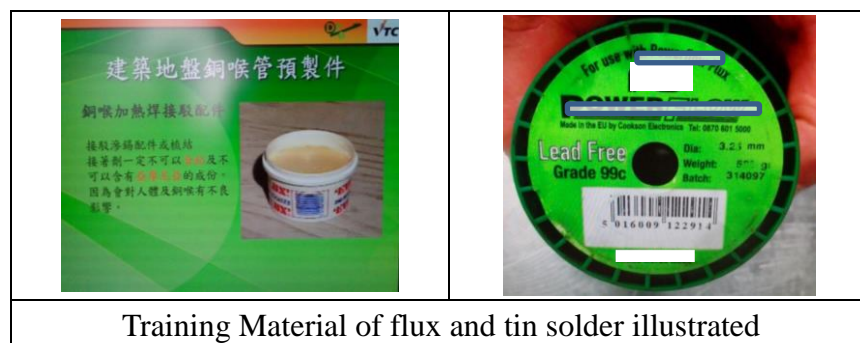
¹⁰ A DIY instruction with average home consumers as the targeted readers can be found in an advertisement <http://waterheatertimer.org/How-to-solder-pipes.html>

¹¹ See Footnote 7

90. WSD issued a Circular letter No. 1/2015 on 13 July ‘reminding’ lead-free tin solders is a requirement as specified in the standards stipulated in Cap 102A. After a scrutiny check the TF was satisfied that lead-free tin solder was not explicitly or implicitly stated as a specification in WSD various materials searched. [Appendix C]

91. Clear specification amiss or otherwise, in practice the TF was informed colleagues from WSD had constantly repeated the importance of using ammonia free flux and lead free tin solders in periodical reviews of Course 56767, the running of which was dedicated to Vocational Training Council (VTC) by WSD for LP applications.

92. The VTC was kind enough to provide the followings training excerpts showing trainees were duly instructed on the use of proper materials:-



學生姓名： _____ 日期： _____
 班別/編號： _____ () 得分 _____ / 9

工作紙

【觀賞影片 (T01A03)】

目的：
藉著觀賞短片認識接駁管道的要求及規格

任務：
依下列指示回答各題 時間：15分鐘

1. 銅喉管的銀焊接之焊接劑，是不能含有哪種化學物質？
 答： 鉛及亞摩尼亞

2. 屈曲銅喉管時，哪類直徑以下的銅管最為適合？
 答： 28mm 或以下

Test Paper

93. Relying to the HKIE's inquiry the Construction Industry Council (CIC) advised relevant courses conducted by the CIC stipulated the use of lead-free solder and trainees were reminded of using of such throughout.

Silver brazing

94. Silver brazing complying with BS EN ISO 17672 is another type of soldering material. This type of material is basically copper with about 2% of silver plus a small content of impurities. The product usually comes in rod-form instead of the usual coil-form as with tin solder.

95. The completed assembly of joints done with silver brazing is stronger than that with tin solder and is usually specified for heavy duty performance and in high pressure applications.

96. For private developments, all copper pipes are concealed: behind building finishes, above decorative ceiling, behind kitchen cabinets, and so forth. The need to ensure a tightly sealed connection does not need to be emphasis more as it would be prohibitively expensive to carry out repair

and rectification if there is any leak. Some developers only allow the use of the stronger silver brazing.

97. The TF found about half the standard specifications from Mechanical, Electrical, & Plumbing Engineering consultants (MEP) stipulated silver brazing either for all joints or for jointing pipes above 54mm diameter.

98. It is noted some workers are not that comfortable with silver brazing connection methods, usually due to lack of experience. But for some plumbing contractors even at a higher cost, about 3 times more for a 54mm capillary connection, it is not uncommon to opt for silver brazing to ensure quality and reliability.

99. At about 400-450°C, the required temperature for using silver brazing is higher than that of the tin solder (200-250°C) and would cause the pipes more docile in the heating process requiring additional care in handling than using tin solder.

100. With this high temperature range the use of larger bottled oxygen-acetylene is required and addition attention is needed when carrying out work on the external walls in a gondola.

101. One characteristic is that the high temperature treatment would turn the surface color of a silver brazing joint a bit whitish for easy inspection.

Flux

102. For soldering connection, the use of flux is needed to create and maintain oxide free surfaces on the surfaces of copper during jointing for a sound bonding with the tin solder material.

103. Flux is corrosive to copper. If excessive flux is used to make a solder joint, when heat is applied to melt the solder, the excess flux may flow along and leak through the joint in contact with and contaminate the water but the effect is usually short termed.

104. Residues of flux left in the pipes after the joint has been made may continue to corrode the copper and cause pitting corrosion. Flux with ammonia or mercury content could create stress points to the copper forming localised corrosion.

105. There are other poorly made jointing and connections due to spitting of molted solder creating balls and tails in the proximity of joints either because of poor workmanship or slightly over-sized fittings. The TF believed the technicality of which would be beyond the scope of this study.

106. The TF opined that strict adherence to BS EN ISO 9453:2014 for lead-free tin solder and BS EN 1254 Part 1 for the capillary fittings manufactured within proper gap tolerances between the pipes and the fittings for the solder drawn by a capillary action would be essential for LP performing proper jointing.

Other Joints

107. For the sake of completeness the TF would briefly visit the other fittings and methods of pipes connections:-

108. Basically besides soldering in-situ there are other methods in joining copper pipes in plumbing installations.

- a. Integral solder ring
- b. Built in assembly
- c. By tools

109. Integral solder ring fittings must be of good quality for proper jointing. Most of the fittings are silver brazing version. Some projects in HK specially specified this type. Faster and tidier job on site as there is no need to use flux. The contact surfaces must be clean. It is less popular for larger scale construction projects due to costs.



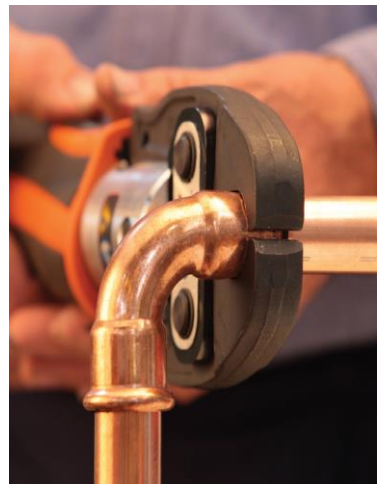
Integral Ring of Silver Brazing material

110. Compression fittings are stamped or sand-cast from copper alloys. Nuts are tightened to seal the joint and no heat is required. It is more expensive and not popular with concealed piping work. The skill level required is less demanding. The joint is not as robust as that from soldering. Often used down stream and at locations with ease for repairs access.



111. Push-fit fittings are made of copper or copper alloy. The jointing of two pieces of pipes is done with force either by hand or a tool. An internal assembly of accessories, typically an “O” ring, would be set in by the mechanical interference to achieve watertight sealing and no heat is required. Surface must be clean before jointing. Many of these fittings could be disconnected and reused. Due to small physical dimension, these fittings are highly versatile and reliable.

112. Crimping fittings are made of the same material as copper pipes. The jointing is done without the need of soldering, adhesive or other jointing material that might cause corrosion and no heat is required. Proprietary crimping tool is needed to make the connection. The advantage is skilled worker is not required. The disadvantage is the tool is quite bulky making it difficult to operate in tight corners.



System Integrity

113. A potable water installation comprising of pipes and joints should be designed to last for 50 years, taking proper consideration of maintenance and operation condition. It has been proved that using capillary joints together with tin solder have become such a reliable part of installation practice to such an extent they last the entire lifetime of the systems on which they are part of.

114. Badly made joints or bends would cause excessive turbulence and localized high water velocity producing alternating stresses to the system. Erosion or corrosion can also occur by trapped cavity or air bubble of joints in an area of negative pressure.

115. All said and done, at the time of writing the TF was informed there were at least three public housing estates done with tin soldering method with no excess lead contamination found.

Preventive Measures

116. The quality of water in distribution could be affected by potential corrosion of various materials that come into contact with the water as it passes through the system. It becomes more critical when the residence time of the water in contact with the system increases with the size of the distribution system decreasing from water supply to reticulation and to the plumbing installations.

117. Corrosion itself is difficult to measure by a simple and single method but the level of lead found at the tenant's tap outlet could give a good indication of the extent of corrosion. The main contaminant of concern is lead. By reducing exposure of tenants to lead may also reduce the exposure to other contaminants.

Supply Side

118. Drinking water in general can be made less corrosive by adjusting its pH or alkalinity at the water treatment plants in reducing corrosion in

the distribution systems and leaching of contaminants in the distributed water¹².

119. Under certain conditions brasses which contain lead may suffer dezincification, a process of selective dissolution of zinc leaving a porous and low strength copper structure behind. With drinking water at pH at a level below 7, plumbosolvency, or the presence of elevated lead concentration in drinking water would occur.

120. Raising the pH remains one of the most effective methods for reducing lead and copper corrosion and minimising lead, copper and iron level in drinking water. Although increasing alkalinity has traditionally been recommended for corrosion control, it is not clear if it is the best means to reduce levels of lead and copper in drinking water.

121. Maintaining proper pH and alkalinity value in a distribution system is a complex matter. There is only a range that suits best related to the leaching of lead from alloy or solder but the combined range is not clear.

122. Due to diverse limitations on the distribution system side, controlling lead content and ensuring material safety from performance of products that come into contact with the drinking water is often a better option.

¹² *“Protection of water supplies from contamination is the first line of defence. Source protection is almost invariably the best method of ensuring safe drinking-water and is to be preferred to treating a contaminated water supply to render it suitable for consumption”*, WHO 1993

Flushing

123. On completion of a project, the plumbing system should be flushed with clean water to remove debris and other foreign matters at full water velocity until the whole system is thoroughly flushed. This could remove reactants like flux residue to minimise pipe works deterioration.

124. All outlets had to be opened to prevent foreign matters from being simply relocated from one section of pipe work to other.

125. Depending on the size of the system flushing is to be repeated to ensure no other extraneous matters were brought into the system in the interim until it was brought to the regular use.

126. During normal usage, periodical flushing would reduce contaminants in particular after prolonged stagnation. When alteration work had been carried out with new brass fittings installed, flushing should be carried out.

‘Zero-lead’ Fittings

127. The approach taken by the States was passing a new legislature¹³ in January 2014 stipulating that the weighted average¹⁴ of all plumbing pipes and fittings in the US would have no more than 0.25% lead or less

¹³ Safe Drinking Water Act (SDWA)

¹⁴ s1417(d), SDWA defines “lead free” to mean “not containing more than 0.2% lead when used with respect to solder and flux and not more than a weighted average 0.25% lead when used with respect to the wetted surface of pipes, pipe fittings, plumbing fittings and fixtures”

by weight in all parts in contact with potable water. At the time of writing, five states had ratified to adopt the regulation.

128. France, Germany, the Netherlands and the United Kingdom (4MS), in January 2015 issued the latest revision aimed to achieve convergence of respective national approval schemes of materials and products in contact with drinking water¹⁵. The proposed range of lead content for various alloys was between as low as 0.1% and as high as 3.5%. The future national standards of 4MS would be based on this common approach upon ratifications.

129. Lead-free materials are more costly and difficult to machine than standard alloys. Whilst lead contamination in drinking water should be closely controlled, lead content in applications of manufacturing & industrial processing, irrigation¹⁶ & outdoors watering, toilets & showers and fire services is not as critical. It may be necessary to adopt a dual system¹⁷ for potable and non-potable applications.

130. The practical concern is that a major revision in products specifications takes time for the manufacturing sectors to cope. The supply chains take preferences in reacting to demands. The 4MS approach was intended to create a larger critical mass of demand.

¹⁵ *Acceptance of Metallica Materials Used for Products in Contact with Drinking Water*, 4th Revision, 20 January 2015

¹⁶ Some countries, like Japan, also had strict control for water used in agriculture and fishing industries.

¹⁷ s1417 SDWA in States provided exemption for industrial processing, irrigation, outdoor watering or where the water is not anticipated for human consumption

131. In HKSAR engineering applications, the British Standards¹⁸ are basically embedded in our regulatory regime. Even with the UK joining 4MS for products commonality to create high market supply, the TF felt availability of all types of fittings with a great deduction in lead content would be quite well down in the distant future.

132. The TF had conducted a comparison of allowable lead content in components of various standards. [**Appendix D**]

Filtration

133. s24 of Cap 102A is a very important provision for WSD to ensure the water quality of the supply side would not be contaminated by reverse flows from the distribution ends.

134. A filter upstream of a tap is always in contact with the potable water if there is no backflow prevention device. Hence a backflow prevention device, such as a check valve, is required to provide isolation. The TF agreed, in particular where industrial types of water treatment were involved.

135. Unless it is of high pressure reverse osmosis process type, a filter downstream of a tap outlet has less chance of contaminating the tap water simply because the tap is normally turned off. Tap water will contact the filter only when the tap is turned on but then the water would not backflow.

¹⁸ As a signatory to CEN-CENELEC International Regulations, the United Kingdom will implement European Standard (EN) as the national standard upon introduction of relevant standards.

136. But misuse and lack of maintenance of the filters installed or an outright purchase of ineffective equipment could cause more harm to health than good. The TF also agreed, in particular with less alerted consumers.

137. WSD has always held a position discouraging installation of filters at the tap (until this episode). But with the advancement in technology, for domestic needs there must be some suitable models that could be connected directly to the tap and fit for the purposes and in fact there are. So much so many household filters, good and bad, are now commonly available in the market attracting attention of the Consumer Journal.

Products Testing

138. In addition to relying on certification of individual component or fitting with low content of lead the other approach is to set up a thorough testing protocol to monitor the end result ensuring quality of supply was not compromised and lead concentration is within the limit in the plumbing installations.

139. AS/NSZ 4020, the joint Australian and New Zealand standard, set up testing procedures of products for use in contact with drinking water. Some of the testing procedures and criteria of BS 6920 were adopted with and without modifications.

140. Two numbers of the same component would have to be tested.

PART I (*continued*)

Water Sampling Testing Protocol

Guidelines

141. The World Health Organisation (**WHO**) in the past years had published guidelines and recommendations to manage the risk from hazards that may compromise the safety of drinking water for the protection of public health.

142. National standards on safety of drinking water were frequently drafted with targeted parameters and testing criteria to meet the recommendations of the WHO “*Guidelines for Drinking-Water Quality*”¹⁹.

143. On testing, analytical sampling methods are employed to monitor the presence of lead to check the quality of water of both the supply side²⁰ and the domestic plumbing installations.

144. To establish the levels of the lead concentration in drinking water, many and various overseas protocols invariably prescribe taking and testing two drawn samples, viz., unflushed and flushed. Procedures of

¹⁹ The latest version is *Guidelines for Drinking-Water Quality - Fourth Edition*, World Health Organisation, Geneva, 2011

²⁰ Useful suggestions can be found in *Guidance on sampling and monitoring of lead in drinking water*, E J Hoekstra et al, JRC Scientific and Technical Reports, European Commission, Joint Research Center, Institute for Health and Consumer Protection.

collecting sampling vary but the same pattern must be followed to obtain true and valid results tested within a particular protocol.

Drawn Water Samples

145. For monitoring the domestic plumbing installations, the point of obtaining sampling²¹ should be a cold water tap where drinking water would be regularly drawn, normally the kitchen tap.

146. The unflushed sample or first draw is taken after a stagnation period, usually between 6 to 12 hours. This is to ascertain the highest level of lead concentration in the plumbing system but it is the least convenient to collect.

147. The flushed sample is taken with water running for a few minutes, typically between 2 to 3, at the locations where taking of the first draw was made. It gives the most consistent value but only reflects the minimum exposure of the water to lead.

148. The subsequent or the flushed draw is to ensure the water inside the plumbing system was flushed to ascertain the quality of the supply.

149. Analysis assessments after collecting both samples could be compared with statistical data to reach an overall assessment of the water

²¹ The Random Daytime sampling is not examined in this study. These samples could reflect more truly the water that the consumer drinks but would require collecting more numbers of sampling to determine the mean level value of lead concentrations.

quality. The TF had compared various protocols on the sampling methodology assessing the water quality as a whole. [**Appendix E**]

Water Sampling in Public Housing Estates

150. With repeated reports of lead content exceeding WHO recommendation of water sampling in the public housing estates, however minimal and insignificant, the general public felt the contaminant of lead is now frequently detected at a level that could be widespread escalating the grave concern of causing adverse health effects.

151. The TF noted the results of samples drawn at different intervals had served different purposes in the episode, sadly, with continuous arguments on which one was more pragmatic, genuine or revealing to ignite further public mistrust and uncertainties.

152. For the tenants, obviously it would be the maximum potential exposure to lead being the paramount and immediate concern.

153. Sentiment prevails, understandably. An articulated remark in an article published by Environmental Testing & Research Laboratories (ETR)²² summed this up succinctly:-

“However if you have an application which uses the water immediately from being turned on, that water is coming from a brass fixture, and the water is for human or animal consumption or any other use where lead would be a concern, then testing is probably a judicious choice. Collecting a sample immediately upon turning on the water after it has been sitting overnight is the conventional way to take this test.”

154. The TF agreed results of the flushed draws carried out by the departments showing a different level of lead containment than the unflushed draws should have given a closer value of the status of the water quality in the system the public *enjoy* (emphasis added).

155. But these results might not been able to alleviate the uncertainties of the tenants stalked by mounting mistrust.

156. The TF understood the technicality and the difficulties in explaining the relationship between the Frist Draw and the Flushed Draw in monitoring the overall water quality.

157. The TF also understood the implication of causing unnecessary and unjustified panic on misinterpretation of Two Tier sampling.

158. But the TF did not agree with WSD’s recommendation and would further remark on this under PART IV.

²² *First Draw and Flush–Lead and Copper*, Environmental Testing & Research Laboratories, Leominster, MA 01453

Credit Due

159. The TF found WSD leaflet “*Hong Kong’s Water Supply – Reducing Lead in Drinking Water*” contains information and advisory passages written in a more approachable (and far from a bureaucratically authoritative) manner for the public to comprehend, albeit a large portion of it is still seemed like a part of a departmental annual report.

160. Nonetheless the public is now more informed with WSD bringing out a useful leaflet after a flurry of instructive circulars and numerous clarifications.

PART II

Public Housing Estates

161. In the course of carrying out this study the HKIE was informed by the Development & Construction Division of Housing Department (**HD**) copy of specifications in DVD-ROM was available at a fee for those who are related to construction industry.

162. An application form St-011e_15.pdf (22.05.2015) must be submitted to the division for due processing and approval.

163. If approved payment was to be made to the Receipts & Disbursement Team and a receipt would be issued.

164. The DVD-ROM had to be collected in person from the Development & Standards Section. It was required to bring along the Institution stamp for identification purpose together with the pre-approved Request Form and the payment receipt.

165. Only 2012 and 2014 versions of specifications were available. The 2012 version was for contracts tendered out between November 2012 and September 2014. The 2014 was for those October 2014 onwards. Each copy would cost HK\$ 170.00.

166. On further inquiry previous editions were not available. Copy of the Main Contractor tender document was also not available. HKIE was

told what were available were indicated in the application form St-011e_15.pdf (22.05.2015).

167. The TF carried out this study based on the 2014 version Specification and a copy of 2012 version of a Main Contract obtained from the trade.

168. Hence the technical content of this report must be read along with the above.

169. The TF understood HKSAR Government has a standing policy on disclosing readily available information of standard documents for the general public access.

170. The TF noted many departments abide to the policy, to this end the TF wondered why HD would restrict information only to those related to the construction industry.

171. The TF also understood recouping charges for the cost of photo-copying was common in the past and justified to prevent abuse. But in these days of web access the TF questioned the need of incurring such kind of administrative costs and the wisdom of preparing DVD-ROM in terms of environmental concerns.

172. The process of acquiring the DVD-ROM was devious involving calling on different sections and demanding a physical presence.

173. The TF had the impression that this level of control was highly unnecessary and detrimental of striving for an edifice of performance outcome.

174. The TF was conscious not to be affected by this initial impression in conducting the study.

Introduction

175. In sorting out information gathered from the trade, the TF had discounted those, gossips in particular, related to the specific contracts and the respective contractors in question bearing in mind the study was on the structural and system-wise *operandi modus* of the Housing Authority (**HA**).

176. In this regards, some paragraphs of this section might appear being written in sort of a circumscribed manner.

177. The TF was also satisfied by examining the operational format and manuals without the actual tendering document, the deduction of the controlling mechanism was conversant with information gathered from the field.

178. The core mission of the HA is to construct and maintain public rental housing (**PRH**) for those unable to afford private rental accommodation.

179. In the development of housing blocks, the annual construction output of new flats built had been quite steady until mid-90s. Since then the annual built quantities could be erratic from time to time.

180. At present HA provided and managed about 670,000 rental flats for a population of about 2.3 million in Hong Kong.

181. HD is in charge of both construction work and the maintenance contracts.

182. The TF understood as an entity providing public housing decisions made by HA could be at times, if not always, politically based. On the other hand, the TF believed the engineering side of flats construction and maintenance should be free from political intervention.

Project Construction

183. There are three critical phases in construction work, viz. Design, Execution and Acceptance.

184. The followings are to examine how HD is managing the system flow of PRH construction.

185. Under the HD present arrangement of plumbing installation is part of the main contract and not under the same monitoring process established for other more developed nominated subcontracting format of similar building services installations.

186. The TF made reference to the more specific building services installations control mechanism where details on the plumbing arrangement were not available to complete the system-wise study. The TF believed this would err on the more demanding side.

Design

187. A good design with proper maintenance will enhance the lifecycle of an installation. Thorough work done in the design phase could shorten the duration of construction; minimise defects and control errors and omissions.

188. An innovative design recognises the benefit of varied methodology and the advancement of new equipment.

189. PRH, previously named as low-cost housings, to untrained eyes, are more like buildings of repetitive works only and equipped with just adequate provisions.

190. Further, for mechanical and electrical installations what with due compliance to various statues, it may also appear to some that there is not much room left for innovation.

191. On the contrary, HD had flared excellently in this through and up to 80s.

192. On the M&E front the TF understood: HD was the first department requiring M&E contractors ISO 9002 certified. In-situ bus-bar system split for low & high levels to cope with increased load demands was an

example of deft reinforcement. Three dedicated lifts each stopping at every third level ensuring passengers access at every one reducing transit time and capital investment was introduced. The first to install residual-current device before Institution of Electrical Engineers promulgated the 15th edition of Wiring Regulations in 1983. Leading the industry as the first in 13A ring circuitry installation and the first project specifying compact fluorescent lamp 11W tubes. The first in Communal Aerial Broadcast Distribution installation at Oi Man Estate. HD also introduced materials and labor variations clause in the BS contracts.

193. At or about early 90s it appears HD might have been extending its strength in procurement power of locally and proprietarily made goods to otherwise standard electrical and mechanical equipment by dictating additional requirements: different testing norms for the main switches & generators, odd tripping characteristic of miniature circuit breaker, fresh testing certificates required for minor change in product assembly, extending the bulkhead design criteria to the short-life SF70-series for lobby lighting, and last by not least the requirement of proven job reliability within HD projects before products were ultimately accepted.

194. Equipment lists were set up first to control local manufacturers and workshops in fitting out supplies and later trying to extend the coverage to include imported electrical and mechanical products.

195. All these create limitations of market participation leading to a chapter of HD construction history not pleasant to revisit.

196. The TF opined, since, the management philosophy of HD in managing risks was by tightening contractor entries and monitoring construction progress by documents with the control drafted at the top of the pyramid.

197. Development of M&E designs became dormant and new products assessment was almost ceased. The expertise and skill of site staff and engineering professionals were bespoke in filling out forms in monitoring the construction program.

198. Even when external MEP consultants were engaged the same schematic design flows and material preference had to be followed. There was no room for innovation and the skill and expertise of external professionals were not utilised.

Execution

199. Execution of a project involves construction work and installation of equipment.

200. The contractors are the parties to execute the construction.

201. The Plumbing and Drainage (**P&D**) tender is included under the Main Contract which is different from other related building services contracts.

202. HD did not keep a list of P&D contractors and due to the domestic contract format communication to P&D contractors were through the main contractors.

203. The TF hence investigated how the P&D contracts would have been managed and monitored if it were under the nominated-sub format by examining the related building services tenders.

Contractor Qualification

204. The HD does not rely on the lists under the Development Bureau and keeps its own list of specialist M&E contractors. The contractors had to apply to be included in the “*Lists of Works Contractors*”.

205. The TF examined the “*Guide to Registration of Works Contractors and Property Management Services Providers*” which sets out HA’s management of contractors.

206. The conditions for initial application are quite reasonable.

207. But a one-off non-refundable application fee at about HK\$50K is required for initial applications. The successful applicants will be put on a probation period.

208. There are other requirements to meet before the contractors were invited to tender. It is HD’s absolute discretion according to a fair and just basis when sending out invitations to treat.

209. In order to be continually retained on the list paying an annual fee of about HK\$9,000 for assessing audit account is required. But the TF was informed even after satisfactory assessment of annual accounts, a listed contractor may still not be invited to tender due to lack of completed projects within a period prior to tender calling date.

210. The TF found that was different from the practice of Development Bureau and defied the sensible approach adopted by some contractors with healthy liquidity declining non-profitable tenders or refusing to jump on the cut-throat-price wagon when the construction market was down.

211. This policy of managing contractors in this mode denies HD exposure to a larger pool of entrants.

212. The trade of air conditioning and refrigeration contractors outright declined registration and hence there was no list established for such specialists. HD refers to the Development Bureau registered list when needed.

Administrative fee

213. The TF did not know whether the fees were paid to HD, a government department or to HA.

214. The TF had examined Cap 283 and found only s4(2)(gb) allows HA “*to charge fees for such other purposes as it thinks fit*”.

215. The TF opined s4(2)(gb) is a specific and dedicated provision under s4(2)(g) where HA has the power “*to develop land and to lay out streets and open spaces for the purpose of providing housing or in connection therewith*”.

216. The TF believed this provision is similar to the specific and dedicated intent attached to s4(2)(e) which governs s4(2)(ee).

217. Without other provisions the TF questioned the legitimacy of HA charging contractors for the admission to and retaining of the approval list.

218. The TF also opined such stringent control on contractors admission qualification does not necessarily guarantee quality and is not conducive to set down a competitive tendering platform. It would only narrow the field to fewer patrons.

219. The TF further noted due to the provisions of the Agreement on Government Procurement of the World Trade Organisation “*HA shall have the right to invite any party other than those in the lists*” and the same conditions and requirements upon Hong Kong based contractors to retain on the approval list are not enforced on foreign firms.

220. The National Treatment requirement of an international treaty does not demand the government to penalise local firms in tendering.

221. The “*Guide to Registration of Works Contractors and Property Management Services Providers*” also listed out codified penalty terms in great details mostly based on strict measurement of quantifiable parameters.

Equipment Specification

222. Proposal of maximum of three brands were allowed in the returned tender. No change was allowed after award of tender. This is similar to the requirements in force with Architectural Services Department (ASD) and Electrical and Mechanical Services Department (EMSD).

223. The TF was informed there was a ‘probation’ requirement of successfully completion of HD projects before equipment was ‘ultimately’ approved.

224. The TF understood and agreed the rationale that choices of certain equipment have to be made with proven track records, but wondered the need of an indifferent application to all types of product:- normal & essential supplies, main & accessory components, safety & performance compliance and statutory & cosmetic supplements, in particular considering:

- a. The construction is mostly about residential flats,
- b. Specifications on some equipment already require quality assurance schemes,
- c. Equipment used in the maintenance work two years after completion of projects would not need to follow the same.

225. The TF wondered why there was a need that reliability must be established with HD projects for electrical & mechanical equipment and why plumbing fittings were exempted.

226. The practice only brings about an exceedingly lengthy approval period to discourage new comers and with the swift technology development, the models in the approval process might already well be obsolete by the time it was ultimate approved

227. The system also does not encourage engineers to stay current with products development even though many of such were already widely installed in other projects.

228. In the past equipment specialist panels were set up in HD to examine and approve new products and compiled an official list.

229. The TF was now led to understand official lists of approval equipment were no longer kept. The role of equipment specialist panels was delegated to the project engineers.

230. Many products launched nowadays are based on proven technology but incorporated with a new concept. It takes experienced engineers, frequently collectively, to appreciate the subtlety.

231. The diversity of building services engineering installations and the ranges of the products suitable for the purposes are simply too diverse for a lone engineer assigned to a project to be fully kept abreast with the latest development in industry.

232. The TF was also informed HD had initiated the work of specifying LED bulkhead by seconding it to outside entities for compiling a list of suitable products

233. The potential suppliers would have to pay for the examining organization for assessment, a duty that a project engineer should be responsible. With this arrangement, it appears the HD engineers would just refer to the list for project acceptance.

234. The TF had grave concern with this trend. The TF opined one of the important duties of BS engineers is to evaluate equipment, its design, availability and application for projects.

235. Trainee engineers not being exposed to equipment assessment and evaluating its suitability for application might not satisfy the training requirement prescribed by the HKIE.

Performance Assess Scoring System (PASS)

236. Before addressing the BSPASS, PASS for the building services scheme, the TF wished to briefly list down the observations on how the Development Bureau monitors its contractors.

237. The standardised report forms set up by the Bureau were to cover qualitative items weighting factors of which, where necessary, could be non-linear and to be supplemented by written comments.

238. The essence was to prevent adverse performance of contractors in projects at hands. When an adverse report arises higher rankings, from D1 to D3 grades depending on circumstances, of officers must be involved. The adverse report was to be in writing.

239. The TF noted HA statement that BSPASS is used as tool to “*monitoring performance*” and to measure the contractors’ work quality during the construction stage. HD also considered the function of BSPASS was “*to encourage the contractors to improve the quality of their work*”.

240. The assessment form of BSPASS included numerous examples of calculating formulae with delineation of weighted scores “*to monitor the contractor’ performance*”.

241. The assessment is further broken down into specific items which can be assessed against *pre-determined* (emphasis added) assessment standards.

242. The TF found the weighting of assessment marks focused more on timely submission of documents as in equipment procurement & delivery and the completion progress than the workmanship.

243. The final score was the overall summation of all quarterly scores and would affect the standing of the contractors for future tenders invitations.

244. It appears the tool could encourage the contractors ‘to improve the quality’ of the project at hands by scoring higher marks so as to be rewarded with a higher grade for future tendering.

245. The TF hence noted and agreed to a certain extent with HA other statement that BSPASS “*has been proven to be a useful tool for selecting the better performing contractors to tender for upcoming projects*”

246. But the TF also found the objective that “*BSPASS assessments are not intended to replace the normal checks, inspections and tests to be carried out by the project team...*” was not effectively materialised and was contrary to the statement that “*BSPASS is, nevertheless, seen as a complementary, checking system for the various aspects.*”

247. The assessments were carried out by inspectors and endorsed by the senior inspector and the project engineer in HD projects. The emphasis was to monitor items prescribed in the BSPASS.

248. The TF opined BSPASS is more about project progress monitoring. It accomplishes its purpose if the quality is more about timely completion than on the quality of workmanship.

249. The process echoes the logic adopted in equipment approval with professional inputs being second fiddle to listed items. This is a prescriptive and quantitative management mode controlled by a form, in ink on a paper sheet.

Form follows function

250. Form in the context of Louis Sullivan's doctrine for engineering applications demands the process prescribed in 'form' must be compatible to the function of achieving a quality structure.

251. The TF opined that HD devised a checklist-type form recording past data to compare with that of the future to extrapolate the quality or the trend of its accomplishment in the project management.

252. The risks and monitoring management is by a quantitative approach with the belief quality will follow.

253. The HD form could serve its function if sufficient data were recorded. With one datum amiss, that particular sector would escape the scrutiny. With the tin-solder amiss, the rest is history.

254. The TF opined the checklist with so many items covered and in specific details could have actually distracted the needed professional attention to details of the general state of workmanship by patrolling inspectors.

Testing and Commissioning

255. The TF located relevant information of plumbing installations in the HD document and found the testing procedures of HD contained more details but still are similar to that of ASD. A brief comparison table is listed below:-

HD	ASD
Testing and Commissioning	
Request for Information (RFI) Forms requesting witnessing to be signed off by Clerk of Works	RFI Forms requesting witnessing to be signed off by Clerk of Works (In case of pumps and Control panels by British Standards Institution (BSI))
Water Sampling Test	
<ul style="list-style-type: none"> - cleansing and disinfection of whole system - water samples collected at various locations –water tanks, domestic flats and non-domestic areas, witnessed by the Clerk of Works - concentration of residual chlorine checked after disinfection - heavy metals content test not required - building water sampling tested by HOKLAS LAB for submission to WSD 	<ul style="list-style-type: none"> - prepared by The Hong Kong Laboratory Accreditation Scheme Laboratory (HOKLAS) LAB and submit to WSD - heavy metals content test not required - [2% welding joint may be inspected since 2012]

256. The TF found the acceptance procedure of HD on testing water quality was in order.

PART II (continued)

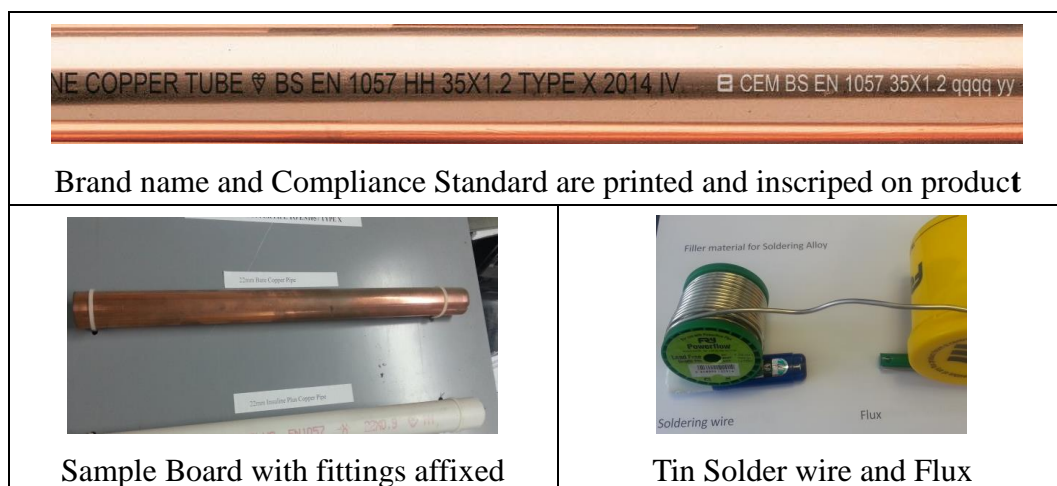
Plumbing Installation

257. The Plumbing installation is included under the main civil tenders in PRH. Clerks of Works are responsible for site inspection.

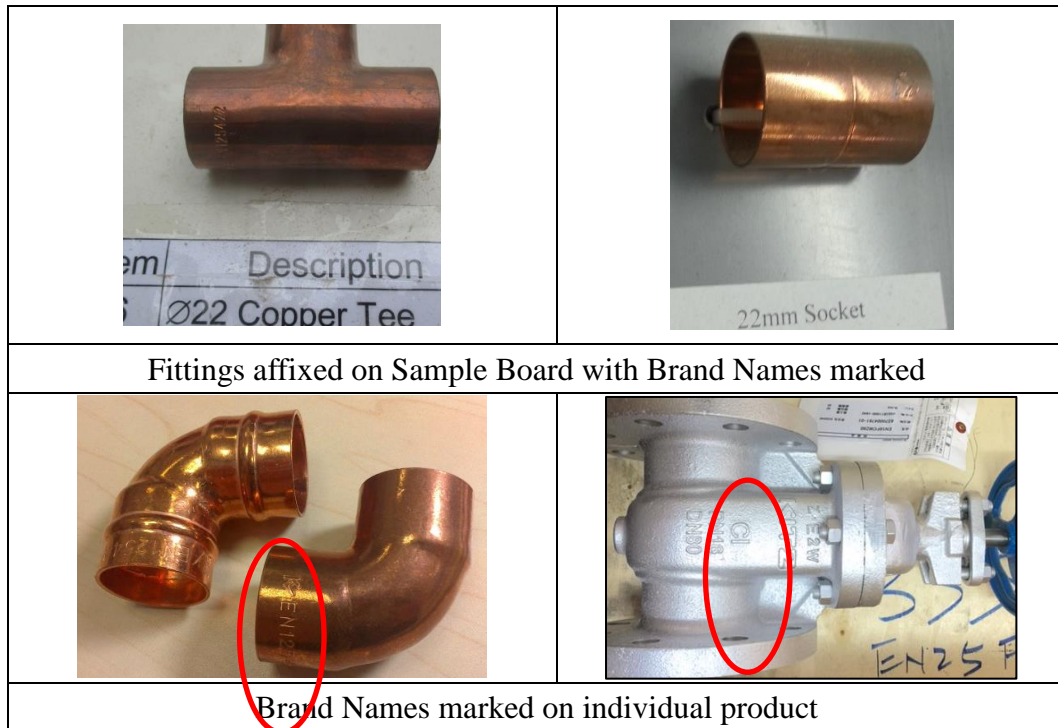
258. HA confirmed catalogue, samples and certificates of proposed materials for plumbing installations were checked on submission and verified upon delivery to site with samples selected for further and physically scrutinized²³.

259. The TF understood the typical process includes submission of a sample board with pipes and all types of fittings affixed and stored on site for ready inspection.

260. The following photos show a typical arrangement of above.



²³ Paper CB(1)1133/14-15(01), *Excessive Lead in Fresh Water Supply in Public Housing Estates*, Legislative Council Panel on Housing, July 2015



261. However WSD Task Force found three noncompliant fittings in Kai Ching Estate:-

“Some valves and taps installed were not those submitted to the Water Authority...and some valves and taps installed do not comply with BS requirement in respect of lead content.”

262. The discrepancies are detailed below:-

Preliminary findings 28

3. Fittings non-complying with British Standard

Elemental analysis of fittings installed on site in Kai Ching Estate

Components		Installed on Site	Lead Content (%)	Submitted to WSD in WWO 46	On the directory list accepted by the WA
		Brand		Brand	
Copper alloy valve	65 mm dia Gate Valve	Victory	7.1 X, 5.9✓, 7.2 X	Waterfront	✓
	35 mm Gate Valve	Victory	7.5 X, 8.7 X	Ring	✓
	20 mm Gate Valve	Victory	7.8 X	Wealthmark	✓
	20 mm dia Stopcock	Victory	6.8 X, 5.9✓	Wealthmark	✓
Copper alloy tap	Shower mixer at toilet	Anspron	1.3✓, 1.5✓	Anspron	✓
	Basin mixer at toilet	Anspron	2.0✓, 2.9 X	Anspron	✓
	Tap at washing machine	Daimler	1.4✓, 1.8✓	A.T.A/Shing Shun	✓
	Single level Sink Mixer at kitchen	Anspron	2.0✓, 2.1✓	Anspron	✓

263. The TF could not understand how the discrepancies could have escaped the attention and inspection of the HD site staff.

264. The TF had compared the standards prescribed in HD specification. It has the most updated version, better than that from the private MEP consultants, better than that of ASD. [**Appendix F**]

265. Lead-free solder was also specified by HD.

266. The TF recognized HD has a good and capable team of building services professional in drafting up the technical specifications.

267. The TF also noted HD suggested lead contamination in PRH was found because there was a lack of awareness (the TF presumed it was in general as specific parties were not mentioned) and that WSD did not require testing of lead.

268. Without reports that lead contamination was also present, the TF felt this statement denied the MEP consultants and ASD colleagues in diligently monitoring and ensuring the project quality of respective private developments and government projects the credit it deserved.

269. In affixing a signature on PART I of WWO Form 046, the AP, presumably it must be HD, should be aware on the design and component details for the project submitted for approval. Equally, in affixing a signature on PART II of the same form, the applicant, again presumably HA or its agent, should also be aware of same.

270. Whether HD colleagues signing Form WWO 046 had full comprehension of the technical matters or otherwise, the notion that there was a need of complying a statutory duty must be known.

271. It is also worth to note the relationship of HD and HA is not of a strict client/contractor commercial nature.

272. Although the use of lead-free soldering was explicitly specified in the tender document, the TF noted in the Paper submitted to Legislative Council HD admitted they “...do not inspect the joints between pipes (including the soldering materials) for lead content. The reason is the construction industry has all along believed that such widely accepted and broadly applied soldering materials comply with relevant requirements.”

273. The TF opined HD’s admittance effectively indicated at least for that particular term of the tender contract, due compliance was not inspected and monitored.

274. The TF opined the omission could have been avoided if:-

- a. BS engineers and inspectors are assigned to monitor plumbing installations, or
- b. Clerks of Works were thoroughly and diligently trained to inspect the plumbing installation, or
- c. An item covering lead-free tin-solder was included in a check-list form.

275. The TF concluded it could be said the failure of on-site monitoring and inspection on the part of HD was a structural deficiency and not one particular to specific projects.

276. The TF firmly believes for on-site inspection and monitoring it should be the expertise and skill of relevant profession to take precedent, not a paper with check boxes.

277. Inspection involves Five Senses: - sight, touch, smell, hearing and taste. The TF had yet to come across a sliding scale of prescripts that could faithfully quantify the quality of senses.

278. The TF opined HD has a team of BS professionals the expertise of them was not exploited to its fullness in supervising BS contracts in general and plumbing contracts in particular.

279. The TF believed the attributes of engineering professionals listed out by the Engineering Council UK which is shared by the HKIE could demonstrate training and expertise of them are well qualified to design & supervisor and assess & manage projects.

Incorporated Engineer	Chartered Engineer
<p>Incorporated Engineers maintain and manage applications of current and developing technology, and may undertake engineering design, development, manufacture, construction and operation.</p>	<p>Chartered Engineers develop solutions to engineering problems using new or existing technologies, through innovation, creativity and change and/or they may have technical accountability for complex systems with significant level of risk.</p>

The theoretical knowledge to solve problems in developed technologies using well proven analytical techniques	The theoretical knowledge to solve problems in new technologies and develop new analytical techniques
Successful application of their knowledge to deliver engineering projects or services using established technologies and methods	Successful application of the knowledge to deliver innovative products and services and/or take technical responsibility for complex engineering systems
Responsibility for project and financial planning and management together with some responsibility for leading and developing other professional staff	Accountability for project, finance and personnel management and managing trade-offs between technical and socio-economic factors
Effective interpersonal skills in communicating technical matters	Skill sets necessary to develop other technical staff
Commitment to professional engineering values	Effective interpersonal skills in communicating technical matters
www.engc.org.uk/ieng	www.engc.org.uk/ceng
Engineering Council London WC1V 7EX, UK www.engc.org.uk	

280. The TF wished to quote a statement from the Development Bureau Contractor Management Handbook on contract performance reporting:

“Reporting Officer (RO) and the Engineer/Architect for the contract are to use their knowledge of the contract in question to reach a conclusion, recognising that the reporting system is administrative and commercial but not contractual.”

Off-site Prefabrication

281. The TF included this topic in the study because whether the structure was one of the contributing factors to lead contamination had been questioned.

282. Precast fabrication is specified in HD project since 1997 and has been widely used in PRH, aided by its great degree of repetitiveness and mass production. This had brought great improvement to prevent water leakage

283. HD advocated some of the other advantages of the off-site prefabrication²⁴:-

- a. Stability of project progress with adverse weather condition avoided
- b. Alleviate the shortage of local skilled labours
- c. Reducing risks of working at height
- d. Lower labour cost by employing semi-skilled labour in the mainland instead of skilled labour on site.
- e. In-situ wet trade work is reduced
- f. Better controlled environment for the wet trade
- g. Plumbing and drainage are cast off-site

284. The TF noted prefabrication was also suggested by Works Branch²⁵ as a mean to reduce the skilled workers of identified trades, plumber being one.

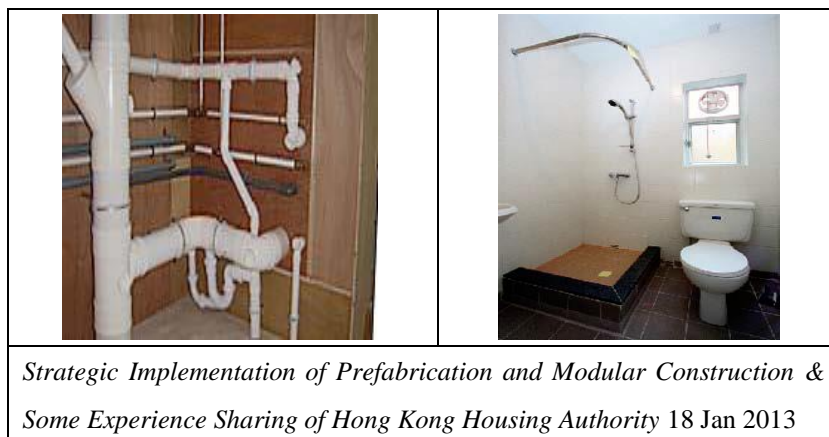
²⁴ *Strategic Implementation of Prefabrication and Modular Construction & Some Experience Sharing of Hong Kong Housing Authority*, Second Construction Technology Forum Construction for Sustainability, 18 January 2013, Joseph Y.W. Mak, Hong Kong Housing Authority

²⁵ *Guidelines for Enhancement of Productivity of Skilled Workers in Public Works Projects*, Works Branch, Development Bureau, March 2013.

285. The TF agreed there was a lack in skilled workers in the plumbing trade but was conscious that prefabrication as a solution to combat the shrinking pool of plumbers, if reliance of it not controlled, would become a cause of a vicious cycle.

286. On balance, the TF had doubt that prefabrication should be extended to ‘Volumetric Precast’ of bathroom cum kitchen, a box-type structure to embody numerous pipe ducts, fittings, tiles, waterproofing membranes.

287. The TF opined the advantages of avoiding adverse weather condition and risks of working at height are not applicable to plumbing works as plumbers would always work inside the kitchen under cover on firm footing.



288. The TF would also wish to question whether the prefabrication work in the Mainland²⁶ would still require workers registered as

²⁶ The TF understood this mode was dropped shortly after it was introduced some two years ago due to breakage. From engineering point of view a rectangular shape is less robust to torsion force, more so if only three-sided. The massive

construction workers with valid green cards and whether the plumbing work was carried out by Licensed Plumbers.

289. The TF also opined if off-site prefabrication is one of the terms and conditions of the contract, why HD would still need to offer extra credit to the contractors in tendering.

290. The TF also noted extra credits would be “*given to innovative design/construction method*” and wondered how the subcontracting factory in the mainland offering the same innovative proposal but fell short of patent right to several tenderers could be benefited.

291. The TF firmly believed innovation, whether in methodology or equipment must be encouraged and rewarded. This opportunity should be open to all parties and all form of services.

292. The TF considered the benefit would diminish if dwelling too much or sketching too far on a successful design and methodology.

weight would cause stress on the bottom slab twisting the fixtures attached it during handling.

Credit Due

Less is more

293. Nonetheless the TF found the versatility of the precast façade modular design as applied to Harmony 1, 2 & 3 and Concord 1 & 2 and the non-standard blocks is a truly contemporary application of Mies van de Rohe motto.

294. There is no need for the TF to speak more.

IV. OBSERVATIONS

295. The following are views of the TF in responding to some of the media reports and propositions from WSD and HD during the episode.

Licensed Plumber

296. WSD issued a statement that by the provision of the ordinance, LP would be the one who should be liable for the alleged lead contamination in water found in buildings, Kai Ching Estate or otherwise.

297. Under Cap 102 it is the LP who has the ultimate statutory duty in ascertaining all plumbing works carried out in due compliance. In addition by the arrangement of Form WWO 046 WSD would only communicate with LP after submission of PART I & II.

298. In this regard the TF agreed with the WSD statement, albeit unfortunately some would view at the turn of the episode that the statement could have been prematurely made victimising the plumber.

299. The HKIE had pointed out Cap 102 and Cap 102A were so outdated that it would not be realistic and justifiable to rely on a lone LP in charge of large projects as PRH development with thousands of flats.

300. In Appendix B, the TF explained the benefit and necessity to induct a strata system of licensing a workforce including professionals, supervisors and workers at different level of competence to cope with the complexity and scale of construction.

301. The TF also proposed registration of P&D contractors is also necessary to extend the statutory liability on the part of the employers for employees in breach of a statutory provision²⁷

Lapse of Product Certificates

302. The TF did not understand the rationale behind this decision of WSD Circular No. 2/2015 dated 11 August 2015 with immediate effect on the withdrawal of approval of products with test certificates issued beyond 5 years.

303. A standard compliance certificate is a test report on sample(s) of products submitted at the time for testing to a particular standard, or part of it, or proprietary requirements. In essence, there is no time limit *per se*.

304. Products compliance to a quality assurance scheme involves on-going and periodical assessment and a certificate issued under this circumstance is almost always time validity dependent. The Kitemark requirement under Category A is of this nature.

305. The TF opined WSD making reference to practices adopted by Water Regulations Advisory Scheme (WRAS) and Drinking Water

²⁷ Sections 38 & 30 of Cap 102 may be useful to catch an employer under the common law of aiding, abetting, counseling or procuring by commission of an offence of its employee but the provisions were only related to “waterworks” and nothing on “inside service”.

Inspectorate (DWI) in only validating certificates within 5 years of testing to justify the decision was not that relevant for application²⁸.

306. By demanding type samples of production tested by HOKLAS accredited laboratories for approval under Category C every 5 year does not make the products at the same league as those manufactured under a quality assurance audit.

307. Fitting components in particular those of lesser value were often purchased in quantity with inventory exhaustion in terms of months if not years. Likewise for odd items procurement with MOQ.

308. There is also no guarantee goods sold under a current certificate would not be from stock of more than 5 years old unless tracing of stock movements similar to perishable goods is in store.

309. Circular No. 2/2015 only brings unnecessary hardship to the industry without much gain in quality assurance.

²⁸ WRAS is a scheme of advisory nature assisting product suppliers to identify and test to appropriate standards meeting the *Water Supply (Water Fittings) Regulations 1999 England and Wales* which is a performance base regulation. Product tested to British Standard compliance is an option, albeit more often than not that option would be the one adopted for compliance approval in UK. DWI is an inspectorate agent by statute to monitor supply sources for the government. WSD is not an agent but an administrative arm of the WA. The ordinance and regulation entrusted to WSD for reinforcement did not provide a clause of time lapse on certification.

310. Whilst it could still be possible to catch up the construction progress with approval of larger projects being held in abeyance pending fresh testing certificates, the implication to emergency repairs cannot be ignored.

311. The TF would agree with the decision if the withdrawal was to enable WSD revisiting the currency of specified standards and/or authenticating those in the inventory. But that should be one-off and could be done in phases.

312. The science of deciding whether a type test certificate suffices or that one with periodical quality assurance is needed requires professional judgment with well experience in engineering practice and product trend & development. This is part of the duty of engineers engaging in plumbing design and specification. The TF opined this should be a pragmatic approach for WSD approving certificates and products.

313. The TF proposed communication with the trade would be beneficial to shape the way forward.

WSD Procedure - Water Sampling Testing

314. On 27 August WSD suggested before taking water samples for testing, run the tap for a few minutes. WSD made reference to ISO 5667-5 in formulating the proposed procedure.

315. This approach was widely queried by the media, politicians and affected occupants²⁹.

316. Taking stagnated water samples instead was advocated by the community at large to be the ‘correct and more accurate’ method.

317. The argument was actually whether taking the flushed draws or the unflushed draws was more relevant to gauge the scale and scope of the lead contaminant situation in PRH then.

318. The TF considered the one preferred by the tenants could better reflect whether the state of tap water was affected by environmental influences as well as leaching problem, if any, of an installation.

[Appendix G]

319. The TF also opined the advocated method suggested by WSD was not only different from many overseas protocols, but also did not follow the ISO 5667-5 in its full context.

320. ISO 5667-5 Guidance document acknowledges the need for taking both draws of unflushed and flushed water samplings for different purposes.

²⁹ “Some members queried the validity of the water sampling tests conducted by the Government as the water samples were collected after running the tap for a few minutes, and requested the Government to collect and test samples of stagnant water in pipes as well”, Paper No. CB(2)2051/14-15(02), Background brief on lead in drinking water incidents, LC, Special House Committee meeting on 1 September

321. In addition, WSD also recommended a very onus procedure in handling containers for collecting water sampling. The proposed procedure was not covered in ISO 5667-5³⁰.

322. The TF hence viewed if other entities taking water samplings for testing without following exactly the same WSD procedure it cannot be said with certainty that the test results thus obtained were ‘invalid’.

323. On the other hand, the TF opined WSD Water Sampling Procedure was biased towards measuring the water quality as supplied to the premises and ignored the effects of plumbing materials, including any possible lead solder, on drinking water quality.

324. If the purpose of water sampling is for identifying the presence of lead solder and non-compliant valves and fittings in the plumbing installations, then initial draw-off water samples should be used.

Test results in the public housing estates

325. HD had released several press releases on the findings of the testing results of water samplings in PRH.

³⁰ The TF made cross reference to ISO 5667-3 & 5667-14. Clause B.3 of ISO 5667-3 stated “*For trace metal analysis, new sample containers should always be used. Sample containers and lids should be thoroughly cleaned with a phosphate-free detergent solution, thoroughly rinsed with metal-free water, soaked for 24h in ~10% volume fraction HNO₃ or ~25% volume fraction HCL, and rinsed with metal-free water*” and Clause 7.2 of ISO 5667-14 stated “*If (access to properly treated new sample container) is not possible, the sampling devices should be cleaned by pre-rinsing with sample material or deionized water to prevent any carryover of sample constituents.*”

326. The TF had tabulated the results for engineering assessments. At the time of writing up this report HD had not yet responded to the HKIE's inquiries on the correctness of the information as gathered from press releases and media coverage as well as details of the sampling selection and testing procedures. [**Appendix H**]

327. The TF noted the data shown were for sampling taken across the whole estate but no information was shown on individual blocks.

328. Without knowing what-when-how the samplings were collected, the TF could only comment on the empirical front.

Contaminated Flats

329. The TF wished to first deal with those estates found with excessive lead in the drinking water systems.

330. The TF noted the percentages of tested samples varied between 2 to 3 percent. The actual number of sampling collected is less important than the locations of the random choices³¹. Obviously, the more numbers of sampling collected and tested the confidentiality level would increase.

331. Some exceeded the 90 percentile with lead contamination higher than the WHO value. If a large percentage of them were clustered in a

³¹ Sites chosen to collect sampling must be representative of the whole system or within the area where problems were to be located. This is fairly complex and familiarity with local knowledge concerning the specific problems, the water source, and the distribution system must be taken into account.

block or two and the sampling was also drawn from flushed samples then the situation was really quite miserable.

332. On the practical front there were some known facts:-

- a. 'delinquent' contractors were 'identified',
- b. workmanship was 'in doubt',
- c. a housing estate comprises of several typical building blocks,
- d. different teams of subcontracting workers are likely taking up work on block basis, if not floors

333. In a major project when tackling questionable workmanship the engineering approach would first scrutinize sampling work of the worker(s) and if found unsatisfactory step up the sampling assessment either in quantities or frequencies, or both.

334. For those estates found with excessive lead, the engineering approach would be first to identify the floors with plumbing installations carried out by the 'questionable' workers with either repeated testing or a larger sampling size. It could be that some floors or some of the blocks installed by other team of workers were 'clean' within the same estate.

335. Statistic testing protocol also echoes the same rationale adopted by engineers in practice – but in reverse order by taking reduced number of sampling on the subsequent lots once the first lot was tested and proved satisfactory.

336. With proper locations chosen and assessing sampling results against designated confidence level, there is no need to test all the 5,204 flats, as at Kai Ching Estate.

Clean Flats

337. For those estates declared by HD found ‘clean’, the TF opined, again without knowing what-when-how, it would be difficult to comment further.

338. But if HD had adopted the WSD testing procedure by only taking the flushed draws sampling for testing, the TF opined that the test results would only show the water quality of the distribution side and not for identifying whether there was lead leaching from the plumbing installations.

339. As such the test results were meaningless for the study of this report to identify the plausible causes of lead contamination, if any.

340. The TF suggested sometime in future run further unflushed draws on the same estates to validate the clean bill. The public will appreciate the reassurance and the data collected would be useful for future statistic.

341. The cut-off date at year 2005 for PRH testing is still practical albeit copper pipes were used in PRH as early as year 2000.

Causation of lead contamination

342. The Taskforce of WSD issued a Preliminary Report³² on 25 September 2015.

343. The Report stated lead-solder joints was the principal if not the sole causation of lead contamination found in ‘all other’ PRH from findings of Kai Ching Estate and Kwai Luen Estate Phase 2 in comparison with that of Hung Hei House at Hung Fuk Estate.

344. Lead leaching tests of fittings samples were carried out. The locations of fittings samplings were dismantled from three sections, viz., the downpipe from the roof to the 14th floor, the branch pipe leading to a flat on same floor and the plumbing installation inside the flat of Hong Ching House, Kai Ching Estate.

345. Unlike others national standards, there is no British Standard specifying methods for lead leaching test for metallic materials. The TF noted a 24-hour stagnation period was used but other parameters were not known. It appears WSD had devised its own for this exercise.

[Appendix I]

346. An in-the-product leaching testing arrangement was shown on how a valve was tested. The alloy composition of the valve was not stated. Details of other ‘various components’ were also not mentioned.

³² The report was in a form of power points presentation supplemented by a Press Release.

347. A sample of elbow with serious defect of a high content of lead and poor workmanship was shown. The fitting was one of the components installed inside the said flat.

348. The TF could only conclude the finding can only demonstrate the seriously defective elbow was the principal cause of known lead contamination found in that particular flat on the 14th floor if it was not a random choice.

349. If the flat was one of a random choice the extent of contamination at Hong Ching House could be widespread and only *could be*. It is because one sampling size out of a block of over 800 flats was not representative enough.

350. The workload in finding out the cause could be streamlined by either taking an engineering approach running random samplings across the whole estate with numbers of sampling prejudiced to the ‘questionable’ contractors or workers, or by sampling methodology with scaled down the sampling size once the first batch results of blocks within an estate were found satisfactory.

351. Under no circumstance the TF believed it cannot be said with certainty that the state of the quality of the entire estate could be remonstrated by the results of testing components of the installation of one single flat.

352. For completeness the TF wished to comment on other points raised in the report.

353. The TF opined the isotopic analysis carried out on the complete plumbing installation of a particular flat could only establish the leaching profile of that offended premise in question. Again a larger sampling size would be needed to establish the same for the whole block, and so forth.

354. For leaching tests, there are two criterion values to meet, viz., Single Product Allowable Concentration and Maximum Allowable Concentration³³.

355. Referring to the test results on Slides 10 & 11, the TF presumed the lead contents were per litre. The TF found there were other components with tested value exceeding the Single Product Allowable Concentration as specified in other national lead leaching testing protocols.

356. In this regard the TF could not agree contribution of lead leaching from other components should be summarily dispensed with. Without further information the TF was not convinced by just referring to Hung Fuk Estate it could be concluded tin-solder was the principal culprit for two estates with 6,700 some flats.

³³ The US and Canada have a dedicated document to determine the contribution of individual component to MAC, basically weighted against the percentage of the total wetted area. For Australia and New Zealand, there is no specification on MAC but two different and identical components were tested. BS 6920 of UK basically related to PVC products. The TF opined the test devised by WSD was more practical testing on new components.

357. The TF could not locate information to explain how analysis of the testing results fittings and components of the flat on the 14th floor could be compared to water quality found at Hung Fuk Estate.

358. The TF agreed there was no point to look at contribution from coupling effect due to joining dissimilar materials or earth current connection.

359. The TF also did not agree with the recommendation of changing to stainless steel pipes and fittings just because substandard tin-solder which had escaped due scrutiny for copper pipes was used.

360. Other housing estates as well as private developments have copper pipes and tin-solder installed but without lead contamination.

361. The TF believed if the fault was more likely due to poor workmanship and lack of supervision, then why should the public coffer have to bear the additional cost to mistakes and omission by others who were paid to do the right job to begin with.

362. Central procurement for tin-solder, a consumable item, is not practical and efficient for construction works. The TF agreed that central procurement could reduce errors but was mindful that it would not be the ultimate panacea.

10µg/litre

363. The TF wished to share with the community the development of the lead content value.

364. The 10µg/liter guideline value adopted by WHO³⁴ was based on the assumption of estimated daily intake by a 5Kg bottled-fed infant. Since infants are the most sensitive subgroup of the population, this guideline value will also be protective for other age groups.

365. It should also be noted the WHO threshold value of 10µg/liter was only provisional³⁵.

366. In 2013 the EU countries adopted 10µg/liter as guideline value and before that it was 25µg/liter³⁶.

367. Hong Kong followed the WHO guideline of the provisional threshold value 10µg/liter for lead and accomplished the target in 1998.

³⁴ http://www.who.int/water_sanitation_health/dwq/guidelines/en/

³⁵ Footnote Page 383, *The guideline on the basis of treatment performance and analytical achievability* 4th Edition, WHO

³⁶ The guideline value limiting lead content has evolved by stages over a long period of time. In 1984, the WHO lowered the guideline value from 100µg/litre to 50µg/litre and in 1993 to 10µg/litre. With step reductions in between it took 20 years for the EU to adopt the WHO Guideline value at 10µg/litre in 2013.

368. To achieve the threshold value many countries have commenced rectification program³⁷. Considering the vast numbers of galvanized pipes in the old installations, interim measures are necessary.

369. This requires much time and money, and it is recognized that not all water will meet the guideline immediately.

370. But a target set is a target to achieve.

371. A guide³⁸ published by Health Canada lay down some sensible interim corrective measures before the piping and fittings are totally and ultimately replaced. Interim corrective measures include educating the public to flush the system before use.

372. In the UK where lead pipes had been abundantly used, improvement and replacement program was initiated with financial assistance³⁹. In Taiwan pipes replacement program was initiated with advice to use only run water. In Singapore orthophosphate was added to reduce lead as a temporary measure. In Toronto NSF-053 filter was used as the interim measure.

373. The TF noted in both Canada and the States the first draws samples found with lead at 15µg/liter could actually indicate the water quality

³⁷ The City of Toronto had a program to replace old pipes installed in the 50s.

³⁸ *Guidance on Controlling Corrosion in Drinking Water Distribution System*, Health Canada, Ministry of Health info@hc-sc.gc.ca, www.healthcanada.gc.ca

³⁹ *Aspects of Water Services Design in the Healthcare Sector*, HK Conference 23 October 2015, Chris Northey

expected for daily use could be as low 5µg/liter, based on statistic collected over the years.

374. The TF hoped the above would illustrate lead concentrations found exceeding the WHO provisional guideline value was not uncommon in other countries.

375. The TF also hoped this could pacify the emotion of the public somewhat and that one sample tested slightly over the WHO limit serves a caution point to trigger further investigation and not an ultimate verdict to replace all the piping and fittings in the installation.

V. RECOMMENDATIONS

Water Supplies Department

376. The TF endorsed various interim rectification measures inducted by WSD but a structured plan to approve, inspect and monitor new installations should be instituted⁴⁰.

377. Cap 102 and Cap102A should be amended to embrace the expertise of professionals and supervisory personnel to take up the statutory duties in design and supervision compliance. Registered plumbing contractors should be inducted. The roles and duties of licensed plumbers to be redefined.

378. The trainings of plumbers should be reinforced. The awareness of the seriousness of potential health impacts arisen from lead contamination and the skill of jointing should be stressed.

379. The level of knowledge and competence of soldering joints performed by plumbers is to be adjusted within the Qualification

⁴⁰ *“The delivery of water that complies with relevant standards within buildings generally relies on a plumbing system...Reliance is therefore placed on proper installation of plumbing and, for larger buildings, on building-specific water safety plans. It is important that plumbers are appropriately qualified, have the competence to undertake necessary servicing of plumbing systems to ensure compliance with local regulations and use only materials approved as safe for use with drinking water. Design of the plumbing systems of new buildings should normally be approved prior to construction and be inspected by an appropriate regulatory body during construction and prior to commissioning of the buildings.”*
 Excerpts from WHO 4th Edition

Framework (QF) regime⁴¹. The weight of the penalty points should also reflect in commensurate with the elevated QF classification.

380. WSD should step up or strengthen the building services section in setting down the criteria of specification and approval of pipes, components and fittings and to maintain a smooth and swift process in approving, monitoring and acceptance of inside services installations. Leaching test for components and fittings should be introduced.

Housing Department

381. HA should revisit the tendering format & arrangement and the project controlling philosophy & programming of all types of contract.

382. The role of professionals should take up the dominant role in project management, not blanks, checklists and numerals. The impression that engineers were not accorded duties in line with their attainments and attributes must be demonstrated incorrect.

383. The duty of building services section should be extended from the role as internal consultants to bear due responsibility in plumbing installation contracts.

⁴¹ In drafting and setting down the scale of competence the apparent same skill or work process would be accorded different levels taking consideration of the circumstances, the potential consequence of mistakes & omissions and the burden of statutory compliance. As an example, the skill of terminating wires to an office fluorescent tube fitting (inconvenience and disturbance), or an advertisement sign at high level (costly repair and loss of revenue) and a control relay in aircraft maintenance routine (hazardous risks and breach of statutory duty) are assigned to different levels under the Qualification Framework.

384. The TF submitted the PRH construction is basically a large scale repetitive work. Adequacy of equipment provision is paramount, not those proprietary and deviated from what are available in the general market⁴².

385. Innovation should be allowed and encouraged in both civil and building services contract. A set of inviting criteria would be required.

Water Quality

386. The Terms of Reference of the Advisory Committee on the Quality of Water Supplies (Hong Kong) should be extended to cover water quality of the inside services by formulating a long term strategy in assessing the water quality at the tap. The priority is with high risks locations and surveillance of potentially exposed population groups, especially the vulnerable ones (small children, pregnant women, workers).

387. There is a need to distinguish the territorial characteristic of Hong Kong. The TF found the categorization of regions by supply sources in a report⁴³ could be reverse-engineered to categorize the types and mixes of buildings in built-up areas for Hong Kong application.

⁴² The recent HD specification change of lampholder from B22 cap to E27 cap is an example of meeting the general market availability albeit the TF opined the British Standard B22 cap is a better design. The TF also noted, albeit again did not agree, the comments from some a few years back in demanding the change to E27 cap so as to allow a wider selection of available CFL lamps for the sake of green concern.

⁴³ *Drinking water 2013 Central and Eastern region of England*, Drinking Water Inspectorate London, UK, SW1P 3JR <http://www.dwi.gov.uk>

388. The public should be informed the potential seriousness or non-seriousness of variable lead contamination tested in the process. The TF believed knowledge is the best mean to suppress panic.

389. Overseas regions with replacement programs widely broadcast preventive measures during replacement cycles, either voluntarily or by law. The TF found a leaflet from University of Massachusetts⁴⁴ very informative and concise for Hong Kong to borrow.

390. Heavy duty hot-water kettles should be controlled either as an *ad hoc* item similar to the pragmatic approach adopted on ‘illegal’ unvented storage water heaters some years ago jointly with EMSD. The TF considered WSD has a duty⁴⁵ to contain substandard appliances for potable usage.

391. For long term other appliances connected to taps should be controlled similar to the EMSD products safety provisions⁴⁶.

⁴⁴ *Healthy Drinking Waters for Massachusetts*, UMass Extension, University of Massachusetts

http://www.umass.edu/nrec/watershed_water_quality/watershed_online_docs.html

⁴⁵ Other sources include use of lead-containing ceramics for cooking, eating or drinking. In some countries, people are exposed to lead after eating food products from cans that contain lead solder in the seams of the cans.

⁴⁶ The TF was shown a case law, *Barnes and Another v. Irwell Valley Water Board* [1936. B. No. 155] CA 1938 in which it was held that the statutory duty of the water supply authority did not derogate from their obligation at common law and was held liable in tort for delay to inform the tenants the known risks of lead contaminated water drawn through a fitting owned by the tenants themselves and that the argument “...sending out a notice would possibly cause mass fear of water quality” was not accepted. The TF did not know whether the case is still a good law but opined the community has the right to know their own position.

Health, Safety and Environment

392. The matured stage of Hong Kong as a city with emphasis in safety, performance and sustainability on infrastructure and superstructure has transcended to the focusing on wellbeing of people.

393. The enforcement departments each vested with different and individual controlling statues and regulations are converging towards the single purpose of public wellness.

394. The Administration should assess and categorise different control scheme with commonality into larger but fewer categories. The TF proposed one stream related to servicing systems headed by a D8 grade civil servant is now in order to track through various enforcing regulations.

395. The TF hoped at least the awakening from addressing this unfortunate episode arisen from two departments could help us to turn a meaningful page in attending the common denominator of public wellbeing in a vigilant readiness with concerted multiple expertise, inputs and efforts for the common good.

Epilogue

*“...with audacity,
I’d concur our system slipped,
with pertinacity,
I’d direct all to have it clipped...”*

Carrie LAM CHENG Yuet-Ngor
The HKIE Honorary Fellow
Chief Secretary, GBS, JP
16 October 2015

Original in Chinese

「…我已經有膽承認我們的制度是有不足不善之處，我亦努力督促所有部門要做跟進善後的工作。…」

APPENDIX A

WSD Specification and Current British Standards

WSD Regulation-Specification	Current British Standards
Regulation	
9. Steel pipes shall- (a) be galvanised; (b) comply with BS 1387 for 'Medium' tubes and tubulars; and (c) if on a fresh water inside service, be lined with internal unplasticised polyvinyl chloride or polyethylene lining approved by the Water Authority. (L.N. 673 of 1994)	
BS 1387	BS EN10255:2004
10. Malleable cast iron fittings for use with steel pipes shall be galvanized and shall comply with BS 143 and 1256 for malleable cast iron and cast copper alloy pipe fittings. (L.N. 320 of 1992)	
BS 143 & BS 1256	BS 143 & BS 1256:2000
11. Wrought fittings of iron or steel for use with steel pipes shall be galvanised and shall comply with BS 1740, Part 1 for wrought iron pipe fittings. (L.N. 320 of 1992)	
BS 1740	BS EN 10241:2000
12. Unplasticised P.V.C. pipes and fittings shall comply with BS 3505 for Class 'D' tubes or equivalent.	
BS 3505 for Class 'D'	BS EN 1452-1:2009, 1452-2:2009, 1452-3:2010,1452-4:2009, 1452-5:2009
13. Copper pipes incorporating screw joints shall comply with BS 2871, Part 2, for copper tubes (heavy gauge) for general purposes and screw thereof shall comply with BS 61, for screw threads for copper tubes.	
BS 2871 Part 2 & BS 61	BS EN 12449:2012 & BS 61:1969
15. Cast copper alloy fittings, for copper pipes screwed in accordance with Table 1 of BS 61, shall comply with the relevant requirements of BS 143 and 1256 for malleable cast iron and cast copper alloy pipe fittings. (L.N. 320 of 1992)	
BS 61 (Table 1), BS 143 & BS 1256	BS 61:1969, BS 143 & BS 1256:2000
16. Copper pipes to be jointed with compression fittings or capillary fittings or by bronze or autogenous welding shall comply with BS 2871, Part 1.	
BS 2871 Part 1	BS EN 12449:2012
17. Capillary fittings or compression fittings shall comply with BS 864, Parts 2 for capillary and compression fittings of copper and copper alloy and compression fittings for pipes laid under the ground shall be Type B. (L.N. 320 of 1992)	
BS 864 Parts 2 (Underground Type B)	BS EN 1254-3:1998
18. Polybutylene pipes and fittings shall comply with BS 7291 Parts 1 and 2. (L.N. 673 of 1994)	
BS 7291 Parts 1 & 2	BS 7291-1:2010
19. Polyethylene pipes shall comply with BS 6730 and BS 6572. (L.N. 673 of 1994)	
BS 6730 & BS 6572	BS EN 12201-1:2011, 12201-2:2011+A1:2013, 12201-5:2011
20. Crosslinked polyethylene pipes and fittings shall comply with BS 7291 Parts 1 and 3. (L.N. 673 of 1994)	
BS 7291 Parts 1 & 3	BS 7291: 2010
21. Chlorinated polyvinyl chloride pipes and fittings shall comply with BS 7291 Parts 1 and 4. (L.N. 673 of 1994)	
BS 7291 Parts 1 & 4	BS 7291-1:2010
Schedule 2 Part 2	
1. Draw-off taps and stop valves of the ordinary screw-down pattern and of nominal size not exceeding 50 mm shall comply with BS 1010, Part 2 for draw-off taps and stop valves.	
BS 1010 Part 2	BS EN 200:2008
2. Sluice valves of nominal size of 50 mm or more shall comply with BS 5163 for sluice valves for waterworks purposes of PN 10 or PN 16 according to the pressure to which the valve will be liable to be subjected under working conditions.	
BS 5163	BS 5163-1:2004
4. (1) Ball valves of the "Piston" type and of a nominal size not exceeding 50 mm shall comply with BS 1212, Part 1 for ball valves and shall comply with the following requirements- (a) valves shall be provided with a washer of suitable vulcanized rubber or some other equally suitable material and the washer shall be enclosed in an internally flanged cap screwed to the piston; (b) the body and piston shall be of a corrosion-resisting alloy, and the lever shall be of a corrosion resisting alloy or of copper and shall be of sufficient rigidity not to bend permanently under working conditions. (L.N. 320 of 1992) (2) Ball valves not being of the "Piston" type shall be sound and suitable and comply with the following requirements- (a) high pressure valves shall close against a test pressure of 1400 KPa, medium pressure valves against a test pressure of 700 KPa, low pressure valves against a test pressure of 300 KPa; and the valves, not being valves having an interchangeable orifice seating, shall have the letters "H.P.", "M.P." or "L.P." respectively cast or stamped on the body of the fitting, and shall, while held in a closed position, be	

capable of resisting a pressure of 2000 KPa;	
(b)-(c) (Repealed L.N. 320 of 1992)	
(d) valves of ferrous metal of a nominal size exceeding 50 mm shall be provided with a flange on their inlets complying with BS 4504, Part 1, Table 16, shall be protected against corrosion by dipping in accordance with the requirements of BS 4164 or by galvanizing in accordance with the requirements of BS 1387 and shall have all their working surfaces lined or faced with, and its orifice seating of, a corrosion-resisting alloy.	
(3) Ball valve floats of a nominal outside diameter not exceeding 300 mm shall comply with BS 1968 for copper floats or with BS 2456 for plastic floats.	
(4) Ball valves when fixed to a cistern shall have the size of the orifice, the size of the float and the length of the lever so proportioned to one another that, when the float is immersed to an extent not exceeding half its volume, the ball valves shall be watertight against the highest pressure at which it may be required to work.	
BS 1212 Part 1	BS 1212-1:1990
BS 4504 Part 1 (Table 16)	BS EN 1092-1:2007+A1:2013
BS 4164	Withdrawn in 2013
BS 1387	BS EN 10255:2004
BS 1968	BS 1968:1953
BS 2456	BS 2456:1990
8. Gate valves shall comply with BS 5154 for copper alloy gate valves for general purposes.	
BS 5154	BS EN 12288:2010
Schedule 2 Part 3 Cold Water Storage Cisterns	
3. A cistern of mild steel not exceeding 5000 litres capacity shall comply with BS 417, Part 2 for galvanised mild steel cisterns.	
BS 417 Part 2	BS 417-2:1987
8. Every hot water cylinder or tank of a capacity of not less than 100 litres shall-	
(a) if made of mild steel, comply with the requirements for cylinders or tanks, as the case may be, of BS 417, Part 2 for galvanised mild steel cisterns, tanks and cylinders; and (L.N. 106 of 1999)	
(b) if made of copper, comply with BS 699 for copper cylinders for domestic purposes or with BS 1566, Parts 1 and 2 for copper indirect cylinders.	
BS 417 Part 2	BS 417-2:1987
BS 699	BS 1566-1:2002+A1:2011
BS 1566, Parts 1 & 2	BS 1566-1:2002+A1:2011
Waterworks Form WWO 46	
Notification/Application for Constructing, Installing, Altering or Removing an Inside Service or Fire Service	
Note 7(i) Copper tubes BS EN 1057	
BS EN 1057	BS EN 1057:2006+A1:2010
Chlorinated polyvinyl chloride pipes and fittings BS 7291 Parts 1 & 4	
BS 7291 Parts 1 & 4	BS 7291-1:2010 BS 7291-4:1990 withdrawn in 2013
Crosslinked polyethylene pipes and fittings BS 7291 Parts 1 & 3	
BS 7291 Parts 1 & 3	BS 7291-1:2010 & 7291-3:2010
Ductile iron pipes BS 4772	
BS 4772	BS EN 598:2007+A1:2009, BS EN 545:2010 & BS EN 969:2009
Galvanized steel tubes (metallic components) BS 1387	
BS 1387	BS EN 10255:2004
Grey iron pipes BS 4622	
BS 4622	Withdrawn in 2013
Polybutylene pipes and fittings BS 7291, Parts 1 & 2	
BS 7291-1 & 7291-2	BS 7291-1:2010 & 7291-2:2010
Polyethylene pipes BS 6730 & BS 6572	
BS 6730 & BS 6572	BS EN 12201-1:2011, 12201-2:2011+A1:2013, & 12201-5:2011
Stainless steel tubes BS 4127	
BS 4127	BS EN 10312:2002
Unplasticised polyvinyl chloride pipes BS 3505	
BS 3505	BS EN 1452-1:2009,1452-2:2009,1452-3:2010,1452-4:2009 & 1452-5:2009
Ball valves BS 1212, Part 1	
BS 1212 Part 1	BS 1212-1:1990
Copper alloy gate valves BS 5154	
BS 5154	BS EN 12288:2010
Draw-off taps and stop valves BS 1010, Part 2	
BS 1010 Part 2	BS EN 200:2008
Mixing valves BS 1415, Part 1 or 2	
BS 1415 Part 1 or Part 2	BS EN 1286:1999

NOTE: More than half of the specified standards were either withdrawn or repealed and replaced.

APPENDIX B

Licensed Plumber

WSD Circular

Employ a Licensed Plumber

A licensed plumber is a person licensed under the Waterworks Regulations to carry out various types of authorized plumbing work connected with the supply of water to domestic, commercial and industrial buildings.

It is an offence for any person or any person who employs a person other than a licensed plumber to carry out installation or modification of water services in a building.

http://www.wsd.gov.hk/en/plumbing_and_engineering/licensed_plumber/employ_a_licensed_plumber/index.html#notes

Recommended Amendment

1. Given the existing requisite qualification for admission as a Licensed Plumber with an ultimate statutory responsibility supervising multi-million project is no longer appropriate, the TF proposed the following amendment to Cap 102 and corresponding regulations to ensure quality of projects and installations at all levels could be safeguarded:-

Rationale

2. From Schedule 2 Cap 102, the TF noted "*Licensed Plumber*" is defined as a person licensed under this ordinance to construct, install, maintain, alter, repair or remove fire services or inside services.
3. Going back to Cap 102 and Cap 102A, the word "*construct*" was not defined. The TF believed the context of the word "*construct*" does not carry an intent of design element.
4. Literal meaning of the word "*construct*" aside, the TF noted by s5(2)(a) of Cap 102A where it states "*If a new inside service is to be constructed or installed, the applicant shall, before submitting an application under*

*subregulation (1) obtain from the Water Authority such information as is relevant to the **design** (emphasis added) of the inside service...". Upon such information obtained the application process would commence. AP is one of the parties required signing Part I of the Form WWO 46¹.*

5. The TF concluded, even if counter arguments were correct², where design of a new building project installation is involved, AP is a more suitable party taking up the responsibility to ensure the design of the construction is in compliant with Cap 102 and Cap 102A. This arrangement is congruous to the need of added vigilance demanding a person with training substantially higher than one at craft level to take on projects design and installation.
6. For public health and safety, designing plumbing and drainage systems must be carried out by professionals for the followings:
 - a. Proper choice of materials to suit the system structure design is fundamental to prevent contamination to drinking water.
 - b. The backflow of contaminated water to the supply side and the buildup of temperature leading to legionella growth must be prevented.
 - c. Dead legs in the system accumulating stagnant water must be avoided.
 - d. Water seals in sanitary system must be preserved to stop spread of disease.
 - e. Adequate rainwater system must be constructed to prevent flooding and leading to overloading of structures.

¹ The TF noted WSD had posted a passage on the departmental website defining *"Works of a minor nature are works which can be completed without the involvement of specialized trade skill and those who do not change the general arrangement of the plumbing installation already approved by the Water Authority, or affect the flow conditions of the plumbing system thus causing possible supply problems."*

http://www.wsd.gov.hk/en/plumbing_and_engineering/licensed_plumber/employ_a_licensed_plumber/index.html#notes.

The TF noted the above passage contained both physical parameters and criteria related to design & structure of a system, the latter of which recipients like AP could easily comprehend. The question is since AP would not be involved in alteration and minor repairs to direct a LP, it would leave to the LP himself, trained with competence at a craft level, assessing the design element to apprehend what works are of a minor nature under all circumstances.

² The TF noted the counter argument that the presence of design element was not the underlying reason to involve AP because (a) in the end the AP was only involved to ascertain the exact locations of meters in a new construction and (b) the AP was not involved in alteration work which could also be a major one requiring design inputs.

7. The complexity and scale of projects arisen from erecting high-rises in dense environment today demand high level engineering expertise and project management skills for the design, supervision and commissioning of both plumbing and drainage systems in buildings. The impacts from and the statutory requirement of the related fire services installations is another immense safety factor for consideration (but would not be covered in this report).

Recommendation

8. The TF opined the role of AP overseeing design on new installations shall remain. In addition, the scope of work of AP should be extended to cover major alteration to be defined by scale and/or scope, and to include communal work of multiple meters and work of high risks locations as food & eateries industries, communal & caring facilities, and health & clinical premises.
9. The qualification of AP must be one at professional level where affiliation to recognized qualifying institutions would require continual professional development and attract disciplinary penalty on breaches of professional conduct in addition to those under the statutory provisions.
10. The obvious choice of the most suitable profession of AP discharging the statutory duties of Cap 102 in terms of the engineering design and system monitoring of plumbing installations is a Registered Professional Engineer in Building Services Discipline and Mechanical Discipline, the latter if with equal proficiency in Plumbing & Drainage systems, under the Engineers Registration Ordinance Cap 409.
11. The TF also viewed, Architects with their professionalism in building projects management should remain as one of the recognized professions for the AP category. Despite the trend of architecture firms of employing an in-house expert in plumbing and drainage design is overtaken by turning to individual MEP consultant firms on project basis, the TF viewed the liability remains the same for an Architect as an AP whether the expertise services is from self, sourced internally or contracted out externally.

12. Cascading downwards, in private developments, inspectors with qualification equivalent to the grade of Associate Member of HKIE (AMHKIE) or trainee engineers in building services discipline are engaged in carrying out routine site supervisions. There are also LPs with qualifications at technician level, equivalent to that of the AMHKIE, which is higher than the current LP entry requirement at craft level plus. They should be recruited filling the mid-section of the workforce pyramid as demanded by the scale and diversity of present day's building and construction contracts.
13. The TF opined a strata type registration system should be inducted. Similar arrangements in site inspection employed by Building Department and various registration schemes of the Electrical & Mechanical Services Department (**EMSD**) would be useful references to consider in revising the role of AP and LP³.
14. For the LP, the TF opined enhancing the coverage of training, classification of types of worker and delineation of the scope of work of each would be conducive to ensure good practice taken up by workers in plumbing installations:-
- a. to introduce topics of health hazards due to heavy metal, legionella, bacteria and other organic concerns should also be introduced in tutoring courses⁴,
 - b. to increase vigorous training in soldering skill,
 - c. to set up different grades of LP either according to the scale or the nature of the work, or both,
 - d. in addition of recognizing perquisite courses conducted by the Vocational Training Council (**VTC**), to also assess the suitability and compatibility of semi-skilled and skilled workers in the plumbing trade registered under the Construction Workers Registration Ordinance (**CWRO**) for registration as LP, perhaps in different

³ Under the Building Ordinance, the AP is required to carry out supervisions and inspection for due compliance in the course of coordinating of the building works. The AP is assisted by five categories of Technical Competent Person at different levels of academic and experience attainment. There are several control schemes under EMSD principally along a structured layer in monitoring and control. Details of such would not be repeated here.

⁴ The TF was informed using lead-free solder in jointing was specifically covered by VTC

- categories of alteration and construction work and at the same time aligning two statutory requirements⁵,
- e. to set up clear guidelines whether a LP can supervise unlicensed workers in plumbing work and if affirmative, how many and to what extent,
 - f. to consider whether assigning the same grade covering both plumbing and fire services work is still desirable or appropriate with inputs from Fire Services Department,
 - g. to revamp the disciplinary penalty to take on factors of health concerns⁶,
 - h. to ensure LP should be personally liable to the work carried out by himself and by those under his supervision at an appropriate scale of penalty,
 - i. to introduce a separate inspectorate class at technician engineer level within the licensing framework for onsite supervision and testing and commissioning,
 - j. to list out clear demarcation on minor repairs works that inspection from WSD would not be required but must be carried out by a LP with record of completion filed with the Authority and a copy of full details given to the applicants

⁵ Under CWRO any person carrying out plumbing work in a construction site must be registered either as a semi-skilled or skilled worker in the Designated Trade of Plumbing. There is no requirement that they must be LP. The TF also noted not all workers so registered under CWRO were LP. At the name suggests the workers would be involved in construction work hence falling under the scope of new installation undertaken by the current Grade I class LP. On the other hand, in addition of the procession of a Green Card for entering into a construction site, if a LP wishes to carry out work within the control of Cap 102 in a construction site the LP must register either as semi-skilled or skilled workers according to qualifications set down by CWRA, failing that register as a General Worker. Under CWRO the semi-skilled and skilled worker have to supervise a General Worker carrying out work in the same designated trade. As a result either a non-LP is supervise a LP performing, say the soldering work, in the construction site or a burden of acquiring licenses for similar works. The TF considered 'disparities' between the two ordinances, (and others), needed to be addressed. CIC has the resources that could supplement and complement training requirements leading to registration of LP and this should be fully utilized. The workers would also be grateful.

⁶ The existing points system is more of check list type and prescriptive approach and cannot reflect the seriousness or consequence of non-performance.

Appendix C

Tin Solder – lead free?

In WSD Circular Letter No. 1/2015 dated 13 July 2015, WSD reminded that *“the requirement of using lead-free solders for copper pipes at fresh water Inside Services is specified in the standard as stipulated in the Waterworks Regulations.”*

In WSD Leaflet *“Hong Kong’s Water Supply – Reducing Lead in Drinking Water”* printed in August 2015, it was stated *“The use of lead-based soldering to connect copper pipes for potable water use has been prohibited in Hong Kong since the 1980s.”*¹

On 14 August 2015 WSD clarified in its departmental web page that *“All works approved by WWO 46 Part III on or after 13 July 2015, the solder materials shall be tested to comply with BS EN ISO 9453.”*

Specification Tracing

1. Although WSD claimed that lead-free solder for copper pipes was a requirement in standard(s) as specified, no clear indication of which particular standard was given before the explicit clarification made on 14 August 2015.
2. The TF first examined clauses of Cap102A and found solder was not mentioned, let alone lead-free solder.
3. Noting s20 stipulating *“every pipe or fitting shall be of the British Standard”*, the relevant standard BS EN 1254-1:1998 covering copper capillary fittings were checked.
4. Clauses contained in BS EN 1254-1:1998 were silent on leaded solder or lead-free solder. Except, Clause 4.2.2 did, tangentially perhaps, stipulate *“Leaded solders shall not be used for manufacture of integral solder ring fittings.”*
5. However the TF did manage to locate the footnote of Table 6 where it stated *“NOTE: Soldering alloys with lead and brazing alloys with cadmium are not*

permitted in installations for water for human consumption". But lead-free solder was not specially mentioned in the main text.

6. BS EN 1057:2006 *"Copper and copper alloys – Seamless, round copper tubes for water and gas in sanitary and heating applications"* was also searched with no result. Lead-free solder was not mentioned.
7. Engineers engaged in design of plumbing installations at times make reference to BS EN 806-2:2005, in which Clause 5.3 stated *"Materials used in pipe joint assemblies – Only solders free from lead, antimony and cadmium shall be specified..."* BS EN 806-2:2005 was not a standard specified in Cap 102A.
8. The TF cannot find specification of lead-free solders in all other WSD documents issued so far.
9. As such the TF could not find clear evidence that lead-free solder was explicitly stipulated by Cap 102, Cap 102A and related documents, and if affirmative the date of such requirement.

Overseas Specifications

10. According to the document *"Solders & Fluxes - No. 9-04-02 June 2012"* published by WRAS, UK, the Water Supply Bye-laws prohibited the use of lead based solders for domestic hot and cold water systems from 1987.
11. The Water Fittings Regulations (and Scottish Water Byelaws 2004), banned the use of lead based solders for domestic hot and cold water systems and other installations where the water was required to be wholesome (i.e. water to be used for drinking, cooking or food production purposes).
12. In the United States, the Safe Drinking Water Act Amendments of 1986 effectively banned the use of lead-containing solders in potable water systems nationwide. Before this, solder containing 50% tin and 50% lead was the most widely used solder for drinking water systems.
13. Part 1.2 of the Australian Standard AS 3500:1998, *"National Plumbing and Drainage – Water Supply – Acceptable Solutions"* stipulated soft solder shall not contain more than 0.1% lead by weight. This requirement was adopted in the *"Plumbing and Drainage Code of Practice"* and given its legal force by its

inclusion in Water Authorities regulations.

14. The TF finally did a check on BS 864-2:1983, the standard that BS EN 1254-1:1998 replaced, and found under clause 5.2.2 *“For potable water applications the solder used for making capillary joints shall be one of the lead free grades of soft solder specified in table 17.”* In Table 17 the maximum percentage of lead content was at 0.1.
15. The TF understood the use of lead-free tin solder must be ‘apparent’ to practicing professionals and from interviews it was also ‘widely’ aware by the more experienced LP in the trade.
16. The TF was also informed by VTC and CIC using lead-free solder was one of the topics in tutoring.
17. In this regard the TF believed the requirement of using lead-free tin solder was in fact one of the WSD requirements and the possibility that its ‘disappearance’ was due to ‘re-shuffling’ of standards could not be discounted.

APPENDIX D

Allowable Lead Content

1. The followings aim to identify the differences and similarities of allowable lead content of various fittings in drinking water distribution system adopted in different regions.
2. The table covers the maximum allowable lead content limit. Both the US and Canada allow a 0.25% of lead content in products of the total wetted parts contacting drinking water. The requirements set out by Australia, New Zealand, UK and HK are in percentage of the weight.
3. For copper pipes, all regions set out a range between 0.01% and 0.05% of lead content by weight. For fittings, gate valves and faucets, the North America requirements are more stringent at 0.25%.
4. As for tin soldering material, UK and HK set out a 'lead-free' requirement but this term is not commonly used by others. The US and Canada are at 0.2% and Australia and New Zealand 0.1%.
5. For HK, the recently issued water supply booklet [18] stated that all materials that come into contact with drinking water (including pipes, joints, soldering materials, valves, taps and other fittings) shall comply with the relevant British Standards for potable water use.

**Comparison of maximum allowable lead content (% weight)
in copper pipes, copper alloy valves and fittings in various regions**

Region	United* States	Canada*	Australia	New Zealand	UK	HK
Copper pipes	0.25% [1,2]; 0.01%#[17]	0.25% [3,4]; 0.01# [17]	0.05% [5-6]		0.085% [9-10]	
Copper alloy gate valves	0.25% [1,2]	0.25% [3,4]	4.5% [8]		8% [11-13]	
Faucets	0.25% [1,2]	0.25% [3,4]	4.5% [8]		not specified [14]	
Tin Solder	0.2% [2]	0.2% [3]	0.1% [7]		'Lead free' [15]	
Other copper alloy valves and fittings	0.25% [1,2]	0.25%[3,4]	4.5% [7]		3% [11, 15,16]	
Weighted-average	<=0.25% [1,2]	<=0.25% [3,4]	Nil		Nil	

* In total wetted parts unless otherwise indicated

By % of weight

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- References:**
- [1] NSF/ANSI 61A-2014a, Drinking Water System Components - Health Effects, American National Standards Institute, 2014
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 - [10] BS 12449:2012, Copper and copper alloys - Seamless, round tubes for general purposes, British Standards Institution, 2012
 - [11] BS 1982:2008, Copper and copper alloys - Ingots and castings, British Standards Institution, 2008
 - [12] BS EN 12288:2010, Industrial valves - Copper alloy gate valves, British Standards Institution, 2010
 - [13] BS 5154:1991 Specification for Copper alloy globe, globe stop and check, check and gate valves, British Standards Institution, 1991
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APPENDIX E

Sampling protocols of different regions

Region	United States	Canada	Australia	New Zealand	UK	HK
Enforcing Authority	Environmental Protection Agency	Health Canada	Dept. of Health & Medical Research Council	Ministry of Health	National Health Authority	Water Supplies Department
No of Draws	TWO -Tier	TWO -Tier	TWO -Tier	TWO -Tier	TWO –Tier	One-Tier
unflushed	after a 6-8 hour period of no water use [3]	after a stagnation period of at least 6 h (with aerator) [4]	after a period of stagnation [10]	after a 12-hour period of no water use [6]	after a period of stagnation [10]	N.A.
flushed	water run for a while at a slow pace [3]	Immediately after the first draw with approximately 5 min of flushing [4]	flush at a uniform rate for 2 min to 3 min [10]	flush for 10-20L of water discarded [6]	flush at a uniform rate for 2 min to 3 min [10]	flush for 2 min to 5 min with removal of filter [15]
Sample Volume (Litre)	1 [1]	1 (for both first and flushed draws) [4]	0.1 [5]	0.15 [6]	not specified	0.25 [15]
Sampling Locations	sample sites throughout the system & at dead ends [1]	drinking water fountains & cold water outlets used for drinking or cooking [4]	representative points relative to the pipe-work distribution system, for example, beginning, middle and end of distribution branches [10]		consumer taps [13]	depending on system and building types plus WSD designated locations [20]
Sampling Size (Statistical calculation Ref [17])	95% confidence related to population size [1]	Number of sample sites is based on system size [4]	95% confidence related to population size [13]	95% confidence related to population size [6]	not specified	developed according to ISO 5667 [20]
Sampling Frequency	monthly [1]	once a year [4]	depends on the period of interest and sample size [8]	monthly [6]	depends on the period of interest and sample size [8]	not specified

Region	United States	Canada	Australia	New Zealand	UK	HK
Monitored Period	not specified	one year [4]	to account for seasonal cycles [8]	12 months [6]	to account for seasonal cycles [8]	not specified
Container	must be fully filled [16]	not specified	rinsed with HNO ₃ to pH <2 bottle [5]	thoroughly rinsed bottle[6]	rinsed with HNO ₃ to pH <2 bottle or other thoroughly rinsed bottle[9-11]	multiple rinsed polyethylene bottles - 1 st rinse: with tap water then filled with Decon 90 (5%) solution); - 2 nd rinse: with deionised water then filled with 1:1HNO ₃ solution (stayed for 2 hours); - 3 rd rinse: 3 times with deionised water [15]
Maximum Holding Time	not specified	not specified	28 days [5]	within the same day [6]	6 months for acidified container; 7 days for plastic container if stored at dark and cool environment [8]	stored in ice-boxes with freezer packs and delivered within the same day [15]
Compliance	90 percentile 0.015 mg/L non-exceedance for first draw; 100 percentile 0.015 mg/L non-exceedance for second draw [1]	90 percentile 0.015 mg/L non-exceedance for first draw; 100 percentile 0.01 mg/L non-exceedance for second draw[4]	90 percentile 0.01 mg/L non-exceedance [5]	95 percentile 0.01 mg/L non-exceedance [6]	0.01 mg/L non-exceedance [10,18]	not specified

Region	United States	Canada	Australia	New Zealand	UK	HK
Sampling Water Temp	cold [3]	cold [4]	constant [10]	cold [6]	constant [10]	cold [15]
Remarks	first draw for lead & copper compliance and to identify high risk locations ; Second-draw to determine if action level is needed (0.15 mg/L) [1-2]	first draw is to ascertain if there is more than 10% of sites exceed lead action level (0.015 mg/L). If yes, second draw on 10% of the sites sampled in first draw should be conducted [4]	Requirements largely based on WHO [7], ISO standards [8-11] and AN/NZS national standards [12]. - first draw is to investigate the effects of materials on water quality - second draw is to check the supply water quality [10]	the difference in lead concentration between two draws in a sample pair taken during the 12-month monitoring period does not exceed 50 percent in lead level, the water is designated as non-plumbosolvent [6]	Requirements specified in Water Supply Regulations [18] (see DWI [13]) and EU Regulations [19] with reference to WHO [7] and ISO [8-11]. -first draw is to investigate the effects of materials on water quality - second draw to check the supply water quality [10]	Performance pledge:- Drinking water quality standard to WHO guidelines and standards [14]. Conditions when sample should NOT be taken are specified [15]

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APPENDIX F

HD Specifications Comparison

Tin Soldering Alloy	
WSD	Not specified
HD	<i>Clause 160.7:</i> - lead free – but no standard specified
ASD	<i>Clause B1.4.3:</i> BS EN 1254-1:1998, Table 6 sections 11 & III and lead-free
Industry	BS EN 29453
	BS EN ISO 9453
	Not permitted
Silver Brazing Alloy	
WSD	Not specified
HD	<i>Clause 150.7:</i> BS EN ISO 17672
ASD	<i>Clause B1.4.3:</i> BS EN 1254-1, 2% silver content, cadmium free
Industry	<=67 mm dia. BS EN ISO 17672, 2% Silver content, lead & cadmium free
	BS 1845 , 2% Silver content, lead & cadmium free
Integrated Solder Ring	
WSD	Not specified
HD	<i>Clause 160.7:</i> BS EN 1254-1
ASD	<i>Clause B1.4.3:</i> BS EN 1254-1
Industry	BS EN 1254-1
Flux	
WSD	Not specified
HD	(1) Not specified for soldering (2) Not permitted for Brazing
ASD	<i>Clause B1.4.3:</i> (1) non-corrosive & manufacturer recommendation for soldering (2) not permitted for brazing copper-to-copper joints
Industry	Ammonia free
	Manufacturer recommendation
Copper Tube	
WSD	<i>Note 7:</i> BS EN 1057
HD	<i>Clause 120.7:</i> BS EN 1057
ASD	<i>Clause C1.2.1:</i> BS EN 1057: 2006 +A1: 2010
Industry	BS EN 1057
Copper and Copper Alloy Fittings	
WSD	<i>Clause 17:</i> BS 864, Parts 2
HD	<i>Clause 130.7:</i> BS EN 1254-1,2,4 & 5 or equivalent standard
ASD	<i>Clause C1.2.2:</i> BS EN 1254-1,2,4 & 5:1998
Industry	BS EN 1254-1,2
Joint	
WSD	<i>Schedule2 Part 2 Clause 4(2)(d):</i> ferrous metal valves >50mm a. inlets flange BS 4504 , Part 1, Table 16, b. corrosion protection to BS 4164 or by galvanizing to BS 1387 , c. corrosion-resisting alloy for working surfaces
HD	<i>Clause 130.7:</i> Bolted flange joints (brazed type) BS EN 1092-3 or equivalent
ASD	<i>Clause 130.7</i> a. <=54mm copper pipe Compression fitting, solder end feed or integral capillary, or brazed capillary b. >50mm copper pipe Solder end feed or integral capillary c. >108mm copper pipe Brazed capillary fittings
Industry	>50mm copper pipe - Flanges to BS 4504

Valves - Ball, Gate & Globe	
WSD	<p><i>Schedule2 Part 2 Clause 4</i> Ball valve, floats <=300mm a. copper floats – BS 1968 b. plastic floats – BS 2456 <i>Schedule2 Part 2 Clause 8:</i> General purposes copper alloy gate valve - BS 5154 <i>Note 7: Ball valves BS 1212 Part 1</i></p>
HD	<p><i>Clause 610.7:</i> Gate Valve a. <=65mm Copper alloy BS 5154 / BS EN 12288 b. >65 mm BS 5163 / BS EN 1074 Non-return valves a. <=65mm): Copper alloy to BS 5154 / BS EN 12288 b. >65mm): BS EN 12334 Globe Valve a. <=65mm) BS 5154 b. >65mm BS EN 13789 Ball valve shall be made of UPVC</p>
ASD	<p><i>Clause C1.6.1</i> a. Non-metallic materials BS 6920-1: 2000 and suitable for potable water usage b. Copper alloy gate, globe and non-return valve BS 5154:1991 or BS EN 12288:2010 <i>Clause C1.6.7 Ball floats</i> a. tinned copper BS 1968: 1953 and BS 2456:1990 b. stainless steel BS EN 10088: 2005 for fresh water application</p>
Industry	<p>A. Gate Valve <=50 mm to BS 5154 / BS EN 12288 and >50 mm to BS 5163 / BS EN 1074 B. Stop Cock BS 1010 Part 2 with female screw thread connected to BS 21 Globe Valve <=50mm to BS 5154 / BSEN 12288, thread screw ends for female taper to BS 21, and >50mm to BS 5152 C. Check Valves to BS 5153 & BS 5154 / BSEN 12288 D. Ball float valves < 50mm to BS 1212 and >= 50mm to BS 1968</p>

- References:**
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 - [2] Cap 102A Water Works Regulation, HKSAR.
 - [3] HA et al (2014) Architectural work specification (2014), Housing Authority: HKSAR.
 - [4] ASD et al (2014) General specification for plumbing and drainage installation in government buildings of Hong Kong Special Administration Region, Architectural Services Department: HKSAR.
 - [5] Major M&E Consultants commercial project specification

NOTE: Standards Number highlight in RED are either outdated or withdrawn.

APPENDIX G

Testing of the Lead Content in Drinking Water – What, When & How

1. In July 2015 WSD included testing of lead and other three heavy metals in the monitoring, in response to excessive level of lead found in the PRH.
2. WSD proposed running the tap from 2 to 5 minutes before collecting the water samples. The period was explained as the approximate time needed to drain stagnated water to obtain flushed water samples so that the results of testing could show the 'true' state of the water quality.

WSD Pledge

3. WSD had adopted the WHO Guidelines (1993) as far back as in 1999¹ but lead was not one of the “*Key parameters selected from 1993 WHO Guidelines for audit analysis*” in the 1999 Audit Commission Report.
4. In the same report the TF noted the Director of Health had indicated:-
“With a large number of parameters, care should be taken to selecting parameters for which local standards² will be developed. A number of factors should be considered, including the geology of the region and the types of human activities (emphasis added) that could lead to the contamination of water”
5. For application in HK, the TF considered the geology of the region were not the typical terrains with surface and underground waters as sources of supplies found in overseas and the types of human activities were not about characteristics arisen from industrial or agricultural. Instead it is about a densely populated municipal with new high-rises and old buildings abutting each other.
6. But the TF also considered if professional building services engineers were consulted, the risk of lead leaching from pipes and fittings in the

¹ Audit Commission Report 1999

² Both Cap 132 and Cap 612 defined “‘drinks’ does not include water other than:- (a) aerated water; (b) distilled water; (c) water from nature springs, either in its natural state or with added mineral substances; and (d) water that is placed in a sealed container and is intended for human consumption.”

plumbing installations should be recognized and put under surveillance.

7. A statement in Volume One of the WHO (1993) stated:-

“Lead is exceptional in that most lead in drinking-water arises from plumbing in buildings and the remedy consists principally of removing plumbing and fittings containing lead.”

8. The TF noted the emphasis of WSD was to ensure water quality on the distribution side. The annex note (Note 35)³ in the Audit Commission Report was correct but that did not mean WSD was not responsible to ensure drinking water was of also of an acceptable quality before acceptance of a new installation.
9. However the TF must add WSD had consistently met the annual performance pledges noting from WSD Annual Reports⁴, the sampling with lead content in water was included and tested to compliance.

Lead in Public Housing Estates

10. For the purpose of our study, since evidences were that the lead contamination was due to faults in the plumbing installations, it is hence not enough to test the quality of the supply side and ignore the footing of individual flats.
11. From the engineering perspective in analyzing faults in construction, the results of the first or unflushed draws could isolate and identify those flats with excessive lead contents arisen from faulty plumbing installations for effective and efficient rectification.
12. Or putting it more positively to identify those flats that lead contaminants were absent or below the threshold guideline so that tenants could go back to their normal daily lives.
13. The proposition from WSD would hence only show the water quality of

³ *“A connection point is the point where the WSD’s water supply system connects to the lot boundary of the consumers’ premises. After the connection points, it is the responsibility of the consumers to ensure that the distribution system inside their building will deliver the same quality of water to the individual consumer’s tap.”*

⁴ The TF found the same status in Reports 1999/2000 and 2002/2003

the distribution supply and decimate the impact of the level of lead content in the plumbing systems.

14. The TF agreed with the test results of subsequent flushed draws could give a correct status of the water quality in the distribution system.
15. The TF believed protocols adopted overseas would be useful for reference in setting up HK own for in long term health and safety protection

Overseas Protocols

16. Most protocols adopted in overseas required collecting both unflushed and flushed samples. Multiple flushed samples were usually collected successively with intervals of a period between 2 to 3 minutes AFTER the unflushed samples were collected at the same locations.
17. The results of the unflushed samples would serve two purposes. One is to establish statistical data to compare with that of the second draws or flushed draws. The second purpose is to step up sampling coverage when a certain percentage of the unflushed draws failed the threshold limit.

Two Tier Monitor

18. Many protocols call for comparisons between two batches of samples, the first draws and flushed draws.
19. The TF noted the publication "*Guidance on Controlling Corrosion in Drinking Water Distribution Systems*" by Health Canada⁵ contained useful suggestions that Hong Kong can adopt with the cautious notes that we do not have past statistical data to compare sampling results and the adjustments needed to the characteristic of densely populated high-rises in our municipal.
20. The TF opined salient points quoted below from the publication of Health Canada would be conducive in assessing lead concentrations and identifying sources of leaching in both the distribution system and residential plumbing.

⁵ Health Canada, Ottawa, Ontario K1A 0K9, www.healthcanada.gc.ca

21. On austerly of contaminants:-

- a. exposure to the contaminant could lead to adverse health effects;
- b. the contaminant is frequently detected or could be expected to be found in a large number of drinking water supplies; and
- c. the contaminant is detected, or could be expected to be detected, at a level that is of possible health significance

22. On sampling:-

- a. The first-tier sampling determines the contribution of lead at the consumer's tap from the internal plumbing following a period of stagnation...so that systems that should be implementing corrective measures are being accurately identified.
- b. When a certain percentage of the first-tier sampling exceeded the target limit, the consumers would be advised to take corresponding measure like flushing before used and a second-tier sampling is to be conducted to establish a lead concentration profile.
- c. The second-tier sampling is successive samples taken after a few minute flushing.

23. The TF opined we need to ascertain the true level of lead contaminant in the plumbing installations of the public housing estates to assess how serious and likely the threat to health it would be. The only means of finding this is by taking samples of the first draw.

APPENDIX H

Inventory of Sampling Flats Tested at Public Housing Estates

	Estates	Total Flats	Samples Taken*
PRH Developments with Lead in Water Samples Exceeding WHO's Provisional Guideline Value			
* () indicates numbers of samples with excess lead tested			
1	Kwai Luen Estate Phase 2 - Luen Yat House, Luen Yuet House	1507	44 (5)
2	Kai Ching Estate	5204	115 (7)
3	Wing Cheong Estate	1488	46 (1)
4	Lower Ngau Tau Kok Estate Phase 1 - Kwai Leung House, Kwai Yuet House, Kwai Hin House, Kwai Sun House, Kwai Fai House	4238	130 (6)
5	Shek Kip Mei Estate Phase 2 - Mei Wui House, Mei Leong House	1558	59 (5)
6	Tung Wui Estate - Wui Sum House, Wui Yan House	1333	52 (4)
7	Hung Hom Estate Phase 2 - Hung Yat House, Hung Yan House, Hung Yiu House	1938	74 (16)
8	Yan On Estate - Yan Hei House, Yan Yuet House, Yan Chung House	2587	69 (5)
9	Choi Fook Estate - Choi Lok House, Choi Sin House, Choi Hay House	2524	90 (13)
10	Un Chau Estate Phase 2 and 4 - Un Lok House, Un Nga House, Un Chi House, Un Hei House, Un Kin House	3533	135 (19)
11	Ching Ho Estate Phase 1 - Ching Chung House, Ching Yu House, Ching Hin House	3167	145 (10)

PRH Developments with Lead in Water Samples Complying with WHO's Provisional Guideline Value			
1	Cheung Lung Wai Estate	1358	45
2	Hung Fuk Estate Phase 1 & 2 - Hung Foon House, Hung Yan House, Hung Hei House, Hung Lok House, Hung Fuk Shopping Centre and Ancillary Facilities Block	2097	150
3	Hung Fuk Estate Phase 3 - Hung Long House, Hung Yat House, Hung Yuet House, Hung Cheong House, Hung Shing House	2808	
4	Shui Chuen O Estate - Ching Chuen House, Long Chuen House, Yan Chuen House, Hei Chuen House	3039	53
5	Mei Tung Estate - Mei Tak House	990	24
6	Yee Ming Estate	2059	102
7	Tak Long Estate – carpark & kindergarten	8164	198
8	Fung Wo Estate	1607	50
9	Cheung Sha Wan Estate - Ancillary Facilities Block	1390	47
10	Lung Yat Estate - Community Hall	990	35
11	Mei Tin Estate - Mei Chuen House	1216	35
12	Shek Lei II Estate - Shek Foon House	839	26
13	Ching Long Shopping Mall	Nil	20
14	Shek Kip Mei Estate Phase 5 - Mei Yick House, Mei Yin House, Mei Sang House, Mei Shing House	2496	73
15	Un Chau Estate Phase 5 - Un Mun House, Un Wai House, Un Yat House	1486	56
16	Domain and Yau Tong Community Hall	Nil	8
17	Choi Fook Estate - Choi Foon House	915	27
18	Choi Tak Estate - Choi Yan House, Choi Yee House	1586	40

19	Kwai Luen Estate Phase 1 - Luen Yan House, Luen Hei House	1470	41
20	Mei Tung Estate - Mei Yan House	799	27
21	Choi Tak Estate - Choi Chun House, Choi King House, Choi Leung House, Choi Yin House, Choi Tak Shopping Centre	2704	82
22	Sha Tin Pass Estate - Wo Tin House, Shun Tin House	1278	53
23	Yau Lai Estate Phase 5 - Cheuk Lai House, Yung Lai House, carpark	2002	36
24	Yau Lai Estate Phase 6 - Yau Lai Shopping Centre	Nil	4
25	Shin Ming Estate - Shin Chi House, Shin Lai House	1974	49
26	Tin Ching Estate - Tin Ching Amenity and Community Building	Nil	24
27	Chai Wan Estate - Wan Poon House, Wan Ying House	1600	46
28	Choi Tak Estate - Choi Shing House, Choi Shun House	1462	69
29	Upper Ngau Tau Kok Estate Phase 2 & 3 - Sheung Hing House, Sheung Shing House, Sheung Fu House, Sheung Wing House, Sheung Hong House, Sheung Tai House - Upper Ngau Tau Kok Estate Shopping & Integrated Service Centre	4584	124
30	Tin Ching Estate Phase 3 - Ching Moon House, Ching Hei House, Chung Yuet House	2365	65
31	Shek Kip Mei Estate Phase 1 - Mei Yue House, Mei Ying House	2033	55
32	Sau Mau Ping (South) Estate - Sau Ho House, Sau Wong House	1598	130
33	Sau Mau Ping (South) Estate - Sau Mei House, Sau Tak House, Sau Sin House	2397	
34	Upper Wong Tai Sin Estate - Wing Sin House	714	22
35	Yau Lai Estate Phase 4 - Tsui Lai House, Hong Lai House, Yan Lai House	2369	121
36	Yau Lai Estate Phase 3 - Ying Lai House, Fung Lai House	1598	

37	Shek Mun Estate Phase 1 - Kin Shek House, Mei Shek House, Supermarket	1958	45
38	Lam Tin Estate - Lam Fai House, Lam Tai House, Lam Bik House, Lam Wai House	3036	102
39	Mei Tin House Phase 3 - Mei Lok House, Mei Mun House, Mei Ting House & Mei Tin Community Centre	2333	71
40	Tin Ching Estate Phase 1 - Ching Pik House, Ching Hoi House & Tin Ching Community Hall	1918	98
41	Tin Ching Estate Phase 2 - Ching Choi House, Ching Wan House, Tin Ching Shopping Centre & Tin Ching Ancillary Facilities Block	1918	
42	Choi Ying Estate Phase 1 - Ying Fu House, Ying On House	1598	137
43	Choi Ying Estate Phase 2 - Ying Hong House, Ying Lok House, Ying Shun House	2397	
44	Choi Ying Estate Phase 3 - Choi Ying Place	Nil	
45	Ching Ho Estate Phase 1 - Shopping Centre	Nil	3
46	Ching Ho Estate Phase 2 - Ching Ping House, Ching Yun House	1598	54
47	Tung Wui Estate - Tung Tau Community Centre	Nil	1
48	Shek Kip Mei Phase 2 - Ancillary Facilities Block	Nil	6
49	Lower Ngau Tau Kok Estate Phase 1 - Lower Ngau Tau Kok Estate Plaza	Nil	3
50	Yan On Estate - Yan On Shopping Centre	Nil	2
51	Oi Tung Estate - Oi Yat House	716	23
52	Shek Pai Wan Estate Phase 2 - Pik Shan House, Pik Yuen House, Pik Wai House, Pik Luk House	2398	95
53	Lei Yue Mun Estate Phase 2 - Lei Lung House	799	27
54	Shek Lei II Estate - Shek Wai House, Shek Yi House	1598	48

55	Ching Ho Estate Phase 3 - Ching Chak House, Ching Long House, Ching Chiu House	2397	81
56	Kwai Chung Estate - Pak Kwai House, Hop Kwai House	1983	81
57	Mei Tin Estate Phase 1 & 2 - Mei Sau House, Mei Lai House, Mei King House, Mei Chi House, shopping centre	3164	95
58	Hoi Lai Estate Phase 3 - Hoi Lai Shopping Centre & Phase 4 - Hoi Shui House	558	29
59	Kwai Chung Estate Phase 3 - Chui Kwai House, Pik Kwai House, Luk Kwai House	2742	84
60	Hin Yiu Estate - Hin Yiu House	799	26
61	Shek Yam Estate - Lai Shek House	340	9
62	Kwai Shing East Estate - Shing Wo House	362	59
63	Tsz Lok Estate - Lok Foon House	265	23
64	Lok Fu Estate - Lok Tsui House	360	16
65	Yat Tung (II) Estate - Mei Yat House, Mun Yat House, Kui Yat House	2782	108
66	Lei Muk Shue Estate Phase 3 - Chui Shue House, Wing Shue House, shopping centre	1983	66
67	Lei Muk Shue Estate Phase 4 - Hong Shue House, Lok Shue House, Kin Shue House	1918	54
68	Yau Lai Estate Phase 1 - Bik Lai House, Sau Lai House, Yi Lai House, Chi Lai House, Nga Lai House, Yat Lai House	2550	78
69	Shek Pai Wan Estate Phase 1 - Pik Long House, Pik Yuet House, Pik Ngan House, Pik Fai House, shopping centre	2877	92
70	Kwai Chung Estate Phase 3 - shopping centre	Nil	6
71	Kwai Chung Estate Phase 4 - Chin Kwai House, Tsz Kwai House	1983	70

72	Kwai Chung Estate Phase 5 - Hiu Kwai House, Ying Kwai House, Yuk Kwai House, Nga Kwai House, Yat Kwai House	4515	152
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Sources:

1. **Legislative Council Special House Committee Meeting on 1 September 2015 Background Brief on Lead in Drinking Water Incidents**
2. **Government Press Release (24 September 2015) Test Results of Water Samples Taken from Public Housing Estates**

APPENDIX I

Lead content leaching tests

1. The followings aim to identify the differences and similarities of lead content leaching test requirements for various fittings in drinking water distribution system adopted in different regions.
2. The table lists out the leaching tests specified in the US, Canada, Australia, New Zealand, UK and HK.
3. In the context of leaching test requirements, the test details of the US and Canada pair is identical, likewise between the pair of Australia and New Zealand. Variants of testing details between these two pairs are also minor. The US-Canada pair sets out a more stringent leaching limit - single product allowable leaching concentration is 5µg/L as compared to 10µg/L for Australia-New Zealand pair. But the latter pair requires simultaneous compliance of duplicate samples.
4. UK only has lead leaching test standard for non-metallic components.
5. For HK, the recently issued water supply booklet [9] stated testing shall follow the British Standards.

Comparison of lead leaching test requirements for drinking water pipes and fittings in various regions

Region		United States & Canada		Australia & New Zealand	UK & HK
Reference		[1]	[1] [2]	[3]	UK [4-8] HK [9]
Inclusion		non-metallic and metallic			non-metallic only
Test sample		materials or finished products			
Test method		in-the-product or immersion			Immersion[4]
Sample size	in-the-product	smallest inner diameter			n/a
	Immersion (min. surface area to volume ratio)	5000 mm ² /L	1000 mm ² /L	1000 mm ² /L [5]	
Sample pre-test	cleaning	rinsed with predicted contaminate-free water	rinsed in flowing tap water	rinsed in flowing tap water [4]	
	conditioning in test water	for a min. of 2 days	for 24 hours	for 24 hours [5]	

Test water	PH value	6.5 and 10 (pipes); 5 and 10 (fittings, valves and faucets)	calcium carbonate of 50 mg/L in chlorine- free or distilled water	7 ± 0.1 [4]
	temperature	23 ± 2 °C	20 ± 2°C	23 ± 2 °C [4]
Exposure time		24 ± 1 h	24 ± 2h	24h [6]
Container	in-the-product	capped with inert materials		n/a
	immersion	materials inert to the test water	glass or polyethylene ware	glass ware [4]
SPAC* Leaching limit		<= 5µg/L	<= 10µg/L (duplicate samples tested)	<=10µg/L [6]

* SPAC = single product allowable concentration

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