Replacement of Mercury-in-Glass Thermometers at Hong Kong Observatory Headquarters

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ABSTRACT: The use of mercury-in-glass thermometer to measure temperature at the Hong Kong Observatory has a long history. Recently, the mercury-in-glass thermometers have been replaced by non-mercury liquid filling thermometers following recommendation from the World Meteorological Organization. Details of the replacement process are described in this paper – including sourcing of suitable non-mercury liquid-in-glass thermometer, conduction of parallel-run study with existing mercury-in-glass thermometer and final selection of the replacement thermometer.

1. BACKGROUND

At the Hong Kong Observatory Headquarters (HKO Hq), the official hourly air temperatures have been observed since 1884 from the mercury-in-glass (MIG) thermometer. Since the implementation of digital thermometers in the 1980s, conventional MIG thermometers have served as backup and manual observations continue daily at 8 a.m. and 8 p.m. local time.

2. REPLACEMENT OF MERCURY-IN-GLASS THERMOMETER

In line with the UNEP[1] Minamata Convention on Mercury (UNEP, 2013), which bans all production, import and export of mercury-added products, the World Meteorological Organization (WMO) has recommended progressive replacement of MIG meteorological instruments by non-mercury (NM) instruments. In this connection, HKO sourced two different brands of NM thermometers as replacement candidates and carried out a parallel run study of both candidates against the operational MIG thermometer at HKO Hq manufactured by Casella UK. Following comparison of temperatures observed from MIG against the candidate NM thermometers, it was ascertained that the performance of one of the candidates was satisfactory. The MIG thermometer at HKO Hq has been replaced by the selected NM thermometer on 26 November 2025.

Details of the parallel run study, including equipment setup and observations strategy are described in Section 2.1. Data analysis and comparison results are presented in Section 2.2.

2.1 Parallel run study on the performance of non-mercury liquid-in-glass thermometers

Two brands of NM liquid-in-glass thermometers, Brand A and Brand B, were tested. Their specifications are listed in Table 1. Specifications of MIG thermometer are also included for comparison.

Table 1: Specifications of MIG and NM thermometers

Brand	MIG	Brand A (NM)	Brand B (NM)
Filling	mercury	alcohol	alcohol
Measuring range	-6 to +49 deg C	-20 to +55 deg C	-20 to +55 deg C
Accuracy	+/- 0.2 deg C	+/- 0.2 deg C	+/- 0.2 deg C

Two Brand A and two Brand B thermometers were set up on 16 November 2023 inside the open Thermometer Thatched Shed at HKO Hq. Brand A and Brand B thermometers were co-located back-to-back with MIG thermometer (see Figure 1). The Thermometer Thatched Shed arrangement with better ventilation is more satisfactory than a Stevenson Screen which is liable to overheat in hot calm weather. A comparison between temperatures measured in the shed and in the Stevenson Screen was made in 1978 (Chen, 1979).

Starting 16 November 2023, manual observations of temperatures measured by the two Brand A, the two Brand B and MIG thermometer were taken by Duty Weather Observer at 8 a.m. and 8 p.m. every day. In order to achieve a larger data set, additional observations were made by non-shift Observatory staff at 9 a.m., 11 a.m., 2 p.m. and 5 p.m. on every working day. From 13 June 2024 onwards, observation times in working days were changed to

[1] The United Nations Environment Programme

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11 a.m., 2 p.m., 3 p.m., 4 p.m. and 5 p.m. to check the performance of NM thermometers in capturing high afternoon temperatures. The aforesaid observations continued up to 30 April 2025, spanning over one year's time.

2.2 Comparison of temperatures measured by mercury and non-mercury liquid-in-glass thermometers

A scatter plot of differences between temperatures from MIG and NM thermometers against temperatures from MIG thermometer for the period from 16 November 2023 to 30 April 2025 was shown in Figure 2. The plot displayed a broad picture of the performances of Brand A and Brand B thermometers. Brand B thermometers performed better than Brand A thermometers with temperatures generally within a difference of 0.4 deg C or less from MIG thermometer temperatures. 0.4 deg C is the achievable measurement uncertainty when comparing two non-working-standard temperature measuring instruments as recommended by WMO (WMO, 2024).

Brand A thermometers, on the other hand, generally recorded higher temperatures compared to those from MIG thermometer. The temperature differences were up to 0.8 deg C when MIG thermometer registered hot temperature of 30 deg C.

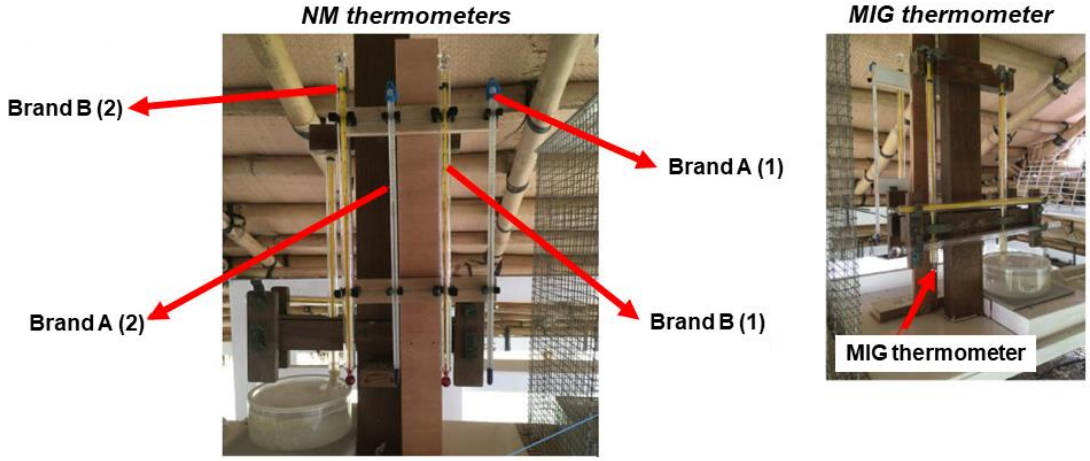
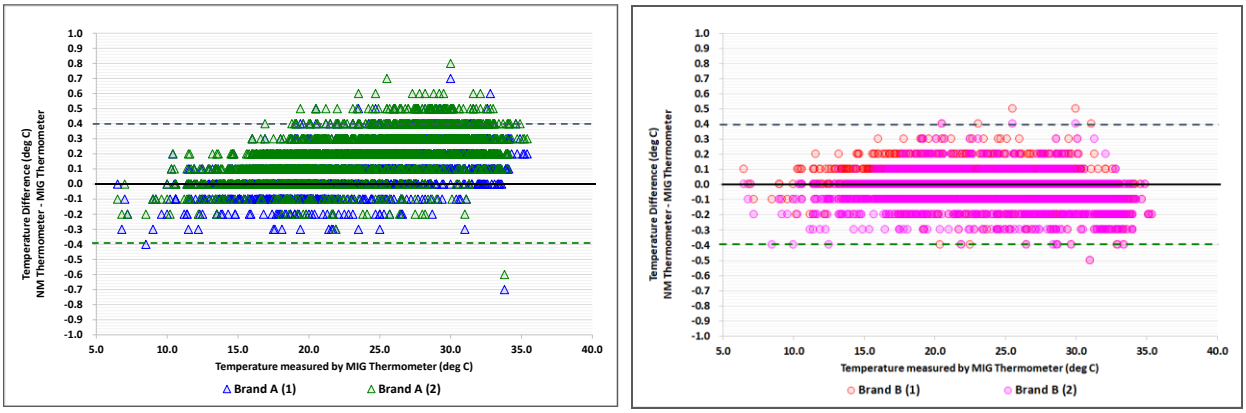


Figure 1: Set-up of mercury-in-glass and non-mercury liquid-in-glass thermometers inside the Thermometer Thatched Shed



2(a) *2(b)*

Figure 2: Differences between temperatures from MIG and NM thermometers against temperatures from MIG thermometer inside the Thermometer Thatched Shed (Figure 2(a) – Brand A vs MIG, Figure 2(b) – Brand B vs MIG, Data Period – 16 November 2023 to 30 April 2025)

A more detailed analysis of the differences in temperatures from MIG and NM thermometers is listed in Table 2.

All three cases of slightly larger than 0.4 deg C difference occurred during the overnight period when temperatures were falling. Cases 1 and 2 were hot temperature scenario with MIG and NM thermometer readings over 30 deg C. It seems that Brand B thermometers' performances dropped slightly during overnight cooling period, especially under hot temperature scenario. This slightly larger difference is transient, minimal and acceptable for a backup manual observation system, and is far outweighed by the significant operational safety gain achieved by eliminating mercury.

Table 2: Summary of the differences between temperatures from MIG and NM thermometers inside the Thermometer Thatched Shed (Data Period: 16 November 2023 to 30 April 2025; Total number of observations: 2442)

Thermometer	No. of observations with a difference of 0.4 deg C or less from MIG thermometer reading	No. of observations with a difference of more than 0.4 deg C from MIG thermometer reading
Brand A (1)	2421	21 (0.5 to 0.7 deg C difference)
Brand A (2)	2340	102 (0.5 to 0.8 deg C difference)
Brand B (1)	2439	3 (0.5 deg C difference, see Cases 1, 2 and 3)
Brand B (2)	2441	1 (0.5 deg C difference, see Case 1)

Case 1: 9 Aug 2024 – Temperature (TT) observed from both Brand B (1) (B1) and Brand B (2) (B2) thermometer differed more than 0.4 deg C from MIG temperature (Date and Time is the time of observation. All temperatures, including temperature difference (diff) are in units of deg C)

Date	Time (HKT)	MIG TT	B1 TT	TT diff B1-MIG	B2 TT	TT diff B2-MIG
9.8.2024	0800H	29.3	29.3	0.0	29.3	0.0
	1100H	31.3	31.2	-0.1	31.2	-0.1
	1400H	32.3	32.1	-0.2	32.1	-0.2
	1500H	32.6	32.6	0.0	32.6	0.0
	1600H	32.6	32.5	-0.1	32.5	-0.1
	1700H	32.0	32.0	0.0	32.0	0.0
	2000H	31.0	30.5	**-0.5**	30.5	**-0.5**
10.8.2024	0800H	29.6	29.7	+0.1	29.7	+0.1

Case 2: 1 Oct 2024 – Temperature (TT) observed from Brand B (1) (B1) thermometer differed more than 0.4 deg C from MIG temperature (Date and Time is the time of observation. All temperatures, including temperature difference (diff) are in units of deg C)

Date	Time (HKT)	MIG TT	B1 TT	TT diff B1-MIG
30/9/2024	0800H	28.5	28.5	0.0
	1400H	32.3	32.2	-0.1
	1500H	32.6	32.6	0.0
	1600H	33.2	33.0	-0.2
	1700H	32.6	32.6	0.0
	2000H	32.1	32.2	+0.1
1/10/2024	0800H	30.0	30.5	**+0.5**
2/10/2024	2000H	30.4	30.4	0.0

Case 3: 25 April 2025 – Temperature (TT) observed from Brand B (1) (B1) thermometer differed more than 0.4 deg C from MIG temperature (Date and Time is the time of observation. All temperatures, including temperature difference (diff) are in units of deg C)

Date	Time (HKT)	MIG TT	B1 TT	TT diff B1-MIG
25.4.2025	0800H	24.0	24.0	0.0
	1100H	25.7	25.8	+0.1
	1400H	25.5	25.5	0.0
	1500H	26.1	26.1	0.0
	1600H	26.1	26.1	0.0
	1700H	26.2	26.2	0.0
	2000H	25.5	26.0	**+0.5**
26.4.2025	0800H	21.7	21.8	+0.1

2. CONCLUSION

In view of the better performance of Brand B thermometers compared to that of Brand A, Brand B thermometer, which is the Model P3500 manufactured by Zeal, was chosen to replace the MIG thermometer at HKO Hq. The same NM thermometer was also used to replace the MIG thermometer at the Meteorological Garden of Observatory's Aviation Meteorological Office located at Chek Lap Kok, continuing to serve as backup of the digital thermometer.

After replacement of the MIG thermometer by NM thermometer, operation safety had been greatly enhanced. Even if the NM thermometer was accidentally broken, no mercury would be spilled out, eliminating negative impacts on human health and the environment.

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