APOLLO 1 EVALUATION REPORT

Issued 23 July 98

The following evaluation report was carried out by a
German DKD accredited calibration laboratory;
Klasmeier Kalibrier - Und Messtechnik GmbH
DKD KALIBIERLABORATORIUM
DKD-K-19001
Isothermal Technology thank Klasmeier Kalibrier
for the kind permission to reproduce their findings.

AN EVALUATION REPORT OF THE APOLLO 1 METAL BLOCK BATH MANUFACTURED BY ISOTHERMAL TECHNOLOGY LTD.

Model: Apollo 851/1

Metal Block Calibrator Serial Number. 171469-1

Temperature Range: 35 to 160° C

INTRODUCTION

The Apollo is a fixed metal block thermal calibration source with five calibrated settings

The Apollos are the 4th generation of Isotech's very first metal block bath. They are based on a very stable analogue 3 term controller with 5 pre-set values and a gold plated low resistance switch to select the fixed temperatures. These models have been recalibrated for up to 10 years and all have remained within their original specification.

The Apollo is ideal for calibrating between 4 and 8 thermometers with diameters up to 19mm.

The Apollo is widely used as a reference standard in hospitals, local government and food industries. Its fixed block, deep immersion depth and moderate operating range allow it to be used without an external reference thermometer.

Evaluated was a unit out of normal production. (Serial No. 171469-1) The unit had not been finally checked from quality-control and for this reason the absolute temperature deviated from the nominal temperature by more than would normally be expected (<0.1°C).This does not affect the calculation of the uncertainty. For the evaluation, the 4x8mm holes were used. Inserts were put in the 19.5mm holes.

Whenever possible this reports follows the recommendations of the *Guideline of*

the DKD-R5-4 Richtlinie des Deutschen Kalibrierdienstes (DKD) for the calibration of temperature block calibrators.

Method:

Standards used were accredidated for the DKD-calibration lab (DKD 19001)

The temperature homogeneity of the holes was evaluated.

The diameter of the refence thermometer for the first part of the evaluation was 4.1mm, the diameter of the holes were 8mm. Due to the recommendation of the DKD Guideline of a maximum airgap of 0.5mm between the holes and the thermometer we evaluated the parameters also with a refence standard 6.5mm in diameter. The airgap was then 0.75mm. The thermometers were placed at the bottom of the holes.

The immersion depth was 160mm.

Method of Measurments:

The surface of the calibration block was insulated with ceramic fibre insulation.

When measuring the axial homogeneity alumnium oxide was used for heat transfer.

The Standards for the homogeneity test were 4.1mm diameter.

Pocket-position

1 Reference Pocket 8mm TOP

2 Measuring Pocket 8mm TOP + 90 deg

3 Measuring Pocket 8mm TOP + 180 deg

4 Measuring Pocket 8mm TOP + 270 deg

Whenever possible this report follows the recommendations of the Guideline of the Deutscher Kalibrierdienstes (DKD) for the calibration of temperature block calibrators. DKD-R5-4

Summary of the results

For the summary and for the calculation of errors, we used the results of the tests with the 6.5mm diameter Semi-standard PRT's

Temperature	Hysteresis	Axial	Radial	Loading-	Stability

in °C	in mK	Homogeneity in mK	Homogeneity in mK	effect in mK	in mK
37	4	15	5	4	21
65	4	35	9	5	2.6
100	14	54	13	11	1.8
121	13	96	9	16	2
130	7	71	15	26	3

	Procedure 1	Procedure 2
Heat up Time	20 minutes from 37°C to 130°C	20 minutes from 37°C to 130°C
Stabilisation time	70 minutes	40 minutes

Apollo Uncertainty, k=2.

Temperature	Uct
130°C	0.08°C

1.Axial Temperature Homogeneity:

Test Method:

In hole 1 a semi standard probe model 935-14-61 Serial No. 16513-1 was placed to measure the block temperature. In the other holes 2 and 4 a semi standard of the same design was placed and raised in 1cm steps and the temperature difference between it and the static probe at the bottom of pocket 1 was recorded. Aluminia powder was placed in the pocket.

The active sensor length for the PRT's is 6mm.

Distance from bottom in cm	Setpoint 37°C dT=T1-T2 in mK	100°C dT=T1-T4 in mK	130°C dT=T1-T2 in mK
0	0	0	0
1	2	30	27
2	12	48	44
3	12	54	67
4	15	52	71
max	15	54	71

Temperature difference between the holes. (Radial Temperature distribution)

Test method: 1**:**

Two model 935-14-16 thermometers were placed in two 8mm holes (1 + 2). Measurements were recorded and then the probes were moved between the two pockets and repeat measurements made. The temperature, dT was calculated to remove the small offsets between the two probes. All four 8mm pockets were surveyed in this way and the result is taken as the worse case value.

Setpoint	Hole 1 in °C	Hole 2 dT in mK	Hole 3 dT in mK	Hole 4 dT in mK	Result in mK (+/-)
37	36.9596	-9	+6	-6	7
65	64.8144	-3	+15	-12	14
100	99.6889	-7	+2	-17	10
121	120.6614	-21	+20	-16	20
130	129.5462	+8	+20	-28	24

Test Method: 2:

Two 935-14-95 thermometers were placed in two 8mm holes (1 + 2). Measurements were recorded and then the probes were moved between the two pockets and repeat measurements made. The temperature, dT was calculated to remove the small offsets between the two probes. All four 8mm pockets were surveyed in this way and the result is taken as the worse case value.

Setpoint	Hole 1 in °C	Hole 2 dT in mK	Hole 3 dT in mK	Hole 4 dT in mK	Results in mK (+/-)
37	36,979	+9	+6	+5	5
65	64,883	+11	+18	+8	9
100	99,811	+1	+26	+8	13
121	120,795	+5	+18	+11	9
130	129,694	0	+29	+3	15

3. Loading Effect.

Test method 1:

The block temperature was recorded in hole 1 with semi standard model, first without loading and then loaded with semi standards model 935-14-95 (6mm diameter by 400mm) in holes 2 and 3. Hole 4 had a thermometer 4.1mm diameter by 300mm.

Temperature in °C	without Loading in °C	after Loading in °C	dT in mK
37	36.9739	36.9753	+ 2
65	64.8188	64.8237	+ 5
100	99.6848	99.6953	+ 11
121	120.651	120.6636	+ 12
130	129.5351	129.5488	+ 14

Test Method 2:

The block temperature was recorded in hole 1 with semi standard model 935-14-95 serial no. 16514-2, first without loading and then loaded with semi standard thermometer model 935-14-95 in hole 2, 935-14-77/2 in hole 3. Hole 4 had a 6mm diameter PRT with a length of 400mm.

Temperature in °C	without Loading in °C	with Loading in °C	dT in mK
37	36.981	36.985	+ 4
65	64.887	64.892	+ 5
100	99.811	99.822	+ 11
121	120.802	120.816	+ 16
130	129.694	129.720	+ 26

Hysteresis

These are the results between measurements from different days. The difference is the reproducibility.

Temperature in °C	19.3.98	23.3.98	Hystereses in mK
37	36.981	36.985	+4
65	64.887	64.891	+4
100	99.811	99.825	+14
121	120.802	120.815	+13
130	129.694	129.701	+7

5. Stability with time:

A semi-standard serial. no. 16513-1 (Procedure1) and ser.no. 16514-2 (Procedure2) was placed in hole 1. The probe was connected to a TTI2 precision temperature indicator and the variation was recorded for a 30 minute period at 5 different temperatures. The ambient temperature was within 23°C +/-5°C

Temperature in °C	Stability (Procedure 1) in mK	Stability (Procedure2) in mK
37	26	21
65	5	2.6
100	5	1.8
121	2.5	2
130	4	3

Calculation of the Uncertainty at 130°C:

Ambient 20°C +/-5°C

Source of Uct	Determination of Uct	Probability distribution	Uncertainty °C	Divisor	ui(t), °C
Standard Thermometer including measurement with standard therm.	Schedule	normal	0.02	2	0.01
Repeatability (Hysterises)		rectangular	0.007	sqrt3	0.004
Axial Temperature distribution	This evaluation report	rectangular	0.071	sqrt3	0.04
Radial Temperature distribution	This evaluation report	rectangular	0.015	sqrt3	0.009
Loading of block	This evaluation report	rectangular	0.026	sqrt3	0.015
Stability with time	This evaluation report	rectangular	0.003	sqrt3	0.002
Ageing of reference thermometer	This evaluation report	rectangular	0.04	sqrt3	0.0231
Repeatability (Hysteresis)	This evaluation report	rectangular	0.007	sqrt3	0.004

Combined Uct		k=1			
Expanded Uct		k=2			0.081

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Test Method: 2:

Two 935-14-95 thermometers were placed in two 8mm holes (1 + 2). Measurements were recorded and then the probes were moved between the two pockets and repeat measurements made. The temperature, dT was calculated to remove the small offsets between the two probes. All four 8mm pockets were surveyed in this way and the result is taken as the worse case value.

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