HYPERION^{PLUS} 936
EVALUATION REPORT

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Hyperion^{PLUS} 936 Evaluation Report

An evaluation report of the Hyperion^{PLUS} 936 bath manufactured by Isothermal Technology Ltd.

Introduction

The Hyperion^{PLUS} 936 is part of the ISOCAL-6 family of products. It can be used as a dry-block, liquid bath, ITS-90 fixed point device, black body and surface probe calibrator.

At Isotech it is our earnest desire to present for our customers' consideration as much useful information as possible and to this end we have spent a substantial amount of time evaluating our products.

The results of the evaluation of a bath can be presented in many formats some of which will give an optimistic or indeed a pessimistic view of how the product operates. This evaluation report is based on the DKD-R5-4 document.

The evaluation based on the DKD document presents almost the worse case error that may occur within the bath.

With some care and proper procedures it is possible to improve considerably upon these uncertainties. We have therefore presented a second evaluation based on the best practice as an Appendix to the evaluation.

Summary of Performance

Metal Block Mode, Option 1, Site Model

TEMPERATURE °C	STABILITY ± °C	RADIAL HOMOGENEITY	AXIAL HOMOGENEITY	UNCERTAINTY*
-25.0	0.014	0.002	0.041	0.075
50.0	0.010	-0.000	0.037	0.074
140.0	0.020	-0.004	0.067	0.081

Liquid Mode, Option 2, Site Model

TEMPERATURE °C	STABILITY ± °C	RADIAL HOMOGENEITY	AXIAL HOMOGENEITY	UNCERTAINTY*
-25.0	0.02	0.002	0.016	0.072
50.0	0.02	0.014	0.030	0.074
140.0	0.03	0.022	0.040	0.077

* Uncertainty is calculated, for the spread k = 2, which is the combined uncertainty x 2 and equivalent to a confidence level of approximately 95% (2 Sigma)

ITS-90 Fixed Point Mode, Option 6

Fixed Point	UNCERTAINTY
Gallium, 29.7646°C	0.001°C
Water, ±0.01°C	±0.001°C

Evaluation with Metal Insert

AXIAL TEMPERATURE HOMOGENEITY

Axial Temperature Homogeneity: The axial temperature distribution is measured at three different temperatures representative of the field of application and covering the extreme temperatures that may occur. A suitable thermometer is used, the sensor length not exceeding 5mm. At least six different measurements per bore are carried out in the calibration zone and adjoining parts of the bore, the distance between measurement points being 1cm.

TEST METHOD

A 935-14-12 probe (designed for small stem conduction) was placed in each of the 4.5mm holes. One probe was raised in 1cm steps and the temperature difference between it and the static probe at the bottom of pocket D was recorded.

AXIAL TEMPERATURE HOMOGENEITY: -25°C

DISTANCE FROM BOTTOM OF INSERT POCKET, CM	TEMPERATURE DIFFERENCE Δ T=TD-TB °C
0	0.002
1	0.002
2	0.002
3	-0.004
4	-0.011
5	-0.021
6	-0.039
(0 Repeat)	0.002

At -25°C the Maximum Variation over 50mm Zone was 0 .023°C
(This includes the measurement error and stem conduction)

AXIAL TEMPERATURE HOMOGENEITY: 50°C

DISTANCE FROM BOTTOM OF INSERT POCKET, CM POCKET D	TEMPERATURE DIFFERENCE Δ T=TD-TB °C
0	0.000
1	-0.002
2	-0.002
3	-0.005
4	-0.011
5	-0.022
6	-0.037
(0 Repeat)	0.001

At 50°C the Maximum Variation over 50mm Zone was 0. 022°C
(This includes the measurement error and stem conduction)

AXIAL TEMPERATURE HOMOGENEITY: 140℃

DISTANCE FROM BOTTOM OF INSERT POCKET, CM POCKET D	TEMPERATURE DIFFERENCE Δ T=TD-TB °C
0	0.005
1	0.010
2	0.017
3	0.018
4	-0.003
5	-0.040
6	-0.062
(0 Repeat)	0.004

At 140℃ the Maximum Variation over 50mm Zone was 0 .045℃
(This includes the measurement error and stem conduction)

RADIAL TEMPERATURE HOMOGENEITY

Radial Temperature Homogeneity: The temperature differences between the zones in the individual bores provided for the measurements are measured with a suitable thermometers at three different temperatures representative of the field of application and covering the extreme temperatures which may occur.

TEST METHOD
A 935-14-12 thermometer (designed for small stem conduction) was placed in each of the 4.5mm holes. Measurements were recorded and then the probes were moved between the two pockets and repeat measurements made. The temperature, Δt, was calculated to remove the small offsets between the two probes.

$\Delta t = 2\,[(t_{AAB} - t_{AAD}) + (t_{ZZB} - t_{ZZD})]$

Temperature, °C	Δ t
-25	0.004°C
50	-0.001℃
140	-0.004°C

Loading Effects

Influence upon radial temperature homogeneity due to different loading: A suitable thermometer is placed into the bore located next to the largest bore. The change in temperature is measured which results when a solid metal rod is introduced into the largest bore which protrudes from the bore by at least 200mm. The measurement is to be carried out at three different temperatures representative of the field of application and covering the extreme temperatures that may occur.

TEST METHOD
Isothermal Technology recommends an external probe is used to determine the insert temperature. For this test the recommended probe model 935-14-61, is connected to the built in indicator of the site model. A second thermometer is introduced to measure the insert temperature independently. A metal rod 340mm long and 9mm diameter is placed in pocket C.

Insert Temperature, 50°C

	No Rod	Δ t	Rod Added	Δ t	Change
935-14-12 - A02+TTI 2	50.011°C		50.002°C		
935-14-61+Site Indicator (In Built)	50.0°C	0.011	50.0°C	0.002	0.009

Although the block temperature is influenced by loading the Hyperion's separate PRT and in built indicator compensates such that errors due to loading are eliminated.

Insert Temperature, 140°C

	No Rod	Δ t	Rod Added	Δ t	Change
935-14-12 - A02+TTI 2	140.016°C		139.993°C		
935-14-61+Site Indicator (In Built)	140.0°C	0.016	140.0°C	-0.007	0.023

Although the block temperature is influenced by loading the Hyperion's separate PRT and in built indicator compensates such that errors due to loading are eliminated.

Stability with Time

Stability with time: The variation of temperature with time in the zones in the individual bores provided for measurements must be sufficiently small. The temperature variations are considered to be sufficiently small when the greatest temperature difference occurring within 30 minutes is smaller than or, equal to, half the uncertainty of the measurement stated.

Stability at –25℃, 30 minute period, ±0.01℃
Stability at 50℃, 30 minute period, ±0.01℃
Stability at 140℃, 30 minute period, ±0.02℃

TEST METHOD
A 935-14-12 thermometer was placed into one of the 4.5mm holes. The probe was connected to a TTI 2 precision temperature indicator and the variation in temperature was recorded for a 30-minute period. The ambient temperature was within 23℃ ±3℃.

HYSTERESIS (REPEATABILITY)
The Hyperion was set to –25℃ and the actual temperature along with the value for the in-built temperature indicator was recorded, then the temperature was raised to 140℃ for two hours. The temperature was then reset to –25℃ and repeat measurements made. The difference was within the resolution of the indicator: -0.1℃

Evaluation with Stirred Oil Tank

AXIAL TEMPERATURE HOMOGENEITY

Axial Temperature Homogeneity: The axial temperature distribution is measured at three different temperatures representative of the field of application and covering the extreme temperatures that may occur. A suitable thermometer is used, the sensor length not exceeding 5mm. At least six different measurements are carried out in the calibration zone and adjoining parts, the distance between measurement points being 1cm.

TEST METHOD

Two 935-14-12 probes (designed for small stem conduction) were placed in a holder such that the two probes were spaced 10mm apart. The probes were arranged to be 15mm from the base of the stirred oil tank. The mid point between the probes was over the centre of the oil tank. One probe was raised in 1cm steps and the temperature difference between it and the static probe was recorded.

AXIAL TEMPERATURE HOMOGENEITY: -25℃ – C10 SILICONE OIL

dL, CM	**TEMPERATURE DIFFERENCE** **Δ T=TD-TB °C**
0	0.003
1	0.006
2	0.002
3	-0.007
4	-0.010
5	-0.012
6	-0.013
(0 Repeat)	0.002

At -25℃ the Maximum Variation over 60mm Zone was 0 .016℃
(This includes the measurement error and stem conduction)

AXIAL TEMPERATURE HOMOGENEITY: 50℃ – C10 SILICONE OIL

dL, CM	**TEMPERATURE DIFFERENCE** **Δ T=TD-TB °C**
0	-0.004
1	-0.007
2	-0.012
3	-0.018
4	-0.022
5	-0.022
6	-0.026
(0 Repeat)	-0.002

At 50℃ the Maximum Variation over 60mm Zone was 0. 030℃
(This includes the measurement error and stem conduction)

AXIAL TEMPERATURE HOMOGENEITY: 140℃ – C10 SILICONE OIL

dL, CM	**TEMPERATURE DIFFERENCE** **Δ T=TD-TB °C**
0	0.008
1	-0.001
2	-0.009
3	-0.017
4	-0.021
5	-0.026
6	-0.032
(0 Repeat)	0.006

At 140℃ the Maximum Variation over 60mm Zone was 0 .040℃
(This includes the measurement error and stem conduction)

RADIAL TEMPERATURE HOMOGENEITY

Radial Temperature Homogeneity: The radial temperature differences are measured with a suitable thermometer at three different temperatures representative of the field of application and covering the extreme temperatures which may occur.

TEST METHOD
Two 935-14-12 probes (designed for small stem conduction) were placed in a holder such that the two probes were spaced 10mm apart. The probes were arranged to be 15mm from the base of the stirred oil tank. The mid point between the probes was over the centre of the oil tank. After measurements were recorded the probes were swapped between positions and then repeat measurements were made.

The temperature, Δt, was calculated to remove the small offsets between the two probes.

$\Delta t = 2\,[(t_{AAB} - t_{AAD}) + (t_{ZZB} - t_{ZZD})]$

Temperature, °C	Δ t
-25 – C10 Silicone Oil	0.002°C
50 – C10 Silicone Oil	0.014°C
140 – C10 Silicone Oil	0.022°C

Loading Effects

Influence upon radial temperature homogeneity due to different loading: A suitable thermometer is placed into the liquid. The change in temperature is measured which results when a solid metal rod is introduced which protrudes from the liquid by at least 200mm. The measurement is to be carried out at three different temperatures representative of the field of application and covering the extreme temperatures that may occur.

TEST METHOD
Isothermal Technology recommends an external probe is used to determine the liquid temperature. For this test the recommended probe model 935-14-61, is connected to the built in indicator of the site model. A second thermometer is introduced to measure the insert temperature independently. A metal rod 340mm long and 9mm diameter is later placed in the liquid.

Liquid Temperature, 50°C – C10 Silicone Oil

	No Rod	Δ t	Rod Added	Δ t	Change
935-14-12 - A02+TTI 2	50.020°C		50.003°C		
935-14-61+Site Indicator (In Built)	50.0°C	0.020	50.0°C	0.003	0.017

Although the block temperature is influenced by loading the Hyperion's separate PRT and in built indicator compensates such that there is,

No additional error due to loading at 50°C

Liquid Temperature, 140°C - C10 Silicone Oil

	No Rod	Δ t	Rod Added	Δ t	Change
935-14-12 - A02+TTI 2	140.037°C		139.997		
935-14-61+Site Indicator (In Built)	140.0°C	0.037	140.0	-0.003	0.040

Although the block temperature is influenced by loading the Hyperion's separate PRT and in built indicator compensates such that there is,

No additional error due to loading at 140℃

Stability with Time

Stability with time: The variation of temperature with time must be sufficiently small. The temperature variations are considered to be sufficiently small when the greatest temperature difference occurring within 30 minutes is smaller than or, equal to, half the uncertainty of the measurement stated.

Stability at –25℃, 30 minute period, ±0.02℃ C10 Silicone Oil
Stability at 0℃, 30 minute period, ±0.001℃ Water
Stability at 50.0℃, 30 minute period, ±0.02℃ C10 Silicone Oil
Stability at 140℃, 30 minute period, ±0.03℃ C10 Silicone Oil

TEST METHOD
A 935-14-12 thermometer was placed in the centre of the liquid with the tip 15mm above the tank base. The probe was connected to a TTI 2 precision temperature indicator and the variation in temperature was recorded for a 30-minute period. The ambient temperature was within 23℃ 3℃.

HYSTERESIS (REPEATABILITY) values are taken from work done with the metal insert, see earlier.

Use with Fixed Points

Isocal Fixed Point Cells

Fixed Point Cells provide fixed point calibration. The International Temperature Scale, ITS-90, specifies for the range -38 to 962℃ values for the melting, freezing or triple points of a metal (or water for the water triple point, 0.01℃). The freezing point of a metal can be defin ed with great accuracy. The accuracy comes not from the precision of electronic or other artificial means but from the purity of a metal and the physics of latent heat.

Using a fixed point cell with the Hyperion is simple. The cell is placed into a sleeve that fits in the well and thermometers to be calibrated are then placed in turn into the cell. As the cell changes state, from a solid to a liquid the temperature remains constant and known - a fundamental constant of nature.

Isocal-6 Fixed Point Cells are built with the same materials and techniques as the larger cells that Isotech manufactures for Primary Standards Laboratories but the smaller size of the cells make them more affordable and practical for the industrial laboratory. For the industrial laboratory Isocal-6 cells provide fixed point reference standards, useful for checking the labs reference thermometers.

Uncertainty Calculations

1, With Metal Insert

Standard Insert, ambient 23+/-3℃. 935-14-12 - A02+ TTI2/3.

Set point = -25℃

SOURCE OF UCT	DETERMINATION OF UCT	PROBABILITY DISTRIBUTION	UNCERTAINTY ℃	DIVISOR	ui(t), ℃
Standard Thermometer including measurement with standard thermometer	UKAS Schedule	Normal	0.04	1	0.04
Axial Temperature distribution	This evaluation report	Rectangular	0.041	√3	0.023
Radial Temperature distribution	This evaluation report	Rectangular	0.004	√3	0.002
Loading of block	This evaluation report	Rectangular	0	√3	
Stability with time	This evaluation report	Rectangular	0.014	√3	0.008
Ageing of reference thermometer	This evaluation report	Rectangular		√3	
Repeatability (Hysteresis)	This evaluation report	Rectangular	0.1*	√3	0.058
Combined Uct		k=1			0.075
Expanded Uct		k=2			0.15

* Resolution of indicator.

Standard Insert, ambient 23+/-3℃. 935-14-12 - A02+ TTI2/3.

Set point = 50℃

SOURCE OF UCT	DETERMINATION OF UCT	PROBABILITY DISTRIBUTION	UNCERTAINTY ℃	DIVISOR	ui(t), ℃
Standard Thermometer including measurement with standard thermometer	UKAS Schedule	Normal	0.04	1	0.04
Axial Temperature distribution	This evaluation report	Rectangular	0.037	√3	0.021
Radial Temperature distribution	This evaluation report	Rectangular	0	√3	0
Loading of block	This evaluation report	Rectangular	0	√3	0
Stability with time	This evaluation report	Rectangular	0.010	√3	0.006
Ageing of reference thermometer	This evaluation report	Rectangular	0	√3	0
Repeatability (Hysteresis)	This evaluation report	Rectangular	0.1*	√3	0.058
Combined Uct		k=1			0.074
Expanded Uct		k=2			0.148

* Resolution of indicator

Standard Insert, ambient 23+/-3℃. 935-14-12 - A02+ TTI2/3.

Set point = 140℃

SOURCE OF UCT	DETERMINATION OF UCT	PROBABILITY DISTRIBUTION	UNCERTAINTY ℃	DIVISOR	ui(t), ℃
Standard Thermometer including measurement with standard	UKAS Schedule	Normal	0.04	1	0.04
Axial Temperature distribution	This evaluation report	Rectangular	0.067	√3	0.038
Radial Temperature distribution	This evaluation report	Rectangular	-0.004	√3	-0.002
Loading of block	This evaluation report	Rectangular	0	√3	0
Stability with time	This evaluation report	Rectangular	0.020	√3	0.011
Ageing of reference thermometer	This evaluation report	Rectangular		√3	
Repeatability (Hysteresis)	This evaluation report	Rectangular	0.1*	√3	0.058
Combined Uct		k=1			0.081
Expanded Uct		k=2			0.162

* Resolution of indicator

2, With Stirred Liquid Tank

Oil Tank, C10 Silicone Oil ambient 23+/-3℃. 935-1 4-12 - A02+TTI2/3.

Set point = -25℃

SOURCE OF UCT	DETERMINATION OF UCT	PROBABILITY DISTRIBUTION	UNCERTAINTY ℃	DIVISOR	ui(t), ℃
Standard Thermometer including measurement with standard thermometer	UKAS Schedule	Normal	0.04	1	0.04
Axial Temperature distribution	This evaluation report	Rectangular	0.016	√3	0.009
Radial Temperature distribution	This evaluation report	Rectangular	0.002	√3	0.001
Loading of block	This evaluation report	Rectangular	0	√3	
Stability with time	This evaluation report	Rectangular	0.02	√3	0.0115
Ageing of reference thermometer	This evaluation report	Rectangular		√3	
Repeatability (Hysteresis)	This evaluation report	Rectangular	0.1*	√3	0.058
Combined Uct		k=1			0.072
Expanded Uct		k=2			0.144

* Resolution of indicator.

Oil Tank, C10 Silicone Oil ambient 23+/-3℃. 935-14 -12 - A02+TTI2/3.

Set point = 50℃

SOURCE OF UCT	DETERMINATION OF UCT	PROBABILITY DISTRIBUTION	UNCERTAINTY ℃	DIVISOR	ui(t), ℃
Standard Thermometer including measurement with standard thermometer	UKAS Schedule	Normal	0.04	1	0.04
Axial Temperature distribution	This evaluation report	Rectangular	0.030	√3	0.017
Radial Temperature distribution	This evaluation report	Rectangular	0.014	√3	0.008
Loading of block	This evaluation report	Rectangular	0	√3	
Stability with time	This evaluation report	Rectangular	0.02	√3	0.0115
Ageing of reference thermometer	This evaluation report	Rectangular	0	√3	
Repeatability (Hysteresis)	This evaluation report	Rectangular	0.1*	√3	0.058
Combined Uct		k=1			0.074
Expanded Uct		k=2			0.148

* Resolution of indicator.

Oil Tank, C10 Silicone Oil ambient 23+/-3℃. 935-14 -12 - A02+TTI2/3.

Set point = 140℃

SOURCE OF UCT	DETERMINATION OF UCT	PROBABILITY DISTRIBUTION	UNCERTAINTY ℃	DIVISOR	ui(t), ℃
Standard Thermometer including measurement with standard thermometer	UKAS Schedule	Normal	0.04	1	0.04
Axial Temperature distribution	This evaluation report	Rectangular	0.040	√3	0.023
Radial Temperature distribution	This evaluation report	Rectangular	0.022	√3	0.012
Loading of block	This evaluation report	Rectangular	0	√3	
Stability with time	This evaluation report	Rectangular	0.03	√3	0.017
Ageing of reference thermometer	This evaluation report	Rectangular	0	√3	
Repeatability (Hysteresis)	This evaluation report	Rectangular	0.1*	√3	0.058
Combined Uct		k=1			0.077
Expanded Uct		k=2			0.154

* Resolution of indicator.