UNITED STATES DEPARTMENT OF COMMERCE
National Institute of Standards and Technology
Gaithersburg, Maryland 20899-8400

CERTIFICATE OF ANALYSIS

International Temperature Scale of 1990

Water Triple-Point Cell
Pond Engineering Model K29H
Serial Number 4041

Tested for
Pond Engineering Laboratories
2501 South County Road 21
Berthoud, CO 80513

13 December 2022

Customer name:	Pond Engineering Laboratories
Device under test:	Water triple-point cell
Model number:	K29H
Serial number:	4041
NIST service ID#:	33360S
Purchase order:	NA
Order:	O-35492
Dates of test:	25 Oct 2022 through 28 Oct 2022
Measurements:	Tobias Herman and Bethany Rodman
Analysis:	Tobias Herman

A direct comparison of your water triple-point cell (Pond Engineering K29H, s/n 4041 was made against our laboratory reference water triple-point cell (s/n A-Q5079). The NIST water triple-point cell is a defining artifact used in the realization of the International Temperature Scale of 1990 (ITS-90) at NIST, and thus provides SI traceability. The measurement system included either an ASL F18 resistance ratio bridge or an Isotech microK-70 resistance ratio bridge, with a 100 Ω Tinsley Model 5685A reference resistor, temperature controlled to 25 °C ± 0.01 °C, and a 25.5 Ω SPRT. Corrections were made to account for the differences in immersion depth of your cell and the NIST reference cell.

As shown in figure 1, the triple-point temperature of your cell differs from the NIST reference cell

by 0.05 mK. As given in Appendix A, the expanded uncertainty (k=2) of the direct comparison is 0.07 mK. As given in Appendix B, the expanded uncertainty (k=2) assigned to the realization of the NIST reference cell is 0.05 mK. The isotopic analysis you submitted indicates that a correction of 0.036 mK should be applied to your cell to account for isotopic deviation from the composition of Vienna Standard Mean Ocean Water (VSMOW); after including this correction your cell differs from the NIST reference cell by 0.02 mK.

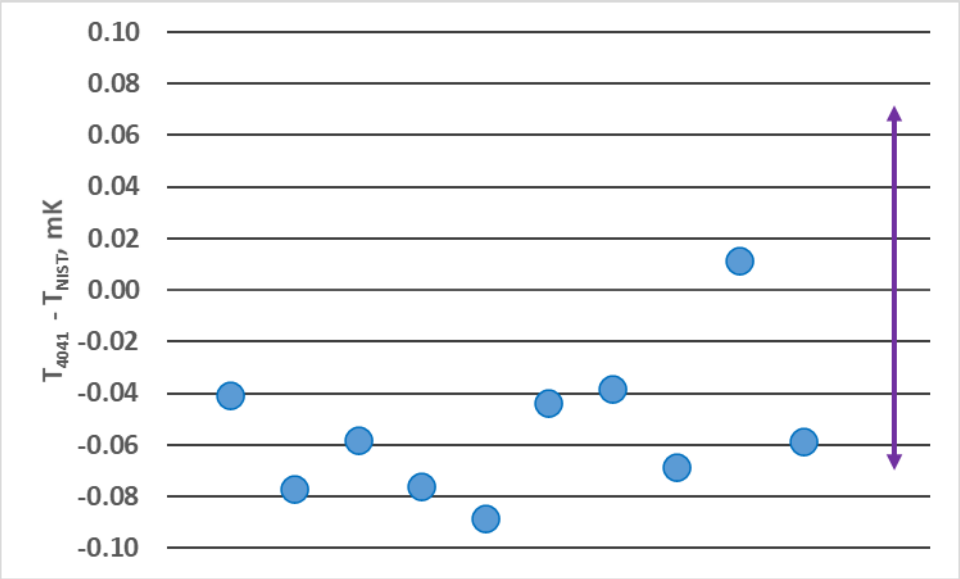

Figure 1. Ten measurements comprising the direct comparison of your water triple-point cell (K29H s/n 4041) with the NIST reference water triple-point cell (s/n A-Q5079). The vertical double ended arrow line indicates the direct comparison uncertainty (k=2).

Figure 2 shows the immersion characteristics (heat-flux test) of your water triple-point cell relative to the ITS-90 assigned hydrostatic-head effect for water. A thermometer must track the hydrostatic-head effect over the bottommost 3 cm of the reentrant well to exhibit proper immersion in a fixed-point cell.

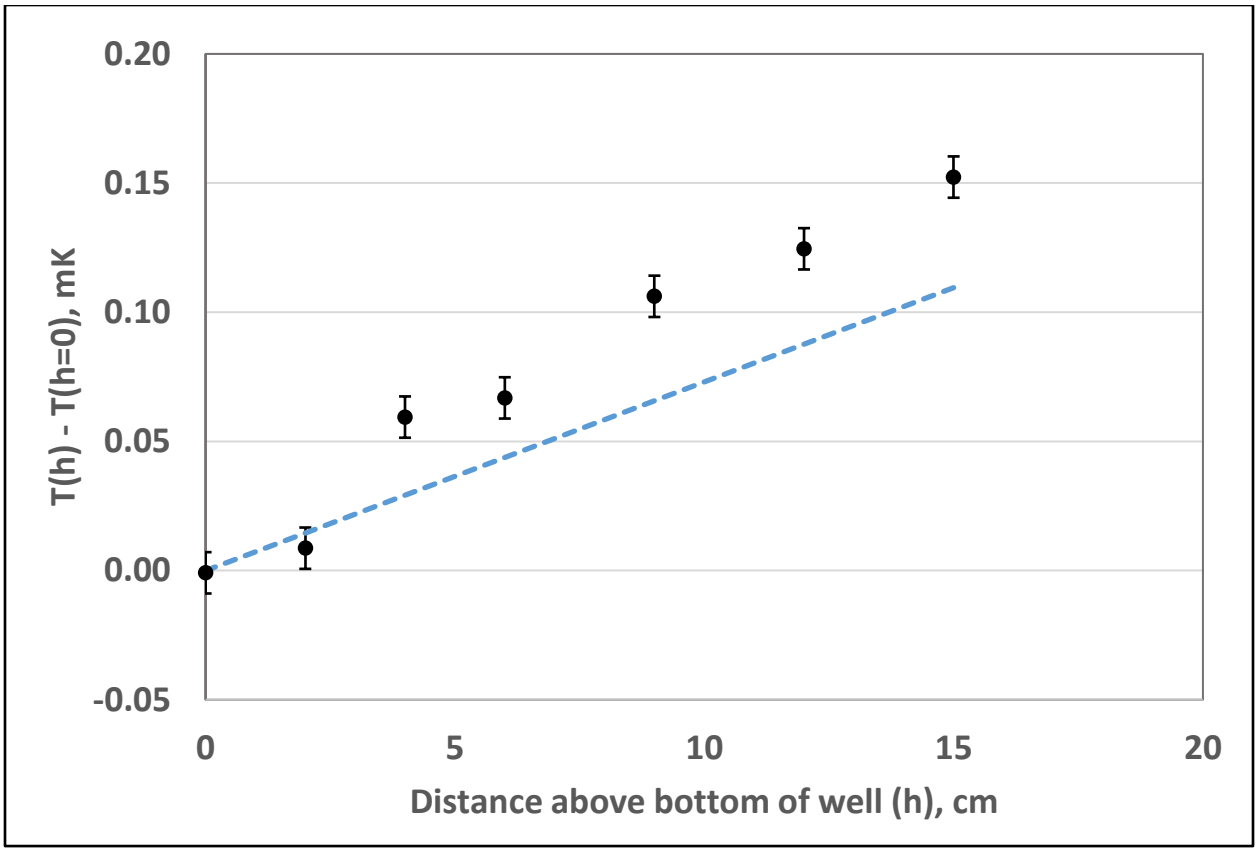

Figure 2. Heat-flux test of a Pond Engineering model K29H water triple-point cell using a Hart Scientific Model 5681 SPRT.

Appendix C supplies a suggested uncertainty budget for you to use in assigning an uncertainty to your water triple-point cell as realized in your laboratory. The values left blank are to be determined by yourself in your laboratory using your equipment and personnel. The supplied values are derived from this certification of your cell and the NIST reference cell uncertainty budget. The suggested application of the supplied values is a conservative approach.

Sincerely,

Julia Scherschligt
Leader, Thermodynamic Metrology Group
Sensor Science Division

Analysis performed by

Tobias Herman
Thermodynamic Metrology Group
Sensor Science Division

Appendix A: Uncertainty budget for direct comparison of the Pond Engineering water triple point cell (K29H s/n 4041) with one of the NIST reference water triple point cells (s/n A-Q5079)

Type A

	u_i / mK	
Bridge Repeatability	0.01	both cells
Direct Comparison Repeatability	0.027	pooled s.d. of pair differences
Total A	0.029	

Type B (rectangular distribution unless otherwise noted)

Isotopic correction	0.002	NIST cell, normal distribution
Hydrostatic-head	0.003	both cells
SPRT self-heating	0.03	both cells
Immersion (Heat Flux)	0.01	both cells, normal distribution
Gas Pressure	0	both cells
Total B	0.020	
Total Standard Uncertainty (k = 1)	0.035	
Total Expanded Uncertainty (k = 2)	**0.07**	

Appendix B: Uncertainty budget for the realization of a NIST reference water triple point cell (s/n A-Q5079)

	u_i / mK
Bridge Repeatability	0.002
Bridge Non-Linearity	0.02
Bridge Quadrature Effects (AC only)	0.01
Reference Resistor Resistance	0.01
Phase Transition Realization Repeatability	0.005
Chemical Impurities	0.01
Hydrostatic Head Correction	0.00
SPRT Self-Heating Correction	0.02
Heat Flux	0.003
Gas Pressure	0.00
Slope of Plateau	0.00
Isotopic Variation	0.002
u_c	0.024
U (k=2)	**0.05**

Appendix C: Suggested uncertainty budget for the Pond Engineering water triple point cell (K29H s/n 4041) after correcting for isotopic composition

	u_i / mK	
Bridge Repeatability		Values and type (e.g. A or B) determined by customer
Bridge Non-Linearity		
Bridge Quadrature Effects (AC only)		
Reference Resistor Resistance		
Phase Transition Realization Repeatability		
Hydrostatic Head Correction		
SPRT Self-Heating Correction		
Heat Flux		
Isotopic Variation		Value supplied by manufacturer

Absolute Value of Direct Comparison Difference	0.018	Type B, normal distribution -- NIST suggested method of applying these uncertainties
Direct Comparison Measurements	0.035	
Chemical Impurities in NIST cell	0.01	

u_c	
U (k = 2)	

Please contact Tobias Herman at either (301) 975-4808 or tobias.herman@nist.gov for assistance in determining the values left blank in Appendix C. These values are necessary for calculating your own fixed-point cell realization uncertainty.