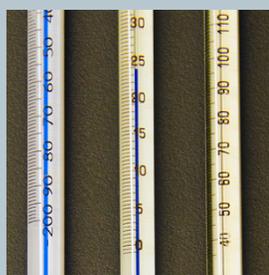


Measurement Uncertainties of Organic Liquid-in-Glass Thermometers

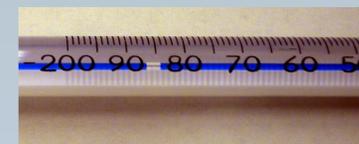


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Abstract

The National Institute of Standards and Technology (NIST) Industrial Thermometer Calibration Laboratory (ITCL) investigated the viability of organic liquid-in-glass thermometers as possible replacements to mercury liquid-in-glass thermometers.

- mercury is a powerful neurotoxin, both national and international standards and regulations to eliminate mercury from the environment are becoming common
 - standards and regulations are making the use and purchase of mercury thermometers for use in the industrial environment problematic
 - NIST stopped calibrating mercury thermometers on 01 March 2011
- We present the calibration and in-use uncertainties the organic thermometers over the temperature range from -196 C to 250 C . Measurements capabilities of the organic thermometers are compared to that of mercury thermometers.

Organic Thermometers Tested

Thermometer Type	Graduation Interval	Maximum Range, C	Number of Thermometers
Partial	1	0 to 250	9
	0.5	0 to 200	4
	0.2	0 to 100	4
Total	1	-200 to 210	5
	0.5	-20 to 50	4
	0.2	0 to 100	3

- Pentane-filled total immersion marked -200 C to 30 C with 1 C increments for below 0 C
- Organic-filled partial and total immersion LIG's thermometers over the range from -20 C to 250 C

Measurement Protocols

Parameters

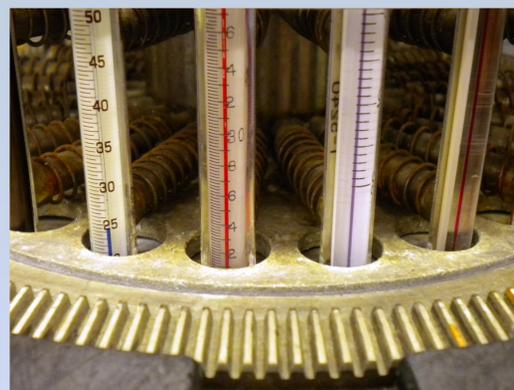
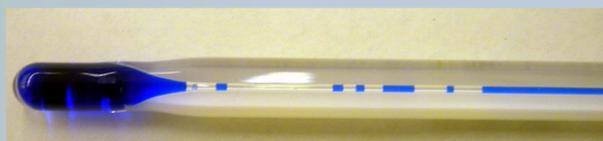
- Temperature range for Organic LIGs: -196 C to 250 C
- 6 measurement cycles
- Order of measurement:
Ice MP, -196 C to -25 C , Ice MP, 5 C to 250 C , Ice MP

Several inherent limitations of organic LIG thermometers investigated to quantify both the calibration and in-use measurement uncertainties

- Short and long-term repeatability
- Thermal cycling
- Drain time of the fluid in the capillary

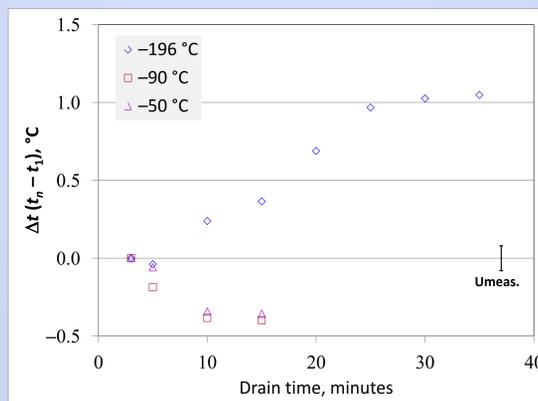
Special measurements of pentane-filled LIGs made at -196 C (LN_2)

- Investigate re-insertion time interval (cryogenic thermal cycling)
- Drain time required for pentane fluid



Measurement System

- Reference Measurement: SPRT with ASL F18
- Digital Video Camera:
 - $1/34$ of scale division resolution
 - Integrated with data-acquisition system
- Comparison Baths
 - LN_2 (-196 C)
 - Ethanol (-97 C to 5 C)
 - Water (0.5 C to 95 C)
 - Oil (90 C to 300 C)
- Ice MP (0 C)



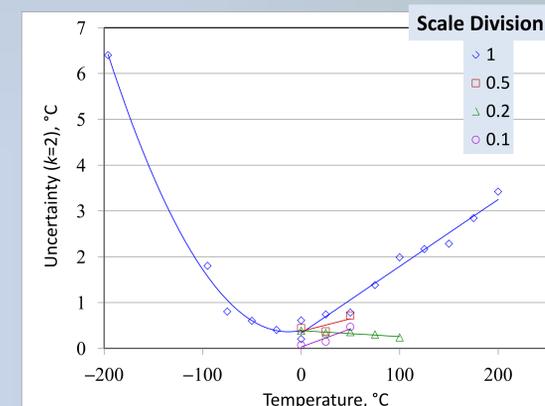
Future Directions

NIST will explore the measurement uncertainty and feasibility of using hand-held and data-logger digital thermometers as replacements for mercury thermometers

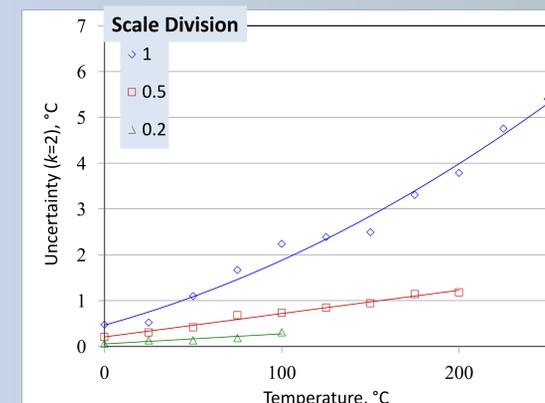


A new NIST Temperature and Humidity Group *Alternative Thermometer Webpage* will act as an information portal for NIST to disseminate scientific-based findings to support the transition away from Hg

Total Immersion Uncertainties



Partial Immersion Uncertainties



NIST LIG Thermometer Uncertainties

Thermometer Type	Graduation Interval	Range C	Organic U ($k=2$), C	Mercury U ($k=2$), C
Partial	1	0 to 250	0.5 to 5.4	0.25
	0.5	0 to 200	0.2 to 1.2	-
	0.2	0 to 100	0.1 to 0.3	0.07
Total	1	-196 to 0	6.4 to 0.2	-
		0 to 200	0.2 to 3.4	0.22
	0.5	-20 to 50	0.4 to 0.7	0.16
	0.2	0 to 100	0.4 to 0.2	0.14

Conclusions

Based on the results of our set of organic LIG thermometers, Organic LIGs are not suitable replacements for mercury LIGs

- Uncertainties
 - Larger than that of Hg
 - Can be expressed with simple linear or quadratic functions
- Corrections are often greater than the graduation interval (scale division)
- Organic fluid wets the column causing fluid to stick to capillary
 - Long drain time: 10 min at $\geq -90\text{ C}$ and 30 min at -196 C
 - Separation of fluid column unpredictable
- Pentane required warming to ambient before re-insertion into $<0\text{ C}$ environments to achieve repeatable results

Notes and Disclaimer:
- thanks to those companies who donated thermometers (analog and digital) for this work
- any commercial products identified in this poster does not constitute endorsement by NIST