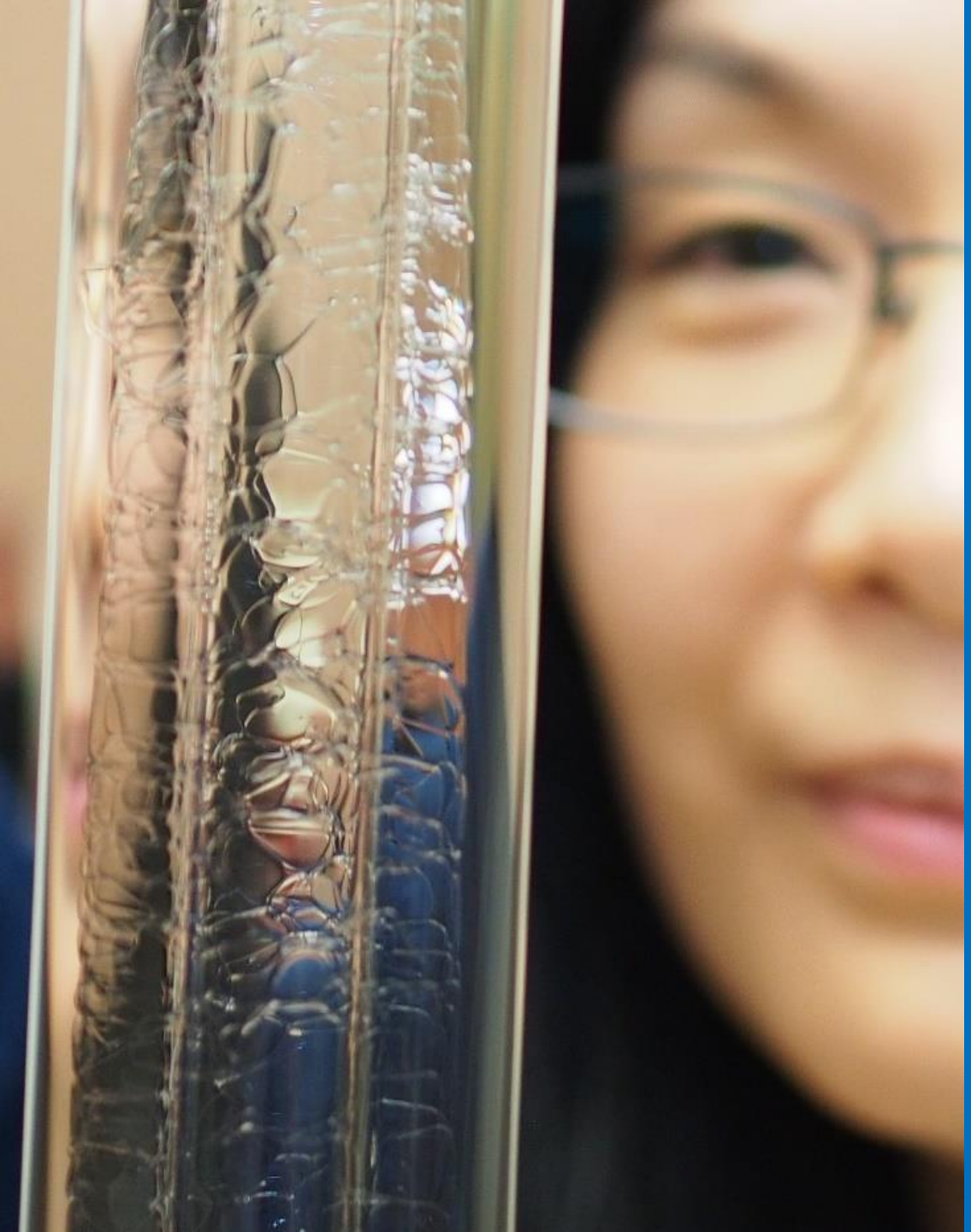


CCT/20-40

Introduction to the Temperature Laboratory of SCL Hong Kong China

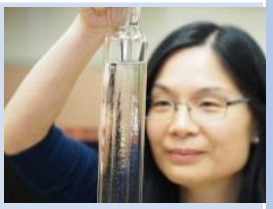
November 2020

About the Standards and Calibration Laboratory (SCL)

The 4 tasks of SCL:

- Establishing and maintaining the reference standards of physical measurement traceable to the International System of Units (SI) for Hong Kong
- Ensuring these standards are recognized worldwide
- Providing calibration services to disseminate the values of these standards
- Disseminating metrological knowledge through other customer services

SCL Milestones in Setting up of Primary Standards

1984	SCL was set up by the Hong Kong Government under the Industry Department.	Hong Kong Government Industry Department 工業署
1986	SCL established a caesium beam frequency standard.	
1986	SCL set up water triple point cell standards.	
1993	SCL acquired copy no. 75 of the international prototype of kilogram.	
1994	SCL established a Josephson array voltage standard.	
1998	SCL established an iodine stabilized helium neon laser as length standard.	
2000	SCL set up a quantum Hall resistance standard.	
2000	Hong Kong China as an Associate of CGPM and SCL as signatory of the CIPM MRA.	BIPM ΜΕΤΡΩ ΧΡΩ
2019	SCL set up a cryogenic radiometer to realize the candela.	

Measurement Standards Maintained by SCL for Hong Kong

Quantity	Base Unit	Method/Facility	Uncertainty
Electric Current	ampere (A)	JAVS and QHRS	1×10^{-7}
Length	metre (m)	iodine stabilized helium-neon laser	4×10^{-11}
Temperature	kelvin (K)	triple point of water cell and ITS-90 fixed points	2×10^{-4} to 10^{-2} K
Time	second (s)	cesium-beam frequency standard	8×10^{-14}
Mass	kilogram (kg)	Copy 75 of the international prototype of kilogram	5×10^{-9}
Luminous Intensity	candela (cd)	Cryogenic Radiometer	0.8 %

Brief History of the SCL Temperature Laboratory

SCL Temperature Laboratory in the 1980s

In the 1980s

- Established in 1984, the SCL Temperature Laboratory adopted the IPTS-68. The PRTs were calibrated by NPL of the UK. SCL set up two triple point of water cells for measuring R(0.01°C) to obtain the R(0°C) used in the IPTS-68 reference equations.
- In 1986, the Temperature Laboratory was accredited by NAMAS (now UKAS) of the UK.
- In 1987 SCL acquired a tin cell and a zinc cell from NPL.

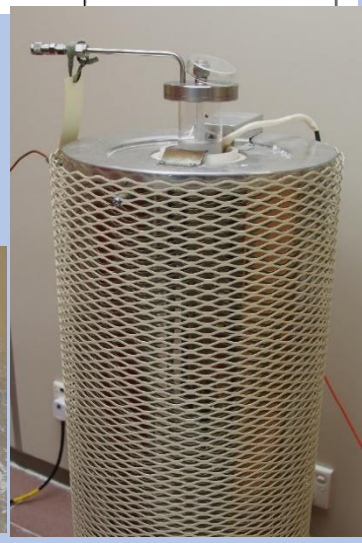
National Measurement Accreditation Service — Calibration No. 0180, page 9 of 9

HONG KONG GOVERNMENT
STANDARDS AND CALIBRATION LABORATORY

Measured Quantities, and Uncertainties for a confidence probability of not less than 95%, for which NAMAS Accreditation has been granted

ITEM	MEASURED QUANTITY, INSTRUMENT OR GAUGE *See* Note 1	RANGE	BEST MEASUREMENT CAPABILITY EXPRESSED AS AN UNCERTAINTY (±)
	TEMPERATURE		
1	Liquid-in-glass thermometers	−30 to 0 °C	50 mK
		Ice point (0 °C)	10 mK
		0 to 70 °C	20 mK
		70 to 230 °C	50 mK
		230 to 450 °C	100 mK
		450 to 550 °C	1 K
2	Platinum resistance thermometers	Triple point of water (0.01 °C)	3 mK
		Triple point of ethylene carbonate (36.3227 °C)	4 mK
		Melting point of gallium (29.7710 °C)	4 mK
		−30 to 0 °C	5 mK
		0 to 70 °C	5 mK
		70 to 230 °C	15 mK
		230 to 550 °C	30 mK
3	Thermocouples	−30 to 230 °C	0.15 K
		230 to 550 °C	0.25 K
4	Digital thermometers	−30 to 70 °C	15 mK
		70 to 230 °C	25 mK
		230 to 550 °C	40 mK

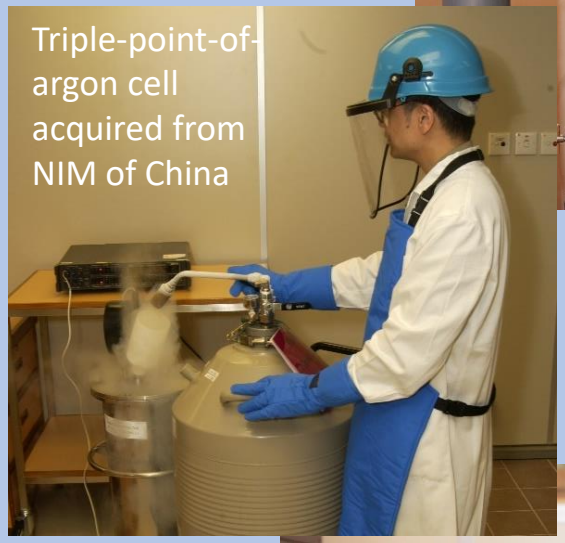
Tin cell acquired in 1987

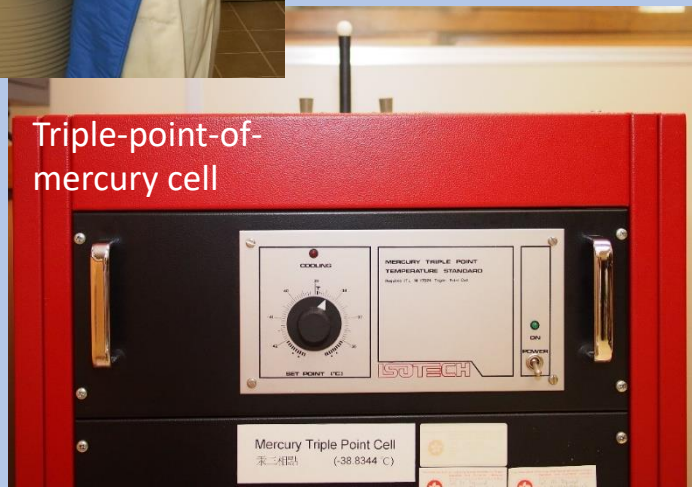


In the 1990s

- SCL adopted the ITS-90 from 1 January 1990.
- SCL realises the ITS-90 by setting up the following fixed points :
  - TP of argon (-189.3442 °C)
  - TP of mercury (-38.8344 °C)
  - MP of gallium (29.7646 °C)
  - FP of indium (156.5985 °C)
  - FP of tin (231.928 °C)
  - FP of zinc (419.527 °C)
  - FP of aluminium (660.323 °C)
  - FP of silver (961.78 °C)
- SCL uses SPRT to provide temperature calibration services. These SPRT were calibrated in house using the above fixed points.


Various temperature fixed points


Triple-point-of-argon cell acquired from NIM of China



Triple-point-of-mercury cell

In the 2000s

- In early 2000, SCL started to set up facilities for radiation thermometry. The first service introduced was for the calibration of infrared ear thermometers.
- Later blackbodies from -40 °C to 1000 °C were acquired and the services extended to radiation thermometers.
- Recently indium, tin, zinc, aluminium, silver and copper fixed point blackbodies were acquired.

Humidity Measurement

- In the early 1990s, SCL set up two 2-pressure humidity chambers and acquired dew-point hygrometers as its humidity reference standards.
- The humidity calibration service was accredited in 1994 by HOKLAS.
- In 1999, a 2-pressure-2-temperature dew point generator was set up.

2-pressure humidity chamber

dew point generator

Current Accredited Calibration Services

Item/Materials	Parameters
Fixed-point cells	argon, mercury, TPW, gallium, indium tin, zinc, aluminium, silver
SPRT	argon, mercury, TPW, gallium, indium tin, zinc, aluminium, silver
IPRT	-80 °C to 550 °C
Thermocouple	-80 °C to 1200 °C
LIGT	-80 °C to 550 °C
Radiation thermometer	-40 °C to 1000 °C
Infrared ear thermometer	34 °C to 43 °C
Blackbody	-40 °C to 200 °C
Digital thermometer	-80 °C to 1200 °C
Temperature chamber	-80 °C to 250 °C
Dew-point hygrometer / dew-point generator	-60 °C to 65 °C
Relative humidity instrument	8 %rh to 95 %rh / 5 °C to 70 °C
Relative humidity chamber	8 %rh to 95 %rh / 5 °C to 70 °C

Peer Reviews

- SCL was accredited by NAMAS between 1985 to 1994. Since 1994, SCL was accredited by HOKLAS.
- Technical assessments were conducted every 2 years.

Area	Peer Reviewer	Date
Temperature	Professor Graham Machin, NPL, the UK	Jan 2019
Humidity	Dr. Hisashi Abe, NMIJ, Japan	Dec 2018
Temperature	Dr Gam Kee Sool, KRISS, Korea	Aug 2016
Humidity	Dr Stephanie Bell, NPL, the UK	Aug 2016
Temperature	Dr. David Rodney White, MSL, New Zealand	Jan 2014
Humidity	Dr. Wang Li, A*STAR, Singapore	Jan 2014
Temperature	Mr. Yoshiro Yamada, NMIJ, Japan	Nov 2010
Humidity	Dr. Chiharu Takahashi, NMIJ, Japan	Nov 2010
Temperature	Dr. Yu Ning Duan, NIM, China	May 2008
Humidity	Mr. Mark Stevens, NPL, the UK	May 2008

Inter-laboratory Comparison

KCDB Ref.	Comparison Title	Status
APMP.T-K3	Realization of the ITS-90 from 234.3 K to 692.7 K 2000-2003	Approved
APMP.T-K4	Comparison of local realizations of Aluminium freezing-point temperatures 2003-2004	Approved
APMP.T-K6	Comparison of humidity standards: dew point temperature 1999-2001	Approved
APMP.T-K7	Comparison of water triple point cells 2007-2009	Approved
APMP.T-S1	Comparison using Type R thermocouples 2005-2006	Approved
APMP.T-S3	Comparison of industrial thermometers 2004	Approved
APMP.T-S5	Thermocouple calibration 2008-2009	Approved
APMP.T-K8	Comparison of high dew point temperatures 2011 – 2013	In Progress
APMP.T-K4.2	Comparison of local realizations of aluminium (Al) freezing-point temperature 2018 - 2019	In Progress
APMP.T-K6.2013	Comparison of humidity standards: dew point temperature	In Progress
APMP.T-K9	Comparison on ITS-90 SPRT Calibration	In Progress
APMP.T-S11	Local realization of radiation thermometer scale from indium point to 2000 °C	In Progress
APMP.T-S15	Calibration of ear thermometers 2016-2018	In Progress

Thermometry CMC

- Up to Nov 2020, SCL has 33 thermometry CMC items listed in Appendix C of the CIPM MRA.

Instrument or Artifact	Value	Expanded Uncertainty
Fixed point cell	-38.8344 °C	1.0 mK
Fixed point cell	0.01 °C	0.2 mK
Fixed point cell	156.5985 °C	1.5 mK
Fixed point cell	231.928 °C	1.5 mK
Fixed point cell	29.7646 °C	1.0 mK
Fixed point cell	419.527 °C	1.5 mK
Fixed point cell	660.323 °C	6.0 mK
Fixed points with bath/furnace	-38.8344 °C	1.0 mK
Fixed points with bath/furnace	0.01 °C	0.2 mK
Fixed points with bath/furnace	156.5985 °C	1.5 mK
Fixed points with bath/furnace	231.928 °C	1.5 mK
Fixed points with bath/furnace	29.7646 °C	1.0 mK
Fixed points with bath/furnace	419.527 °C	1.5 mK
Fixed points with bath/furnace	660.323 °C	6.0 mK

Instrument or Artifact	Value	Expanded Uncertainty
SPRT	-38.8344 °C	1.0 mK
SPRT	0.01 °C	0.2 mK
SPRT	156.5985 °C	2.0 mK
SPRT	231.928 °C	2.0 mK
SPRT	29.7646 °C	1.0 mK
SPRT	419.527 °C	2.0 mK
SPRT	660.323 °C	6.0 mK
IPRT	-40.0 to 230.0 °C	0.006 °C
thermocouple	-80.0 to -30.0 °C	0.25 °C
thermocouple	-30.0 to 550.0 °C	0.15 °C
LIGT	0.0 to 0.0 °C	0.007 °C
LIGT	0.0 to 100.0 °C	0.02 °C
LIGT	100.0 to 250.0 °C	0.03 °C
LIGT	250.0 to 300.0 °C	0.05 °C
LIGT	-30.0 to 0.0 °C	0.03 °C
LIGT	300.0 to 450.0 °C	0.2 °C
Digital thermometer	-80.0 to 230.0 °C	0.006 °C
Dew-point hygrometer	-60.0 to -40.0 °C	0.2 °C
Dew-point hygrometer	-40.0 to 30.0 °C	0.15 °C

Our Standards and Equipment

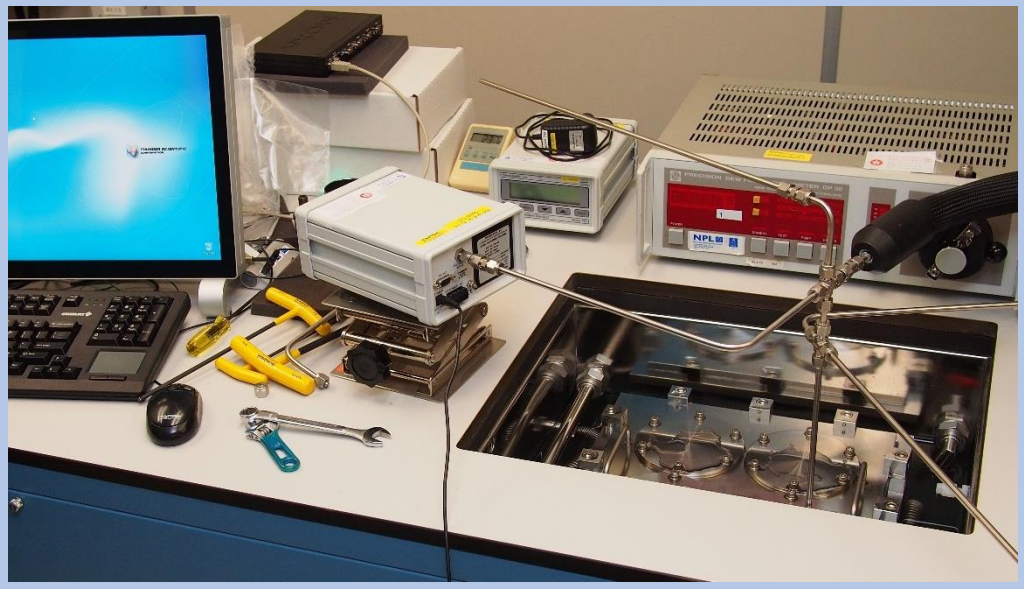
Contact Thermometry	
Temperature fixed points	argon(x3), mercury(x2), TPW (x7), gallium (x5), indium (x2), tin (x3), zinc (x4), aluminium (x4), silver (x2)
AC Resistance bridge	F17 (x3), F18 (x1), F900 (x2), CTR9000 (x1)
PRT	SPRT (more than 15), HTPRT (x6)
Thermocouple	type R (x4), gold-platinum (x1)

Our Standards and Equipment

Non Contact Thermometry	
Fixed point blackbodies	indium (x2), tin (x2), zinc (x2), aluminium (x2), silver (x2), copper (x2)
Blackbodies	-40 ˚C to 0 ˚C blackbody (x1), 0 ˚C to 50 ˚C blackbody (x1), 150 ˚C to 200 ˚C blackbody (x1), 200 ˚C to 1000 ˚C blackbody (x1), Infrared ear thermometer blackbody (x2)
Reference radiation thermometers	Heitronics (x1), Chino (x1), Minolta (x 1)

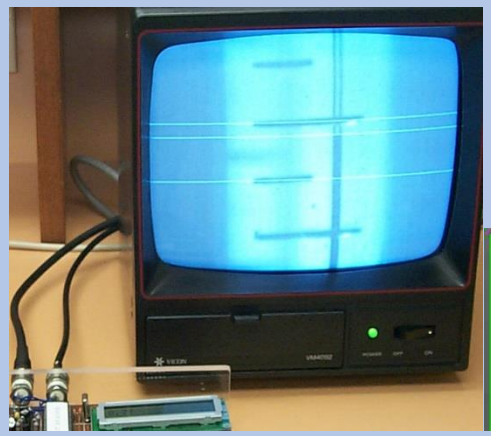
Our Standards and Equipment

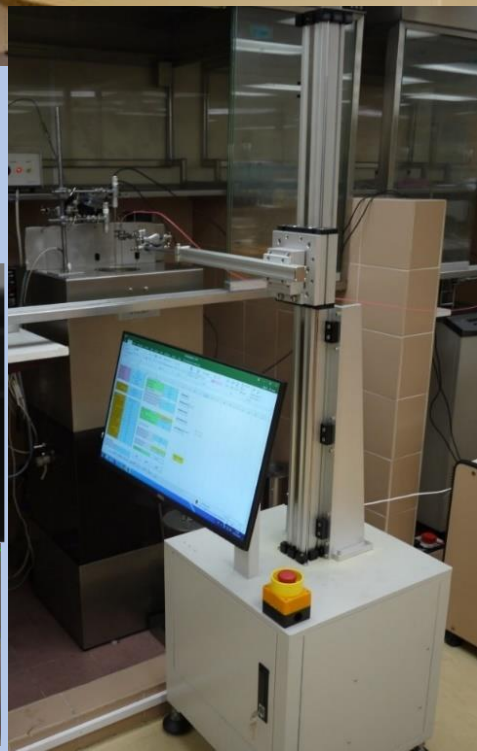
Humidity	
Dew point generator	Thunder 3900 (x1)
Humidity chambers	Thunder 8500 (x1), Thunder 9500 (x1), Thunder 2500 (x2)
Dew point hygrometers	Michell S4000 (x1) , Michell S8000 (x1), MBW DP30 (x1), General Eastern 1311 (x 2), RH Systems 373 (x1)



Development Work

- In 1998, a digital thermometer calibration system with optical character recognition (OCR) capability was developed on a Sun workstation. In 2013, a similar system was developed on Windows platform using a smart camera.
- In 2000 an electronic LIGT reader was designed.
- In 2017, an automatic thermocouple inhomogeneity scanning system was built.



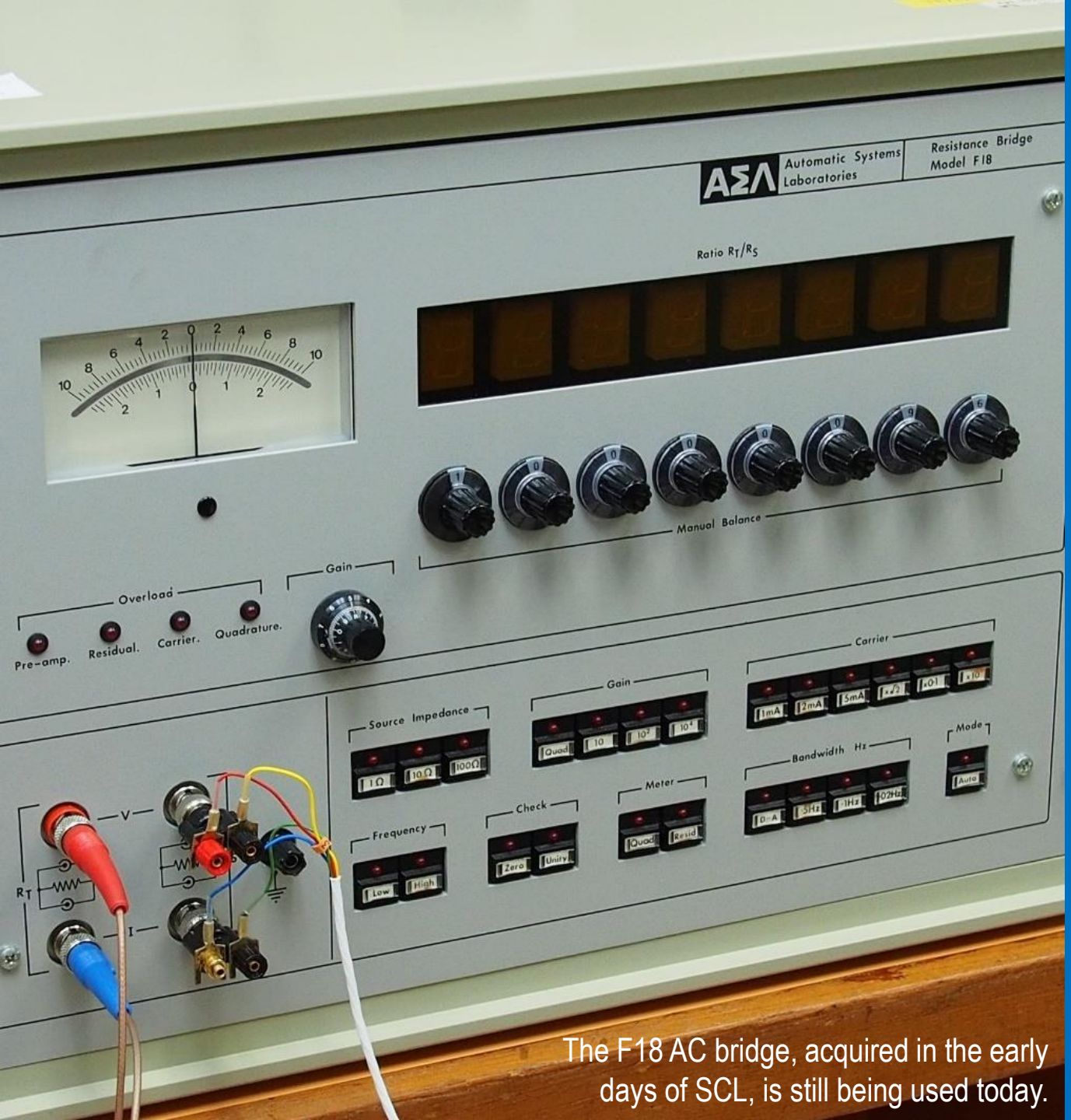


Technical Papers Published

- C. P. Cheung, H. S. Lam, C. M. Tsui, C. M. Leung, “Measuring the Performance of Temperature Chambers in Accordance with IEC60068-3-5:2018,” *NCSLI 2020 Conf*., August 2020
- C. P. Cheung, C. M. Tsui, C. M. Leung and C. F. Ma, “Implementation of Instantaneous Comparisons Method in Temperature Gradient Evaluation of Stirred Liquid Temperature Baths,” *Tempmeko & Tempbeijing 2019*, Chengdu, China, June 2019.
- Julian C. P. Cheung, Brenda Lam, C.M. Tsui, C.F. Ma and C.M. Leung, “An Adaptive Thermocouple Inhomogeneity Scanning System”, *NCSLI 2019 Conf*, August 2019.
- Julian C. P. Cheung and Aaron Y. K. Yan, "An Automated Thermometer Calibration System Using Optical Character Recognition and Video Imaging Technology," *NCSLI Measure J. Meas. Sci*, vol 8, pp. 32-38, December 2013.

Why We Apply to be an Observer

- SCL's growth in the past was slow. There was no increase in manpower for 20 years.
- In recent years, due to the Government's support for innovation and technology, SCL has been given more manpower and resources. SCL is increasing the size of its technical staff by 24 %. There is also a larger budget for equipment acquisition. We have acquired a PJVS, a cryogenic radiometer, and is procuring a hydrogen maser clock.
- Against this backdrop, we plan to do better in the field of thermometry. Although we have 36 years' experience in thermometry, there are many areas we should improve. Our initial focus will be in the radiation thermometry area.
- We believe being able to join the CCT as an observer will help us greatly in this direction by giving us direct exposure to leaders in this field. We hope, with support from members, we can improve our capabilities as an CGPM Associate and make more contributions to the metrology community in the APMP areas.



The F18 AC bridge, acquired in the early days of SCL, is still being used today.

Thank You