

Development of a superconducting reference device for precision thermometry below 1 K

W.A. Bosch, A. Chinchure, J. Flokstra, M.J. de Groot, R. Jochemsen, F. Mathu, A. Peruzzi, D. Veldhuis

Abstract A superconducting Reference Device (SRD1000), including 10-12 reference points in the temperature range 10 mK - 1 K is being developed to provide a direct and accurate traceability to the new Provisional Low Temperature Scale (PLTS-2000). Bulk superconductive samples of $\text{Ir}_x\text{Rh}_{100-x}$ alloys (temperature transition T_c between 15 and 100 mK), single crystals of AuIn_2 ($T_c = 160$ mK), AuAl_2 ($T_c = 208$ mK) and Zn ($T_c = 850$ mK) were prepared, analyzed and tested. The results of low temperature acceptance tests are presented.

if you are looking for...

- Calibration of measurement equipment
- Testing of measurement equipment against specifications
- Uncertainty analysis
- Contract research
- Consultancy on measurement protocols
- Consultancy on quality control
- Training and education in the field of measurements, calibration, measurement uncertainty and quality control

...check with NMI VSL for reliability and credibility in measurements

Experimental set-up at NMI Ultra-low Temperature facility

- A gold-plated OHFC copper comparator block was attached to the mixing chamber stage of a ^3He - ^4He dilution refrigerator. A Melting Curve Thermometer cell, a SRM 768 NIST superconductive device and up to three SRD test devices were mounted on the comparator block (see figure 1).

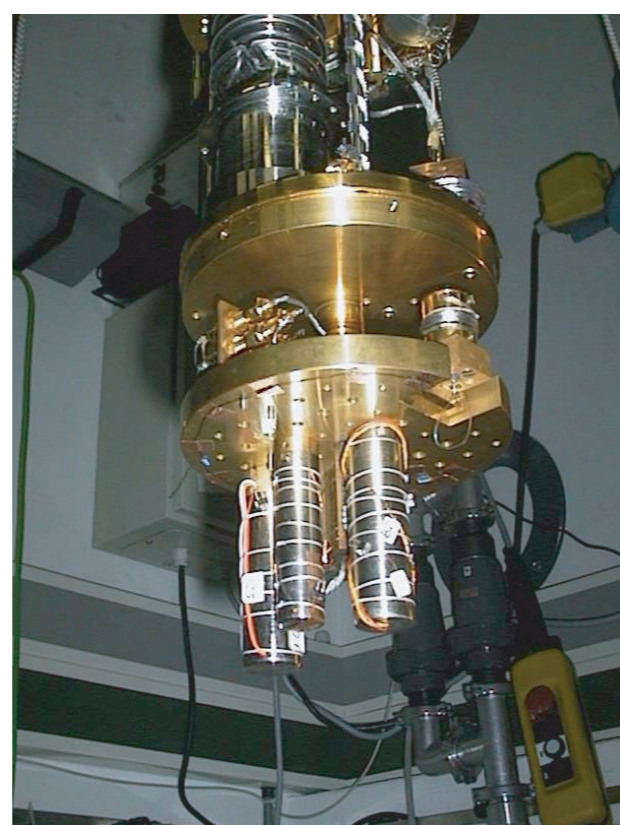


Figure 1: Experimental set-up.

Results

- An overview of the reference points and materials selected for the SRD1000 is presented in table 1. Superconducting transition temperatures T_c and width of the transitions W were measured. The best results obtained thus far are summarised in table 1.

Table 1: Overview of the proposed PLTS-2000 reference temperatures and best results obtained.

Proposed reference temperature [mK]	Selected metal sample	Sample specification	Observed T_c [mK]	Observed W [mK]
1180	Al	4N7 Al foil	1164	8.0
850	Zn	melt 6N Zn shot	850.3	3.0
520	Cd	5N Cd foil	529.3	3.5
250 – 300	Ti/Au bilayer	to be measured	-	-
250 – 300	Mo/Au bilayer	to be measured	-	-
208	AuIn_2	melt 5N4 Au, 6N In powder	208	0.4
160	AuAl_2	melt 5N4 Au, 6N Al powder	161.3	0.2
100	Ir	melt 4N5 Ir powder	99.8	0.5
60	$\text{Ir}_{92}\text{Rh}_{08}$	melt 4N5 Ir, 4N Rh powder	61.3	0.5
35	$\text{Ir}_{80}\text{Rh}_{20}$	melt 4N5 Ir, 4N Rh powder	34.0	0.9
22	$\text{Ir}_{73}\text{Rh}_{27}$	melt 4N5 Ir, 4N Rh powder	20.5	1.5
15	W	4N single crystal	15.5	0.1

Superconducting transitions

- The superconducting transitions of the samples included in the SRD test devices were monitored by a dedicated mutual inductance detection system developed by Hightech Development Leiden.
- The figures 2 and 3 show examples of the transitions of respectively AuIn_2 , AuAl_2 , Ir and $\text{Ir}_{80}\text{Rh}_{20}$.

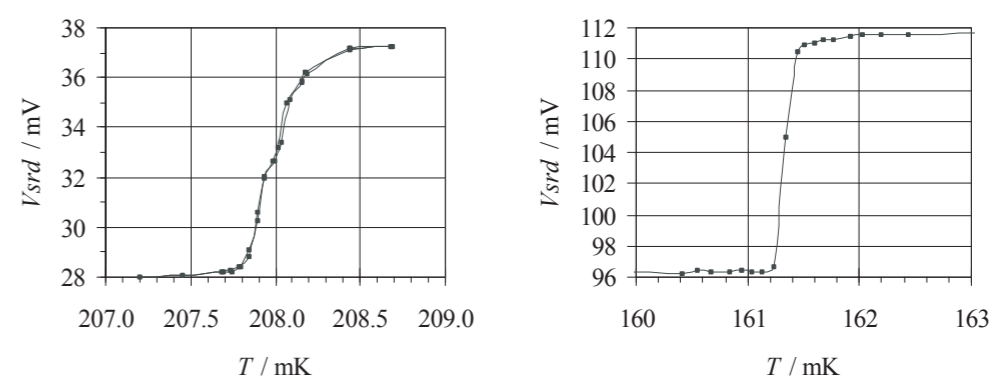


Figure 2. Transitions of AuIn_2 ($T_c = 208.0$ mK, $W = 0.4$ mK) and AuAl_2 ($T_c = 161.3$ mK, $W = 0.2$ mK).

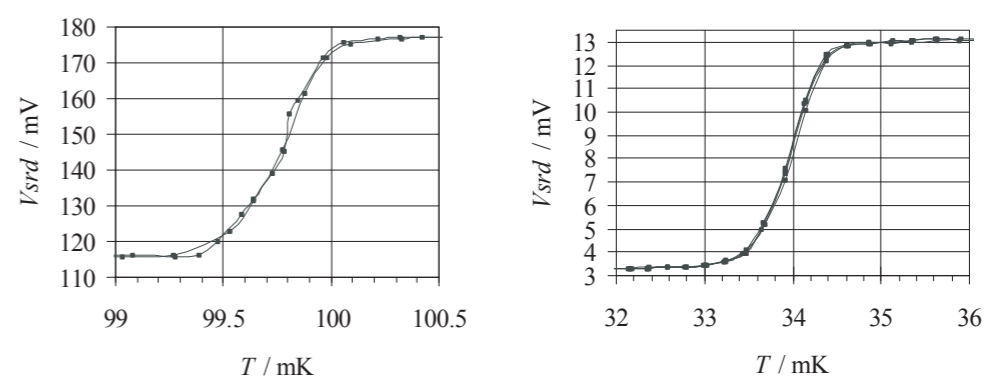


Figure 3. Transitions of Ir ($T_c = 99.8$ mK, $W = 0.2$ mK) and $\text{Ir}_{80}\text{Rh}_{20}$ ($T_c = 34.0$ mK, $W = 0.9$ mK).

Conclusions and further developments

- Measurements on samples of $\text{Ir}_{92}\text{Rh}_{08}$, Ir, AuIn_2 , AuAl_2 , Cd, Zn and Al have shown that the base materials selected and preparation techniques developed allow us to realize reference temperatures to support the PLTS-2000 above 50 mK. For these temperatures the reproducibility (defined as 12.5 % of the transition width) is less than 0.1 % of the temperature.
- For the proposed materials preparation techniques are being improved and new samples will be tested.
- Finally a pilot series of SRD1000 will be developed and distributed to various European metrological institutes and industrial partners, which will evaluate this series to determine its suitability as transfer standard for the PLTS-2000.

For information on this poster please contact:

Wim A. Bosch
Hightech Development Leiden
HDLinfo@xs4all.nl
Tel: (+31) 70 521 06 72
www.xs4all.nl/~hdleiden/srd1000

Andrea Peruzzi
NMI Van Swinden Laboratorium B.V.
aperuzzi@nmi.nl
Tel: (+31) 15 269 1519

More information

In case you have specific questions or applications outside this poster, please contact us. We are pleased to provide you with the requested information.

NMI Van Swinden Laboratorium B.V.
P.O. Box 654
2600 AR Delft
The Netherlands
Telephone: (+31) 15 26 91 500
Fax: (+31) 15 26 12 971
http://www.NMI.nl

