

# EVALUATION OF SUPERCONDUCTIVE REFERENCE DEVICE SRD1000 PROTOTYPES

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The SRD1000 uses the superconductive transitions of 10 samples to provide reference temperatures for the calibration of secondary thermometers in the range from 15 mK to 1200 mK. The device was developed in the frame of EU project “Ultra-Low Temperature Dissemination” by four partners in the Netherlands and prototypes were evaluated by partners in four other laboratories. Each laboratory independently performed extensive measurements on a prototypes: these consisted of residual magnetic field tests, repeated observations of the transitions under specified controlled thermal conditions and determination of the transition temperature and transition width of each transition. The results of the evaluation are reported in this paper.

## The SRD1000 sensor

The SRD1000 sensor consists of (see figure 1):

- Planar niobium micro-coils (a1) to detect the superconducting to normal transitions of the reference samples.
- 10 reference samples directly attached (a2) to the micro-coils.
- A gold-plated copper holder (b1) to which the micro-coils system is thermally attached.
- A magnetic shield composed of an inner niobium shield and an outer Cryoperm shield (c).



Figure 1: The SRD1000 sensor.

## Thermometry and uncertainty

The thermometry adopted by each lab in the evaluation of the assigned prototype originated from the respective local PLTS-2000 realizations.

Following different approaches, each laboratory independently estimated the uncertainty in the determination of the transition temperature values. The principal uncertainty components arose from the PLTS-2000 (or ITS-90) realization, the residual magnetic fields and the localization of the transition mid-point.

	Nomin. Temp. /mK	CNRS-CRTBT /mK	PTB /mK	BNM-INM /mK	NPL /mK	NMi VSL /mK
W	15	0.04 (0.03)	0.06 (0.04)	-	-	0.2
Be	20	0.04 (0.03)	0.06 (0.04)	-	-	0.2
Ir <sub>80</sub> Rh <sub>20</sub>	35	0.04 (0.03)	0.24 (0.06)	-	0.20 (0.06)	0.2
Ir <sub>92</sub> Rh <sub>08</sub>	60	0.06 (0.04)	0.20 (0.06)	0.6 (0.2)	0.10 (0.08)	0.2
Ir	100	0.06 (0.04)	0.14 (0.06)	0.4 (0.1)	0.12 (0.10)	0.2
AuAl <sub>2</sub>	160	0.08 (0.07)	0.14 (0.10)	0.4 (0.1)	0.16 (0.12)	0.5
AuIn <sub>2</sub>	208	0.16 (0.14)	0.20 (0.14)	0.4 (0.1)	0.32 (0.24)	0.9
Cd	520	0.18 (0.12)	2.90 (0.12)	4.0 (0.1)	1.20 (0.20)	0.6
Zn	850	0.10 (0.06)	1.08 (0.06)	6.0 (0.2)	0.58 (0.10)	0.8
Al	1180	4 (4)	0.48 (0.36)	1.4 (0.2)	1.1 (1.0)	1.0

**Table 1:** Expanded uncertainty ( $k = 2$ ) claimed by the laboratories in the determination of the transition temperature of each reference point. In parenthesis the expanded uncertainty ( $k = 2$ ) in their realization of the PLTS-2000 at the transition temperature of each reference point of the SRD1000 is reported. The last column refers to preliminary tests at NMi VSL.

## Magnetic field tests

Magnetic field tests were performed on the SRD1000 prototypes. The results of these tests can be summarized as follows:

- The AC measuring field of the micro-coils system is 0.3  $\mu$ T and the corresponding  $T_c$  depression is less than 22  $\mu$ K.
- The residual field is less than 0.4  $\mu$ T for both perpendicular and parallel directions to the micro-coils plane.

## Results

All the superconductive transitions observed, are shown in Figure 2. To compare the transitions observed in different devices, the output of the SRD1000 is reported as percentage of the total voltage change along the transition.

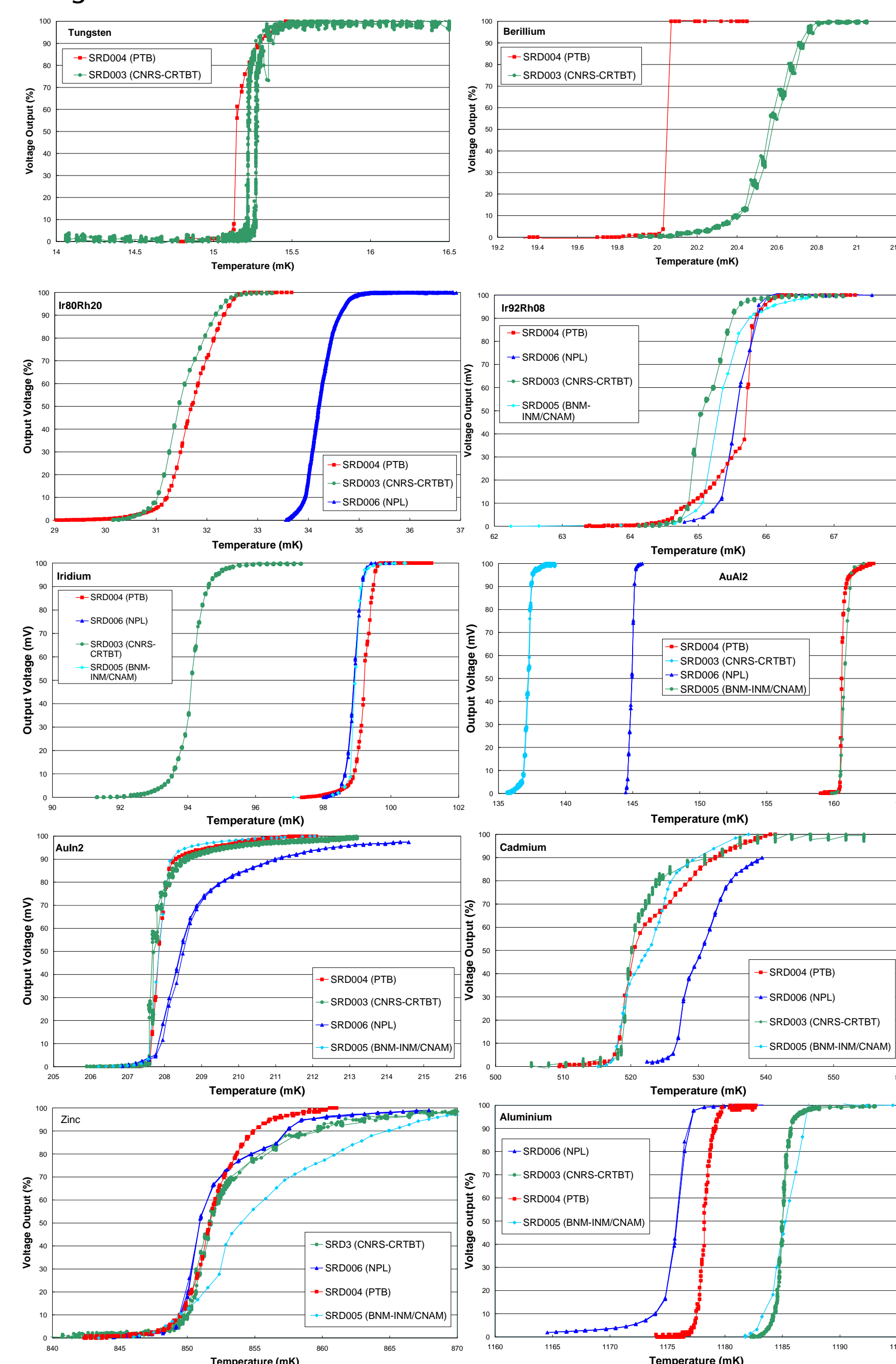


Figure 2: The transitions observed by the laboratories on the assigned SRD1000.

## Conclusions

- The evaluation performed on the four prototypes proved that the SRD1000 is a convenient and reliable means of transferring the Provisional Low Temperature Scale 2000 (PLTS-2000).
- The transition temperature values of the SRD1000 can be determined with an uncertainty that ranges from a few hundredths of mK (at the lowest temperatures) up to about 1 mK (at the highest temperatures).
- The residual magnetic field tests demonstrated that the magnetic shielding of the SRD sensor is very effective (attenuation factor higher than 500).

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