Practical Realisation of 0 °C Temperature Standard

J. Rabiega

Poznań University of Technology, Chair of Heat Engineering
Piotrowo3 Str. 60-965 Poznań, Poland
Rabiega@put.poznan.pl

Abstract. *The main purpose of the paper there was to build, check and test behavior of 0 °C temperature standard. The stand has to be simple, cheap and easy to build. Described bellow stand provides accuracy of ± 0,01 °C and works impeccable in our Chair since several years.*

Introduction

In our Chair of Heat Engineering are performed many important investigation that should very exactly. For temperature measurements we use RTD sensors type PT100 connected to precise DMM with 4-W cables. That solution we use for range from -50 °C to +200 °C. Our DMM is of good quality. It's 7½ digits DMM Keithley 2010 model. The main problem with that measurement method is to have precise RTD sensors and to place them in a measurement stand properly.

Our PT100 best sensor provider ALF SENSOR from Kraków equips them in a measurement protocol that states value of R_0 and R_{100} for them. Because he is our provider for several years we found that his early production differs from nowadays production. We lost faith in his measurement protocols.

We decided to build our own 0 °C and 100 °C temperature standard to calibrate the RTD sensors by ourselves. The standard of 0 °C is ready to present while standard of 100 °C has to be improved. In our opinion it's easer to build 0 °C temperature standard. In described standard we get temperature of 0 °C with accuracy of ± 0,01 °C.

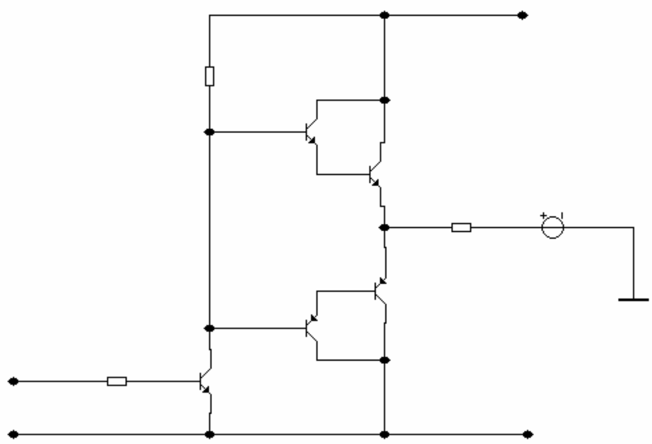
Describe of standard stand

It's impossible to build adiabatic chamber where ice melts extremely slowly all time in temperature of 0 °C. So when the melting process is unavoidable we should mix ice-water mixture in the pseudo-adiabatic chamber. When we stop mixing, in a standstill state warmer water falls down on a bottom of vessel and we get bigger temperature differences between upper and lower part of vessel.

So we tried to build small mixer. It was not so easy because blades of fan were hitting in ice. Than we decide to mix ice-water mixture by vessel rotating. The vessel had to rotate in two directions: clockwise and counterclockwise. From pseudo-adiabatic chamber with ice-water mixture and RTD sensors inside there were cables sticking out. If we'd rotate chamber in one direction the cables would twist.

The ice-water melting chamber with a rotating device is shown on a picture 1. As a adiabatic chamber we used 1 liter metal thermos. DC engine is powered from supply unite shown on picture 2.

Pic. 1 Thermos on the rotating device.

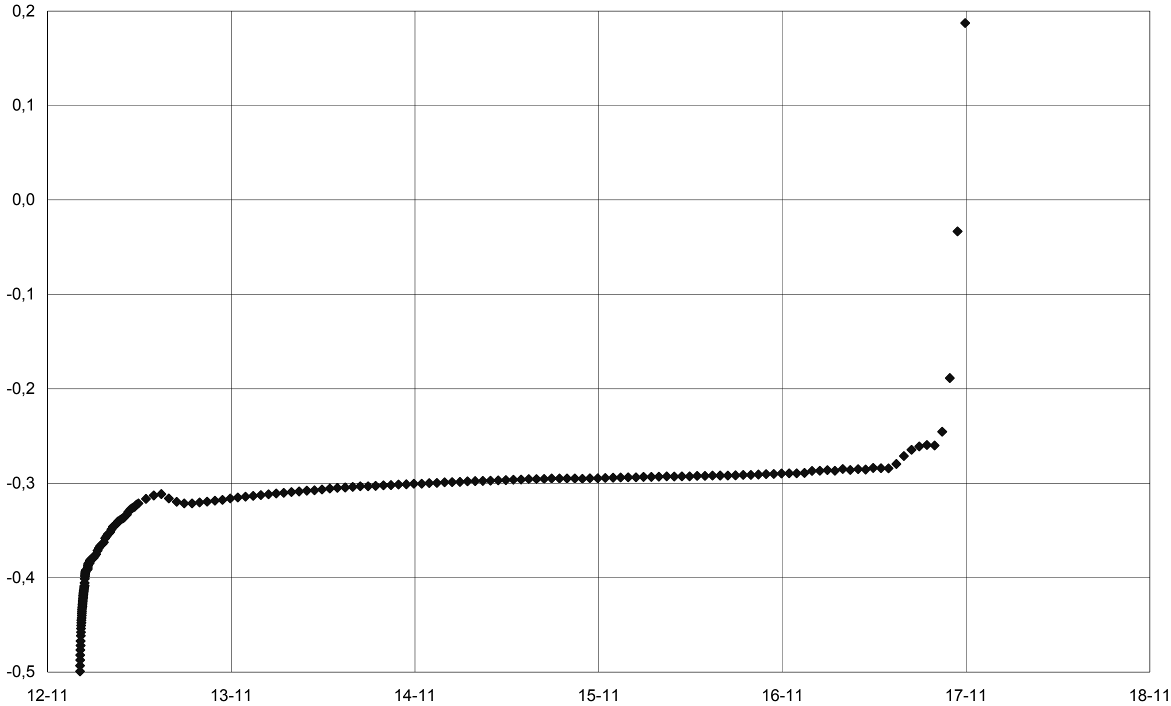


Pic. 2. Electric scheme of power supply unit.

Measurement results

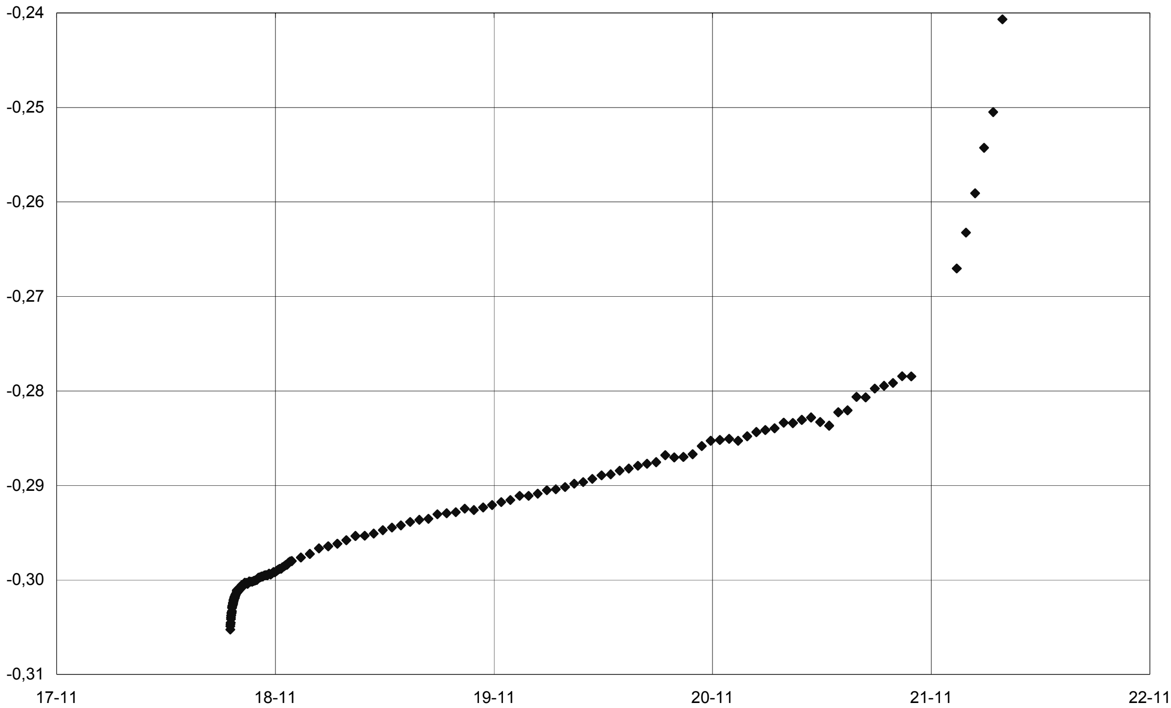
Typical RTD sensor of ALF-SENSOR production has a shape of cylinder with diameter of 5 mm and longitude of 300 mm. Casing of sensor is build in metal, it means that measurement averages temperature along longitude of cylinder. For testing 0 ^{o}C temperature standard stand we build our own RTD sensor that is covered with plastic cylinder diameter of 5 mm and longitude of 50 mm. That sensor could measure temperature in point. Than we put a plastic sensor in a cupper tube of ALF-SENSOR dimensions.

Metallic thermos was fulfilled with ice cubes of walnut shape and 200 ml of distillated water was poured on the bottom. Ice was from distillated water. Thermos was tightly closed, putted on rotating device and registration of temperature started. Rotations were of 360^{o} and with frequency of 0,5 Hz. Melting process was very slow. It lasted for 3 – 5 days. On picture 3 there's shown plot of resistance of RTD sensor against time. For PT100 ideal sensor R_0 = 100 Ω. On the vertical axe there's difference of resistance to 100 Ω.



Pic. 3. Changes of resistance during melting process measured on the bottom of vessel.

Characteristic resistance for that calibration was R_o = 99,683 Ω. A little bit dif-ferrent result we obtain when sensor was covered with cupper tube. Changes of resis-tance during melting processes measured in the centre of vessel there's shown on pic- ture 4. For that calibration R_o = 99,691 Ω. Growth of temperature observed on pic. 3 is of 21 mK per day while observed on pic. 4 is of 14 mK per day and that result seams to be nearer real value.



Pic. 4. Changes of resistance during melting process measured in the middle of vessel.

Results and Conclusion

Proposed and build 0 ^{o}C temperature standard fulfills it's duty quite properly. From practical reason adding a drop of water at the beginning of calibration become useless. When we start calibration from pure ice fulfilling the vessel it's easer to obse-ve point of melt-starting. Calibration lasts several hours.

Temperature standard is constructed for long and thin thermometers in metal housing and R_o = 99,691 Ω result of calibration (pic. 4) is better then R_o = 99,683 Ω result (pic. 3) obtained for bottom of vessel.

Difference between results of two calibrations expressed in temperatures (8 mΩ = 21 mK) is a good approximation of calibration accuracy. Our 0 ^{o}C temperature stan-dard is easy to build, cheap and of good accuracy on the level of ± 0,01 ^{o}C.

References

[1] Wiśniewski S.: Pomiary temperatur w badaniach silników i urządzeń cieplnych. *Warszawa, WNT 1983*
[2] Wiśniewski S.: Wymiana ciepła. *Warszawa, WNT 1979*
[3] Fodemski R.: Pomiary cieplne. *Warszawa, WNT 2001*
[4] NANMAC Temperature Measurements Handbook. *USA, NANMAC Corporation 1998*