

The He3 Thermometer [IQM01-003-01]

Notes:



This sign indicates something you need to know to use the instrument properly.



The text with this sign gives you some information that is useful to know.

The He3 thermometer assembly [IQM01-003-01] (Fig.1) contains the Cernox 1020 thermometer calibrated from 0.40 K to 300 K, and field calibrated to 7 Tesla. It comes with the following three calibration files.

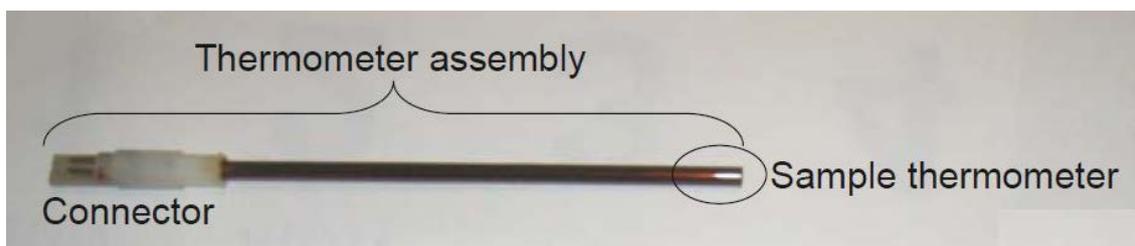


Fig. 1

#CMPxxxT_VsR.dat: Temperature vs resistance table to be used by the Cryocon 32B temperature controller.

#CMPxxxHT_Coeff.dat: Chebyshev polynomial coefficients for temperatures above 2K.

#CMPxxxCoeffTable.dat: Sets of Chebyshev polynomial coefficients for temperatures below 2K, calibrated for magnetic field up to 7T.

*xxx = Thermometer serial number

These files are normally found in the “C:\iHelium3\data” folder and are specified in the “C:\iHelium3\ihelium3.ini” file as below.

1CH CoeffTable File=#CMPxxxCoeffTable.dat

1CH HighTemp Coeff File=#CMPxxxHT_Coeff.dat

1CH T_VsR File=#CMPxxxT_VsR.dat

#CMPxxxT_VsR.dat:

This file is a table of temperature (left column) vs resistance (right column). At startup, “iHelium3.exe” software uploads the contents of this file to the Cryocon 32B temperature controller.

```
<<#CMPxxxT_VsR.dat >>  
T_AISTHT1, 'R1@HT1'  
309.933117193596, 44.6509103393555  
299.179934519308, 45.7897578430176  
296.689170607238, 46.0605296325684  
290.560977192516, 46.7505676269531  
///
```

#CMPxxxHT_Coeff.dat:

This file is a single set of coefficients for the Chebyshev polynomials for use above 2K. Note the He³ Cernox thermometer is not calibrated for magnetic field above 2K.

#CMPxxxCoeffTable.dat:

This file consists of sets of coefficients for the Chebyshev polynomials for use at temperatures below 2K. The “iHelium3.exe” software generates the field-corrected temperature from these sets of coefficients.

 The temperature reading on the Cryocon 32B is not corrected for the applied magnetic field. As a result the 32B displays a different temperature from that on the iQuantum software for finite fields. The temperature set point sent to the Cryocon is deliberately shifted to compensate for applied magnetic field.

The “iHelium3.exe” calculates the sample temperature from resistance using the following Chebyshev polynomial equations.

$$\log_{10} T_{Temp} = \frac{a_0}{2} T_0(x) + \sum_{n=1}^N a_n T_n(x)$$

$$T_0(x) = 1, \quad T_1(x) = x, \quad T_n(x) = 2xT_{n-1}(x) - T_{n-2}(x) \text{ for } n \geq 2$$

$$x = \frac{(Z - Z_L) - (Z_U - Z)}{Z_U - Z_L}$$

$$Z = \log_{10} R$$

T_{Temp} : Temperature(K)

a_n : Chebyshev coefficient

Z_L, Z_U : lower and upper limit of Z

R : Resistance of the thermometer



Note that the constant term is $a_0/2$, not a_0 , of note if you are accustomed to LakeShore's definition.

"#CMPxxxHT_Coeff.dat" is formatted as follows:

```
<<#CMPxxxHT_Coeff.dat >>
2.90122874399 : ZU
1.68505647555 : ZL
#CMPxxx      : Thermometer S/N
2.7820928371 : a0
-1.12609039087 : a1
-.0113640825276 : a2
////
```

"#CMPxxxCoeffTable.dat" contains sets of coefficients of the Chebyshev polynomials for use below 2.0 K at the following magnetic fields:

0 Oe, 2000 Oe, 4000 Oe, 6000 Oe, 8000 Oe, 1T, 2T, 3T, 4T, 5T, 6T, 7T

```
<<#CMPxxxCoeffTable.dat>>
ZU ZL a0 a1 a2 a3 a4 //// : Coefficients at 0 Oe
ZU ZL a0 a1 a2 a3 a4 //// : Coefficients at 2000 Oe
ZU ZL a0 a1 a2 a3 a4 //// : Coefficients at 4000 Oe
ZU ZL a0 a1 a2 a3 a4 //// : Coefficients at 6000 Oe
////
```

To generate a temperature in a magnetic field, the software interpolates between two temperatures calculated for the two neighboring calibration fields above and below the current field. The interpolation is performed against $\sqrt{|H|}$ since Cernox's magnetoresistance behavior is approximated as this. For example, to get a temperature at 3,000 Oe:

- 1, Calculate two temperatures using two set of Chebyshev coefficients at 2,000 and 4,000 Oe.
2. Then perform interpolation as below.

$$Temp_{3,000\text{ Oe}} = Temp_{2,000\text{ Oe}} + \frac{Temp_{4,000\text{ Oe}} - Temp_{2,000\text{ Oe}}}{\sqrt{4000} - \sqrt{2000}} \times (\sqrt{3000} - \sqrt{2000})$$

 The calibration in magnetic fields is based on the Coulomb blockade thermometry. The Coulomb blockade thermometer is once calibrated against the factory-calibrated ruthenium oxide thermometer in a zero or relatively low field, and then is used as the reference thermometer in finite magnetic fields.