dataTaker

Technical Note

TN-0023

Applying Thermocouple Calibration Corrections

To improve the accuracy of thermocouples it is possible to have them calibrated by a calibration lab. In this particular scenario, a calibration lab has provided a certificate which identifies calibration data at certain temperatures.

1 Prerequisites

- Nil

2 Required Equipment

- *dataTaker* DT80 range data logger
- Thermocoupes with calibration certificates
- PC with Microsoft Excel

3 Process

To apply these calibration corrections in the dataTaker, we utilise polynomials, but first we must generate the polynomial. The technique is to calculate a polynomial equation to calculate the adjustments.

3.1 Calculating the Polynomial Factors

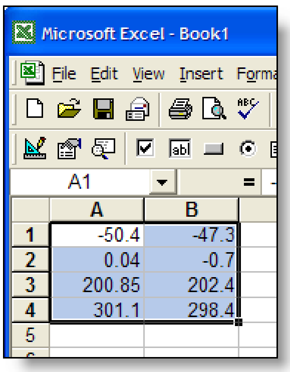
The results from the calibration lab are expressed as corrections at measured temperatures. These appear in Table 1 below:

Test	Reported Temp	Corrected Temp	Correction
1	-50.40°C	-47.30°C	3.10°C
2	0.04°C	-0.70°C	-0.74°C
3	200.85°C	202.40°C	1.55°C
4	301.10°C	298.40°C	-2.70°C

Table 1 - Calibration Data

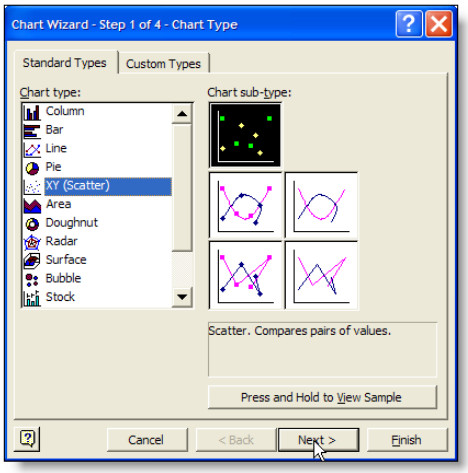
To use a Polynomial correction, firstly calculate the terms of the polynomial. To do this use the ‘Trend Line’ feature of Microsoft Excel

- Open Excel and enter the “test” and “measured” temperature values into two columns

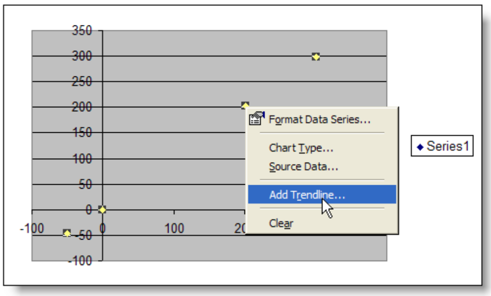


- Highlight the Table and Click the Chart Wizard ICON

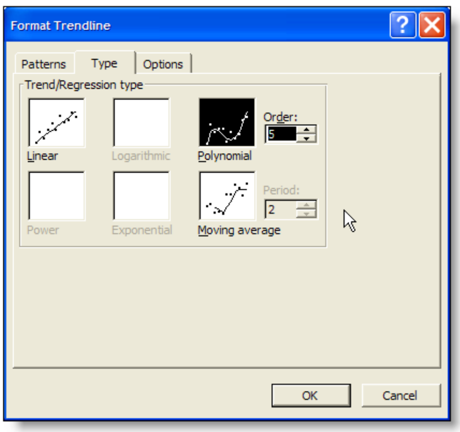
- Select XY Scatter
- Click Finish



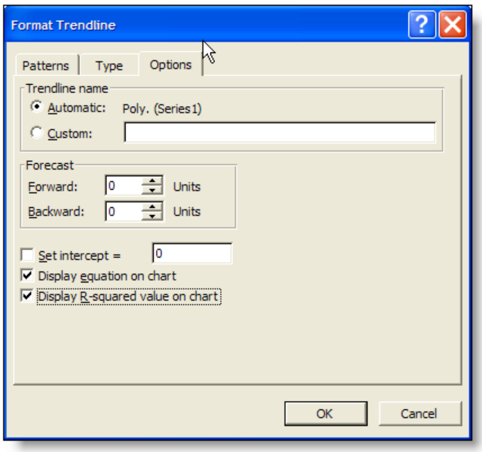
- Right-click on one of the Graph Points and select 'Add Trendline'



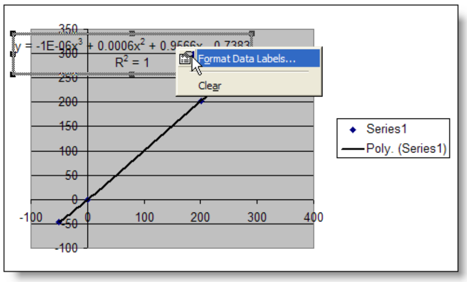
- Select the Polynomial Box and set the Order to 5
- Click the Options Tab



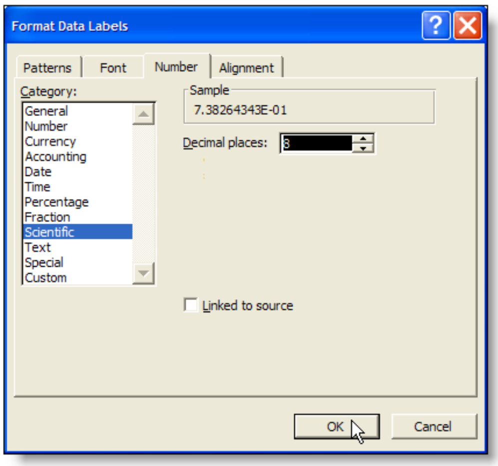
- Check 'Display Equation on Chart'
- Check 'Show R-squared value on Chart'
- Click OK



- When the trend line is produced and the equation is displayed, right click on the Equation and Select 'Format Data Label'



- Select the Scientific Format and set the decimal places to around 8
- Click OK
- Right-click the equation and select Copy



The polynomial for the correction is:

y = -1.49953975E-06x3 + 5.74059250E-04x2 + 9.56585619E-01x - 7.38264343E-01

R2 = 1.00000000E+00

Note how the value of R2 is exactly 1, this is how well the polynomial relates to the data points, where a value of 0 is poor and 1 is ideal. The value of R2 will change with the Order of polynomial selected earlier. You can try to change this number to increase the R2 value.

3.1.1 A Warning when using polynomials

It is necessary to confirm the polynomial correction within the range of temperatures that are being used, as polynomials can produce unexpected results outside the calibration range.

In this instance, the values given by the polynomial below –100deg C are incorrect. To see this you can right-click on the graph and zoom out.

3.2 Applying the polynomial using the dataTaker program language

The format of the dataTaker polynomial is as follows:

$Y = k_0 + k_1 x + k_2 x^2 + k_3 x^3 + k_4 x^4 + k_5 x^5$

And in dataTaker language is

```
Yn=k0,k1,k2,k3,k4,k5"units"
```

NOTE: The notation of the polynomial in the dataTaker is reversed compared to the notation of that generated in Excel.

- Fill in the constants with those generated by Excel and you would now have:

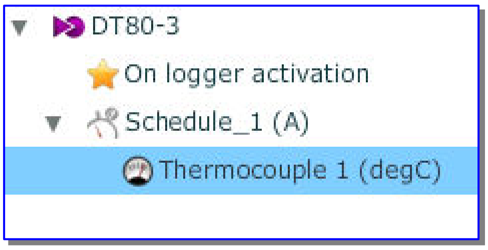
```
Y1=-7.38264343E-01, 9.56585619E-01, 5.74059250E-04, -1.49953975E-
06"adjDegC"
```

- To use this polynomial for a measurement, add the polynomial number as a channel option.

```
1TK("TSTemp",Y1)
```

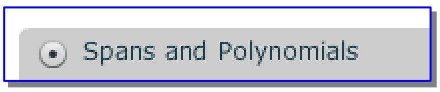
3.3 Applying the polynomial in dEX

- Click on the channel to which you want to apply the calibration

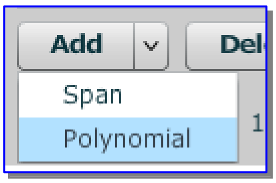


- Click on the Scaling tab

- Check “Spans and Polynomials”



- Click the “Add” button
- Select “Polynomial”



The format of the dataTaker polynomial is as follows:

$$Y = k_0 + k_1 x + k_2 x^2 + k_3 x^3 + k_4 x^4 + k_5 x^5$$

NOTE: The notation of the polynomial in the dataTaker is reversed compared to the notation of that generated in Excel.

- Populate the values for k_0 , k_1 , k_2 and k_3

Polynomials are used to define calibrations for non-linear sensors. Each defined polynomial can have up to six polynomial coefficients. The logger evaluates a polynomial according to the formula:

$$y = k_0 + k_1 x + k_2 x^2 + k_3 x^3 + k_4 x^4 + k_5 x^5$$

where x is the raw channel reading, and $k_0..k_5$ are the coefficient terms.

k_0	-7.38264343E-01	k_4	0
k_1	9.56585619E-01	k_5	0
k_2	5.74059250E-04		
k_3	-1.49953975E-06		

- Double-check your values against the original equation generated by Excel
- Save your configuration to the logger and confirm that the recorded values are in the correct range.