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An Introduction to Calibration – Temperature Sensors

Wednesday, 6 April 2022 | Technical Topic Webinar

Presented By

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CRICOS Provider Number: 03567C | Higher Education Provider Number: 14008 | RTO Provider Number: 51971

Common Questions/FAQs

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Introduction - Presenter

Dr. Wilhelm Johann van den Bergh

- Recent PhD graduand (Doctor elect?).
- Thesis topic: ***Experimental investigation into the effects of low mass and heat flux and transient vapour quality and heat flux on boiling R-245fa in horizontal pipes.***
- Started at EIT in November 2021.

Agenda

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1	Welcome and Introduction
2	The importance of being calibrated
3	Accuracy and precision
4	Sample case: temperature
5	Sample case: differential pressure
6	Conclusion and Q&A

What is calibration?

Aligning the values of a measurement device with a known standard.

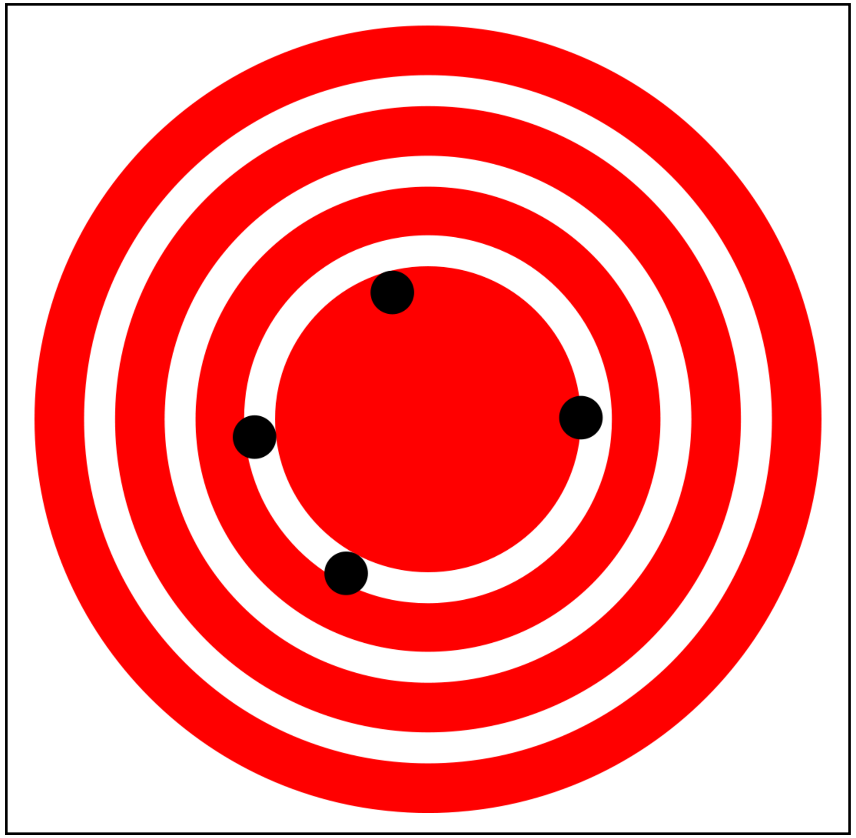
- Known standard: Either physical or theoretical.
- SI units.
- Alternatively, known quantities of measure (i.e. differential pressure).
- Calibration ‘teaches’ a measuring instrument to produce results more in line with the ideal.

What is calibration?

Commonly, modern measurement techniques spit out an electrical signal.

- I.e. Thermocouple uses the Seebeck effect (change in temperature results in tiny voltage change).
- Strain gauges
- Differential pressure gauges
- Resistance temperature detectors
- If something causes a reliable, linear, measurable electrical effect it can be used to measure that something.

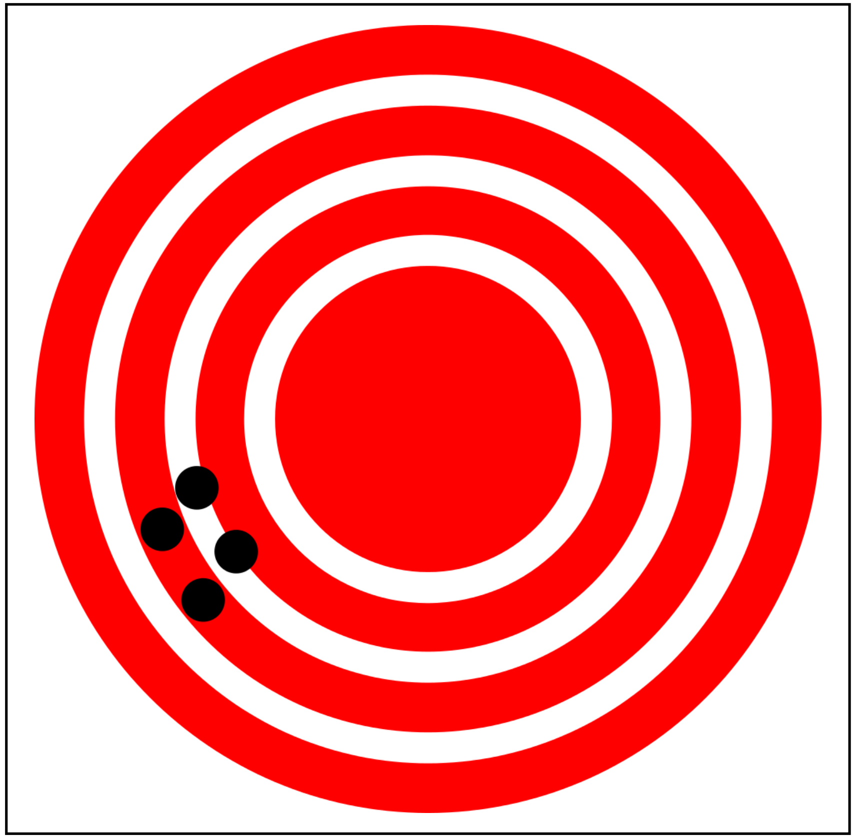
Accuracy and precision



Accuracy

- How close you are to the mark

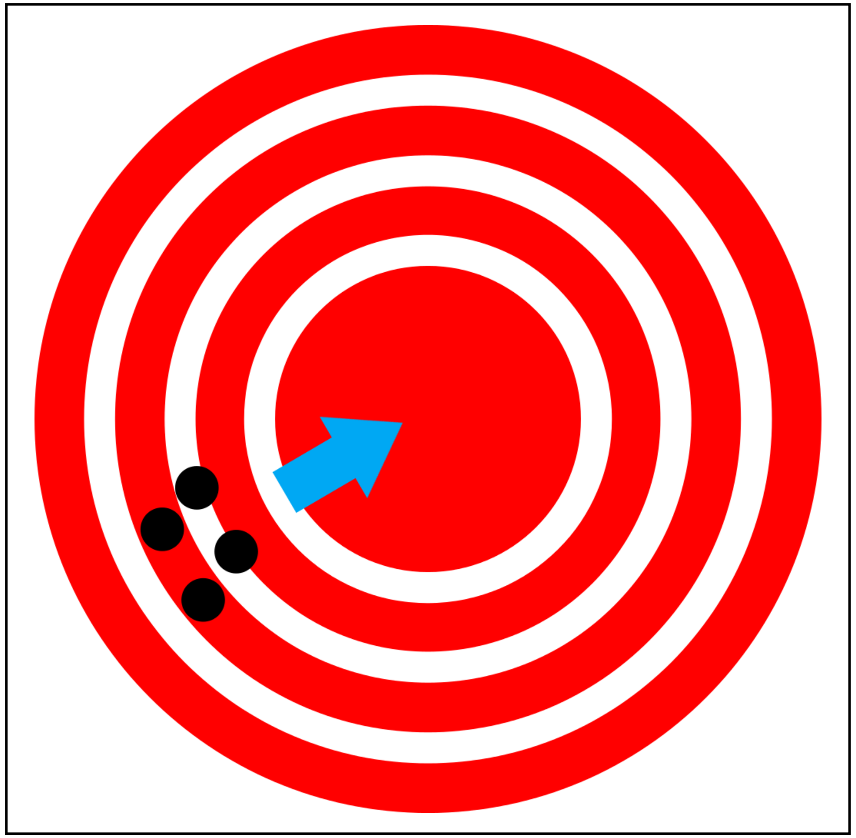
Accuracy and precision



Accuracy
- How close you are to the mark

Precision
- How close your values are to each other

Accuracy and precision

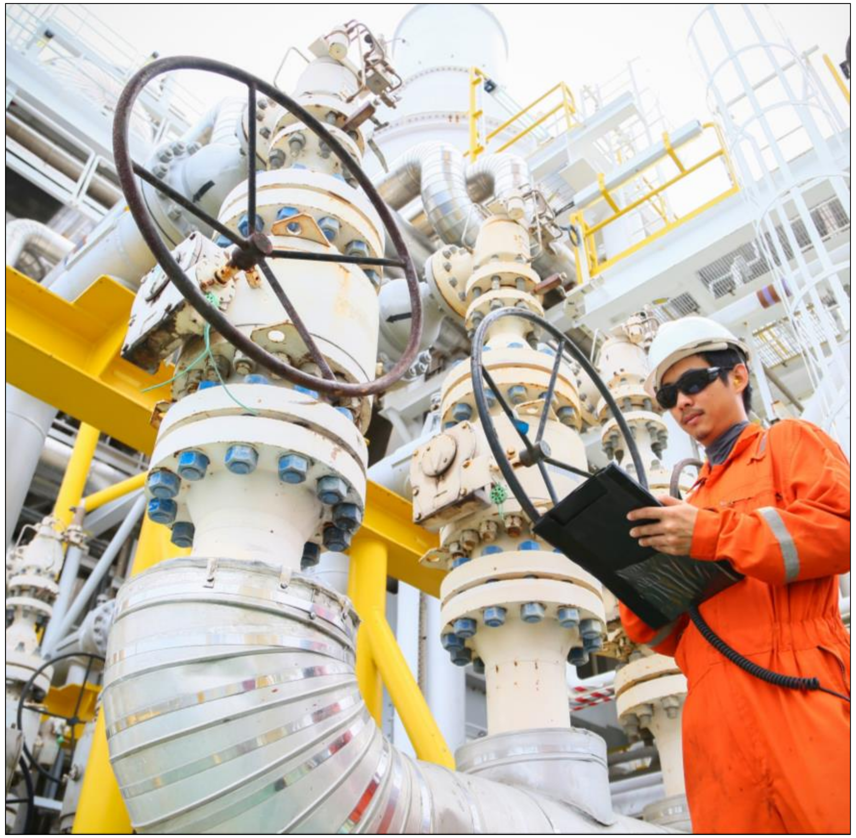


Accuracy
- How close you are to the mark

Precision
- How close your values are to each other

Goal of calibration: Improving both.

The importance of being calibrated



In everyday life:

- Saves money
- Saves time

In engineering:

- More efficiency
- Saves money
- Saves time
- …saves lives!

Examples: Everyday life

In everyday life, people are concerned with things that make their lives easier and saves them time and money.

- Tachometer and odometer in a car
- Thermostat in a kettle, home, stove
- Electrical metering devices
- Scales
- Rulers
- Etc...

Examples: Engineering

Engineers are also concerned with saving time and money. Lives too!

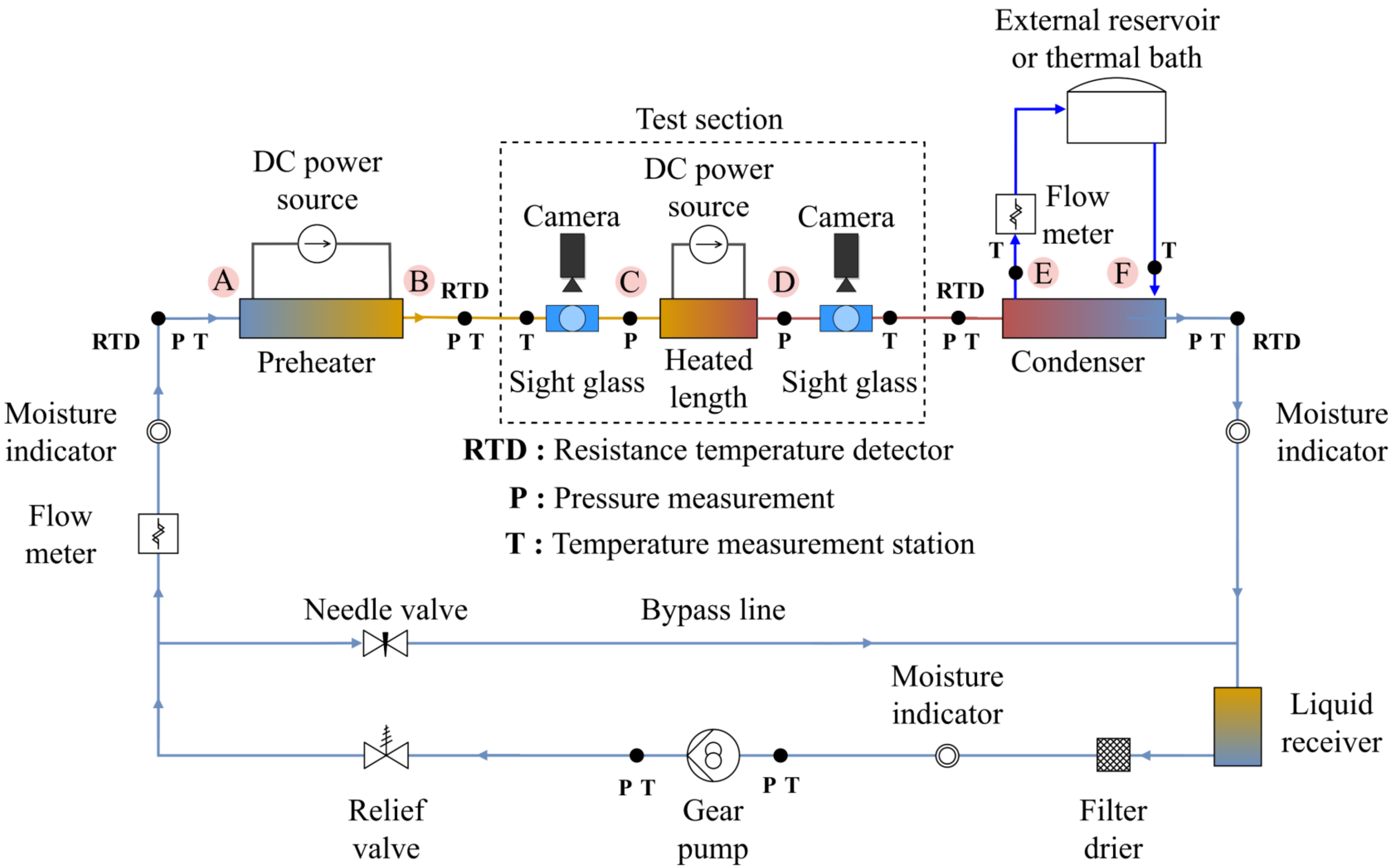
- Strain gauges
- Flowmeters
- Temperature measurement
- Pressure measurement
- Voltage and current
- Etc…

How is it done?

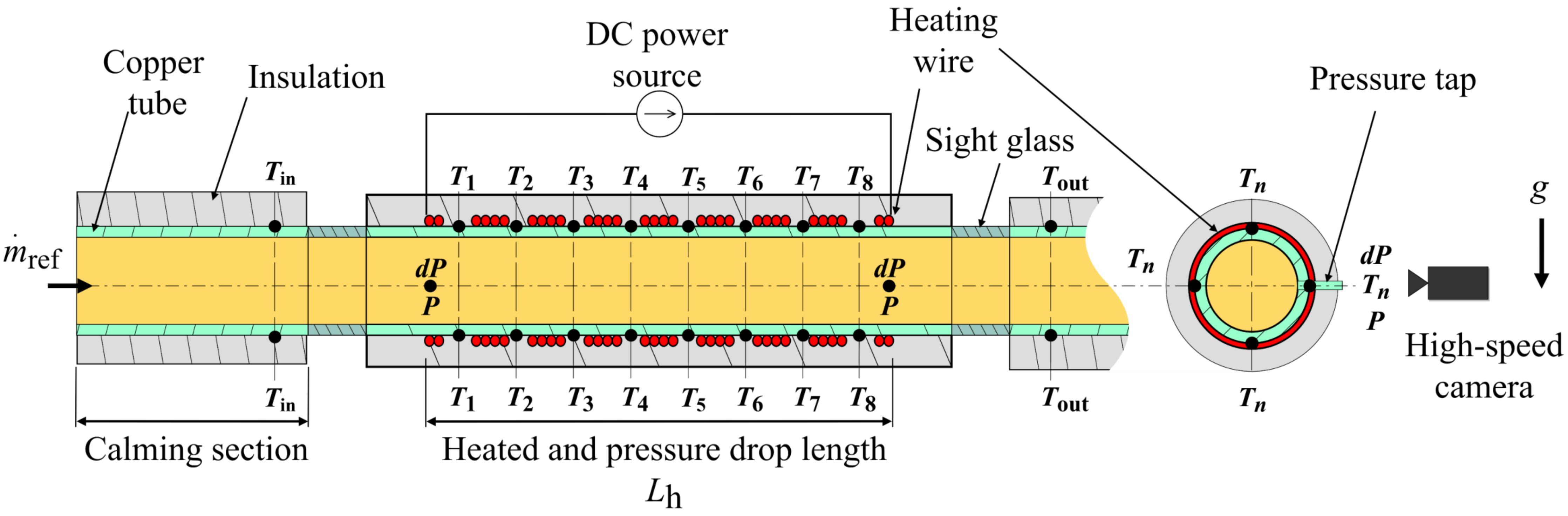
As mentioned, an ideal to compare to is needed.

- Thermocouples: Need a reliable temperature measurement.
- Differential pressure sensors: Need a carefully controllable, reliable way of imposing a pressure difference.
- Strain gauges: Same
- Etc…
- Need a reliable way of recording data.
- Need a reliable way of linear curve fitting.

Sample case: Experimental apparatus



Sample case: Experimental apparatus



dP **:** Differential pressure measurement port
P **:** Absolute pressure measurement port
T **:** Temperature measurement station

Sample case: Temperature

Experimental apparatus: Pt100

- Rated at 1/10 DIN (0.03 degrees accurate at 0 degrees).
- Would be used to calibrate thermocouples in the test section.
- 4 situated throughout system to monitor.

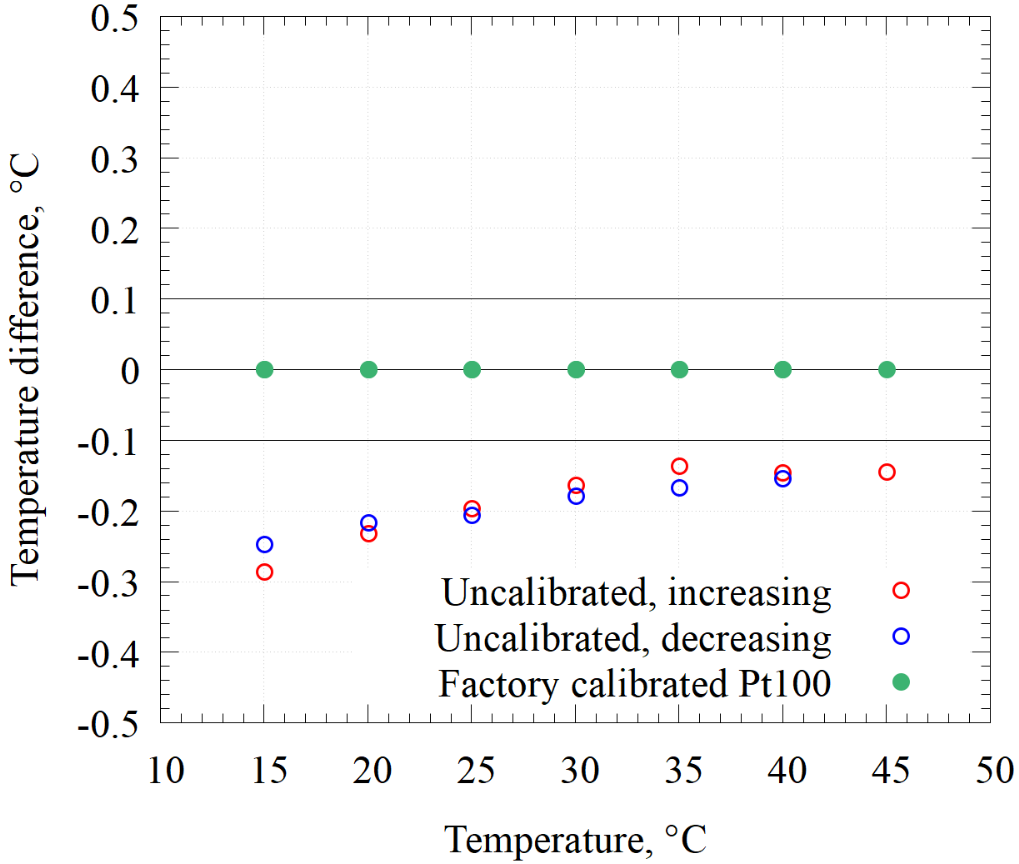
Experimental apparatus: T-type thermocouple

- Rated at 0.5 degrees at 0 degrees.
- 40 of these used on test section, 32 on rest of facility.

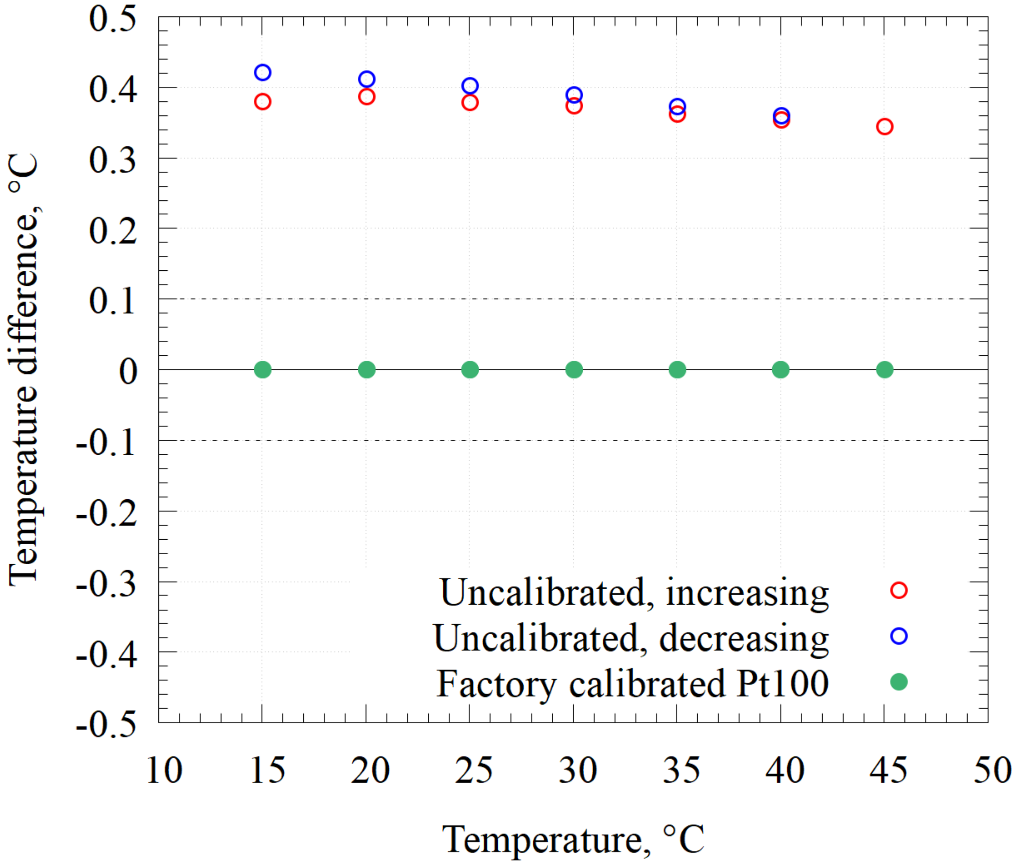
How do the uncalibrated results look?

Sample case: Temperature

An uncalibrated Pt100



An uncalibrated thermocouple



Calibration procedure

Calibrating the Pt100s

1. Insert into well-insulated adjustable thermal bath (Lauda Proline RP1845C)
2. Insert pre-calibrated Pt100 into thermal bath (DigiCal DCS2) .
3. Set thermal bath to maintain a certain temperature (i.e. 15 degrees).
4. Wait for steady state, record 10 minutes of data.
5. Rinse and repeat in 5 degree increments up to 45 degrees, then come down again (to capture possible hysteresis).
6. Process the data in Matlab or similar to get a linear calibration equation.

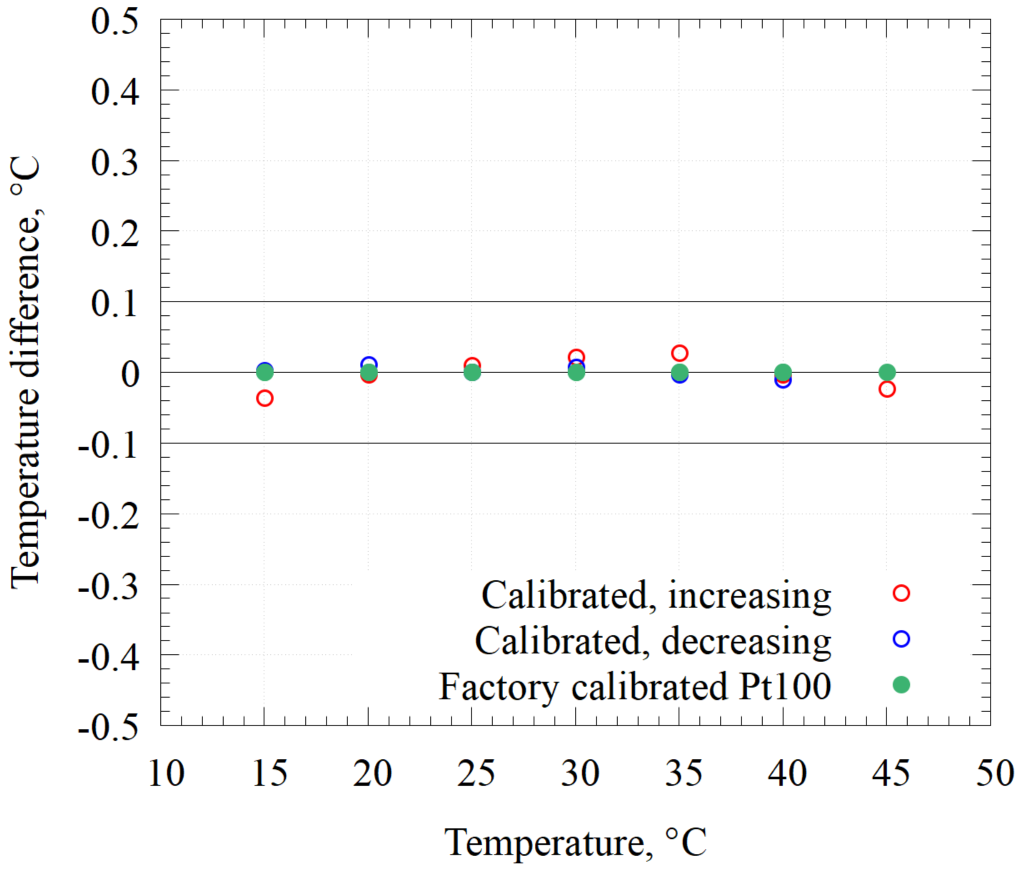
Calibration procedure

Calibrating the test thermocouples

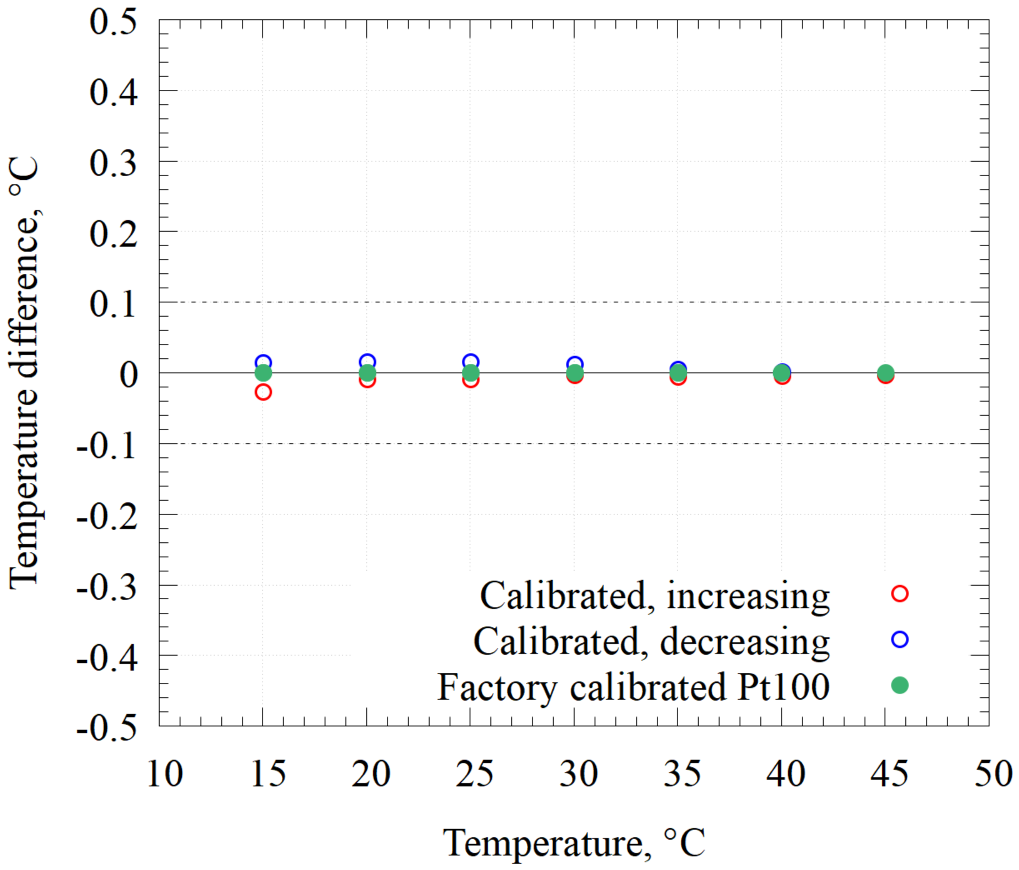
1. Thermocouples are welded to the test piping (to ensure contact).
2. Can't pre-calibrate them in the thermal bath like the Pt100s.
3. The calibrated Pt100s are installed and system fired up.
4. Thermal bath is now connected to the system.
5. Same procedure as for the Pt100s from here on in.
6. Took a while…system redesign needed.

Sample case: Temperature

A calibrated Pt100



A calibrated thermocouple



Sample case: Differential pressure

Experimental apparatus: Validyne DP15 connected to Validyne demodulator.

- Physical interface with fluid
- Measures the difference in pressure between two sides of a diaphragm.
- Spits out a voltage between -10 and 10 V.
- At 10 V, the maximum rated pressure difference should be present.
- At 0 V, zero pressure difference.
- This voltage has to be adjusted on the demodulator.

Calibration procedure

- Simple straight line: P = mV (where m = the diaphragm max. rating).
- Diaphragms rated at 0.86 kPa, 8.6 kPa, and 14 kPa were used.
- DP15 was connected to a water column manometer and factory calibrated differential pressure sensor.
- Equal heights in the columns = zero pressure difference: Turn the zero knob on the demodulator until you read zero voltage.
- Increase the water height slowly on one side until maximum pressure had been reached: Turn the span knob on the demodulator until you read +/- 10 V.
- Repeat until you don't have to adjust the zero or span.
- Worked… kind of.

Caution!

Be extremely careful when calibrating!

- Depending on the application and equipment: Needs to be redone periodically.
- Hysteresis.
- Linearity error in sensors.
- Interpolation not extrapolation!
- Lack of precise and accurate standard.

Conclusions and observations

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1. Calibration is crucial for many industries (laboratories, factories, etc.).
2. Critical to have a standard against which to calibrate.
3. Pressure, temperature, differential pressure… all can and should be calibrated.
4. It should be repeated regularly.
5. Use of software is handy, but not crucial. Can be done by hand.
6. Cost benefit.
7. Caution should be applied.

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Q&A

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