Two Methods of Calibration
Two Methods of Calibration

By Comparison
Two Methods of Calibration

- With Fixed Points
Comparison Calibration

Calibration is usually performed by comparing an industrial temperature sensor to a standard thermometer (whose characteristics are known), in a volume controlled at constant temperature.

This is called comparison calibration.
Zeroth Law

If two systems are in thermal equilibrium, each having the same temperature as a third system, the two systems have the same temperature as each other".

That is, if A and C are both at temperature t, and B and C are both at temperature t, then A and B are both at the same temperature.
Zeroth Law

- It is the Law that permits us to make calibrations by comparison of an unknown thermometer with a standard thermometer.
- Rephrasing, “if a calibrated thermometer is at the same temperature as a calibration bath, and a thermometer under test is at the same temperature as that calibration bath, then the calibrated thermometer and the thermometer under test are at the same temperature.”
Comparison Calibration

- Don’t Mix Evaluation and Calibration
- Standard Thermometers, Indicators and Reference Resistors Need:
  - Calibration Certificates
- Comparison Baths Need:
  - Evaluation Reports
  - Thermal Surveys
Comparison Calibration

- In our secondary lab
  - All *comparison* baths are surveyed every four years
  - The auditors never expect to see a calibration certificate
Fixed Point Calibration

- Fixed Point Calibration
- Against a “fixed point”
Fixed Point Calibration

- Water Triple Point Cell
- More ‘accurate’
- Used on the ITS-90 Scale
## ITS-90 Fixed Points

<table>
<thead>
<tr>
<th>FIXED POINT</th>
<th>PHYSICAL PROPERTY</th>
<th>TEMPERATURE °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Argon</td>
<td>Triple Point</td>
<td>-189.3442</td>
</tr>
<tr>
<td>Mercury</td>
<td>Triple Point</td>
<td>-38.8344</td>
</tr>
<tr>
<td>Water</td>
<td>Triple Point</td>
<td>0.010</td>
</tr>
<tr>
<td>Gallium</td>
<td>Melt Point</td>
<td>29.7646</td>
</tr>
<tr>
<td>Indium</td>
<td>Freeze Point</td>
<td>156.5985</td>
</tr>
<tr>
<td>Tin</td>
<td>Freeze Point</td>
<td>231.928</td>
</tr>
<tr>
<td>Zinc</td>
<td>Freeze Point</td>
<td>419.527</td>
</tr>
<tr>
<td>Aluminium</td>
<td>Freeze Point</td>
<td>660.323</td>
</tr>
<tr>
<td>Silver</td>
<td>Freeze Point</td>
<td>961.78</td>
</tr>
</tbody>
</table>
Fixed Point Calibration Laboratory

Will look at other fixed points later
Fixed Point Calibration

- A Practical Example
- Gallium ITS-90 Fixed Point
  - Gallium
  - Melts at 29.7646°C
Two Methods of Calibration

- With Fixed Points
Second Method of Calibration

- Fixed Point Calibration
  - Against a “fixed point”
  - E.g a Flask of Melting Ice
Fixed Point Calibration

- Water Triple Point Cell
  - More ‘accurate’
  - Used on the ITS-90 Scale
Fixed Point Calibration

- A Practical Example
- Gallium ITS-90 Fixed Point
  - Gallium
  - Melts at 29.7646°C
A Practical Example

A Gallium Cell
A Practical Example

A Gallium Apparatus
A Practical Example

Gallium Cell

- Cell Placed in Apparatus

- 22°C

- 30.2°C
A Practical Example

Gallium Cell

- The cell is at room temperature 22°C
- Gallium is a metal that melts at 29.7646°C
A Practical Example

Gallium Cell

- The Apparatus is set to Melt the Solid Metal
- The Apparatus raises to around 30.2°C
A Practical Example

The temperature of the cell starts to rise

30.2°C
A Practical Example

The metal starts to melt at 29.7646°C. The temperature remains constant at this temperature until all the metal has melted, latent heat.
A Practical Example

Only when all the metal has changed state to a liquid does the temperature rise to the apparatus temperature (30.2°C).
A Practical Example

- Gallium Cell
  - The Plateau can last for many hours
  - During this time different thermometers are placed into the cell for calibration
  - The temperature is determined by the purity of the metal
- Not Electronics
A Practical Example

- **Gallium Cell**
  - When the melt is complete switched to FREEZE
  - Cell is cooled and the metal changes state back to a solid
  - Ready to be used again

- The Isotech Apparatus freezes the cell from the bottom upwards to prevent damage to the cell due to expansion as the metal freezes