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The care and maintenance of Standard Platinum Resistance Thermometers, SPRTs

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Agenda

- Introduction
- SPRT Construction
- Mechanical Treatment
- Thermal Treatment
- Maintenance
- Transportation

Introduction

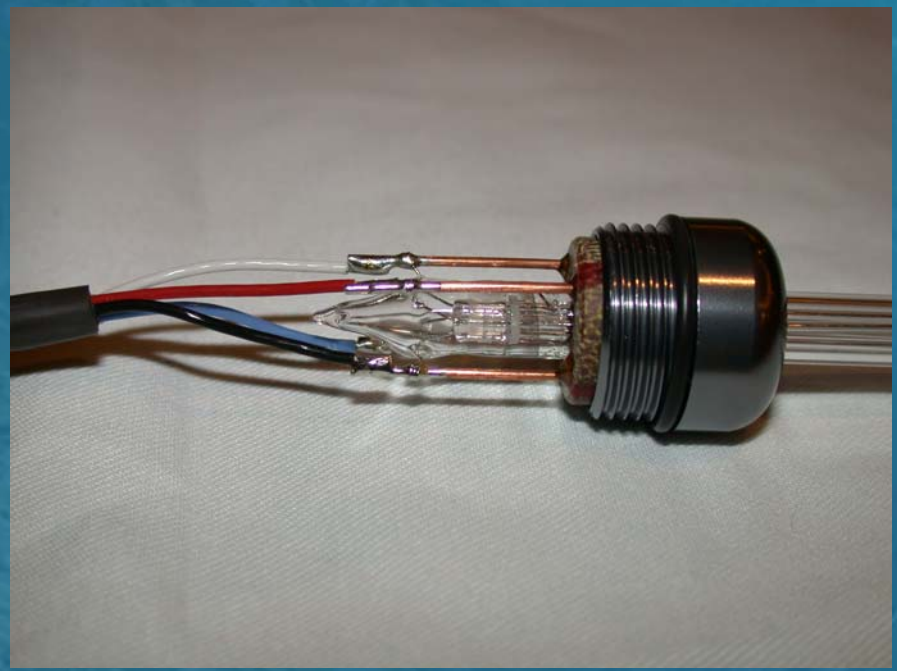
- Standard Platinum Resistance Thermometers (SPRTs) are the workhorse of modern temperature calibration
  - Cover -260°C to 960°C
  - Accuracies approaching 1 mK
  - If properly maintained offer years of service

SPRT Construction

- High purity platinum wire
  - Diameter depends upon temperature range and nominal resistance value
  - Platinum wire is further heat treated to burn off remaining contaminants and anneal wire
- Strain-free coil is placed upon either quartz (preferred) or mica cross frame support
  - All material needs to be very clean to prevent contamination
  - Careful selection of materials also provides protection against contamination at high temperatures

Gas mixture and sealing critical to long life

- The gas mixture inside of the SPRT is critical to long term stability
  - Balanced between preventing oxidation and contamination
- Seal construction critical to maintain solid barrier to atmosphere throughout a wide temperature range
  - At Hart our platinum leads exit through 7 different layers of fused silica glass to effectively match the expansion coefficient of platinum wire



Mechanical treatment

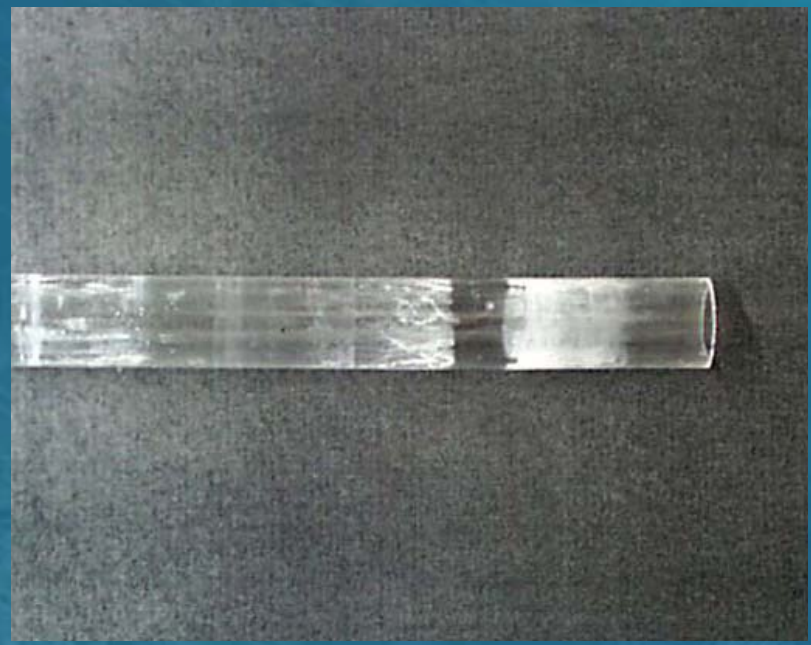
- SPRTs sensing element is fragile
  - Metal sheath does not provide any better mechanical protection than fused silica sheath
- Even if damage isn't visible (examples to the right are extreme) accumulation of shock and vibration effects over time can significantly change R_{tpw} value
  - A change of 0.1 milliohms will cause a 1 mK in temperature for a 25 ohm SPRT

This sensor was damaged by shock during shipping and handling

This sensor was damaged by vibration. Notice shorting of coils.

Thermal treatment

- Cleanliness is important!
  - Allways clean SPRT with ethanol before using above 100°C
  - Devitrification is caused by contamination of the fused silica causing the sheath to become brittle and gas permeable
  - A human fingerprint will accelerate the devitrification process
- Never move an SPRT form a high temperature heat source directly into room air
  - Above 480°C SPRTs should be carefully cooled at a rate of 150°C per hour
- Keep the SPRT handle cool
  - High temperature damages the seal, cable insulation and solder connections



Devitrification of fused silica tube

Hart SPRT max temperature

Hart Model Number	Maximum Temperature
5680, 5682, 5683	480°C
5681, 5698, 5699	670°C
5684, 5685	1070°C

Never subject SPRT to temperatures above the manufacturers maximum specification!

Maintenance

- SPRTs like any piece of sensitive equipment requires periodic maintenance
- Maintenance consists of
  - Regular assurance tests to ensure confidence in operation
  - Periodic calibration
  - Cautious annealing

Assurance testing

- Depending upon usage and application resistance tests at the TPW point are important to determining performance and maintenance tasks
  - Control charts or records should be maintained
  - Always use most recent Rtpw value for best accuracy
- Offset generally linear
  - Gallium / RTPW ratio >= 1.1187

Ideal SPRT control chart

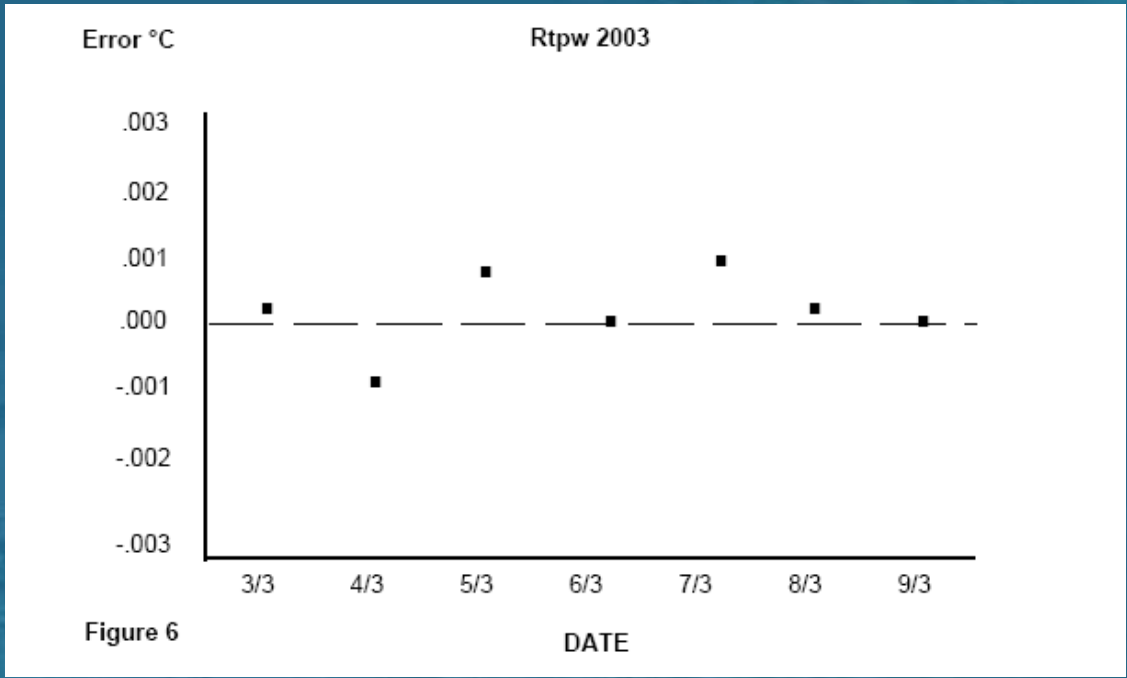


Figure 6

- SPRT R_{tpw} data should appear random
- As long as data falls within ±0.003°C the SPRT should not need annealing

Control chart showing contamination

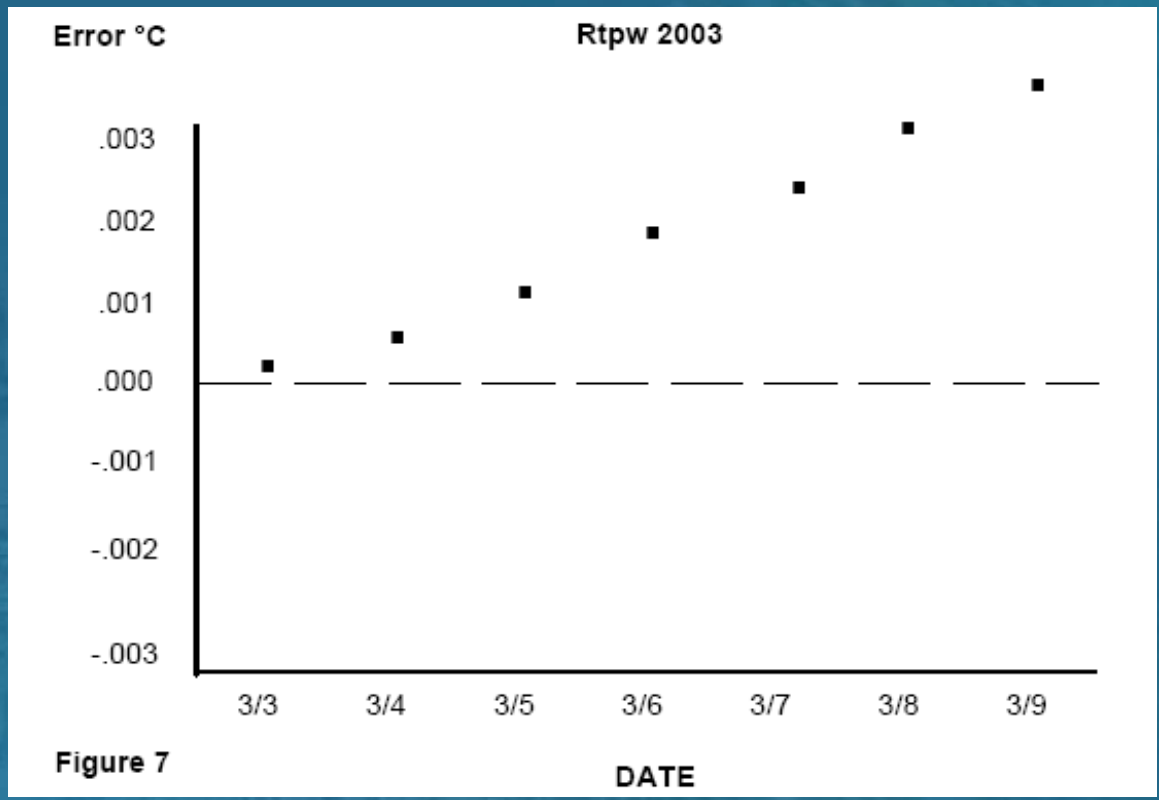


Figure 7

- Steady upward trend is indicative of contamination, oxidation or severe mechanical shock occurring during usage

Control chart showing seal failure

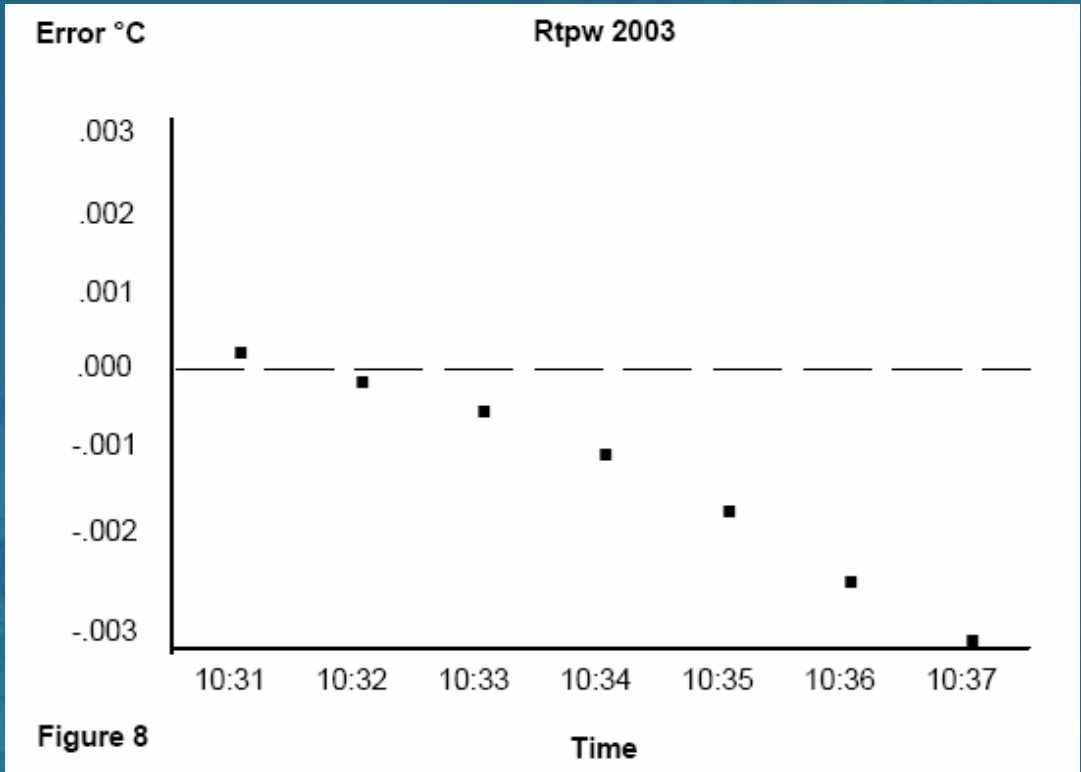


Figure 8

- Downward drift is indicative of a faulty seal allowing condensation to collect on the sensor reducing resistance – note the short time scale in chart above

Control chart showing mechanical failure

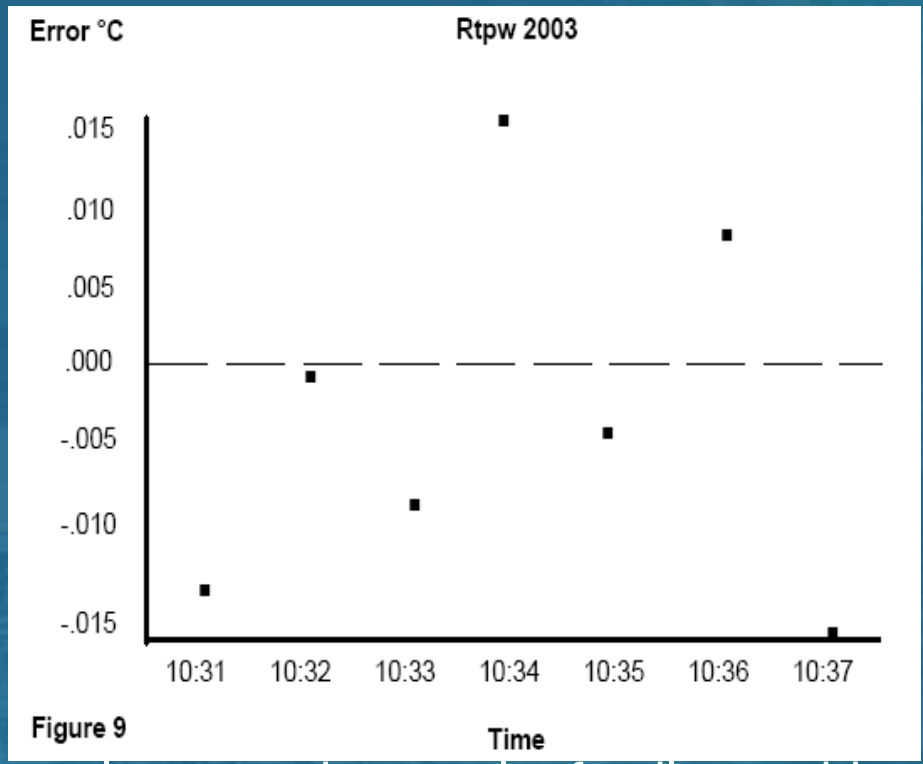
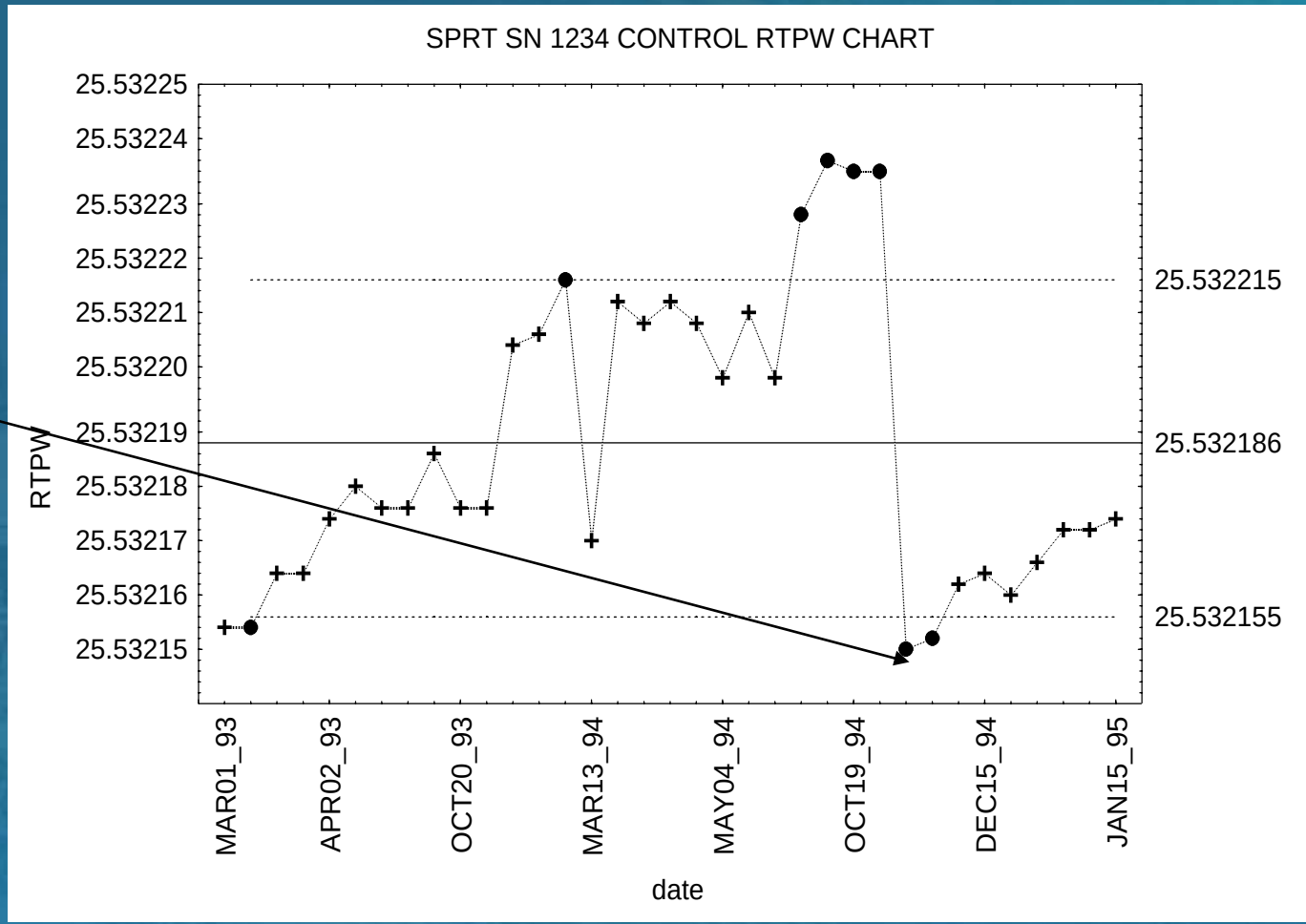


Figure 9

- Erratic Rtpw values are the result of coils touching, broken or loose wiring or Pt grain growth
- Often a slight tap on the handle will cause readings to jump

Control chart showing annealing correction

Probe annealed



Why anneal?

- Normal usage subjects SPRT to vibration which induces strain on the sensor which changes the resistance
- Heating and cooling an SPRT will trap point defects in the crystalline structure of the sensor changing resistance
- Between -40°C and 300°C a surface of platinum oxide ($Pt0_2$) forms on the surface of the sensor wire – 0.5 mK/hr
- Between -300°C and 500°C the body of platinum wire is oxidised – several mK per hour
- Supplemental ITS-90 – if SPRT used above 700°C always anneal before low temperature measurements, especially RTPW.

Annealing will help correct all of these issues and bring the nominal Rtpw back closer to its original value

Recommend annealing temperatures for Hart SPRTs

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Hart Model	Annealing Temp*	Time
5680, 5682, 5683	480°C	2 hours
5681, 5698, 5699	670°C	2 hours
5684, 5685	700°C	2 hours

*Annealing temperature should be based upon the highest temperature point used when the SPRT was calibrated. For example if the highest point used to calibrate the SPRT was Zinc (419°C), they the annealing temperature should be 480°C

Annealing furnace

- The proper selection of an annealing furnace is critical
- At annealing temperatures sensor contamination from the furnace material is likely
  - Metal and ceramic furnace material should be not be used
- Temperature uniformity and stability in the zone where the sensor is located is important
- Being able to set the temperature ramp rate is very useful for safe heating and cooling of the SPRT

Annealing procedure based upon NIST research

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Range of SPRT Use	Procedure
Up to Zinc Point (419.527°C)	Hold at 450°C to 480°C for 4 hours
Up to Aluminum Point (660.323°C)	Thoroughly clean Heat from 500°C to 670°C 1 hour Hold at 670°C – 1.5 hours Cool to 500°C – 3 hours Remove to room temperature
Up to Silver Point (961.78°C)	Measure Rtpw for baseline Thoroughly clean Heat to 970°C – 2 hours Holt at 970°C – 1 hour Cool to 500°C – 4 hours Remove to room temperature

Transportation

- Hand carrying is advisable to guarantee calibration integrity
- Hand carrying is not often possible over long distances
  - In this case a suitable container is required
    - Soft material to protect against shock and vibration
    - Large enough to provide space around the SPRT
  - Express or shipment by Air often provides better handling

Hart's SPRT carrying case

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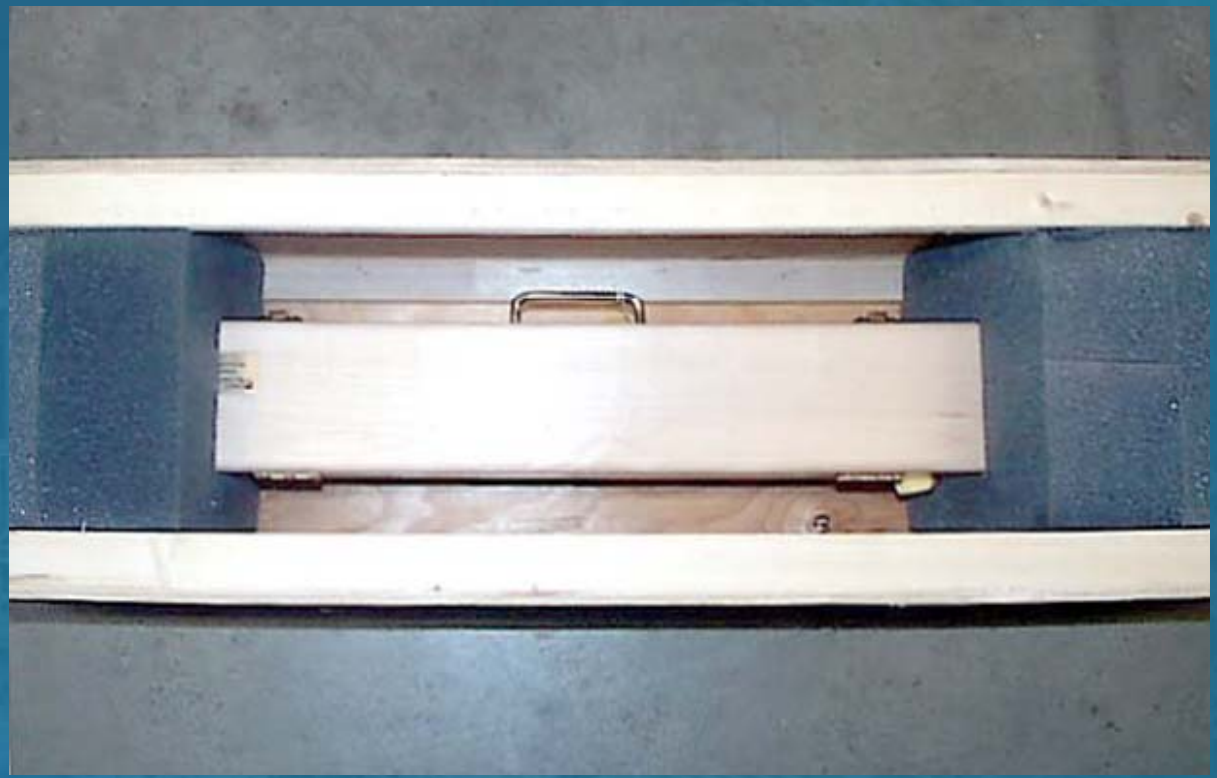
Carrying case inside of shipping container



Summary

- SPRTs are excellent standards for the precise measurement of temperature
- Careful construction and handling ensures good performance for a long time
- Periodic maintenance and testing in important to guarantee the performance or your SPRT