QUARTZ-SHEATH SPRTs

Quartz-Sheath SPRTs	Models 5681, 5684, and 5685
Typical drift rate less than 0.001 K annually	
Proprietary gas mixture ensures high stability	
Most experienced SPRT design team in the business	

Choosing the right platinum thermometer as your primary standard may be the most critical purchase decision in your lab. Unfortunately, other manufacturers are pretty secretive about how their SPRTs are made. They won't tell you much more than you can already see by looking at one. Long-term reputation used to be a reliable indicator, but the leaders of a few decades ago have lost their original craftsmen and design scientists. There are only a few active SPRT design groups in the world today.

So how do you know you're making the best purchase? Self-proclaimed expertise shouldn't convince you. You should expect some sound evidence that the company is qualified in the ongoing science of SPRT development. At Hart we'll tell you how we make an SPRT. We'll let you talk to the people here who design, build, and calibrate SPRTs. Finally, when you buy one, if you don't like it, we'll take it back and return your money.

Hart has three quartz-sheath SPRTs covering the ITS-90 range of –200°C to 1070°C. The Model 5681 is used from –200°C to the aluminum point at 660.323°C. The Model 5684 and the Model 5685 cover higher temperatures up to 1070°C and can be calibrated at the silver point.

Yes, they have all the features you would expect in a world-class SPRT. They have gold-plated spade lugs, a strain-relieved connection to the four-wire cable, convection prevention disks, the finest quartz glass available, delustered stems, and the purest platinum wire available.

The purity of a thermometer's platinum wire is critical to meeting ITS-90 requirements. Maintaining that purity over the life of the thermometer impacts long-term stability. The quartz glass tube of the SPRT should be properly sealed to prevent contamination of the platinum sensor. Others use mechanical assemblies and epoxy seals. These introduce additional materials to the thermometer's internal environment and can be prone to mechanical failure, risking exposure of the platinum to impurities.

Theoretically, the best seal would be a direct seal between the quartz glass and the platinum wire. However, the quartz glass used in thermometer sheaths has a very small coefficient of expansion while platinum has a much larger coefficient of expansion. If you simply sealed the sheath's glass to the platinum wire, these different rates of expansion would result in a poor seal as the assembly is exposed to changing temperatures.

We've figured out a way to match the expansion coefficients of the glass sheath and the platinum wires. We do it by creating a graduating seal that's made of 18 separate pieces of glass, each with a different coefficient of expansion. The expansion and contraction rate of the final piece of glass matches that of the platinum, resulting in an overall seal that prevents gas leakage and impurity penetration for at least 20 years.

Fusing each piece of glass to the next is a painstaking process. Sure it costs us extra! But the results are worth it.

Of course, there's more!

We use only pure quartz glass materials for the cross frames, disks, and tubes. We don't use mica or ceramic materials. We have a special glass-treating process to increase the resistance of the quartz to devitrification and remove more impurities than the typical cleaning process.

We've done some research to find the best-performing balance of argon to oxygen in the tube. Some oxygen in the sheath is necessary to minimize the danger of the platinum being poisoned by foreign metals at high temperatures, but too much oxygen at temperatures below 500°C accelerates the oxidation process affecting the integrity of the platinum. We've got a balance that provides exactly the right protection for the platinum.

Specifications	5681	5684	5685
Measuring Temperature Range	–200°C to 661°C	0°C to 1070°C†	0°C to 1070°C†
Nominal R_{TPW}	25.5Ω	0.25Ω	2.5Ω
Specified Current	1 mA	14.14 mA	5 mA
Resistance Ratio	W(302.9146 K) ≥ 1.11807 and W(234.3156 K) ≤ 0.844235	W(302.9146 K) ≥ 1.11807 and W(1234.93 K) ≥ 4.2844	
Sensitivity	0.1Ω/°C	0.001Ω/°C	0.01Ω/°C
Drift Rate	< 0.002°C/100 hours at 661°C (typically < 0.001°C)	< 0.003°C/100 hours at 1070°C (typically < 0.001°C)	
Sensor Support	Quartz glass cross	Quartz glass strip with notches	Quartz glass cross
Diameter of Sensor Pt Wire	0.003" (0.07 mm)	0.016" (0.4 mm)	0.008" (0.2 mm)
Protective Sheath	Quartz glass Diameter: 0.28" (7 mm) Length: 20.5" (520 mm)	Quartz glass Diameter: 0.28" (7 mm) Length: 26.8" (680 mm)	

†The official maximum temperature of an SPRT as a defining interpolation instrument of the ITS-90 is 961.78°C, but these types of SPRTs were found to be stable up to at least 1070°C. The annealing temperature during the stability test was 1085°C. The lower temperature limit of these types of SPRTs can be as low as –200°C. In general, it is suggested that a 25-ohm SPRT be used below 0°C.

Each of these seemingly small things adds up to better uncertainties and less drift. Hart's SPRTs typically drift less than 0.001°C per year.

5681: –200°C to 661°C

This 25-ohm thermometer is the workhorse of the ITS-90 ranges. It can be calibrated for any of the subranges from the triple point of argon to the freezing point of aluminum. The 5681 meets the ITS-90 requirements for resistance ratios as follows:

$$W(302.9146K) \geq 1.11807$$

and

$$W(234.3156K) \leq 0.844235$$

5684 and 5685: 0°C to 1070°C

ITS-90 extended the use of the platinum thermometer from 630°C to 962°C. The 0.25-ohm HTPRT sensor uses a strip-shaped support made from high-purity quartz glass. The 2.5-ohm model uses a quartz glass cross frame. Stability after thermal cycling is excellent, and the design is reasonably tolerant of vibration. Choose from 0.25-ohm or 2.5-ohm nominal R_{TPW} values. In addition to meeting the resistance ratio requirements shown above, these thermometers meet the following additional criterion:

$$W(1234.93K) \geq 4.2844$$

After all, this really is about W!

Ordering Information

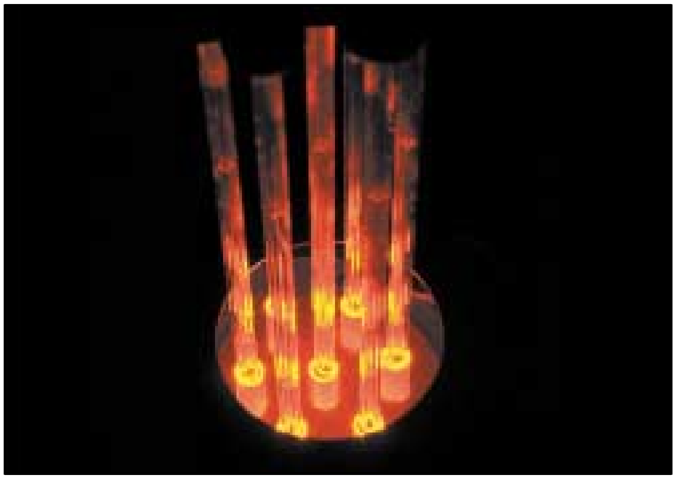
5681 SPRT 25.5Ω, 661°C

5684 SPRT 0.25Ω, 1070°C

5685 SPRT 2.5Ω, 1070°C

See page 15 for SPRT calibration prices.

A close-up of a 25-ohm spiral-wound helix SPRT element.



A batch of Hart SPRTs being annealed in a specially constructed, non-contaminating furnace.

QUARTZ-SHEATH SPRTs

Stability tests of 2.5Ω SPRTs (5685)

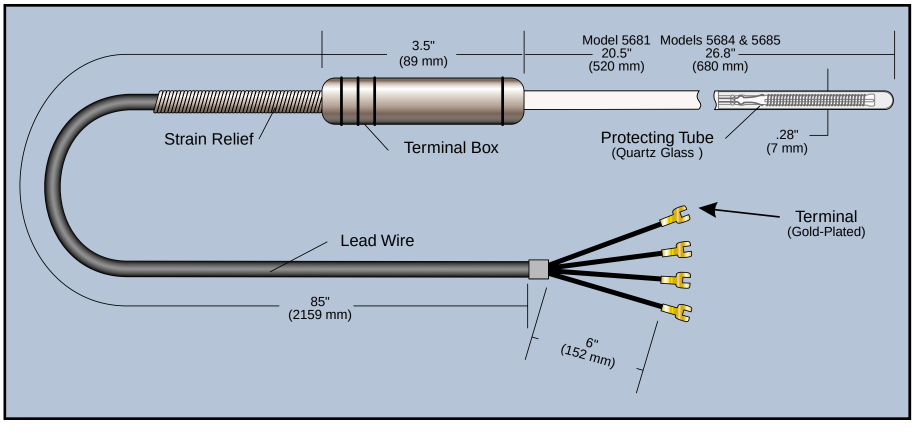
R_{TPW} (Ω)				Total annealing time at 1085°C (hours)	Notes
S/N 2001	S/N 2002	S/N 2004	S/N 2006		
2.475910	2.463342	2.469168	2.458491	25	
2.475914	2.463354	2.469171	2.458499	50	
2.475905	2.463357	2.469168	2.458504	75	
2.475910	2.463355	2.469160	2.458514		After a thermal cycle†
2.475917	-	2.469162	2.458523		After a thermal cycle†

†Thermal cycle procedure: Put the tested SPRT into a furnace at 962°C. Take the SPRT out of the furnace after 20 minutes and cool it in the air. Insert the SPRT into the furnace again, and after 30 minutes decrease the temperature of the furnace from 962°C to 480°C at a rate of 100°C per hour. Finally, take the SPRT out of the furnace, cool it in the air, and measure its R_{TPW}.

Stability tests of 25Ω SPRTs (5681)

R_{TPW} (Ω)				Total annealing time at 660°C (hours)	Notes
S/N 1008	S/N 1009	S/N 1010	S/N 1013		
25.57653	25.70259	25.57474	25.53706	25	
25.57641	25.70255	25.57452	25.53702	50	
25.57639	25.70248	25.57450	25.53696	75	
25.57644	25.70247	25.57449		100	
25.57641	25.70256	25.57443	25.53692		After a thermal cycle†
25.57641	25.70258	25.57443	25.53694		After a thermal cycle†

†Thermal cycle procedure: Put the tested SPRT into a furnace at 660°C. Take the SPRT out of the furnace after 20 minutes and cool it in the air. Insert the SPRT into the furnace again, and after 30 minutes decrease the temperature of the furnace from 660°C to 480°C at a rate of 100°C per hour. Finally, take the SPRT out of the furnace, cool it in the air, and measure its R_{TPW}.



Technical Tip

Maximize Your SPRT's Performance

Amazingly high accuracies can be obtained from a good SPRT if it is handled correctly. Expanded uncertainties as low as a few tenths of a millikelvin at 0°C are possible provided you:

- Avoid physical shock or vibration to your SPRT. An SPRT is a delicate instrument, highly susceptible to mishandling.
- Make a measurement at the triple point of water after each measurement. Use the resistance ratio W(t) rather than the absolute resistance to calculate the temperature.
- Measure at two different input currents and extrapolate the results to determine the value at zero current. This will eliminate the often-ignored effects of self-heating.