I.1: Commissioning of a fully automated temperature sensor calibration system

Vacuum components of accelerator machine need temperature monitoring at various critical hot spots, such as weld joints during the beam operation of accelerators. Temperature monitoring system, based on K-type and N-type thermocouples as sensing elements suitable for accelerator environment, has been developed in house at RRCAT.

In Indus-2, at present more than 166 locations on the vacuum chambers around the ring are monitored by thermocouple sensors. As a result of the continuous round-the-clock beam operations, these sensors, which are in the line of sight, are subjected to intense bremsstrahlung radiations (BR) inside the tunnel. This develops temperature offsets and uncertainties over a period of time. Similarly, high temperature lab furnace facility in RRCAT employs noble thermocouple sensors (S-type) and base metal thermocouple sensors (N-Type) for temperature monitoring and control. All these sensors are required to be calibrated periodically for optimum results.

An automated temperature sensor calibration system traceable to National Institute of Standards and Technology (NIST) published standards, covering the temperature range for both the applications has been procured and commissioned in RRCAT for periodic calibration of temperature sensors. Figure I.1.1 shows the front panel view of the automated temperature sensor calibration system.

Fig 1.1.1: Front panel view of the automated temperature sensor calibration system.

The fully automated temperature sensor calibration system comprises of drywell thermocouple calibrators for two different temperature ranges viz. 30 °C to 350 °C and 300 °C to 1200 °C. The reference thermocouple is S-type which covers a temperature range of 30 °C to 1450 °C. The set up has a precision temperature scanner which is an accurate and flexible temperature data acquisition system which scans and records temperature up to 20 input channels and scan speeds as fast as 10 channels per second.

The whole system is integrated with a calibration management software communicating with sub-systems via RS-232 link. A pneumatic pressure calibrator equipped with internal motorised pump capable of generating pressure and vacuum from -800 mbar to 20 bar is also part of this calibration set up and is integrated with the calibration management software. This facilitates calibration of pressure indicators as well as 24 V DC, 4-20 mA loop powered pressure, differential pressure as well as flow transmitters. The calibration report is generated instantaneously in excel or pdf format and historical calibration data can be retrieved. The calibration settings can also be retrieved from historical data bank. Following are the major technical specifications of the system.

(A)	**30 °C to 350 °C temperature range**
	• Stability: ± 0.01°C • Axial uniformity at 40 mm (1.6 in): ± 0.04 °C full Range • Radial uniformity: ± 0.01°C • Immersion depth: 150 mm • Well dia. : To suit insert of OD 30 mm
(B)	**300 °C to 1200 °C temperature range**
	• Stability: ± 0.1°C • Stabilization time: 3 hours at or below 700 °C and 2 hours above 700 °C • Axial uniformity at 60 mm max. (2.4 in): ± 0.2 °C for full range • Radial uniformity (hole to hole) : ±0.1 °C at 300 °C, ±0.20 °C at 700 °C, ±0.25 °C at 1200 °C • Immersion depth: 360 mm • Well dia.: To suit insert of OD 35 mm • Heater power: 4000 W at 230 V AC • Heating time (25 °C to 1200 °C): less than 45 minutes
Reference thermocouple type: Platinum rhodium 10 % vs. platinum (Type S) Accuracy (special tolerance) Up to 600 °C: ± 0.6°C Up to 1450 °C: ± 0.1% of reading	
Precision temperature scanner: Up to 40 isolated universal inputs. Selectable scan speed: Up to 10 channels /s. 6-1/2 digit display resolution for dc voltage, dc current, and resistance	
NIST traceable certificate with data at 300 °C, 700 °C, 1000 °C, and 1200 °C	

During installation and commissioning phase, the calibration system was subjected to series of mandatory factory acceptance tests and site acceptance tests. The system was accepted after various sensor calibration trials were taken for different ranges.

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