1. **Fiber Optic Hot-Spot Temperature Monitoring**

The transformer oil and winding temperature and the hot spots shall be monitored using the zero-drift Gallium Arsenide (GaAs) Fiber Optics technology. The product shall at a minimum meet the following criteria:

1. The monitor shall have capability to read up to 24 fiber optic temperature channels and a reading range of -80 ⁰C to +300 ⁰C with a total system accuracy of ± 1 ⁰C. It shall have 8 analog output channels (resolution of ± 0.1 ⁰C), 8 Form C relays with galvanic isolation, a highly readable 7‑segment LED display
2. The monitor shall have an internal reference optical sensor to insure optical module and system integrity for reliable readings (optical system integrity verification).
3. The monitor shall have 8 fully configurable analog outputs (user configurable with either 4-20mA or 0-10V) channels for sending data out to third party system such as SCADA.
4. The monitor at a minimum shall have the following communication capabilities
   1. RS 485 and Ethernet communication ports
   2. Gigabit Fiber Optic Ethernet port (SFP module) and Copper Ethernet (RJ45) designed to operate in for high electrical fields and harsh environments.
      1. Redundant Ethernet communication should be standard when both copper and fiber Ethernet are enabled
   3. **Serial:** Modbus, DNP3
   4. **Ethernet:** HTTP, Modbus TCP, DNP3, IEC-61850 & IEC-60870-5-104
5. The monitor shall meet the following Environmental operating requirements:
   1. IEEE C37.90 (Dielectric strength); C37.90.1-2002 (Fast transient &Oscillatory).
   2. Conducted/Radiated Emissions and Surge Withstand: 61000-4-3 (Radiated RFI); 61000-4-4 (Burst); 61000-4-5 (Surge); 61000-4-6 Induced (Conducted) RFI; 61000-4-8 (Magnetic field); 60255-5 (Dielectric strength);
   3. Electrostatic discharge: 6kV contact discharge and 8kV air discharge, Device was connected according to IEC 61000-4-2
   4. Radiated, radio-frequency, electromagnetic field immunity test: 20V/m, 80MHz- 1,0GHz and 10V/m, 1,4GHz – 2,0GHz and 1V/m 2,0GHz – 2,7GHz. Device was connected according to IEC 61000-4-3
   5. Burst on signal and data lines: 4kV, Device was connected according to IEC 61000-4-4
   6. Immunity against Magnetic fields: 100A/m, 50Hz continuous Device was connected according to IEC 61000-4-8
   7. The Light source lifespan shall be rated for 100 years of continuous use without accuracy degradation over the light source’s lifespan.
6. Fiber Optic temperature Sensors shall be based on the proven zero-drift wavelength-shift Gallium Arsenide (GaAs) technology, oil-immersed TFS-TG-xxx type,200 µm all silica, Torlon disk, with a protection layer in radiant green colored PTFE Teflon protective spiral-wrap for improved visibility and mechanical strength. Sensors shall withstand exposure to hot kerosene vapor during the transformer insulation drying process.
7. Fiber Optic temperature sensor tips and tip/disk assemblies shall meet the following:
   1. No greater than 2pC (pico-Coulomb) partial discharge in mineral oil under 60 Hz AC stress per ASTM D149, Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies and negative lightning impulse conditions per ASTM D3426, Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Material using Impulse Waves
   2. The sensor cable must not have any additional sheath in between Fiber and Spiral wrap to deliver high dielectric strength and reduce risk of air bubbles getting trapped.
   3. Fiber optics sensors to withstand pull test of forces exceeding 60 N (1 kg-f (kilogram-force) is about 10 N (Newton)
   4. End interface ST connectors made of high precision Zirconia with 5µm tolerance, for optimal light energy transfer
   5. Should support extension of fiber optic cable within transformer tank with the help of dielectric connector for ease of installation.
8. The optical signal shall be brought out of the tank using a solder-glass optical feedthrough (without use of O-rings or seals), withstanding pressure in excess of 200 PSI. A 316L Stainless steel-based tank wall plate accommodating up to 25 optical feedthroughs shall be installed on the tank. The optical feedthroughs shall be assembled on the Tank Wall Plate and assembly shall be pressure-tested by the seller. A protective 316L stainless steel-based interface box (I-Box) cover designed to mate with the wall plate shall be supplied, that is leak proof (IP66), protecting all optical feedthroughs and extension cables.
9. Fiber Optic Sensors shall be directly installed in each phase of the transformer windings (4 each in LV & HV phB, 2 each in LV & HV PhA and phC) to measure the winding hotspot and oil temperatures (1 top oil sensor, near top of phB coil). All sensors shall be monitored during the heat-run test using a compatible fiber optic temperature monitoring system, the hottest sensors for each phase shall be identified, and temperature data for all sensors recorded and reported in the test report. The hottest sensors shall be connected to the monitor for long term monitoring purposes. The locations shall be proposed by the Manufacturer and locations finalized by agreement of the Purchaser.
10. The monitor to shall have industrial electronic components and have the capability to log data greater than 30 years, for 24 fiber optic channels at 10 second interval rate and operate on a standalone basis without any external communication. Operating temperature range should be from -40 oC to +75 oC.
11. The monitor shall have built in secure webserver with ability to configure, view and log data with a local installation of the software.