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WHITE PAPER

Eliminating premature failure of exhaust gas sensors in 7F and 9F class turbines

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Premature Sensor Failure in 7F and 9F Turbines

Standard exhaust gas sensors in 7F and 9F class turbines are at risk of premature failure. As temperatures rise, the radiation shield and sensor sheath expand at different rates. A gap forms between the seat in the radiation shield and the stop on the sensor, causing the sensor to vibrate due to gas flow velocities and input vibrations from the turbine. This vibration contributes to the sensor tip breaking, causing the sensor to fail and the gas turbine to trip. See *Figure 1.* (Refer to Calculation 4: Difference in Thermal Expansion Calculation).

Conax Technologies' Patented Solution

Conax Technologies' patented Spring-Loaded Exhaust Gas Sensors address the problem of having sensor tips break off prematurely in service. This exclusive design solution features the addition of a high temperature compression spring that is inserted between two spacer tubes. The spring's oscillating characteristics dampen the vibrations and keep the temperature sensor tip stable within the radiation shield by ensuring a continuity of contact between the stop on the sheath and the seat of the radiation shield.

Figure 1

New standard exhaust gas sensor.

Standard exhaust gas sensor after vibrations have caused the tip to break and sensor to fail.

Thermal Expansion Calculations

The interface between the radiation shield and the sensor creates a thermal expansion mismatch, which is defined as:

Calculation 1: Linear Thermal Expansion Formula

- As an object is heated or cooled, it expands or contracts in an amount proportional to the change in temperature.
- $\Delta L = (\alpha)\ (L_O)\ (\Delta T)$
  Where:
  ΔL = change in object length
  α = linear expansion coefficient
  L_O = initial length of object
  ΔT = change in temperature

Calculation 2: Radiation Shield Thermal Expansion

- Material: 316 SST
- ΔL_{rs} = (.0000187mm/mm°C)(220.9mm)(649°C)
  ΔL_{rs} = 2.684mm

Calculation 3: T/C Thermal Expansion

- Material: Inconel 600
- ΔL_{tc} = (.0000155mm/mm°C)(220.9mm)(649°C)
  ΔL_{tc} = 2.224mm

Calculation 4: Difference in Thermal Expansion

This calculation shows the gap between the radiation shield and the thermocouple.

- Gap = $\Delta L_{rs} - \Delta L_{tc}$
- ΔL_{tc} = 2.684mm – 2.224mm
  Gap in contact = 0.460mm [0.018in]
  See *Figure 2.*

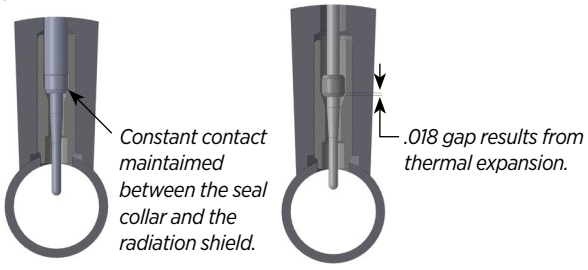
Calculation 5: Spring information

- Material: Inconel X750
- Spring rate of 17 lbs/in at 1200°F
- Approximate Spring Compression, 0.88"
- Approximate Spring Preload, 14.89 lbs

Calculation 6: Qualification Testing

- Vibration testing in 3 axes at resonant frequency at 6G's for 10 million cycles

Figure 2



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Rigorous OEM and Field Testing

Conax Technologies' hermetically designed exhaust gas thermocouples have been rigorously field tested and have proven to be more reliable than other suppliers' products for Frame 7F and 9F class turbine applications. Qualification tests include:

- Vibration testing to 10 million cycles of simulated on-turbine operation
- Thermal cycling the measuring tip 20,000 times between 1220°F (660°C) and room temperature
- Thermal cycling the hermetic terminal head 600 times between 700°F and -65°F (370°C and -54°C)

The patented Conax sensors passed all OEM qualification tests and met all design specifications required by the OEM.

The Conax unit is manufactured with an all welded construction that is superior to brazing in prolonging the life of the thermocouple. This thermocouple is a direct replacement for all other exhaust gas thermocouples on Frame turbines and can help lower total costs.

Precise Installation

Conax Spring Loaded Exhaust Gas Sensors are designed to ensure proper installation every time. The stop at the sensing end of the thermocouple seats firmly into the radiation shield which allows the junction to be in the proper position, providing optimum response time and accurate temperature measurement.

The bushing is also fabricated of material that reduces the possibility of seizure in the radiation shield. The cold end features a ceramic insulated junction box using two different size studs or a keyed 2-pin circular connector to guarantee proper installation every time. It also enables a convenient, stress-free orientation of the thermocouple junction box as it relates to the mating cable.

About Conax Technologies

Conax Technologies is a designer and manufacturer of standard and custom engineered temperature sensors, compression seal fittings and feedthroughs, probes, sensor wires, electrodes, and cable and harness assemblies. The company is headquartered in Buffalo, New York, with locations on the U.S. west coast, Canada, Europe and Asia.

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