Delta Controls CORPORATION

Failure Diagnosis of Model HTP, HTS or HTX Claus Thermal Reactor Thermocouple

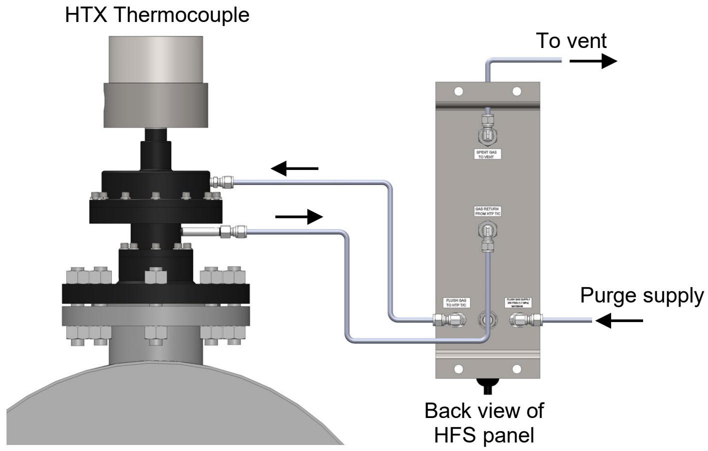
Measurement of temperature in the Claus Thermal Reactor is a severe and demanding application. Installed devices must tolerate the high temperatures, thermal shock, corrosion, vibration and shifting refractory. In addition, handling and installation must be done carefully to prevent damage during installation.

I. Understanding the Delta Controls purged thermocouples

Delta Controls Models HTP, HTS and HTX thermocouples rely on well-known temperature and voltage characteristics of high-purity noble metal conductors to accurately measure high temperatures in a Claus reactor. Even though the thermocouple is encased in a ceramic thermowell, under conditions inside a reactor process, gases can slowly diffuse through the thermowell. When gases contact the thermocouple, they corrode and contaminate the thermoelement wires. This results in a voltage output reduction and erroneously low temperature measurements. Therefore, a flush gas station sweeps away process gases as they enter the thermowell, before thermocouple wire contamination occurs. The flush gas station prolongs thermocouple life in this hostile environment.

Model HFS Flush Gas Station is connected to the thermocouple body as shown to the right. The plant nitrogen gas supply connects to the pressure regulator inlet. The regulator outlet connects to the top inlet connection of the thermocouple body. The thermocouple outlet connects to the flowmeter inlet (bottom connection). The flowmeter outlet vents to a safe location.

Under normal operational conditions, purge pressure should be set to 5 psig (0.35 bar) above reactor's operating pressure. Flow rate should be set and maintained at approximately 11 liters per hour.



II. Common Causes of Failure

Thermocouple failure is most often the result of process gases contacting thermoelement wires. In general, the rate at which the thermocouple fails is directly related to the amount of exposure the thermocouple has to the process gases. A broken thermowell usually causes thermocouple failure within days or months. A purge supply loss may go unnoticed for months while the thermocouple output slowly degrades. Failure can be caused by a variety of reasons:

a. Breakage during installation. This failure is usually due to:

   i. Mishandling or improper installation.

   ii. Misalignment or improper refractory borehole location causes breakage by refractory shifting pushing on inserted ceramic component parts. Borehole must be centered and perpendicular to flange face to minimize possibility of failure due to shifting refractory. Use Delta Controls Model HRG Refractory Drilling System to create properly sized borehole.

b. Thermal shock during startup: Startup should be gradual, even if refractory does not need dry-out cycle.

c. Direct impingement of burner flame on thermowell tip.

d. Process upsets can cause sudden temperature changes that can thermally shock the thermowell.

e. Large temperature excursions can exceed thermoelement's melting point, causing immediate failure.

f. Refractory shifting can break the thermowell. Shifting can be due to different coefficients of thermal expansion between reactor shell, castable or IFB, and refractory brick. Thermocouple boreholes can accommodate minor refractory shifting, but large shifts can result in thermowell breakage.

g. Incorrect installation or incorrect purge station operation can allow contaminating process gases to slowly degrade the thermocouple.

h. A flush media of air results in degradation of platinum thermoelement and premature failure.

i. Contaminated flush media can introduce water, hydrocarbons or oxygen to the thermoelement causing degradation and potential blockage.

III. Diagnostics

a. **System Installation** – Verify the flush gas piping installation follows Models HTP, HTS or HTX's installation and operating manual directions.

b. **Pressure Setting** - Verify pressure regulator is set at least 5 psig (0.35 bar) above reactor's operating pressure. [Normally 15 psig (1 bar) is suitable.] If set lower than reactor pressure, process gases can enter the thermowell resulting in premature thermoelement failure.

c. **Flow Setting** - Verify the flowrate, indicated on flowmeter, is approximately 11 lph. Yellow sulfur deposits inside the flowmeter indicate a broken thermowell.

d. **Quick Check for Purge Integrity** – Increase Model HFS pressure regulator to 30 psig (2 bar). The flow rate indication on the flowmeter should increase.

e. **Quick Check for Leaks or Thermoelement and Thermowell Breakage**

   i. Gently close the flowmeter's needle control valve. Remove piping connection from flowmeter's outlet and install a temporary pressure gauge.

   ii. Open the flowmeter valve. The pressure on the gauge attached to the outlet and the regulator's gauge should show approximately the same value. If not, it is likely the thermoelement well is broken. In this case, maintain a positive pressure on the pressure regulator to keep a high flow through the thermocouple into the (broken) thermoelement well. The additional flow may provide an extended operating time for the thermoelement.

f. **Complete Test for Leaks or Thermoelement and Thermowell Breakage**

i. Gently close the flowmeter's needle control valve. Remove piping connection from flowmeter's outlet and install a temporary pressure gauge.

ii. Install a shut-off valve in tubing line between the pressure regulator and the thermocouple's inlet.

iii. With the valve open, allow the thermocouple loop to pressurize to 25 to 35 psig (1.7 to 2.4 bar). Check for pressure loss.

iv. If no pressure loss is observed, close the valve and reduce regulator's pressure to near zero.

v. Loosen supply line connection fitting from shutoff valve.

vi. Observe rate of pressure drop on gauge attached to flowmeter outlet fitting. Pressure loss within five minutes indicates a possible leakage in the thermoelement well or seal.

vii. If no sign of leakage or pressure drop, open the inline valve and observe pressure loss on the flowmeter's outlet gauge.

g. **Electrical Checks**

i. Remove enclosure cover and ensure all terminal connections are tight.

ii. Inspect the insulation of each thermocouple extension lead wire connected to transmitter. Note: Ensure wire has not overheated and wire is not grounded at the conduit hubs through the insulation. A high temperature insulated thermocouple extension lead wire must be used.

iii. Check wiring connections in temperature transmitter.

iv. Remove wires from transmitter terminals and verify continuity between positive and negative wires for each thermoelement. Continuity indicates element junctions and lead wires are intact. No continuity detected indicates an open circuit in the thermocouple loop. Disconnection can occur at thermocouple junction, inside thermocouple assembly, or in the extension lead wire from transmitter.

v. If continuity between the thermocouple wires occurs, verify there is no continuity from either wire to the ground. Continuity to ground indicates a short resulting in measurement error.

vi. Check if the mV reading across the two thermocouple wires is an appropriate value for the thermocouple type and corresponds to reactor temperature. (If mV reading is unstable, temporarily ground one wire while measuring.) If value reads correctly, problem may lay within the transmitter system.