Heat Transfer Calculations for the Use of an Infrared Temperature Sensor

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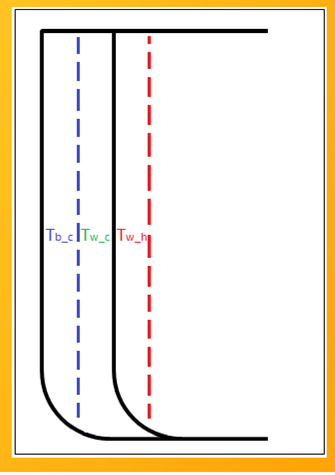
Background

The corrosion within double-shell tanks (DST) at the Hanford Site is managed by stringently following the operating specifications given in OSD-T-151-00007, "*Operating Specifications for the Double-Shell Storage Tanks.*" The OSD outlines specific temperature requirements for waste based on chemical composition and pH. Chemical composition, pH and temperature data are found via physical samples, measuring devices and modeling. Due to the complexity and size of these storage tanks, many of the methods allow for a great deal of uncertainty. These samples and temperature measurements are taken more than 10 feet from the tank wall due primarily to equipment and technical constraints. Those results are then fed into models to estimate wall conditions which, for some, have never been validated with real data. Temperature uncertainty can be reduced by using a non-contact infrared pyrometer (IR sensor). With only a few small upgrades to Washington River Protection Solutions' (WRPS) currently operational equipment– an annulus inspection camera and the ultrasonic testing crawler– real wall temperature measurements can be made.

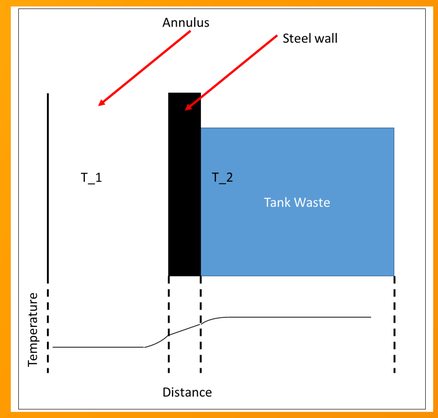


Double-shell tank cross section with labeled temperature variables

Where: T_{b_c} *temperature of the cold bulk air in the annulus*

T_{w_c} *boundary temperature on the outside of the tank*

T_{w_h} *temperature on the inside of the tank wall*



Results & Benefits

The conservative calculations performed show that the infrared temperature sensor will provide a valid reading for the temperature on the inside of the primary tank wall. This permits the use of the Raytek IR sensor which can be strapped to the inspection camera and placed inside the annulus to record temperatures at different elevations. With this direct temperature reading, it is possible to validate the simulated models currently being used for temperature and corrosion purposes, as well as map the waste stratification based on large differences in temperature with respect to tank level.

Raytek IR temperature sensor attached to the annulus inspection camera

Purpose

Initial heat transfer calculations were made in order to test the feasibility of using an infrared (IR) temperature sensor to derive the temperature on the inside wall of the double-shell tanks (DST). This method is preferred as it **can be attached to an inspection camera** and thus can be controlled remotely with **no impact on the tank farm operations,** "piggy backing" on the already scheduled tank inspections. The collected data from the IR temperature sensor can also be used to **map out waste stratification, validate currently used models, and check that the temperature of the waste meets requirements to avoid corrosion**. The main objective of using an IR temperature sensor is to derive the temperature on the inside of the primary tank wall to ensure it is below the specified temperature, as stated in OSD-T-151-00007 (OSD), in order to avoid corrosion.

Methodology

To derive the temperature that the IR sensor will read, it was assumed that the temperature on the inside of the primary tank wall, T_{w_h}, as well as the temperature of the bulk air in the annulus, T_{b_c}, was known. Heat transfer equations were used to calculate the temperature outside the primary tank wall, T_{w_c}. Other assumptions were made in order to provide conservative results. The equations used were:

$$Q = U \cdot A \cdot (T_{w\_h} - T_{b\_c})$$

$$U = \frac{1}{\frac{1}{h_w} + \frac{d}{k} + \frac{1}{h_a}}$$

$$T_{w\_c} = T_{w\_h} - \frac{Q \cdot d}{k \cdot A}$$

Future Scope

The IR sensor still needs to be tested in a lab setting in order to accurately set the emissivity and see how it performs on blemished steel. Once this is done, it will be deployed during the next annulus inspection of DST AN-106.

Acknowledgements

DOE-FIU Science & Technology Workforce Development Program,
Terry Sams and Benjamin Holmesmith (WRPS).

FIU Applied Research Center