Furnace and Heater Tube Inspection

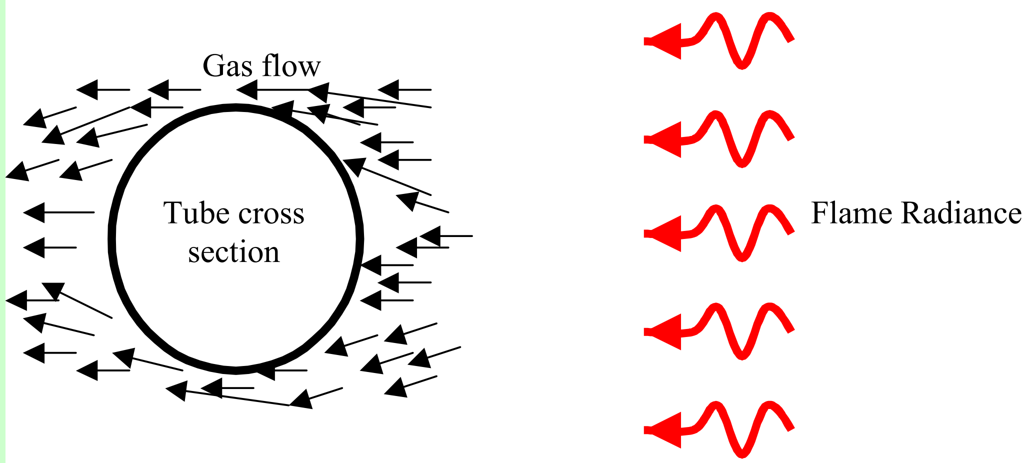
- *By Ron Lucier, ITC Course Moderator, EPRI Level III*

"Hands On" Thermography Training, Certification, and Support

One of the more challenging applications of infrared thermography is in the measurement of process heater and furnace tubes. In fact we get dozens of inquiries each year from our clients on this very subject. Since this is a very complex subject it is probably appropriate to start from the beginning.

Process Heaters

There are as many uses for process heaters as there are designs. The basic configuration consists of a shell (outer casing), tubes (where the process fluid flows) and a heat source. These units are both thermodynamically and hydraulically complex.



In the simple drawing above we illustrate convective gas flow, which is turbulent, and radiant heat from the flame, refractory and other tubes – all non-uniform and time varying. When you view tube from an access port typically you can only see a portion of the tube or the tube at an oblique angle. Therefore, the odds are stacked against you from the start!

Why are heater tubes of interest anyway?

There are several reasons for inspecting tubes. Qualitatively slag buildup on the outside of the tube can be readily identified. Buildup on the inside of the tube (coking) is a bit more difficult but commonly performed. In both cases the slag or coke prevents the transfer of heat into the process fluid. In the case of slag buildup, the process fluid may not be sufficiently heated, affecting downstream processing. The case of coking on the inside of the tube is more serious. Since the coke has an increased resistance to heat transfer, the tube surface temperature increases. After all it is the flow of the process fluid that is keeping the tube "cool" in the first place. In fossil boilers this is called "DNB" – Departure from Nucleate Boiling and is usually

(Continued on page 2)

INFRARED TRAINING CENTER

16 Esquire Rd.

N. Billerica, MA 01862

Phone: 978-901-8405

Fax: 978-901-8832

Email: info_us@infraredtraining.com

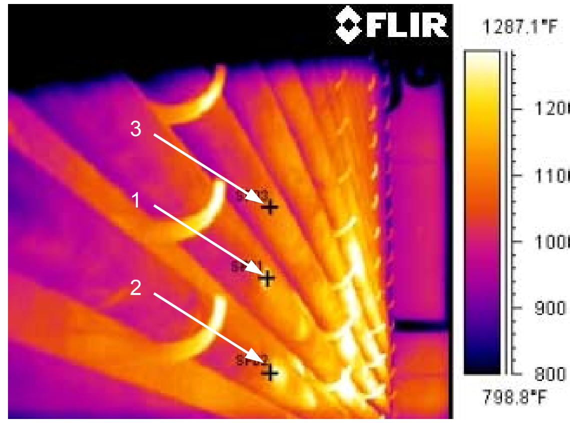
Furnace and Heater Tube Inspection

"Hands On" Thermography Training, Certification, and Support

(Continued from page 1)

caused by flame impingement, which initiates a layer of steam on the inside of the tube. The external tube surface, unable to conduct its heat to the water, increases dramatically, causing a failure (opening) in the tube.

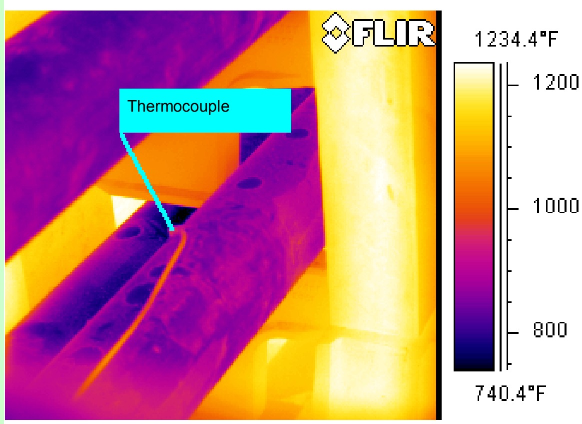
In the image to the right, a visual inspection yielded no indication of external slag or fouling, therefore the hot spots indicated are due to coke buildup on the inside of the tubes. This has caused the tube surface temperature to increase by 177 °F over the expected – and desired – temperature of 1100 °F.



Spot 1 1277 °F, Spot 2 1255 °F, Spot 3 1100 °F

The great emissivity debate

To calculate the temperature you need to know the emissivity & background. To calculate the emissivity you need to know the temperature and background. Oops, we're in an infinite loop!



The emissivity of the tube surface is very tough to determine and typically is derived from two sources – correlated to thermocouple measurements or folklore ("we've always assumed 0.88"). The former process is tough to accomplish but the preferred method. The latter has value in that existing trend data may exist. We are working on a better method of measuring process heater tube emissivity and will report on it in the future!

Simplified Heater Inspection Method

The following method assumes that you have a short-wave camera with a flame filter installed. The process here was developed for a heater with vertical tubes.

Initial Camera Setup

- ☑ 16° lens
- ☑ Flame Filter

(Continued on page 3)

INFRARED TRAINING CENTER

16 Esquire Rd.

N. Billerica, MA 01862

Phone: 978-901-8405

Fax: 978-901-8832

Email: info_us@infraredtraining.com

Furnace and Heater Tube Inspection

(Continued from page 2)

- ☑ Extended Range 2 (as required)
- ☑ PCMCIA Card installed
- ☑ Emissivity = 0.92
- ☑ Background temperature – 1800° F
- ☑ Distance = 0.0 meters
- ☑ Auto Temperature Mode – Average
- ☑ Auto Temperature Area – Box

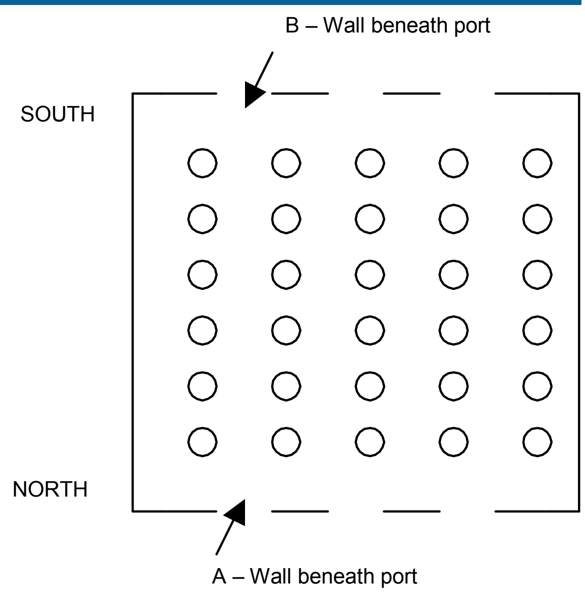


Image Acquisition

1. Focus on far wall, store image
2. Focus on far row of tubes, store image
3. Focus on near row of tubes, store image
4. Repeat for every other inspection port

Initial Measurement (done in the lab)

1. Use emissivity = 1.0, measure far wall with Auto Temperature Box on Average.
2. Enter that value for background Temperature.
3. If you are looking NORTH, use the A value.
4. If you are looking SOUTH, use the B value.
5. This must be measured for each inspection port you look in.

Process Measurement

1. Using the correct Background Temperature, set emissivity = 0.92, record tube temperatures.
2. Set emissivity to 0.96, record a second set of temperatures.
3. Report both values to give a range of temperatures (e.g. Tube 1-20 is between 1632 °F and 1641 °F)

(Continued on page 4)

"Hands On" Thermography Training, Certification, and Support

INFRARED TRAINING CENTER

16 Esquire Rd.

N. Billerica, MA 01862

Phone: 978-901-8405

Fax: 978-901-8832

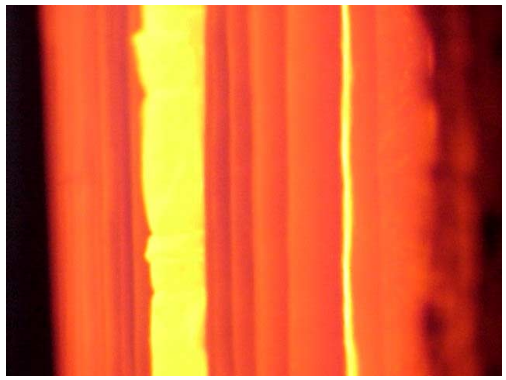
Email: info_us@infraredtraining.com

INFRARED TRAINING CENTER

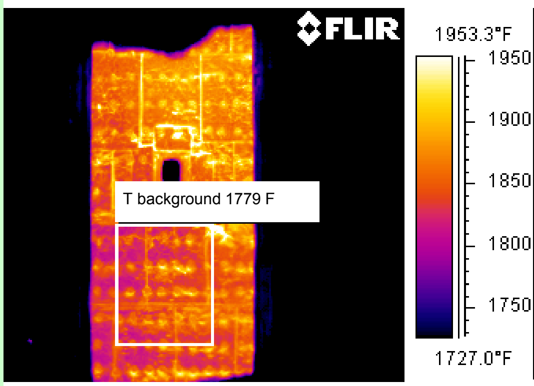
Furnace and Heater Tube Inspection

(Continued from page 3)

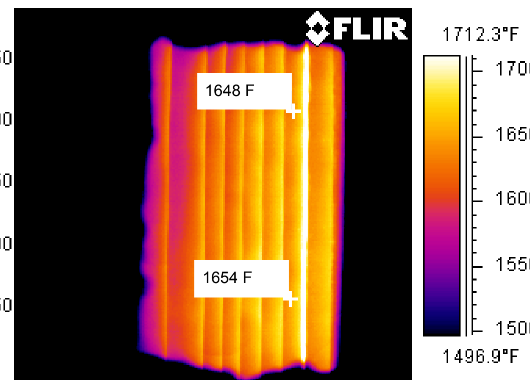
Sample Thermal Images - Heater



Visible Image of Tubes



Infrared Image of far wall below inspection port. Emissivity = 1.00 to measure T background which averages 1779 °F



Typical measurements using the correct background and an emissivity = 0.92

Conclusion

IR offers the operators of process heaters the ability to visualize the heat transfer that their point measurements are recording. There are probably many other methods used to gather this data.◆

"Hands On" Thermography Training, Certification, and Support

INFRARED TRAINING CENTER

16 Esquire Rd.

N. Billerica, MA 01862

Phone: 978-901-8405

Fax: 978-901-8832

Email: info_us@infraredtraining.com