Monitoring the Process Conditions in Oil Field Production Vessels with Infrared Technology

Danny Sims, ChevronTexaco – Mid Continent Business Unit
Operations Standardization & Improvement Group

ABSTRACT

This paper presents the different techniques that have enhanced past uses of infrared (IR) cameras and some new time. techniques that have been developed. These techniques focus on using IR to monitor the crude oil process conditions in various storage, treatment, and transfer tanks used in oil production fields. One primary focus is to ensure that foaming, solids, and other crude oil process conditions are known and properly handled to optimize the cost of handling, processing, and transferring. The overall effect of the IR program is to reduce operating cost. This program has also had a very positive effect on the environment by reducing corrosion-related leaks and increasing the reliability of the tankage.

Keywords: crude oil, oil production, infrared inspection, maintenance

INTRODUCTION

In 1999, several chemical technicians at a West Texas facility asked for help in locating and measuring the interface pad in the gunbarrel tanks on these properties. The IR activities at this time were focused on electrical inspections, but since this request, there has been a significant redirection of typical inspection routines. What started as simply checking for levels in tanks has now, nearly five years later, expanded to finding interface pads and locating tank “bottoms” and has become an equal part of the normal inspection routines. Inspecting these tanks and vessels can contribute large dollar savings to the company and help significantly in lowering our operating expenses.

INSPECTION TECHNIQUE

Detecting levels, solids, and interfaces in tanks and vessels is usually just a trial-and-error technique. The biggest problem is to get the best thermal differential between the tank or vessel wall and the internal medium. In most cases, the optimal time for this is from mid-morning to late afternoon, especially here in West Texas, where we usually have lots of sunshine. The more differential you have between the wall and internal medium, the better the thermal resolution is. Sometimes it may be necessary to try inspecting at different times of the day and in different ambient conditions to achieve the best results. If time permits, I like to get a shot on the sunny side of a tank in the mid-morning and the dark or non-sunny side also. In the late afternoon, with the sun on the opposite side, I will take another series of images and compare them to get a better overall picture of what is going on inside the tank or vessel. You just have to experiment with different tank and vessel applications, as well as with different ambient conditions, to get the best results.

PRODUCTION GUNBARREL

A gunbarrel is a large tank that is used to separate oil from water as it flows from the producing wells. Figure 1a gives a visual image of a gunbarrel tank; Figure 1b shows a thermal image. These gunbarrels range from 500 barrel tanks up to 10,000 barrels. They are made from either steel or fiberglass and are usually painted black. Gunbarrels are located within a tank battery that also includes a number of oil and water storage tanks. A battery uses a Lease Automatic Custody Transfer unit (LACT) to monitor the oil being sold to the pipeline companies. If the contaminants in the oil (water, sediment, and other matter) exceed a preset limit, usually 1%, the oil sales are diverted back to a storage tank for treatment. This oil will go through another treating process to be within acceptable limits before it can
be introduced back into the sales tank. This is like the assembly line being disrupted at a factory. Bottom line: no sales, no money.

Figure 1a. 5000 barrel capacity gunbarrel tank

Figure 1b. Thermal Image of gunbarrel tank

Figure 2. 750 barrel capacity gunbarrel; internal properties before being cleaned

The gunbarrel is a vital part of the crude oil sales and water treating process. The crude from the producing wells goes directly into them where the gas, oil, water, and small amounts of solids go through a separation process. The oil separates and floats upward, and the gas also goes to the top of the gunbarrel. The heavier water and solids settle in the bottom. Figure 2 shows an example thermal image of a gunbarrel tank showing all these layers. The layer between the oil and water is called the interface pad. This layer is a normal part of the separation process, but sometimes the paraffin, asphaltenes, and iron compounds can become suspended within the interface pad. When this happens, the pad becomes thicker and can become hard, inhibiting the separation process and causing a number of operational problems. By using infrared to locate these pads and their thickness, operations obtains a good idea of what is going on within the tank and can take measures to correct it. If a large interface pad is caught before it gets too thick and hard, chemicals can be added to try and break up the suspensions within the gunbarrel. Treatment can be quite expensive. For example, a 750 barrel capacity gunbarrel with a 4’ interface pad of paraffin and asphaltenes may cost up to $20,000 to treat with a solvent/dispersant type chemical, including the necessary pumps, trucks, and
manpower to accomplish the job. Another method is to shut down operations to the gunbarrel and physically remove the contents, which usually requires personnel to go in and scrape out the solids, load them into trucks, and dispose of the waste materials. As can be seen, it is best to keep these severe conditions under control, and infrared is helping to do just that. By implementing normal routine inspections and getting a baseline condition on these gunbarrels, especially after one is cleaned out, the growth of the interface pads can be followed and treated with small amounts of chemicals accordingly to keep within operational limits. Figure 3 is the gunbarrel tank shown in Figure 2 after cleanup. It is saved as a baseline image for future reference.

Some other issues that large interface pads may cause result from the interface pad being pushed out the top of the gunbarrel. When this happens, it can cause lines to plug up and may cause tanks to spill over due to the plugged lines. If the gunbarrel is not doing its job properly, it affects the entire oil sales process.

![Figure 3. Same gunbarrel tank shown in Figure 2 after cleaning; baseline image](image)

**WATER STORAGE TANKS**

Oil and water storage tanks are another area where infrared has become a great benefit to ChevronTexaco. Water storage tanks are usually associated with water injection plants and receive the water from the crude oil batteries and gunbarrels. The water is then re-injected into the producing formations to enhance oil production. Some problems associated with water tanks are oil that has not been separated from the water, and, as with the gunbarrels, solids and other unwanted compounds. Infrared thermography can be used to locate these levels of “bottoms” - settlements and oil layers floating on the water, which can be recovered and sold. Figure 4 is an example thermal image of one such storage tank showing substantial bottoms. Figure 5 is a thermal image of a water storage tank with substantial oil floating on the water.
Figure 4. 20,000 barrel water storage tank with substantial bottoms

Storage tanks with a large accumulation of bottoms are also more prone to tank bottom corrosion problems. These accumulations affect or add to the corrosion and can cause a tank bottom to leak. By finding and documenting these potential corrosion problems, product losses can be minimized or prevented. The liquid volume measured in these tanks is also directly affected by the amount of bottoms in the tank. Infrared thermography can effectively give operations personnel important data to help them make decisions on maintenance and operational issues.

Figure 5. Water storage tank with 2’ oil layer on top of water

Maintenance personnel can also use infrared imaging to assist in making the decision when to schedule tank clean-outs, instead of scheduling them on a regular basis. This could eliminate spending money on unnecessary clean-outs, which range from $1,000 to over $10,000, depending on the size of the tank and severity of the fill. There are also safety benefits to minimizing the number of tank cleanings performed.
OIL STORAGE TANKS

Oil storage tanks receive the oil that flows from the gunbarrels. Here it is stored until sold through the LACT units discussed earlier. Sometimes an oil storage tank, or “run tank,” can have similar problems that the gunbarrels have, or problems resulting from a gunbarrel’s upset condition. Often, some of the unwanted compounds, i.e., paraffin/water, asphaltenes, and iron can be introduced into the run tanks and settle at the bottom of the tanks. After a period of time, these accumulations create another series of problems. If these solids and trapped water are introduced into the LACTs, called “bad oil” condition, the oil will be turned down by the pipeline company and re-introduced back into the system for further treatment, which interrupts the oil sales. Figure 6 is a thermal image showing a possible bad oil situation from the LACT unit, because it is drawing the saleable oil from the run tank through the sediment accumulation in the bottom of the tank. When this happens, it is possible to draw the unwanted sediments out with the good oil, creating the bad oil situation that would stop the actual sale of the product. This bad oil condition can be remedied by adding chemical and re-circulating, or in extreme cases, the tank may have to be cleaned. Again, the tank bottoms is a contributing factor to tank bottom corrosion, which, over time, can increase the chances of a product leak. Infrared inspections on these oil storage tanks can be a proactive tool to help eliminate or minimize the risk, especially if a routine periodic inspection program is in place.

Figure 6. Run tank with a possible “bad oil” situation

PRODUCTION VESSELS

Production vessels are closed vessels that are normally used to separate large volumes of gas, water, and oil before going into a gunbarrel. In some cases, a gunbarrel may not be used at all, and the separators or free water knockout takes care of the water and oil separation process. Sometimes an oil heater may be used to enhance the separation process by heating up the oil and water to a specific temperature to more effectively separate the water and solids.

Infrared thermography is used on these vessels to help locate sediment accumulations and to help locate levels within the internal compartments of the vessels. A production separator usually has an internal inlet plate to redirect the inlet flow. As the oil/water rises, there are a series of baffles to assist the separation process, and the oil eventually floats into an oil “bucket,” and the water goes into a water “bucket” or compartment. Figure 7 shows a horizontal separator with a moderate amount of sediment fill in the separator. Notice the oil in the bucket on the left end of the vessel.
Figure 7. Horizontal production separator with moderate sedimentation in the bottom

Figure 8 is an image of a free water knockout. The sediment fill in the bottom of the vessel is evident, and up above is the interface layer. Infrared thermography has also been very helpful in the start-up of some of these vessel installations that have accompanying variable speed drive (VSD) motor/pump combinations to pump out the oil and water sections. By using infrared to locate the individual oil and water levels, it becomes easy to set up the level instrumentation that controls the VSDs and to keep the appropriate level in each compartment.

Figure 8. Free water knockout with moderate sediment fill and interface pad
OIL HEATERS

Oil heaters are usually vertical vessels and are used to heat the crude oil and water where the separation of phases may otherwise be difficult. Heating the oil/water to a specific temperature, usually around 120°F, helps to separate the oil and water from the mixture. In Figure 9 you can see the individual sections of the heater.

SUMMARY

As you can see, infrared has become a widely used proactive tool at ChevronTexaco in the MidContinent Business Unit. It provides the data needed to understand what is going on inside of these tanks and vessels, instead of just making an educated guess. This knowledge allows the luxury of being able to prioritize maintenance efforts on these tanks and go right to the most critical problems first, minimizing the potential environmental risks of tank run-overs and leaks. It also helps not only in identifying those tanks and vessels that are high priority risks, but it also allows deferral of maintenance on tanks that do not need attention. In the past, vessels may have been cleaned whether they needed it or not. Now, the necessary funds can be spent to work on the equipment that needs it, saving sometimes up to $20,000 to $40,000 on cleaning and disposal costs.

To sum things up, below is a quote from a maintenance planner.

“Using Infrared Thermography has helped us to…”

1. **Investigate** suspected trouble areas to classify and quantify immediate risks.
2. **Identify** pending failures in areas where NO trouble was suspected.
3. **Justify**: It’s always difficult to risk-rank pending work, but by using infrared, the justification is obvious and unquestionable.
4. **Follow-up**: Once you have taken care of a problem, it’s easy to document it and then institute a follow-up to identify a period for recurring problems.
When all of the above are taking place, you prevent costly (unplanned) downtime and lost production, which adds significantly to ChevronTexaco's bottom line.

5. **Repeatability**: Once a problem is identified, the next step is to look for similar problems in similar equipment. If Skim Tank #1 has 8’ of solids in it, it’s a safe bet that Skim Tank #2 may have the same problem.

   *Rick LaNoue, Maintenance Planner*

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