Abstract:

Oil and gas industry requires nondestructive testing to ensure the condition of in-service components to operate the ageing facility safely and continuously. Having a drainage line in the storage tank is one of the most important components for safety and maintenance. If there is a blockage in the drainage line, it will affect the facility safety, continuous operation of the storage tank and oil and gas business. This paper discusses the combination of infrared thermography and computed radiography nondestructive methods to avoid such type of situation. Infrared thermography is a science to detect infrared energy which is emitted from an object, converting the detected energy into apparent temperature, and displaying the converted apparent temperature in the form of infrared thermal imaging. This method is used to identify the oil and gas storage tank drainage line blockage in the form of thermal patterns above the absolute zero limit by using non-contact thermal imaging devices. This type of detection is good to identify the location approximately based on the thermal image quality. This thermal image is not enough to confirm the accurate location so reliable image is needed to eliminate the blockage. The introduction of powerful computer is producing a reliable image, which was made significant impact on the nondestructive testing. Computed radiography with phosphor image plate technique has increased the capability to produce a reliable image in terms of accuracy, visualization and measurement. It has different techniques to detect pipe discontinuities such as erosion, general corrosion, dent, wall thickness measurement, localized corrosion, pitting and welding discontinuities. This paper has used the double wall double image superimpose technique to detect and confirm the oil and gas storage tank drainage line blockage among all other computed radiography techniques. Through this combined condition monitoring methods, can identify and confirm the sectional replacement location of the blockage line which will save costs and prevent failures.

Keywords: Infrared Thermography, Computed Radiography, Infrared Camera, HD Scanner and Storage Tank

1 Introduction:

Storage tanks are used all over the world in oil and gas production to store the bulk containment of fluids at different phases in the refinery process. Most of the oil and gas industries are using the American Petroleum Institute’s API 650 and 653 for the design, fabrication, erection, inspection, in-service inspection and integrity of storage tanks. Some principal features of storage tanks are: sampling and gauging hatch, vapor vent, relief, inert gas blanket, drains, fire protection, earth connection and manhole. Storage tank drains are used to eliminate any water that splits up from the product during storing operation. They also are used to vacant the tank to clean and conduct internal inspection or repair. If there is any blockage in the drainage pipe, the storage tank can’t remove the separated water from the product. The water will mix with...
the product then it will lead to quality issue and it will affect the business. Oil and gas industry requires nondestructive testing to avoid such type of quality issue without affecting the business. This paper gives solutions to solve such type of drainage blockage by using a combination of infrared thermography and computed radiography methods to identify the drainage block and to operate the tank safely and continuously.

2 Drainage of Storage Tanks:

The drainage of storage tanks can be a highly accidental and potentially hazardous to operation and asset integrity management. To confirm the water and oil separation, the operator is conventionally carrying out to confirm the separation. The operator physically opens the drain valves and carries out visual checks to witness the water/oil change. If the operator found the water / oil changes in the tank, the operator closes the valve. This process needs the existence of an operator in the high potential risk area, the area may lead to a high uncertain consequence at any time. When the crude oil is transferred into the storage tanks, the water contained in the hydrocarbon has settled at the bottom of the tank because the water is heavier than oil. Before starting the refining process, it is necessary to filter the accumulated water from the storage tank in order to avoid contaminating the hydrocarbon. If the water is not properly filtered, there is a change to mix the product with water. It may lead to hydrocarbon release, which means loss of product and accidental oil spill. The water evacuated via the drain, then it is sent to the treatment plant. These statements are clearly saying that the oil and gas storage tanks drainage lines are one of the critical components in the oil and gas assets.

3 Infrared thermography:

Visual image, thermal image and measured infrared energy which is emitted from the object are captured by using infrared thermography imaging and measurement camera. All materials emit infrared energy above absolute temperature, which is $-273.15^\circ$ C. Human eyes can’t detect the emitted infrared energy because its wavelength is too long. The emitted infrared energy is greater for high temperature materials and lesser for cold objects. Most of the oil and gas equipments are operated certain temperature and the equipment get cold or hot before they fail. Infrared thermography can detect the visible image and hot and cold temperature patterns in the visible and infrared region of the electromagnetic spectrum. These heat patterns help to identify the fault of the components before they fail. Infrared thermography detects the infrared energy which is emitted from an article, the detected energy converted into apparent temperature and the converted apparent temperature displayed as an infrared image. Accurately, infrared means “away from red” and thermography means “temperature plotting”.
4 Infrared Camera:

The infrared camera measures the temperature, which is emitted from an object in the form of infrared radiation. The emitted infrared radiation quality be governed by on various object parameters such as emissivity, humidity, distance, etc. To measure the temperature more accurately, the object parameters must be provided for the camera. The important object parameters and their values are provided for the camera are: emissivity of the object - 0.95, reflected apparent temperature - ±20°C, the distance between the object and the camera – 3m, relative humidity - -50% and the temperature of the atmosphere - ±20°C. The infrared camera can able to capture the thermal images without direct touching of the component. The captured thermal images contain actual temperature measurements for each pixel within the image. With this capability, the infrared camera can map the cold and hot thermal patterns and then exercise to calculate the apparent temperatures of the points in the problem. The object parameters inserted into the camera of this research are shown in table 1.

<table>
<thead>
<tr>
<th>Measurements</th>
<th>Value</th>
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<tbody>
<tr>
<td>Emissivity</td>
<td>0.95</td>
</tr>
<tr>
<td>Object Distance</td>
<td>3m</td>
</tr>
<tr>
<td>Atmospheric Temperature</td>
<td>±20°C</td>
</tr>
<tr>
<td>Relative Humidity</td>
<td>-50%</td>
</tr>
<tr>
<td>Reflected Temperature</td>
<td>±20°C</td>
</tr>
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Table 1: Object Parameters

5 Blocked Drainage Pipe Inspection and Temperature Analysis:

Infrared thermography is a condition monitoring technique which measures the radiant heat pattern emitted from different bodies. This nondestructive testing method is applied to identify the blockage of the storage tank drain pipe. The underground area of the pipe has excavated to perform the infrared thermography inspection as shown in the figure 1. The suspected spot 1 and spot 2 areas are highlighted on the isometric drawing as shown in figure 1. The storage tank drain valve has closed due to the blockage and informed the operator to open the valve around 5pm of the evening before start the inspection. The inspection has carried out around 7pm of the evening after open the valve because the water and the pipe to reach maximum equilibrium state. The water settled inside the drain pipe before the blockage and the water settled area acted as a cold spot as well emitted lesser infrared radiation as shown in figure 2. The water not settled inside the drain pipe after the blockage and the empty pipe area acted as a hot spot as well emitted greater the infrared radiation as shown in figure 3. The spot 1 and spot 2 temperatures are shown in table 2 and 3.
The spot 1 and spot 2 temperature difference are shown in table 4. From this temperature difference and thermal patterns, the infrared result concluded that the blockage is in between spot 1 and spot 2 of the drain pipe and suggested to conduct computed radiography to know the exact location of the blockage.

Figure 1: Excavated and Suspected Areas on the Isometric

Figure 2: Spot 1 Thermal and Visual Image

Figure 3: Spot 2 Thermal and Visual Image
Computed radiography (CR) is producing a digital image at the same time it is replacing the conventional X-ray film also it compromises massive advantages than conventional radiography. It has totally eliminated the use of darkroom process and the time to produce the image is drastically shortened. Photostimulable phosphor image plates are used as an image receptor in computed radiography. The phosphor image plates are kept in a cassette like conventional radiography before they expose. The phosphor image plate contains a thin layer of phosphor grains, which is known as a photostimulable phosphor. When the image plate is exposed to X or gamma radiation, the penetrating radiation is exciting the phosphor electrons and entombed in the lattice inevitably until the second round of illumination stimulation start. When the phosphor image plate is exposed to a small amount radiation, the high-intensity laser beam striking the previously trapped electrons to return to their respective valence bands at the same time it is letting off visible light. A photomultiplier tube will read this visible light and convert it into an electric signal via an analog-to-digital converter then the image digitized and mapped onto a pixel matrix. The laser light erases the image so that the same image plate can be reused repeatedly around a thousand times if carefully handled.

Durr NDT is using TreFoc laser focussing technology in computer radiography high definition – CR 35 scanners. With the help of TreFoc, the laser beam is adjusted perfectly to obtain optimal image results and the highest signal-to-noise ratio in any application. An iris diaphragm fitted inside of the laser tube which adjusts the laser beam diameters. The optimum results of computed radiography image are achieved by selecting the perfect laser beam diameter and high sensitivity image plate. The unique TreFoc laser
technology gives perfect high-resolution image with the best signal to noise ratio and low exposure time for wall thickness measurement. While changing the laser beam diameter, the operator should consider the maximum resolution of the imaging plates. The laser beam can read all exposed image plates, but achieving the high resolution image with the lowest noise depends on selecting the laser beam diameter, and type of image plate and enough exposure time. 50\(\mu\)m laser beam diameter used for corrosion measurements, the 25\(\mu\)m laser beam diameter used for weld inspection, metal casting and 12.5\(\mu\)m laser beam used for aerospace and composite materials. This research has been conducted with the 50\(\mu\)m laser beam diameter to identify the blockage.

8 Double Wall double images Superimpose technique for blocking drainage pipe:

As per the Infrared thermography resulting recommendation, the computed radiography double wall superimpose technique has performed on the suspected area. The suspected area has marked on the isometric drawing as shown in figure 4. The source is placed on one side of the suspected area and the image plate is placed on the opposite side of the suspected area as shown in figure 5. Iridium -192 source beam focused to the middle section of the examination part which is normal to the material surface at that point of the suspected area. The suspected area of the object has placed in between the source of radiation and the image plate with a suitable source - to - image plate distance, the radiation is allowed to penetrate the part of the required exposure time and the latent image adequately recorded. The image plate has scanned by using HD scanner and the images analyzed by using the D-Tect software. A foreign material was found in the drainage pipe as shown in figure 6. From the image, the computed radiography result concluded that the foreign material has blocked the drain pipe and recommended to do sectional replacement repair to operate the storage tank safely and continuously.

Figure 4: Computed Radiography Spot in Isometric Drawing
Results and Discussion:

The infrared thermography spot 1 temperature is 32.26°C and the Spot 2 temperature is 35.64°C. The temperature difference between spot 1 and spot 2 is 3.38°C. The results are revealed that the storage tank drainage pipe blockage in between the spot 1 and spot 2 areas and it opened the way to identify the exact location of the blockage through computed radiography. According to the recommendation of the infrared thermography result, the computed radiography double wall superimpose technique carried out and the results revealed the storage tank drainage pipe blockage area exact location. It also helps the maintenance team to do proper sectional replacement in the blocked area. The results of both methods are revealing that the combination of nondestructive testing condition monitoring methods helps to operate the aged oil and gas storage tanks in a safe and reliable manner. The research results will help to operation and asset integrity engineers to solve similar critical components issues in the future.
10 Conclusion:

This paper presented a combination of infrared thermography and computed radiography nondestructive testing methods to detect blockage in the oil and gas storage tank drainage pipe. The infrared thermography results are showing the cold and hot spots on the suspected areas of the drainage pipe. The cold spot is clearly indicating that the water flowed and settled inside the pipe until the blockage area so that the spot emitted lesser infrared radiation. The hot spot is clearly indicating that the water neither flow nor settle inside the pipe so that the spot emitted greater infrared radiation. The blockage of drainage pipe location was confirmed in between spot 1 and spot 2 from the interpretation. The computed radiography double wall double image superimpose technique is showing the middle portion of the pipe from top to bottom superimposed image. The computed radiography image is clearly indicating that the blockage was inside of the drainage pipe due to entrapment of foreign material. The blockage exact location was identified from the interpretation and solved the issue through the combination of infrared thermography and computed radiography nondestructive testing. Applying combination of nondestructive testing methods will innovate new research ideas to solve such type of issues in the future.

References


