USING INFRARED IMAGING IN THE OIL AND GAS INDUSTRY

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Infrared imaging (IR) can be a useful tool in the oil and gas industry. At ChevronTexaco, IR is used as a proactive maintenance tool in our oil and gas producing facilities and plants. IR was first introduced in the 1980's as a tool to inspect electrical systems for loose or bad connections on overhead distribution systems and overheating equipment, mainly motors and transformers. In the past we have primarily used IR for electrical inspections, but have also found that it is useful in finding anomalies on mechanical equipment as well, such as belt alignment and tension on rod pumping units or overheating bearings on a transfer pump to name a few. In the last two years we have found that IR can help tremendously in finding tank and vessel level and interface problems. It is also useful as an aid in identifying and scheduling tank maintenance, such as tank cleanouts and chemical treatment procedures and dosages. In this paper we will discuss these different applications of IR technology at ChevronTexaco.

Briefly let's go over the basics of IR. Infrared thermography is the ability to measure temperature **without contact,** by the amount of radiation that is emitted by a target. This is the same radiation that can be felt when your hand is held over hot coals in a barbecue pit. Since a fixed relationship exists between the temperature of an object and the amount of energy it radiates, target temperature can be accurately determined by measuring the amount of radiated energy. We can now use a device that is actually a wavelength converter, that we call a Radiometer. Radiometers include the common gun type (point & shoot) infrared devices that give a single point temperature value or the more complex, Infrared Imager. The Imager is a microprocessor controlled piece of electronic equipment that has the capabilities to allow corrective settings to be input into the programs of these Imagers that will compensate for atmospheric and target errors such as emissivity and reflected temperature. They also have the capability to produce an actual image that represents the thermal characteristics of the target. The image can be digitally stored and transferred to software programs for manipulation and report generating purposes. Infrared thermography is ideally suited for our industry due to its ability to make accurate **non-contact** temperature measurements on high voltage and rotating and operational equipment without equipment interruptions.

Stanley Davis introduced the infrared program to the Permian Business Unit in the mid 1980s using contractors to survey pumping units and their electrical systems in Texaco's Sundown, Texas Office. The project had great success but was limited due to the availability of reliable contractors and cost of their services. In 1997 with the growth in demand for these services and the advancement of technology, the Permian Business Unit created an Infrared Thermography position.

Advancements to IR Imager technology, which made for lighter more compact equipment and added digital IR imaging plus the software to accommodate these images made the analysis and reporting faster, more reliable and added the ability to store these reports and images in electronic files and databases. This also gave us the ability to now do electronic historical tracking and trending in reports and the ability to e-mail reports or post them on a website. These advancements to the IR technology also improved the IR image resolution tremendously. In the past this image always had to be accompanied by a photograph to identify the anomaly on the equipment and even then was hard to do. Now an additional photo is not usually necessary to pinpoint the actual anomaly, but is occasionally included to enhance the analysis.

Electrical IR Inspections: Infrared thermography is ideally suited to electrical inspections because electrical circuits have a current flowing through the conductors. When a connection becomes loose or is not making a good connection a low resistance is introduced into that current flow, which produces heat at that point. IR can easily detect this increased heat and by comparing this anomaly's temperature to ambient temperature or to similar components of the same voltage and current, a temperature delta-t or rise can be determined. This rise or delta-t then can be compared to a table (Table 1) and a priority class can then be assigned to that anomaly. This priority class will determine whether the anomaly will be simply monitored for a period of time or it may be addressed immediately, depending on the rise in temperature and equipment service criticality. When applied properly IR can result in significant savings and less downtime in operations thus increasing cash flow. IR technology has been proactively used in locating potentially catastrophic events and reducing electrical costs and failures. Electrical inspections may include substations and electrical distribution systems all the way down to individual disconnects and control panels on wells or pumps. Here are three examples of how IR has helped on electrical systems at ChevronTexaco in the Permian Business Unit.

(1) A potential Y2K catastrophe was avoided in 2000 as a result of shooting transformers at one of our West Texas gas plants. A transformer secondary bushing was found to be slightly warm in September of 1999 and tracked over the next two months (Chart 1). The transformer was a 333 KVA transformer (Image 1) that would have taken the plant down had it failed. It was also a one-week lead time item at best. This would have shut down the plant for a minimum of 5 days and at 100 MMCF per day would be crucial to Texaco's bottom line. . Fortunately a planned shut down was allowed and new equipment installed. The plant was down for less than four (4) hours and operations continued smoothly.

(2) Another discovery came recently in one of our Southeastern New Mexico operations where we found a problem in an OCR on one of our primary lines that feeds a large portion of our producing properties. The OCR was found to be hot (Image 2) and the unit was replaced and taken in for evaluation. It was found that the actual read-out displaying the number of trips was much lower than the actual number of trips. This unit was on the verge of failure. A failure would have meant the loss of production and electrical equipment damage. This is another example of proactive activity with infrared technology.

(3) In September of 2002 after inspecting our substation at a West Texas field we found one of the solid blade cut-outs supplying 12.5 kv to one half of the entire field was approximately 120 deg. F. above ambient temperature (Image 3 & 4). After preparations were made, the affected substation power side was switched over to the other side for a short period of time and repairs were made on the faulty cut-out. Power was then switched back to the normal side of the substation and production was brought back to normal with minimal loss and downtime.

These are just a few of the examples and applications for using IR on electrical systems, but as you can see, it does not take but one or two of these to add to the bottom line.

Mechanical IR Inspections: Mechanical IR inspections are becoming more and more important and ever increasing. **A** rotating machinery mechanical inspection might consist of motor/coupling alignment (Image 5), belt tension and alignment, bearings (Image **6)** and seals. Other non-rotational equipment could be cooling fan tubes (Image *7)*, fired equipment refractory like an Amine Reboiler (Image 8) and Oil Heaters. IR inspections on mechanical equipment components such as bearings and pump seals have the best success when they are on a regularly scheduled time-based inspection. Component temperatures and ambient conditions can be trended and compared to predict impending failures of equipment. These impending failures can be predicted and caught before the equipment fails, taken off line and repaired to prevent catastrophic failures and unexpected downtime.

IR on Tanks and Vessels: IR inspections on tanks and vessels at our producing and gas facilities has become one of the most requested inspections at the current time as a tool to aid in the maintenance and troubleshooting in tank upset conditions. Infrared Imaging can be very helpful on these tanks and vessels to first locate and measure the actual liquid level within the tank. This can be very helpful especially if there are no level switches or level gauges installed. Most tanks have liquid level or "head" switches and/or electronic level gauges, whose operation can be checked easily and quickly with infrared. Tanks that are painted, usually have a high emittance, which makes for a good thermal differential between the cooler product in the tank and the tank wall being warmed by the bright West Texas sun. The greater the differential the better, but for a difference of at least a 10 degree F. yields the best results. Tank level detection is similar to roof inspections except reversed. That is, instead of inspecting at night after a warm day you inspect in the early part of the day when the liquid in the tanks are cool and the sun is warming the tank wall. With some experimenting you can determine the best times for different tank and liquid combinations.

In the latter part of 1999 a chemical technician at one of our Dawson county field's management team (FMT) asked me if I thought we could use infrared to find a gunbarrel's interface pad (Image 9). This is the layer between the oil and water, which is normally part oil, water, paraffin and any other materials produced from the wells, in a suspended state. In this particular area they were having a lot of paraffin build-up problems from the wells. Parrafin is very waxy and thick and reduces flow in wellheads and flowlines dramatically, sometimes completely plugging them off. **A** successful chemical treatment program had been implemented for the wells to produce without restrictions from the paraffin. However the problem was that spot treated wells would flush the paraffin through their piping down the flowline where it ended up in the gunbarrel. This created another problem by forming hard thick layers of paraffin mixed into the interface layer. The paraffin layers were not allowing the gunbarrel's normal separation process to occur. It was getting so bad that some of these interface layers were so hard and thick the lease technicians could not force a steel rod through it. The gunbarrels were either pushing the interface layer over the top into the storage/sales tanks or the crude oil was simply not separating from the water. As a result sales were interrupted or shutdown due to “bad oil” detection from the LACT units. In February of 2000 we started looking at gunbarrels with infared imaging to see if we could identify the cause of the problem. It was pretty amazing that we not only could see the liquid level in the top part of the tank but we could see the actual layers of water, oil and interface within the tank.

Infrared Imaging can also be used to locate and measure sediment accumulations in tank bottoms (Image10). This can be a problem because having a layer of sediment on the bottom of these tanks can cause premature corrosion, as well as affecting the oil quality. Cathodic protection systems are in use at nearly all of ChevronTexaco’s facilities, however, if the bottoms layer or sediments gets thick enough it affects the cathodic protection process by blocking or impeding the signal from the sacrificial “anode” that’s inside the tank. With a thick layer of sediment in the tank, the corrosion acts on the tank bottom instead of the anode. We are trying to implement inspecting these tank bottoms as part of ChevronTexaco’s routine corrosion inspection program.

The internal liquid flow (Image 11) in a vessel can also be viewed using infrared imaging. This can aid maintenance personnel by giving them a thermal representation of what’s going on inside the vessel. For example, they may suspect a problem with the internal baffle in a vessel. The thermal image allows them to see and verify correct or incorrect operation without opening the vessel for physical inspection or the addition of additional instruments. Image 11 shows the internal baffles and levels of a free water knockout.

BENEFITS OF USING INFRARED IMAGING ON PRODUCTION STORAGE TANKS &VESSELS

Infrared imaging can locate tank levels in most cases from ground level instead of up on tank platforms and without tank intrusion. Tank intrusion becomes a huge factor because there are many tanks that contain liquid that in turn contains hydrogen sulfide (H2S) gas that is very deadly. Normally, to measure the level or “gauge” high H2S identified tanks, lease operators have to put on a full set of fresh air breathing equipment and have a stand-by person on the ground below with breathing equipment on also.

Maintenance personnel can 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 .

Operations personnel could also use infrared imaging to assist in problems encountered when they have “bad oil” or upset situations especially the gunbarrels and run tanks. The image below (Image 12) shows a possible “Bad Oil” situation from the LACT Unit because it’s sucking the saleable Oil from the Oil Storage or “Run” Tank through the sediment accumulation in the bottom of the tank. When this happens it is possible to suck the unwanted sediments out with the “Good Oil” creating the “Bad Oil” situation which would stop the actual sales of the product. This “Bad Oil” condition could be remedied by adding chemical and re-circulating or in extreme cases the tank may have to be cleaned.

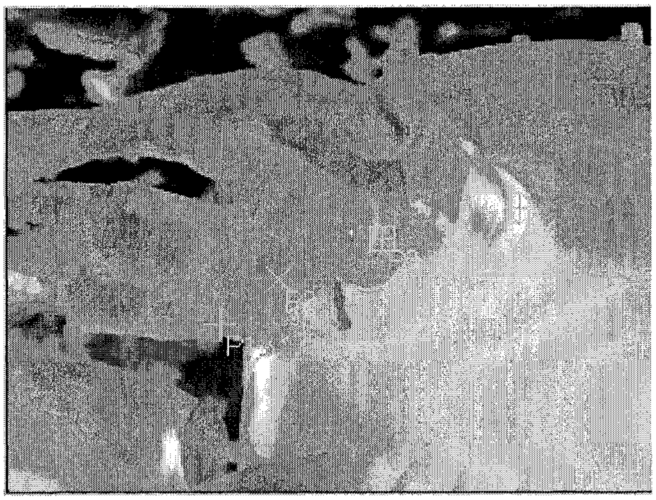
Several of our field teams, in conjunction with their chemical provider’s, have adopted regular gunbarrel IR monitoring to aid in making adjustments to the chemical treatment programs on the gunbarrels. (Image 13) below shows a gunbarrel just following a clean-out on 5/17/00. (Image 14) shows the same gunbarrel on 3/8/01 with a substantial increase in the interface pad width. By doing the gunbarrel monitoring twice a year we can have a record of the chemical treating program’s effectiveness and can save money by only treating when necessary.

The list of potential uses for infrared technology is endless. In 1999 and 2000, we estimated that infrared technology saved the ChevronTexaco Permian Business Unit approximately $1.5 million. Whether doing electrical, mechanical or tank and vessel inspections IR has many uses in the oil and gas industry. The more we use it we will likely find even more applications to help us better maintain our electrical systems and facilities in the petroleum Industry.

NOTE: Priority ratings are based on the temp. rise of the exception (problem) above the temp. of a defined reference, which is typically the measured ambient air temp., a similar component under same conditions and load, or the maximum allowable temp. of the component. These ratings are based on no wind (calm) conditions. When windy conditions are prevelant these ratings will change. (revised 11/08/00)

Table 1

PRIORITY	PRIORITY RATING	REPAIR ACTION
	20 - 40 F. DEG.(-7 - 4 C.)	MONITOR
B	40 - 70 F. DEG. (4 - 21 C.)	REG. MAINT. SCHD.
C	70 - 100 F. DEG. (21 - 38 C.)	ASAP
D	100 F. DEG. AND OVER (38 C.)	IMMEDIATELY



Left Secondary Bushing = P1

Mid Left Sec. Bushing = P2

Mid Right Sec. Bushing = P3

Right Secondary Bushing = P4

Tank below Bushing's = P5

Ambient Air Temperature = P6

These data points apply to Chart 1 below:

Image 1 – Warm Transformer Bushing (internal anomaly)

TB2 West Transformer Sec. Bushings

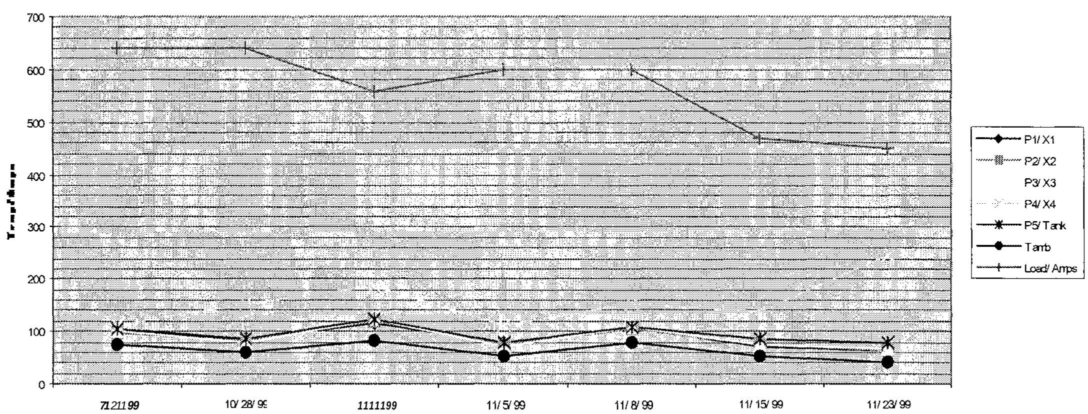


Chart 1

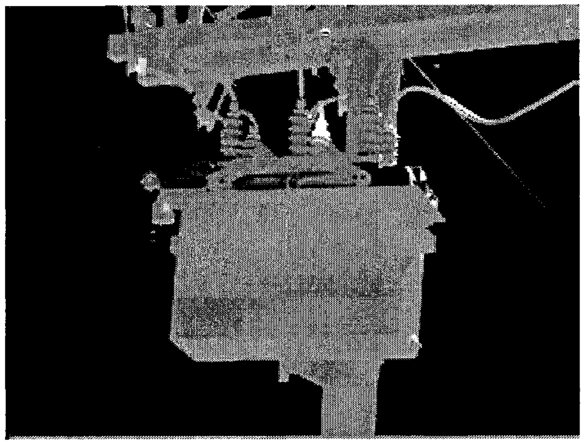


Image 2 – OCR Bushing

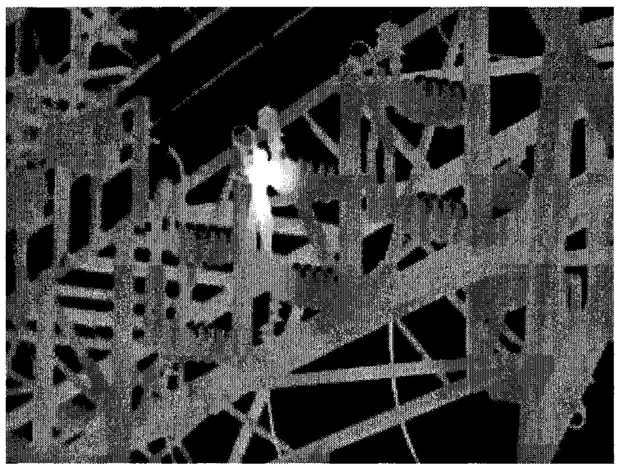


Image 3 – Substation Switch

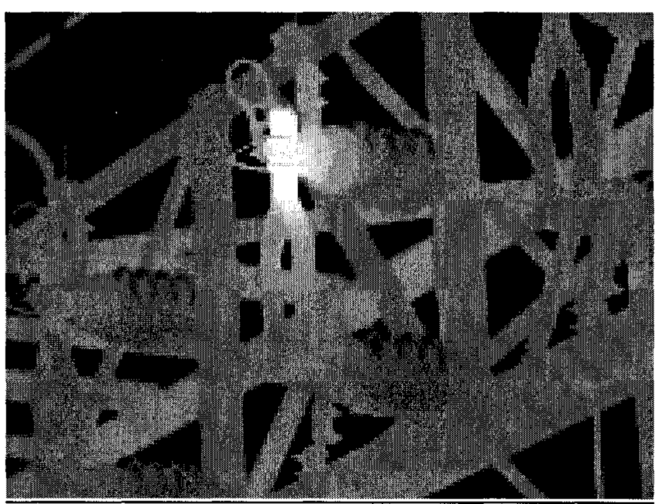


Image 4 – Substation Switch

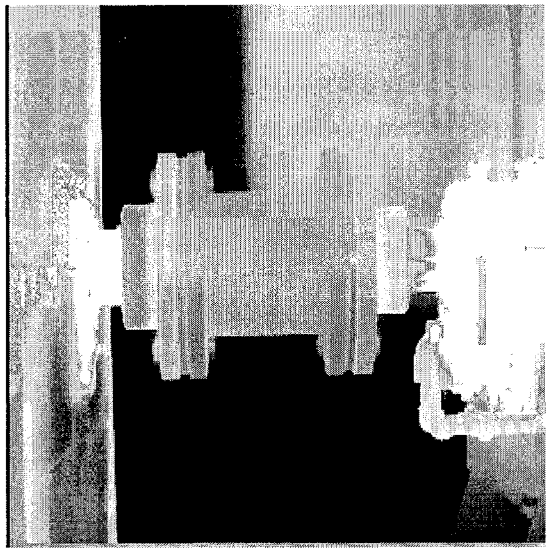


Image 5 – Motor/Pump Coupling

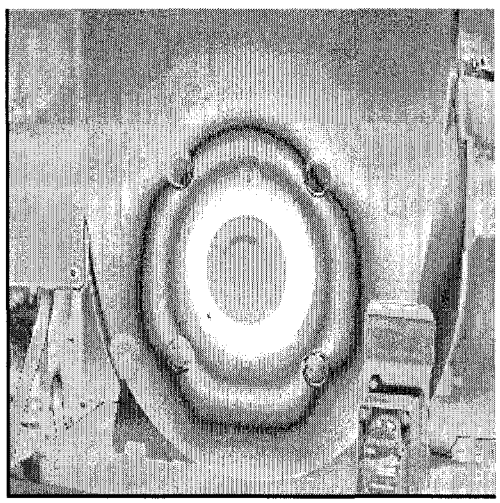


Image 6 – Motor Bearing

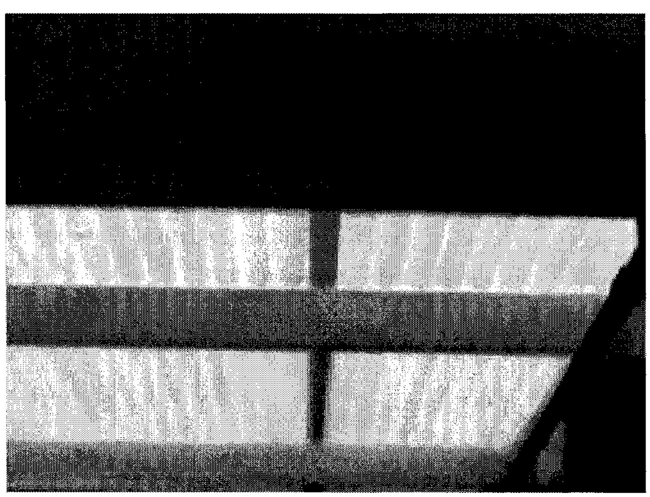


Image 7 – Fin Fan Tubes

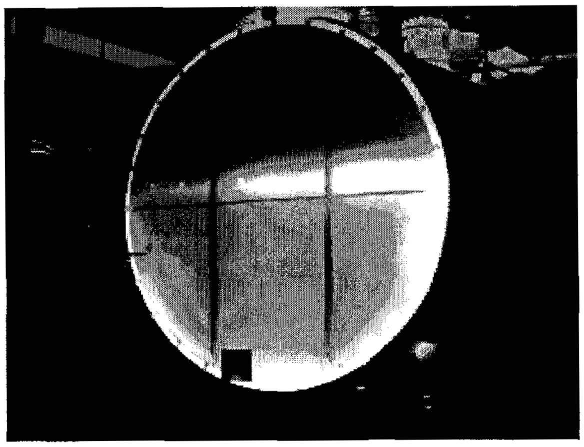


Image 8 – Amine Reboiler Door with Bad Refractory

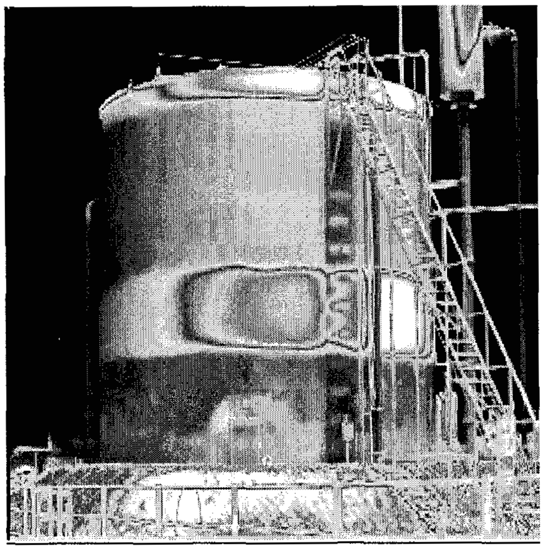


Image 9 – Gunbarrel Interface Pad

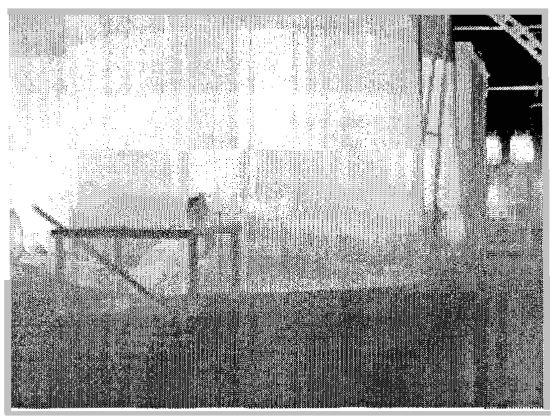


Image 10 – Water Tank Bottom's

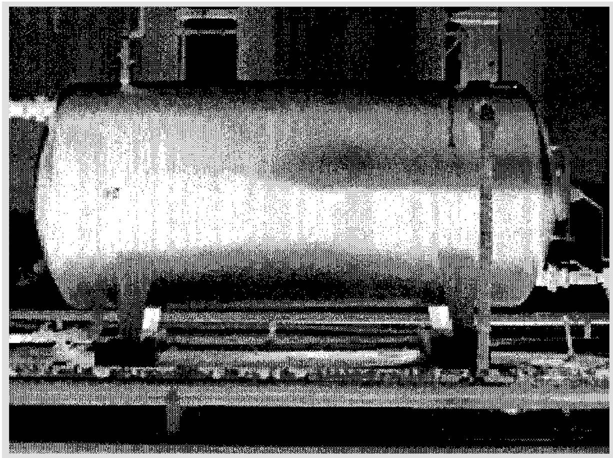


Image 11 – Free Water Knockout with Settlements

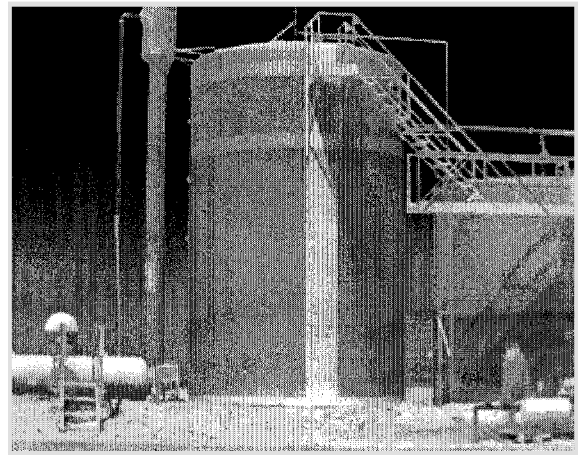


Image 13 – Gunbarrel after Clean-out

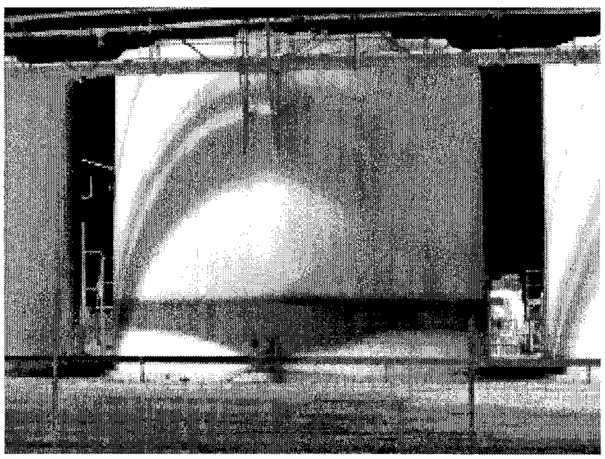


Image 12 – Oil Tank Bottom's

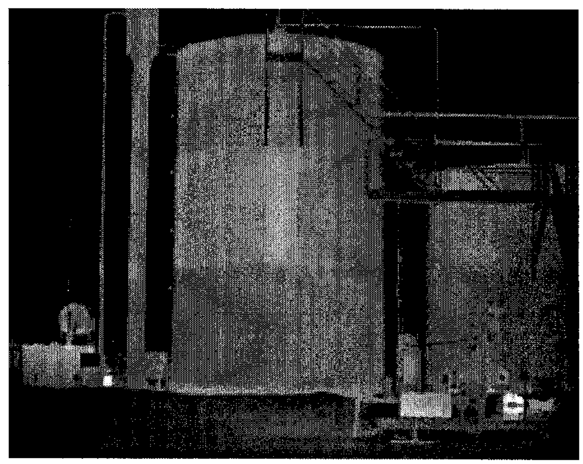


Image 14 – Gunbarrel 10 Months after Clean-out