Crude Settling Tanks

MTG (Mass Tank Gauge) is the most advanced development in inventory control for liquid storage tanks. MTG is a single probe installed through the tank roof on any type of flange 3 inches or larger. MTG provides all measurement parameters including level, multiple and average temperature, mass, volume, density and water interface as well as self-calibration features making this probe virtually universal and maintenance free. This article, however, will concentrate on MTG applications with Crude Settling Tanks.

The versatile features of MTG allows for unique applications capabilities, particularly for crude settling tanks. The common questions arising with day-to-day settling tanks operating are as follows:

- How much water is being pumped into the tank? – Helps to estimate the well performance
- How much water is stored in the tank?
- Where is the free water cut?
- Where is the emulsion layer cut?
- How much water/oil content is in the emulsion layer?
- What is the percentage of water above some critical levels? – For example oil sump level.

The answers to the above questions could be of great help in attaining a more efficient settling tank operation. Indeed, it allows diagnosing production problems at early stage, saving manpower, avoiding human related errors, automating most of the procedures, and reducing the tank operation cycle.

The MTG Probe provides the right answers.

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Inventory and Custody Transfer issues

The BP/Amoco Terminal at Galeota Point in Trinidad consists of 5 large storage tanks of a quarter to a half million barrels each. The tanks are more than 60 ft tall and are equipped with external floating roofs. The oil for these tanks is received from offshore rigs and is delivered from the tanks to marine tankers for further transportation to refineries. The main difficulty for this custody transfer operations has always been a correct accounting for the amount of water content in oil delivered from the rigs, present in the tanks and finally shipped to the marine tankers.

The traditional way used at the terminal for years included letting the oil settle in the tanks for days with periodical manual probe sampling at different heights. The desired quality was achieved by manually controlled water bleed off through the valves located around the perimeter of each tank. The ultimate goal has always been to have less than 0.5% of water above the "critical level" before shipment of the oil to the tankers. The critical level (determined by suction pipe location) is at 4.5 feet, while the floating roof legs are 6 feet.

The above traditional sampling practice and calculation could hardly provide the true quantity of emulsified water in the oil, even with the most sincere attempts of the highly qualified and dedicated Terminal staff. The method could at best provided approximation of what was going on in the tank. Indeed, depending on an oil well performance, the free water layers in tanks could vary from a few inches to three – four feet, while the emulsified layer varies from the free water level up to more than 10 feet, gradually dissolving into pure product. The situation is even more complicated during the periodic Acid Jobs when the emulsified layer exceeds 20 feet. The emulsion itself varies in its "thickness" or actual content of water in oil. The manual sampling method suffers a lot of uncertainties and the calculations assumed that there is a linear distribution of water content between the sampling points due to completely unknown distribution of emulsion in oil.

The uncertainties above caused miscalculation of the water content in the tanks resulting in large quantities of water supplied to tankers. For BP/Amoco, it meant extra expenses transporting sea water from Trinidad to the US, royalties and taxes paid on water rather than oil, miscalculation of actual oil wells efficiency, long settling times (facilities cost), etc.

There were no reliable automatic tank-gauging systems installed at the tanks. There was actually no reason for equipping the tanks with accurate gauges for level if the water content would remain manual. As a result all gauging operations were performed manually.

The Right Answer

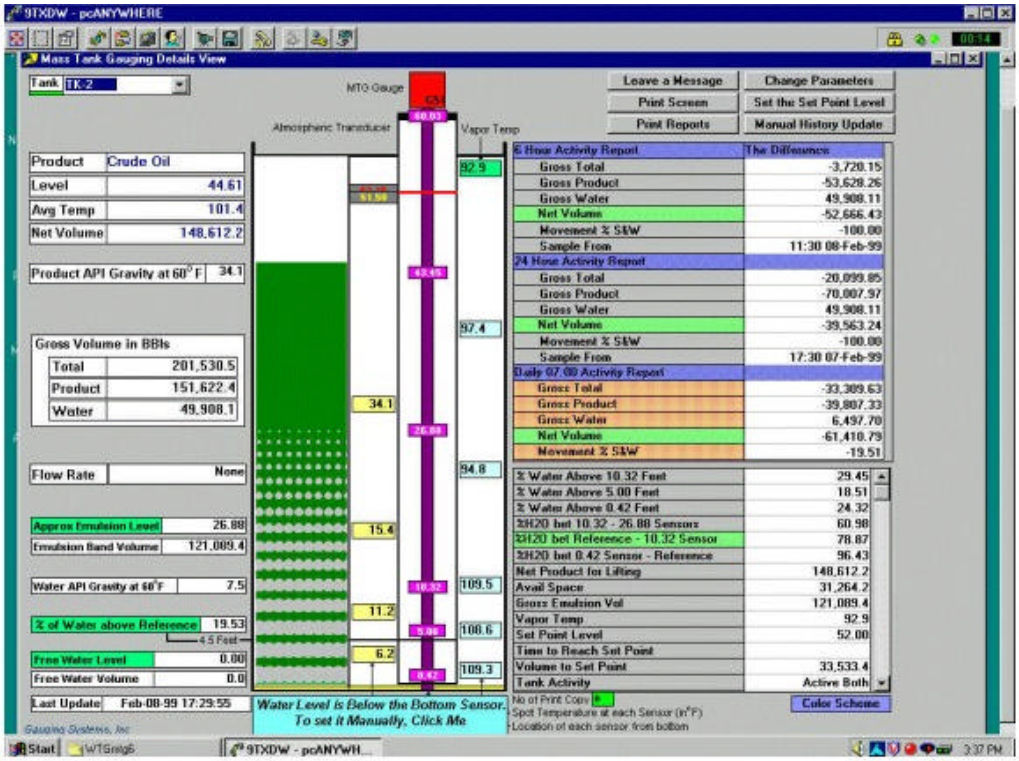
In 1998 a new technology was introduced at the Terminal. That was the first generation of MTG gauge.
The probe configuration included 6 sensor units. Each sensor unit consisted of accurate pressure and temperature cell. The bottom sensor unit was located close to the tank floor, the next one around the critical level of 4.5 feet, the third unit at around 12 feet, two more units at around 26 and 40 ft and a reference unit in the gas/atmosphere.

The MTG probe was communicating with GSI Win TG software providing some additional data processing and the graphical interface for the measurements. The probe was measuring multiple pressures, temperatures, density layers, level and percentage of water above the sensor locations. In addition, operators were presented with the graphical display showing the oil/emulsion/water distribution in the tank, multi-point and average temperature, gross and net volume, history of movements and more. For the first time, operators could see a virtual snap shot of what is going on in their tank.

Not only did they receive information about the product inventory and water content in the tank, they also could remotely monitor the filling, emptying and water bleed off processes. This helps to choose the optimal

modes of operation and judge about the current oil well performance even when the tank is being filled.

The below picture is an actual display capture taken from the operator console at the site. It provides an unprecedented amount of information. However, even more comprehensive is the display presently available to the operators after the software upgrade was introduced in 1999.



After installation the system underwent very thorough tests for more than 6 months with regular sample taking and data comparison. To assure correct results, the manual samples were taken at more points than usual over the tank height. Every sample was carefully analyzed at the Terminal Lab and repeated should there be a doubt of sampling quality or consistency.

The results of the testing confirmed the excellent system performance. At this time the second generation of MTG was out on the market and the Terminal not only upgraded the first system but also purchased another one for a second tank.

Lightning Effect!

The success story continued with the second probe as well. The Terminal was ready to upgrade the whole Terminal with MTG technology, when forces of nature introduced their corrections to the plans and inadvertently demonstrated additional advantages of MTG probes.

A thunderstorm hit Galeota Point and a lightning directly hit, Tank number 3, the one next to the two tanks equipped with the MTG probes. The tank caught on fire and all electrical/electronic equipment on the whole Terminal went out of order.

It is worth mentioning that Galeota Point Terminal is a very modern facility beautifully equipped with the most advanced instrumentation and control systems.

The Terminal was prepared to replace both probes… but all that had to be replaced was one IS barrier at a total cost of around a hundred dollars. Both probes were up and running immediately afterwards with no other maintenance required!

Due to repair and maintenance works on the Terminal the upgrade (API 653) of the rest of the Tanks with MTG probes is now scheduled for 2001-2002.

Total solution for oil inventory, production monitoring and bleed off process automation

MTG probe – the only tank gauge in the world providing the right answers for crude settling tanks makes it possible to engineer comprehensive solutions for crude terminal automation as in the example below.

The proposed solution includes the following equipment for each tank:
- One or more MTG probes to monitor oil and water inventory currently in the tank
- Water drain valves with optional status diagnostics and optional remotely controlled shut-off valves to provide for bleed off process automation and control
- Bled water flow meter to account for bled water quantity and provide the production monitoring
- Additional software upgrade (one for all tanks).

The advantages of the proposed scheme are as follows:
- Significant tank turnover cycle reduction
- Eliminating any probability of oil draining through water bleed off channels
- Complete 24 hours remote automatic control of the water bleed off procedure
- Constant overall production monitoring during tank filling and simu ltaneous water bleed off

Listed below are the detailed functions of each piece of the proposed system:

MTG probe – allows monitoring the oil inventory and water – emulsion situation in tanks at any given point of time.

Automatic water drain valves provide for water bleed off and automatic shut-off when a noticeable amount of product comes into the valve. Those are pure mechanical devices to be installed at all water bleed off points of a tank.

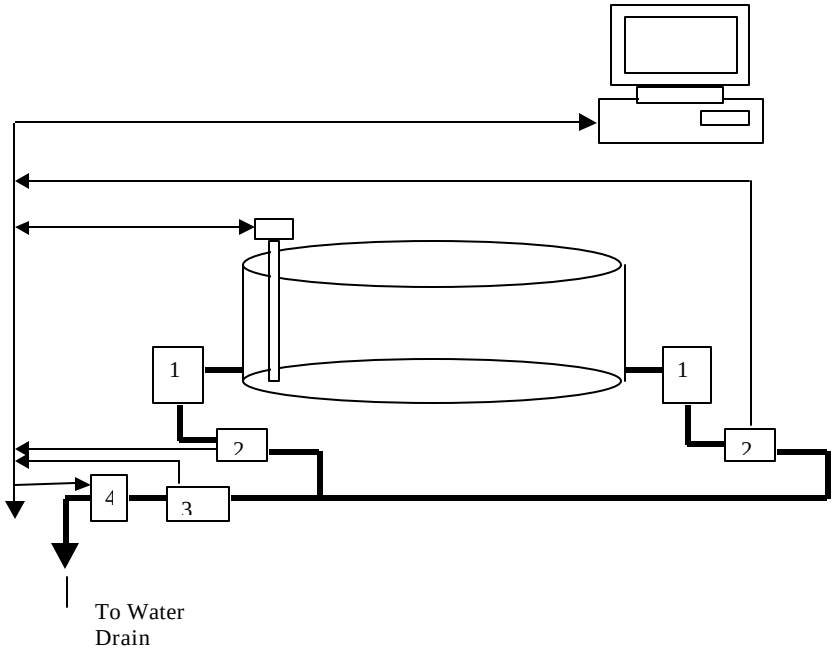
Optional status diagnostic device installed at each water drain valve provides remote status diagnostics and monitoring including such situations as
- Water drain in process – report
- Oil is being drained – alarm
- No movement at the valve outlet – report

Optional remotely controlled shut-off valves provide for shut-off of the bleed off line in emergency situation (product is detected in the bleed off line) or for operational needs (operational decision is taken to halt the bleed off procedure). The shut-off valves may be installed at each bleed off point to allow for individual control or at overall bleed off line – one per tank.

Bleed water flow meter shall be installed to measure bleed water output to provide for continuous production monitoring when tank is filled and water is bled at the same time.

The figure below illustrates the proposed solution

It shows schematically a tank with an MTG probe installed. There are automatic drain valves (1), diagnostic device (2), bled water flow meter (3) and a remotely controlled shut-off valve (4). The thick lines show the pipes and thinner arrowhead lines show the information line with arrow direction indicating the data flow direction.



The number of devices (one MTG probe, two water drain valves, one shut-off valve, etc.) is shown for example only. The actual configuration is to be chosen depending upon degree of automation and accuracy required.

The following are the further enhancements that may be added to the above solution to provide for more accurate accounting and control

1. **Horizontal tank profiling to measure accurately situations with uneven water and emulsion distribution.** This can be achieved by installation of additional MTG probes. More than one MTG probe per tank would allow taking into account the horizontal distribution of water in the tank and providing for more accurate inventory. For very large tanks it is recommended that three probes be installed at 120 degrees around the tank perimeter.

2. **Highly accurate oil in water concentration measurement in the bleed water line.** GSI is capable of supplying an additional device for measurement density of bleed water with superb accuracy. This may provide for accurate calculation of the concentration of oil in the bleed water as well as to an additional alarm if this concentration exceeds the desired level.

3. **Individual shut off valves for each of the bleed off points.** This would allow stopping remotely the bleed off process from each of the bleed off outlets while bleed off continues from the others – may be useful in case of uneven water distribution across the tank perimeter