



A Reoccurring Loss Control Dream: A Tank Full of Money

I recently had another opportunity to give a paper at a School on Hydrocarbon Measurement. Again, because of the influx of work and the human tendency to procrastinate, things began to build up, and my time was squeezed from all directions. I waited until the proverbial last minute to start my paper. I worked well into the night. I found it hard to put across a simple message that people would clearly understand. Finally, I just went home to get some sleep.

When I got home I went straight to bed and was out before you could say "American Petroleum Institute, Manual of Petroleum Measurement Standards, Chapter 3 -Tank Gauging", I was asleep.

I awoke in the middle of the night thirsty, and went to the kitchen to get a glass of water. I walked out of the bedroom and straight into the back yard. I thought to myself, "Where is the kitchen?" Did my wife remodel the house today? However, there sitting in the middle of the backyard, was an aboveground storage tank (AST). "How strange", I thought.

I went back into the bedroom and woke my wife.

I said; "Honey, there is an Aboveground Storage Tank (AST) in the backyard."

She asked, "Have you been drinking?"

I said, "No, I was unable to find the kitchen."

She asked me, "Maybe it's filled with oil? Maybe we're rich!"

I said, "I don't know what's in the AST but thought I will go back and check."

I put on my Nomex, Safety boots, Hard hat, Ear plugs, and Safety glasses and went to the backyard. I climbed the stairs of the cone roof tank to the top, and opened the API 24" manway. It didn't smell like petroleum. I couldn't see any liquid, so I went back into the bedroom to get my certified explosion proof flashlight. When I came back and shined the light into the manway, all I could see was money. Lots and lots of money!

I climbed down the tank stairway and ran back into the bedroom.

I told my wife, "The AST in the backyard is full of money!"

She said, "Full of money? Are you sure you have not been drinking?"

I said, "Yes, money, and no, I'm not drinking. At least not yet."

She said, "You are a tank gauging expert, how much money is in the AST in the backyard?"

I said, "Lots and lots of money."

She asked "How much money? Ten dollars, a thousand dollars? Maybe a million dollars?"



Being an expert in tank gauging, I went back out to the AST in the backyard with a NIST certified measuring tape. The AST measured the tank, 24 feet in height. Using the tape to measure outage from the top of the manway to the top of the money, it measured 7 feet and 1/32nd inch.

I went back into the house and told my wife, "We have exactly 17 feet and 1/32nd inch of money."

She asked, "If your API certified tape is graduated in 1/8ths or 16ths of an inch, why did you measure 32nds of an inch?"

I said, "It just sounds more accurate than the 1/8ths required by API MPMS 3.1A - manual reference measurement accuracy."

She said, "Boys will be boys, you have to measure everything. So how would you prove this accuracy in real petroleum storage tanks or in a cylinder of water?"

I thought to myself, she has been reading our white papers on the difference in Volume vs. Level measurement, certified accuracies, etc.

She then asked, "If all the money was stacked up it would be 17 feet high, with no 32nds of an inch?"

I said, "No, it would be a lot more than that. It looks to be 17 feet high across the diameter of the tank."

She asked, "What is the volume of the money in the tank?"

Dumbfounded, I couldn't answer. She had been paying attention all these years when I was talking about the measurement of volume and not level when I pumped gasoline at the gas station.

She asked me, "What is the diameter of the tank? Would that be enough information to calculate how much money is in the tank?"

I said, "The AST in the backyard is very similar to tanks that I have strapping tables on at work. I can estimate the amount of money, or the volume of money, by the height and diameter of the AST!"

She then asked me, "How can you tell me the amount of money in the AST if you don't know what type of money is in the AST? Is it filled with ones? Is it fives or tens? Are there any twenties or fifties? Did you see any hundreds? In other words, what is the quality of the money in my tank? Have you seen my slippers?"

We then went together to the AST for a further look inside.

We looked into the manway. There were ones, fives, tens, twenties and an occasional fifty and hundreds.

My wife asked, "What's this?"

I said, "That is a gauge well for measuring and sampling the product within an AST."

She said, "Shouldn't we measure and sample the money in the gauge well to get an accurate measurement of quality over the height of the tank?"

Together we measured the money in the gauge well. It was eight feet from the reference point.

She asked, "Did we lose a foot of money?"



I said, "It could be the extra weight on the roof. Didn't you notice the roof flexed when we climbed on top of it?"

She said, "What did you say? Are you calling me fat?"

I said, "No, Dear. The tank roof naturally flexes when it is filled. The gauge well is used to provide a stable reference point that's not effected by roof movement when installed correctly, but outage can still be effected by bottom movement."

She said, "That's what I thought you said."

We then took a sample from the gauge well. It was fifties, hundreds, an occasional one, and nothing but paper near the bottom.

My wife asked, "How can you estimate the amount of money in the AST if the quality of the product varies with depth?"

I said, "Stratification; Maybe we need to measure multiple strata in order to determine the quality of non-homogeneous denominations. I need to think about this one."

She asked, "How come there is nothing but paper towards the bottom of the tank? Should we subtract the paper from the volume? However, are you sure we are not losing any money from our tank? The level has gone down a foot. Are you positive there isn't a leak or something?"

Just then we saw a fifty fluttering by in the wind. It was followed by bills of most denominations.

She asked, "What's happening?"

I said, "I think we are suffering from emissions?"

She said, "How much money are we losing from emissions?"

I said, "I don't know. We need to close the manway and the gauge hatch."

She quickly did.

We then climbed the stairs back down to the bottom of the tank. We were standing there pondering the situation when my wife noticed a pile of money at the base of the tank.

She asked, "Is the money overflowing out of my tank?"

I said, "No, we just measured it. There is still room left within the tank so I don't think the money is overflowing our tank."

She asked, "The sun is coming up, could my money have expanded and ruptured my tank?"

I said, "No, we just looked in the gauge hatch and exposed the money was vented to Ambient conditions, so there is no expansion, over pressure, or vacuum in the vapor space of our tank. Maybe it's just settling."

Maybe was I dreaming. This was starting to sound very, very familiar.



She asked, "Could there be a hole in my tank?"

I said, "I'm not sure, there could be a hole causing a leak in our tank."

She said, "You measured the level of the money, Mr. Tank Gauging Expert, but you still can't tell me how much money or the volume of money inside my tank!"

Just then I remembered my tank gauging lullaby, "API Manual of Petroleum Measurement Standards Chapters 3.6 - Measurement of Liquid Hydrocarbons by Hybrid Tank Measurement Systems, API MPMS Chapter 16.2, API MPMS Chapter 18.2, API MPMS Chapter 7.4 Temperature, API Standard 2350 Overfill Protection, Vapor Emission Monitoring, Leak detection, etc..

As I awoke, my wife was standing there with a cup of coffee.

She asked, "Did you finish your paper?"

I said, "Yes, I think so."

Moral of the Story:

The product in your tank is money.

- You need to physically install and test tank gauges on a petroleum storage tank in operation to see what data, actual measurement accuracy of all parameters, and benefits that technology can provide.
- Within most of the world, you don't determine the measurement quantity or product quality by measuring only Level (OIML R-85 certification).
 - Do you buy and sell petroleum by LEVEL? NO.
 - Petroleum products are bought or sold by VOLUME (parameters include product quality) and chemicals by MASS.
 - When I see tank gauging project specification state only a required gauge accuracy level, it shows to me a total lack of knowledge in tank gauging metrology or use of a vendor written specification (whose technology lacks other VOLUME parameters accuracy).
- In metrology, the ATG should be tested against a known reference (Using standards for manual reference hand lines, electronic thermometer, density samples, and water (pasted tape) from the same product media and physical tank entry (with or without a Gauge well), measuring or calculating all (Volume) parameters for the purpose of 1) ATG calibration and 2) Verification of ATG accuracy for custody transfer or inventory.
 - If the ATG (multiple instruments) measure various parameters from different locations (or product media, i.e., inside or outside the gauge well, in the middle of the tank or on a pipe leg outside the tank, you will get different results than the reference measurement (cumulative error).
 - In an ATG System, if you use one or two instruments capable of measurement to custody transfer accuracy and two to three bad instruments (cumulative error) for Volume. Does this make the ATG System custody transfer accurate, or misleading, or does it depend upon the measurement standard (location) it's being used?
 - Installation error or in tank location error
 - Instrument capability – Technology and Accuracy
 - Advertising - It could be misleading if custody transfer certification of only one parameter is applied to the customers need for loss control, i.e., example LEVEL.



- Again, Volume is measured by either Hybrid Method (Level, Temperature, Density, & Water) and/or Hydrostatic Method (Mass, Density, & Water). API MPMS 3.6 and 16.2 or similar ISO, GOST, etc. standards.
- All measured or calculated Volume parameters must be installed properly, in the correct location, and have the technology to measure them accurately vs. the manual reference measurements.
 - Vendors should specify within a quote any changes from advertised equipment accuracy to lesser quality equipment and accuracy.
- Require an ATG that can provide both Quantity and Quality measurement of the product using valid measurement technology and calculations for each parameter.

MTG "Multi-function Tank Gauge":

- MTG "Multi-function Tank Gauge" provides the measurement of Volume by both Hybrid and Hydrostatic Methods to custody transfer accuracy.
- MTG "Multi-function Tank Gauge" provides measurement of both Quantity and Quality from the same location as the manual reference measurements gauge well or without gauge well).
 - Some technologies require "still product" to provide accurate measurement, inaccurate gauge well design and installation can also cause level error.
 - Technologies requiring the whole use of a gauge well and a separate gauge well for manual reference measurements will always produce cumulative measurement error.
- MTG "Multi-function Tank Gauge" is bottom referenced and optionally provides roof / bottom movement indication or measurement. Tank top outage measurement devices do not measure roof or bottom movement (measurement error).
- MTG "Multi-function Tank Gauge" provides real time Quality Sampling of Product at the Top, Middle, and Bottom to insure homogeneous product quality for gasoline, Diesel, Jet fuel, etc. to meet recent API standards for fuel quality and testing before distribution.
- MTG "Multi-function Tank Gauge" provides product stratification parameters (Density, Water, and Temperature) for operations:
 - Schedule product operations based upon knowledge of what is happening in the tank and the time frame, not estimates.
 - Electricity use (Mixers, Heaters, etc.)
 - Crude settling, De-watering of tanks (use of De-emulsifiers)
 - In-tank Blending (Homogeneous product condition)
 - Temperature monitoring (Overheating, discoloration, etc.)
 - Monitoring of vapor space for
 - Pressure relief vent settings (Icing over relief vents, stuck vents, etc.)
 - Inert gas blanketing
- MTG "Multi-function Tank Gauge" can also provide other Loss Control (Safety, Environmental) benefits:
 - Unauthorized Movement
 - Leak detection (Mass sensitivity)
 - Product contamination
 - Incorrect line-ups (Transfers)
 - Theft
 - Tank Rupture Monitoring (Over Pressure and Vacuum)
 - Hydrocarbon vapor emission monitoring
 - Overfill protection (Redundant 3055, 3018, 3024 gauge options)
 - High-High, High, Low-Low sensor alarms
 - Critical sensors (Vapor and Mass)
- MTG is a tank gauge designed for Low Mean Time Before Repair (MTBR).
 - Intrinsically Safe Barriers (off the shelf replacement) Spares required



- Transmitter card – replace card and re-plug in non-volatile memory card with stored parameters for that tank. Spares required
- Middle sensors failure(s) is no issue for continued operation. Schedule replacement.
- Critical sensors (redundant critical sensors can be installed in either hot or cold mode)
- Fully Redundant MTG for critical applications eliminates MTBR on single MTG failure
 - Operations requiring two gauges on one tank (through one tank opening)
 - Operations by two parties (Distributors, Lease holders, Government agencies, etc.)
- MTG “Multi-function Tank Gauge” has two interactive (patented) self-calibrating methods.
 - Does a non-calibrated gauge represent a failure with requested manufacturer service representing the Mean Time Before Repair?
- MTG “Multi-function Tank Gauge” is a tank top mounted, bottom referenced probe (Innage gauge)
 - The 2” diameter (to 60’) allows for installation directly within a 6” or larger gauge well (with room to do manual reference measurements) or without a gauge well. Larger diameter is used on taller tanks.
 - No moving parts
- MTG “Multi-function Tank Gauge” is configured to provide optimal application needs per tank based upon completed MTG Questionnaire.
 - Required data (most usable data from a tank gauge)
 - Required accuracy (local standards)
 - Number of sensors and location
- Only one tank entry and one electrical connection (for both power and signal) is required. It is bottom referenced (standard), with NO moving parts.
- MTG measures or calculates the following data from the gauge head: Volume, Level, Mass, Multi-point temperature or Average product temperature, Multi-strata density (True density), Average (Reference) product density, Total Water (Free water, Emulsified Water, Entrained water), Vapor pressure, Vapor temperature, Vapor density, and unauthorized movement (leak detection) by mass. Optional Ambient sensor for: Ambient pressure, Ambient temperature, and Ambient Density.

New patents (U.S.) and patents pending (International) will allow additional sensor types and additional MTG capabilities in the near future.

Remember the lullaby, “American Petroleum Institute, Manual of Petroleum Measurement Standards; Chapter 3.6 Measurement of Liquid Hydrocarbons by Hybrid Tank Measurement Systems” and Chapter 16.2 Mass Measurement of Liquid Hydrocarbons in Vertical Cylindrical Storage Tanks by Hydrostatic Tank Gauging, these are the only two standards for volumetric measurement of Hydrocarbons within a petroleum storage tanks.

