Calpine Geysers' Units 18 and 20's Stretford System Froth and Balance Tank Level Measurement

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Keywords

Stretford abatement system, H2S abatement, froth tank, balance tank, level measurement; non-contacting radar, bubbler, air emissions control equipment

ABSTRACT

Depending on the global location of the geothermal plant, H2S abatement may be required to meet local environmental regulations. At Calpine's Geysers, a number of the operating power plants have Stretford H2S Abatement systems while others are equipped with burner-scrubber systems. The primary abatements systems for surface condenser vent gases are the Stretford Abatement systems. Burner-scrubber systems are in use on the direct-contact condenser units. Ten of the Geysers power plants use Stretford Abatement; the five remaining units use the burner-scrubber system.

This paper focuses on the liquid level measurement technology in use in the Stretford system froth and balance tanks. These tanks were initially designed with "bubbler" level measurement systems, when the plants were constructed by Pacific Gas & Electric (PG&E) in the 1980's. Tank level measurement in these systems is particularly challenging because the Stretford solution and froth are two phase solutions containing high concentrations of suspended solids and have a highly variable solution density. Lower density foam and froth layers tend to form on solution surfaces causing false level indications in instruments that depend on solution height and density such as bubblers. Additional difficulties are encountered when suspended solids settle in the tank bottoms, effectively reducing the tank volume.

In 2012, the bubbler systems were replaced with non-contacting radar level transmitters. Non-contacting radar level transmitters have been used on the froth and balance tanks since that time.

The Stretford process is reviewed; the froth and balance tanks, which are part of the Stretford Abatement system, are detailed; bubbler technology is over-viewed; and finally, non-contacting radar as a solution in these applications is discussed.

Introduction

Calpine Geysers' Units 18 and 20 are power plants that use the Stretford Abatement system to remove H2S from non-condensable tail gas. Within the Stretford process are several tanks, namely the froth tank and the balance tanks, which, for their initial installation used bubblers for level measurement. In 2012 the bubblers were replaced with non-contacting radar level units.

Process Description

The process as described by Benn, et. al.:

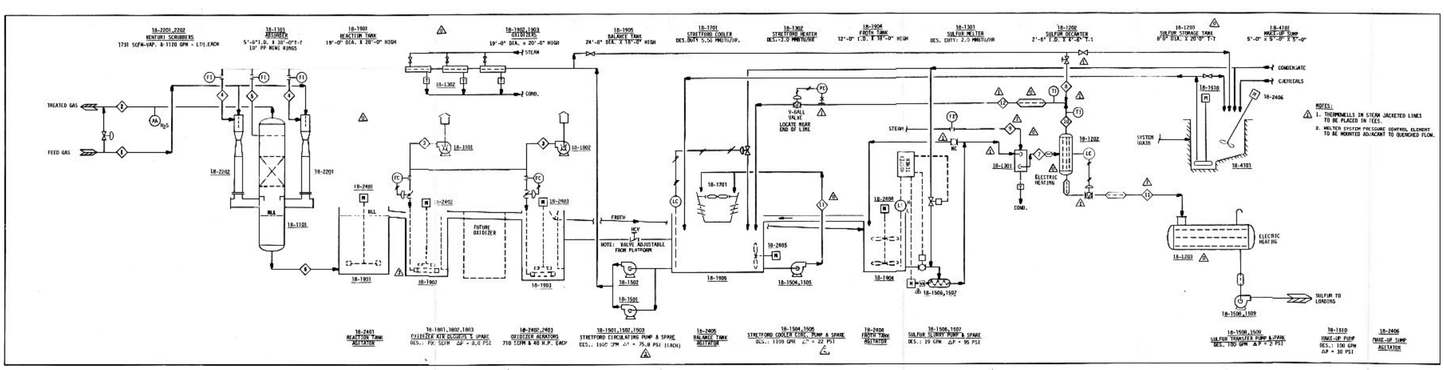

Figure 1. Process Flow Diagram of Calpine's Unit 18.

The non-condensable gas from the gas removal unit first passes into the two Venturi scrubbers in parallel. Most of the lean Stretford solution passes through the Venturi scrubber(s) as the motive fluid. In the case of U14 with its very low current gas flows, an unusually large fraction of the H_2S appears to be removed across the Venturi scrubbers; gas enters the Venturi scrubbers with ~ 3 vol% H_2S and exits the baffle/channel device into the main part of the Absorber with only roughly 20-120ppmv of H_2S remaining. The gas then passes upward through a single bed Absorber in order to remove the remainder of the H_2S. The absorber contains Flexi-ring packing, which is a large diameter, open-type, plastic, random packing. H_2S is removed to less than 1 ppmv typically, well under the 10ppmv permit limit.

From the sump, at the bottom of the absorber, the solution then flows via gravity through a line that enters near the bottom of an open-topped, stirred reaction tank. The purpose of the reaction tank is to allow the sulfide that was dissolved into the liquor in the Venturis and absorber to react to from elemental sulfur particles. From the reaction tank, the solution flows sequentially through two equally- sized, round, stirred oxidizers. Two blowers supply air to the oxidizers. The oxidizers serve two primary functions, 1) they separate the sulfur particles from the liquor via froth floatation, and 2) they re-oxidize the vanadium catalyst contained in the Stretford liquor. Diesel or other flotation /frothing aids are not currently used, although equipment is believed to be available to do so.

Lean Stretford solution underflows a weir in the second oxidizer to the balance tank. Dedicated pumps circulate a stream of lean solution from the balance tank up and into a cooling tower/evaporator located above the balance tank The purpose of the cooling tower/evaporator is to maintain the water balance of the system. Another set of three (3) pumps (two operating, and one, spare), Stretford Circulating Pumps, send lead Stretford solution from the balance tank back around to the Venturi scrubbers and to the top of the absorber. Froth crated in the oxidizers overflows the second oxidizer via a weir into the stirred froth tank. From the froth tank the sulfur froth is pumped via a progressive cavity pump to a "Straight line" continuous belt filter, with belt wash. The washed cake discharges and, if meeting product specifications, is sold.[1]

Unit 18 and Unit 20 Bubbler Installations on Froth and Balance Tanks

The process in the froth and balance tanks consist of: foam; liquid; and liquid with solids near the bottom of the tank. Both tanks are agitated, open to the atmosphere and have a temperature of close to 100 °F. The purpose of the froth tank is to agitate the tank contents to a uniform consistency for the filter belt, the next unit downstream of it. Once filtered, if the sulfur meets product quality control limits, the sulfur can be sold as an agricultural soil amendment. The balance tank is used to feed the circulating pumps and ensure there is sufficient volume for them to draw from. The balance tank has a small evaporative cooler mounted directly over it, and, the liquid in the process has the color of root beer with some foam on top. Both tanks are agitated continuously. The tanks are epoxy-coated carbon steel with dimensions 20-25' diameter and 10-20' high).

The challenge with measuring level with traditional differential pressure technology on these tanks is that the specific gravity is not consistent throughout the contents. There is foam and liquid with solids in the area of interest in the tank. Further, there is a 32" offset at the bottom of the tank.

A bubbler system is a top-down tank level technology requiring no bottom or side tank penetrations. It is a straight-forward system that works well for liquids with fluid properties similar to water regardless if the fluid is a slurry or has solids in it and can withstand air being passed through it. Further, bubbler systems have been used on less critical applications successfully. (See Fig. 2 as an example of a bubbler panel)

Each of us has, likely, seen and experienced bubbler technology. Just think for a moment of using a straw to drink liquid from a glass. Consider the glass as a tank and the straw, the bubbler tubing. As you blow through the straw you are sending "compressed air" through the liquid in the glass. The higher the level in the glass, the harder one has to blow. There is a corresponding relationship between the pressure being applied and the resulting level. If one were to add a gauge to the system and connect the straw to it, while one is blowing on the straw, one would get a corresponding pressure measurement from which one could measure the level.

Obviously, this technology is for vented tanks and the process must tolerate air being bubbled through it. It requires compressed air to create the constant back pressure on the transmitter, which may have some costs associated with it over the lifetime of the installation. The bubbler is used with a differential pressure (d/p) transmitter from which the electronic signal can be sent to the distributed control system for monitoring tank level or for tank level control. If the liquid to be measured contains mud, solids or fiber particles or other debris, these tend to plug the impulse line (the "straw"), and create an artificially high pressure, resulting in erroneous level readings.

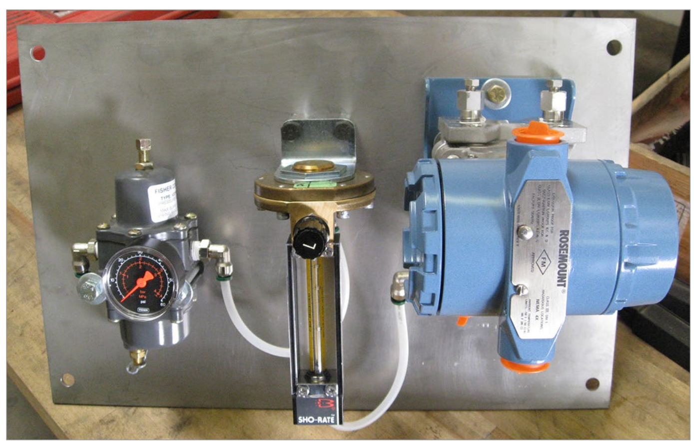

Figure 2. Example of bubbler panel.

In the past few years, Calpine Geysers has updated the level measurement in their processes to provide more reliable measurements. The majority of these updates are on condensers, cooling tower basins, and displacer-replacement applications. These applications now use radar technology. Given the success with these measurements, the froth and balance tank level measurements were considered good candidates to be updated (See Fig.3 and Fig 4 for current non-contacting radar installations at Unit 18).

Non-contacting radar, like bubbler technology, is a top-down technology. The technology, however, works independent of changing density or specific gravity. Thus, the solids in these tanks are not an issue, making radar a good fit for these applications.

Non-Contacting Radar Installations

Figure 3. Unit 18 Balance Tank Non-Contacting Radar Installation.

As the solids settle out in the tank, the density and specific gravity are higher at the bottom of the tank and the specific gravity becomes smaller closer to the top of the liquid and foam surface. The consistency of the solution in the balance tank is similar to that of water or a foamy root beer; while the consistency in the froth tank on the surface is that of pea soup.

The distance to the surface is measured by short radar pulses, which are transmitted from the antenna at the tank top. When the radar pulse reaches the media with a different dielectric constant, part of the energy is reflected back to the transmitter. The time difference between the transmitted and reflected pulse is proportional to the distance to the product surface, from which the level, volume, and level rate of change are calculated.

Figure 4. Unit 18 Froth Tank Non-Contacting Radar Installation.

Applications, with, for example, turbulence, foam, long measuring ranges, disturbing objects, and low dielectric constants can reduce the energy reflecting back, and in worst case eliminate it completely with the result that no surface can be detected. The reflection intensity can, however, be improved by using a high performance radar with dual-port technology.

That this is a top-down technology means it can be installed without emptying the tank of its contents. There are no moving parts and no recalibration is needed, thus maintenance is reduced. Many different antennas are available as are various mounting options. The antenna selected for these particular applications was the 4” 316 stainless steel model.

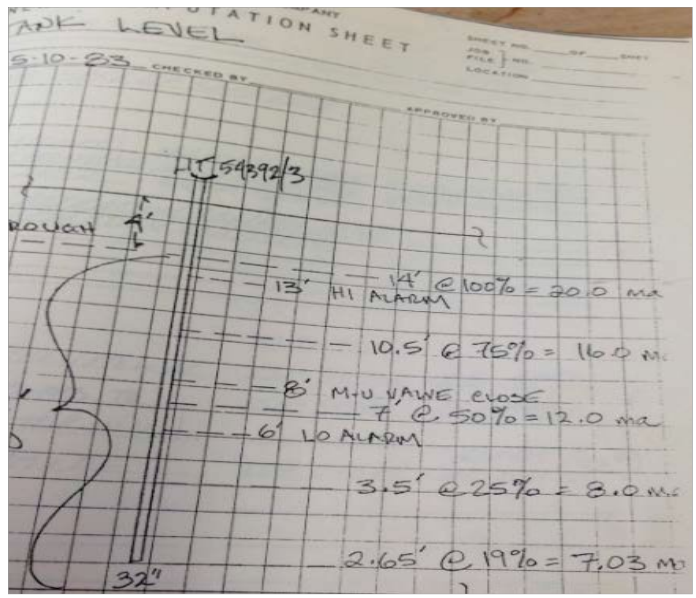

Figure 5. Initial bubbler configuration with offset.

There were some limitations in these installations on the placement of the radar units. The balance tank has the cooling tower located directly above it and both the froth and balance tanks have agitators. Using a tool within the radar transmitters’ software called circular polarization allowed the radar units to be mounted within the constraints presented. Circular polarization mitigates the need to mount the radar unit at a specified distance from the tank wall; circular polarization has the capability to rule out obstacles, such as agitators and baffles that may produce echoes, which for some radar units, may register falsely as the surface level.

Commissioning and Use of the Radar Units

The non-contacting radar units that are installed utilize HART® as the communications protocol. (Alternatively, Foundation Fieldbus is available.) HART® rides asynchronously over the 4-20mA signal to give access to the device configuration and allow troubleshooting. With HART®, one can be connected to the device anywhere in the 4-20mA loop. This is particularly helpful if the radar unit is mounted on a tall tank. Using the HART® protocol eliminates the need to climb to the top of tank where the

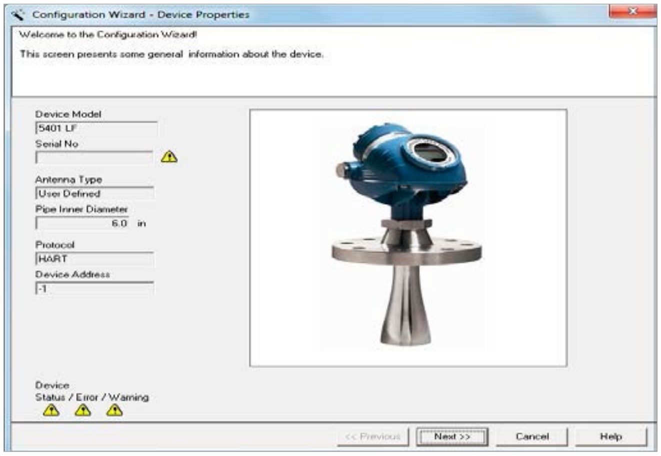

Figure 6. Radar Master Wizard Transmitter Screenshot.

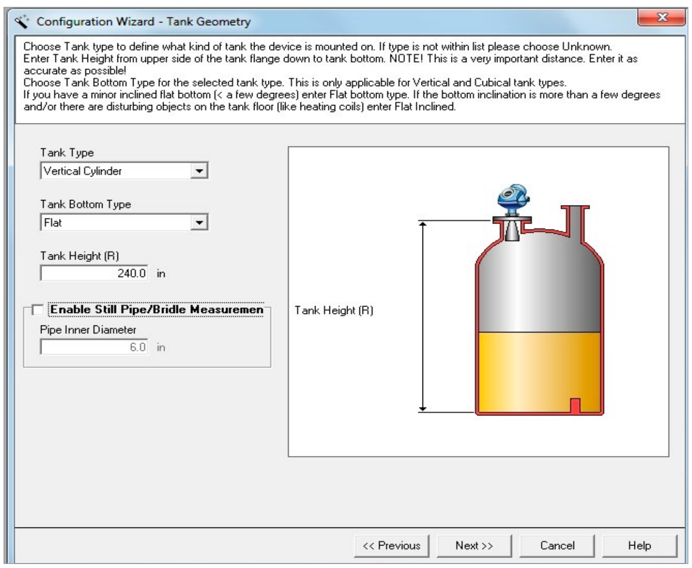

Figure 7. Radar Master Wizard Tank Geometry Screenshot.

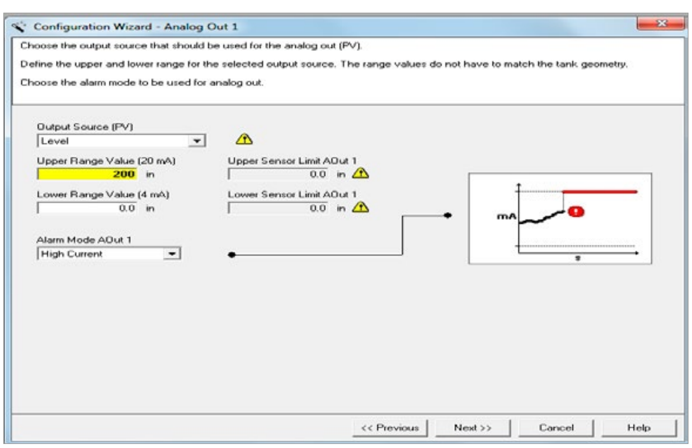

Figure 8. Radar Master Wizard Analog Output Screenshot.

transmitter is mounted thus reducing the exposure to safety hazards (tall tank, narrow stairs, and a dark stormy night as an example); rather, one can simply communicate with the device from an I/O card in a termination panel in a safer, drier environment.

These units were configured using HART® protocol, as mentioned, with a HART® modem and complimentary Radar Master software. Radar Master is a graphical tool for on-line and off-line configuration, logging, capabilities, and service. A basic wizard will quickly walk the user through the commissioning process as below. (See Figures 6, 7, and 8).

Another feature of Radar Master allows masking of the noise returned from internal tank obstacles. Echo curves are tools t hat allow the technician or operator to analyze the microwave energy peaks detected by the radar. In the Rosemount Radar Master, if the return is from a known tank obstacle, it is possible to register this as a false echo peak. In the diagram below (See Fig. 9), the radar is installed on a tank with two obstacles in the tank. The gray regions show these returns registered as false echoes allowing the radar to track the true surface peak as below.

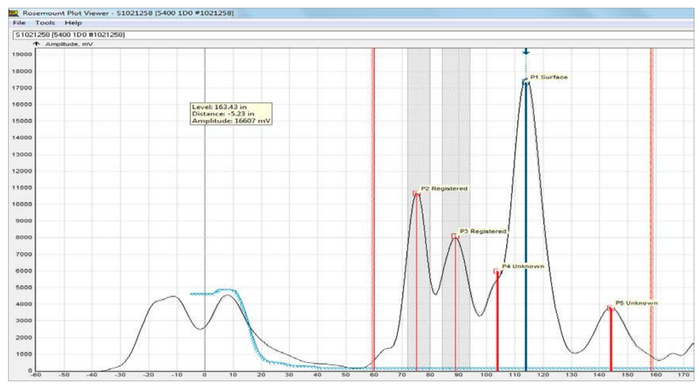

Figure 9. Radar Master False Echo Registration Screenshot.

Conclusion

This paper has reviewed the replacement of a bubbler system with non-contacting radar on the froth and balance tanks in the Stretford Abatement System at Calpine Geysers' Units 18 and 20. To date, the units have provided reliable tank level readings in tanks that have challenging processes and internal tank obstacles.

Reference

Benn, Brian, and , Kenneth E. McIntush, Carrie Ann M. Beitler, Darryl L. Mamrosh, and Dr. O. E. Hileman, 2010, "Unit 14 / Sulphur Springs H2S Abatement Process Screening and Stretford Improvements Study — Part 1", *GRC Transactions*, Vol. 34, paper #1028813

[1] B. Benn, K. McIntush, C.A.M. Beitler, D.L. Mamrosh, Dr. O.E.Hileman, "*Unit 14 / Sulphur Springs H2S Abatement Process Screening and Stretford Improvements Study — Part 1*", *GRC Transactions*, Vol. 34, 2010, (paper 1028813).