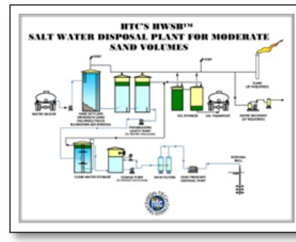
Automation in Salt Water Disposal Plants

Taking Advantage of 21st Century Technologies in 2014

INTRODUCTION



Todays SWD Plants demand a a large dose of 21st centruy automation. Using up-to-date automation translates to more oil revenue and less facility and well maintenance. Automation often makes the difference between a very successful SWD Plant and one with protracted payout, or worse. Since the balance between success and failure can rest on the shoulders of automation, and because comprehensive SWD Plant automation systems are few and far between, this paper attempts to bridge the knowledge gap that leads to technical and economic success in the SWD business.

THE INDUSTRY: PAST AND PRESENT

The petroleum industry is steeped in tradition, nostalgia, and luck. In the earliest days of the industry fewer than one attempt in ten to drill for oil was a success. Luck played a big a part in who became an oil baron and who wound up on skid row.

As more and more oil fields were discovered the image of oil blowing out over the crown burned into the memory banks of generations of oil workers. It embodied the nostalgia of past success. For decades oil well drillers actively sought out this image. They eagerly hoped to achieve it so they could be their generation's newest oil tycoon. Today however, this same image triggers thoughts of environmental disaster and negative financial ruin. The BP oil spill in the Gulf of Mexico comes to mind.

What a change!! This is just one of thousands of changes that have taken place since Drake's first oil well blew in on August 12th, 1859.

Change has propelled the oil industry toward greater and loftier goals every step of the way. Most change has had its roots in advancing technologies, and automation has played a big role. But automation didn't exist in 1859! First we had to experience the evolution of electricity and electronics, and then came automation. These interrelated technologies have literally taken us out of the darkness and into the light.

Today, we rarely drill a "dry hole" because of evolving technologies centered on electronics and automation. The marriage of these two technologies has taken the "luck" out of finding oil, and has made the dependence on manual oilfield operations almost obsolete. But, the operative word here is "almost".

TRADITION: "WE'VE ALWAYS DONE IT THAT WAY"

Perhaps the bane of the 21st century in any oilfield operation when we ask why we're doing whatever it is we're doing is the statement, "because we've always done it this way". It's the tradition of a 154 year old industry that's suffered from severe "boom" and "bust" cycles, losing new knowledge in every single cycle. The few who remained in every bust had nothing to fall back on except the ways of the past, making it harder and harder for new technologies to find their way in.

This reliance on the ways of the past is responsible for stemming the course of progress in some parts of our industry. It stifles growth and hand cuffs opportunities to enjoy prosperity in an industry that should be its proudest moments. And happily, it's changing!!

Look at the contrasts! The drilling side of the industry is being led out of the darkness by the likes of Helmerich and Payne and National Oilwell Varco who have made great strides in the field of automated oil well drilling. The results are dramatic. It took months to drill the 59' deep Drake well in 1859. Today we routinely drill 12,000' directional wells in ten days.

On the production side of industry, automation has been slower to take hold. The first attempts at automation were unreliable and barely affordable. Then, with the advent of the 'space program" came a dramatic evolution in solid state electronics. By 1970 basic automation systems were being installed on offshore platforms to enhance operating safety. Fiber optics replaced hard wire. And then came Apple, and the computer age. By 1995 automated smart devices were becoming commonplace. Automation was about the is finally coming into its own. Leases are operated at least semi-automatically with operating data sent via SCADA systems to the local operations and engineering staff for evaluation. Yet, in the SWD side of the industry, pumps are started and stopped by hand, or by older on-off technologies like "Murphy" switches. Most tanks levels are determined by hand, or not at all. Fluid quality, if it is a concern at all, is determined by samples sent to off-site labs that may not generate results for days or weeks. Why? Because we've always done it that way.

It's time for change! It's time to move into the 21st century!

SALT WATER DISPOSAL WELLS – THE HEART OF ANY SWD PLANT!

Each water disposal or water injection well is unique and different form oil producing wells. The completion is totally different, often opening a large cavernous area in the zone targeted to take the water that will be eventually pumped into it. The most porous sands are usually targeted because they have the highest probability of accepting large quantities of water at the lowest injection pressures. These are often less stable formation intervals than we see in search for oil or gas. As such, these less stable formations are prone to slough, and when they do the formation collapses inward toward the well bore, eventually sealing it off.

Nearly all petroleum geologists agree that it is quite important to keep water flowing into these wells to avoid well bore damages such as sloughing. Doing so prolongs the life of the well. But who knew? Most SWD Plant owners are investor-owned companies with no petroleum geologist or automation specialists on staff! So, since no one knows, ignorance is bliss.

The result is that most SWD Plants inject water into their respective disposal wells on cycles of "on-again, off-again". In any one instant the flow rate may be very high, and in the next instant no flow at all. This scheme is perpetuated because we've always done it that way. High-low switches like Murphy switches turn high pressure disposal pumps on when tank levels get high, and off when levels are low. The results are predictably awful … and costly!

Can automation overcome this dilemma? Of course!

What should be done? An automation specialist should be called in to design a marriage of necessary hardware and software to manage each SWD Plant so the high pressure pumps continue to run 24/7/365, or at least to conditions as close to this as physically possible.

Is this doable? Of course it is!

SWD PLANT "MUST HAVE" AUTOMATION

While every SWD Plant is different, the automation needs remain reasonably consistent. In overview, they are:

1. *Establish steady-state flow wherever possible.*
2. *Use throttling level transmitters in all cases.*
3. *Use dedicated PLC ladder logic.*
4. *Use VFD/VSD systems to control pump motor speeds consistent with tank and proportional to tank level transmitter outputs and PLC algorithms.*
5. *.Operate high pressure pumps so water is injected downhole 24/7.*

MAKING IT HAPPEN

Selecting the right components and developing site-specific compute code is not for the faint of heart. The facility designer should provide a bill of materials that includes the level detection and level transmitting end devices, and the size and type of the pumps based assuming the above five "must have" automation principals. Low shear pumps should be used throughout the process portion of the plant, while high shear pumps can be used downstream of the final water clarification stage.

The automation specialist should select a cost effective, commonly available, PLC such as the GE 90/30 or GE 90/70, or the Allen Bradley 5000, Siemens S5/S7, or equal. He/she should select the system he/she is most familiar with, as the control logic and code development methods are different for each one.

In the most general of terms the software should:

1. *Control the ability of any/all offload trucks to offload into the facility.*
    a. *In the event of an upset or high tank level condition one or more of the offload lanes should be shut off to prevent additional offload events until the alarm condition is resolved.*
2. *Confirm that each truck is properly grounded.*
    a. *Stop any offload event break in the ground circuit.*
3. *Identify each individual truck to be offloaded.*
    a. *Measure the amount of fluids offloaded and account for it truck-by-truck.*
4. *If offload pumps are installed, start and stop these pumps.*
    a. *Drivers are to initiate the start signal.*
    b. *The automation system logic is responsible to allow or disallow the permissive signal for any offloading event.*
5. *Monitor the pressure differential across any/all inlet filters/strainers.*
    a. *Alarm when the pressure differential is within 75% of maximum to alert the truck driver.*
    b. *Shut down any offload lane when 100% of the preset pressure differential is exceeded.*
6. *Monitor and control the level in the initial receiving tank(s)*

   a. *A throttling level transmitter should be installed in each receiving tank.*
      i. *These can be Guided Wave Radar (GWR), Ultra-sonic LLCs with built-in densitometers, or equal.*
   b. *If transfer pumps are used to move the fluid out of the receiving tank(s) the 4-20 ma output from this level transmitter should be used to control the pumping speed(s) of the pump(s).*
      i. *If more than one pump is used, they should be cascaded using the PLC to do so on a 4-12 ma/12-20 ma split.*
   c. *A high level ESD level transmitter should be installed in each receiving tank which should shut the Plant down in the event of either a high –high or a low-low alarm condition.*

7. *In some plants a de-sanding vessel is used to separate and collect fine particulates that may enter the Plant. A dual channel GWR transmitter is to be used to detect sediment build-up in the bottom of the de-sanding tank.*
   a. *It should alert the Plant Operator to remove the sediment when it reaches a level of 5 feet.*
      i. *It should shut down the plant if the sediment level reaches 6' as this approaches the limit of the tank to accept and store these heavy solids safely.*
8. *Water storage tanks either receive the water next, or after it is clarified. In either event, they should be also fitted with dual channel GWR's tuned to detect the liquid/gas interface and the oil-water interface.*
   a. *The PLC should graphically display the tank total level and oil layer level at all times for the Operator to see.*
      i. *This, and all PLC inputs, should be trend lined and the trends should be graphed to the Operator and all others can see and changes in both short-term and long-term trends.*
   b. *As the oil level increases the operator should be alerted to either float it off to oil storage, or pump it off to oil storage through the oil-water separator (Gunbarrel, or HWSB™ Skim Tank).*
   c. *The PLC should alarm when any of these tanks reaches either a high or low level condition.*
      i. *The PLC should shut the plant down, or isolate the individual offending tank if possible.*
         1. *When each water storage tank is fitted with automatic inlet and outlet valves.*
   d. *If a pump or pumps are used to evacuate the water storage tanks, the speed of the pump(s) should be controlled by:*
      i. *The level in the water storage tanks.*
      ii. *The PLC logic on a feed-forward basis.*
         1. *When there are no trucks offloading, the PLC logic should slow down the low pressure charge pump to the high pressure pump(s) and the high pressure pump(s) to assure that the plant has the maximum water possible to feed the disposal well with at least minimal flow 24/7*
         2. *When one or more trucks is offloading, the PLC logic should speed the charge pump and the high pressure pump it feeds based to assure that the plant does not reach a high-high level condition..*
9. *Monitor the level in the oil-water separation vessel (Gunbarrel or HWSB™ Skim Tank).*
   a. *If the level increases to consume 25% of the freeboard space above the normal oil-water interface, alarm the operator.*
   b. *If the level increases to75% of the freeboard space shut the Plant down as an Emergency Shut Down (ESD) condition.*

      i. *The PLC should annunciate this and all alarms and shutdowns on a first-out basis tied to the time of the trigger occurred.*
   c. *Monitor the oil-water interface level to determine any/all growth in the "emulsion" layer.*
      i. *Alarm the Operator when the oil-water interface level has dropped 2 feet.*
         1. *Instruct the Operator to drain the "interface drawoffs" manually until the alarm clears itself.*
         2. *Automatically drain the BS&W if the Interface Drain connection is fitted with an automatic valve.*

10. *A surge tank is commonly used downstream of all storage and separation process vessels. The PLC should monitor, trend, and annunciate this level at all times.*
    a. *As this level increases slowly the charge pump feeding water from this tank to the High Pressure pump, and the High Pressure Pump should be caused to increase pumping rates by slowly increasing the motor speeds.*
       i. *The feed-forward logic should buffer this based on the offload events occurring at the same time.*
          1. *If several trucks are offloading as the Surge Tank level is rising, the Charge Pump and the High Pressure Pump speeds should be increased more rapidly.*
          2. *If there are no offload events occurring as the Surge Tank level begins to rise, then little or no pump speed changes should be initiated.*
    b. *If the Charge Pump and High Pressure pump are running at 100% and the Surge Tank level continues to increase, the VFDs should increase the motor speeds to the limit of the system (often 100 Hz)*
       i. *Even though conventional wisdom is for controlling motor speeds on a 0-60 Hz. Basis, the addition of 10:1 turndown VFDs normally allows for the increase in speed up to 100Hz without damage to the VFD or the motors they interface with.*
11. *All short-term alarms, shutdowns, and trends should be visible to all authorized personnel on the end device of their choice (i-Pads, smart phones, home PCs, etc.).*
    a. *All long term alarms, shutdowns, and trends should be recorded electronically and should be monitored, studied, and reviewed at a central location.*
12. *Water and oil quality should be monitored, alarmed when out of limits, and trended 24/7.*
    a. *The PLC should alarm or shutdown the Plant as the owner instructs.*
13. *Well injectivity rates and pressures should be measured and recorded.*
    a. *In the event the well volume disposed in any 24 hour period reaches 75% of its allowable permitted volume the PLC should alarm the condition to alert the Operator of the condition.*
       i. *If the volume approaches 95-98% of the permitted daily volume the Plant should be shut down.*
    b. *In the event the wellhead pressure exceed 85% of the permitted pressure the PLC should alarm so the operator can slow down the truck traffic and allow the well to recover.*
       i. *If the well head pressure reaches 95-98% of the permitted maximum pressure the Plant should be shut down.*
          1. *Until the plant can be adjusted for either fewer loads or offload events of over longer durations can be implemented.*
          2. *Or until the well can be worked over or stimulated to accept more water.*

ABOUT THE AUTHOR AND HTC

Bill Ball is the founder and owner of HTC, Inc. He has a long history of oilfield separation system design experience, which when coupled with his hands, field focused experience, make him one of the industry's leading SWD Plant design engineers today. After his university studies his career started in a 1,000,000 b/d waterflood operation where he was responsible for the evaluation and performance improvement of all surface facilities used in that project. Through this hands-on effort he discovered the many inherent design deficiencies and applied the modifications needed to improve the process efficiency of each. In the 50 years since Bill has accumulated a lifetime of "doing exemplified by his nine patents.

The culmination of Bill's work is the DFSD™ De-sanding tank and the HWSB™ Skim Tank. These are the backbone of his 21st century SWD Plant designs. The results are an unparalleled quality improvement in the effluent oil and water streams.

Today, HTC, Inc. is one of the industry's leading low-cost surface facilities design firms. HTC specializes in salt water disposal (aka SWD) plant, flowback water treatment plants, and crude oil processing and dehydration/desalting plant designs worldwide. HTC associates and affiliates blanket every field of engineering discipline making HTC a full service firm capable of complete turnkey designs.

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