Produced Water Treatment Equipment: Replace or Repair?

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INTRODUCTION:

It's no secret the offshore oilfield is aging. From the Gulf of Mexico, to the North Sea, to the Middle East and beyond, operating platforms are now nearing; with many surpassing the 40 year old mark. Many are in remarkably good condition but others are not. Many of the equipment packages on older platforms have not faired as well as the platform itself has. In general, offshore equipment designs incorporate a 20 – 30 year design life and that only applies with an aggressive maintenance program. Offshore Produced Water treatment equipment is no exception. In fact, this equipment faces a tougher challenge than most other topside equipment: high operating temperatures, salt laden atmosphere, open to atmosphere designs and geometries that accelerate corrosion all add up to a reduced life span. More often than not operators engage in the replacement of Skimmers, CPI unit and Flotation Cells more frequently than other equipment on the platform. The Operator must ask himself is this the practical thing to do? Although equipment replacement is sometimes preferred, is it more practical to refurbish existing equipments rather than replace it? **This is the main focus of our discussion**.

The fact is that over the course of equipment's normal lifetime, conditions change including process water characteristics, operating temperature, presence of solids, but the single most significant change that occurs is the absolute increase in produced water. In the life span of a production platform the water may increase 200% and sometimes more. Insufficient data at the onset of a project is usually the culprit that leads to equipment under-sizing or even incorrect choice of equipment. When the equipment has reached its life expectancy, or its practical usefulness what do we do, **Repair or Replace?**

There are two variables that help answer the Repair or Replace question. One is available space and the other is available funds. If we have the space and if we have the funds we may without question opt for equipment replacement. This is generally a sure thing especially if there are changes in the government regulations or process specifications that might warrant an improved design This option allows us to research and possibly test new technologies during our replacement process. Without available space or funds we may opt for repair of the existing equipment. Once our course is chartered we should embark on a "Do Diligence" before we start the finalization of the decision process.

Replacement:

What are the main factors involved?

Time and Money

- Engineering review for new equipment
- New equipment choice and costs
- Field Pilot testing of new equipment
- Cost for Transportation and mobilization
- Cost for Installation, Startup and operation
- Equipment interface with existing control systems

Strong considerations are given to replacement especially if there is new technology available that may fit into our process or even improve our method or quantity of treatment. Obvious other considerations are equipment availability, electrical requirements, flow capacities, and available utilities. All part of the prescreening process. However if the field is aging and has a lack luster performance we might strongly consider repair. Time and funds available are also a strong consideration.

Repair:

What's involved?

● Site visit to define present physical condition and operating limits
● Provide a Wastewater Equipment Survey including observations and recommendations
● Cite potential improvements to existing equipment
● Wastewater analysis
● Proposal to implementation improvements
● Pilot testing

Since our focus in this paper is on repair rather than replacement let's focus on some of the techniques available to do the repair and enhancements to existing wastewater equipment.

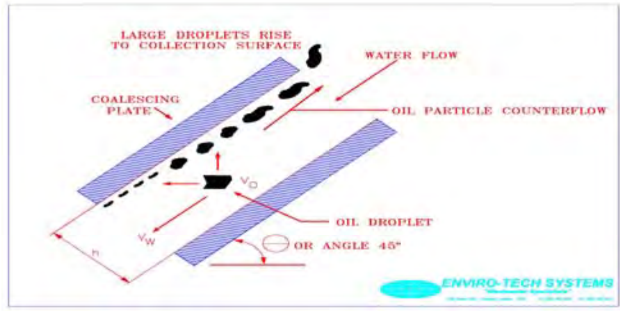
Skimmer Tanks and CPI units

Problems associated with Skimmer Tanks and CPI Units.

1. Undersizing
2. Premature Corrosion
3. Solids collection
4. Plate Pack replacement and removal

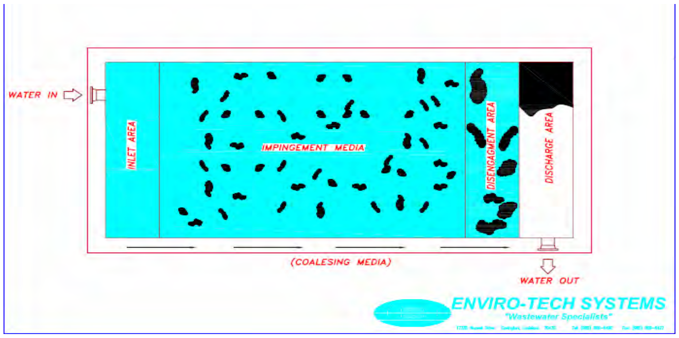
A. Solutions for under sizing:

1. **Addition of closely Spaced Plates:**



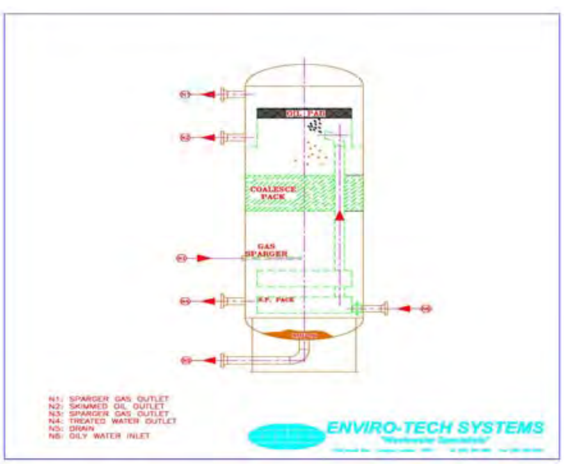
Since Skimmers and CPI's efficiency are dependent on retention time and retention time is dependent on available volume of the tank which generally cannot be changed, we must set our sites on other ways to improve efficiency. Although the volume cannot be changed the internal processing of that volume can be enhanced. Stokes law is applied to Skimmer tanks, stating that the collection of oil droplets is dependent on the rising velocity of oil droplet as well as the distance of rise for an oil droplet. Both are essential variables to the performance, this among other criteria. In short, reducing the distance of rise for the oil droplet will enhance performance. There are methods available today for doing this. The addition of closely spaced plates in the flow path defining the rising distance of the oil droplet to be shorter than in the tank is one method. This enhancement allows for a more efficient separation process even amid the potential for reduced retention time. In other words with the addition of the closely spaced plates you can increase the throughput without increasing the retention time required for separation.

2. Coalescing Plates



A second way to enhance efficiency is by the addition of coalescing plates at the inlet of the Skimmer or CPI. By design the coalescing plate adds crucial surface area necessary for oil particle growth. This growth in turn adds to an increase in velocity of the oil droplet rising to the collection surface. The estimated growth of the particle is about three (3x) and this has been determined in field studies. If the idea of coalescing plates is considered, a method to clean and remove them easily should be employed. When heavy concentrations of solids may be present other consideration should be made

3. Spargers



A final method of enhancement and perhaps the most practical commercially is the addition of Gas Spargers. Gas Spargers are a relatively new method developed within the last decade for improving water treatment equipment performance. Since gas is generally plentiful on an offshore platform the sparger system becomes more practical than all other enhancements. Gas under pressure is pushed through a sparger tube to create minute bubbles flowing into the process as a method to efficiently remove the incoming oil. In a Skimmer or CPI this can be retro fit to enhance the operation and to aid in handling increased process. However there is a caveat, Spargers require a clean environment for extended operation. Since there are very small openings in this minutely porous gas tube there is a tendency to plug over time. Scale and sludge tend to build up in the sintered tube and over time render the sparger tube inoperable. When this occurs the tubes must be removed and cleaned much like a radiator is cleaned with caustic and acid solutions. This is time consuming and somewhat costly and in some instances frequently reoccurring and causing the potential for unnecessary downtime. At best if the process is generally clean the Sparger enhancement may work with infrequent cleaning but if not beware. With this choice, consideration should be given to having a spare set of spargers on the jobsite.

B Solutions for Premature Corrosion

Add a properly sized cathodic protection system along with a good internal coating system sufficient for the process. Size the Cathodic Protection system for a practical life span and make the anodes removable for future replacements and or upgrades. Also be careful to ensure the anodes are not grounded to the bare area in the vessel. This may cause premature corrosion or more importantly minimize the anode's sacrificial activity in that selected area. For an anode to work properly it should be completely submerged in the process liquid (not in oil) and placed properly so that it can see what it is protecting.

C. Solids Collection in the Skimmer or CPI

This is a problem that has been perpetuated since the beginning of practical equipment design. Elaborate solids removal processes have been designed in vessels but with little success. This is generally because of poor vessel geometry and lack of jetting systems and removal methods in the design. Skimmer tanks and CPI tanks are generally square tanks with voids in the ends and corners of the vessel. This allows for sand and solids build up in those areas with festering bacteria creating an environment for corrosion. A change in the geometry from square to round will provide a better way to handle the solids, even preventing the buildup of them in those void areas. Additionally sloped bottoms in rectangular tanks helps to improve the handling and processing of solids after their collection. Further more, jetting systems strategically positioned in collection areas helps to slurry solids for removal.

The combination of the above enhancements may make the impractical, practical in improving existing equipment

Induced Gas Flotation Cells

Problems associated with Flotation Cells

1. Undersized
2. Leaking hatches
3. Oil removal
4. Premature Corrosion
5. Solids collection and removal

Solutions for under sizing

Induced Gas Flotation Cells can be characterized as either Mechanical or Hydraulic Operation. The mechanical operation uses a mixing system to create the bubbles required for flotation. The Hydraulic type uses a pump to create the bubbles; both are similar in principle but different methods. Since the Mechanical flotation cell is the most difficult to add enhancements to we will discuss it first. The only enhancements that have been effectively applied to improve processing capability and increased flow rate are to the agitator assembly itself. Since the mixing process efficiency is determined by the combined effects of the Agitator RPM, the impeller size, and the retention time we don't have much to work with. Testing units with an increased RPM has found some success. Slightly increasing the RPM has enabled some operators to increase processing capability and hydraulic flow all the while and improving efficiency. Another method proven is the addition of Spargers in the final cell. This too has increased overall performance

Since Flotation Cell efficiency is not generally sensitive to particle size, process enhancements are few. One of the most significant improvements is hydraulically fine tuning the recirculation system. Most Induced Gas Flotation Cell today operate on a design that incorporates a relationship between the recirculation rate, the discharge pressure of the pump and the flow rate of the process. Some units boast a recirculation rate of 125% of the process design with a low pressure discharge to conserve horsepower. This is really a design flaw rather than a good design practice. First the increased recirculation rate adds to the volume of water being processed in the vessel. This in turn leads to a decreased retention time. Also the combination of high recirculation rates and low discharge pressures has not provided good bubble distribution in each cell. The reverse of this becomes the improvement. Decreased recirculation rates and higher pressures, increases retention time and improves bubble dispersion therefore increasing overall efficiency.

The Enviro-Cell™ Induced Gas Flotation Cell now in service for several years has proven the new technological advancement showing increased efficiency in the Hydraulic Flotation Cell design.

Since we cannot increase the overall size of an existing Flotation Cell this modification explained above can be added to the existing process within practical cost. A simple Eductor retro-fit is all it usually takes to see higher efficiencies instantly.

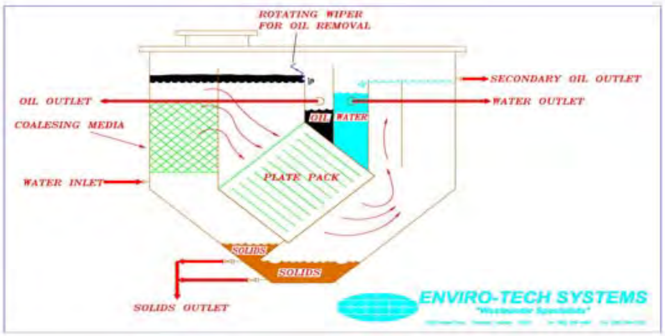
Another cost effective modification to the Induced Gas Flotation Cell is improved gasification of the process with more bubbles per cross sectional area of each cell. In short the addition of multiple Eductors in each cell can improve the overall performance of the existing Flotation Cell. This two can be carried out with commercial practicality. Generally an internal piping change to suit the addition of the additional Eductors is all that is needed to institute the improvement. Placing Multiple Eductors in each cell strategically places the bubble across the flow path with more bubbles in the flow path therefore providing increased efficiency. The Eductors can be designed with a quick release feature for easy access and easy remove ability for maintenance. The benefit from this enhancement is increased performance and higher efficiency while operating under the same vessel parameters.

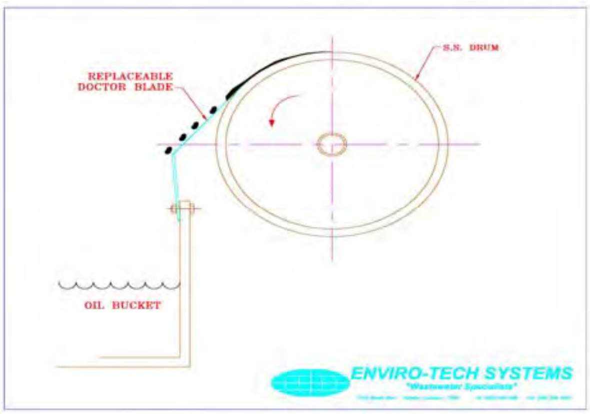
Additionally, Spargers are also a practical enhancement to the Induced Gas Flotation Cell for increased performance and efficiency.

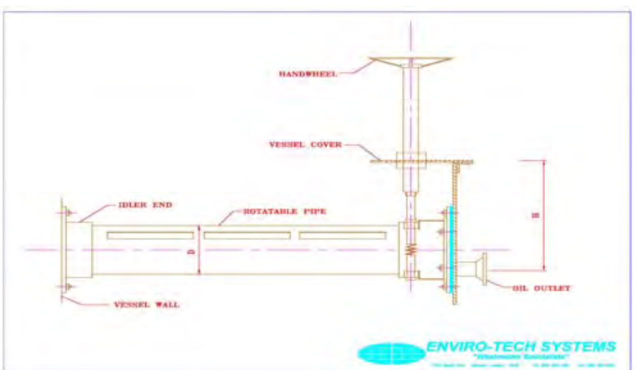
Leaking Hatches

Leaking hatches are a common problem within the Flotation Cell family of manufacturers. A new directive of the MMS is to review existing equipment for gas leaks with an Infrared Video Camera illustrating to the Operator the exact leak point. Some manufacturers have vulcanized gasket surfaces attached to the hatch; some have a channel frame for a removable sponge type material. Both cases have their drawbacks. The vulcanized is by far the superior material however after repetitive opening and closing the gasket begins to deteriate. Additionally overtigtening creates undue pressure on the gasket seal to the steel hatch and either the elastomer begins to crack or the steel portion of the hatch begins to penetrate the elastomer. The end result is a leak at the hatch door. This leak in turns allows for liquid to seep between the gasket surface and the hatch door creating a place for corrosion to commence.. To counteract this problem Enviro-Tech Systems has developed a removable gasket which is cemented to the hatch door surface for a long lasting seal. The flexible design of the elastomer is not only oil resistance but is flexible over time maintaining a sufficient seal even after continuous opening and closing. In the unlikely event that the seal breaks or the gasket surface begins to deteorite you simply remove the gasket and replace. The entire process takes only a few minutes. Using the Enviro-Tech Systems replaceable hatch gasket system allows for continued use of the steel hatch door without having to dispose of both the hatch door and the gasket surface. This gasket system can be retrofit to existing gasket surfaces now in use with the same ease of installation. Since the MMS now reviews and checks the condition of gas seals on the Flotation Cell this becomes imperative.

Rotating Oil removing systems





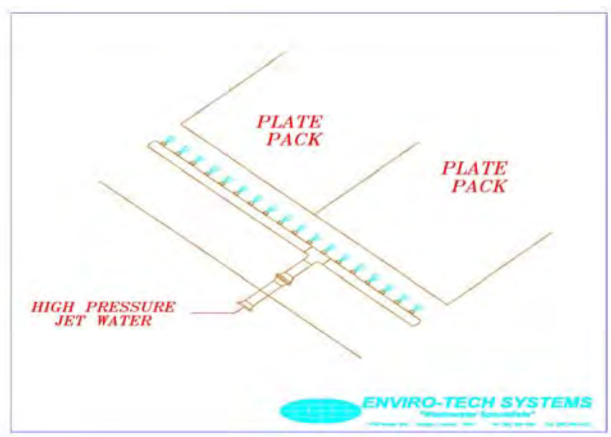


Most existing Flotation Cells feature a rotating wiper system to remove the floating oil collected in each cell. This type of removal system is effective but requires considerable routine maintenance. The constant rotation of the wiper paddles places wear on the paddles, paddle drives and the tank surface where it makes contact. When designing a new Induced Gas Flotation Cell consideration should be given to the elimination of the rotating wiper system and the installation of an adjustable oil weir for removal of collected hydrocarbons. This system provides a series of adjustable weirs in each cell allowing for the spillover of collected oil from the mainstream flotation cell into the oil bucket with minimum water carryover. This design in some cases can be retrofit into existing Induced Gas Flotation Cell This design allows for independent adjustment of levels in each cell accounting for any un-levelness in the installation or even movement due to wave action. When designing for FPSO's or other facilities with potential for movement, consideration should be given to the addition of our internal movement design to prevent sloshing from roll, heave and pitch.

Corrosion

Geometry also plays a role in lowering corrosion. A cylindrical geometry is recommended for both corrosion resistance and greater structural integrity. Cathodic protection should be considered along with a good internal coating for minimizing corrosion. Also designing the cathodic protection system as removable for future replacement and upgrades makes maintenance more practical.

Solids Collection and Removal



Solids are a condition of most processes and can be found in all aspects of the produced water treating facility and especially in Flotation Cell. Because they are typically the last place in the process for collection, solids tend to settle there. Typically we would like to facilitate solids removal upstream of the IGF but sometimes due to lack of retention time or poor chemical programs they are not. Providing a suitable method of removal having a solids outlet in each compartment with isolation valves, and or internal jetting is the best solution for their removal. Otherwise, the alternative is to shutdown the vessel and clean it, which is usually the case in most applications. Remember bacteria that grow in the solids collected are also a place to house oil which may affect the outlet ppm. So plan ahead to keep the vessel devoid of solids by any means.

Sampling

Our final consideration is effluent sampling. Sampling is a critical issue especially when the effluent is close to the maximum discharge requirement. It becomes essential to make every possible effort to have a clean sample point at the least. By providing this you eliminate the possibility of a contaminated sample. There are several ideas that can be incorporated in a sample point. First the sample point ideally should be placed in the center of the effluent conduit or pipe keeping it off the bottom of the conduit minimizing potential for contamination. Secondly, the sample probe assembly should be retractable for easy cleaning even while the discharge conduit is in operation. A simple series of valves and removable fittings allow for this design. The combination of the above will insure a proper sample point and a clean sample.

Conclusion

Replace or Repair?

Hopefully we have enabled ourselves to make an educated response to our question as stated.

We have learned that there is no clear cut answer to the question on whether to Replace or Repair. The answers lie within our own parameters.

1. Do we have the funds available?
2. Do we have the space available?
3. Is there new technology available?

Answering these questions and more will determine our course of action.