Developing and Implementing An Aggressive Water & Waste Water Strategy (W3S) Plan At Raytheon Company In Tucson, Arizona

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This paper discusses the use of "front of the line" treatment and recycling technologies that have allowed for closure of an $8 Million Water and Wastewater Treatment Facility at Air Force Plant (AFP) 44 in Tucson. Shortly after Raytheon's purchase of Hughes Aircraft Company at the end of 1997, consolidation plans were unveiled that called for the closure of numerous wet process shops in Tucson - Printed Wiring Board Fabrication Facility, Circuit Card Area and the Metal Finishing Shop. Some quick calculations told us that our Industrial Waste Treatment Plant (IWTP) capable of providing up to 300 gpm of polished water as well as processing up to 700 gpm of wastewater was not going to be needed (or affordable) in the near future. As a result, a Water & Waste Water Strategy (W3S) Team was created that was made up of a diverse group of personnel from EH&S, Facilities Engineering, Process Engineering, Area Users and Legal Departments. Each wet process area had to be evaluated under the premise that the treatment facility would close at the end of 2000. Some wet processes were replaced with dry ones. For example, a non-VOC paint replaced a zinc-iron phosphate coating. A chromate conversion coating for certain aluminum based missile components was eliminated as the missile was hermetically sealed until firing. Still other processes (anodizing, nickel plating) were offloaded to local vendors as the volume was too low to justify an in-house operation. For the remaining wet processes, the final strategy called for the implementation of a wide range of recycling systems with their own polished water makeup capability to close loop the operation. Recycling strategies to be discussed in detail include aqueous cleaner and associated rinsewater recycling via membrane technology, waterfall paint booth water recycling via electroflotation technology, electrochemical deburr rinsewater recycling via ion exchange technology, vibratory deburr solution recycling via centrifuge technology and circuit card area rinsewater recycling via carbon and ion exchange technology.

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Introduction

Figure 1. Industrial Waste Treatment Plant (IWTP) at Air Force Plant (AFP) 44

An $8 Million Industrial Waste Treatment Plant (IWTP), shown in Figure 1, has been in use at Air Force Plant (AFP) 44 in Tucson since 1995. Capabilities include waste treatment of concentrated acid and alkaline wastes, wastewater treatment up 700 gpm and water recycling up to 300 gpm. However, shortly after Raytheon's purchase of Hughes Aircraft Company at the end of 1997, consolidation plans were unveiled that called for the closure of numerous wet process shops at the AFP 44 site to include the Printed Wiring Board Fabrication Shop, the Circuit Card Area and the Metal Finishing Shop.

Some quick calculations told us that the existing IWTP was not going to be needed (nor could be afforded) in the near future. As a result, a Water & Waste Water Strategy (W3S) Team was created that was made up of a diverse group of personnel from EH&S, Facilities Engineering, Process Engineering, Area Users and Legal Departments. Each wet process area had to be evaluated under the premise that the treatment facility would close at the end of 2000. Some wet processes were replaced with dry ones. For example, a non-VOC paint replaced a zinc-iron phosphate coating. A chromate conversion coating for certain aluminum based missile components was eliminated as the missile was hermetically sealed until firing. Still other processes (anodizing, nickel plating) were offloaded to local vendors as the volume was too low to justify an in-house operation. For the remaining wet processes, the final strategy called for the implementation of a wide range of recycling systems with their own polished water makeup capability to close loop the operation. Recycling strategies to be discussed in detail include aqueous cleaner and associated rinsewater recycling via membrane technology, waterfall paint booth water recycling via electroflotation technology, electrochemical deburr rinsewater recycling via ion exchange technology, vibratory deburr solution recycling via centrifuge technology and circuit card area rinsewater recycling via carbon and ion exchange technology.

Aqueous Cleaner and Associated Rinsewater Recycling Via Membrane Technology

Figure 2. Aqueous cleaner recycling system (left) integrated with wash unit (right).

Aqueous cleaner solutions are now continuously recycled via membrane technology. See Figure 2. Oils and other contaminants are removed from the cleaning solution via passing the solution through a 0.1 micron ultrafiltration membrane constructed of sintered 316 stainless steel with a titanium oxide coating.

Rinsewaters are also continuously recycled. Residual oils and cleaning chemistry is first removed via passing the rinsewater through a traditional 0.005 micron ultrafiltration membrane. Other salts are then removed to further polish the water prior to return to the rinse tank via passing it through a traditional 0.0006 micron reverse osmosis membrane.

Oil and dirt is collected in a concentrate tank and periodically transferred into 55 gallon drums for offsite.

A complete description of all processes is contained in the 2000 AESF/EPA Conference for Environmental Excellence proceedings[1].

Waterfall Type Paint Booth Water Recycling Via Electroflotation Technology

Figure 3. Electroflotation unit recycles paint booth waters from lacquer spray operation.

Russian electroflotation technology has been under study and implementation at AFP 44 since 1997 when a full scale demonstration of the process was conducted for the U.S. Air Force by Raytheon, Mendeleyev University of Chemical Technology of Russia in Moscow and a U.S. based equipment manufacturer. At that time, it was demonstrated that oil could be removed from an aqueous cleaning solution and that paint could be removed water.

The first production unit is shown in Figure 3. Wastewaters from a "waterfall" type paint booth at a lacquer coating station can now be recycled via removal of paint contaminants with the electroflotation technology. As shown in Figure 4, electroflotation is the process of generating a controlled stream (blanket) of dispersed hydrogen and oxygen bubbles that rise through a wastewater solution attaching to insoluble paint contaminants to form a flotosludge which is then skimmed off while the water returns to the paint booth. Flotosludge paint wastes are further dried and offsited as industrial waste.

A complete description of the electroflotation process is contained in the 1999 AESF/EPA Conference for Environmental Excellence proceedings[2].

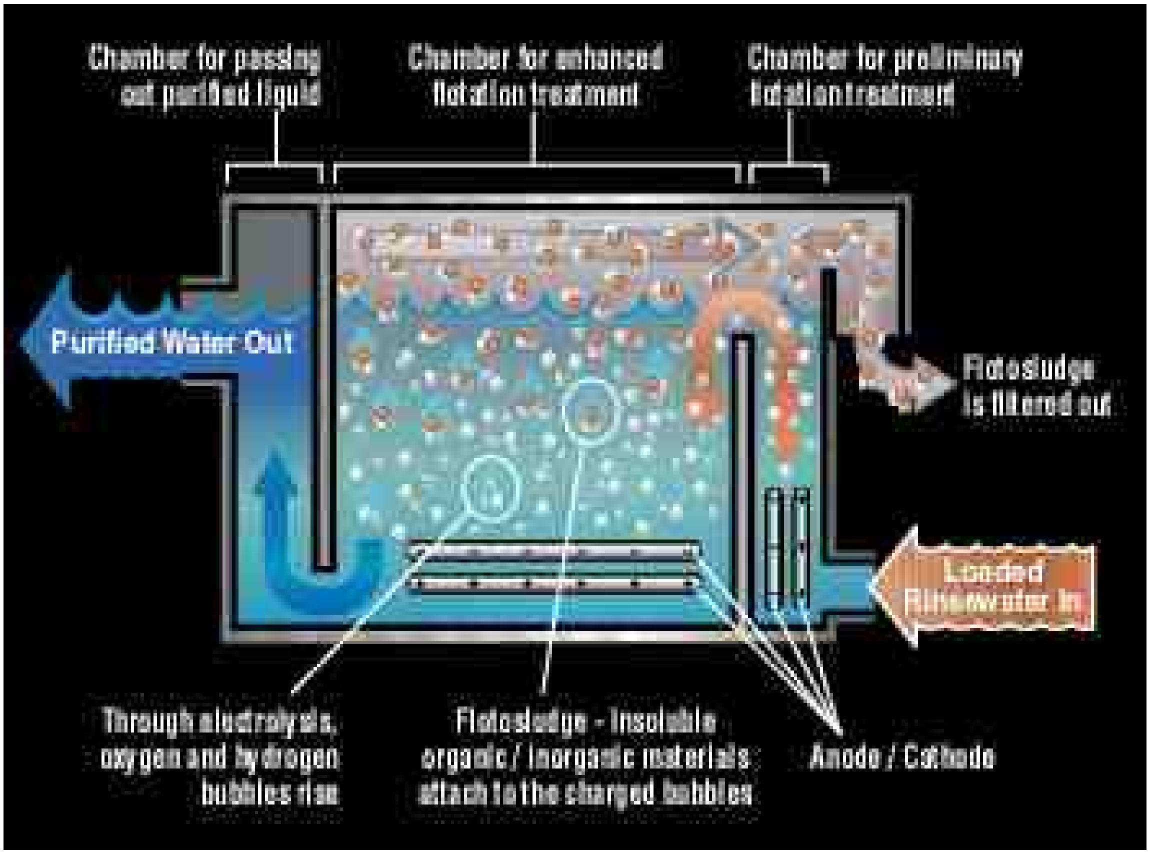

Figure 4. Electroflotation theory.

<u>Metal Removal With Water Recycling Via Ion Exchange Technology</u>

Rinsewaters are continuously recycled (See Figure 5) at an Electrochemical Deburr (ECD) Process utilized to remove large machining burrs on rocket motor cases. The water recycling is first accomplished by removing metal from an aluminum bearing rinse tank or from an iron bearing rinse tank via a cation ion exchange resin. The water is then sent through a traditional anion exchange resin to remove residual salt ions. A local water treatment company who subsequently regenerates the resins and recovers the metals periodically exchanges the spent (loaded) resin columns.

The recycling effort saves approximately 1 gallon per minute (gpm) of wastewater having to be offsited. It may not sound like much but it all adds up…

1 gpm X 60 min/hr X 8 hrs/day X 5 days/wk X 52 wks/yr X $0.40/gal offsite cost

equals a savings of about $50,000 per year minus capitalization (about $13,000), upkeep and ion exchange column costs.

Figure 5. Rinsewater recycler at electrochemical deburr station.

Vibratory Deburr Solution Recycling via Centrifuge Technology

Machine parts are circulated through automated vibratory deburr units (Figure 6) containing soap solution and ceramic media shapes to remove tiny burrs created during the machining operation. The solution is now continuously recycled (See Figure 7) via passing it through filters to remove solids and then passing through a centrifuge to further remove fine particles. The soap solution is then sent back to the process. Solid wastes are collected in 55 gallon drums and offsited.

The old method was to run at 3 gpm for the five deburr units. The recycler cost approximately $25,000 and the upkeep has been minimal. Obviously, it would not have been practical to offsite 3 gpm of wastewater on a similar schedule seen with in the electrochemical deburr area but it does show what can be achieved with sound recycling technologies.

Figure 6. Vibratory Deburr Units for removing burrs from machined hardware.

Figure 7. Centrifuge based recycling system in vibratory deburr area.

Water Recycling in the Circuit Card Area

Figure 8. Fully aqueous wash system for removal of HF1189 flux from circuit cards.

During an effort to eliminate the use of 1-1-1 trichloroethane in the early 1990's at AFP 44, a new flux was developed in house (Hughes–Fullerton, CA) called HF1189. The citric and malic acid based flux could be removed with just a hot (130^{o}F) and high purity (4 megohm) deionized water. As a result, multiple water based cleaning systems like the one shown in Figure 8 were installed and are still in use. More importantly, these systems also had rinsewater recyclers so that the rinsewaters pass through carbon and mixed bed deionization columns before being reheated and sent back to the process. This forward thinking has been very useful in today's efforts to reduce wastewater.

A more aggressive cleaning process system is utilized on circuit cards that will eventually be parylene coated. The particular wash unit shown in Figure 9 came to AFP 44 from another site during the Raytheon transition and did not have recycling capability. It was decided not to deal with the 40 gallon cleaning solution but the rinsewater is now recycled via a similar system to the one utilized for the HF1189 flux, i.e., carbon and ion exchange.

Figure 9. Wash unit for cleaning circuit cards prior to parylene coating.

Other Areas Requiring Cleaning Systems

There are yet other areas on the plantsite requiring cleaning systems of many different types and end uses such as the precision cleaning of optics and space components like the ultrasonic cleaning unit shown in Figure 10. These systems are small in volume and so far have no recyclers justified. Wastewater is simply hauled off.

Figure 10. Ultrasonic cleaning system for precision hardware.

SUMMARY

It has been a major effort close looping the relatively few remaining wet processes in use at AFP 44. Work still continues in implementing recyclers in operations such as precision cutting saws which use up to 3 gpm of water, leak test stations and other miscellaneous engineering scale wet processes.

Was it a waste of time and money?

The measurable reduction in costs to treat remaining wastewaters via offsite and recycling technologies as compared to the old ways was deemed extremely significant and earned the Water and Wastewater Strategy (W3S) Team a Raytheon Corporate EH&S Innovation Award.

The answer is yes.

[1] Paul Fecsik and Lyle Carman, Proc. AESF/EPA Conference for Environmental Excellence, p. 233 (2000).

[2] Paul Fecsik, Gene Maitino and Phil Hinton, Proc. AESF/EPA Conference for Environmental Excellence, p. 285 (1999).