# The Road to a Cyanide Free Plating Shop

*Glen H. Graham, Oklahoma City Air Logistics Center, Tinker AFB,OK*

Beginning in May of 1989 a plan was initiated to eliminate the use of cyanides in the Plating Shop at Tinker AFB, OK. We were using cyanides in cleaners, stripping solutions, cadmium plating, copper plating and silver plating. We have successfully accomplished the last hurdle this year silver plating. This paper will detail the implementation of each successful substitution along the road to a cyanide free plating shop.

For more information, contact:
Glen H. Graham, Chemical Engineer
OC-ALC/LPPEE
3001 Staff Drive 2B93
Tinker AFB, OK 73145 – 3034
Tel: 405-736-2018
E-mail: Glen.Graham@tinker.af.mil

The Oklahoma City Air Logistics Center (OC-ALC) at Tinker AFB, OK maintains a large family of aircraft and gas turbine engines and operates one of the largest plating shops in the Department of Defense. Finishing services include hard chrome, nickel (hard and soft), electroless nickel, silver, copper, abrasive particle and zinc/nickel plating. We have chromate conversion coating of aluminum, magnesium, Ion Vapor Deposited Aluminum (IVD), Type I, II and III anodizing, and black oxide coatings. Also, we have a large stripping process line for plating and plasma spray coatings and some specialty etching solutions.

In May of 1989 the DoD held a joint workshop in Dayton, OH of all Armed Services engineers and chemist involved in repair / overhaul processes that used chemicals. The intent of the workshop was to identify those steps necessary to reach an absolute minimum usage of hazardous materials in plating, cleaning and stripping processes and to eliminate duplication of pollution prevention among the Services by sharing in our efforts. These substitutes were to be equivalent or superior to the current processes and result in at least a fifty percent reduction in three years (1992) or elimination if possible. The plating processes group came up with three areas of environmental concern; cadmium, chrome, and cyanide.

We did a survey of how much cyanide, cadmium, and chrome we had used in 1988. We decided to start on the cyanide reduction first. We were using cyanides in alkaline cleaners, in strip solutions, and cadmium, copper, and silver plating. The results for the cyanide use are shown in Table 1 and it was the beginning of our road to cyanide elimination on our shop. Our ultimate goal was to continue reducing cyanide until it was all eliminated even though our initial challenge was a 50% reduction. Since our immediate goal was to reach a 50 % reduction, we began our road in the areas that would result in the biggest reductions the fastest; alkaline cleaning and stripping.

The first step down the road was the biggest impact, alkaline cleaners. In working with our vendors we had already reduced the cyanide in our electrolytic alkaline cleaners from 14 ounces per gallon to 8 ounces per gallon. One of our vendors had a cyanide free alkaline cleaner which was normally used at 190° to 200° F as a soak cleaner, but they felt it could be used at 130° to 140° F as an electrolytic alkaline cleaner. We consider our sulfamate nickel line to be our most sensitive process so we replaced one cyanide cleaner tank with the non-cyanide. We keep close record of parts going through the nickel plating tanks using the non-cyanide. We processed the parts with our normal process for 6 months without any plating failures. Since we could not tell any difference in performance or quality of the end nickel plating, we decided to replace the remaining cyanide cleaner tanks. As our other 6 tanks became ready for a new make up, they were then replaced with the non-cyanide cleaner. One of the big facts that contributed to us being able to make this change is that the gas turbine engine parts that we plate are initially cleaned when they first come in for overhaul. The success of this change was reported to other Air Logistics Centers, DoD repair centers, and Original Equipment Manufactures (OEM). The non-cyanide cleaner was added to the Qualified Products List (QPL) in the Technical Orders (T.O.) for repairs. Since our first non-cyanide cleaner was proven satisfactory, we have found other suppliers that meet the performance requirements, however they were more difficult to maintain for our Solution Maintenance crew and have not been used. AESF policy does not allow vendors products to be mentioned in papers presented at their conferences. Anyone interested in specifics will have to contact me later. This step down our road to being cyanide free gave us a 49.3 % reduction.

The next step was rather a small one. We had a few tanks with a low amount of cyanide in rinses. We simply eliminated the cyanide in the rinse water and rinsed more thoroughly before going to next process step. Since this step was mainly to keep from contaminating an alkaline bath with acid, good rinsing accomplished the purpose.

Our third step, the replacement of the cyanide nickel strippers, was our second largest step. These strippers are used to remove nickel/alumunide and tungsten carbide plasma sprays, nickel/cadmium and nickel plating. It was made relatively easy for us though since San Antonio Air Logistics Center had just received the final report on a project that they funded to find non-cyanide nickel strippers. Their report showed several strippers that worked successfully, but they were unable to use them since they were not approved alternates in their T.O.'s. Since our Material Management Engineers had authorized Process Engineering to make changes in T.O. solutions that did affect the form, fit or function of the parts, we were able to try some of the candidates from the report. We found that some of the strippers required additional steps and the personnel on the strip line did not like the additional work. After 6 months of production processing of parts, we were able to select one meet all our requirements and most closely gave results similar to a cyanide stripper. We completed our implementation of our first three steps down our road by the end of 1990. At that time we had surpassed the DoD's initiative of 50 % reduction by achieving a 73.8 % reduction. Since our initial qualification we have one solution that is equivalent or superior to our first source.

Our fourth step, cadmium cyanide, was much more difficult to take than our previous steps. This step meant that we could achieve two goals by eliminating cadmium and cyanide at the same time. The difficulty lay in the long-term use of cadmium and nickel/cadmium by the DoD for corrosion control. This meant coming up with an alternate or alternates that would meet low temperature (below 400°F) as well higher temperatures (up to 900°F).

The Air Force began looking for cadmium and nickel / cadmium alternatives in the mid 1980's. Ion Vapor Deposited (IVD) aluminum is a process where aluminum wire is melted in a vacuum and catholically deposited on the parts. LVD aluminum was found to be superior to cadmium in corrosion tests. Many of the Air Logistics Centers installed the IVD aluminum units. We began operating ours in 1987, but we found a lot of resistance to change. Also, the IVD aluminum could not be used on tread items or internal diameters. We were able to get engineering approval for IVD aluminum on several parts. With cadmium plating also being approved we found that the parts ended up going back to plating instead of the IVD aluminum. We really were not able to reduce the cadmium usage this way.

We have used electroless nickel plating on several parts for years for corrosion protection. These were primarily non-rotating and non-threaded parts from aircraft. These applications gave us ample experience in using electroless nickel for corrosion control on parts. This provided us with another option for complex part corrosion control.

In 1991 the use of alkaline zinc / nickel coatings as cadmium replacement in automotive applications was spreading in Europe, Japan and the United States. A lot of testing was done, which showed that it was very superior to cadmium or nickel cadmium coatings.

We had meetings with several engineers responsible for aircraft and turbine engine parts, but they felt that there were too many engineers involved for them to get the changes authorized for all parts even though we could show equal or superior coatings to cadmium or nickel / cadmium coatings. We came to the conclusion that the only way to get out of any type of cadmium plating was to eliminate the option. At OC-ALC we were able to obtain upper management authorization to depose of our cadmium plating capabilities and offer the responsible engineers for parts require cadmium

plating coatings four options; (1) IVD aluminum; (2) zinc / nickel, (3) electroless nickel, and contracting out.

In November of 1991 we deposed of our cadmium plating tank capability and by February 1992 all parts had been converted to one of the first three items. All our test data obtained a year later showed that in every respect the alkaline zinc / nickel exceeded cadmium and most of the nickel / cadmium requirements and our three coating options provide superior corrosion protection for the parts. Thus we eliminated cadmium usage and reduce our cyanide by 79.4 % of our 1988 level.

Our fifth step down, copper plating, our road was another small one and relative easy to implement. A new alkaline non-cyanide copper plating solution came on the market in 1993 and was proving to work well in production environments. We were able to depose of our copper cyanide bath, leach the tank, bring up the new solution and use the same rectifier. We have used the solution as a copper strike or copper plating without having to change our plating parameters. The solution has been found to be long lasting with our normal solution maintenance procedures.

Our sixth step, silver stripping from steels not stainless, proved to be a little more complex than the previous steps. Here again we had the benefit of some work done at SA-ALC since they had implemented a non-cyanide silver strip and were operating it. We obtained the same solution and tried to use it. We found excessive smutting on the parts and it was unacceptable for production. The supplier was unable to help us since they manufactured it for chrome stripping. Until we were able to talk to the man actually using the strip at SA-ALC, we could not figure out how to make it work. We found that there were a few simple changes that had to be made that were different from the way we operated our cyanide strip. Once the correct procedures were put into production we able to eliminate one more cyanide solution. By the end of 1995 we had traveled down our road to being cyanide free to a 91.6 % reduction from our base line.

Our last step, silver plating, proved to take the longest to accomplish. Initially we minimized our operating tanks to one silver strike and one silver plating solution which reduced our cyanide usage to about 3000 pounds a year and brought to a total of around 95 % reduction from the 1988 baseline. After this accomplishment in the early 1990's, we ran into difficulty in finding a non-cyanide silver plating solution that would operate on a daily basis. A testing program run for us showed one solution which meet all our physical requirements, but production could not maintain the solution as needed for daily plating. At that time we came to a stand still on final elimination of cyanides.

In 1999 when the manufacturer of the copper strike / plate solution that we are using began marketing a non-cyanide silver solution. We tested it and found it to work satisfactorily, however we did not implement into production because of renovations being done on the silver plating line. In June of 2001 we began using the non-cyanide silver plating solution. It does not plate as simply as cyanide silver and it has a slightly different appearance, but it is manageable to obtain 99 + % silver on a daily basis. The main problem encountered in switching to the non-cyanide solution was the difficulty in plating thickness over 0.001 inches per side. We worked on this for sometime and came up with a very involved process, which extend our plating time. However on inventorying the parts that we plate we found only two (2) parts that had this requirement. We requested an engineering change to the Technical Order requirement to allow build up using soft nickel or copper plating with less than 0.001 inches of silver plating. This allowed the functional surface of silver plating while restoring the dimensional requirements. Another is the anode to cathode ratio is important. The solution works better with an even or higher ratio of cathode to anode. The component that regulates dissolving of the anode must be added daily to maintain the silver concentration. The solution is more conductive than a silver cyanide solution so lower amps per area have to be used and different times. It is enough different to cause some operator resistance at

first. As we use it, daily we are becoming more proficient in obtaining consistent good plating from this solution and the operators are able to produce parts satisfactorily.

So twelve years after beginning our journey down the road to a cyanide free plating shop, we have meet and exceed the goals given us in Dayton in May of1989. We have met our personal goals for cadmium plating and cyanide usage by eliminating both. What is next for us is the third component of the Dayton workshop, chrome plating. We have met the 50 % reduction goal mainly through a reduction in workload, but the complete elimination of chrome plating will be a difficult task. We expect to see a further reduction by implementing HVOF plasma spray coatings. These coatings are limited to line of sight applications. This could result in a 60% reduction of our current chrome plating workload. A task has been undertaken to try and find a plating solution for the remaining non line of sight parts.

This has been an interesting journey for us. Even though we know the cyanide technologies are simpler to operate and more forgiving of operator errors, we have found equivalent or superior products to do the same function. We have seen our plating and finishing industry lead in all environmental areas. Great strides have been made in pollution prevention, environmental controls, and water use minimization. As we continue our journey, it will be interesting to see where the road to future leads us.

TABLE 1

CYANIDE USAGE BEFORE FY89

| USE | IN TANKS | USEAGE FOR YEAR | TOTAL/USE |
|---|---|---|---|
| 1. Alkaline Cleaners | 7,800 lbs. | 5,000 lbs. | 32,800 lbs. |
| 2. Nickel Strippers | 4,700 lbs. | 11,300 lbs. | 16,000 lbs. |
| 3. Silver Stripping | 1,500 lbs. | 6,600 lbs. | 8,100 lbs. |
| 4. Silver Plating | 2,350 lbs. | 2,750 lbs. | 5,100 lbs. |
| 5. Cadmium Plating | 1,700 lbs. | 2,000 lbs. | 3,700 lbs. |
| 6. Copper Strike/Plate | 200 lbs. | 300 lbs. | 500 lbs. |
| 7. Cyanide Rinse | 100 lbs. | 200 lbs. | 300 lbs. |
| TOTALS | 18,350 lbs. | 48,150 lbs. | 66,500 lbs. |