Breakouts 1 and 2, May 23, 2006
"Chrome Plating Replacement (Line-of-Sight and Non-Line-of-Sight)"
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Current Uses

There are 22 plating shops at Army facilities, 8 of which are considered to be large facilities. Some ammunition plants do hard chrome plating on an as-needed basis to make equipment that makes ammunition.

Currently, chrome plating is applied to missile launching at Letterkenney. Red River now sends out its chrome plating to a contractor, although it still has plating capabilities. This was a business decision unrelated to the PEL. Several plants are below the detection limit of 1 $\mu g/m^3$. The only remaining problem is with removing masking.

If a facility does not meet the PEL, industrial hygiene staff immediately shut down the facility until the violation is addressed (usually only 1-2 days) and the cause is determined. Medical staff do bloodwork on employees monthly—more often than required. If a contractor runs the facility, it is liable for the violation. However, the plating process discharges to the depot's wastewater treatment plant, so a wastewater violation is DoD's responsibility.

Any good plating shop meets the new PEL. So why is there such an outcry about the rule? A few shops do not the PEL, and even if they do, a glitch could cause a violation (non-DoD shops may also have more trouble complying). Shops need better process control to prevent this—a lot of them run on equipment from the 1940s and 1950s. The Aniston shop is a potential problem; it runs 24/7, with operators on mandatory overtime. Mistakes are more likely.

Some shops operate as if the PEL is 2.5, since that (the action level) is the point at which they start to incur additional compliance costs.

Barriers and Drivers

Aside from the gun barrel program, no driver is pushing people to stop using chrome plating, especially since the end product, Cr plate, is not toxic (nickel is a bigger health concern). Some stakeholders are pursuing new initiatives to replace chrome; particularly Caterpillar, which has decided to be a "sustainable" manufacturer. For small parts, it's cost-effective to continue plating, but for others it's an easy decision to switch. Eventually life cycle costs will be the driver.

Like Alumiplate, chrome plating can also be a closed process, in which case it would not be hazardous at all. Plating can be automated, with machinery taking the parts in and out of the tanks, thus eliminating the point of human exposure. The process would require only one worker in a remote room. There would be no need to comply with the 8-hour exposure limit. It would also be better for quality control. Automation also reduces

costs—chrome plating is actually cheap once labor costs are eliminated. However, automation might not be practical for repair, unless one chose to simply deplate and replate. For complex parts and complex masking, it's difficult to meet timing requirements during the repair process; this affects quality. Therefore, it might be easier to just switch to HVOF. Hydrogen embrittlement is less of a problem with HVOF and is easier for repairs.

In addition, although one can find test results that show certain HVOF characteristics are inferior, field results demonstrate otherwise. For the Air Force, it has made sense to switch all its landing gear (its high value parts) to HVOF, since it doesn't use chrome plating in many other parts. Army and Navy use chrome plating for many more types of parts, and it would be much more difficult to change all parts over, and a difficult decision to change over just some.

Changes in commercial industry may be drivers. Air France requires its planes to contain no chrome plating, even though the end result is not toxic (possibly because it does not want to be exposed to hexavalent chromium during maintenance). This decision may also be based on incorrect assumption that all chrome is dangerous.

Resistance to change is a big barrier. If there are no environmental or health issues and facilities are in compliance, why should they switch?

Adoption of Alternatives (New Research)

LOS alternatives can come from the NLOS arena. Eric Brooman of AFRL discussed some testing results for new NLOS coatings. The best was electroless Ni-P-SiC. Other candidates were also nickel-based. The lab examined whether electroless nickel exceeded the performance of hard chrome and whether new criteria were necessary for specific applications, because the basis for the controlling specification was based on the material used at the time (chromium) and not on any particular performance requirements.

AFRL also has an advanced NLOS program, which is testing chromium- and nickel-free coatings. Most are cobalt based. (One of these, Niplate 700 is scheduled to be installed at Tinker Air Force Base). Any of these could also be used for LOS applications, and to replace thin dense chrome. All the candidates being tested are based on cobalt, and an environment, safety, and health risk assessment for cobalt is being done.

AFRL is also researching two kinds of nanocomposites, nanocrystalline, and nanoparticles (which contain normal-size crystals but nanoparticles). Additions of micron or nano-sized particles (e.g., SiC, WC, diamond) improve hardness and wear resistance. The lab is focusing particularly on tungsten carbide and silicon carbide. These composites increase hardness. All are wet processes. The lab is looking at characteristics such as hardness, adhesion, corrosion, and wear. These candidates are now being incorporated into advanced NLOS.

The coatings tested in the advanced NLOS program include two electrolytic coatings, two nanocomposites, and two improved nanocomposites. Limited studies have been performed on the toxicity of cobalt compounds.

ESTCP has an ongoing project testing nano cobalt phosphorus. Components coated with nano CoP can be heat-treated, have increased abrasion resistance, and increased ductility. Hydrogen embrittlement is an issue, however.

Nanotechnology is not currently used in gun barrels, although nanowhiskers could go into gun ceramics in the future.

Paul Chalmer of NCMS described a pulse plating project with Faraday Labs, in which it achieved hexavalent chromium performance from a trivalent chromium bath. Trivalent chromium is relatively weak because it forms cracks that extend through the plating down to the base material. Hexavalent chromium is stronger than trivalent chromium because it has microcracks, which intersect each other and prevent any one crack from propagating all the way through. Pulse plating involves plating at different frequencies, stopping cracks at the boundary between each layer (this would be useful for gun barrels). The plating achieved equivalent thickness, but decreased hardness. In a turning shaft test of regular hexavalent chromium vs. pulse plated chromium vs. steel, pulse plated chromium was best. In another test, hexavalent chromium performed better. A report on this research will be available soon.

Additional comments provided after meeting:

- Chromium is an ESOH issue, even if metallic chromium itself is not hazardous or toxic
- New chromium PEL is easy to comply with - issue is with providing separate and adequate facilities (e.g., showers, changing areas, separate entrances and exits, eating areas) and protective equipment for the workers
- Problems could remain (e.g., with demasking, coating stripping, grinding, paint removal) even if plating tanks in compliance.

Remaining Needs

- Without significant drivers, the options continue to be the status quo and HVOF. Significant amounts of money have been spent to qualify HVOF; similar funding would be required to qualify new NLOS coatings.
- It might be a better investment to upgrade existing chrome plating. Better process control leads to better throughput, better quality parts, and improved worker safety.
- Funding is an issue, as always. Congressional earmarks are the best way to ensure that funding will not be diverted, especially in the current political environment.
- Facilities should plan for how they will implement upgrades if promised funding gets cut (do not just move old equipment to the new shop).