The MONITOR

Aeronautical Systems Center (ASC/ENVV)

Vol. 8, No. 7, Fall 2003/AFMC Public Release Number 1103

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The MONITOR is a quarterly publication of the Headquarters Air Force Materiel Command (AFMC) Pollution Prevention Integrated Product Team (P2IPT) dedicated to integrating environment, safety, and health related issues across the entire life cycle of Air Force Weapon Systems. AFMC does not endorse the products featured in this magazine. The views and opinions expressed in this publication are not necessarily those of AFMC. All inquiries or submissions to the MONITOR may be addressed to the Program Manager, Mr. Frank Brown.

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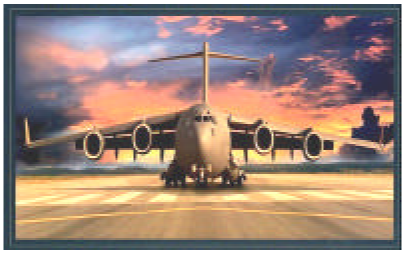
FEATURE STORY

AFRL and C-17 System Program Office Team to Insert Emerging Technologies into Weapon System



One of the challenges facing Air Force Materiel Command (AFMC) is closing the gap between technology development and technology insertion into weapon system production through the systems engineering process. Generally, new programs are hesitant to insert innovative technologies due to the heightened risk. Additionally, production programs avoid these technologies due to the potential disruption and associated risk to the Program. This article summarizes the lessons learned to address the challenges of inserting innovative technologies, being researched and developed by Air Force Research Laboratory (AFRL), into the C-17 systems engineering process, while mitigating potential disruption/risk to the Program.

Background

The key to the success of this effort has been bridging the gap between the AFRL technology development process with Boeing's systems engineering process, and the C-17 System Program Office (SPO) Technical Integrated Change Roadmap (TICR). A specific Integrated Product Team (IPT) has been formed between AFRL, Materials and Manufacturing Directorate (AFRL/ML), C-17 SPO, and Boeing to capture the efforts used in working this integration. Aligning these processes will ensure that technologies are identified, developed, and timely transitioned to the C-17 airframe to meet Air Mobility Command's (AMC's) top requirements. The successful and timely insertion of innovative technologies into the C-17 Program will be the benchmark for other platforms to reduce the "barrier to entry" of new technologies into legacy aircraft.

AFRL, SPO, and OEM Partnership

Historically, AFRL/ML SPO Collocates have worked directly with the SPO Engineers to identify top issues/requirements, which are then annually briefed to the AFRL/ML Executive Group. The data presented by the Collocates is an integral part of AFRL/ML's future planning and programming process.

The successful and timely insertion of innovative technologies into the C-17 Program will be the benchmark for other platforms to reduce the "barrier to entry" of new technologies into legacy aircraft.

Since December 2002, one initiative has successfully streamlined the AFRL/ML requirements generation process by focusing on viable solutions that meet SPO emerging issues through a series of Technical Working Groups (TWG). Bringing together the right stakeholders and technologies has facilitated the alignment of the existing AFRL and SPO technology transition processes. This initiative works in concert with the existing C-17 SPO TICR. The vision of the TICR is to bridge the gap between lab development technologies and implementation, and to achieve a strong link between investments in technology and the benefits to the C-17 Program by creating an all-encompassing plan for future technology modifications.

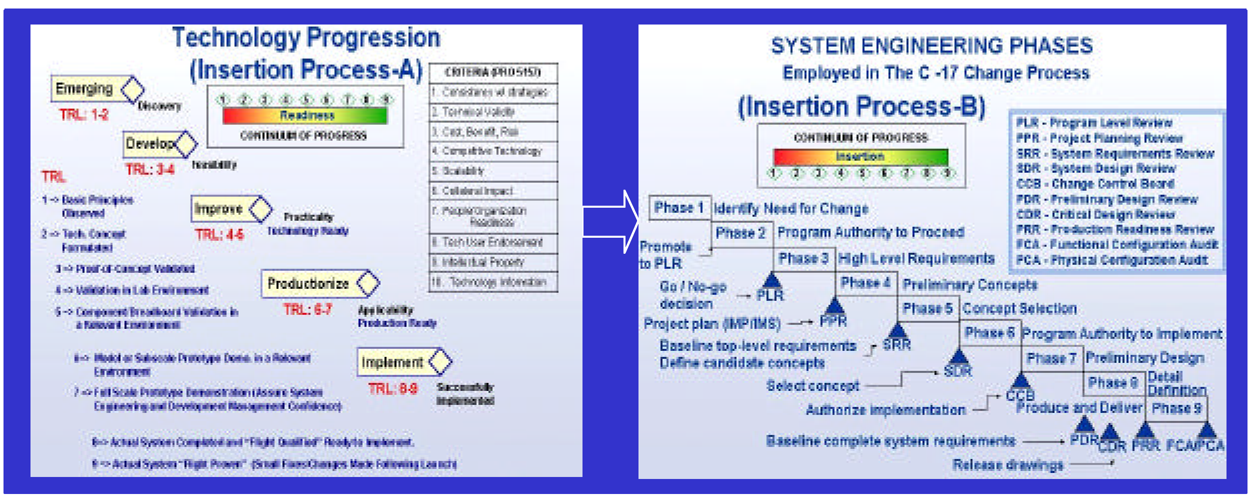
The AFRL technology progression process includes nine steps that track the Technology Readiness Level (TRL), from the discovery of the emerging technology (TRL #1) to actual system "Flight Proven" (TRL #9). The Systems Engineering Process used by the C-17 change process includes nine implementation phases from identifying the need for change (Phase 1) to production and delivery (Phase 9). Once a proof of concept of a technology is validated (TRL 3), the AFRL technology transition process aligns with the SPO systems engineering development process until the Program gives the authority to implement (Phase 6). At this point, the AFRL technology transition process is considered successful and the SPO continues the final phase through until production and delivery.

The C-17 TIM is tracking 25 validated technologies for insertion on the C-17 airframe. The effective date for transition has already been established for 8 of the 25 technologies.

C-17 Technical Interchange Meeting (TIM) Successes

The success of the C-17 TIM has been to build the communication links between the AFRL and SPO technology transition processes and track the identification, development, and transition of technologies to the C-17 airframe that meet the C-17 user's top priorities. This effective process has greatly reduced the time in matching technologies to serve high priority needs. Within six months of development, the C-17 TIM is tracking 25 validated technologies for insertion on the C-17 airframe. The effective date for transition has already been established for 8 of the 25 technologies.

To date, there have been several TIMs between AFRL/ML, C-17 SPO, Boeing C-17 Airframe IPT, and Boeing (Phantom Works) with the specific purpose of reviewing ongoing AFRL/ML technology development programs



C-17 TIM has established a forum to bridge the gap between the AFRL, Boeing, and SPO technology transition processes and identifying opportunities for technology insertion through the C-17 airframe IPT. The critical factor to the success of this effort has been the working relationship established among the stakeholders over the last year.

The Titanium (Thin Wall) Casting is the most matured technology identified for transition on the C-17 airframe. Currently, it is at TRL 8 (AFRL transition process) and Phase 8 (SPO transition process) and is scheduled for transition on the P-113 aircraft in 2003. Coating technologies such as High Temperature Coatings for Titanium Slats, Fast Dry Touch Up, and High Impact Coatings were identified as new areas of interest. AMC in part, identified the needs for these technologies. For example, the C-17 Rapid Topcoat was initiated at AMC request to significantly shorten the 72 hour "dry-to-fly" cure time for the Advance Performance Coating (APC) to ensure rapid re-deployment from both field repair and maintenance operations.

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Hazardous Materials and Processes

Overview of Common Manufacturing and Maintenance Industrial Processes That Use Hazardous Materials

A study conducted in 1990, indicated that aerospace manufacturing operations typically generate two to four pounds of hazardous waste per pound of new aircraft, while maintenance at the Air Logistics Centers (ALCs) can generate twice the amount over a normal 20 year life cycle of an aircraft.

> ***Painting, depainting, surface cleaning, and surface finishing are four major processes that account for a majority of the hazardous waste generated during manufacturing and maintenance.***

Painting, depainting, surface cleaning, and surface finishing are four major processes that account for a majority of the hazardous waste generated during manufacturing or maintenance. Another study, also conducted in the early 1990's, found that managing hazardous materials on an airframe, over a 20-year operating life, cost over $500,000 million. Although regulatory compliance and waste disposal cost often represent the high cost burden in hazardous materials management, other significant costs are associated with medical surveillance, workplace monitoring, special storage and handling, and long term liability associated with waste management. In 1990, this liability in the US was assessed to range between $8 and $11 billon.

Today, the same four major processes continue to be the focus of emerging regulatory drivers for aerospace processes. An overview of these four processes and other common industrial processes that have been or are being addressed through pollution prevention projects are discussed below.

Four Major Manufacturing and Maintenance Processes that Use Hazardous Materials

Painting – Painting operations during manufacturing and maintenance have historically used EPA-17 materials. Primers and topcoats are the two general types of paints applied to an aircraft during manufacturing and maintenance. Historically, topcoats have used solvent-based polyurethane coatings that contain various pigments. Most topcoats are mixed in two separate parts just prior to application that result in an irreversible chemical reaction and give the desired properties to the cured product. High solid coatings, powder coatings, and metal wire arc spray are three coatings that are used on various parts and have eliminated some of the EPA-17 materials that were used in topcoat applications. The long term goal of pollution prevention initiatives is to identify a zero Volatile Organic Compound (VOC), zero Hazardous Air Pollutant (HAP) topcoat.

The use of chromated primers continues to pose a risk to Air Force industrial processes with emerging Occupational & Safety Health Administration (OSHA) chromium standards. Air Force Materiel Command (AFMC) and the Department of Defense (DoD) have invested significant resources in identifying alternatives to chromated primers for both interior and exterior application.

Depainting - Paint stripping is a dominant maintenance process than manufacturing. Stripping is conducted to inspect, repair, and then repaint a part. Historically, methylene chloride and MEK have been used in the repair of any coated part. These solvents were sprayed, brushed, or immersed on the component and the solvent/paint residue removed by washing or scraping. Methylene chloride has been the most common paint stripper used by the Air Force. Water jet blasting, laser paint stripping, Flashjet, Plastic Media Blasting, and Carbon Dioxide (CO_2) Stripping are some of the viable alternatives for this process.

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Surface Cleaning - Almost every traditional cleaning method uses an EPA-17 material or an Ozone Depleting Substance (ODS). Some of the chemicals historically targeted for elimination/reduction included 1,1,1-trichloroethane (TCA), CFC-113, trichloroethylene, perchloroethylene, MEK, methyl isobutyl ketone (MIBK), toluene, xylene, and methylene chloride.

Surface cleaning operations continue to be subjected to stringent emerging regulations. Often, when one material has been substituted for another material, the new material eventually becomes a target for substitution. For example, trichloroethylene and 1,1,1-TCA, used historically for vapor degreasing, were replaced with perchloroethylene. Now we have been looking for substitutes to perchloroethylene due to stricter regulatory requirements. In several cases, n-propyl bromide has been substituted for perchloroethylene in vapor degreasing.

Currently, the major driver in surface cleaning is finding viable alternatives to the use of HCFC-141b and CFC-113. Additionally, emerging VOC and HAP reduction requirements under the Clean Air Act (CAA) are driving further investigation of alternatives for these types of materials.

Surface Finishing (Plating/Anodizing) - Historically, surface finishing has been the largest source of hazardous waste in aircraft production. Any system that contains aluminum, stainless steel, high strength steels, magnesium, or titanium probably used hazardous chemicals in the treatment of the metal. The typical operations involved in surface finishing include the following:

- Chemical Milling - allows for the production of very thin skin materials (e.g., aluminum, titanium). For example, a concentrated sodium hydroxide solution is used for chemical milling of aluminum.
- Deoxidizing – has typically used a solution containing chromic acid to remove oxide from the metal surface as an initial preparation
- Etching – process used to prepare surfaces for structural adhesive bonding which historically has used a chromium containing etch solution (e.g., FPL etch, containing sodium dichromate).

AFP 44 has substituted FRA-90 for MDA (a suspected human carcinogen) in the composite component fabrication process.

Ion Vapor Deposited Aluminum (IVD) has replaced the use of cadmium plating at all AF ALC for most applications, except for inner diameter parts and for brush plating.

- Anodizing - has typically used chromic acid to form a thin, corrosion resistant coating on aluminum prior to painting. Chromic acid provides corrosion protection, easy process control, and causes no adverse impact on aluminum. Many facilities have successfully replaced chromic acid anodize with alternative acid solutions (see related article on page 30)
- Electroplating – deposits metal (chromium, cadmium, nickel, zinc, etc.) on metal surfaces for enhancing corrosion protection or hardness among other uses. Almost all nuts, bolts, and screws are plated with cadmium, chromium, or nickel. High Velocity Oxygen Fuel (HVOF) has emerged as the technology of choice to eliminate chrome plating. Ion Vapor Deposited Aluminum (IVD) has replaced the use of cadmium plating at the ALC in most applications. Electroless nickel plating has been a relatively common substitute for nickel plating.

Other Key Processes Targeted for Hazardous Materials Reduction

Composites – Composites typically require the use of MEK and Methylene Dianiline (MDA) (a suspected human carcinogen) in manufacturing and repair. Air Force Plant 44 has substituted FRA-90 for MDA in the composite component fabrication process. Additionally, AFRL is demonstrating/validating substitution of PMR-15 (containing MDA) with AFRPE composite and associated adhesive (see page 21).

Electronics – Cleaning, fluxing, and soldering are three areas of concern in electronics. The electronics industry, out of necessity, has high cleanliness standards. Historically, cleaning electronics had required the use of TCA and CFC-113 before and after the soldering process. Elimination of lead solder has become an emerging issue that is being addressed by weapon systems and through the Joint Group on Pollution Prevention (JG-PP).

Fuels, Lubricants, & Hydraulic Fluids – All fuels by nature are hazardous, but benzene in particular, as a carcinogen, is targeted for elimination/reduction. JP-4 contains as much as 25% benzene. Hydrazine has been targeted by AFMC for minimization. ASC is currently participating in an AFRL project to replace hydrazine in the F-16 Emergency Power Unit (EPU) and the U-2 Emergency Start System (ESS). Many hydraulic fluids contain barium as a corrosion inhibitor. AFRL is executing a project to replace barium containing fluids with biodegradable operational fluids.

Historical Perspective: Hazardous Materials Used in Air Force Industrial Processes and Weapon Systems

Ozone Depleting Substances (ODS), EPA-17 materials and their compounds continue to be chemicals of concern in Air Force industrial processes and weapon systems. Stringent Environmental Protection Agency (EPA) and Occupational Safety & Health Administration (OSHA) regulations continue to target these materials. In fact, all EPA-17 materials are also Volatile Organic Compounds (VOC) or Hazardous Air Pollutants (HAP) and therefore subjected to emerging Clean Air Act (CAA) regulations. This article provides general information on these classes of materials.

Class I and Class II ODS

In 1989, the Department of Defense (DoD) used 4,255 metric tons chloroflourcarbons (CFCs), with CFC-113 accounting for the largest usage. Although the use of most Class I ODS has been eliminated, the Air Force still continues to use CFC-113 in many cleaning processes. The continued use of CFC-113 represents a risk to a weapon system, since prolonged storage could lead to product degradation. The same is true for the continued use of various halons (e.g. Halon 1201 and 1301) for fire suppression.

Class II Ozone Depleting Substances (ODSs) (HCFC = Hydrochlorofluorocarbon)

1. HCFC-21	10. HCFC-131	18. HCFC-226	26. HCFC-243
2. HCFC-22	11. HCFC-141	19. HCFC-231	27. HCFC-244
3. HCFC-31	12. HCFC-142	20. HCFC-232	28. HCFC-251
4. HCFC-121	13. HCFC-221	21. HCFC-233	29. HCFC-252
5. HCFC-122	14. HCFC-222	22. HCFC-234	30. HCFC-253
6. HCFC-123	15. HCFC-223	23. HCFC-235	31. HCFC-261
7. HCFC-124	16. HCFC-224	24. HCFC-241	32. HCFC-262
8. HCFC-131	17. HCFC-225	25. HCFC-242	33. HCFC-271
9. HCFC-132			

NOTE: Some common Class II ODSs are R-21 and R-22

Class I Ozone Depleting Substances (ODSs) (CFC = Chlorofluorocarbon)

1. CFC-11	13. CFC-215
2. CFC-12	14. CFC-216
3. CFC-13	15. CFC-217
4. CFC-111	16. Halon 1011
5. CFC-112	17. Halon 1202
6. CFC-113	18. Halon 1211
7. CFC-114	19. Halon 1301
8. CFC-115	20. Halon 2402
9. CFC-211	21. Methyl Bromide
10. CFC-212	22. Methyl Chloroform
11. CFC-213	23. Carbon Tetrachloride
12. CFC-214	

NOTE: Mixtures of these chemicals are included i.e. CFC-500 & CFC-502 etc., Methyl Chloroform (MCF) = 1,1,1 Trichloroethane (TCA), Refrigerants commonly have an "R" prefix i.e. CFC-12 = R-12

The immediate concern for Class II ODS is associated with the use of HCFC-141b for cleaning electronics/avionics and aircraft oxygen system components. Air Force Research Laboratory (AFRL), Warner Robins Air Logistics Center (WR-ALC), HQ Air Force Materiel Command Logistics Branch (HQ AFMC/LGPE), and the Propulsion Environmental Group (PEWG) have executed various projects for elimination of HCFC-141b. Future bans on the production of Class II ODS require that researchers are adequately funded to identify alternatives, for HCFC-21 and HCFC-22.

EPA-17 Materials and Compounds

All the EPA-17 materials are also considered VOCs or HAPs and hence regulated under the Clean Air Act for air quality (NAAQS) and as hazardous air pollutants (NESHAPs). Additionally, several of these material are identified or suspected carcinogens (e.g., cadmium and chromium) and hence continue to be evaluated by OSHA for more stringent permissible exposure levels (PELs). Many of these materials. The EPA-17 materials have been classified into four main categories and are further discussed below.

Heavy Metals (Cadmium, Chromium, Lead, Mercury and Nickel)

Lead and mercury are commonly used in batteries. Chromium compounds are used in the aerospace industry in anodizing, deoxiding, plating, alodining, painting, chemical milling, paints, and sealants. Cadmium, mercury, and lead have known to bioaccumulate. This means that when present in relatively low concentrations, they can still be found in substantial concentrations in plant and animal tissue. Except for mercury, all these metals are classified as carcinogenic.

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Chlorinated Organics (Carbon tetrachloride, chloroform, methylene chloride, tetrachloroethylene, 1,1,1-trichloroethane, and trichloroethylene)

Chlorinated organics have been used as solvents for cleaning and degreasing and as carrying agents in paints and coatings. Methylene chloride has been used as a paint stripper. Trichloroethylene and 1,1,1-TCA have been used for vapor degreasing.

Aromatics (Benzene, Toluene, and Xylene)

Benzene, toluene, and xylene are common to gasoline and fuels. They are used as common carrying agents for paints and coatings. Toluene is the most common of the three chemicals used in paint solvents. All these chemicals contribute to creating ozone.

Other Chemicals (Methyl Ethyl Ketone, methyl isobutyl ketone, and cyanide)

MEK and MIBK are ketones and are used as common chemical solvents in adhesives and coatings for aerospace products. MEK is used as a wipe solvent to prepare metal surfaces for application of coatings and sealants. Cyanide salts are used in electroplating metals.

EPA 17: Adding "and compounds" to six of the chemicals turns the EPA 17 into the EPA 1000+. In addition to all these chemicals are Volatile Organic Compounds (VOCs) or Hazardous Air Pollutants (HAPs)		
1. Benzene	7. Lead and compounds	13. Tetrachloroethylene (PERC)
2. Cadmium and compounds	8. Mercury and compounds	14. Toluene
3. Carbon Tetrachloride*	9. Methylene Chloride	15. 1,1,1 Trichloroethane (TCA)*
4. Chloroform	10. Methyl Ethyl Ketone (MEK)	16. Trichloroethylene (TCE)
5. Chromium and compounds	11. Methyl Isobutyl Ketone (MIBK)	17. Xylenes
6. Cyanide and compounds	12. Nickel and compounds	

*NOTE: *These two chemicals are also ODSs. Chloroform is not Methyl Chloroform, Tetrachloroethylene = Perchloroethylene*

Project Definition and Making Smart Choices in Material Selection

Although, the Air Force has made great strides in reducing hazardous waste generation, the continued use of banned materials and the introduction of new materials to a process or weapon system must be carefully considered. When material selection decisions are made in the design phase, additional consideration should be given to the lifecycle impact in operation, maintenance, and disposal phases. Feedback from the logistics community on the operational and maintenance impacts of hazardous materials is essential to the system designers.

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Therefore, establishing a process for integrated hazardous materials management assures that the potential impacts are evaluated whenever a material selection or process design is performed for a new or existing weapon systems.

The attached set of questions and instructions were prepared by Lt. Col Denton Crotchett and first appeared in the September 1997 issue of the MONITOR. Lt. Col Crotchett's thoughts and ideas are still relevant as we move forward in formulating projects to mitigate the risks and cost associated with our hazardous materials and processes.

Making Smart Choices in Material Selection

General Questions to Ask

- Does any material have a shelf life? A shorter shelf life may lead to wasted materials that drive up disposal costs.
- Can smaller containers be substituted to mitigate impact of exposure, spill, or waste?
- Are there any special handling requirements for each material/chemical/substance candidate and alternative?
- Will any special materials be needed on the weapons system, any sub-system, or for any maintenance equipment to contain or store hazardous materials?
- Will the materials and quantities used initiate or add to reports required by federal/ state/local regulatory agencies? (e.g., Emergency Procedures and Community Right to Know Act, Toxic Release Inventory, Clean Air Act, Clean Water Act, National Pollution Discharge Elimination System.)

Project Considerations

- Involve experts in the evaluation process: Materials selection and evaluation requires input from many different specialists including industrial hygiene, occupational health, toxicology, acquisition pollution prevention, materials science, process engineering, systems safety, ground safety, operational safety, explosive safety, environmental management, and environmental compliance. These experts should participate in any environmental or human exposure testing and/or review the results of this testing.
- Define processes and tasks: To truly evaluate the hazards and risks from each material/chemical requires knowledge of the process and how the material is used in the process. A change in the material may cause a change in the process; i.e., multiple rinse cycles, longer drying times, additional capital equipment. Occupational health hazards, other than those related to chemicals and materials, should also be identified for each process. Workers may also be exposed to noise, radiation, heat/cold, safety, fire, and explosive hazards. The combinations of processes, materials, and hazards to perform a job/task/requirement can then be compared to make informed decisions.
- Identify issues related to maintenance activities: Materials/Chemicals used to perform maintenance procedures and those contained within each sub-system can cause exposures. Exposures to maintenance personnel could occur during procedures which empty, purge, and refill materials and from the clean-up of spilled materials. Exposures could also occur from cleaning, washing, stripping, painting, lubricating, welding, brazing, soldering, plating, metal treating, cutting, sanding, grinding, rubbing, and other maintenance procedures. The materials may also have environmental impacts.

Project Considerations (Continued)

- Consider accidental spills and discharges: If materials/chemicals are contained within the weapons system or its sub-systems, the potential for accidental spills or discharges must be considered. The site of the spill should also be considered (e.g., on the ground, in flight, in a storage facility, in a maintenance shop) as this affects the approach personnel would take to respond to a spill.
- Special facilities requirements: The use of certain materials/chemicals often require the construction of special maintenance and storage facilities. These facilities may need special ventilation systems, special waste containment or collection systems, special waste treatment or neutralization systems, or any other engineering controls.
- Consider training requirements: Training may include: maintenance procedures, use of PPE, use of engineering controls, emergency response/evacuation procedures, spill clean-up procedures, hazard communication required by the Occupational Safety and Health Administration, safety hazards, health hazards, waste disposal, and record keeping.
- Special requirements: Will Wage Grade/General Schedule (WG/GS) civil service employees be entitled to Environmental Differential Pay because of the hazards associated with any material or process?
- Operational considerations: Since the materials/chemicals used in, on, and with the weapon system will go to war with the system, the designers must consider all ESH issues when applied to a bare base or pre-engineered deployment site and wartime scenario. The special facilities may not be there and the use of special PPE may slow down the maintenance process if work/rest cycles for heat or cold stress injuries/illnesses need to be implemented. Additionally, in the stress of the moment, from the Operations-Tempo of war fighting, ground crew and maintenance personnel may not exactly follow the required procedures or may take short-cuts which will increase the risk of potential exposures and other mishaps. The fewer the special procedures, special PPE, special facility requirements, etc. needed during wartime scenarios, the better. If designers make it easy for the people (ideally no PPE, no special procedures, no special facility), then workers will not forget something critical concerning ESH issues. The more complicated the process the more apt people are to forget something.
- Manufacturing/Production: Each prime contractor and sub-contractor should be making smart business decisions about the use of hazardous materials which will minimize the manufacturing costs. This will, in turn, help to minimize the weapon system's life cycle cost.
- Life-cycle costs: If the use of any of the material candidates and alternatives drive special handling, special PPE, special storage and maintenance facilities, environmental and exposure monitoring, additional medical surveillance, special training, special disposal, etc., the life-cycle costs of these items for both peacetime and wartime scenarios should be considered and included in the life-cycle cost of the weapons system. Any trade studies used to make decisions on the material selections should also be reviewed.
- Disposal/Demilitarization of the system: The disposal/demilitarization procedures and processes for the weapons system need to be evaluated. Disposal and potential recycle opportunities should be identified.

Specific Questions to Ask: Project Definition Phase

- Have the appropriate experts been consulted?
- Have all material/chemical candidates and alternatives, and the quantities needed, which will be used in or on the weapon system and its sub-systems, or for its operation, been identified?
- Is there enough toxicological information known about the hazardous materials?
- For complex materials, such as mixtures of solvents/cleaners, or for multi-step process which may mix chemicals, is enough information known about potential synergistic or antagonistic effects of the mixtures on humans?
- Is any toxicological testing needed to characterize hazards to humans?
- Will any qualification, acceptance, or flight testing be needed to select materials and processes?
- Have all processes for storage, operation, use, maintenance, support and disposal of the weapon system and its sub-systems been identified and defined?
- Have all subordinate tasks within these processes been identified and described?
- For each task, have all material/chemical candidates and alternatives, the quantities needed, and the application method(s) been identified?
- Are any of these materials hazardous materials or radioactive materials?
- Are Material Safety Data Sheets (MSDSs) available on each hazardous material candidate and alternative?
- Is enough information known about the effects each material/chemical/substance candidate and alternative will have on other materials used in or on the weapons system and its sub-systems?
- Have other safety, chemical, physical, radiological, biological, and ergonomic hazards associated with each process and task been identified? (e.g., noise, lifting, repetitive motion, cutting, falling, microwaves.)
- Will any federal/state/local regulatory agencies require permits or licenses for the system operation, maintenance, materials, or processes? (e.g., air emission or waste water discharge permits, radioactive material licenses.)

Specific Questions to Ask: ESH Issues During Operation and Maintenance

- What are the estimated exposures to personnel which may occur during the routine maintenance procedures?
- What are the potential exposure routes (inhalation, skin contact, skin absorption, ingestion)?
- Are any exposures likely to exceed existing exposure limits?
- If material has cumulative effects, what is the life-time exposure to an individual worker from these exposures?
- Is any testing needed to better characterize exposures to maintenance workers?
- Will maintenance activities cause additional exposure monitoring by industrial hygiene and occupational health specialists?
- Will they cause additional medical surveillance and occupational health training?
- Will engineering controls (e.g.; exhaust ventilation) be needed to control exposures to maintenance workers?
- Will the maintenance personnel be required to wear personal protective equipment (PPE)?
- Will the PPE be routine (i.e., eye protection, gloves, aprons, hearing protection, etc.) or will special PPE (e.g., chemical resistant encapsulation suits, supplied air respirators) need to be developed and/or procured?
- What are the waste disposal requirements for each material/chemical/substance candidate and alternative?
- How much waste will be generated during each maintenance process or task?
- Will any waste be recycled?
- Will any of waste be a hazardous waste as defined in the Resource Conservation and Recovery Act (RCRA) (See 40 CFR 260-265) or similar state/local codes?
- Can a release to the environmental (soil, water, air) occur from the maintenance process or task?
- Is the release likely to exceed existing environmental contaminant limits/standards?
- Is any testing needed to better characterize release to or impacts on the environment?
- Will maintenance activities cause additional environmental monitoring to ensure compliance with regulatory requirements?
- Will engineering controls (e.g., exhaust stack scrubbers, waste water treatment) be needed to control or prevent releases to the environment?
- What special training will need to be given to the maintenance personnel, the aircraft ground crew, the storage facility personnel, and emergency response personnel?
- When and where will this training take place? Will periodic refresher training be needed?

Specific Questions to Ask: Spills, Discharges, Disposal Issues

- Where will the accidental spill/discharge occur?
- How will each material candidate and alternative be treated or neutralized if spilled?
- How will each material candidate and alternative and any treatment or neutralization processes or chemicals affect the materials used in the construction of the storage and maintenance facilities?
- How much material is likely to be released? How will the remainder be captured?
- Can exposure to ground crew, maintenance workers, storage facility occupants, emergency response personnel, or other workers occur from the accidental spill/discharge?
- How often are accidental exposures likely to occur?
- What are the potential exposures routes (inhalation, skin contact, skin absorption, or ingestion)?
- What are the estimated exposures to personnel from each accidental exposure?
- If any material has cumulative effects, then what is the life-time exposure to an individual worker from these accidental exposures?
- Are any exposures likely to exceed existing exposure limits?
- Is any testing needed to better characterize exposures to ground crew, maintenance workers, storage facility occupants, emergency response personnel, or other workers?
- Can a release to the environment (soil, water, air) occur from the accidental spill or discharge?
- What concentration is likely to be released to the environment?
- What impact will this have on the soil, air, water, plants, animals, human receptors?
- Is any testing needed to better characterize release to or impacts on the environment?
- How will each material candidate and alternative and any treatment or neutralization process or chemicals affect the materials used in the construction of the storage and maintenance facilities? Will special construction materials need to be selected?
- Will special safeguards be necessary to mitigate incompatibilities with surrounding activities?
- What measures can be taken to mitigate or reduce possible spill scenarios?
- Do special emergency response or clean-up procedures need to be developed?
- Will any chemicals/materials be needed to prepare the system for disposal, recycling, sale, or demilitarization?
- What are the estimated quantities of materials generated during the disposal and demilitarization processes?
- Will any of the system materials be recycled or sold for scrap?
- Do any of the materials used in the weapon system require special handling?
- Do any of the materials used in the system require disposal as a hazardous waste or as a radioactive material?

POLLUTION PREVENTION PROJECTS

AN OVERVIEW OF HQ AFMC P2IPT FUNDED PROJECTS

Headquarter Air Force Material Command Pollution Prevention Integrated Product Team (HQ AFMC P2IPT) identifies and funds pollution prevention projects that reduce the environmental compliance burden to the Air Force and improve AFMC's maintenance and manufacturing processes. A brief overview of some of these ongoing and completed projects is provided in the table below and the text description provided on pages 17-25. These projects are being tracked in the AFMC's *Solutions Database*. If you would like additional information, please contact the appropriate Project Manager listed below or Frank Brown (ASC/ENVV) at Frank.Brown@wpafb.af.mil.

HQ AFMC P2IPT Funded Pollution Prevention Projects

Project Title/Number	POC/Phone
Edwards Air Force Base (AFFTC) See page 17 ♦ CO2 Cleaning of Aerospace Ground Equipment (FSPM024016)	April Lawrence/DSN 527-1468
Air Force Research Lab (AFRL) See pages 17-22 ♦ Alternative Cleaners for Aerospace Systems (ZHTV02W118)	Maj Cliff Thorstenson/DSN 785-2247
♦ Aqueous Parts Washers (ZHTV02CP73)	Dave Ellicks/DSN 468-3284
♦ Cadmium Plating Alternatives (ZHTV01WL24)	Capt Tim Allmann/DSN 986-5697
X Demonstrate Quench Vane Technology for Reduced Emissions • *Reverse chronological NOx trend in fighter aircraft.*	Carlos Arana/DSN 785-5974
♦ Digital Radiography for the Elimination of Chemical Film Processing (ZHTV02W149)	Damaso Aguila Carreon/DSN 884-1882
♦ Specialty Coating Laser Removal System (ZHTV02W165)	Randy Straw/DSN 785-5598
♦ Elimination of Barium-Containing Fluids (ZHTV02WL22)	Lois Gschwender/DSN 785-7530
♦ Evaluate Effects and Environmental Compliance of Cleaning Compounds (ZHTV02CP03)	Dave Ellicks/DSN 468-3284
♦ Evaluate Environmentally Benign Deicing (ZHTV02W125)	Capt Tim Allmann/DSN 986-5697
X Evaluate Non-Chromated Conversion Coatings (ZHTV02W153)	John Speers/DSN 986-5699
X Evaluate Non-Cyanide Nickel Strippers (ZHTV02W151)	John Speers/DSN 986-5699
♦ Hydrochlorofluorocarbon HCFC-141b Replacements	Maj Cliff Thorstenson/DSN 785-2247
♦ Heavy Metal Alternatives for Internal Surfaces (ZHTV02W152)	Joe Kolek/DSN 986-5700
♦ Hi Temp HVOF Coating Applications (ZHTV02W131)	Joe Kolek/DSN 986-5700
X HVOF Coatings for Aircraft Components • *Conduct performance testing, metallurgical analysis and comparison to Electrolytic Hard Chrome (EHC) of various HVOF applied coatings on ASM 4340 high strength steel substrates.*	Joe Kolek/DSN 986-5700
X Low VOC Polysulfide Primer Testing (ZHTV02CT01) • *Evaluate performance of NESHAP (National Emission Standards for Hazardous Air Pollutants) compliant polysulfide primer (PR-1432GV) as a specialty coating for corrosion prone areas of aircraft.* • *Expand use of the primer to the complete outer mold line (OML) of the aircraft.* • *Determine the range of environmental conditions and processing parameters for optimal coating system performance.*	Mike Spicer/DSN 785-0942
♦ Hi Temp Composite Free of MDA (ZHTV02W163)	Mark Forte/DSN 674-4589
♦ NDI thru HVOF Coatings	Joe Kolek/DSN 986-5700
♦ Non-chrome Aluminum Pretreatments (ZHTV02W137)	Dr. Eric Brooman/DSN 986-6063

X ***- Indicates projects without text descriptions on pages 17-25.***

HQ AFMC P2IPT Funded Pollution Prevention Projects (Continued)

Project Title/Number	POC/Phone
Air Force Research Lab (AFRL) (Cont.) See pages 17-22 ♦ Oxidizer Vapor Recovery System (ZHTV02W119)	Capt Tim Allmann/DSN 986-5697
♦ Polymers as Replacement for CARC (ZHTV02CP87)	Dave Ellicks/DSN 468-3284
♦ Reduce Aircraft Particulate Emissions Using Fuel Additives	Edwin Corporan/DSN 785-2008
X Sol-Gel Technology for Adhesives and Sealants • *Eliminate volahle organic compound (VOC) emissions & hexavalent chromium from pre-bond preps using Sol-Gel technology.*	Jim Mazza/DSN 785-7778
X Zero VOC Topcoat • *Identify and evaluate new "0" VOC topcoat formulations against MIL-C-85285 spec.* • *Evaluate coating systems using Environmental Security Technology Certification Program (ESTCP) water reducible formulation.* • *Evaluate new "0" VOC topcoat formulations with several different primers.* • *Evaluate new "0" VOC topcoat formulations at field environmental conditions.*	Mike Spicer/DSN 785-0942
Aeronautical Systems Center (ASC) See page 23 **X** AFP44 – Appliques for Missiles • *Reduce VOCs at Air Force Plant (AFP) 44.*	Richard Lantis/DSN 785-2918
X AFP44 – Eliminate MDA • *Eliminate MDA (class A3 carcinogen and HAP) by substituting a new chemical at AFP44.*	Richard Lantis/DSN 785-2918
X AFP44 – Laser Based Surface Activation of Composites • *Reduce solid waste from pre-painting operations at Air Force Plant (AFP) 44.*	Richard Lantis/DSN 785-2918
X AFP44 – VOC Elimination – Powder Coat Follow-on • *Expand powder painting at Air Force Plant (AFP) 44.*	Richard Lantis/DSN 785-2918
X AFP44 – VOC Reduction – Plural Heated Spray of RAM Coatings • *Reduction of VOCs (methyl ethlyl ketone (MEK), toluene) by process substitution at Air Force Plant (AFP) 44.*	Richard Lantis/DSN 785-2918
X Elimination of CFC-113 in Wipe Cleaning of Oxygen Components (AFMC02PV31) • *Qualify alternative existing solvents to replace chlorofluorocarbon CFC-113 and hydrochlorofluorocarbon HCFC-141b in wipe cleaning aircraft oxygen systems.*	Frank Brown/DSN 785-3566
♦ Environmentally Friendly Alternative for Ballistic Liner Coating (AFMC02PV16)	Mary Wyderski/DSN 986-6178 Chuck Fabian/DSN 785-6088
X Environmentally Friendly Deicing Material Compatibility Testing • *Unique weapon system materials must be tested for compatibility with new deicing materials.* • *CWAA- pollution from storm water discharge must be eliminated, new products selected are alternatives to urea-based deicers.*	Capt Scott Steigerwald/DSN 674-6670
X Environmentally Friendly Portable Aircraft Deicing/Anti-icing Unit (AFMC02PV17)	Mary Wyderski/DSN 986-6178
X Hydraulic Fluid Purification (AFMC02PV06) • *Perform the final tests needed to incorporate Hydraulic Fluid Purification as a Standard Maintenance Process (SMP) within the USAF.*	Don Streeter/DSN 785-3550
X Hydrazine Replacement Feasibility • *Evaluate monopropellant fuels as potential replacement for hydrazine currently used in F-16 Emergency Power Unit (EPU) and U-2 Emergency Start System (ESS).*	Mary Wyderski/DSN 986-6178 Amy Mercado Vince/DSN 785-1747
X Ion Vapor Deposition • *Demonstrate a sputter coat process that can be applied to internal surfaces for corrosion protection in lieu of cadmium.*	Chuck Valley/DSN 785-3567
X Joint Strike Fighter Reclamation • *Qualified a process to demilitarize and recycle superalloys from condemned gas turbine engine components to reduce U.S. dependence on strategic materials.*	Mary Swinford/DSN 785-4169 x3185

X ***- Indicates projects without text descriptions on pages 17-25.***

HQ AFMC P2IPT Funded Pollution Prevention Projects (Continued)

Project Title/Number	POC/Phone
Aeronautical Systems Center (ASC) (Cont.) See page 23 **X** Multi-Weapon System/Environmentally Compliant Infrared Topcoat (AFMC02PV12) • *Modify current infrared topcoat and meet advanced weapon system requirements.* • *This project will eliminate HAPs and VOCs, including xylene, methyl ethlyl ketone (MEK), and MIBK.*	Mary Wyderski/DSN 986-6178 Chuck Fabian/DSN 785-6088
X Nickel Metal Hydride Battery • *Provide engineering services & analysis of a nickel-metal hydride (Ni-MH) battery design modification and integration test for implementation on F-16 block 25/30/32 and other military aircraft. Fabricate & test Ni-MH cells & batteries (43 Ah) that have an Energy Density > the 75 Wh/kg environmental goal. Fabricate prototype 22 Ah Ni-MH cells & batteries for all F-16 aircraft using the technology demonstration phase results.*	Frank Brown/DSN 785-3566
X EA RAM Coatings (AFMC02PV20) • *Reduce concentration of typically high VOC/HAP radar absorbing material (RAM) coatings to a minimal level of at least 150 g/L. This project will reduce cure time by 75%.*	Capt Lowell Usrey/DSN 785-6522
X PEWG – Advanced Non-Hazardous, Non-Corrosive Cleaning for Engines • *Qualify an alternative for pre Non-destructive inspection (NDI) cleaning and pre Eddy Current Inspection that doesn't require coating removal.*	Mary Swinford/DSN 785-4169 x3185
X PEWG – ESD for Repair on Engine Components (AFMC02LP01) • *Develop Electro Spark Deposition (ESD) as an alternative for hard chrome plating for localized repair to reduce the requirement for hard chrome stripping in gas turbine engine (GTE) repair.*	Mary Swinford/DSN 785-4169 x3185
X PEWG – HazMat Alternatives for TF33 et.al. Engines (AFMC02LP27) • *Identify alternatives for Aerospace Manufacturing & Rework National Emission Standard for Hazardous Air Pollutants (NESHAP) targeted chemicals, Class I/II ODSs (Ozone Depleting Substances), and EPA-17, AFMC-24, & EO 13148 hazardous material (HazMat) called out in gas turbine engine (GTE) technical orders (TOs):* – *General Electric Aircraft Engines (GEAE) GTEs: F101, F110* – *Pratt & Whitney (P&W) GTEs: TF33, F100* – *Rolls-Royce GTEs: TF56*	Mary Swinford/DSN 785-4169 x3185
X PEWG – Qualify SermeTel W Alternative • *Qualify Chromium VI+-free replacement for SermeTel W to reduce Chromium VI+ usage while lowering repair and overhaul costs and worker exposure to confirmed carcinogen.*	Mary Swinford/DSN 785-4169 x3185
X PEWG – Validation of Advanced Thermal Spray Coatings (HVOF) (AFMC02LP38) • *Qualify High Velocity Oxygen Fuel (HVOF) thermal spray as an alternative for hard chrome wet plating for localized repair to reduce the requirement for hard chrome stripping in gas turbine engine (GTE) repair.* • *Qualify HVOF coatings for repair of military GTEs.* • *Demonstrate and qualify advances in thermal spray materials and equipment for GTE applications (including nanostructured powders and nickel coatings).*	Mary Swinford/DSN 785-4169 x3185
X Qualify Hand Wipes Used in Cleaning of Oxygen Components • *Evaluate wipes to use with solvents to clean oxygen equipment.*	Frank Brown/DSN 785-3566
Headquarters Air Force Materiel Command, Logistics (HQ AFMC) See pages 23-25 Aircraft Oxygen Line Cleaning (ZHTV02G015) • *Identify and validate a technology using non-ozone depleting chemicals to clean oxygen lines on DoD and NASA aerospace vehicles. Joint project with Naval Air Systems Command (NAVAIR) & NASA. This project will eliminate the use of chloroflurocarbon CFC-113 in the cleaning of aircraft oxygen lines.*	Linda Willis/DSN 986-3679
♦ Boeing Aircraft and Missiles Non Chromate Primer for Aircraft Outer Mold Line (ZHTV02G002)	Steve Finley/DSN 787-8090
♦ Coating Alternatives for Support Equipment (ZHTV02G014)	Steve Finley/DSN 787-8090

X ***- Indicates projects without text descriptions on pages 17-25.***

HQ AFMC P2IPT Funded Pollution Prevention Projects (Continued)

Project Title/Number	POC/Phone
Headquarters Air Force Materiel Command, Logistics (HQ AFMC) (Cont.) See pages 23-25 ♦ Demonstrate Powder Coating Technology (ZHTV02G506)	Steve Finley/DSN 787-8090
X Environmentally Safe Wipe Solvent for Pretreatment (ZHTV02G516) • *Improve adhesion of organic coatings on titanium and stainless steel structures.* • *Reduce or eliminate use of chrome, lower VOCs and HAPs associated with paint process.*	Dennis Knotts/DSN 986-2632
♦ Lead-free Solder (ZHTV02G513)	Warren Assink/DSN 674-0151
♦ Replacement of Hard Chrome Plating on Hydraulic Actuators (ZHTV02G021)	Warren Assink/DSN 674-0151
♦ Replacement of Hard Chrome Plating on Landing Gear	Warren Assink/DSN 674-0151
♦ Replacement of Hard Chrome Plating on Propeller Hub	Warren Assink/DSN 674-0151
♦ Test a Non-Chromated Primer for Use within the Interior of USAF Aircraft (ZHTV02G514)	Steve Finley/DSN 787-8090
Oklahoma Air Logistics Center **X** Increase ACS System Capability (WWYK991019Z1) • *Eliminate/reduce methylene Chloride and benzyl alcohol/peroxide paint strippers in aircraft component part depaint operations. Reduce aircraft component part depaint flow time.*	Mark Harris/DSN 336-5986
Ogden Air Logistics Center **X** DemVal Alternative Material for C3I & Tactical Shelters (KRSM202627A1) • *Demonstrate & validate an alternate material for tactical shelters.*	Terry Holland/DSN 777-2860
X DemVal Electrospark Disposition (ESD) • *Reduce Electrolytic Chrome VI Plating and reduce associated wastes.*	Craig Shaw/DSN 775-6934
X Elimination of Methylene Chloride in Paint Stripping Processes • *Eliminate Methylene chloride use in paint stripping of landing gear components in Hill AFB Building 507 paint stripping tanks.*	Brad Christensen/DSN 586-0161
X Replace Chromic Acid Anodize Strip Solution • *Replace the use of chromic anodize strip solution.*	Dick Buchi/DSN 775-2993
Warner Robins Air Logistics Center (WR-ALC) See page 25 **X** Chemical/Waste Reduction in Paint Stripping • *Chemical/waste reduction in paint stripping through installation of a plastic media blast (PMB) process for identified parts.*	Ron Morton/DSN 468-5479 Chris King/DSN 468-1354
X DemVal Low VOC Erosion Resistant Coatings • *Assess and validate the properties of newly developed low VOC coatings that show potential for use as protective coatings for application on composite substrate materials. These coatings have to withstand damage from aggressive depaint processes while protecting the damage sensitive substrate materials.*	Richard Slife/DSN 468-1197 x139
X DemVal Powder Coating Booth • *Purchase powder coating booth and oven as deemed feasible under study by WL effort funded in FY00.*	Richard Slife/DSN 468-1197 x139 Dave Ellicks/DSN 468-3284
X Non-Chemical Alternative Depaint Process – Composites (UHHZ011324) • *Identify and assess candidate media for the purpose of developing a dry media blast (DMB) process to use on composite materials/ small radomes.*	Richard Slife/DSN 468-1197 x139
X Reduce/Eliminate Methylene Chloride from Paint Stripping (UHHZ020013) • *Some radomes and approximately 15% of the parts stripped, due to type material, short run small quantity or geometric constraints will have to be chemically stripped even after the plastic media blast (PMB) and Flashjet facilities are in full production mode. Effort will identify, test and seek to qualify environmentally friendly chemical options for remaining workload.*	Dave Bury/DSN 468-1197 x140

X ***- Indicates projects without text descriptions on pages 17-25.***

HQ AFMC P2IPT Funded Pollution Prevention Projects (Continued)

Project Title/Number	POC/Phone
Warner Robins Air Logistics Center (WR-ALC) (Cont.) **See page 25**	
X Replacement of Chromic Acid Anodize Process • *To validate boric-sulfuric acid anodize processing of C-130 aircraft parts (primarily propellers) at Robins Air Force Base as an option to chromic acid anodizing of high strength structural aluminum alloys.*	Dave Bury/DSN 468-1197 x140 Chris King/DSN 468-1354
♦ Expanded Flight Test Selective Stripping Coating System (SSCS) (UHHZ011325)	Richard Slife/DSN 468-1197 x139

X ***- Indicates projects without text descriptions on pages 17-25.***

♦ AFFTC/EMCP – Carbon Dioxide (CO_2) Cleaning of Aerospace Ground Equipment (Completed)

The purpose of this project was to test, evaluate, and implement a carbon dioxide ($C0_2$) cleaning process for surface preparation of aircraft ground equipment (AGE) prior to painting. Currently, Edwards AFB uses pressurized water cleaning system for this process, which generates hazardous waste and air emissions from contaminated wash water and cleaning solvents. The CO_2 blast cleaning process will eliminate several extremely high risk hazardous and air emission compliance sites at the facility and will save almost $9,000 annually through reduction in hazardous waste management costs. The technology was implemented at Edwards AFB in 2003. Contact April Lawrence, AFFTC/EMP april.lawrence@edwards.af.mil.

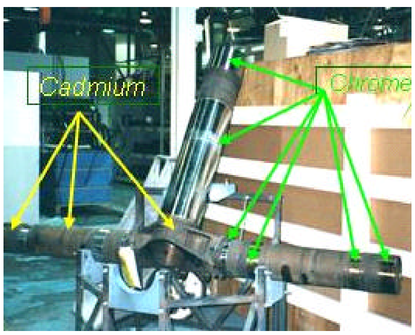
♦ AFRL/MLSC – Alternative Cleaners for Aerospace Systems (Completed)

The purpose of this project was to demonstrate and validate an environmentally acceptable, cost effective alternative to Freon-113 and 1,1,1-Trichloroethane used for precision cleaning of electronic and oxygen system components in space and missile systems. When implemented, this project will eliminate up to 11 tons of Class I ODS currently being used by the Air Force for precision cleaning. The final report for this project has been completed. The transition of alternatives to Air Force Space Command (AFSPC) is anticipated to occur in FY04. Contact Maj Cliff Thorstenson, AFRL/MLSC, Clifford.Thorstenson@wpafb.af.mil.

When implemented, this project will eliminate up to 11 tons of Class I ODS currently being used by the Air Force for precision cleaning.

♦ **AFRL/MLS-OLR – Evaluate and Select Aqueous Parts Washers (FY99 – Present)**

The purpose of this project is to identify, reduce, or eliminate hazardous waste generated from aqueous parts washers (APW) during maintenance operations. Under Phase I, the Air Force Corrosion Program Office (AFCPO) recommended alternative processes that will save 72% a year in disposal costs (that translates to $1.13M AF wide) and is now implemented at many bases. With leveraged funds, AFCPO tested and improved APW design changes that resulted in a four-fold increase in service life, 42% reduction in process time, and 90% reduction in hazardous waste generation. These improvements have been transitioned and are now commercially available. Field demonstrations of identified modifications and procedures are now underway and documentation information of maintenance guidance for field users is being developed under the current phase of this project. Full transition of final results is expected in FY04 at all AF field and depot locations. Contact Dave Ellicks, AFRL/MLS-OLR, David.Ellicks@wpafb.af.mil.



♦ **AFRL/MLSC – Cadmium Plating Alternatives (FY00 – Present)**

The purpose of this project is to identify, assess, test, and qualify selected materials as alternatives to cadmium plating. Under this project, an analysis of the Air Force aircraft cadmium plated applications, including performance & process requirements was conducted. Additionally, alternative candidates were identified and test protocols established for conducting screening of alternatives. Final report is anticipated to be completed in FY04 with products to be fielded in FY07. Contact Capt Tim Allmann, AFRL/MLSC, Timothy.Allmann@wpafb.af.mil.

♦ **Evaluation of Digital Radiography for the Elimination of Chemical Film Processing (AFRL/MLS-OLT) (FY02 – Present)**

The purpose of this project is to evaluate digital radiography for elimination of chemical film processing for Non-Destructive Inspection (NDI). Under this project, a test plan applicable to all weapon systems was prepared to address imaging issues, including the requirements for imaging curved surfaces or shots requiring cut film. This project eliminates the hazardous waste stream associated with chemical processing of x-ray film and silver recovery and is anticipated to save $1,200 per aircraft. Implementation is anticipated in FY05. Contact Damaso Auguila Carreon, AFRL/MLS-OLT at Damaso.Carreon@wpafb.af.mil.

♦ **AFRL/MLSC – Specialty Coating Laser Removal System (FY01 – Present)**

The purpose of this project is to demonstrate/validate the use of a handheld laser on specialty coatings on weapon systems. It will also evaluate the use of a "glove-box" cabinet containing a handheld stripping laser to strip small-off-equipment components. Under this project, test panels and components that are representative of aircraft coating systems and substrates will be manufactured and stripped with TEA-CO2, Nd:YAG, and Diode portable lasers. This project eliminates the use of methylene chloride, methyl ethyl ketone (MEK), hand sanding, and plastic media blast (PMB) and will address over 140+ AFMC compliance sites. Elimination of contaminated abrasive blast media will alone save $4 million annually. Transition is planned for FY05. Contact Randy Straw, AFRL/MLSC at Randall.Straw@wpafb.af.mil.

♦ **AFRL/MLBT – Elimination of Barium Containing Fluids in Aircraft Hydraulic Systems (FY00 – Present)**


Anomoly Noted with Rust Inhibited Fluid

The purpose of this project is to replace barium containing fluid with biodegradable operational fluids. The US Army has issued a directive to stop the use of inhibiting fluids (such as barium) and the Navy is also drafting a similar directive. This project will conduct mechanical, chemical, and storage tests for barium containing and operational fluids. Parts will be observed for corrosion and photographed and analyzed according to a preset schedule. Transition is planned for FY05. Contact AFRL/MLBT, Lois Gschwender at Lois.Gschwender@wpafb.af.mil.

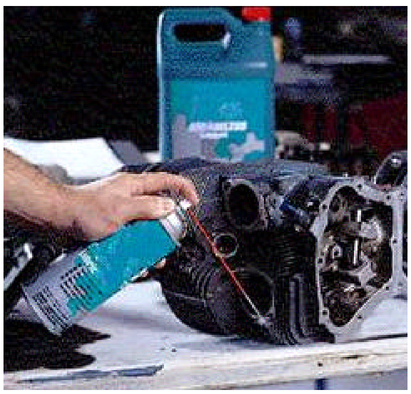
The US Army has issued a directive to stop the use of inhibiting fluids (such as barium) and the Navy is also drafting a similar directive.

♦ **AFRL/MLS-OLR – Evaluate Effects and Environmental Compliance of Cleaning Compounds (FY02 – Present)**

The purpose of this project to develop a performance based cleaning specification for inclusion into T.O. 1-1-8, 1-1-691, and 1-1-689. This project first identified cleaning processes for inclusion into a Cleaning Material Qualification Protocol (CMPQ) and determined performance requirements for each cleaning process. Various cleaning materials and processes will be tested for inclusion into the CPQM. This project will allow for the adoption of cleaning materials based on performance rather than chemical composition and is expected to save $490,000 annually through addressing over 3,740 compliance sites. Incorporation of new specifications in the associated TOs is expected in FY05 at all AF field and depot locations. Contact Dave Ellicks, AFRL/MLS-OLR at David.Ellicks@robins.af.mil.

♦ AFRL/MLSC – Evaluate Environmentally Benign Deicing/ Anti-icing (FY01 – Present)

The purpose of this project is to identify and demonstrate the effectiveness of commercially available materials as alternatives to current aircraft and runway deicing and anti-icing fluids. This project will eliminate the costly containment operations associated with current deicing materials. Additionally, the project is anticipated to save the Air Force over $600,000 annually by eliminating of hazardous material and hazardous waste associated with deicing operations. Contact Capt Tim Allmann, AFRL/MLSC, Timothy.Allmann@wpafb.af.mil.



♦ AFRL/MLSC – Hydrochlorofluorocarbon HCFC-141b Replacements for Aerospace Systems Cleaning (FY01 – Present)

The purpose of this project is to identify and qualify alternatives to HCFC-141b in cleaning electronic/avionic and aircraft oxygen system components. The manufacturing and importing of HCFC-141b was banned on 1 January 2003 under the Clean Air Act. If viable alternatives are identified, this project will eliminate 27,000 pound of HCFC-141b used in the AF annually. Transition of successfully qualified alternatives is expected in FY04. Contact Maj Cliff Thorstenson, AFRL/MLSC, Clifford.Thorstenson@wpafb.af.mil.

♦ AFRL/MLSC – Heavy Metal Alternatives for Internal Surfaces (FY99 – Present)

The purpose of this project is to demonstrate/validate and implement alternatives to Electrolytic Hard Chrome (EHC) plating for Non-Line of Sight (NLOS) applications. It is anticipated that $150,000 will be saved annually through addressing chrome plating related compliance sites at the ALCs. Specifically, a cost avoidance of $108,000 annually is anticipated at OO-ALC related to chromium disposal costs. Contact Joe Kolek, AFRL/MLSC, Joseph.Kolek@wpafb.af.mil.

♦ AFRL/MLSC – High Temperature High Velocity Oxygen Fuel (HVOF) Coating Applications (Completed)

The purpose of this project is to conduct a material and metallurgical analysis of HVOF coatings at elevated temperatures. Under this project, test specimens from high temperature alloys used for gas turbine applications will be prepared and coated with HVOF. Extensive fatigue and tensile testing will be conducted at elevated temperatures, and materials and metallurgical analysis of the coating and the substrate evaluated. The data collected in this project will help facilitate the transition of HVOF coatings and an alternative to chrome plating for high temperature gas turbine applications. The final report is anticipated to be completed by FY03. Contact Joe Kolek, AFRL/MLSC at Joseph.Kolek@wpafb.af.mil.

♦ **AFRL/MLSA – High Temperature Composite/Adhesive Structural Material Free of Methylenedianiline (MDA) (FY01 – Present)**
The purpose of this project is to demonstrate and validate the substitution of PMR-15 with AFRPE. PMR-15 is used in trailing edge, gearbox covers, transmission housing, inlet particle separators, vent tubes, fan start assembly, external exit flaps, and core cowls structures. PRM-15 contains methylenedianaline (MDA), a suspected human carcinogen. Savings of $5.5 million over 5 years is anticipated from this substitution from reduced personal protective equipment reduction, hazardous waste disposal, specialized training/clean room maintenance, and specialized equipment maintenance. Transition is planned for FY04. Contact Mark Forte, AFRL/MLSA at Mark.Forte@wpafb.af.mil.

Savings of $5.5 million over 5 years is anticipated from the substitution of PRM-15 with AFRPE from reduced personal protective equipment reduction, hazardous waste disposal, specialized training/clean room maintenance, and specialized equipment maintenance.

♦ **AFRL/MLSC – Non-Destructive Inspection through High Velocity Oxygen Fuel (HVOF) Coatings (Complete)**
The purpose of this project is to compare the ability of the current Non Destructive Inspection (NDI) techniques available at the depot and field level to detect cracks under HVOF coatings versus Electrolytic Hard Chrome (EHC) coatings. This project was completed in FY02 and the full transition of the HVOF technology to OO-ALC is anticipated by FY05. Contact Joe Kolek, AFRL/MLSC at Joseph.Kolek@wpafb.af.mil.

♦ **AFRL/MLSC – Nonchrome Aluminum Pre-Treatments (FY00 – Present)**
The purpose of this project, a part of a joint Department of Defense (DoD) effort that is led by the Navy, is to test and evaluate alternatives to the use of hexavalent chrome containing aluminum pre-treatments for depot maintenance operations. If successful, the project will eliminate the use of approximately 60,000 gallons of hexavalent chromium currently being used. To date, X-It Prekote has successfully been implemented for this process at Hill AFB. Contact Dr. Eric Brooman, AFRL/MLSC at Eric.Brooman@wpafb.af.mil.

♦ **AFRL/MLSC – Oxidizer Vapor Recovery System for Space & Missile Systems (Complete)**

The purpose of this project was to demonstrate and evaluate the use of microwave technology for destruction of hypergolic fuel and oxidizer vapors. Hypergolic fuel contains hydrazine and nitrogen tetroxide present in oxidizer vapors. This project has the potential to save $100,000 annually through elimination of hazardous waste and disposal cost associated with this process. Field test of the microwave system was conducted in FY02 and the final report on the project was completed in FY03. Contact Capt Tim Allman, AFRL/MLSC at Timothy.Allman@wpafb.af.mil.

♦ **AFRL/MLS-OLR – Polymers as Replacement for Chemical Agent Resistant Coatings (CARC) (Completed)**

The purpose of this project was to evaluate environmentally compliant polymer and powder coatings to replace MIL-C-29475 Chemical Agent Resistant Coatings (CARC). Under Phase I of the project, AFCPO evaluated candidate coatings for chemical agent resistance, corrosion protection, weatherability, and abrasion/impact resistance. The final technical report was completed and accepted. Field-testing was not conducted on the best alternatives due to a joint service research effort that was started in 2001. The next step will be to accomplish a field service evaluation in which this coating will be applied to two operational F-16 aircraft for a period of 18 months. Contact Dave Ellicks, AFRL/MLS-OLR at David.Ellicks@wpafb.af.mil.

♦ **AFRL/PRTG– Reduce Aircraft Particulate Emissions Using Fuel Additives (Ongoing)**

The purpose of this project is to demonstrate parts per million (ppm) fuel level additives that reduce particulate emissions from gas turbine engines by 50% or greater. Currently over 34 installations are within or adjoin counties at risk of exceeding the pending EPA $PM_{2.5}$ standard. Based on the testing conducted to date, seven additives have shown to reduce particulate emissions in atmospheric pressure combustors relative to neat JP-8 fuels. Contact Edwin Corpan, AFRL/PRTG at Edwin.Corpan@wpafb.af.mil.

Currently over 34 installations are within or adjoin counties at risk of exceeding the pending EPA $PM_{2.5}$ standard.

♦ **ASC/ENVV (F-16 Program) – Environmentally Friendly Alternative for Ballistic Liner Coating (Completed)**
The purpose of this project was to modify the current ballistic liner coating used on the F-16. The project can reduce AF Plant emissions by 431 tons (210 aircraft buy for F-16) and in turn reduce the planned F-16 depot modification program. Additional AFP4 VOC reduction can be achieved by implementing the alternative for the JSF and F/A-22 programs at the facility. The modified system was originally worked internally by the original equipment manufacturer (OEM) that included both manual application and robotic processing. Technology transition is expected in FY05. Contact Mary Wyderski, ASC/YPVE at Mary.Wyderski@wpafb.af.mil.

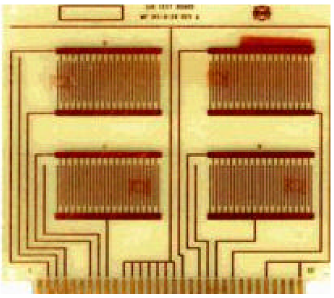
♦ **HQ AFMC/LGPE – Test a Non-Chromated Primer for Use Within the Interior of USAF Aircraft (FY99 - Present)**
The purpose of this project is to demonstrate/validate the use of a non-chromated primer on AF weapon systems. When successfully implemented, this project will eliminate the use of 7,000 lbs of chromed primer used by AFMC annually. This represents a 72% reduction in the use of chromated primers by AFMC. Additionally a 60% reduction in VOCs is also anticipated. This project represents the Air Force portion of the joint project now complete. Currently the AF is conducting flight-testing on the KC-135. Contact Steve Finley, HQ AFMC/LGPE at Steven.Finley@wpafb.af.mil.

When successfully implemented, the Non-Chromate Primer for Aircraft Outer Mold Line project will eliminate the use of 7,000 lbs of chromed primer used by AFMC annually.

♦ **HQ AFMC/LGPE – Coating Alternatives for Support Equipment (FY99 - Present)**
The purpose of this project is to validate low/no VOC and non-chromate coating systems for support equipment. This project can reduce VOC and HAP releases as well reduce the amount of chromates and other hazardous materials released into waste streams that are produced from support equipment. Contact Steve Finley, HQ AFMC/LGP-EV at Steven.Finley@wpafb.af.mil.

♦ **HQ AFMC/LGPE – Demonstrate Powder Coatings Technology (FY01 –Present)**

The purpose of this project is to demonstrate a powder coating technology that will be used instead of organic coatings on non-flight critical components. This project can reduce VOC and HAP and comply with the AFMC strategy to implement powder coatings. Final test report and transition plan are expected to be completed Feb 06 with implementation beginning Feb 07. Contact Steve Finley, HQ AFMC/LGP-EV at Steven.Finley@wpafb.af.mil.

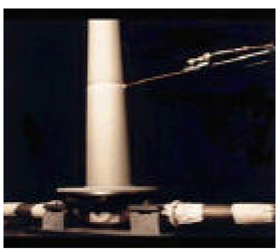


♦ **HQ AFMC/LGPE – Lead Free Solder (FY02 – Present)**

The purpose of this project is to determine the impact of the industry's switch to lead-free solder on the weapon system owner's current operations and repair procedures. This will reduce the impacts that can occur due to European Union Regulations, while reducing the use of lead-solder. The Joint Test Report is expected for completion Jan 06 and information passed to all weapon systems by Feb 06. Contact Warren Assink, HQ AFMC/LGP-EV at Warren.Assink@wpafb.af.mil.

♦ **HQ AFMC/LGP-EV – Replacement of Hard Chrome Plating on Hydraulic Actuators (FY00 - Present)**

The purpose of this project is to demonstrate HVOF coatings on utility and flight control actuators at OO-ALC. Phased implementation will begin Spring 04 and final report completed Fall 05. Contact Warren Assink HQ AFMC/LGP-EV at Warren.Assink@wpafb.af.mil.

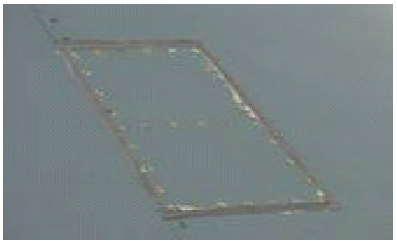


♦ **HQ AFMC/LGP-EV – Replacement of Hard Chrome Plating on Landing Gear (FY96 – Present)**

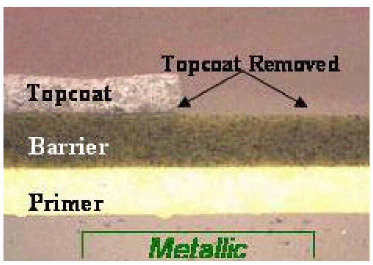
The purpose of this project is to demonstrate validate HVOF coatings on USAF airplane landing gear at OO-ALC. Phased implementation is anticipated in 2003. Contact Warren Assink, HQ AFMC/LGP-EV at Warren.Assink@wpafb.af.mil.

♦ **HQ AFMC/LGP-EV – Replacement of Hard Chrome Plating on Propeller Hubs (FY99 – Present)**

The purpose of this project is to demonstrate and validate HVOF coatings on C-130 T-56 propeller Barrel-Tail shaft and Sleeve-Level to the C-130 Program management at WR-ALC. This project has the potential to extend the life of prop hub. In FY02 initial operating testing began at Naval Depot Jacksonville. Contact Warren Assink, HQ AFMC/LGP-EV at Warren.Assink@wpafb.af.mil.



♦ **HQ AFMC/LGP-EV – Test a Non-Chromated Primer for Use within the Interior of US Air Force Aircraft (FY02 – Present)**
The purpose of this project is to demonstrate and validate non-chromated primer for aircraft interiors with leverage work coming from non-chromated project for outer mold lines. This project has the potential of a 40% reduction of hexavalent chromium on all components and interior surfaces as well as reduce VOC and HAP emissions. Implementation should begin Aug 05. Contact Steve Finley, HQ AFMC/LGP-EV at Steven.Finley@wpafb.af.mil.



♦ **WR-ALC/MAPE – Expanded Flight Test Selective Stripping Coating System (SSCS) (FY95 – Present)**
The purpose of this project is to validate performance and benefits of SSCS, which removes only the topcoat and leaves the barrier coating intact to encapsule hazardous materials in the primer, on C-130, F-15, F-16, and KC-135 by completing a flight-test. This project has the potential to reduce hazardous waste by 95% as a result of not having to strip the substrate and will reduce cost of ownership. Implementation Plan and Final Report should be completed Jun 05 and Jan 06 Technical Order should be approved. Contact Richard Slife, WR-ALC/MAPE at Richard.Slife@robins.af.mil. ⬢

Air Force Plant 4

Air Force Plant 4 (AFP4), located in Fort Worth, TX, is owned by the Air Force and operated by Lockheed Martin Aeronautics Company. The facility was opened in 1941 for the manufacturing of the B-24 bomber.
In the past, the plant has also produced B-32, B-58, and F-111. The facility currently supports the manufacturing of the F-16, F/A-22 (mid-fuselage section and various subsystems), and the future production of the Joint Strike Fighter (JSF), and various sub systems.

AFP4 supports the manufacturing of the F-16, F-22 (mid-fuselage section and various subsystems), and the future production of the Joint Strike Fighter (JSF), and various sub systems.

In 1992, USA Today highlighted the Ozone Depleting Substances (ODS) emissions from Department of Defense (DoD) facilities and installations. At that time, the top position for DoD emitters was AFP4, with an annual emission of 275 tons in 1987 and 1988. AFP4 accelerated the elimination of ODSs by execution of a Wipe Solvent Replacement Project for CFC-113, which accounted for 90% of emissions.

An additional 5% was attributed to the use of 1,1,1, TCA in vapor degreasing. In fact, historical use of tricholorethylene (TCE) for degreasing activities has resulted in groundwater contamination that has placed the facility on the Superfund Site for remediation.

With the ban on ODS Production, the remaining 5% ODS elimination was aggressively pursued in 1993. As a result, AFP4 has eliminated the use of the ODS in its processes. Today, the Hazardous Materials Management Program manages all materials that are brought on site as dictated by its restricted and banned material lists.

Many of the current processes and coatings involved in manufacturing use chromium as a corrosion protection for aluminum. The challenge for AFP4 is to find substitutes to these chromium processes and obtain the buy-in from Program Managers to eliminate chromium from chemical processes. Working jointly with the F-16 Program and Aeronautical Systems Center (ASC), several pollution prevention projects have been funded to eliminate chromium and other EPA-17 materials from the manufacturing facility (see related article on F-16 on pages 27-30).

Successful projects that have reduced chromium usage include the following:

- Replacing chromic acid anodizing with sulfuric acid anodizing for treating aluminum (AFMC Funded Project)
- Replacing molten salt heat treatment solution containing chromium with a hot air oven/glycol quench heat treat system to heat treat aluminum parts.
- Converting wet paint booths using a waterfall system to control particulate emissions with dry paint filters.
- Removing part of chromated deoxidizers used in chemical processing to produce a solution with low metal content (F-16 Program Funded Project).
- Replacing an Etch with phosphoric acid anodize.
- Replacing a tri-acid cleaning solution containing chromium with nitric acid hydrofluoric (F-16 Program Funded Project)
- Replacing a sodium dichromate solution with a seal containing less than 200 ppm chrome.

Wastewater discharge from metal finishing processes has significantly declined from these efforts. In 1990, 13,000 pounds of chromium were discharged to wastewater. By 2001, less than 200 pounds were being discharged.

In 2002, AFP4 received the Stockholm Industry Water Award.

Air Force Plant 44

Air Force Plant 44 (AFP44), located in Tucson, AZ, is owned by the Air Force and operated by Raytheon Missile Systems Company. The plant was established in 1950 when the Air Force contracted with Hughes for Falcon missile and radar/fire control. Between 1951-52, Hughes built the plant and began manufacturing the Falcon missile for the Air Force. AFP44 primarily manufactures missiles for all branches of the US Military and for foreign countries. The facility covers 2,900 acres (95% government owned) and 2.1 million square feet (51% government owned).

Although AFP44 is located in an air quality "attainment" area, the Air Force and Raytheon have been working together to lower the air emissions from the plant. All these efforts have resulted in the facility obtaining a "synthetic" minor permit for Hazardous Air Pollutants (HAPs). The facility is looking at obtaining a similar status of Volatile Organic Compounds (VOCs).

Although AFP44 is located in an air quality "attainment" area, the Air Force and Raytheon have been working together to lower the air emissions from the plant. All these efforts have resulted in the facility obtaining a "synthetic" minor permit for Hazardous Air Pollutants (HAPs).

The solutions that have contributed to this success include the following:

- Use of electrostatic spray gun system in lacquer painting operations (MEK/ toluene reduction).
- Use of powder paint coatings for missile airframes and other components (MEK/toluene reduction).
- Use of FRA-90 in the composite component fabrication process (methylenediailine elimination).
- Use of an aqueous cleaner to replace vapor degreasing in circuit card cleaning operations prior to conformal coating (eliminated 10.1 tons/year VOCs).
- Use of two carbon dioxide (CO_2) "frozen pellet" stripping systems for decontaminating equipment and removing light rust coating (eliminated solvent use and plastic media blasting).

Although the Industrial Wastewater Treatment Plant (IWTP) was originally designed to accommodate 750 gal/min of wastewater, today it has been completely closed. In 2000, the wastewater flow was reduced to 600,000 gallons (from a 1998 level of 4.5 million gallons) when the printing wire board and circuit card assembly manufacturing was moved to other sites. In 2002, "front-end" recycling on many manufacturing process lines further reduced this flow to 250,000 gallons per year. Finally, the flow of the IWTP was completely shut off with the implementation of atmospheric evaporators.

The solutions contributing to AFP44's ability to shut down the IWTP include the following:

- Aqueous cleaning solution and rinsewater recycling using ultrafiltration and reverse osmosis (1.2 million gallons/yr wastewater eliminated).
- Installation of Electroflotation Technology (processes 36,000 gal/yr wastewater).
- Conversion of five waterfall paint booths to dry filtration.
- Installation of new stereo lithography rapid-prototyping system (eliminated disposal of 500 gal/yr IPA).

In 2001, Raytheon received the Arizona Governor's Pride award for Industrial Pollution Prevention.

AFP4 Replaces Chromated Deoxidizer

Historically, the F-16 program has used a Tri-Acid (nitric/hydrofluoric/chromic) deoxidizer solution treatment prior to anodizing and chemical film treatments on aluminum.

Deoxidizers are used to remove surface oxidation prior to additional surface treatment. Anodizing, chemical conversion coating and bonding applications require this pretreatment.

Deoxidizers are used to remove surface oxidation prior to additional surface treatment. Anodizing, chemical conversion coating and bonding applications require this pretreatment. This evaluation concentrated on the compatibility with the anodizing and chemical conversion treatments in the main Lockheed Martin Aeronautics (LM Aero) process line at AFP4. LM Aero Process Control is responsible for the deoxidizer process, which is included in Process Standards 74.02-2 and 74.02-3. The deoxidizer needs to be evaluated as a system with the sulfuric acid anodize (FPS-3090), chromic acid anodize (MIL-A-8625 Type I), and chemical conversion coating (MIL-C-5541). The deoxidizer is also used to etch aluminum alloys for penetrant inspection per NDTS 1101 and the etchant solution needs to meet the requirements of FPS-1051. The results of this effort are summarized on the next page.

Screening Tests & Results

The screening program tested nine (9) candidates for corrosion resistance, paint and seal bond adhesion, and electrical resistance. Corrosion resistance was conducted on unprimed panels of anodized 2024, anodized 7075, and conversion coated 2024. Paint adhesion was evaluated using MIL-PRF-23377 and MIL-PRF-85552 primers. Seal bond adhesion was evaluated using FMS-3014 primer and adhesive. The deoxidizers were also assessed for dye penetrant testing compatibility, machine mark pitting, and grain boundary attack on 2124 aluminum under the magnification of an optical microscope and a scanning electron microscope (SEM).

- Deoxalume 2310 (Henkel Surface Technologies
- Oakite 60FD (Chemetall Oakite)
- Oakite 231 (Chemetall Oakite)
- Aldox V (Turco Aviation)
- Sanchem 1000 (Sanchem, Inc.)
- Smut-Go NC (Turco Aviation)
- Smut-Go NCB (Turco Aviation)
- Henkel TD-3057 (Henkel Surface Technologies)
- Bi-Acid System (Nitric/Hydrofluoric)

During testing, Process Control switched from the Tri-Acid etch to one of the candidate deoxidizers, Turco Smut-GO NCB, in the anodize and chemical conversion coating process lines. There were inconsistencies in the composition of the product and it was later replaced with a two-tank nitric/hydrofluoric acid system. The Bi-Acid (Nitric/Hydrofluoric) etch was included with the other candidates for testing at this time and the Turco Smut-Go NCB was dropped.

All of the tested candidate deoxidizers passed the paint adhesion tests but only Henkel TD-3057 passed the electrical resistance test. From testing data Henkel TD-3057, Aldox V, Oakite 60FD, and the Bi-Acid system were selected for qualification testing. The crucial performance factor for the qualification phase of the program was the uncoated panel corrosion resistance test. This test method was also used to evaluate the manufacturer's recommended immersion time for each potential system. The Oakite 60FD deoxidizer was discontinued by the manufacturer in the qualification phase and was therefore eliminated from the project. The best performer for all processing was the Bi-Acid, then the Aldox V, followed by the Henkel TD-3057.

Henkel TD-3057, Aldox V, and the Bi-Acid system were examined for etching effects on 7050-T7451 and 7475-T7351 aluminum. Aldox V and the Bi-Acid system were the best candidates in both corrosion resistance and etchant effects. The Bi-Acid system was validated for the F-16 finishing process through testing. It was preferred to Aldox V because of previous experience using it and lower cost. The high nitric acid of the system is still a concern and is one of the high volume items on LM Aero's Toxic Release Inventory (TRI) list.

The Bi-Acid system was validated for the F-16 finishing process through testing. It was preferred to Aldox V because of previous experience using it and lower cost.

For further information, please contact Ms. Mary Wyderski at DSN 986-6178.

AFP4 Replaces Chromated Prebond Etchant With Phosphoric Acid Anodize

Air Force Plant 4 has successfully completed a project to identify, test, and qualify a non-chromated prebond etch for use in the structural bonding process. The existing chromated products in the process included a deoxidizer, an etchant, and a structural adhesive primer (FPS-3018, Form II) for bonding of aluminum alloys. There were no viable non-chromated candidates for the Form II primer at the start of the project. Therefore, the project focused on surface preparation aspects only. Details related to this effort are provided below.

Project Description & Results

The project focused on replacing the chromated modified Forrest Product Laboratories (FPL) etch solution used to prepare the surface of the substrates prior to bonding. The four promising candidate processes identified through literature search and selected for testing include the following:

- FPL Etch with Quarter Strength Chromate - contains a reduced amount of sodium dichromate and was added in case a fully non-chromated candidate failed
- P2 Etch – is a sulfuric acid and ferric sulfate blend developed and patented by the Army.
- Phosphoric Acid Anodize (PAA) – is widely used as an alternative to FPL etch and is considered to be one of the better techniques for guaranteeing lasting durability. A number of Air Force facilities have used PAA for years and have had positive results.
- Sulfuric Acid Anodize (SAA) – is an anodize process that is now being used at LM Aero for general anodizing of parts.

The SAA didn't pass the T-peel testing and was consequently dropped from testing.

Quarter strength FPL etch and P2 etch showed a tendency to cause smutting during the processing of 2024-T81 aluminum panels. The quarter strength FPL etch had favorable T-peel results and double overlap sheer results. The quarter strength FPL was dropped from testing because it didn't completely eliminate chrome, and the smutting raised questions about the quality of the adhesive bond. The P2 etch process came close to qualifying, but failed a key salt fog durability test. PAA was qualified for use on F-16 parts at LM Aero due to its superior performance in testing.

Solution Implementation

The PAA and a bi-acid deoxidizer (see related article on page 27) were jointly qualified for the bondline. Facilities were installed in order to accommodate the new deoxidizer and the PAA process. A production qualification was conducted for F-16, F/A-22, and F-2 components that confirmed the scale-up to production tank sizes. The surface preparation of F-16 components for structural bonding is now a chrome-free operation.

The P2 etch process came close to qualifying, but failed a key salt fog durability test. PAA was qualified for use on F-16 parts at LM Aero due to its superior performance in testing.

For further information regarding this process change, please contact Ali Khan at DSN 785-3236 or Mary Wyderski at 986-6178.

AFP4 Success Story: Replacement of Chromic Acid Anodize With Thin Film Sulfuric Acid Anodizing System

In 1999, Engineering specifications FPS-3001 and FPS-3090 were revised to allow use of Thin Film Sulfuric Acid Anodize (TFSAA) process at Air Force Plant 4 (AFP4) operated by Lockheed Martin – Aeronautics in Fort Worth, Texas. This article provides an overview of this process substitution.

Background & Process Substitution

The primary finish for aluminum and aluminum alloy parts applied at AFP4 had historically been an anodic coating formed using chromic acid solution meeting the requirements of MIL-A-8625, Type I. This treatment served as both a corrosion resistant layer and a basis for subsequent organic finishes. While the performance of the anodic coating was excellent, the solution used for anodizing contained high concentrations of chromic acid.

A suitable substitute for chromic acid anodize required compliance to the following criteria:

- Meet all performance requirements of the current process;
- Remain compatible with all organic coatings currently applied to parts processed in the chromic acid anodizing solution; and
- Be implemented in the existing chemical process facility with minimal facility changes.

The initial screening activities conducted in the late 1980's and early 1990's indicated that conventional sulfuric acid anodizing, per MIL-A-8625 Type II, was not an acceptable replacement for chromic acid anodize because the resulting anodic coating weights were too high, causing concern for fatigue life on structural alloys. An alternative, thin film sulfuric acid anodizing (TFSAA) process was sought, allowing for the elimination of chromic acid while maintaining anodic coating weights at a level similar to that of chromic acid anodize.

Using small pilot systems, Engineering developed an alternate process using low concentration sulfuric acid operating at controlled room temperature. The Materials & Process (M&P) Engineering Group at Lockheed Martin Aeronautics performed the initial engineering tests, and finalized the operating parameters for the TFSAA system. Testing included coating weight, paint adhesion, corrosion resistance, and primer adhesion.

Production qualification for TFSAA included qualification plan tests on a full-scale system. The qualification plan tests specifically included the coating weight, corrosion resistance, and paint adhesion testing as specified in MIL-A-8625, and added sealant adhesion, nitrile-phenolic bonding adhesion, and fuel tank resistance metrics. Further evaluations investigated TFSAA fatigue properties and mixed load processing capabilities. All testing indicated that the performance of TFSAA met the same requirements of chromic acid anodizing.

In 1998 and 1999, the Production TFSAA system successfully passed all qualification metrics. Required planning modifications for both the F-16 and F/A-22 were worked prior to the conclusion of qualification efforts, and in July 1999, the production system was qualified for use. The chromic acid anodizing system was retained for emergency backup capability, but was not needed and the chromic acid anodize process was shutdown at AFP4 in December 1999.

For additional information regarding this effort, please contact Mr. Ali Kahn at DSN 785-3236 or Tony Phillips (Lockheed Martin) at 817-935-4724.

PEWG Project Qualifies Non-Chrome Alternative to Zinc Chromate Primer

The Propulsion Environmental Working Group (PEWG), in conjunction with the Joint Group on Pollution Prevention (JG-PP), completed a project that qualified two alternatives for zinc chromate primer.

Galvanic corrosion occurs when two dissimilar metals or alloys contact each other, and the elements of an electrochemical cell are present. Galvanic corrosion has historically been controlled by applying a protective coating, such as a chromate-containing primer, on the surfaces of the parts requiring corrosion protection. Although chromate-containing primers offer significant corrosion protection, the toxicity and suspected carcinogenicity of chromium raises environmental, safety, and health concerns. For this reason, manufacturers have begun to identify and evaluate acceptable alternatives for chromate-containing primers. These alternative technologies commonly generate less pollution than chromate primers, and have fewer associated health and safety risks.

OC-ALC/MAPE is implementing the use of the qualified alternative in gas turbine engine repair and overhaul processes which previously required the use of zinc chromate primers without a topcoat.

At the OEM, a JG-PP project site, chromium contained in zinc chromate primer was identified as a hazardous material (HazMat) of concern, and targeted for elimination or reduction. The zinc chromate primer provides galvanic corrosion protection for internal and external surfaces of aircraft engine components (inserts and fasteners) used in aircraft engines manufactured by the OEM. The substrates protected are primarily aluminum alloys used in F100 engine components and magnesium alloy used in F119 engine components.

The Joint Test Protocol, PW-P-1-1, for Validation of Alternatives to Zinc Chromate Primer for Galvanic Corrosion Protection for Inserts and Fasteners in Aircraft Engines, dated June 20, 1996 (revised May 11, 1998), documents the critical technical and performance requirements that an alternative must satisfy to be qualified. The Potential Alternatives Report, PW-A-1-1, for Alternatives to Zinc Chromate Primer for Galvanic Corrosion Protection for Inserts and Fasteners in Aircraft Engines, dated March 3, 1998, lists the four potential alternative primers that the project technical representatives recommended for testing. The primers included: Alumazite ZDA (Tiodize Co., Inc.), TT-P-645B Zinc Molybdate Primer (Randolph Products Company), TT-P-664D High Solids (Zinc Phosphate) Primer (Randolph Products Company), and ZRC Cold Galvanizing Compound (ZRC Products Company).

The OEM subjected each potential alternative primer to six laboratory-screening tests: substrate coverage, adhesion, limited hot corrosion, salt spray corrosion, water resistance, and fuel/oil resistance. The ZRC Cold Galvanizing Compound failed hot corrosion testing on aluminum (Al) and magnesium (Mg) alloys. The other three potential alternative primers passed laboratory screening and were subjected to Phase I Material Compatibility Testing in accordance with the Joint Test Protocol (JTP). All three potential alternative primers passed Phase I testing (zinc chromate baseline primer failed Phase I Hot Corrosion Testing on nickel alloy Hastelloy X) and were subjected to Phase II Durability and

Corrosion Resistance Testing. The Alumazite ZDA primer failed the Salt Quench with Intermediate Heating Test on both Al and Mg alloys and was eliminated from further consideration. Joint Test Report PW-R-1-1 for Alternatives to Zinc Chromate Primer for Galvanic Corrosion Protection for Inserts and Fasteners in Aircraft Engines dated January 28, 1999 is available for review.

Based on the results of this testing, OEM concluded that TT-P-664D High Solids (Zinc Phosphate) Primer and TT-P-645B Zinc-Molybdate Primer are both acceptable alternatives to zinc chromate primer, with TT-P-664D being preferred, for providing galvanic corrosion protection for inserts and fasteners used in aircraft engines manufactured at OEM. OC-ALC/MAPE is implementing the use of the qualified alternative in gas turbine engine repair and overhaul processes which previously required the use of zinc chromate primers without a topcoat.

For further information, please contact Ms. Mary Swinford at DSN 785-4169, ext 3185.

This article was submitted by Ms. Penny Kretchmer, PEWG.

PEWG Project Qualifies Deionized Water & HFE/HFC Mixture as a Replacement to HCFC 141b for Hot Engine Leak Test

An oil leak occasionally develops when a gas turbine engine is being operated in a test cell. Localized cleaning of the engine must be done fast to locate the source of the leak and correct the problem in order to allow test operations to quickly resume. The common cleaners currently in use in many engine test cells are HCFC 141b and Isopropyl Alcohol (IPA). Each of these chemicals presents both safety and environmental concerns. HCFC 141b is a Class II Ozone Depleting Substance (ODS) with a production phase-out scheduled for 31 Dec 02. It is also an Emergency Planning & Community Right-To-Know Act (EPCRA) reportable chemical. IPA is a volatile organic compound and a flammable liquid that is miscible in water and not captured in oil/water separators. Test cell managers have stated that they want alternatives to these cleaning chemicals.

The common cleaners currently in use in many engine test cells are HCFC 141b and Isopropyl Alcohol (IPA). Each of these chemicals presents both safety and environmental concerns.

Project Description & Results

At an initial meeting, alternative cleaner characteristics which were determined to be "Critical to Quality" (CTQ) were identified.

The cleaners evaluated against the CTQ included the following:

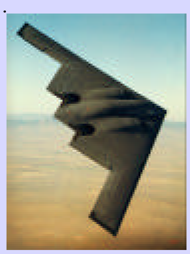
- Aqueous Cleaners (De-ionized water, emulsifiers, floaters, alkaline saponifiers)
- Semi-aqueous cleaners (terpenes, solvent-surfactant mixes)
- Non-flammable, high and low boiling solvents (hydrofluorethers (HFEs), hydrofluorocarbons (HFCs), perfluorocarbons)
- High flash-point VOCs (kerosene, JP fuel, esters)
- Low flash-point non-VOC (acetone)
- Low flash-point VOCs (IPA, octane, esters)
- High flash-point non-VOCs (siloxanes, butoxyethanol)

The cleaning alternatives with the best potential were de-ionized water, HFEs and HFCs. A T700 engine test cell at OEM's facility was used to demonstrate that a spray of de-ionized water could be used for localized cleaning of gas turbine engine surfaces in a test cell environment. Initial tests of the use of deionized water in the T700 test cell were very successful. The deionized water spray quickly and effectively removed gross oil contamination so that the source of leaks could be pinpointed. De-ionized water can be used as an alternative to HCFC 141b and isopropyl alcohol for removing gross oil contamination. The use of a de-ionized water spray is safe to personnel, compatible with engine hardware, environmentally friendly, inexpensive, and easy to use. A OEM proprietary mixture of Dupont Vertrel(r) XF (hydrofluorocarbon) and 3M Novec(tm) HFE-7100 (hydrofluoroether) was also evaluated and determined to be an organic solvent replacement for HCFC 141b and isopropyl alcohol. As this mixture is non-flammable, it has excellent oil solvency properties and is compatible with external gas turbine engine metals and coatings. These cleaners were evaluated for use in a test cell environment, but were not evaluated for cleaning in prep-to-ship applications. De-ionized water was selected as the preferred alternative since it does not conduct electricity and won't leave water spots or other residues on the engine. De-ionized water and a HFE/HFC mixture were identified, tested, and qualified as alternatives to HCFC 141b and isopropyl alcohol for hot engine cleaning applications. The cleaners were evaluated for use in a test cell environment, but were not evaluated for cleaning in prep-to-ship applications.

The use of de-ionized water spray was implemented in the T700 test cell in April 2001. The process was then leveraged to the F414 engine test cell also at the OEM facility.

The use of de-ionized water spray was implemented in the T700 test cell in April 2001. The process was then leveraged to the F414 engine test cell also at the OEM facility. A successful test on an F414 engine was completed in August 2001. The test proved that there were no adverse results from the external spraying of the engine with de-ionized water (no presence of water in the electrical connectors). The demonstration simulated external engine cleaning after a fuel or oil leak and it included concentrating deionized water spray on all of the electrical connectors. The results were that six engine connectors (E-2, E-3, P38, P29, P21 and P56) had some water in the outer shell, but none in the pin area. The demonstration was considered successful since the outer shell, by design, is not waterproof (the back shells have drain holes to allow water to exit; the connector seals are internal to keep moisture out of the pin cavity).

For further information, please contact Ms. Mary Swinford at DSN 785-4169, ext 3185.



THE MONITOR ON INTERNET

This issue of the MONITOR is available on the Internet at the ASC site (http://www.engineering.wpafb.af.mil/esh/news/news.htm#monitor). The current issue of the MONITOR is in a Portable Document Format (PDF) file which requires a reader program for viewing or downloading. The Adobe Acrobat reader is available for downloading at no cost.

Vendor Information

Cleaning/Degreasing

Elixair SkyWash
Elixair SkyWash is the safe alternative to MEK for the removal of surface soils such as, grease, oils, wet and tacky polysulphide sealants and adhesives. It has been independently tested to some of the most stringent specifications of the military and major airframe manufactures for paint and sealant adhesion. This water based cleaner is extremely environmentally friendly as tested to the ACF-50 Fish Acuity protocol. SkyWash will remove Skydrol, carbon exhaust trails and other hard to remove soils. SkyWash is also listed in Air Force TO 1-1-3 and soon will be included in TO 1-1-691 and 1-1-8.

Elixair SkyWipes
Elixair SkyWipes is the companion product to SkyWash. They are a non-woven material that saturated with the SkyWash fluid. They are handy for the clean up of surface areas prior to sealant application and adhesives. They are an MEK replacement product that is fast and convenient for hand and tool clean up. SkyWipes have no obnoxious odors and are pleasant to use in confined work spaces. Wiping down with SkyWipes prior to painting or sealing leaves a water break-free surface. SkyWipes are listed in Air Force TO 1-1-3 and will soon be listed in TO's 1-1-691 and TO 1-1-8.

SkyWash and SkyWipes are listed in Air Force TO 1-1-3 and will soon be listed in TO's 1-1-691 and TO 1-1-8.

Elixair SkyRestore
Elixair SkyRestore is the most efficient product for the removal of cured polysulphide sealants. SkyRestore's chemical action shears the polysulphide molecule, breaking it up into short lengths, rendering it soluble and very easy to remove. SkyRestore does not contain aromatic or halogenated solvents and the ingredients are biodegradable making them "environmentally friendly". The removal of many different sealants and adhesives is quick and easy with SkyRestore It has a low V.O.C. and replaces MEK, which has been classified as hazardous. SkyRestore is being used by many major aircraft repair facilities and soon will be listed TO 1-1-691 and other TOs.

Novec fluid HFE-71DE
Novec fluid HFE-71DE is an excellent cleaning, rinsing and drying agent. Its increased solvency, low surface tension, nonflammability and constant composition during boiling make it ideal for immersion and vapor degreasing, and for medium-duty cleaning of soils such as oils, greases and waxes.

HFE-71DE fluid is low in toxicity, non-ozone-depleting, has a low global warming potential, and is listed as "acceptable without restrictions" under the U.S. EPA's Significant New Alternatives Policy (SNAP) program.

CallaSolve 120
CallaSolve 120 is a water dilutable D-limonene based solvent emulsion cleaner designed for heavy duty cleaning of aerospace equipment including aircraft, ground equipment and AGE engines. CallaSolve 120 is listed as a qualified product in Mil-C-87937 B Type I (USAF) and is authorized for use by General Aircraft per T.O. 1-1-691 and T.O. 1C-135 (K) A-3-4 for aircraft cleaning.

CallaSolve 120 is infinitely water dilutable while maintaining a stable emulsion. The formula contains high-purity D-limonene, emulsifiers, stabilizers, surfactants and a selection of corrosion inhibiting additives designed specifically for aircraft substrates.

CallaSolve 120 is listed as a qualified product in Mil-C-87937 B Type I (USAF) and is authorized for use by General Aircraft per T.O. 1-1-691 and T.O. 1C-135 (K) A-3-4 for aircraft cleaning.

AquaWorks-G
AquaWorks G is a government approved product meeting military specification MIL-PRF-87937B, Type II water dilutable cleaning compound and Type IV heavy duty, water dilutable cleaning compound for aerospace equipment.

M-Aero-NS
This non-silicated product is designed to clean ferrous and non ferrous surfaces such as aluminum, magnesium, steel, copper and brass. It has a moderate foam profile and is used in low agitated bath operations. It provides excellent degreasing at moderate temperatures. It is approved for use under MilSpec 87937B, Cleaning Compounds and Aerospace Equipment.

Inclusion of any vendor information does not constitute an endorsement by the Air Force. Vendor claims of meeting military standards and specifications should be confirmed.

Useful Websites

Agency	Description	Web Address
QNR	Advanced Concept Technology Demonstration	http://www.acq.osd.mil/asc/
DoD	Commercial Technologies for Maintenance Activities	http://ctma.ncms.org/
DoD	Dual Use Science and Technology	http://www.dtic.mil/dust/
NSF	Environmental Engineering and Technology	http://www.eng.nsf.gov/bes/Programs/Environmental_Engineering_Basi/environmental_engineering_basi.htm
DoD	Environmental Security Technology Certification Program	http://www.estcp.org
EPA	Environmental Technology Verification Program	www.epa.gov/etv/
Many	Joint Group of Pollution Prevention	www.jgpp.com
DoD	Joint Technology Exchange Group	http://www.jdmag.wpafb.af.mil/jteg.htm
DOE	Office of Industrial Technologies: Overview of Various Programs	http://www.oit.doe.gov/programs.html
DOE	Office of Industrial Technologies: “National Industrial Competitiveness through Energy, Environment, and Economics (NICE\3\)	http://www.oit.doe.gov/nice3/
Many	Propulsion Environmental Working Group	http://www.pewg.com

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