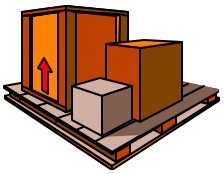
POLLUTION PREVENTION MEASURES FOR THE AEROSPACE INDUSTRY

Facility Modifications

- Improve material tracking & inventory practices
- Improve material usage, handling, & storage
- Improve scheduling batch production to reduce tank cleaning frequencies
- Recover copper sulfate from etching & stripping processes by cooling & crystallization
- Substitute drip pans for rinse tanks in circuit board facility
- Utilize ion exchange metal recovery to reduce sludge production

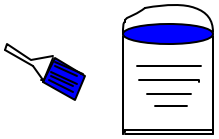
Electronic/Final Assembly



- In-line solvent recovery on vapor degreasing
- Extend solvent life by avoiding unnecessary solvent additions
- Recycle glycol coolant & hydraulic oil
- Use low VOC coating operations
- Install halogenated solvent recovery system
- Frequently inventory & reduce use of shelf-life sensitive material to save material, money, & costs of disposal for outdated hazardous materials

Parts Painting

- Use water-based primers
- Use low VOC paints (or powder coatings) & solvents
- Use proportional mixers for multi-component paints
- Use fiber or deep bed air filters to replace water wall spray booths
- Use plastics beads or other mechanical method for paint stripping
- Use electrostatic paint application methods
- Use low-solvent topcoat paints
- Install solvent recovery system for waste paints & sludges
- Install oxidative destruction system for VOC emissions
- Use high volume, low pressure application technology



Solvent Cleaning

1. Equipment Modifications

- Install cleaning tank covers with an impervious material to prevent vapor loss
- Install a vapor level control device for sump shut-off if vapor level rises above chiller
- Increase freeboard space on tanks (freeboard ratio $\geq$ 0.75)

- Install freeboard chillers on tanks

1. Equipment Modifications Continued

- Slow speeds of parts removed from vapor zone (< 11Fpm for automated parts handling)
- Rotate parts to allow condensed solvent to be removed
- Use cleaning devices rather than chemicals to clean transfer lines
- Use super-heated vapor degreasers to facilitate drying and minimize solvent drag-out

2. Chemical Changes

- Use dry & non-solvent cleaning procedures when feasible
- Substitute less hazardous solvents (ie. petroleum solvents instead of chlorinated solvents) or alkali washes
- Use coolants that have a long life

3. Process Changes

- Use counter-current cleaning methods where possible
- Recover spent solvent on- or off-site
- Preclean parts by wiping, air blowers, or pre-dipping in cold mineral spirits
- Centralize and consolidate cold cleaning operations to minimize vapor losses
- Extend life of cleaners through filtration and replenishment
- Increase drain times for parts before & after washing to reduce dragout
- Remove sludge from cleaning tanks on a regular basis

Machine Shop

- Use water soluble coolants
- Use water-based cutting fluids
- Separate dye penetrants from water
- Consider ultrafiltration for water/organic mixtures
- Phase out flammable solvents & use water-based cleaners

Additionally, the Aerospace Industry may have metal finishing, plating, printed circuit board fabrication processes, and fiberglass fabrication.

Metal Finishing, Plating, & Printed Circuit Board Fabrication

1. Process Changes:

- Reduce dragout

  - Decrease bath viscosity and/or decrease bath surface tension

- Lower the withdrawal rate of parts from a bath
- Increase the drain time over the plating tank
- Install drain boards, drip bars, & drip tanks
- Carefully rack & remove parts to minimize entrapment of bath materials
- Design parts to promote drainage (ie.- no cups or shelves)
- Design plating racks with a minimum surface area to promote drainage
- Use oil-free compressed air knives to free parts of plating films
- Use fog & spray rinses of deionized water to reduce wastestream contaminants

C Modify rinsewater

- Still rinse or drag-out tank
- Rinse tank mixing
- Install water supply control valves to regulate water feed rates
- Spray rinse to use impact & diffusion to wash parts & reduce water usage
- Fog rinse to reduce water usage by using air pressure to rinse
- Cascade rinsewater recycling
- Countercurrent rinse with multiple tanks to reduce rinse flows

C Maintain plating baths by removing impurities using filtering, activated carbon adsorption, chemical precipitation, and using deionized water for makeup and as rinsewater

C Dragout recovery of rinsewaters through evaporation of hot chromium baths, ambient temperature nickel baths, & metal cyanide baths

C Dragout recovery of rinsewaters through reverse osmosis of the following plating baths: acidic nickel, nickel sulfamate, copper pyrophosphate, Copper sulfate, nickel fluoroborate, zinc chloride, zinc sulfate, & cyanide baths for copper, zinc, & cadmium

C Use ion exchange process for purifying spent process baths, recovery of anodizing baths, & dragout recovery of acid copper, acid zinc, nickel, tin, cobalt, & chromium baths

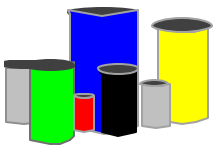
C Use electrodialysis to regenerate chromic acid etchant and drag-out recovery of rinsewaters (use with a still rinse tank)

C Use ultrafiltration as a wastewater treatment process for reduction of spent coolants, cleaners, & rinsewaters; to regenerate alkaline cleaners, coolants, or process baths

C Use electrolytic metal recovery

C De-water sludge by use of mechanical device (ie. centrifuges, filter presses, vacuum filters, sludge dryers)

2. Chemical Changes



C Chemical substitutes for Alkaline Cyanide Plating Baths include:

- Zinc plating substitutes: ammonium or potassium chloride, acid sulfate, chloride, & fluoroborate baths

- Cadmium plating substitutes: cadmium chloride & acid baths of cadmium oxide, sulfuric acid, distilled water & anionic compounds
- Copper plating substitute: copper sulfate
- Tin plating substitute: acid tin chloride

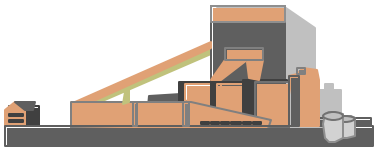
C Chromium plating bath

substitution of hexavalent chromium solutions with trivalent chromium solutions reduce hexavalent chromium dragout concentrations

C Use sulfuric acid or hydrogen peroxide to substitute chromic acid in pickling solutions & bright dip
C Substitute cyanide cleaners with trisodium phosphate or ammonia
C Substitute sulfuric peroxide for persulfate in copper etchants
C Use treatment chemicals that produce less sludge (ie. caustic soda instead of lime)
C Use solvent alternatives (ie. alkaline cleaners, high pressure hot water washings, steam cleaning, mechanical blasting to replace chemical strippers)
C Recover & reuse spent solvents

The key to pollution prevention in PCB manufacturing is to minimize chemical dragout; minimize the amount of water used for rinsing; & the recovery, reuse, & recycle of copper.

Fiberglass Fabrication



1. Best Management Practices

C Control materials inventory to more efficiently utilize raw materials (ie. limit the amount of clean-up solvent issued to lamination employees per day)
C Localize & isolate high emission & hazardous waste-generating operations
C Confine gel coat applications
C Filter contaminated air by dry or wet filtration
C Incinerate or filter styrene emissions that cannot be prevented
C Control air flow & exhaust
C Use gloves to reduce the number of times employees must clean their hands
C Use containers with self-closing lids for work station clean-up solvents

2. Use of Chemicals

C Substitute acetone with solvents that dissolve resin, but do not evaporate as readily (ie. dibasic esters and Ship Shape)
C Use aqueous emulsifiers to separate resin. Aqueous emulsifiers do not evaporate & eliminate emissions
C Use additives for suppressing the release of styrene (Resin suppliers can provide information on various suppressors). ie. Catalysts such as benzoyl peroxide or using UV curing resins, low styrene resins

- Choose resins that reduce both the styrene and total monomer content to effectively reduce voc emissions
- Recover and recycle spent acetone and other clean-up solvents

3. Changes to Production Processes or Equipment

- Use air assisted airless spray guns or high volume low pressure spray guns for resin applications that require spray lay-up to reduce material losses due to excessive fogging, overspray, turbulence, and bounce-back
- Utilize fiber reinforcements that are presaturated with resins (prepregs) to practically eliminate the atomization of pollutants
- In-house resin impregnation would minimize external emissions and can be setup to feed saturated reinforcing materials directly to the molding operation
- Roller dispensing of resin reduces styrene emissions without requiring modifications in molds & materials. Catalyzed resins can be transferred to the molding surface to eliminate material losses from spray vaporization, fogging, overspray, turbulence, & bounce-back
- Utilizing a closed molding system such as vacuum bag molding or infusion reduces waste & emissions of styrene. Resins are confined until curing is complete

The above ideas are only suggestions for waste minimization. As with any new process or change, a facility needs to consider the following before implementing a change in chemicals or procedures:

- Technical feasibility & product quality
- Worker safety & retraining
- Waste handling & environmental impact