V. RESULTS OF THE ANALYSIS

ELECTRONICS AND HIGH TECHNOLOGY EQUIPMENT CLEANING

Table 5-1 summarizes the applications and companies that participated in the project in testing alternatives. It also specifies the alternatives that were tested and were effective.

IRTA worked with a number of companies that have operations that require flux removal. For flux removal operations, plain D.I. water, water-based saponifiers, acetone, acetone/IPA blends and D.I. water/acetone/IPA blends are suitable.

Teledyne Controls and Hydro-Aire both conduct printed circuit board rework operations. Teledyne uses a water soluble flux and a number of alternatives including plain water worked effectively for removing the flux. The company converted to a blend of D.I. water containing small amounts of acetone and IPA. In some cases, the operators clean the reworked boards in Teledyne's water cleaning equipment with D.I. water. At Hydro-Aire, the company uses rosin flux. An acetone/IPA blend effectively removed the flux. The blend is being tested for compatibility. Hydro-Aire has water cleaning equipment that uses a saponifier with low VOC; the operators can clean the reworked boards in this equipment.

Teledyne Microelectronic Technologies was able to eliminate one of their cleaning operations in hybrid manufacture altogether. In the manufacturing process, Teledyne is primarily cleaning flux from the assemblies. Although Teledyne delayed work on the project, they did test a number of water cleaning alternatives with success.

In the case of Corona Magnetics and Cicoil Corp., flux removal is also a major cleaning task. Corona Magnetics can use acetone or an acetone/IPA blend to remove the flux in place of plain IPA and a vapor degreaser. The Cicoil flux could not be removed with a formulation with 100 grams per liter VOC or less. The company must use a blend of 50 percent IPA/50 percent acetone because the assemblies are also contaminated with silicone grease. Companies using silicone grease might be able to identify an alternative mold release agent but IRTA did not pursue this change in this case.

There are apparently two electric motor manufacturers in the SCAQMD jurisdiction. Sterling used a VOC solvent but the application was for surface preparation prior to coating, not for cleaning electronics devices. The company has now converted to acetone for this operation. This operation is not included in Table 5-1.

There are a number of electric motor rebuilders in the SCAQMD jurisdiction. IRTA worked with one electric motor rebuilder in the past, Brithinee Electric. That company uses water-based cleaners exclusively. During this project, IRTA worked with Walton, a company that performs most cleaning with water-based cleaners. The company has one operation where an exempt solvent, D5 a volatile methyl siloxane, is now used. IRTA tested a water-based cleaner for this operation that was also effective.

Table 5-1
Electronics and High Technology Applications Cleaning Alternatives

Type of Application and Companies	Alternative(s)
Printed circuit board rework	
Teledyne Controls	D.I. water, acetone/IPA/D.I. water blend, water-based cleaner
Hydro-Aire	acetone, acetone/IPA blend, water-based cleaner
Hybrid circuit manufacture	
Teledyne Microelectronic Technologies	not cleaning, water-based cleaners
Transformer component manufacture	
Corona Magnetics	acetone, acetone/IPA blend
Flexible and cast cable manufacture	
Cicoil Corp.	water-based cleaner, acetone, acetone/IPA blend, volatile methyl siloxane
Electric motor rebuilding	
Walton	D5, water-based cleaner
Field electrical equipment maintenance --energized equipment	
Burbank Water & Power	HFC and HFE aerosol cleaners
Field electrical equipment maintenance --non-energized equipment	
Burbank Water & Power	water-based cleaners
Solar cell manufacture	
Northrop Grumman (formerly TRW)	acetone
Optics manufacture	
Northrop Grumman (formerly Litton Guidance & Control Systems)	material change, physical barrier, hot water, acetone, water-based cleaners
Manufacture of gauges	
Astro Pak	acetone, acetone/IPA blend

For field electrical equipment, IRTA worked with two companies, Burbank Water & Power and Covanta Energy. For cleaning non-energized equipment, IRTA tested water-based cleaners and a soy/water blend that cleaned effectively. Burbank Water & Power

has been using a water-based cleaner for cleaning non-energized equipment for many years. For cleaning energized electrical equipment, most companies, including Burbank Water & Power, are using aerosol formulations containing HCFC-141b, an exempt chemical. IRTA tested a few alternatives that contained exempt chemicals or exempt chemical/VOC blends. Although the exempt chemical/VOC blends worked well, it is not clear whether they are recommended by the manufacturers for cleaning energized electrical equipment at this time.

Northrop Grumman (formerly TRW) uses IPA to clean solar cells. IRTA tested acetone based alternatives which worked effectively. Northrop Grumman is conducting testing to determine whether the acetone leaches components from the wipes and contaminates the solar cells in the cleaning. IRTA has suggested that the company try cleaning with an acetone/D.I. water blend during this testing. Diluting the acetone makes it much less aggressive; the removal of particles should still be adequate but the D.I. water may prevent the acetone from leaching components.

Northrop Grumman (formerly Litton Guidance & Control Systems) has been cleaning optics used in laser applications without VOC solvents for several years. IRTA worked with the company in an earlier project and has included the information in this document to demonstrate that optics companies using handwipe operations covered in Rule 1171 can find alternatives similar to those used by Northrop Grumman. For example, the company converted from pitch to thermoplastic which is easier to clean with acetone and water-based cleaners in either batch loaded cold cleaners or handwipe operations.

Astro Pak cleans a variety of scientific instruments and IRTA worked with the company on testing alternatives for cleaning aerospace gauges. Acetone was found to perform better than IPA, the currently used VOC solvent.

COATING AND ADHESIVE APPLICATION EQUIPMENT CLEANING

Table 5-2 summarizes the types of coatings and adhesives that were cleaned during the project, the companies that used these coatings and adhesives and the alternatives that were tested and were effective.

In the case of Vacco, none of the alternatives tested by IRTA were able to clean the adhesive residue. IRTA discussed the issue with 3M, the adhesive supplier and suggested that a low VOC alternative could be found if 3M would reformulate the adhesive from tetrahydrofuran (THF) to tetrahydrofurfural alcohol. 3M refused to consider reformulation. IRTA did not test blends of acetone and THF but this approach could be successful at some concentration of acetone.

For all the other categories and companies listed in Table 5-2, IRTA identified and tested alternatives that worked successfully. IRTA obviously did not test every coating or adhesive that is used and there may be coatings or adhesives that could not be cleaned with the alternatives tested here. In a few cases, water-based cleaners work effectively. For the most part, acetone based cleaners seem to be widely applicable. In some cases,

plain acetone cannot clean effectively and other components like methyl acetate or a special surfactant designed to clean high solids coatings were designed to perform the cleaning. In the case of Murphy Industrial Coatings, Inc., the architectural industrial maintenance coatings, additional testing using the acetone/surfactant blend should be conducted to refine the costs.

Table 5-2
Coating and Adhesive Application Equipment Cleaning Alternatives

Type of Coating/Adhesive and Companies	Alternative(s)
Aerospace epoxy primers and polyurethane topcoats	acetone
Hydro-Aire	
Gulfstream	
California Propeller	
Metal solventborne coatings	acetone
American Security Products	
Metrex	
Wood solventborne coatings	water-based cleaner, acetone
Oakwood	
Bausman & Father	
Autobody primers, basecoats and topcoats	acetone, acetone/methyl acetate
Holmes Body Shop	
Westway Industries, Inc.	
Architectural enamel and industrial maintenance coatings	acetone, acetone/surfactant
PCM Leisure World	
Murphy Industrial Coatings, Inc.	
Foam fabrication adhesives	acetone, soy
Hickory Springs	
High solvent adhesive	none
Vacco	
Waterborne Coatings	water
Oakwood	
Bausman & Father	
American Security Products	
PCM Leisure World	

IRTA did not work with any facilities that used electrostatic spray equipment. IRTA has held discussions with one supplier of electrostatic spray equipment. According to a Graco representative, companies can use low-VOC, low toxicity alternatives if they have

the proper electrostatic spray equipment. Specifically, the company has designed electrostatic spray equipment with the proper grounding to use waterborne coatings. This spray equipment, since it is designed to use water, can be cleaned with plain water. The company has also designed spray equipment for use with acetone coatings and this spray equipment can be cleaned with acetone. The important point is that the proper cleanup solvent must be used with the specific equipment designed for that purpose.

IRTA did not test plain water for cleaning waterborne coatings and adhesives during the project. Several of the companies that participated in the project, including American Security Products, Oakwood, Bausman & Father and PCM Leisure World, either use waterborne coatings today or used the coatings in the past; all of these companies used plain water for cleanup of the spray equipment when cleaning waterborne coatings. Many other companies have used waterborne coatings for many years and have used plain water for cleanup.

PRINTING APPLICATION EQUIPMENT CLEANING

Table 5-3 summarizes the types of inks that were the focus of the testing, the companies that used these inks and the alternatives that performed successfully.

In a few cases, the alternatives performed at least as well as the cleaner the companies were using. At Teledyne, for instance, the acetone worked more effectively in cleaning the ink than IPA.

At Owens Illinois, the soy cleaner worked very effectively and the workers liked it better than their current solvent.

IRTA tested a soy based cleaner at Southern California Screen Printing. It did not perform as well as their current cleaner and it required more labor. The company is now in the process of converting to a water-based cleaner that they identified and they believe it performs better than their current high VOC cleaner.

At Nelson Nameplate, the acetone/glycol ether blend worked well but more would be used than the current cleaner on the solventborne ink because of the high vapor pressure of acetone. The high acetone content of the cleaner removed Nelson's emulsion. IRTA identified and tested an alternative emulsion with Nelson and the new emulsion remained intact during cleaning with the acetone blend. This cleaner as well as plain water worked effectively on Nelson's UV curable ink.

The alternative cleaners that were tested at City of Santa Monica Paint Shop worked as well as the cleaner that was being used. When using the acetone cleaner, the City must remove the ink immediately so the stencil is not damaged.

Table 5-3
Printing Application Equipment Cleaning Alternatives

Type of Ink and Companies	Alternative(s)
Solventborne dielectric ink Teledyne Microelectronic Technologies	acetone
UV curable ink for plastics Owens Illinois	soy cleaner
UV curable ink for banners Southern California Screen Printing	soy cleaner
UV curable metal ink Nelson Nameplate	water cleaner, acetone/glycolether blend
Solventborne metal ink Nelson Nameplate	acetone, acetone/glycol ether blend
Solventborne metal and plastic sign ink City of Santa Monica Paint Shop	acetone, acetone/glycol ether blend, soy
Plastisol textile ink Stith Quick Draw Melmarc Total Enterprises	water-based cleaners, soy cleaner
Waterborne specialty flexographic ink Huhtamaki	water-based cleaners

In the plastisol ink category, two of the textile printers, Melmarc and Total Enterprises, dropped out of the testing program before the testing and analysis could be completed. Preliminary results at these facilities indicated that water-based cleaners and soy based cleaners were effective at cleaning the ink. At Stith, water-based cleaners could not really be tested because the company's emulsion was water soluble. The soy based cleaner that was tested was effective in cleaning the ink but it added a rinsing step to the process. According to Stith, the soy cleaner also caused pinhole damage to the stencil but this problem was not observed at any other facility that tested soy based cleaners. At Quick Draw, both a water-based cleaner and a soy based cleaner were tested for several months. This company used an emulsion and blockout that were solvent and water resistant. Both cleaned the ink effectively. Again, the soy based cleaner required an additional rinse step. Since two of the participants dropped out of the testing program, IRTA believes additional work with textile printers should be done to further refine the costs of the alternatives.

Huhtamaki has been using a water-based cleaner for several years; IRTA tested an alternative water-based cleaner that performed as well as that cleaner for removing specialty flexographic ink.

RECOMMENDATIONS

In the course of this project, IRTA focused on finding alternatives in three categories including:

- electronics and high technology cleaning applications
- coating and adhesive spray equipment cleaning
- screen and specialty flexographic ink cleanup

Table 5-4 shows the information contained in Table 1-1 in the introduction and background section.

In the first category in Table 5-4, "Product Cleaning," IRTA was able to find low-VOC alternatives that were cost effective in every case except Teledyne Microelectronic Technologies and Cicoil. Teledyne was willing to perform only limited testing. In Teledyne's application, the cleaning is primarily flux removal which can be accomplished by a wide range of low-VOC alternatives. The results of the testing in this category indicate that the 100 gram per liter VOC limit can be met. In the case of Cicoil, IRTA tested a number of alternatives and the only low-VOC formulation that worked for the application of cleaning the silicone grease was a blend of acetone and IPA with a VOC content of about 400 grams per liter. For Cicoil's other cleaning applications, the 100 gram per liter VOC limit can be met.

In the second category, "Cleaning of Solar Cells, Lasers, Scientific Instruments and High Precision Optics," IRTA also identified low-VOC alternatives that performed well and were cost effective. Northrop Grumman (formerly TRW) is conducting leaching tests on the solar cells with acetone which should be completed within the next year. The results of the testing in this category indicate that the 100 gram per liter VOC limit can be met.

In the third category, "Repair and Maintenance Cleaning of Electrical Apparatus Components and Electronic Components," IRTA identified low-VOC alternatives that were cost effective except in the case of cleaners for energized electrical equipment. Companies have traditionally used exempt solvents like TCA, CFC-113 and HCFC-141b in aerosol packages for energized electrical equipment contact cleaning. TCA and CFC-113 production have been banned and, more recently, the production of HCFC-141b has also been banned. The alternatives that will be available for this application are HFCs or HFEs which are exempt chemicals blended with DCE which is a VOC. These formulations have a much higher VOC content than 100 grams per liter.

In SCAQMD Rule 1171, the District provides an exemption from VOC limits for aerosol products if 160 fluid ounces or less of the aerosol product are used per day. The data provided by Burbank Water & Power indicates that the company used far less than 160 fluid ounces of aerosol products per day. It is unlikely that other companies would use

more than 160 fluid ounces of the aerosol products in a day. This suggests that companies that are performing energized electrical cleaning with aerosol products already meet the requirements of Rule 1171. Thus, IRTA believes that setting a VOC limit of 100 grams per liter for the entire third category is reasonable.

Table 5-4
Target VOC Content for Rule 1171

Cleaning Application	Target VOC Content (grams per liter)
Product Cleaning	
Cleaning of Electrical Apparatus Component and Electronic Component Products • Printed circuit board rework • Cleaning hybrid circuits • Cleaning general electrical components • Cleaning electric motors	100
Cleaning of Solar Cells, Lasers, Scientific Instruments & High Precision Optics	100
Repair & Maintenance Cleaning	
Electrical Apparatus Components & Electronic Components • Field cleaning of electric motors, generators, energized equipment • In-house cleaning of electric motors and other electrical equipment during rework, refurbishing or rebuilding	100
Coating & Adhesive Application Equipment Cleaning • Cleaning of spray guns (general) • Cleaning of spray guns used for architectural coating • Cleaning of electrostatic spray guns • Cleaning of adhesive application equipment • Cleaning of application equipment for satellite/radiation effect coatings	25
Cleaning of Ink Application Equipment • Screen printing • UV printing • Specialty flexographic printing • UV lamp cleaning	100

In the fourth category, "Coating and Adhesive Application Equipment Cleaning," IRTA identified low-VOC alternatives that were cost effective for every company except VACCO. IRTA did not test cleaning agents for cleaning equipment used to spray every possible adhesive or coating but the results of the testing indicate that it is reasonable to expect that a limit of 25 grams per liter could be met. This is based on the wide range of

coatings and substrates successfully tested during this project. Only two companies, VACCO and one other company, use the high VOC thin metal laminating adhesive in the Basin. The District could provide an exemption for cleaning application equipment that has been used to apply this specific adhesive.

In the fifth category, "Cleaning of Ink Application Equipment," IRTA identified low-VOC cost effective cleaners for all the companies that participated in the project. In one of the subcategories, textile printing, IRTA was not able to gather implementation data. For this subcategory, IRTA suggests that more implementation information be obtained before the lower VOC limit for cleaners of 100 grams per liter goes into effect. For the other subcategories, IRTA believes the 100 gram per liter VOC limit can be achieved. IRTA worked with several companies that used UV curable screen ink and the results indicate that the 100 gram per liter limit can be achieved for UV printing operations. IRTA worked with one company that has been using a low-VOC cleaner for cleaning specialty flexographic ink. This indicates that the 100 gram per liter VOC limit can be achieved for this type of printing. IRTA did not work with any companies that clean UV lamps because input from industry prior to the project initiation indicated that the 100 gram per liter VOC limit for this application can be achieved easily.

In summary, then, IRTA tested a variety of alternatives for cleaning in electronics and high technology applications, coating and adhesive application equipment and printing application equipment. IRTA tried to cover all of the categories of cleaning in the application areas and worked with a number of companies on their processes. The project did not involve testing cleaning alternatives for all contaminants, coatings, adhesives or inks but it did focus on many different widely used types of these materials. IRTA believes it is reasonable to expect that a limit of 100 grams per liter could be met.