WATER-BASED PARTS WASHER SYSTEMS: CASE STUDY CONVERSIONS

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PREFACE

This document was produced under contract with the Santa Barbara County Air Pollution Control District with funding from the U.S. Environmental Protection Agency. It presents detailed case studies of seven auto repair and industrial facilities in Southern California that have converted from mineral spirits to water-based cleaning systems. It also presents information on the types of water-based cleaning systems that will be used as replacements for mineral spirits parts cleaning systems. The case studies demonstrate that the water-based cleaning alternatives are technically feasible and cost effective for a variety of different types of facilities for repair and maintenance cleaning. Cal/EPA's Department of Toxic Substances Control published and distributed the report and the case studies. The information presented here should be of use to users of parts washers, vendors of water-based cleaning systems and regulatory agencies that wish to disseminate outreach material.

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TABLE OF CONTENTS

I. INTRODUCTION

In 1996, the South Coast Air Quality Management District (SCAQMD) amended their cleaning rule, Rule 1171, to require a conversion to solvents with 50 grams per liter Volatile Organic Compound (VOC) content or less by January 1, 1999 in repair and maintenance cleaning. The traditional solvent used for this purpose is mineral spirits and the alternative that most firms will adopt to comply with the rule is a water-based cleaner. The conversion from mineral spirits to water-based cleaning systems in repair and maintenance cleaning is underway in the four county area covered by the SCAQMD—Los Angeles, Orange, San Bernardino and Riverside counties.

The Santa Barbara County Air Pollution Control District (APCD) is not planning to amend their rule to require the conversion. The APCD does have an interest in encouraging the voluntary conversion from mineral spirits to water-based cleaners in the Santa Barbara area. In that light, the APCD requested assistance from U.S. EPA Region IX to collaborate on a project to assist seven auto repair and industrial facilities in Southern California in converting to water-based cleaning systems and to develop case studies. The APCD funded the Institute for Research and Technical Assistance's (IRTA's) Pollution Prevention Center (PPC) to carry out the project.

IRTA is a nonprofit organization established to help users adopt pollution prevention methods in cleaning, dry cleaning, paint stripping, coating and adhesive applications. IRTA runs and operates the PPC. The mission of the PPC is to assist firms in implementing low and non-solvent technologies. IRTA and the PPC provide pollution prevention technical assistance to individual firms and also work with whole industries on test and demonstrations of new and emerging technologies.

Mineral spirits are used in some 600,000 parts cleaners in the U.S. for cleaning oil and grease from parts in auto repair facilities, other vehicle repair operations, machine shops and other industrial operations. More than 70,000 of these parts cleaners are located in California. In the jurisdiction of the SCAQMD, there may be more than 40,000 parts cleaning units; about 25,000 of these are in auto repair facilities and 15,000 are in industrial facilities.

The mineral spirits used today for parts cleaning contains traces of toxics like benzene, an established carcinogen, toluene which causes central nervous system problems and xylene which can cause birth defects. The low vapor pressure blends may contain n-methyl pyrrolidone which is a reproductive and developmental toxin. Workers generally use the parts cleaners without gloves so they are exposed directly to the chemicals. Mineral spirits are classified by EPA as Volatile Organic Compounds (VOCs) which contribute to photochemical smog. The emissions from facilities that conduct parts cleaning also expose the surrounding community to toxics. The spent mineral spirits are hazardous waste and, if they are disposed of improperly, they can cause site contamination.

IRTA, with funding under the EPA's Environmental Justice Pollution Prevention (EJP2) Program, conducted a developmental study of water-based cleaners as alternatives to mineral spirits in auto repair facilities in 1995 and 1996. The demonstration project involved testing water-based cleaners in 18 auto repair facilities to determine their feasibility and to optimize their conditions of use. Four generic types of equipment and four water-based cleaning formulations were tested at various concentrations. The spent water-based cleaners were analyzed to determine if they were hazardous waste or if they met wastewater discharge standards. Filters were also analyzed to determine if they were hazardous waste.

The results of the study indicated that water-based cleaners were a viable alternative to the mineral spirits used today. The SCAQMD decided to require a conversion to water-based cleaners in 1996 and other air districts in California began examining their rules to determine if a conversion should be required. Because the water-based cleaning systems offer an overall advantage from the human health and environmental standpoint and because, in most cases, the water-based cleaning systems are less costly than the mineral spirits systems, it is likely that many shops will make voluntary conversions over the next several years.

In 1995 when IRTA performed the developmental study, there were very few vendors that offered formulations, equipment or systems for this sector. Over the last three years, largely because of the SCAQMD conversion requirement, numerous vendors have begun offering new products based on water-based cleaning. Many of the facilities that are making a decision to convert to the new systems are very small businesses and they do not have the resources or the expertise to evaluate the range of alternative systems.

In that light, IRTA selected seven facilities in Southern California that represent a range of repair and maintenance cleaning needs. One of these facilities had already converted to a water-based cleaning systems at the beginning of the project. This facility had participated in IRTA's earlier developmental EJP2 project. IRTA provided technical assistance to the other six facilities to assist them in testing several different alternatives and selecting the system that was best for them. IRTA then prepared one-page case studies of the seven facilities that include cost information on the switch to water-based cleaning. The California Department of Toxic Substances Control (DTSC) agreed to publish and widely distribute these case studies.

Section II of this document provides information on the water-based cleaning formulations and the different types of parts cleaning systems that are available for repair and maintenance cleaning. It also includes information on the regulations that affect the water cleaning systems. In Section III, the case studies are presented. The assumptions used in the cost analysis are also summarized. The conclusions of the analysis are provided in Section IV. Finally, a bibliography of related IRTA publications is presented in Section V.

II. BACKGROUND

This section provides background on the regulations that affect the use of cleaners for repair and maintenance cleaning. It provides a summary of the water-based formulations and equipment available for cleaning in this sector. Finally, it presents information on air, wastewater and hazardous waste regulations that affect water-based cleaning.

REGULATIONS ON REPAIR AND MAINTENANCE CLEANING

The SCAQMD is the only air district in California that has passed a regulation that requires a conversion away from mineral spirits in repair and maintenance cleaning. The regulation, Rule 1171 "Solvent Cleaning Operations," was substantially amended in 1996. The rule requires the use of solvents with a VOC content of 50 grams per liter or less in repair and maintenance cleaning by January 1, 1999. Although some chemicals that are exempt from VOC regulations might comply with this standard, most facilities will adopt water-based cleaners to comply with the rule. Other California air districts, some air districts outside the state and some states are considering adopting similar rules. To date, however, the only rule that requires a conversion is SCAQMD Rule 1171.

The SCAQMD has jurisdiction over a four-county area in Southern California that includes Los Angeles, Orange, Riverside and San Bernardino Counties. There are an estimated 40,000 parts cleaners that are used in repair and maintenance cleaning in that area. Some 25,000 of these parts cleaners are in auto repair facilities and 15,000 are in industrial facilities. The SCAQMD estimates that the rule will lead to a VOC emissions reduction of 20 tons per day by 2010. A massive conversion is now underway in Southern California and there are numerous new vendors offering formulations, equipment and services to support the rule.

WATER-BASED CLEANING SYSTEMS FOR AUTO REPAIR

When IRTA initiated the developmental water-based cleaning demonstration in auto repair facilities in 1995, there were very few vendors offering water-based cleaners, equipment or systems as alternatives to mineral spirits. The 1996 Rule 1171 amendments spurred the development of numerous additional cleaners, equipment and systems for the automotive and industrial repair and maintenance cleaning sector. At this stage, some vendors offer one or several water-based cleaning formulations. Some offer both a formulation and one or more types of equipment. Still others offer a complete cleaning system. The formulations and the equipment are discussed and described briefly below.

Water-Based Cleaning Formulations

Numerous water-based cleaning formulations are being offered for use in the repair and maintenance cleaning sector. These cleaners generally contain surfactants or builders with additives like rust inhibitors as appropriate. Some of the cleaners contain solvent additives; common solvents added to water-based cleaners are terpenes, glycol ethers and alcohols. To be effective, however, water-based cleaners do not require solvent additives. In fact, some of the most effective cleaners in this sector have no solvent additives.

In some of the equipment being sold in this sector, workers' hands contact the cleaner (see below). When this is the case, the cleaner will damage the skin if it has a high pH. Thus, in many systems, cleaners that are neutral or only slightly alkaline are more suitable.

Some water-based cleaners emulsify the oil and grease and some are designed to reject it. With certain types of enzyme systems (see below), emulsifying cleaners are appropriate. In non-enzyme systems, however, cleaners that reject oil are more practical. The oil and grease float on the surface of the bath and they can be removed with physical methods like skimming or use of an absorbent. The cleaning formulation will have a much longer bath life and will be less costly if it is designed to reject oil and grease.

Parts Cleaning Systems

Traditional parts cleaners for use with mineral spirits are generally constructed of steel or stainless steel. Two types of equipment are used in the field today with solvents. The most widely used cleaning unit is the sink-on-a-drum. The sink generally has a faucet and brush applicator. The part is cleaned in a sink work area and the solvent drains into a drum below. The drum is changed out on a regular schedule and replaced with fresh solvent. The second type of solvent equipment is an immersion system. A false sink is the work area. It can be removed to reveal the reservoir below which can be used for soaking parts that are more difficult to clean.

There are three differences between solvent and water cleaning equipment. First, water cleaning equipment does not have to be constructed of metal. Steel, stainless steel and plastic units are available. Second, water cleaning equipment must contain a heater since water-based cleaning formulations perform better if they are heated. Third, a greater range of cleaning equipment options is available for use with water cleaners. For instance, water-based cleaners can be sprayed whereas the flammable mineral spirits would pose a fire or explosion hazard if sprayed.

There are five generic types of cleaning systems available for use with water-based cleaners. Each of these is described briefly below.

Sink-on-a-Drum Parts Washer. This unit consists of a sink mounted on a drum that has a fluid capacity ranging from about 15 to 40 gallons. It contains a heater, a pump, a faucet and brush applicator. Figures 1-1 and 1-2 show a plastic sink-on-a-drum and a view of the inside of the sink respectively. The cost of these units ranges from about $400 to $1,700 depending on the material of construction and the features. They can contain filters and/or oil skimmers which extend the bath life of the water-based cleaner.

Sink-on-a-Drum Parts Washer

Figure 1-1

Figure 1-2

Enzyme System. Enzyme systems are generally modified sink-on-a-drum units and are commonly made of plastic. They contain a specially formulated surfactant based emulsifying neutral enzyme cleaner. Microbes are added to the system either in an impregnated filter or directly into the cleaning formulation. The cleaner emulsifies the oil and grease and the microbes break down the contaminants into carbon dioxide and water. Like the sink-on-a-drum unit, the enzyme system has a heater and a pump. Units generally have a 15 to 30 gallon liquid capacity. One type of system is shown in Figure 2-1. The cost of this type of unit ranges from about $900 to $1,500.

Enzyme System

Figure 2-1

Immersion Parts Washer. The difference between this unit and a sink-on-a-drum is that the immersion system has a false sink that can be removed and a reservoir that is accessible for cleaning or soaking. This unit also contains a heater and a pump and has a liquid capacity of 30 to 60 gallons. Again, it can be constructed of metal or plastic. The cost of these units is somewhat higher than for the sink-on-a-drum, ranging from about $900 to $1,700. Filters and oil skimmers can be added to these systems. Two views of a plastic unit are shown in Figure 3-1 and 3-2.

Immersion Parts Washer

Figure 3-1

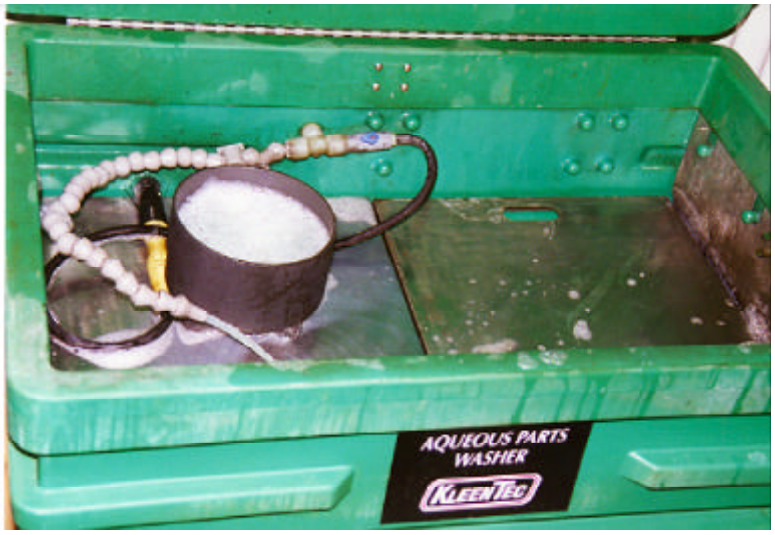

Figure 3-2

Spray Cabinet. This type of unit operates by spraying and/or flushing high pressure cleaning formulation in an enclosed cabinet. The parts are placed inside the cabinet, generally on a platform, and the door is closed. The spray nozzles are positioned to target specific areas of the parts. The mechanical action provided by the worker for the other units is automated in the case of the spray cabinet.

Spray cabinets are made of metal and some have plastic tops. They can be classified as top or front loaders. The liquid capacity of the smaller units for use in this sector ranges from 20 to 100 gallons. These units are generally heated to a higher temperature than the other types of units because workers' hands do not come in contact with the fluid. The units can include filters and oil skimmers. The cost of a spray cabinet ranges from $2,000 to $6,000. A front loader spray cabinet is shown in Figure 4-1.

Spray Cabinet

Figure 4-1

Ultrasonic Systems. These systems must be made of metal. They rely on cavitation energy generated by ultrasound to clean the parts. Basically, tiny bubbles are formed which provide the mechanical action to "scrub" the parts. This type of system is most effective for cleaning parts with complex geometries and passages like carburetors, valve bodies and fuel injectors. The systems consist of a generator and a set of transducers. Like the spray cabinet, ultrasonic cleaning is automated. Several types of systems are being offered in this sector and they are expensive, ranging in cost from about $3,000 for a small unit to more than $12,000 for a larger system. An ultrasonic system is shown in Figure 5-1.

Ultrasonic Systems

Figure 5-1

System Selection

Table 1 below provides a summary of the different system types and a description of their characteristics. It also gives guidance to firms for selecting an appropriate cleaning system. Because workers' hands come in contact with the cleaner in the sink-on-a-drum, enzyme and immersion units, they should use neutral pH cleaners. In the case of the automated systems—the spray cabinet and the ultrasonic system—either a neutral or alkaline pH cleaner can be used. The spray cabinet and ultrasonic systems are more expensive than the other units but the higher cost is justified if the shop spends a lot of time cleaning. In shops with multiple bays, a combination of sink-on-a-drum systems and one or two spray cabinets or ultrasonic systems might be an optimal choice.

Table 1
Water-Based Cleaning System Characteristics

System	Cleaner	Application/ Characteristics	Cost
Sink-on-a-drum	neutral	hand scrub	$500 - $1,500
Enzyme system	neutral	hand scrub, indefinite bath life	$1,000 - $1,500
Immersion unit	neutral	hand scrub, soak	$800 - $1,700
Spray cabinet	neutral/ alkaline	automated, labor saving	$2,000 - $6,000
Ultrasonic unit	neutral/ alkaline	automated, labor saving; transmissions, carburetors	$3,000 - $12,000

REGULATIONS THAT AFFECT THE CONVERSION TO WATER-BASED CLEANING

SCAQMD Rule 1171 requires firms to use cleaners that have a VOC content of 50 grams per liter or less in repair and maintenance cleaning by January 1, 1999. This regulation will spur the conversion but there are other regulations that firms must comply with. These are regulations concerning waste-water and hazardous waste. These are discussed below.

Spent Water-Based Cleaning Baths

Many of the water-based cleaning systems offered today include oil skimmers and filters. These features extend the bath life of the cleaner. Eventually, however, the spent cleaning bath will have to be changed out. The frequency of the changeout depends on contaminant loading, the oil rejection capability of the cleaner and the methods of oil removal that are employed. The microbes in the enzyme units biodegrade the oil and the baths in these systems may last indefinitely. Some of them have been operating in the field for more than two years without the need for changeout.

The spent water cleaning baths, when they require changeout, do not meet publicly owned treatment works (POTW) or sanitary district discharge standards and they may or may not be hazardous waste. In IRTA's earlier developmental study, several spent baths were analyzed. None of the spent baths met discharge standards because of the presence of metals and oil and grease that exceeded the allowed levels. About three-fourths of the baths were classified as hazardous waste in California and the U.S. because of the presence of metals like cadmium and lead.

There are several methods of disposing of the spent water cleaning baths. The first and most common method of disposing of the spent bath is to ship it off-site as hazardous or non-hazardous waste. If the bath is non-hazardous waste, it can be taken by any firm that uses appropriate disposal methods. If the bath is hazardous waste, it must be picked up by a licensed hazardous waste transporter, typically at a higher cost. The waste must be stored in a properly labeled hazardous waste container. In most cases, the accumulation time is 180 days. This accumulation time applies after the generator has accumulated 100 kilograms of hazardous waste.

The second method of disposing of the spent cleaning bath is to use a wastewater treatment system to treat the bath before discharge. In order to exercise this option, the firm must obtain written permission from the POTW or sanitary district. If the spent bath is hazardous waste, a DTSC tiered permit will be required for the treatment.

The third method of disposing of the spent cleaning bath is to treat it in an evaporator. This type of treatment will probably require an air district permit. If the bath is hazardous waste, the treatment will require a DTSC tiered permit. If the bath is evaporated and recondensed and the recovered water is used on-site, no tiered permit is required. If the spent bath is not hazardous waste, no tiered permit will be required.

Oil Products, Filters and Sludge

Some of the water-based cleaning systems are equipped with oil skimmers. The oil removed from the bath with the oil skimmer can be taken off-site by an oil recycler. Oil recyclers cannot legally accept spent filters if they are classified as hazardous waste. The sludge that remains from the evaporation process may be classified as hazardous waste. Oil recyclers cannot legally accept this sludge if it is classified as zardous waste. The filters and sludge, if they are hazardous waste, can be shipped off-site by a licensed hazardous waste transporter.

III. CASE STUDIES

During 1998 and the latter part of 1997, IRTA staff worked with several facilities to assist them in converting to water-based repair and maintenance cleaning systems. Six of the case studies described here reflect the technical assistance work. One of the case studies is a facility that made an earlier conversion.

The case studies represent a range of different types of facilities that have made the transition from mineral spirits to water-based repair and maintenance cleaning systems. The first case study, the Los Angeles Department of Water and Power (DWP) Palmetto facility, is a city maintenance operation. The second case study, Corvette Services, is an auto repair facility that specializes in repair and restoration of Corvettes. The third case study, Brithinee Electric, is an industrial facility that repairs and rebuilds electric motors. The fourth case study, Diesel/Fuel Injection Specialties, is a small auto repair facility that repairs diesel vehicles of all kinds. The fifth case study, Newhall Carburetor & Auto Repair, repairs carburetors of all kinds. The sixth case study, Santa Monica Nissan, is an auto repair dealership. The seventh case study, UR#1, is a small Honda service auto repair facility.

In each instance, the case studies provide information on the mineral spirits systems the company used in the past and the water-based system or systems they adopted. Each case study summarizes and compares the costs to the facilities of using mineral spirits and water-based cleaners. The assumptions used in the case studies are discussed below.

CASE STUDY COST ASSUMPTIONS

Most of the case study companies leased their mineral spirits equipment and servicing, which often includes changing out the bath regularly and disposing of it. In contrast, most companies purchase their water-based cleaning equipment. For the cost analyses presented in the case studies, the annual equipment costs were determined by assuming that the equipment lifetime is five years. The equipment is likely to last much longer in most cases and this is a conservative assumption.

Service costs were determined on a case-by-case basis for each facility. The costs from servicing mineral spirits units may be charged monthly, bimonthly or quarterly and they nearly always include disposal. Servicing water-based cleaning units may or may not include disposal.

The base hourly mechanic/technician labor cost was estimated with input from each facility. The time spent cleaning was estimated through interviews with facility personnel.

The cost of electricity for running the pump in a mineral spirit unit was estimated at $5 per month or $60 per year. The electrical cost for operating a water-based sink-on-a-drum, enzyme or immersion system was estimated at $10 per month or $120 per year. The electrical cost for operating a spray cabinet was estimated at $40 per month or $480 per year. Finally, the electrical cost for operating an ultrasonic unit was estimated at $50 per month or $600 per year.

The cost of disposal of the spent water-based cleaner was estimated at $200 for a 55-gallon drum. This cost is based on disposal of a hazardous waste. It is an overestimate of the actual cost in cases where the spent bath is not hazardous waste. Small baths of 20 or 30 gallons can be changed out twice before they fill a 55-gallon drum; changing out a large bath with a 50 or 60 gallon capacity once fills the drum.

No regulatory fees are paid to the air districts for use of either a mineral spirits or water-based cleaning system. If a facility installed a clarifier and the spent cleaner was classified as hazardous waste, then a

tiered permit from Cal/EPA's Department of Toxic Substances Control would be required. The local sanitary district would also charge discharge fees and a permit fee. The clarifier used by one of the case study facilities was already permitted and the fees are the same as they would be without the conversion. Enzyme systems were assumed to not require disposal; the filters used in these systems, however, do require disposal.

The assumptions used in the cost analysis for each case study facility are described in more detail below.

L.A. Department of Water and Power

DWP replaced three mineral spirits units with two water-based cleaning units, one sink-on-a-drum and one immersion system. The service charge of $4,810 is the actual annual charge for the mineral spirits units. This service charge includes leasing of the three units, cost of the chemical and disposal. The total purchase price of the two water-based cleaning units was $2,200. Assuming a five-year equipment lifetime, this amounts to an annual fee of $440. The cost of purchasing the water-based cleaner for a one-year period amounted to $200.

In the case of the mineral spirits, DWP personnel were assumed to clean for one hour per day for 260 days each year. The labor cost was determined by assuming an hourly labor rate of $19.23. The cleaning time with the water-based cleaning unit was assumed to be 10 percent more than for the mineral spirits unit.

The electrical cost for the mineral spirits was assumed to be $5 per month per machine. For the three mineral spirits machines operated by DWP, the total annual cost amounted to $180. The electrical cost for each water-based cleaning machine was assumed to be $10 per month. The total electrical cost for the two water-based cleaning machines that replaced the three mineral spirits units is $240 per year.

There is no charge for disposal of the water-based cleaners because the baths are treated in a permitted clarifier.

The total cost to the facility for using mineral spirits was $9,990 per year. The total cost to the facility for using the water-based cleaners was $6,380 per year. The facility found they could eliminate one cleaning system in the conversion. Even taking this into account, the cost of using the water-based cleaner is lower for the facility than using the mineral spirits cleaning units.

Corvette Service Company

This facility used a mineral spirits sink-on-a-drum that they owned. They paid a service fee of $672 annually which included the cost of the chemical and the cost of disposal. The shop purchased a spray cabinet for $4,825. Assuming a five-year equipment lifetime, the annual cost of the water cleaning unit is $965. Corvette services is projected to change out their 80-gallon bath four times per year. The yearly cost of the chemical replacement and makeup amounts to $225 for three 40-pound pails of cleaner.

The time spent cleaning with the mineral spirits unit was 45 minutes per day. Assuming a labor cost of $12.50 per hour, the labor cost for using the mineral spirits unit was $2,438 per year. The spray cabinet reduces the labor cost substantially, by 90 percent; the labor cost of cleaning with the spray cabinet is $244 per year.

The mineral spirits unit electrical cost was assumed to be $5 per month or $60 per year. The electrical cost of the spray cabinet was estimated at $40 per month or $480 per year.

The water-based cleaning bath is projected to be changed out four times per year; the cost of the disposal is $1,200 annually.

The total annual cost of using the water-based cleaner at $3,114 is slightly lower than the cost of using the mineral spirits. This is true even though the firm purchased a higher cost spray cabinet.

Brithinee Electric

This firm historically used two mineral spirits units. The service cost, which included leasing the cleaning units and the cost of chemical replacement and disposal, was $5,000 per year. Brithinee replaced the two mineral spirits units with a spray cabinet and an ultrasonic unit. The cost of the ultrasonic unit was $3,200 and the cost of the spray cabinet was $4,800. Over a five-year lifetime, the total cost for the two units is $1,600 per year.

The water-based cleaning units are each changed out six times per year. The ultrasonic unit, with a 25 gallon capacity, uses a 30 percent concentration of cleaning agent. The spray cabinet, with a 50 gallon capacity, uses a 15 percent concentration. Assuming the baths are changed out six times a year, that 10 percent cleaner is required for makeup and that the cleaning agent price is $5 per gallon, then the total cost of the water-based cleaner is $495 annually.

Brithinee Electric estimates that the labor cost for the mineral spirits and water-based cleaning units is about the same because many small parts need to be racked for cleaning in the water-based systems. The annual labor cost in each case is $14,000.

The mineral spirits electrical cost is $5 per month per cleaning unit, for a total cost of $120 annually. The electrical cost of the spray cabinet and the ultrasonic unit is $40 and $50 per month respectively, for a total annual cost of $1,080.
The disposal cost of the water-based cleaner amounts to $450 per year; 450 gallons are disposed at a cost of $1 per gallon. In fact, Brithinee actually transfers the spent cleaner to a larger spray cabinet to replace evaporative and dragout losses. The disposal cost is incurred when the large spray cabinet is changed out. To be conservative, the cost of disposal is counted here.

The cost of using the water-based cleaning systems, at $17,625, is lower than the cost of using the mineral spirits units, at $19,120. This is true even though Brithinee purchased two higher cost water-based cleaning systems.

Diesel/Fuel Injection Specialties

This facility replaced a mineral spirits unit with an ultrasonic cleaning unit. The servicing cost for the mineral spirits unit, which includes leasing, chemical and disposal costs, was $1,680 per year. The cost of the ultrasonic unit was $9,300 or an annual cost of $1,861, assuming a five-year equipment lifetime. The concentration of water-based cleaner in the bath is 10 percent. The 60-gallon bath is changed out six times a year and an additional 10 percent cleaner is required for makeup. The price of the cleaner is $15 per gallon. The annual water cleaner cost amounts to $594.

One worker spent 50 weeks per year cleaning with the mineral spirits unit at a cost of $350 per week; the total labor cost was $17,500. Assuming that the automated water-based cleaning system requires 10 percent of the labor, the labor cost for using the water system is $1,750 annually.

The electrical cost for the mineral spirits unit is set at $5 per month or $60 per year. Using electrical bills for the facility, the annually electrical cost for the water-based cleaner is placed at $684.

The water-based cleaning bath requires changeout six times a year at a price of $200 per drum for disposal. Assuming one drum per disposal, the annual disposal cost is $1,200.

The total annual cost of using the water-based cleaner—$6,089—is about one-third the cost of using the mineral spirits units—$19,240. Most of the cost advantage comes from the reduction in labor through use of an automated system.

Newhall Carburetor & Auto Repair

This facility used a carburetor cleaning unit at a cost of $75 per month or $900 per year which included lease of the unit, cost of chemical and cost of disposal. The firm converted to an ultrasonic cleaning unit at a cost of $3,000 or $600 per year assuming a five-year equipment lifetime. The 25-gallon bath is changed out six times a year and 10 percent additional cleaner is required as makeup. The total annual water-based cleaner cost, assuming a price of $15 per gallon, is $248.

With the carburetor cleaning unit, the shop spent 20 minutes cleaning each carburetor by hand and they typically clean 10 carburetors per week. At a labor rate of $22 per hour, the labor cost with mineral spirits was $3,667 annually. With the water-based cleaner, since the system is automated, the labor cost is one-tenth the cost or $367 annually.
The electrical cost for the mineral spirits unit was estimated at $5 per month or $60 per year. The electrical cost of the ultrasonic unit is assumed to be $50 per month or $600 per year.

The disposal cost for the water-based cleaner, assuming six changeouts per year and a disposal cost of $200 per drum for three drums, is $600.

The total annual cost of using the water-based cleaner is $1,815. This is nearly one-third the $4,627 annual cost of using mineral spirits.

Santa Monica Nissan

This facility had seven mineral spirits parts cleaners but were actually using only five. The annual service fee for the units was $10,380 which included lease of the units, chemical cost and disposal. The firm purchased one 50-gallon spray cabinet for $4,000 and leases four enzyme water-based cleaning units at $59 per unit per quarter. The annual cost amounts to $1,744. This total cost also includes the cost of water-based cleaning solution.

For mineral spirits, the labor cost was determined by assuming 15 minutes cleaning per day for each of the 18 bays, six days per week, 52 weeks per year and a labor cost of $19.58 per hour. The total labor cost for using mineral spirits is $27,490. The four enzyme units require 10 percent more labor than the mineral spirits unit and the spray cabinet reduces the labor by 90 percent over the remaining mineral spirits unit. The total labor cost for the water cleaning systems is $24,741 annually.

The electrical cost for the mineral spirits units was estimated at $5 per unit per month for a total cost of $300 per year. The electrical cost for the four enzyme systems is $10 per month per unit and the electrical cost for the spray cabinet is $40 per month. The total electrical cost for the water systems is $960 per year.

The spray cabinet is changed out three times per year; assuming a cost of $200 per drum, the disposal cost is $600 per year. The enzyme system filter disposal cost is $100 per year. The total disposal cost is $700 per year.

Santa Monica Nissan substantially reduced their cost of cleaning by converting to the water-based systems. With mineral spirits, the total annual cost was $38,170; with the water-based systems, it is $28,145. The total cost reduction amounts to about 26 percent.

UR#1

This facility used a mineral spirits parts cleaner at a service cost of $900 per year which included lease of unit, cost of the chemical and cost of disposal. The shop purchased a used sink-on-a-drum water-based unit for $500. Assuming a five year lifetime for the equipment, the total annual cost is $100. The 20-gallon water-based cleaning unit requires changeout twice per year and also requires a 10 percent makeup. Assuming a cleaner concentration of 30 percent and a cleaner cost of $10 per gallon, the annual cost of cleaner amounts to $132.
The shop cleans for 15 minutes per day. At a labor cost of $16.50 per hour, the cost of cleaning with the mineral spirits unit is $1,031 per year. The water-based cleaning unit requires 10 percent more cleaning time at an annual labor cost of $1,134.

The electrical cost of the mineral spirits unit is $5 per month or $60 per year. The electrical cost of the water-based cleaning unit is $10 per month or $120 per year.

The unit is changed out twice a year and the cost of disposal of one drum of hazardous waste is $200.

The cost to UR#1 for cleaning with the water-based cleaner, at $1,686, is about 15 percent less than cleaning with the mineral spirits, at $1,991.

CASE STUDY DESCRIPTIONS

The case studies were developed as stand-alone one-page descriptions. They include a summary of the company background, a discussion of the cleaning units the company tested and ultimately selected and a cost comparison of the mineral spirits systems and the water-based cleaning systems. The case studies are presented below.

DEPARTMENT OF WATER AND POWER
Facility Eliminates One Parts Cleaner and Saves Money

The Los Angeles Department of Water and Power (DWP) has replaced its solvent parts washers with aqueous cleaning systems at its Palmetto facility in downtown Los Angeles. DWP runs a machine shop and conducts fleet maintenance on eighty-five automobiles and construction vehicles at the Palmetto site.

Three mineral spirits parts washers were formerly used for cleaning parts. Two of the parts washers were the immersion type and the third was a sink-on-a-drum. The cost of DWP's previous service contract for equipment, solvent, and disposal was $185 per unit every six weeks. For the three mineral spirits parts washers, the total annual service cost was $4,810.

Nearly three years ago, before the South Coast Air Quality Management District (SCAQMD) modified their rule to require a conversion to water-based cleaners, DWP began testing water-based systems to replace the mineral spirits. The shop employees were uncomfortable with the hazards of using mineral spirits and were looking for a safer, but effective, alternative. DWP settled on Green Unikleen, an aqueous based surfactant cleaner with neutral pH. "It's a good all-around cleaner for our shops," says Ernie Peltz, an equipment mechanic. "That's all we're using here now." This cleaner has received Clean Air Solvent Certification from SCAQMD.

The machine shop uses the water-based cleaner for machine maintenance and for cleaning non-mobile equipment. Fleet maintenance uses the Green Unikleen for cleaning engine parts from trucks and heavy construction vehicles. The mechanics at the Palmetto shop have been able to meet all of their cleaning needs by using only two water-based immersion parts washers. By converting to water-based cleaning, they were able to eliminate one of the parts cleaners they used with mineral spirits.

The price of the two immersion units DWP purchased was $2,200. During the first cycle, the water-based cleaner lasted ten months before it was spent. Cleaning chemical costs for DWP have plummeted. Now they purchase about $200 dollars worth of Green Unikleen annually and dispose of the aqueous waste themselves. DWP has a permitted clarifier for water treatment prior to discharge to the sewer. They no longer pay any servicing fees though labor and electrical costs are slightly higher.

Not having to pay servicing charges has saved DWP over $3,000 a year in maintenance cleaning costs. Being able to dispose of the spent cleaner in the permitted clarifier saves about $250 of the $3,000. The bulk of the savings comes from the fact that the cleaner lasts ten months rather than six weeks. "It doesn't take long to save some money by changing from mineral spirits to water-based cleaning," says Peltz.

LA Department of Water and Power Cost Comparison

	Mineral Spirits	Aqueous Cleaning
Annual Equipment Cost	0	$440
Chemical Cost	0	$200
Labor Cost	$5,000	$5,500
Electricity	$180	$240
Disposal	0	0
Service Charges	$4,810	0
Total	$9,990	$6,380

HIGH-TECH RESTORATION COMPANY OPTS FOR WATER-BASED CLEANING SYSTEM
Shop Makes Voluntary Conversion

Corvette Service Company in Carpinteria, California provides complete automotive services, including repair and restoration, for Corvettes. Owner Ed Wittwer employs three full-time and two part-time workers and has been in business since 1980. The company is often involved in warranty work and special projects for various companies.

During repair and restoration, Corvette Service Company frequently needs to clean parts. Sometimes this is just a quick clean to remove gross oil and grease during a repair job. Other times, during major overhauls or a restoration project, a thorough cleaning is necessary. For restoration, the parts must be completely clean and look like new. For several years, Corvette Service Company's cleaning needs were satisfied with a customer owned mineral spirits parts washer that was serviced by a large national parts cleaning provider.

Corvette Service Company is not faced with a requirement to convert away from mineral spirits. The shop is in the jurisdiction of the Santa Barbara County Air Pollution Control District (APCD). The APCD has no regulation but is encouraging shops in the area to investigate the water-based cleaning alternatives. Says Gary Hoffman of the APCD "we have a voluntary program and we believe that some shops will see the cost advantage and environmental benefit of adopting the water-based cleaners."

Corvette Service Company began investigating alternative water-based systems in 1998 with the help of the Institute for Research and Technical Assistance, a technical nonprofit organization. Because of their involvement in research and development activities, the firm was comfortable testing a wide variety of cleaning systems and water-based cleaners. Over a period of several months, the company tested everything from enzyme cleaners in a sink-on-a-drum configuration to an ultrasonic cleaning system. In the end, the firm decided to purchase a spray cabinet because it was able to handle large parts, offered labor savings and the distributor provided excellent customer service.

Corvette Service Company is now using a Model SJ-15 spray cabinet made by Landa Water Cleaning Systems sold by Clean & Coat Systems of Santa Maria. The price of a large front-loader spray cabinet with filtration and skimming capabilities was under $5,000. "Any of the systems you'll have to play with, but overall we are satisfied with the spray cabinet," comments Ed Wittwer.

The spray cabinet is large enough to clean an engine block and works well even on very dirty and greasy parts. The big bonus of the spray cabinet is labor savings. Because the cleaning system is automated, the technician loads the parts but does not have to clean them by hand. The cabinet utilizes a water-propelled spray bar that spins around a stationary parts basket. The technician only does some touch-up cleaning or quick, small jobs by hand.

"We decided to make this change because we wanted to stay in compliance and be progressive. While there isn't much of a cost savings initially, we think we can make the spray cabinet into a profit center," says Ed Wittwer.

Corvette Service Company Cost Comparison

	Mineral Spirits	Aqueous Cleaning
Annual Equipment Cost	0	$965
Chemical Cost	0	$225
Labor Cost	$2,438	$244
Electricity	$60	$480
Disposal	0	$1,200
Service Charges	$672	0
Total	$3,170	$3,114

MOTOR REBUILDER CONVERTS TO WATER-BASED CLEANER
Small Delicate Parts Cleaned More Effectively

Founded by Wallace Brithinee and his family in 1963, Brithinee Electric employs about 50 people. Located in Colton, the company is operated today by sons Wallace P. and Donald Brithinee. Initially, the firm concentrated solely on the repair of industrial electric motors. Today, it also sells new motors and electronic drives, and manufactures sophisticated motor control panels.

About 35 million horsepower of industrial electric motors are repaired each year in the U.S. This far exceeds the horsepower supplied by new motor manufacturers. Brithinee Electric alone repairs approximately 3,000 motors each year, ranging up to 1,500 horsepower in size.

Like other motor repair companies, the firm used a large steam cleaner to clean the motors before rebuilding. This system generated a large amount of wastewater and was very labor intensive. In an effort to reduce pollution as well as cut labor costs, the company purchased a huge spray cabinet with a 20,000 pound capacity and a 1,500-gallon reservoir several years ago. The spray cabinet has an oil skimmer so the water cleaning formulation is used for several months before it is changed out.

In addition to the large spray cabinet, Brithinee Electric used two mineral spirits parts cleaners to clean small parts. These units were serviced by a large national parts cleaning provider. The Institute for Research and Technical Assistance (IRTA), a technical nonprofit organization, began working with Brithinee Electric to test alternative systems the firm could use to comply with South Coast Air Quality Management District (SCAQMD) Rule 1171. This rule requires a conversion to water-based cleaners in repair and maintenance cleaning by January 1, 1999. IRTA arranged for the company to test a small spray cabinet from Better Engineering, which was ultimately purchased.

Lynda Butek, facility manager, who is responsible for environmental activities at the company, is a big fan of water-based cleaners. “We are a progressive company and we want to minimize the exposure of our workers and the community to hazardous chemicals. The use of water-based cleaners allows us to clean our parts effectively and to be a responsible company,” she says.

Brithinee Electric wanted another system that would be capable of cleaning parts that sometimes have crevices and blind holes. For this, they purchased an Alpha Cleaning Systems 18-inch cubed ultrasonic system, developed for that purpose. The new system has been operating for several months and is very effective.

According to Wally Brithinee, “The ultrasonic cleaning system minimizes our parts cleaning labor. We want to be out in front in our industry. We are active in our trade association, the Electric Apparatus Service Association, and we want to serve as an example for other electric motor rebuilders in the country.”

Brithinee Electric Cost Comparison

	Mineral Spirits	Aqueous Cleaning
Annual Equipment Cost	0	$1,600
Chemical Cost	0	$495
Labor Cost	$14,000	$14,000
Electricity	$120	$1,080
Disposal	0	$450
Service Charges	$5,000	0
Total	$19,120	$17,625

DIESEL SPECIALTIES OPTS FOR ULTRASONIC CLEANING SYSTEM
Conversion Dramatically Reduces Labor Cost

Jorge Mazariego owns and runs a busy shop in Santa Ana, California called Diesel/Fuel Injection Specialties. The shop has three employees who work on five or six foreign and domestic cars each day. The kinds of parts that are repaired in the shop include engines, sensors and fuel injectors.

The shop leased one immersion system from a large mineral spirits service supplier for $140 per month. Diesel/Fuel Injection Specialties regularly works on parts with complex passages like fuel injectors and sensors. To clean these parts in mineral spirits, Mr. Mazariego had one employee working full time cleaning parts all day every day. To remove the grease and oil from the passages and blind holes, the technician often had to use a toothpick.

South Coast Air Quality Management District Rule (SCAQMD) 1171 requires a conversion away from mineral spirits cleaners beginning in 1999 and Mr. Mazariego was concerned. "When I became aware of the regulation, I started looking at different water cleaning systems," says Mr. Mazariego. Like other small shop owners, he was not sure that he could find a water-based cleaning system that could clean the parts he works on and do it at a reasonable cost.

Alpha Cleaning Systems sells ultrasonic cleaning systems for the automotive market and the firm offered a large unit to the shop for testing. These types of systems have been used in the industrial cleaning sector for many years. They are very effective in cleaning parts with blind holes and crevices. After a month of testing all kinds of parts in the machine, Mr. Mazariego decided to purchase the unit. Although the unit had a high price tag, it was much more effective than the mineral spirits parts cleaner the shop had always used. "We clean all our parts in the ultrasonic system now," says Mr. Mazariego. "It can clean fuel injectors in about 15 minutes and they look like new."

The water-based cleaner used in the ultrasonic cleaning system is made by W.R. Grace and is provided to Diesel/Fuel Injection Specialties by Applied Cleaning Technologies (ACT). According to Mike Halbert of ACT, "this cleaner is certified as a Clean Air Solvent by SCAQMD. We are having good success with the cleaner in ultrasonic systems."

With the purchase of the ultrasonic system, the shop was able to assign the worker that cleaned parts all day to other activities. This meant a savings of $350 per week on labor costs. Mr. Mazariego is very happy with the water-based cleaner. "The new system saves me time and money," he says. "Because of the regulation, I found a much better cleaning system."

Diesel / Fuel Injection Specialties Cost Comparison

	Mineral Spirits	Aqueous Cleaning
Annual Equipment Cost	0	$1,861
Chemical Cost	0	$594
Labor Cost	$17,500	$1,750
Electricity	$60	$684
Disposal	0	$1,200
Service Charges	$1,680	0
Total	$19,240	$6,089

CARBURETOR REBUILDER MOVES TO WATER-BASED CLEANING
Water-Based Cleaners Effective for Internal Passages

Newhall Carburetor & Auto Repair is located outside Los Angeles in Newhall. Jay Tallent, the owner of the shop, does all the rebuilding and repair work himself. He has one employee who handles the bookkeeping. Mr. Tallent started working in the shop in 1991 and purchased it in 1993. He has repaired and rebuilt thousands of carburetors over the period.

Like other auto repair shops, Newhall Carburetor relied on a mineral spirits parts cleaner for quickly cleaning parts of all kinds. About three years ago, Mr. Tallent decided to investigate water-based parts cleaners. After evaluating the systems available at the time, he decided to purchase a Zymo enzyme system. The enzyme system cleans the parts well and minimizes disposal costs. Says Mr. Tallent, "the enzyme unit performs about as well as the mineral spirits unit and it is much cheaper. It's better for your hands and the environment."

The shop also had a carburetor cleaning unit that used a mineral spirit combined with a chlorinated solvent for cleaning the carburetors. Although the carburetor cleaning unit used agitation to enhance the cleaning, an hour of cleaning time was required for each carburetor. An additional 20 minutes of hand cleaning in the enzyme system was also necessary to clean the carburetors adequately.

The Institute for Research and Technical Assistance (IRTA) began working with Newhall Carburetor in 1997 to test alternative methods of cleaning carburetors with water-based cleaners. IRTA arranged for a heated carburetor cleaning unit to be built and it was tested at the shop. It did not perform well even though the water cleaner was heated to a fairly high temperature. IRTA arranged for the shop to test an ultrasonic system from Alpha Cleaning Systems and this system performed very well. After a period of testing, the Tallents decided to purchase an 18-inch cubed ultrasonic system. They are using it very successfully today for cleaning all the carburetors the shop repairs.

Mr. Tallent is extremely pleased with the aggressive cleaning action of the ultrasonic system and its ability to penetrate the blind holes and crevices in carburetors. "I had a $900 boat carburetor that was caked with varnish that I wouldn't have been able to remove with traditional cleaning methods. In the past, I would have had to discard the carburetor," he says. I was able to clean it up really well with the ultrasonic cleaner in about 30 minutes. It saved me a lot of time and the customer didn't have to purchase a replacement carburetor."

The ultrasonic unit reduces Mr. Tallent's labor significantly. "I save a lot of time with this system. All I do is turn the unit on and I can walk away and do other things," he states. Because of the labor savings, the total cost of using the new ultrasonic system is only about one-third the cost of using the old carburetor cleaning unit.

Newhall Carburetor & Auto Repair Cost Comparison

	Mineral Spirits	Aqueous Cleaning
Annual Equipment Cost	0	$600
Chemical Cost	0	$248
Labor Cost	$3,667	$367
Electricity	$60	$600
Disposal	0	$600
Service Charges	$900	0
Total	$4,627	$1,815

DEALER CONVERTS TO ENZYME SYSTEMS AND SPRAY CABINET
Saves on Disposal Cost

Santa Monica Nissan is located in Santa Monica and is part of the Miller Automotive Group which has eight service facilities in the Southern California area. The dealership employs 35 service people and operates 18 service bays. Twenty technicians provide servicing for about 100 cars each day.

The company used seven mineral spirits parts cleaners that were leased from a large national service provider. Each technician used the sink-on-a-drum units for about 15 to 20 minutes per day cleaning auto parts. They are paid a flat rate for each job they complete. Says Jack Miller, the Service Manager at Santa Monica Nissan, "we need a cleaning system that works well and quickly."

Early on, Santa Monica Nissan tested only one water-based cleaning system that had been provided by a large parts cleaning service provider. "It was like cleaning with hot water," says Jack Miller about the system he had tested. "It worked so poorly, we did not have a good feeling about the rule requirement to convert to water-based cleaners." South Coast Air Quality Management District Rule 1171 requires a conversion from mineral spirits to water-based cleaners in repair and maintenance cleaning by January 1, 1999.

Over the next several months, the Institute for Research and Technical Assistance, a nonprofit technical organization, assisted Santa Monica Nissan in testing several different types of water-based cleaning formulations and cleaning equipment. After thoroughly evaluating the costs, the company decided to purchase four enzyme systems and one spray cabinet. All eight of the Miller automotive Group shops purchased the same types of systems.

The advantage of enzyme systems is that the microbes "eat" the oil and the baths last indefinitely before they need to be changed out. Jack Miller saw this as a strong advantage. "All the waste we generate from these enzyme systems can be hauled off at a cost of about $100 per year," he says. The technicians spend slightly longer cleaning with the enzyme system but they can use the spray cabinet on heavy cleaning jobs to save time. According to Mr. Miller, "the parts cleaned in the spray cabinet are cleaned faster and better than with mineral spirits."

Santa Monica Nissan has saved a considerable amount of money by making the conversion to water-based cleaners. The total cost of using the mineral spirits units was about $38,170 annually; the cost of using the water-based systems, is much lower, at $28,145 annually.

Santa Monica Nissan Cost Comparison

	Mineral Spirits	Aqueous Cleaning
Annual Equipment Cost	0	$1,744
Chemical Cost	0	0
Labor Cost	$27,490	$24,741
Electricity	$300	$960
Disposal	0	$700
Service Charges	$10,380	0
Total	$38,170	$28,145

SMALL SHOP SWITCHES WATER-BASED SYSTEM
Longer Bath Life Lowers Cost

Chris Ngo worked as a mechanic at a Honda dealership for many years. He bought UR#1, a Honda Acura service facility located in Garden Grove, California, in 1993. He and three full-time employees do all the servicing and repair work at the full service shop. The shop personnel work on as many as 15 cars each day.

The Institute for Research and Technical Assistance (IRTA) began working with the UR#1 in 1997 to assist the shop in identifying and purchasing a water-based parts cleaner. South Coast Air Quality Management District (SCAQMD) Rule 1171 required a conversion away from VOC solvents by January 1, 1998 so UR#1 needed to find a suitable alternative system.

UR#1 had leased a mineral spirits sink-on-a-drum parts cleaner from a large national service company for many years. This parts cleaner was used to clean all the parts that required cleaning during repair and service. IRTA arranged for the shop to test a variety of alternative systems to determine which was most suitable for their cleaning needs. Two different enzyme systems and two sink-on-a-drum water-based cleaning systems were tested over a several month period.

According to Chris Ngo, "one of the units stood out as the best. It cleaned the best of all the units we tested." Mr. Ngo ended up purchasing a used system supplied by Mirachem. "We clean transmission valve bodies and CV joints and the Mirachem solution really cuts the grease and oil," says Mr. Ngo. "It cleans better than the solvent and it's good for the workers and the environment."

The cost of the solvent system used at UR#1 amounted to nearly $2,000 per year. Because of the extended bath life of the water-based cleaning system, the cost of the new cleaning system is lower, at about $1,700 per year. "We're a small shop and we like the savings from the water cleaning unit," says Mr. Ngo.

UR#1 Cost Comparison

	Mineral Spirits	Aqueous Cleaning
Annual Equipment Cost	0	$100
Chemical Cost	0	$132
Labor Cost	$1,031	$1,134
Electricity	$60	$120
Disposal	0	$200
Service Charges	$900	0
Total	$1,991	$1,686

IV. SUMMARY AND CONCLUSIONS

SCAQMD Rule 1171 requires a conversion away from mineral spirits to cleaners with 50 grams per liter VOC content or less in repair and maintenance cleaning by January 1, 1999. Most facilities in Southern California will comply with the rule requirements by adopting water-based cleaning systems. Other air districts and states will look to the experience in Southern California to provide guidance in adopting future regulations.

There are a variety of water-based cleaners and cleaning systems available that can satisfy the cleaning requirements of the auto repair and industrial facilities that will be affected by the rule. A number of water-based cleaners with no solvent additives are available and they clean very well. These water-based cleaners perform better if they are heated and all of the systems contain heaters.

Five types of water-based cleaning systems are being offered by vendors. The first type of system, the sink-on-a-drum, is likely to be used most widely. It is a sink with a brush mounted on a drum. Parts are placed in the sink and cleaned by hand. The second type of system, the enzyme cleaning unit, is in the configuration of a sink-on-a-drum. Microbes in the system biodegrade the oil and the advantage of this type of unit is that the bath may last indefinitely without the need for changeout. The third system is an immersion unit with a false sink. Parts can be soaked in this type of unit. The fourth type of system is a spray cabinet which cleans more aggressively than the other types of units. It relies on high pressure spray and a higher temperature to clean the parts. The fifth system type is the ultrasonic unit which also cleans very aggressively. It is most suitable for carburetors, transmissions and fuel injectors.

Facilities in Southern California have been converting to the water-based cleaning systems over the last year. IRTA has assisted many businesses in testing, evaluating and implementing alternative systems. This report presents seven case studies that describe the conversion choices of various different types of facilities with a range of cleaning activities. These facilities converted to all five of the different water-based system types—sink-on-a-drum, immersion unit, enzyme system, spray cabinet and ultrasonic unit.

This report also includes a cost comparison for each case study facility. In all cases, the cost to the facility for using the water-based cleaning system is lower than the cost of using the mineral spirits system. In some cases, the reason the cost is lower is that the water-based cleaners require changeout less frequently than the mineral spirits. In other cases, where the facilities have purchased spray cabinets or ultrasonic units, the cost is lower because of the labor savings from use of the automated systems.

About 40,000 cleaning units in the South Coast Basin have traditionally used mineral spirits. Some 25,000 of these units are in auto repair facilities and 15,000 are in industrial facilities. The case studies presented here should be useful in providing guidance to other facilities in selecting an appropriate water-based system.

The water-based cleaners are better than solvents from an overall human health and environmental standpoint. They reduce worker exposure and exposure to the surrounding community. They reduce smog formation. Finally, the case studies presented here show that the water systems provide a cost advantage to the users.

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