Safer Alternatives to Solvent Aerosol Automotive Cleaning Products

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EXECUTIVE SUMMARY

Background

The Air Resources Board (ARB) estimates that VOC emissions from automotive aerosol cleaning products amounted to 17.1 tons per day in 2000. Many of the solvents used in these products are also classified as Toxic Air Contaminants (TACs). The ARB prohibited the use of chlorinated solvent aerosol automotive products in 2002. The California Department of Health Services Hazard Evaluation System & Information Service (HESIS) began observing cases of peripheral neuropathy, a nerve disease that affects the feet, legs, hands and arms, in automotive mechanics. HESIS attributed these cases to the use of hexane which was being used in place of the chlorinated solvents in the aerosol cleaning products.

HESIS contracted with the Institute for Research and Technical Assistance (IRTA), a technical nonprofit organization, to identify and test alternative safer water-based aerosol cleaning products. The focus was on developing and testing alternative aerosol cleaners for four categories of automotive cleaning including engine degreasing, carburetor and fuel injection system cleaning, brake cleaning and general purpose degreasing. The ARB also contracted with IRTA to conduct a related project that involved investigating low-VOC, low toxicity alternatives and the research and testing for the HESIS project were expanded and enhanced.

Methods

The approach to the research was to first identify existing water-based aerosol cleaners that were used commercially. The criteria for these cleaners was that they contain at least 70% water and no more than about 27.5% VOC. IRTA identified 11 water-based aerosol cleaners that met these criteria. The second step was to identify other water-based cleaners used by automotive and industrial firms that were not currently packaged in aerosol form. IRTA identified 18 water-based cleaners in this category.

Preliminary testing of the aerosol and non-aerosol products was conducted in a laboratory setting to screen the cleaners that performed best. IRTA collected a variety of different engine, fuel injection system, brake system and general parts that contained heavy grease and oil from four auto repair facilities. The first phase of the preliminary testing involved comparing the performance of the existing aerosol water-based cleaners and the non-aerosol water-based cleaners with the performance of solvent baseline solvent cleaners. The second phase of the preliminary testing involved packaging some of the water-based cleaners that were not in aerosol form in aerosol packages. The existing and new aerosol cleaners were tested again and compared with the baseline cleaners. Three of the existing aerosol water-based cleaners and ten of the non-aerosol water-based cleaners performed well enough in the screening tests to go on the field testing stage.

IRTA recruited 13 auto repair facilities, three automotive detailers, one car wash and three consumers to conduct the field testing of the alternative low-VOC products. Two problems arose during the preliminary testing, however, that made the field testing more complex. First, all of the water-based cleaners, including the cleaners already in aerosol form, foamed when they were put in an aerosol package. Foaming cleaners are acceptable in engine degreasing where the engine and undercarriage can be rinsed with water after they are applied. Foaming cleaners are not normally acceptable for carburetor and fuel injection system cleaning, brake cleaning or general purpose degreasing. Second, some of the auto repair facility technicians indicated they would be reluctant to test water-based cleaners for carburetor and fuel injection system cleaning because of concerns about water in the fuel system.

Eight foaming aerosol water-based cleaners were obtained for testing in engine degreasing. IRTA also developed three non-water-based cleaners based on acetone and soy for testing in the carburetor and fuel injection system cleaning category. IRTA asked the manufacturers of the non-aerosol water-based cleaners to reformulate them so they could be packaged in aerosol form without foaming. This was a challenging assignment and only three manufacturers elected to provide four non-foaming water-based cleaners for testing in the brake cleaning/general purpose degreasing categories.

Results

Auto repair facilities do not perform engine degreasing as a rule. The eight foaming aerosol water-based cleaners were tested at three auto detailers, one car wash and with three individual consumers. Three of these cleaners are commercial products and all three contain solvent additives. The remaining five cleaners are not commercial products and they do not have solvent additives. All facilities and consumers indicated that at least one of the alternative cleaners worked as well as or better than their current cleaner. The VOC content of six of the cleaners is 10% and this contribution is from the hydrocarbon propellant that was used for all of the water-based cleaners.

Three blends of a soy based cleaner and acetone were tested for carburetor and fuel injection system cleaning at the 13 auto repair facilities participating in the project. Soy and acetone are both low in toxicity. Soy is very low in VOC content and acetone is exempt from VOC regulations. All three cleaners performed adequately in this application and two performed as well as or better then the cleaners used currently. These cleaners were packaged with a carbon dioxide propellant so the VOC content of the cleaners was near-zero.

Four non-foaming water-based cleaners were tested at the 13 auto repair facilities for brake cleaning and general purpose degreasing. Two slightly foaming water-based cleaners were also tested for these cleaning applications. Three soy/acetone blends with a carbon dioxide propellant, one soy/acetone blend with a hydrocarbon propellant and one acetone cleaner with a hydrocarbon propellant were also tested at some of the facilities. Three of the non-foaming water-based cleaners and two of the soy/acetone blends with carbon dioxide propellants performed adequately for brake cleaning and/or general

purpose degreasing. The non-foaming water-based cleaners were packaged with hydrocarbon propellants and their VOC content was about 10%. The soy/acetone blends had a near-zero VOC content.

Alternative propellants were investigated for use with the water-based cleaners. The best performing alternative propellant was carbon dioxide, which is not classified as a VOC. This propellant can cause the aerosol cans to corrode when it is used in conjunction with a water-based cleaner. This limitation might be overcome with addition of a corrosion inhibitor to the water-based cleaner.

The raw materials cost of the alternative water-based and soy/acetone cleaners is somewhat higher than the raw materials cost of the currently used solvent based products. The water-based cleaners and soy/acetone blends tested with success during this project are lower in toxicity than the high-VOC solvent based cleaners used today.

Conclusions

Alternative low-VOC, low toxicity water-based and soy acetone based aerosol cleaners were tested for engine degreasing, carburetor and fuel injection system cleaning, brake cleaning and general purpose degreasing. These alternatives performed adequately and, in some cases, very well. The VOC content of the alternative cleaners ranged from zero to 10%. If carbon dioxide could be used as a propellant for the water-based cleaners, the VOC content of the alternative products would be near-zero. The alternative products developed and tested during this project are lower in toxicity than the products used in aerosol automotive cleaning applications today.

I. INTRODUCTION

The Air Resources Board (ARB) estimates that about 4.5 million aerosol spray cans and spray bottles of automotive cleaning products are sold in California each year. In 2000, emissions of Volatile Organic Compounds (VOCs) from these products amounted to about 17 tons per day (tpd); emissions of chlorinated solvents from these products were estimated at 5.2 tpd. In April of 2000, the ARB adopted an Airborne Toxic Control Measure (ATCM) that prohibited the production for sale or distribution of automotive products containing chlorinated solvents that are classified as Toxic Air Contaminants (TACs) after June 30, 2001. The ATCM prohibited the use of such products after December 31, 2002.

The non-chlorinated automotive cleaning products contain a number of VOC solvents that are also classified as TACs. These include toluene, xylene, methyl ethyl ketone (MEK), methanol and hexane. After the prohibition of use of the chlorinated solvents became effective, the California Department of Health Services Hazard Evaluation System & Information Service (HESIS) observed cases of peripheral neuropathy in automotive mechanics. Peripheral neuropathy is a disease that affects the nerves in the feet, legs, hands and arms. HESIS attributed these cases to the use of hexane, a replacement for the chlorinated solvents in the automotive aerosol products. ARB was also concerned that suppliers would reformulate the cleaning products with VOC solvents, like hexane, that are also toxic. To prevent this outcome, ARB further regulated the VOC content of the cleaners.

Table 1-1 shows the VOC emissions from four categories of aerosol automotive products based on ARB's 1997 Consumer and Commercial Products Survey. The emissions from each category are presented in tons per day (tpd). The table also shows the VOC limits that were in effect in December, 2002 and December, 2004.

Table 1-1
Emissions and VOC Limits for Automotive Consumer Products

Consumer Product Category	VOC Emissions (tpd)	VOC Limits (Wt. %)	
	2000	12/31/2002	12/31/2004
Brake Cleaners	5.8	45	-
Carburetor and Fuel-Injection Air Intake Cleaners	6.9	45	-
Engine Degreasers	2.3	50	35
General Purpose Degreasers	2.1	50	-

The four categories of aerosol automotive cleaning products are used by auto repair facilities, car washes, detailers and do-it-yourself mechanics at home. Brake cleaners are used to remove dust, oil, grease and brake fluid from brake assemblies during repair or

replacement. Carburetor cleaners are used to remove dirt, fuel deposits, oil and grease from carburetors, chokes, throttle body valves or other linkages in a fuel injection system. Engine degreasers are used to remove grease, oil and dirt from the external surfaces of engines. General purpose degreasers are used to remove dirt, oil or grease from parts of various types, generally when a repair is being made.

The U.S. EPA sponsored a project to identify, develop and test water-based cleaners as alternatives to solvent cleaners in auto repair facilities (IRTA, 1997). The South Coast Air Quality Management District later regulated the VOC content of these cleaners. The U.S. EPA also sponsored a project to identify, evaluate and implement water-based cleaning alternatives for brake cleaning. The project involve converting seven facilities to water-based cleaning equipment and formulations that were shown to be effective and lower in cost than the aerosol products (IRTA, 1999).

To achieve further reductions in toxic solvent emissions from aerosol automotive products, new technologies are required. HESIS contracted with the Institute for Research and Technical Assistance (IRTA), a technical nonprofit organization, to identify, develop and test alternative aerosol water-based cleaners that are safer for workers. The ARB also contracted with IRTA to conduct a similar project that focused on reducing VOC emissions. The HESIS project scope was expanded and enhanced and the two projects were conducted together. This document summarizes the results of the project.

Section II of this document provides information on the approach that was used to find, test and demonstrate alternative near-zero-VOC water-based cleaning aerosol automotive products. Section III describes the preliminary testing of existing water-based cleaners and other low-VOC products on automotive parts. It also identifies a technical problem encountered in packaging the water-based cleaners in aerosol form. Section IV describes the field testing of the alternative cleaners. Section V provides information on an investigation of alternative propellants which was undertaken to determine if the VOC content of the aerosols could be further reduced. Section VI presents a cost evaluation and comparison of the new low-VOC cleaners and cleaners that are used currently. It also includes a comparison of the toxicity of the low-VOC alternative cleaners and the high VOC solvent cleaners used currently. Finally, Section VI summarizes the results and conclusions of the research.

II. RESEARCH APPROACH AND METHODS

The first step in the project was to identify and assess existing water-based aerosol cleaners that were already used in automotive cleaning. After investigating, IRTA identified 19 aerosol water-based cleaners of this type. IRTA and ARB staff established criteria for selecting these water-based aerosol cleaners for further testing in this project. The criteria were that the cleaner contain at least 70% water and that the cleaner contain less than 275 grams per liter or 27.5% VOC content. Eleven of the 19 aerosol water-based cleaners met these criteria.

The second step in the project was to identify additional non-aerosol existing water-based cleaners that could be tested during the project. IRTA had assisted many auto repair and industrial facilities in converting from solvent to water-based cleaners and IRTA staff was familiar with a number of water-based cleaners that were effective in cleaning automotive and industrial parts. IRTA identified 18 cleaners that could be tested during the project.

The third step in the project was to develop a protocol for the screening testing that would be conducted before the field testing. The purpose of the screening tests was to test the 11 water-based aerosol cleaners and the 18 water-based non-aerosol cleaners to determine which of them might clean in the automotive applications of interest well enough to be field tested.

Auto repair facilities recycle their metal parts when they change them out during a repair. For the screening tests, IRTA collected a variety of used automotive parts from four auto repair facilities that were being discarded. These parts were soiled with dirt, oil and grease. They included brake parts, carburetor and fuel injection parts, engine parts and other general parts.

The screen testing protocol had two phases. Phase I involved testing the aerosol water-based cleaners and the non-aerosol water-based cleaners in pesticide bottles on the parts collected from the auto repair shops. Aerosol cleaners perform cleaning in two ways. First, they dissolve the contaminants. Second, they blow the contaminants off the parts with the propellant and air pressure. Because some of the water-based cleaners were not in aerosol form, they would not be expected to perform as well as the aerosol cleaners. IRTA investigated traditional spray bottles and pesticide application spray bottles and found the pressure to be higher with the pesticide spray bottles. The cleaners that performed best in the Phase I screening tests were slated to go on to the Phase II screening tests.

The Phase I testing involved comparing the alternative cleaners with baseline cleaners that were commonly used by the industry. The cleaners were sprayed for a 10 second duration onto a portion of the soiled parts that were collected. The cleaning effectiveness was evaluated by inspecting the portion of the part cleaned by the cleaner and by conducting a water break free test. The water brake free test has been used historically to

determine if a part is clean. The theory is that if the water "sheets" off a part, it is clean. In all cases, the alternative cleaners were compared with baseline cleaners. As part of the Phase I testing, IRTA took the alternative cleaners to three auto repair facilities and conducted the testing with the technicians. IRTA relied on the facility personnel to evaluate the cleaning effectiveness of the alternatives. Of the 29 water-based cleaners tested in Phase I, four of the water-based aerosol cleaners and 14 of the non-aerosol water-based cleaners performed well enough in the Phase I screening test to move on to Phase II.

Phase II of the testing involved packaging the non-aerosol water-based cleaners in aerosol packages with hydrocarbon propellants. Hydrocarbon propellants were selected for the screen testing because most solvent aerosol cleaners use them and IRTA did not want a difference in performance of the propellant to influence the cleaning capability of the cleaners. The laboratory testing in Phase II was conducted in the same manner as the Phase I laboratory testing. IRTA also tested the 18 cleaners with eight auto repair facilities for the Phase II screen testing.

Ten water-based cleaners performed well in the Phase I and Phase II screening tests in the laboratory and at the auto repair facilities. These included two commercial cleaners that are already packaged in aerosol form and eight cleaners that are not commercial aerosol products. In the screening tests, IRTA also tested two solvents in non-aerosol form in case they were needed in the field testing. One of these was acetone, which is exempt from VOC regulations and low in toxicity. It performed well in the screening tests. The other cleaner was a soy based product, which is very low in VOC content and toxicity. This cleaner did not perform very well in the screening tests.

Two significant issues emerged during the screening tests. The first issue involved foaming. The commercial water-based aerosol products were all dispensed as a foam. When the non-aerosol water-based cleaners were packaged in aerosols, they too foamed. Some of the cleaners were dispensed as a thick foam and some as a thinner foam. As discussed in more detail later, foaming is a desirable characteristic for engine degreasing but it is not desirable for the other three cleaning applications.

The second issue concerned carburetor and fuel injection system cleaners. Because these cleaners can enter the fuel system, some of the auto repair facility personnel indicated they would be reluctant to use a water-based product in these applications.

The fourth step in the project was to conduct the field testing of the cleaners. IRTA recruited 13 auto repair facilities, one car wash, two detailers and three consumers to conduct testing of the alternatives. The auto repair shops were selected to span a range of facility types. They included dealerships, service stations that perform repairs, brake shops and general automotive repair facilities.

IRTA tested eight different foaming water-based aerosol products with the car wash, the two detailers and the three consumers to determine their effectiveness for engine degreasing. Three of the products were commercial aerosol products and all three of

them contained solvent additives. The remaining five cleaners were packaged by the manufacturer of each water-based cleaner. None of these products contained solvent additives. All shops and consumers found at least one cleaner that performed as well as or better than their current cleaner.

IRTA formulated three products that were blends of acetone and soy to test in carburetor and fuel injection system cleaning applications. These cleaners were tested in the auto repair facilities participating in the project. In all cases, every technician found an alternative that performed as well as or better than their current cleaner.

Because foaming cleaners are not desirable for brake cleaning and general purpose degreasing, IRTA requested that the manufacturers of all of the water-based cleaners that performed well in the screening tests reformulate their cleaners and package them so they would not be dispensed as a foam. This turned out to be a challenging assignment. IRTA obtained six non or low-foaming water-based cleaners from three manufacturers for field testing in brake cleaning and general purpose degreasing. These cleaners were tested in the auto repair facilities participating in the field tests. Two of these cleaners performed almost as well as or as well as the commercial products used today and a third cleaner performed almost as well as the products used today. IRTA also tested non-water-based cleaners for brake cleaning and general purpose cleaning. Two of these performed well in the cleaning applications.

Section III of this document provides a detailed discussion about the Phase I and Phase II preliminary screening tests. Section IV discusses the results of the field testing in much more detail.

III. SCREENING TESTS OF ALTERNATIVE CLEANERS

IRTA began the research by investigating water-based cleaners that were low in VOC content and low in toxicity. Two categories of cleaners were examined for their applicability to automotive aerosol cleaning. The first category of cleaners is existing water-based aerosol cleaners. The second category of cleaners is non-aerosol water-based cleaners used in automotive and industrial cleaning applications. Each of these cleaner categories is discussed below.

Existing Aerosol Cleaners

IRTA used two lists to identify existing water-based aerosol automotive products. The first list was provided by ARB staff and it includes 57 companies. IRTA also used another list provided by the South Coast Air Quality Management District (SCAQMD). It is entitled "Suppliers and/or Manufacturers of Low VOC (less than 50 g/l) Cleaning Aerosol Spray Cans." This latter list specifies nine companies. Both of these lists are provided in Appendix A.

IRTA staff also performed a search on Google Internet Search Engine and investigated certain terms and combinations of terms. These terms were:

- Aqueous
- Automotive
- Aerosol
- Water
- Clean

For companies on the two lists and those identified through the Google Search Engine, IRTA first determined whether the listed companies that supply the products had a web site. If the company had a web site, IRTA staff tried to identify water-based aerosol automotive products offered by the companies for brake cleaning, carburetor and fuel injection system cleaning, engine degreasing and general purpose degreasing. In some cases, IRTA staff obtained the Material Safety Data Sheets (MSDSs) from the web sites. In other cases, IRTA staff called the companies to discuss whether they had water-based products and obtain the MSDSs. In certain instances, the companies refused to provide the MSDSs.

Using these sources, IRTA staff identified products that were obviously water-based, products that were likely to be water-based and products that were possibly water-based. When necessary, IRTA staff made phone calls to vendors to verify whether or not the products were water-based. IRTA staff eliminated products that did not contain water, were not in an aerosol package or were not for automotive use.

IRTA staff found 40 products that were likely to be water-based automotive aerosol products. Of these 40 products, 12 were obviously water-based aerosol automotive products. The MSDSs of these 12 products were obtained from the manufacturers. Of

the remaining products, only seven more water-based aerosol automotive products were identified. The MSDSs of these seven products were also obtained.

A list of 19 water-based automotive aerosol products were identified in the search. IRTA examined the MSDSs for all of the products to determine if they met IRTA's criteria of near-zero-VOC. A cleaner met these criteria if the water content was 70% or greater or if the VOC content was less than about 275 grams per liter or 27.5%. There were 11 cleaners that met the criteria.

IRTA contacted the vendors that sell the 11 cleaners to obtain samples for the preliminary screening tests. One of the manufacturers did not send a sample of the cleaner so it could not be tested. Table 3-1 shows the cleaners that were included in the first phase of the preliminary screening and the characteristics of these cleaners.

Table 3-1
Existing Water-Based Aerosol Automotive Products
With Less Than 27.5% VOC Content Included in Preliminary Screening

Manufacturer	Product Name	Water Content	VOC Content
BioChem Systems	Bio T General Purpose Foam	50-90%	low
The Berkebile Oil Co.	Berkebile 2+2 Super Cleaner	unknown	low
Mirachem	Mirachem All Surface Safe Cleaner/ Degreaser	unknown	161 g/l
Sunshine Makers	Foaming Simple Green-Wheel Cleaner	90%	50 g/l
Sunshine Makers	Foaming Simple Green-Total Auto-motive Foaming Cleaner	90%	50 g/l
Berryman Products	All Purpose Clean-R	unknown	unknown
Berryman Products	New Engine Degreaser	30-50%	high
Radiator Specialty Co.	Foaming Wheel Cleaner	unknown	low
Drummond Amer-ican Corp.	Zonk!	70-80%	264 g/l
Radiator Specialty Co.	Foamy Engine Brite Degreaser	70-80%	low

Other Non-Aerosol Water-Based Cleaners

IRTA staff have extensive experience in the South Coast Basin working with auto repair facilities in parts cleaning and in brake cleaning. Under SCAQMD Rule 1171, auto repair facilities (and other companies performing repair and maintenance cleaning) are required to use cleaners with 25 grams per liter or less VOC. Because of the low VOC content cleaner requirements for cleaners in the South Coast Basin, many vendors are supplying water-based cleaners to automotive shops.

IRTA tested a number of water-based cleaners that are not available in aerosol form currently in the screening tests. These cleaners are manufactured by a number of different companies. Some have been used in the automotive sector and others are used primarily in the industrial sector for cleaning. Table 3-2 summarizes the cleaners that were tested in the preliminary screening tests.

Table 3-2
Water-Based Products Not Currently in Aerosol Form
Included in Preliminary Screening

Manufacturer	Product Name
Kyzen Corp.	Metalnox 6309
	Metalnox 6319
	Metalnox 6432
	Metalnox 6410MS
Applied Cleaning Technologies	Spray Clean 12
	Scrub Tub 8
AX-IT	AX-IT Spray
	AX-IT Immersion
Brulin	GD-815
	GD-1990
Magnaflux	Daraclean 200
	Daraclean 212
	Daraclean 236
	Daraclean 238
	Daraclean 257
	Darasolv 7
	Darasolv 11
Mirachem	Mirachem 750

Other Non-Water Based Cleaners

IRTA also screen tested two additional non-water-based cleaners, soy and acetone. One of the soy based cleaners is offered by AG Environmental Products and is sold under the trade name Soy Gold. The soy products have very low VOC content and are also low in toxicity. Acetone is available from multiple producers. Acetone is exempt from VOC regulations and is fairly low in toxicity.

Automotive Parts Collection for Screening Tests

IRTA gathered several different parts for the screening tests. These parts were collected from auto repair facilities. Auto repair shops, when they replace a part, send the discarded parts for metal recycling. IRTA collected four large containers of parts from four different facilities for the screen testing. The parts are generally contaminated with

large quantities of dirt, oil and grease that would typically be encountered in an automobile.

The parts that were used for the testing fall into four categories according to the regulatory classification of different aerosol cleaner types:

Brake Parts

- Eleven disc break rotors
- Two brake assembly parts

Carburetor/Fuel Injection System Parts

- Two carburetors
- Two fuel injectors

Engine Parts

- One long block engine assembly with head

General Parts

- One piston rod
- Three U joint bearings and U joints
- Twelve hydraulic lifters
- Two flywheels
- One torque converter
- Two emission control equipment assemblies

  One heater core
- One transmission yolk
- One trans axle casing
- Two torsion bars
- One suspension A frame
- Three water pumps
- One BMW valve cover
- One oil pan
- Two idler arms
- One strut
- One oil pump
- One belt idler
- One master cylinder
- One alternator
- One automotive transmission assembly

Preliminary Screening Tests

IRTA used a two-phase approach to screen test certain cleaners. As discussed in Section II, IRTA identified 10 existing aerosol water-based products that were screen tested. IRTA also identified 18 other non-aerosol near-zero-VOC water-based cleaners that were

screen tested. Two other non-water-based cleaners, acetone and soy, were also tested. Thus, a total of 30 cleaning agents were tested in the first phase of the screening tests.

In the first phase of the screening tests, the cleaning capability of the alternative products was compared with the cleaning capability of baseline solvent aerosol products. All of the products were tested at a test facility, a company called Applied Cleaning Technologies (ACT), on the automotive parts described earlier. The existing water-based aerosol cleaners were tested in aerosol form. The non-aerosol water-based cleaners were tested using pump pesticide application bottles. IRTA also tested the soy and acetone in the pesticide application bottles.

All of the products--the baseline solvent cleaners and the alternative cleaners--were sprayed for a 10 second duration onto a portion of the parts listed above. The cleaning effectiveness was evaluated by inspecting the portion of the part cleaned by the cleaner and by conducting a water break free test. The water break free test has been used historically to determine if a part is clean. The theory is that if water "sheets" off a part, it is clean. The water break free test may be too stringent for this application where stringent cleanliness is not required but it does serve as a guide. In all cases, the alternative cleaners were compared with the baseline solvent based aerosol cleaner in terms of cleaning effectiveness.

In the first phase of the screening tests, IRTA also took the non-aerosol water-based cleaners to three auto repair facilities and conducted the testing using the pesticide application bottles. IRTA requested that the facility personnel evaluate the cleaning effectiveness of the alternatives.

The results of the first phase of the screening tests indicated that four of the 10 low-VOC aerosol cleaners performed well enough to continue on to the Phase II testing. The cleaners that were carried on to the second phase of the screening tests were:

- Mirachem All Surface Safe Cleaner/Degreaser
- Radiator Specialty Co. Foamy Engine Brite Degreaser
- Sunshine Makers Foaming Simple Green-Wheel Cleaner
- Berryman B-33 Engine Degreaser

The 18 water-based cleaners that are not currently in aerosol form were screen tested using the pesticide applicators and they were compared with the solvent aerosol products. Of these cleaners, it was judged that 14 cleaners performed well enough to go on to the second phase of the screening testing. These included:

- Magnaflux Daraclean 200
- Magnaflux Daraclean 236
- Magnaflux Daraclean 238
- Magnaflux Daraclean 257
- Kyzen Metalnox 6432
- Kyzen Metalnox 6319
- Kyzen Metalnox 6410MS
- Brulin GD1990

- Brulin GD815
- Applied Cleaning Technologies Spray Clean 12
- Applied Cleaning Technologies ScrubTub
- AX-IT Spray
- AX-IT 3X Spray Cleaner
- Mirachem 750

Acetone and Soy Gold were tested in the first phase of the screening tests and compared with the solvent aerosol products. Acetone performed well and Soy Gold did not perform well.

In the second phase of the screening tests, three aerosol packagers agreed to package the 18 water-based cleaners that were not currently in aerosol form. The companies that did the packaging include:

- CRC Industries, Inc.
- Hydrosol, Inc.
- Radiator Specialty Company

IRTA arranged for the water-based cleaner manufacturers and distributors to provide three gallons each of the cleaner to one of the three packagers. The packagers packed the cleaners in aerosol containers that were all propelled by hydrocarbons. In the preliminary screening tests, hydrocarbon propellants were used for all the cleaners so a difference in performance of the propellant would not influence the cleaning capability of the cleaners.

IRTA again conducted the laboratory testing of the 22 cleaning agents using the parts containing oil and grease collected from the auto repair facilities. This time, however, the cleaning agents were all in aerosol form so the tests could be conducted with aerosols and the cleaning capability compared with the solvent aerosol cleaners.

Table 3-3 presents the Phase II results of IRTA's laboratory testing at ACT. The table shows each of the cleaning agents that was tested in the first column. The four different cleaning applications are shown across the top of the table. For each application, the solvent baseline cleaner that was compared with the alternative water-based cleaners is also identified in parenthesis. An entry of S in the table indicates the cleaner performed the same as the baseline cleaner and an entry of N indicates the cleaner did not perform as well as the baseline cleaner.

Also in the second phase of testing, IRTA took one can of each of the 22 cleaners to eight auto repair facilities for them to test. IRTA participated in all of the testing and asked for the opinion of the technicians on the cleaning capability of the cleaners. The testing at the auto repair facilities was conducted on brakes and on parts of various types. Thus the

Table 3-3
Results of Laboratory Screening Tests

Application (Baseline Cleaner) / Cleaner Name	Engine Degreasing (CRC Engine Degreaser)	Carburetor and Fuel Injection System Cleaning (Gumout Choke & Carb Cleaner)	Brake Cleaning (CRC Brake Parts Cleaner)	General Purpose Degreasing (CRC Engine Degreaser)
Daraclean 200	**N**	**S**	**S**	**S**
Daraclean 236	**S**	**N**	**N**	**N**
Daraclean 238	**N**	**N**	**S**	**S**
Daraclean 257	**S**	**S**	**S**	**S**
Metalnox 6432	**S**	**N**	**S**	**N**
Metalnox 6319	**N**	**S**	**S**	**N**
Metalnox 6410MS	**N**	**S**	**N**	**N**
Brulin 1990GD	**N**	**N**	**N**	**N**
Brulin 815GD	**N**	**S**	**S**	**N**
ACT Sprayclean 12	**S**	**S**	**S**	**S**
ACT ScrubTub	**S**	**N**	**N**	**N**
AX-IT Spray Cleaner	**S**	**S**	**N**	**N**
AX-IT 3X Spray Cleaner	**S**	**N**	**N**	**N**
Mirachem 750	**N**	**N**	**S**	**N**
Mirachem All Surface Safe	**S**	**S**	**N**	**N**
Foamy Engine Bright	**S**	**S**	**S**	**S**
Simple Green Wheel Cleaner	**S**	**S**	**N**	**N**
Berryman B-33 Engine Degreaser	**S**	**S**	**S**	**N**

Note: S = Same as baseline; N = Not as good as baseline

results were meaningful only for brake cleaning and general purpose degreasing. The results did not apply to carburetor and fuel injection system cleaning or engine degreasing.

The results of the Phase II screening tests performed in the laboratory and at the auto repair facilities are presented in Table 3-4. The table lists the names of the cleaners that were tested down the side. Across the top, the locations of the testing are indicated. The first eight columns identify the results for the testing at the auto repair facilities. The ninth column summarizes the testing that IRTA conducted in a laboratory setting at ACT. The entries in the table are C, which means the cleaner was close in performance to the shop's current cleaner or the baseline cleaner selected for comparison but not quite as good; S, which is the same as or as good as the shop's current cleaner; and B, which is better than the shop's current cleaner. Blanks in the table indicate that the cleaner did not perform well. The tenth column in the table shows how many times the shops or IRTA in the laboratory testing, taken together, ranked the cleaner the same as or better than the current or baseline cleaner. The eleventh column shows how many times the shops or IRTA, taken together, ranked the cleaner the same as, better than or close to the same as the current or baseline cleaner. For the laboratory testing results in Table 3-4, IRTA entered an S if the cleaner performed the same as the baseline cleaner for both general purpose degreasing and brake cleaning in Table 3-3.

If the table showed a 0, 1 or 2 in the last two columns, the cleaner was judged to be ineffective. These cleaners were eliminated from the field testing. On this basis, there were eight cleaners that were judged to be effective enough to undergo field testing. They include:

- Daraclean 200
- Daraclean 238
- Daraclean 257
- Metalnox 6410
- Brulin 1990GD
- ACT Sprayclean 12
- AX-IT Spray Cleaner
- Foamy Engine Brite

Two additional cleaners that performed well in the Phase I screening tests were also judged to be effective enough to undergo field testing. These include:

- Metalnox 6432
- Mirachem 750

Three cleaners that did not perform well according to the information in Table 3-3 but did perform well for engine degreasing are Mirachem All Surface Safe, Simple Green Wheel Cleaner and Berryman B-33 Engine Degreaser. Except for the Mirachem cleaner, these cleaners are also commercial products used for auto parts cleaning. Mirachem and Simple Green agreed to send aerosol cleaners for the field testing so these two additional cleaners were field tested in engine degreasing.

Table 3-4
Laboratory and Field Screening Test Results for Alternative Water-Based Cleaners

Cleaner Name	ARCO Partnership	Morgan's Auto Service	Connell Chevrolet	Guaranty Chevrolet	Brake Master	Santa Monica Auto Center	German Auto Technik AG	Samo Wheel and Brake Service	ACT / IRTA	Same & Better	Same, Better & Close to Same
Daraclean 200		S	S		S		S	S	S	6	6
Daraclean 236			B	S						2	2
Daraclean 238			S	S	S	S			S	5	5
Daraclean 257	S	S	B	S		S			S	6	6
Metalnox 6432										0	0
Metalnox 6319		S		S						2	2
Metalnox 6410MS	S	S	B		S					4	4
Brulin 1990GD	S	S	S		S					4	4
Brulin 815GD								S		1	1
ACT Sprayclean 12	S	C	S				S	C	S	4	6
ACT ScrubTub							S			1	1
AX-IT Spray Cleaner		B	B	S		S		S		5	5
AX-IT 3X Spray Cleaner										0	0
Mirachem 750										0	0
Mirachem All Surface Safe	S							C		1	2
Foamy Engine Brite				S		S		C	S	3	4
Simple Green Wheel Cleaner	S						S			2	2
Berryman B-33 Engine Degreaser								C		0	1

Note: C = close in performance to current cleaner; S = same as or as good as current cleaner; B = better than current cleaner

One issue that arose during the screening tests is that all of the water-based cleaners packaged in aerosol form are foaming cleaners. These types of cleaners are used today in engine degreasing where the engine is rinsed with water after the degreaser is applied. Foaming cleaners are not commonly used in the other three applications, brake cleaning, general purpose cleaning and carburetor and fuel injection cleaning. The non-foaming solvent aerosol baseline cleaners are effective in part because of the mechanical pressure that dispensing the liquid at high pressure imparts. The auto repair technicians simply spray the cleaner until the cleaner and the mechanical action dislodge the contaminants. The same procedure does not work with foaming cleaners. In some cases, the foam is thick and it remains on the surface for a period; in other cases, the foam drips off fairly quickly. In the case where the foam remains on the surface, it has some time to solubilize the contaminants. In both cases, however, there is virtually no mechanical action that aids in the contaminant removal. In instances where foam is left on the part, the technician would have to rinse it for inspection. The bottom line is that it was essential to have the brake and general purpose cleaners packaged as non-foaming cleaners for the field testing.

Another issue that arose during the screening tests is that many auto repair technicians indicated they were reluctant to test water-based cleaners for carburetor and fuel injection system cleaning activities. They were concerned that the water would enter the fuel system. Based on these concerns, IRTA decided not to field test the water-based cleaners for this cleaning category.

IV. FIELD TESTS OF ALTERNATIVE LOW-VOC CLEANERS

Two issues were identified in the screening tests described in Section III. First, it is difficult to find water-based cleaners that do not foam when they are packaged in aerosol form. There are a number of water-based cleaners used today in industrial cleaning that are designed to not foam. They are used in spray cabinets and conveyor systems. These cleaners, however, are all used at higher temperature and they are not sprayed with air or propellant. Even cleaners designed to not foam in industrial applications will likely foam when they are packaged and dispensed in an air and propellant stream. Finding and packaging water-based cleaners that did not foam in an aerosol package was very challenging. It required knowledge and art in finding the right cleaner and packaging it properly so it did not foam. IRTA solicited non-foaming cleaners from several water-based cleaner suppliers.

Second, many of the auto repair technicians were uncomfortable using water-based cleaners for carburetor and fuel injection system cleaning. As a consequence, IRTA made the decision to not test water-based cleaners for this application.

Approach to Field Testing

IRTA recruited 13 auto repair facilities to assist in testing the alternative low-VOC cleaners. These facilities included dealerships, brake shops, service stations that also do repairs and general automotive repair shops. IRTA also recruited three automotive detailers, one car wash and three consumers to assist in the field testing. A list of all of these shops and consumers is provided in Appendix B.

IRTA originally planned to provide each of the facilities participating in the field testing a one-week supply of each of the alternative cleaners. In practice, however, this presented problems. First, some of the facilities did not have as many jobs as anticipated so the cleaners could not be tested so quickly. Second, when the facility personnel thought the cleaner did not work well, they were understandably reluctant to test it extensively. Third, in some cases, the shop owners did not communicate to the technicians that they should test the alternatives.

IRTA revised the testing strategy to accommodate these problems. IRTA visited the facilities often, at least once a week, when the testing was underway. This was beneficial because the IRTA staff could also work with the technicians during this time to observe the performance and advantages or disadvantages of the cleaners firsthand.

For the field testing, IRTA developed a questionnaire for the technicians and consumers. IRTA generally filled out the questionnaire when the technician or consumer finished using the alternative cleaner by asking the opinions of the person conducting the testing. At some of the facilities, IRTA worked with more than one technician so there were multiple completed questionnaires. At one of the facilities, one technician filled out one of the questionnaires himself. A sample of the questionnaire is shown in Appendix C.

The balance of this section focuses on the three categories of automotive aerosol cleaning. The applications and the cleaning tasks differ significantly. IRTA treated engine degreasing and carburetor and fuel injection system cleaning separately but combined brake cleaning and general purpose degreasing.

Engine Degreasing

IRTA did not perform engine degreasing with the 13 auto repair facilities participating in the project since they do not perform engine degreasing. IRTA decided to recruit detailers, car washes and consumers to assist in evaluating the alternative water-based aerosol engine degreasers. Although detailers and car washes do not use aerosol products, they do know about degreasing engines. IRTA believed the personnel in car washes and detailing companies would have expertise in evaluating the capability of the water-based cleaners for degreasing the engine. IRTA also believed they would have expertise in comparing the cleaning capability of the alternative water-based cleaners to the bulk cleaners they commonly use. IRTA also identified three consumers who work on their cars and routinely perform engine degreasers to evaluate and compare the alternative water-based engine degreasers with the solvent engine degreasers they commonly use.

Detailers and car washes do not use aerosol engine degreasers to degrease the engines. Rather, they purchase and use bulk cleaners in high pressure sprayers. Virtually all detailers and car washes already use water-based cleaners for degreasing engines. The bulk water-based cleaners may contain small amounts of solvent additives but these are generally very small. The VOC content of these cleaners is very low, close to zero. The detailers and car washes use the bulk cleaners because they are much less costly than aerosol products. Consumers do use aerosol engine degreasers.

The bulk concentrate of the water-based cleaner used by detailers and car washes is most often diluted with water and is applied with a high pressure sprayer. The cleaner solubilizes the contaminants and, more important perhaps, the pressure blasts the contaminants from the engine, the engine compartment or the under carriage of the vehicle. The engine is then rinsed with plain ambient temperature or heated water in a pressurized spray applicator. Figures 4-1, 4-2 and 4-3 show a detailer detailing a car. Figures 4-1 and 4-2 show the detailer applying the water-based cleaner and the water rinse respectively. Figure 4-3 shows the detailer cleaning the under carriage of the car with the same water-based cleaner.

Consumers use aerosol engine degreasers to clean their engines. They apply the cleaners and then rinse the contaminants and the cleaner from the engine, generally with a hose. The solvent aerosol degreasers do not foam whereas all of the commercial aerosol water-based cleaners on the market do foam. The foaming cleaners sit on the engine for a period and solubilize the contaminants. They can then be rinsed off with plain water.

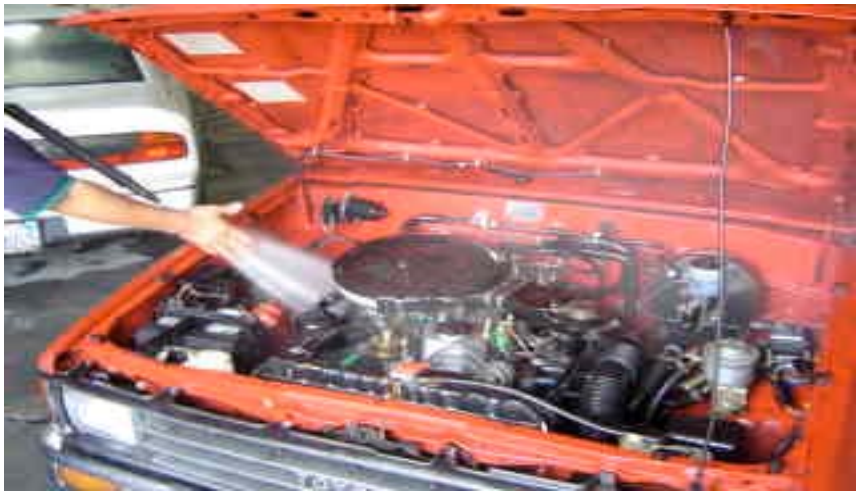


Figure 4-1. Detailer Applying Water-Based Cleaner to Engine

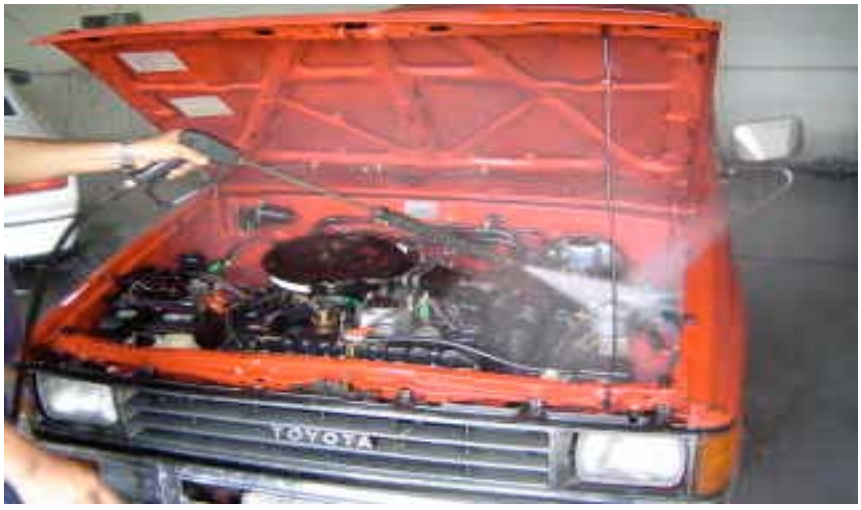


Figure 4-2. Detailer Rinsing Engine

Figure 4-3. Detailer Cleaning Undercarriage of Truck

IRTA tested a total of eight water-based engine degreasers with the car wash, the detailers and the consumers. As discussed earlier, IRTA screened commercial products and identified four commercial water-based aerosol products that could be tested. These cleaners met the criteria of containing at least 70% water and a VOC content of about 27.5%. All of these products contained solvents. Three of the manufacturers provided large quantities of the products for testing. These products include:

- Foamy Engine Brite Degreaser
- Simple Green Wheel Cleaner
- Mirachem All Surface Safe Cleaner/Degreaser

IRTA tested five additional water-based cleaners that were not previously in aerosol form. Each of the manufacturers arranged to have the cleaners packaged in aerosol form. These cleaners, like the three commercial aerosol products, foamed and this was appropriate for the engine degreasing cleaning task. The additional five cleaners include:

- AX-IT L-7768
- L-7820 ScrubTub
- Kyzen Aerosol Cleaner
- Kyzen Aerosol Degreaser 11
- Kyzen Engine Degreaser 2

MSDSs for the eight products that were tested in engine degreasing are shown in Appendix D. Note that all of the commercial aerosol water-based cleaners contain solvent additives and that all five of the alternative water-based cleaners contain no solvent additives. All eight of the cleaners use hydrocarbon propellants.

Tables 4-1 and 4-2 show the results of the engine degreasing tests. In both tables, the facilities participating in the testing are listed in the first column. The cleaners that were tested are shown across the top. Table 4-1 presents the adequacy of the cleaners which is simply a measure of whether the cleaner cleaned or did not clean. A zero in the table indicates the cleaner did not work; a one indicates the cleaner did work. As noted in the table, it was not possible to test all of the cleaners with all of the facilities or consumers because of scheduling difficulties. L-7820 ScrubTub and Kyzen Aerosol Degreaser 11, for example, were not tested by all facilities and consumers.

Table 4-2 ranks the alternative water-based cleaners in comparison to the bulk water-based cleaner routinely used by each of the facilities. The feedback from the consumers was not included in Table 4-2 because the consumers indicated they do not use the same engine degreaser every time they degrease the engine. They use the product that is low cost and available when they need to perform the cleaning task. The ranking values in Table 4-2 range from zero to 3. A zero indicates that the cleaner performance was poor. A 0.5 indicates that the cleaner performed marginally well. A 1 indicates that the cleaner was almost as good as the current cleaner. A 1.5 indicates that the cleaner was nearly as good as the current cleaner. A 2 indicates that the cleaner performed as well as the current cleaner. A 2.5 indicates that the cleaner performed somewhat better than the current cleaner and a 3 indicates that the cleaner performed better than the current cleaner.

Table 4-1
Alternative Engine Degreasers – Adequacy of Cleaning

Facility	Foamy Engine Brite	Simple Green	Mirachem All Surface	AX-IT L-7768	L-7820 ScrubTub	Kyzen Aerosol Cleaner	Kyzen Aerosol Degreaser 11	Kyzen Engine
Triple Shine Detail	1	1	1	1	1	0		0
VREJ Detail	1	1	1	1		0	1	1
New Image	1	1	1	1	1	1	0	1
California Car Wash	1	0	1	1	1	1		1
Consumer 1	1	1	1	1		1	1	1
Consumer 2	1	1	0	1	1	1	1	1
Consumer 3	1	0	0	1		0	1	1

Key: 0 = Did not clean; 1 = Cleaned

The values of Table 4-1 show that most of the facilities and consumers participating in the project thought that all of the alternative cleaners performed acceptably. Foamy Engine Brite, a commercial product, and AX-IT L-7768 were tested by all participants and all indicated they cleaned. L-7820 ScrubTub was tested by only four participants but all agreed it cleaned. All of the remaining cleaners cleaned adequately according to a majority of the participants.

Table 4-2
Alternative Engine Degreasers – Ranking

Facility	Foamy Engine Brite	Simple Green	Mirachem All Surface	AX-IT L-7768	L-7820 ScrubTub	Kyzen Aerosol Cleaner	Kyzen Aerosol Degreaser 11	Kyzen Engine
Triple Shine Detail	1	2	1	1	2	0		0
VREJ Detail	2	2.5	2	1		0	2.5	2.5
New Image	1	1	1	1	2	2.5	0.5	2.5
California Car Wash	1	0.5	1	1	2	2		1
Consumer 1								
Consumer 2								
Consumer 3								

Performance Key: 0 = Poor; 0.5 = Marginal; 1 = Almost as good as current cleaner; 1.5 = Nearly as good as current cleaner; 2 = As good as current cleaner; 2.5 = Somewhat better than current cleaner

Table 4-2 shows that several of the alternative cleaners received rankings that indicate the cleaner was almost as good or as good as the current cleaner. Four of the cleaners were ranked somewhat better than the current cleaner by at least one of the facilities that evaluated them. Only two cleaners were judged to be poor by one or two of the facilities that evaluated them.

In general, Table 4-2 shows that alternative water-based cleaners are acceptable when compared with the current cleaners used by the detailers and the car wash that participated in the project. Table 4-1 shows that the consumers who conducted testing in the project also found that most of the alternatives worked. An interesting point that was noted by IRTA staff during the testing is that the younger technicians and consumers appeared to prefer the alternative cleaners with no solvent additives over the commercial product water-based cleaners which did have solvent additives. In contrast, the older technicians and consumers preferred the cleaners containing solvents. One consumer said "if it doesn't smell bad like a solvent, it won't work." All of the products foamed and the consumers indicated they liked a foaming cleaner. In contrast, the technicians indicated they preferred non-foaming cleaners, perhaps because the non-aerosol cleaners they use currently do not foam.

Carburetor and Fuel Injection System Cleaning

Virtually all auto repair facilities purchase two cleaners. First, they purchase a brake cleaner or general purpose cleaner that is used for performing brake jobs and for some general purpose cleaning. The technicians view brake cleaners and general purpose degreasers as interchangeable. Second, they purchase a carburetor cleaner which they consider faster evaporating. This cleaner is used for cleaning throttle body valves and for preparing gaskets, which are sealed using a gasket sealer for bonding with metal parts.

New automobiles sold today have fuel injection systems rather than carburetors. Some older cars on the road still have carburetors. A picture of a carburetor cleaned during the project is shown in Figure 4-4. Most of the carburetor cleaner used today is used for cleaning throttle body valves. Nearly all auto repair facilities use a different type of cleaning method for flushing fuel injection systems. This system uses two different materials. The first is a blend of high VOC solvents provided with a dispenser system that can be hooked up to the fuel injection system. This cleaner is flushed through the system with the engine running. As a consequence, the ingredients in the cleaner are combusted and the VOC solvents are not emitted. The second material is an additive that is poured into the fuel tank. This material is not a solvent and it is not emitted; again, it is combusted when the fuel is burned. IRTA did not attempt to find alternatives for the additives flushed through the fuel injection system. IRTA did try to find alternatives to the cleaner labeled carburetor cleaner that facilities purchase and use for various activities.

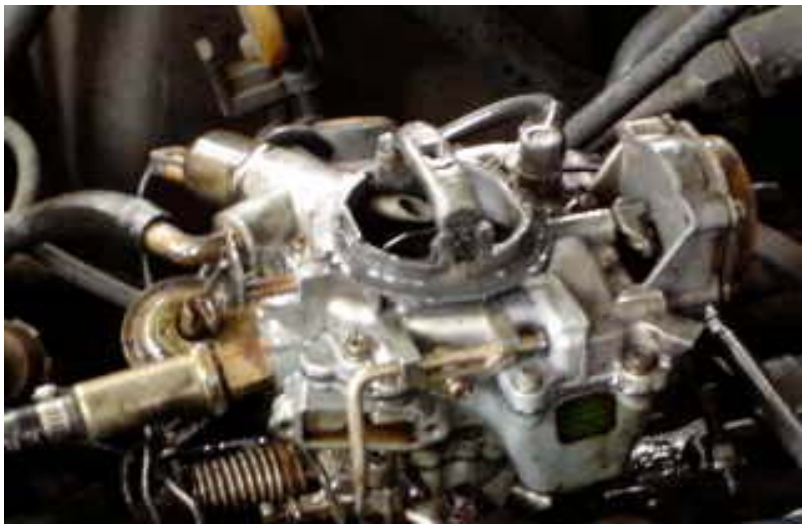


Figure 4-4. Carburetor Cleaned With Alternative Cleaners

An issue about the legality of testing alternative carburetor cleaners without registering them first was raised before the field testing began. IRTA investigated this issue which is described in Title 40 Part 79 of the Code of Federal Regulations. The statute states that any designated additive, which includes so-called aftermarket aerosol additives, in a research, development or test status and not offered for commercial sale is exempt from the registration requirement.

As mentioned earlier, many of the participating auto repair technicians were reluctant to test water-based cleaners as an alternative to the carburetor cleaner they use today. IRTA decided to formulate three difference cleaners for testing in this application. IRTA blended three different compositions of acetone, a VOC exempt solvent, with a soy based cleaner. Acetone has a very high vapor pressure and evaporates quickly; the solvent is also low in toxicity compared with other solvents used by this industry today. IRTA has tested soy products extensively in other projects and it is a very effective ink and carbon cleaner. The SCAQMD has tested the VOC content of several soy formulations and has found them to have less than about 25 grams per liter VOC content. This translates into 2.5% VOC. The soy cleaners are low in toxicity but they are oily and have a low vapor pressure making them slow evaporating.

IRTA decided to test three alternative soy/acetone cleaners. Because of the slow evaporation rate of the soy, all three cleaners had at least 50% acetone. The first cleaner was a 50%/50% soy/acetone blend. The second cleaner was composed of 65% acetone and 35% soy. The third cleaner was composed of 75% acetone and 25% soy. One packager used a hydrocarbon propellant but IRTA did not test these cleaners for carburetor and fuel injection system cleaning. A second packager was willing to package the cleaners with a carbon dioxide propellant and IRTA tested these formulations for carburetor and fuel injection system cleaning. All three cleaners have close to zero VOC content.

The 50% soy product was tested by 11 technicians at nine auto repair facilities. The 35% soy product was tested by 13 technicians at ten auto repair facilities. The 25% soy product was tested by 12 technicians at eight auto repair facilities. The technicians tested the cleaners on carburetors if they had vehicles with carburetors and for intake and throttle body valve cleaning if they had vehicles with fuel injection systems. One water-based cleaner, a brake cleaner provided by Kyzen called Cyber Solv 11, was tested by one mechanic at one facility. He did not know it was a water-based cleaner and he was testing it in other applications as well. MSDSs for the soy based cleaner used in the blends and acetone are shown in Appendix E. An MSDS for the Cyber Solv 11 product is also shown in the appendix.

Tables 4-3 and 4-4 show the test results for the alternative low-VOC carburetor and fuel injection system cleaners at each of the participating auto repair facilities. The facilities are listed in the first column of both tables. In some cases, more than one technician at a facility tested the cleaners. The first name of the technician is shown after the name of the facility.

Table 4-3 illustrates the adequacy of the three soy/acetone cleaners and the one water-based cleaner. A zero indicates that the cleaner did not clean and a 1 indicates that the cleaner cleaned adequately. A blank in the table means that the cleaner was not tested at the facility. The values show that only one mechanic at one facility stated that one of the soy/acetone blends was not adequate. All other technicians stated that the cleaners were adequate. The technician that tested the water-based cleaner also thought it was adequate.

Table 4-4 ranks the alternative low-VOC cleaners in comparison to the carburetor cleaner used by each facility today. A zero indicates the cleaner performed poorly. A 0.5 indicates the cleaner performed marginally well. A 1 indicates the cleaner performed almost as well as the current cleaner. A 1.5 indicates the cleaner performed nearly as well as the current cleaner. A 2 indicates the cleaner performed as well as the current cleaner. A 2.5 indicates the cleaner performed somewhat better than the current cleaner. Finally, a 3 indicates the cleaner performed better than the current cleaner.

The results indicate that all of the cleaners were ranked at least almost as good as the current cleaner. The 35% soy/acetone blend was ranked better than the current cleaner by four of the 13 technicians that tested it. Three other technicians ranked the cleaner somewhat better than the current cleaner. The remaining six technicians indicated the cleaner performed as well as the current cleaner. The 25% soy/acetone blend was ranked slightly lower. Only two technicians ranked it almost as good as the current cleaner and one technician ranked it nearly as good as the current cleaner. The remaining nine technicians ranked it as good as or somewhat better than the current cleaner. The 50% soy/acetone blend was tested by 11 technicians. One of them ranked it as performing marginally well, three of them ranked it as almost as good as the current cleaner, four of them ranked it as good as the current cleaner and three ranked it as somewhat better than the current cleaner. The water-based cleaner tested by one technician was ranked as good as the current cleaner.

Table 4-3
Alternative Carburetor and Fuel Injection System Cleaners – Adequacy of Cleaning

Facility	50% Soy/ Acetone	35% Soy/ Acetone	25% Soy/ Acetone	CyberSolv Degreaser 11
ARCO	1	1	1	
Shell (Santa Monica)		1	1	
Samo Tire				
Morgan's Auto Service	1	1	1	
S.M. Auto Center – Aljerome			1	
S.M. Auto Center – Rene	1	1	1	
S.M. Auto Center – Catarino		1	1	
S.M. Auto Center – Esmet	1			
Big Blue Bus	1		1	
Brake Master		1		
German Auto Technik	1	1		
Mercedes Benz	1	1	1	1
Connell Chevrolet - Tony	0	1		
Connell Chevrolet – Joe		1		
Ira Newman Automotive - Scott	1		1	
Ira Newman Automotive - Norm	1	1	1	
Shell (Rose) – Luis			1	
Shell (Rose) – Avelino			1	
Shell (Rose) – Jesus	1			
Guaranty Chevrolet - Mechanic 1		1		
Guaranty Chevrolet - Mechanic 2		1		

Key: 0 = Did not clean; 1 = Cleaned

Qualitative comments by the technicians indicated that the 25% soy/acetone blend and the 35% soy/acetone blend performed better than the 50% soy/acetone blend because the latter blend evaporated too slowly. The technicians currently use fast evaporating cleaners and they like that feature. Many technicians also mentioned the smell of the soy/acetone products. They also stated that it was not objectionable, just notable.

One issue that arose during the testing concerned the fact that technicians use the carburetor cleaner for preparing gaskets for bonding to metal surfaces with a gasket sealer. A few of the technicians stated that the soy/acetone blends left an oily residue. If the surface of the gasket has a residue, the sealant will not stick. The mechanics tried alant after the wiping. Another alternative that could be used for the gasket preparation

Table 4-4
Alternative Carburetor and Fuel Injection System Cleaners – Ranking

Facility	50% Soy/ Acetone	35% Soy/ Acetone	25% Soy/ Acetone	CyberSolv Degreaser 11
ARCO	1	2	2.5	
Shell (Santa Monica)		3	2.5	
Samo Tire				
Morgan's Auto Service	1	2	1	
S.M. Auto Center – Aljerome			2	
S.M. Auto Center – Rene	2	2.5	2	
S.M. Auto Center – Catarino		2.5	2	
S.M. Auto Center – Esmet	2			
Big Blue Bus	2		1	
Brake Master		2		
German Auto Technik	2	2		
Mercedes Benz	2.5	3	2.5	2
Connell Chevrolet - Tony	0.5	2		
Connell Chevrolet - Joe		2		
Ira Newman Automotive - Scott	1		2	
Ira Newman Automotive - Norm	2.5	3	1.5	
Shell (Rose) - Luis			2	
Shell (Rose) - Avelino			2	
Shell (Rose) - Jesus	2.5			
Guaranty Chevrolet - Mechanic 1		2.5		
Guaranty Chevrolet - Mechanic 2		3		

Performance Key: 0 = Poor; 0.5 = Marginal; 1 = Almost as good as current cleaner; 1.5 = Nearly as good as current cleaner; 2 = As good as current cleaner; 2.5 = Somewhat better than current cleaner; 3 = Better than Current Cleaner

is a very high acetone content aerosol product. Such products are already on the market in Southern California.

In general, the alternative carburetor and fuel injection system cleaners performed as well as or better than the current carburetor cleaners purchased by auto repair facilities. The 25% and 35% blends were preferred by the technicians over the 50% soy cleaner because they evaporated more quickly.

Brake Cleaning and General Purpose Degreasing

As discussed earlier, most auto repair shops purchase two types of cleaners. One of these cleaners is a fast evaporating carburetor cleaner and the other is a brake cleaner or general purpose degreaser. The shops perform their brake cleaning and general purpose degreasing generally with the same cleaner. Some technicians and shops have a preference for a particular cleaner but many purchase the cleaner that is the lowest cost when they need additional cleaner.

General purpose degreasing is performed when a part needs to be replaced or repaired. Technicians often spray the part with an aerosol cleaner to remove any dirt, grease or oil so they can examine the part and replace or repair it as necessary. Figure 4-5 shows a technician performing general purpose degreasing.

Older vehicles, manufactured in the 1980s and before have drum brakes on both the front and the back. Before about 1995, vehicles were manufactured with disc brakes on the front and drum brakes on the back. In the last 10 years, vehicles are often manufactured with disc brakes on both the front and the back. Figure 4-6 shows a picture of a vehicle with the tire removed and the brakes exposed. Figure 4-7 shows a closer view of the brake assembly.

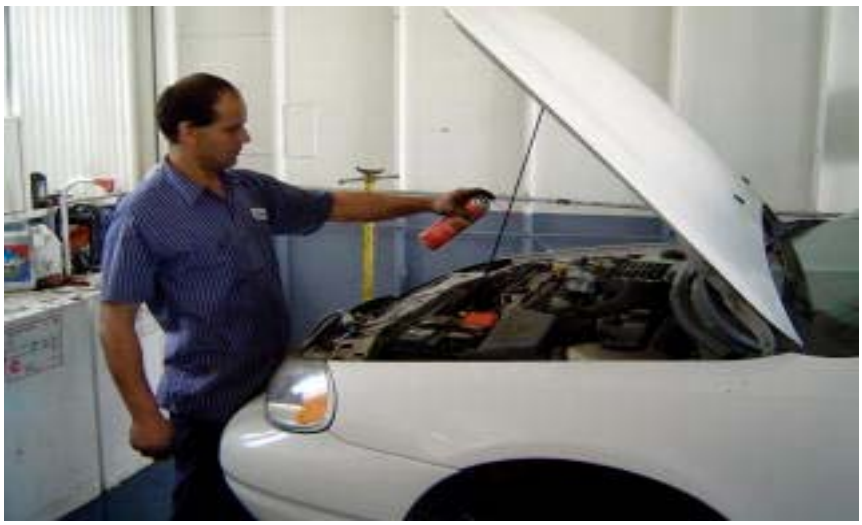


Figure 4-5. Technician Performing General Purpose Degreasing

Drum brakes are cleaned when the technician repairs or replaces parts like brake pads or brake cylinders. The major contaminant that is removed is dust. When technicians inspect or adjust the brakes, they often do not clean them. Disc brakes include a caliper, which is the brake mechanism, and a rotor, which is the steel disc. Technicians clean the caliper when a repair is necessary. Contaminants can include dust and, if there is a leaky seal, brake fluid. The rotor is always cleaned. Some technicians remove the rotor and clean it with soap and water in a sink. If the rotor needs to be machined, the technician will clean the particulate contaminants before reinstalling it. Other technicians use a brake cleaner to remove dust, oil or fingerprints. When the rotor is replaced, it is packed

in a corrosion inhibitor and technicians also clean this material when they install the new rotor.

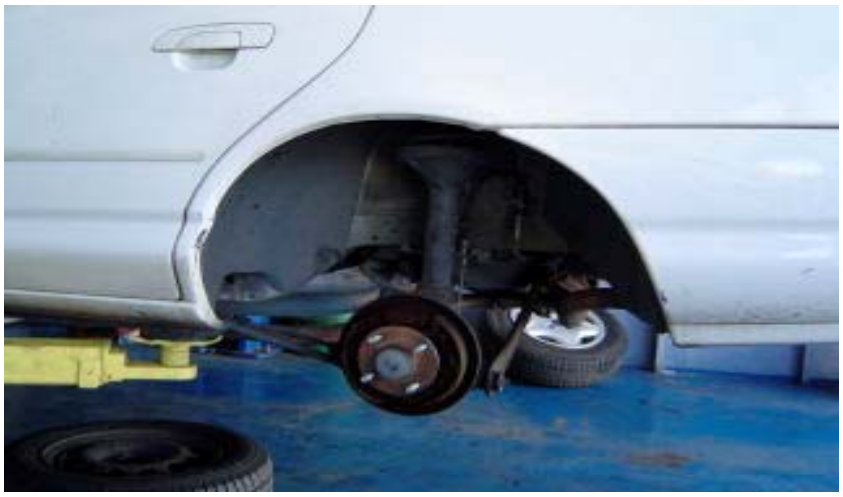
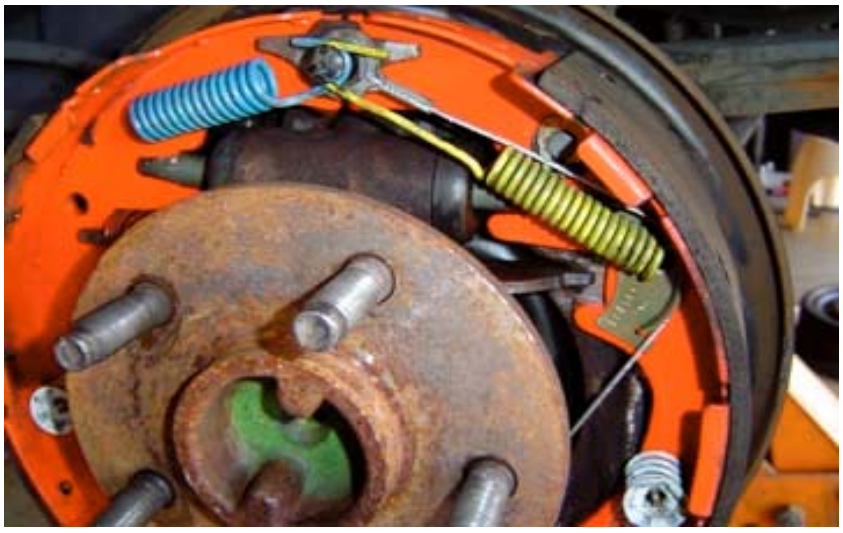


Figure 4-6. Vehicle With Brakes Exposed



4-7. Closer View of Brake Assembly

In Southern California, many auto repair shops use water and/or water-based cleaners in small brake cleaning equipment. Some of these shops do not use solvent aerosol brake cleaners at all and others use solvent aerosol brake cleaners to augment the water-based systems. Both disc brakes and drum brakes can be cleaned with these water-based brake cleaning systems. Most of the time, estimated at 90% by auto repair technicians, only dust or fingerprints are removed during a brake job. The remaining 10% of the time, oil or grease needs to be removed during a brake job.

Because auto repair technicians generally consider brake cleaners and general purpose degreasers to be interchangeable, IRTA requested that the facilities test all of the water-based cleaners for both purposes. As discussed earlier, IRTA needed non-foaming cleaners to test in these applications. Some of the formulators agreed to reformulate their

foaming cleaners and have them packaged. The water-based cleaners that were tested for brake cleaning and general purpose degreasing include:

- AX-IT L-7769
- Mirachem Automotive Cleaner
- Kyzen Cyber Solv 11
- Kyzen Cyber Solv
- Kyzen Aerosol Cleaner
- Kyzen Aerosol Degreaser 11

Because the soy/acetone blends formulated for testing as carburetor cleaners performed well, IRTA decided to test some of them for brake cleaning and general purpose degreasing. IRTA tested the three soy/acetone cleaners packaged in carbon dioxide propellant and also tested one soy/acetone blend packaged in a hydrocarbon propellant to see if the propellant made a difference in cleaning capability. IRTA also decided to test an acetone cleaner packaged in a hydrocarbon propellant to determine if acetone alone could function as a cleaner in this sector. The non-water-based cleaners that were tested include:

- 50% soy/50% acetone with carbon dioxide propellant
- 35% soy/65% acetone with carbon dioxide propellant
- 25% soy/75% acetone with carbon dioxide propellant
- 35% soy/65% acetone with hydrocarbon propellant
- acetone with hydrocarbon propellant

A total of six water-based cleaners and five low-VOC non-water-based cleaners were tested for brake cleaning and general purpose degreasing. MSDSs for these products are shown in Appendix F. Not all the cleaners were tested at all of the participating facilities but the water-based cleaners were all tested by at least eight of the facilities.

Table 4-5 and 4-6 summarize the results of the general purpose degreasing tests. The shops and particular mechanics that performed the testing are shown in the first column. The first table focuses on the adequacy of the product. A zero indicates the product did not work and a 1 indicates the product was adequate. Blanks in the table indicate the product was not tested. Table 4-6 shows the cleaner ranking compared with the shop's current cleaning. A zero indicates the cleaner performed poorly. A 0.5 indicates the cleaner performed marginally well. A 1 indicates the cleaner performed almost as well as the current cleaner. A 1.5 indicates the cleaner performed nearly as well as the current cleaner. A 2 indicates the cleaner performed as well as the current cleaner. A 2.5 indicates the cleaner performed somewhat better than the current cleaner. Finally, a 3 indicates the cleaner performed better than the current cleaner.

The tables show that two of the soy acetone cleaners with the carbon dioxide propellant were judged adequate by nearly all mechanics who tested them and they were generally ranked at least as good as the current product. The Kyzen Cyber Solv products were judged adequate by most facilities.

Table 4-5
Alternative General Purpose Degreasers – Adequacy of Cleaning

Facility	AX-IT L-7769	Mirachem Automotive Cleaner	Kyzen CyberSolv 11	Kyzen CyberSolv	Kyzen Aerosol Cleaner	Kyzen Aerosol Degreaser 11	50 % Soy/Acetone (Carbon Dioxide)	35% Soy/Acetone (Carbon Dioxide)	25% Soy/ Acetone (Carbon Dioxide)	L-7752 35% Soy/Acetone (Hydrocarbon)	L-7750 Acetone (Hydrocarbon)
ARCO – Mechanic 1	0	0			0	0		1	1	1	
ARCO – Mechanic 2			1	1							
Shell (Santa Monica)	0	0						1	1	0	
Samo Tire			1	1	0	0	1				
Morgan's Auto Service	0	0	1	1	0	0				1	
S.M. Auto Center – Eduardo					0						
S.M. Auto Center – Julio						1					
S.M. Auto Center – Aljerome			1						1		
S.M. Auto Center – Rene	1	0							1	1	
S.M. Auto Center – Catarino								1	1	1	
S.M. Auto Center – Esmet			1	1							
Big Blue Bus - Mechanic 1		0	1	1	0	0		1	1		
Big Blue Bus - Mechanic 2			1		0	1			1		
Big Blue Bus - Mechanic 3					0						
Big Blue Bus - Mechanic 4					0						
Big Blue Bus - Mechanic 5			1	0							0
Big Blue Bus - Mechanic 6			1								
Big Blue Bus - Mechanic 7			1	1							
Brake Master					0	0					
German Auto - Mechanic 1	0	1	1	1	0	0				1	
German Auto - Mechanic 2			1	1	0						
Mercedes Benz – Ken		0	1	1				1	1		1
Mercedes Benz – Francisco			1	1							
Connell Chevrolet – Joe	0		0	0	0	0			0		
Connell Chevrolet – Bruce					0	0					
Connell Chevrolet – John						0					
Ira Newman Auto – Scott	0	0		0	0	0		1			
Ira Newman Auto – Norm			1								
Shell (Rose) – Nick	0				0	0					
Shell (Rose) – Jesus			1	1							
Shell (Rose) – Luis			1						1		
Guaranty Chevrolet	0				0	0					

Key: 0 = Did not Clean; 1 = Cleaned

Table 4-6
Alternative General Purpose Degreasers – Ranking

Facility	AX-IT L-7769	Mirachem Automotive Cleaner	Kyzen CyberSolv 11	Kyzen CyberSolv	Kyzen Aerosol Cleaner	Kyzen Aerosol Degreaser 11	50 % Soy/Acetone (Carbon Dioxide)	35% Soy/Acetone (Carbon Dioxide)	25% Soy/ Acetone (Carbon Dioxide)	L-7752 35% Soy/Acetone (Hydrocarbon)	L-7750 Acetone (Hydrocarbon)
ARCO – Mechanic 1	0	0			0	0		2	2	0	
ARCO – Mechanic 2			1	1							
Shell (Santa Monica)	0	0						2	2	0.5	
Samo Tire			1	0.5	0	1	1				
Morgan's Auto Service	0	0	1.5	1.5	0	0				1	
S.M. Auto Center - Eduardo					0						
S.M. Auto Center - Julio						0.5					
S.M. Auto Center - Aljerome			1						2		
S.M. Auto Center - Rene	1	0							2	1	
S.M. Auto Center - Catarino								1	2	1	
S.M. Auto Center - Esmet			2	1							
Big Blue Bus - Mechanic 1		0	2	2	0	0		2.5	2		
Big Blue Bus - Mechanic 2			2		0	2			2		
Big Blue Bus - Mechanic 3					0						
Big Blue Bus - Mechanic 4					0						
Big Blue Bus - Mechanic 5			0.5	0							0
Big Blue Bus - Mechanic 6			0.5								
Big Blue Bus - Mechanic 7			1	1							
Brake Master					0	0					
German Auto - Mechanic 1	0	1	1	1	0	0				0.5	
German Auto - Mechanic 2			1	0.5	0						
Mercedes Benz - Ken		0	2	1				2	2.5		0.5
Mercedes Benz - Francisco			1	1							
Connell Chevrolet - Joe	0		0	0	0	0			0		
Connell Chevrolet - Bruce					0	1					
Connell Chevrolet - John						1					
Ira Newman Auto - Scott	0	0		0	0	0		2			
Ira Newman Auto - Norm			1.5								
Shell (Rose) - Nick	0				0	0					
Shell (Rose) - Jesus			1	1							
Shell (Rose) - Luis			0						0		
Guaranty Chevrolet	0				0	0					

Key: 0 = Poor; 0.5 = Marginal; 1 = Almost as good as current cleaner; 1.5 = nearly as good as current cleaner; 2 = As good as current cleaner; 2.5 = Somewhat better than current cleaner; 3 = Better than current cleaner

Tables 4-7 and 4-8 show the results for brake cleaning. According to Table 4-7, a majority of the shops found the AX-IT L-7769 cleaner and the Mirachem cleaner adequate. All of the shops found the Kyzen Cyber Solv 11 adequate and a large majority of the shops found the Kyzen Cyber Solv adequate. Most shops that tested the soy/acetone blends with the carbon dioxide propellant and the acetone cleaner found them adequate.

The AX-IT L-7769 cleaner was tested by nine mechanics at nine facilities for general purpose degreasing. This cleaner did not perform well in this application. It worked better if it sat on the part for 20 or 30 seconds and was handwiped or if it was applied multiple times. The cleaner was tested by 17 mechanics at 11 facilities for brake cleaning. The majority of mechanics found it adequate for general drum brake cleaning and cleaning of brake dust but not for cleaning oil or grease.

The Mirachem automotive cleaner was tested by eight mechanics at eight facilities for general purpose degreasing. The product did not cut grease and oil without additional wipe cleaning. The cleaner was tested by 13 mechanics at 10 facilities for brake cleaning. The majority of technicians indicated it was adequate for general drum brake cleaning and cleaning of brake dust but inadequate for removing oil and grease without additional handwiping.

The Kyzen Cyber Solv 11 was tested by 18 mechanics at 10 facilities for general purpose degreasing. Sixteen of the 18 mechanics found the cleaner adequate and one found it inadequate for this purpose. Some mechanics noted that it worked better when the aerosol cans were shaken well. One mechanic did not like the smell and another indicated it left a residue. The cleaner was tested by 15 mechanics at 10 facilities for brake cleaning. The majority of mechanics found it to be adequate for general drum brake cleaning, cleaning of brake dust, oil, grease and contaminants. Some mechanics indicated they would prefer a faster drying time.

The Kyzen Cyber Solv was tested by 14 mechanics at 10 auto repair facilities for general purpose degreasing. The majority of mechanics found the product adequate but several indicated they preferred the Cyber Solv 11 product. Three mechanics found the product inadequate for general purpose degreasing. Again, some of the technicians found the product better when it was well shaken. For brake cleaning, the product was tested by 15 mechanics at 10 facilities. The majority of the mechanics found it adequate for general drum brake cleaning, cleaning of brake dust, oil, grease and other contaminants. Most of the technicians indicated they would prefer a faster drying time.

The Kyzen Aerosol Cleaner was tested by 16 mechanics at 11 facilities for general purpose degreasing. All mechanics found it inadequate for this purpose even with handwiping. This cleaner and the Kyzen Aerosol Degreaser 11 discussed below were packaged by a different packager than the Cyber Solv products discussed above. As a consequence, they foamed slightly and this definitely detracted from the cleaning capability. For brake cleaning, this cleaner was tested by eight mechanics at seven auto

Table 4-7
Alternative Brake Cleaners – Adequacy of Cleaning

Facility	AX-IT L-7769	Mirachem Automotive Cleaner	Kyzen CyberSolv 11	Kyzen CyberSolv	Kyzen Aerosol Cleaner	Kyzen Aerosol Degreaser 11	35% Soy / Acetone (Carbon Dioxide)	25% Soy / Acetone (Carbon Dioxide)	L-7752 35% Soy/Acetone (Hydrocarbon)	L-7750 Acetone (Hydrocarbon)
ARCO – Mechanic 1	1	0				0				
ARCO – Mechanic 2			1	1						
Shell (Santa Monica)	0	1								
Samo Tire	1	0	1	1	0	0	0	0	0	
Morgan's Auto Service	1	1	1	1	0				0	
S.M. Auto Center – Eduardo					1					
S.M. Auto Center – Julio						0				
S.M. Auto Center – Aljerome	1	1	1	1						
S.M. Auto Center – Rene	1		1	1						
S.M. Auto Center – Catarino		1								
S.M. Auto Center – Esmet			1	1						
Big Blue Bus - Mechanic 1	1	1	1	0		1	1	1		
Big Blue Bus - Mechanic 2	0	0					1			
Big Blue Bus - Mechanic 3	1	1								
Big Blue Bus - Mechanic 4	0									
Big Blue Bus - Mechanic 5	0									
Big Blue Bus - Mechanic 6	0									
Big Blue Bus - Mechanic 7			1	1						
Brake Master	1	0	1	1	1	0			0	1
German Auto - Mechanic 1			1	1						
German Auto - Mechanic 2			1	1						
Mercedes Benz – Ken			1	1	0					
Mercedes Benz – Francisco		0								
Connell Chevrolet – Joe					0					1
Connell Chevrolet – Bruce	1	0	1	0	0	0			0	
Connell Chevrolet – Brian			1	0				1		
Ira Newman Auto – Scott						0				
Ira Newman Auto – Ira Sr.	0	1	1	1			1		1	
Shell (Rose) – Nick	1				0	1				
Guaranty Chevrolet	1					0				

Key: 0 = Did not Clean; 1 = Cleaned

Table 4-8
Alternative Brake Cleaners – Ranking

Facility	AX-IT L-7769	Mirachem Automotive Cleaner	Kyzen CyberSolv 11	Kyzen CyberSolv	Kyzen Aerosol Cleaner	Kyzen Aerosol Degreaser 11	35% Soy / Acetone (Carbon Dioxide)	25% Soy / Acetone (Carbon Dioxide)	L-7752 35% Soy/Acetone (Hydrocarbon)	L-7750 Acetone (Hydrocarbon)
ARCO – Mechanic 1	1	0.5				0				
ARCO – Mechanic 2			1	1						
Shell (Santa Monica)	0	1								
Samo Tire	1	0	1	0.5	0	1	0	0	0	
Morgan's Auto Service	2	2	1	1	0				1	
S.M. Auto Center – Eduardo					0					
S.M. Auto Center – Julio						0.5				
S.M. Auto Center – Aljerome	2	2	3	2						
S.M. Auto Center – Rene	1		1	1						
S.M. Auto Center – Catarino		1								
S.M. Auto Center – Esmet			2	2						
Big Blue Bus - Mechanic 1	1	1	1	0		0	2	2		
Big Blue Bus - Mechanic 2	0	0					2			
Big Blue Bus - Mechanic 3	1	1								
Big Blue Bus - Mechanic 4	0									
Big Blue Bus - Mechanic 5	1									
Big Blue Bus - Mechanic 6	1									
Big Blue Bus - Mechanic 7			1	1						
Brake Master	0	0	2	2	0	0			0	2
German Auto - Mechanic 1			0.5	0.5						
German Auto - Mechanic 2			0.5	0.5						
Mercedes Benz – Ken			2	1	0					
Mercedes Benz – Francisco		0								2
Connell Chevrolet – Joe					0					
Connell Chevrolet – Bruce	1	0	1	0	0	0			0	
Connell Chevrolet – Brian			1	0				1		
Ira Newman Auto – Scott						0				
Ira Newman Auto – Ira Sr.	0	1	2	2			1		1	
Shell (Rose) – Nick	0				0	1				
Guaranty Chevrolet	1					0				

Key: 0 = Poor; 0.5 = Marginal; 1 = Almost as good as current cleaner; 1.5 = nearly as good as current cleaner; 2 = As good as current cleaner; 2.5 = Somewhat better than current cleaner; 3 = Better than current cleaner

repair facilities. The majority of mechanics found it inadequate for this purpose.

The Kyzen Aerosol Degreaser 11 was tested by 14 mechanics at 11 auto repair facilities for general purpose degreasing and it was tested by nine mechanics at nine facilities for brake cleaning. The majority of mechanics found the cleaning inadequate for both cleaning tasks. Two mechanics did rate the cleaner as almost as good as their current cleaner for brake cleaning. Again, the slight foaming was a problem.

Because the soy acetone blends with the carbon dioxide propellant performed well for carburetor and fuel injection system cleaning, IRTA worked with several mechanics to test them for general purpose degreasing and brake cleaning. None of the project participants tested the 50% soy/acetone blend for brake cleaning. One technician tested the product for general purpose degreasing and he indicated it performed almost as well as his current cleaner. The 35% soy/acetone blend was tested by six mechanics at six facilities for general purpose cleaning and by four mechanics at three facilities for brake cleaning. For general purpose degreasing, all six mechanics indicated the product worked as well as or better than their current product. For brake cleaning, three mechanics indicated it was adequate. Some mechanics indicated it left an oily residue. The 25% soy/acetone blend was tested by 10 mechanics at seven facilities for general purpose cleaning and by three mechanics at three facilities for brake cleaning. Eight mechanics indicated it worked as well as the product they currently use for general purpose degreasing. Two mechanics indicated the product left an oily residue, which they could easily wipe off with a rag. Two mechanics indicated it was adequate for brake cleaning and one thought the cleaning was inadequate. They mentioned that the product left an oily residue.

The 35% soy/acetone blend with a hydrocarbon propellant was tested by six mechanics at five facilities for general purpose degreasing and by five mechanics at five facilities for brake cleaning. Five mechanics indicated it performed acceptably for general purpose cleaning. The majority of mechanics found it inadequate for general drum brake cleaning and the cleaner did not perform well for cleaning grease and oil. Most mechanics complained of a bad smell; the product had an over-spray mist that remained in the air for a period.

IRTA tested the acetone product with a hydrocarbon propellant with two mechanics in two facilities. The mechanics indicated that the cleaner was not very effective for general purpose degreasing but performed acceptably as a brake cleaner.

V. ALTERNATIVE PROPELLANT TESTS

Although it was not originally part of the project plan, IRTA decided to investigate alternative propellants for two reasons. First, hydrocarbon propellants are the most commonly used propellants in automotive aerosol cleaning products. These propellants are VOCs and contribute to smog. Most of the water-based cleaners tested during this project had no solvent additives so they are low in VOC content. The major contributor to the VOC content of these products would be the propellant. Second, alternative propellants were investigated because they could improve the delivery of the alternative products. In particular, the soy/acetone products for carburetor and fuel injection system cleaning were packaged with both hydrocarbon and carbon dioxide propellants and IRTA found that the carbon dioxide propelled products had a better delivery and cleaned better.

The alternative propellants that were investigated are shown in Table 5-1. The table also shows the approximate cost of the propellants. The cost of a typical hydrocarbon propellant, called NIP-46, is also shown in the table. The cost of the nitrogen propellant is listed as negligible because so little is required.

Table 5-1
Typical Hydrocarbon and Alternative Propellants

Propellant	Cost Per Pound
NIP-46	$0.29
Dimethyl Ether (DME)	$0.60
HFC-152a	$1.85
Carbon Dioxide	$0.15
Nitrogen	negligible

DME is classified as a VOC. Even so, IRTA decided to test it because it is soluble in water-based cleaners and one packager indicated that it might be possible to use less DME than the hydrocarbon propellant. A lower DME percentage in the package would lead to a lower VOC for the cleaner. The figures in Table 5-1 indicate that DME is about twice as costly as the hydrocarbon propellant on a per pound basis.

HFC-152a is a hydrofluorocarbon. It is exempt from VOC regulations. The HFC has a relatively long atmospheric lifetime but it contains no chlorine or bromine so it does not contribute to stratospheric ozone depletion. It does, however, contribute to global warming. Because its atmospheric lifetime is lower than other HFCs, it contributes less to global warming. A disadvantage of the HFC is that it is much more costly than the hydrocarbon propellant.

As mentioned above, IRTA was impressed with the performance of the carbon dioxide propellant. Carbon dioxide is not classified as a VOC and, as the values of Table 5-1 show, it is lower cost than the hydrocarbon propellant. Generally, because it is a higher pressure propellant, less of it is required than the hydrocarbon propellant. On balance, it

is much less costly to use than the hydrocarbon propellant. The major disadvantage of carbon dioxide arises when it is used with highly alkaline water-based cleaners. It can react with the alkaline components forming carbonic acid which can lead to corrosion of the can.

Nitrogen is also an attractive propellant because it is not classified as a VOC and it is very low cost. There are two problems that have been observed with nitrogen propellants. First, some packagers claim it loses pressure as the product is expelled from the aerosol. Second, other packagers claim that it has lower pressure on a continuous basis as the product is expelled.

Propellant Tests

IRTA thought it would be useful to have one of the water-based cleaners packaged in all the alternative propellants. An Australian company indicated they had packaged water-based materials used for other purposes with nitrogen propellants for many years and that the delivery was very good. IRTA asked the company to package a few cans in nitrogen propellant and the company agreed to perform the packaging. IRTA shipped the Australian company the Kyzen Cyber Solv, the product that worked best in the brake cleaning/general purpose cleaning field tests. IRTA contacted the company several times but could not get a response. IRTA staff identified another packager in the U.S. that was willing to package the cleaner with all of the alternative propellants.

All of the cans packaged with the alternative propellants contained 340 grams of product and propellant combined. Table 5-2 shows the proportion of product and propellant in the six products that were packaged.

Table 5-2
Alternative Product and Propellant Weight

Propellant Type	Product Weight (grams)	Propellant Weight (grams)	Propellant Percent (by weight)
NIP-46	272	68	20
DME1	272	68	20
DME2	289	51	18
HFC-152a	272	68	20
Carbon Dioxide	332	8	2
Nitrogen	338	< 2 (95 psig)	<0.1

Two DME formulations were packaged to investigate whether less DME than hydrocarbon propellant could be used. Note that more product and less propellant was also used in the carbon dioxide propelled package. Less than two grams of the nitrogen propellant was used. The packager used about 95 psig pressure nitrogen after filling the can with about 338 grams of product.

Results of the Tests

IRTA first tested the alternative propellant packages in a laboratory setting. Motor oil was applied to a metal surface and each of the aerosols was sprayed for a 10 second duration onto the oil. The results of the testing indicated that the three of the aerosols worked well. These included the hydrocarbon propelled package, the DME package at higher DME concentration and the HFC-152a propelled package. The carbon dioxide propelled packaged worked better than these three in terms of cleaning capability and delivery. The package containing DME at lower concentration did not work well. The nitrogen propelled package did not deliver enough pressure for effective cleaning and delivery. IRTA did not observe a decline in pressure as the product was expelled but rather noted a lower delivery pressure throughout.

IRTA invited representatives from industry and government agencies to one of the auto repair facilities that participated in the testing of the alternative products. The purpose of this field visit was to demonstrate the cleaners that performed best for brake cleaning/general purpose degreasing and carburetor and fuel injection system cleaning. Another purpose of the field visit was to demonstrate the testing of the water-based cleaner packaged in the alternative propellants. The technicians at the auto repair facility tested the aerosol cans containing the alternative propellants on engine parts. The results of this testing were virtually the same as the laboratory tests conducted by IRTA.

The extensive field testing with the soy/acetone blends that utilized a carbon dioxide propellant and the comparative tests of the alternative propellants convinced IRTA that it would be very desirable to use a carbon dioxide propellant in the water-based cleaning products both for a better delivery and a lower VOC content. With this in mind, IRTA opened one of the cans containing the Cyber Solv with the carbon dioxide propellant three months after receiving the packages. The bottom and sides of the cans were rusted. The packager also placed a can packaged with carbon dioxide propellant in an oven at 120 degrees F for 30 days. After removal, he observed that the product had de-tinned the can in the liquid phase and that there was vapor phase corrosion.

Carbon dioxide is a very good propellant. It is low cost and it provides a very good delivery. The Cyber Solv is not forming carbonic acid because of the low pH of the alkaline cleaner. One packager who packages a number of water-based cleaners for many applications indicates that the problem could be solved with the addition of a corrosion inhibitor to the water-based cleaner. Although the cleaner contains a corrosion inhibitor to make the cleaner safe for cleaning certain metals, it would require the addition of another corrosion inhibitor to prevent corrosion of the can.

VI. COST AND TOXICITY COMPARISON OF CURRENT AND ALTERNATIVE PRODUCTS

VOC Content of Alternative Cleaners

Table 6-1 shows the products that worked effectively in each of the application areas and their VOC content. The table also shows the VOC content limit of the product category that is effective on December 31, 2004. The VOC content of the cleaners was estimated from the MSDSs for the products. The midpoint of the VOC content was selected in all cases.

Table 6-1
Alternative Products and VOC Content

Category of Cleaning	VOC Content Requirement	Alternative Product	VOC Content of Product
Engine Degreasing	35%		
		Foamy Engine Brite	23.5%
		Simple Green	10%
		Mirachem All Surface Safe Cleaner	16.1%
		AX-IT L-7768	10%
		L-7820 ScrubTub	10%
		Kyzen Engine Degreaser 2	10%
		Kyzen Aerosol Degreaser 11	10%
		Kyzen Aerosol Cleaner	10%
Carburetor and Fuel Injection System Cleaning	45%	50% Soy/50% Acetone	0%
		35% Soy/65% Acetone	0%
		25% Soy/75% Acetone	0%
Brake Cleaning/General Purpose Degreasing	45%/50%	AX-IT L-7769	10%
		Kyzen Cyber Solv	10%
		Kyzen Cyber Solv 11	10%
		35% Soy/65% Acetone	0%
		25% Soy/65% Acetone	0%

Eight alternative engine degreasers are shown in Table 6-1. These include all of the engine degreasers tested in the project. Three of these cleaners, Foamy Engine Brite, Foaming Simple Green and Mirachem All Surface Safe Cleaner are commercial aerosol products. All three of these products have solvent additives. The other five products were packaged in aerosol form for the testing and none of them has a solvent additive. Six of the eight cleaners tested in the engine degreasing category have a VOC content of

10%. For five of these cleaners, the only VOC contribution is the hydrocarbon propellant. More research on carbon dioxide propellants could reduce the VOC content of these cleaners to near-zero.

The three alternative cleaners that were tested for carburetor and fuel injection system cleaning all have a VOC content of zero%. In these cases, a carbon dioxide propellant rather than a hydrocarbon propellant was used.

The table shows five cleaners for the combined category of brake cleaning/general purpose degreasing. These were the cleaners that performed adequately in brake cleaning and/or general purpose degreasing. Three of the cleaners are water-based; they were packaged with a hydrocarbon propellant and the propellant is the only contribution to the VOC content. Again, as was the case for engine degreasers, more investigation of carbon dioxide propellants with water-based cleaners could result in a VOC content for the alternative products of near zero%. The other two cleaners that performed well in this category are two soy/acetone blends packaged with a carbon dioxide propellant. These cleaners have a VOC content of zero%.

Cost Analysis and Comparison

During the project field testing, some of the facility personnel tested the alternative cleaners exclusively for a short period and some did not. The alternative cleaners were not tested for a sustained and lengthy period. As a result, it is not possible to draw conclusions from the field test information on whether more or less of the alternative cleaner would be required to perform the same cleaning tasks as each facility's current cleaner. The facilities participating in the project used a variety of different cleaners; often they purchased different cleaners from one month to the next based on the lowest cost product.

For the cost analysis presented here, IRTA made several assumptions. First, IRTA used one commercial product in each of the three cleaning categories as the baseline cleaner. Second, IRTA assumed that the type of can, valve and other packaging materials was the same for all cleaners. In effect, IRTA used the raw materials cost of each product for the cost comparison. It was not possible to compare the price of the products themselves since most of the alternative products are not commercial and they do not have a price. Furthermore, according to one industry source, there is no rule of thumb for the percent of the product price accounted for by the raw materials cost. Thus, the approach used here avoids estimation of the markup, profits and other disparate considerations of the individual companies selling the products. Third, IRTA included the propellant cost in the analysis because IRTA wanted to examine the cost impacts of alternative propellants. Fourth, the raw material costs for the cleaners are presented as ranges rather than as specific values to protect the confidential nature of the information.

Table 6-2 shows the raw material cost of the baseline and alternative cleaners for the engine degreasing category. The baseline cleaner, Engine Brite Heavy Duty Engine Degreaser, is a solvent based cleaner. It is an ARB designated Low Vapor Pressure

(LVP) cleaner with a VOC content of about 15 percent. The raw material cost of the baseline cleaner is 20 to 40 cents per pound. The raw material cost of Foamy Engine Brite is lower than the raw material cost of the baseline cleaner. The raw material cost of the other alternative cleaners is slightly higher than the cost of the baseline cleaner

Table 6-2
Raw Material Costs of Baseline and Alternative Engine Degreasers

Cleaner	Raw Material Cost Including Propellant (cents per pound)
Engine Brite Heavy Duty Engine Degreaser--Baseline	20 to 40
Foamy Engine Brite	15 to 30
Foaming Simple Green	35 to 45
Mirachem All Surface Safe Cleaner	40 to 50
Scrub Tub	40 to 50
Kyzen Engine Degreaser 2	35 to 45
Kyzen Cyber Solv Experimental Degreaser 11	35 to 45
Kyzen Aerosol Cleaner	35 to 45
AX-IT L-7768	35 to 45

Table 6-3 shows the raw material costs of the carburetor and fuel injection system cleaners. The baseline cleaner, in this case, is a MOC product called Throttle-Body & Air-Intake Cleaner. The raw material cost of the two cleaners that performed best in these applications, the 35% soy product and the 25% soy product, is slightly more expensive on a pound-for-pound basis than the raw material cost of the baseline cleaner.

Table 6-3
Raw Material Costs of Baseline and Alternative Carburetor and Fuel Injection System Cleaners

Cleaner	Raw Material Cost Including Propellant (cents per pound)
MOC Throttle-Body & Air-Intake Cleaner--Baseline	30 to 40
50% Soy/50% Acetone	45 to 55
35% Soy/65% Acetone	40 to 50
25% Soy/ 75% Acetone	40 to 50

Table 6-4 shows the raw material costs of the baseline and alternative brake cleaners/general purpose degreasers. In this case, the baseline cleaner is CRC Brakleen Brake Parts Cleaner--Non-Chlorinated. The raw material cost of the alternatives is slightly higher than the raw material cost of the baseline cleaner.

Table 6-4
Raw Material Costs of Baseline and
Alternative Brake Cleaners/General Purpose Degreasers

Cleaner	Raw Material Cost Including Propellant (cents per pound)
CRC Brakleen Brake Parts Cleaner Baseline	30 to 40
AX-IT L-7769	35 to 45
Kyzen Cyber Solv	35 to 45
Kyzen Cyber Solv Experimental Degreaser 11	35 to 45
35% Soy/65% Acetone	40 to 50
25% Soy/75% Acetone	40 to 50

As mentioned earlier, the field tests did not provide sufficient information to determine whether more or less of the alternative cleaners would be required to substitute for the high VOC cleaners used currently. The values of Tables 6-2 through 6-4 allow a sensitivity analysis. If twice as much of the alternative cleaners was required, the cost of the alternatives would be more than twice the cost of the current cleaners. If half as much of the alternative cleaners was required, the cost of the alternatives would be somewhat more than half the cost of the current cleaners.

The price of raw materials that are petroleum based has increased substantially over the last few months because of increasing energy costs and because of high oversees demand. If this increase were sustained or continued, prices of the baseline cleaners and the soy/acetone cleaners would increase further. The prices of the water-based cleaners would be affected less because most of these cleaners contain at least 50 percent water. Thus further increases in raw material costs would reduce the cost of the water-based cleaners tested in engine degreasing and brake cleaning/general purpose degreasing relative to the baseline cleaners.

Toxicity Comparison

IRTA performed a toxicity comparison of the low-VOC alternative cleaners tested during this project with the baseline solvent based cleaners used in the cost comparison. IRTA received assistance in this investigation from HESIS. HESIS staff evaluated the toxicity of the baseline and alternative cleaners based on the components listed on the MSDSs. The MSDSs for the baseline cleaners are provided in Appendix G.

The baseline cleaner for engine degreasing is Engine Brite Heavy Duty Engine Degreaser. The VOC content of this cleaner, because it is classified as a Low Vapor Pressure (LVP) material under the consumer product regulations, is 15%. The MSDS for this cleaner lists petroleum distillate, aliphatic, petroleum naphtha and 2-butoxy ethanol. The CAS number for petroleum distillate, aliphatic indicates that it is diesel fuel, No. 2. This chemicals is listed as an A3 carcinogen by the American Conference of

Governmental Industrial Hygienists (ACGIH). It is absorbed through intact skin and it has a Threshold Limit Value of 100 milligrams per meter cubed to protect against irritation. The chemical is not on any toxics lists. The petroleum naphtha CAS number indicates it is the same as heavy aromatic solvent naphtha (petroleum), the EPA Registry Name. Toxicity data were not available for review but the 25 submissions under EPA Toxic Substances Control Act (TSCA) Section 8E for the chemical indicate adverse effects on health and/or the environment. Consistent with other organic solvents, heavy aromatic solvent naphtha (petroleum) is probably a central nervous system depressant and a mucous membrane irritant. It is not on any toxics lists and no occupational health limits for the chemical have been developed. 2-Butoxy ethanol can damage red blood cells and cause anemia. It also is a central nervous system depressant. The chemical was recently removed from EPA's Hazardous Air Pollutants (HAP) list but is still listed on California's AB2588 list. 2-Butoxy ethanol is a VOC. The baseline cleaner also contains ethoxylated nonyl phenol, a known endocrine disruptor.

The baseline cleaner in the carburetor and fuel injection system and brake cleaner/general purpose degreaser categories are called MOC Throttle-Body & Air-Intake Cln and CRC Brakleen Brake Parts Cleaner--Non-Chlorinated respectively. Both of these cleaners contain the solvents acetone, toluene and methyl alcohol which are nervous system toxicants and respiratory irritants. In addition to general solvent toxicity, exposure to methyl alcohol has been associated with visual disturbances and neuropathy and exposure to toluene during pregnancy can damage the developing fetus. Methyl alcohol and toluene are on EPA's HAP list. Toluene is included on California's Proposition 65 list as known to the State to cause developmental toxicity. As indicated by its relatively higher Permissible Exposure Limit in California of 500 ppm, acetone is considered to be low in toxicity compared to most other industrial solvents.

HESIS staff examined the MSDSs for the water-based cleaners tested during the project and indicated that they appeared to be relatively low in toxicity. Two of the alternative low-VOC water-based cleaners tested in engine degreasing have solvent additives listed on the MSDSs. One of these, Foamy Engine Brite, lists 2-butoxy ethanol, aliphatic petroleum distillate and aromatic petroleum distillate. The toxicity of these chemicals is discussed above. They are present in small quantities, however, and are not likely to pose a high toxic risk. One of the other cleaners, Foaming Simple Green, also lists 2-butoxy ethanol, again in a very low concentration.

Three alternative low-VOC soy/acetone blends were tested for carburetor and fuel injection system cleaning. HESIS staff evaluated the soy cleaners and indicated they were very low in toxicity. They also indicated that acetone is lower in toxicity than most other organic solvents.

Based on the HESIS evaluation of the chemicals listed on the MSDSs, the low-VOC alternative cleaners are of low toxicity and pose significantly less risks of health hazards than the high-VOC baseline solvents. Although a few of the water-based cleaners contain solvent additives, the concentrations of the additives are low. The alternative

cleaners that contain soy/acetone blends are also of low toxicity when compared with other solvent based baseline cleaners.

VII. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Emissions of VOCs from consumer product aerosol automotive cleaners were estimated at about 17 tons per day in 2000. Many of the VOC solvents used in the cleaners are also toxic. HESIS is concerned that automotive mechanics are exposed to toxic solvents. Additional reductions in the solvent content of aerosol automotive cleaning products requires development of new alternative products.

This project involved developing, testing and demonstrating low-VOC, low toxicity water-based and soy/acetone based cleaners as potential alternatives in four automotive cleaning activities including engine degreasing, carburetor and fuel injection system cleaning and brake cleaning/general purpose degreasing.

Eight water-based cleaners were tested in engine degreasing. Three of these cleaners are commercial aerosol products and all three contain solvent additives. The remaining five cleaners are non-aerosol cleaners that were packaged in aerosols for testing during this project. All five of these cleaners have no solvent additives. The eight cleaners tested in engine degreasing all had hydrocarbon propellants; they were tested with three automotive detailers, one car wash and three consumers. The automotive detailers and the car wash do not use aerosol engine degreasers. They degrease engines with bulk water-based cleaners which are less costly. IRTA believed that the automotive detailer and car wash personnel could judge whether the aerosol engine degreasers performed well. The consumers use aerosol degreasers and they could readily judge whether the cleaners worked effectively. Some of the participants liked certain cleaners better than others but, on balance, all of the eight cleaners performed adequately. The VOC content of six of the eight cleaners was 10%.

Several of the technicians at the 13 auto repair facilities that participated in the project indicated they were reluctant to test water-based cleaners for carburetor and fuel injection system cleaning because the water could enter the fuel system. IRTA developed three cleaners that are blends of soy and acetone for testing in this cleaning area. All three of the cleaners were packaged with carbon dioxide propellant. Two of the cleaners, a blend of 35% soy and 65% acetone and a blend of 25% soy and 75% acetone, performed very well. The third cleaner, a blend of 50% soy and 50% acetone, did not perform as well as the two other cleaners. The VOC content of the cleaners tested and found effective in this cleaning category is near-zero.

An issue that arose during the preliminary screening tests of the cleaners was that all of the water-based cleaners, when put in an aerosol package, foamed. This is a desirable characteristic for engine degreasing but is not acceptable for brake cleaning and general purpose degreasing. Three of the water-based cleaner suppliers elected to reformulate and repackage their cleaners so they would not foam. The resulting four non-foaming water-based cleaners were tested for brake cleaning/general purpose degreasing. Two slightly foaming cleaners were also tested in this cleaning application. Because the soy/acetone blends performed well for carburetor and fuel injection system cleaning,

some of them were also tested with some of the auto repair facilities. Three of the non-foaming water-based cleaners and two of the soy/acetone blends performed adequately for brake cleaning and/or general purpose degreasing. The water-based cleaners have a VOC content of 10% because they are packaged with a hydrocarbon propellant. The soy/acetone cleaners have a VOC content of near-zero.

Alternative propellants were investigated and tested in a limited way. One of the non-foaming water-based cleaners was packaged using several alternative propellants including hydrocarbon, DME, HFC-152a, carbon dioxide and nitrogen. The hydrocarbon, DME, HFC-152a all performed fairly well. The hydrocarbons and DME are VOCs so the VOC content of cleaners using these propellants is higher. HFC-152a is exempt from VOC regulations but it is expensive and it does contribute to global warming. The carbon dioxide propellant performed very well; it is not a VOC and it is low cost. When water-based cleaners are packaged with carbon dioxide propellants, the aerosol can may rust. It is possible that this rusting could be prevented by adding a corrosion inhibitor to the water-based cleaners. If carbon dioxide could be used as the propellant for the water-based cleaners, the VOC content of the aerosol cleaners tested in this project would be near-zero. More work needs to be done in this area to investigate how carbon dioxide propellant could be used for water-based cleaning aerosol packages.

The raw material cost of the alternative low-VOC, low toxicity cleaners was compared to the raw material costs of baseline solvent cleaners used today in the automotive cleaning sectors. The raw material cost of the alternative cleaners on a pound-for-pound basis was higher than the raw material cost of the baseline cleaners.

The toxicity of the alternative cleaners tested during this project is lower than the toxicity of the traditional solvent based baseline cleaners. Most of the water-based cleaners that were tested had no solvent additives. Soy is low in toxicity and acetone is lower in toxicity than almost all traditional organic solvents.

VIII. REFERENCES

• Mike Morris and Katy Wolf, "Parts Cleaning in Auto Repair Facilities, The Conversion to Water," Institute for Research and Technical Assistance, prepared in partnership with the City of Los Angeles Bureau of Sanitation, Cal/EPA's Department of Toxic Substances Control and the South Coast Air Quality Management District for U.S. EPA, April 1997. (IRTA, 1997)

• Mike Morris and Katy Wolf, "Brake Cleaning in Auto Repair Facilities: The Conversion to Water," Institute for Research and Technical Assistance, Prepared for U.S. EPA, September 1999. (IRTA, 1999)

Appendix A
Lists of Companies Contacted for Existing Water-Based Aerosol Cleaners

CARB List of Automotive Aerosol Suppliers

COMPANY	ADDRESS	CITY	STATE	ZIP	ZIP4
3M COMPANY	3M CENTER BLDG 250-3E-02	ST PAUL	MN	55144	1000
AEROSOL MAINTENANCE PRODUCTS	9150 VALLEY VIEW ROAD	MACEDONIA	OH	44056	
AEROSOL SERVICES	425 SOUTH NINTH AVE	CITY OF INDUSTRY	CA	91746	
AERVOE PACIFIC COMPANY	1198 SAWMILL ROAD	GARDNERVILLE	NV	89410	6120
AMREP INTERNATIONAL INC	990 INDUSTRIAL PARK DRIVE	MARIETTA	GA	30062	2433
ARCO CHEMICAL	3801 WEST CHESTER PIKE	NEWTOWN SQUARE	PA	19073	
BALKAMP INC	2601 SOUTH HOLT ROAD	INDIANAPOLIS	IN	46241	
BERKEBILE OIL COMPANY INC	PO BOX 715	SOMERSET	PA	15501	0715
BERRYMAN PRODUCTS, INC.	3800 EAST RANDOL MILL ROAD	ARLINGTON	TX	76011	
BG PRODUCTS, INC.	7015 SOUTH WICHITA	WICHITA	KS	67213	
CERTIFIED LABORATORIES (NCH)	PO BOX 2493	FORT WORTH	TX	76113	2493
CHEMICAL PACKAGING	PO BOX 9947	FORT LAUDERDALE	FL	33310	
CHEMWAY SYSTEMS, INC	PO BOX 1625	BAY CITY	TX	77404	
CLAIRE MANUFACTURING COMPANY	500 VISTA AVENUE	ADDISON	IL	60101	4423
CRC INDUSTRIES INC	PO BOX 5000	WARMINSTER	PA	18974	0586
CURTIS INDUSTRIES	6140 PARKLAND BLVD	MAYFIELD HEIGHTS	OH	44124	
CYCLO INDUSTRIES LLC	10190 RIVERSIDE DRIVE	PALM BEACH GARDENS	FL	33410	4881
DEL REY CHEMICAL COMPANY	1170 CENTRE DRIVE BLDG H	CITY OF INDUSTRY	CA	91789	
DIVERSIFIED BRANDS	31500 SOLON ROAD	SOLON	OH	44139	
DRUMMOND AMERICAN CORP	600 CORPORATE WOODS PKWY	VERNON HILLS	IL	60061	
EIS BRAKE PARTS STANDARD	PO BOX 1315	BERLIN	CT	06037	
EXXON CHEMICAL	13501 KATY FREEWAY	HOUSTON	TX	77079	
EZON PRODUCTS, INC	1900 EXETER ROAD	GERMANTOWN	TN	38	
FIRST BRANDS CORPORATION	83 WOOSTER HEIGHTS ROAD	DANBURY	CT	06813	1911
HYDROSOL	8407 SOUTH 77TH AVENUE	BRIDGEVIEW	IL	60455	
IG-LO INC (Under VALVOLINE)	PO BOX 14000	LEXINGTON	KY	40512	
IMPERIAL INC	PO BOX 11008	GREEN BAY	WI	54307	1008
JUSTICE BROTHERS INC	2736 HUNTINGTON DRIVE	DUARTE	CA	91010	
KAR PRODUCTS	461 NORTH THIRD AVENUE	DES PLAINES	IL	60016	
KEM MANUFACTURING (NCH)	PO BOX 152170	IRVING	TX	75015	2170
KENT INDUSTRIES (PREMIER FARNELL)	4500 EUCLID AVENUE	CLEVELAND	OH	44103	
LAWSON PRODUCTS INC	1666 EAST TOUHY AVENUE	DES PLAINES	IL	60018	3683
LILLY/GUARDSMAN	4999 36TH	GRAND RAPIDS	MI	49512	
LOCTITE CORPORATION	1001 TROUT BROOK CROSSING	ROCKY HILL	CT	06067	
LPS LABORATORIES INC	PO BOX 105052	TUCKER	GA	30085	5052
MAC'S INC (Under VALVOLINE)	PO BOX 14000	LEXINGTON	KY	40512	
MANTEK (Under NCH)					
MOC PRODUCTS, INC	12306 MONTAGUE STREET	PACOIMA	CA	91331	
NATIONAL CHEMSEARCH	PO BOX 152170	IRVING	TX	75015	2170
OSBORN MANUFACTURING	5401 HAMILTON AVENUE	CLEVELAND	OH	44114	3997
PENNZOIL PRODUCTS CO	PO BOX 2967	HOUSTON	TX	77252	
PENRAY COMPANIES	440 DENNISTON COURT	WHEELING	IL	60090	
PREMIER (FARNELL) AUTOWARE CO	4500 EUCLID AVE (BOX 94884)	CLEVELAND	OH	44101	4884
QUEST CHEMICAL CORP	12255 FM 529	HOUSTON	TX	77041	
RADIATOR SPECIALTY COMPANY	PO BOX 159	INDIAN TRAIL	NC	28079	
RAWN COMPANY INC	PO BOX 9	SPOONER	WI	54801	
SEYMOUR OF SYCAMORE INC	917 CROSBY AVENUE	SYCAMORE	IL	60178	
SNAP PRODUCTS	501 BASINGER RD (BOX 269)	PANDORA	OH	45877	
SPRAY PRODUCTS CORPORATION	PO BOX 737	NORRISTOWN	PA	19404	
TAYLOR MADE PRODUCTS CO (AMP)	9100 VALLEY VIEW ROAD	MACEDONIA	OH	44056	

CARB List of Automotive Aerosol Suppliers

TECHNICAL CHEMICAL COMPANY	PO BOX 540095	DALLAS	TX	75354	
THE CHARLES MACHINE WORKS	PO BOX 66	PERRY	OK	73077	
TRANSTAR AUTOBODY TECHNOLOGY	2040 HEISEMAN DRIVE	BRIGHTON	MI	48114	
WARREN DISTRIBUTION	727 SOUTH 13TH STREET	OMAHA	NE	68102	3204
WINZER CORPORATION	10560 MARKISON ROAD	DALLAS	TX	75238	
WYNN OIL COMPANY	1050 WEST FIFTH STREET	AZUSA	CA	91702	6510
X LABORATORIES INC (Under PENRAY)	440 T DENNISTON COURT	WHEELING	IL	60090	
ZEP MANUFACTURING	1420 Seaboard Industrial Ave	ATLANTA	GA	30318	

Suppliers and/or Manufacturers of Low VOC (less than 50 g/l) Cleaning Aerosol Spray Cans

COMPANY NAME	TELEPHONE #
ARROW ENVIRONMENTAL SOLLUTIONS INC.	(213) 689-1516
CYCLO INDUSTRIES, INC	(800) 843-7813
GRANITIZE PRODUCTS COMPANY, INC.	(562) 923-5438
MARK V PRODUCTS, INC.	(800) 877-6282
MOC PRODUCTS COMPANY, INC.	(818) 896-2258
NED HELEY CO.	(714) 848-2251
TECH SPRAY, L.P.	(800) 858-4043
WESTERN CHEMICAL COMPANY	(714) 538-3053
ZEP MANUFACTURING COMPANY	(877) 428-9937

Appendix B
Companies and Consumers That Participated in the Field Testing of Low-VOC Cleaners

Auto Repair Facilities

- ARCO
Santa Monica, CA

- Big Blue Bus
Santa Monica, CA

- Brake Master
Santa Monica, CA

- Connell Chevrolet
Costa Mesa, CA

- German Auto Technik AG
Santa Monica, CA

- Guaranty Chevrolet
Santa Ana, CA

- Ira Newman Automotive
Anaheim, CA

- Morgan's Auto Service
Santa Monica, CA

- Mercedes Benz
Santa Monica, CA

- Samo Wheel and Brake Service
Santa Monica, CA

- Santa Monica Auto Center
Los Angeles, CA

- Shell
Placentia, CA

- Shell
Santa Monica, CA

Automotive Detailers

- New Image
Santa Ana, CA

- Triple Shine Detail
Glendale, CA

- VREJ Detail
Glendale, CA

Car Wash

- California Car Wash
Glendale, CA

Consumers

- Paul Dehloff
Corona, CA

- Brett Balz
Corona, CA

- Steve Poole
Brea, CA

Appendix C
Example of Questionnaire Used in the Field Testing

Automotive Aerosol Field Testing Interview

Date	User	Owner / Manager	Interviewer	Product I.D.

Type of Cleaning Performed (Circle One Only)			
General Purpose Degreasing	Brake Cleaning	Engine Degreasing	Carburetor & Fuel Injection System Cleaning

Current Product	Current Weekly Usage	No. Mech. Using Product	Test Product Weekly Usage

Question	User's Response
Did it clean sufficiently	
Did you like the delivery rate	
Did you like the delivery pattern	
Did it dry sufficiently	
Did it adversely effect substrates (metals, plastics, painted surfaces, etc)	
Did the product have a smell	
Did it have an objectionable odor	
Did it leave an unacceptable residue	
Did it have too much foam	
Cleaning versus current product. (Terrible, almost as good, as good, better)	
Did you use more volume than your current cleaner	
Did it take longer to clean	
Did you like the product	
Would you buy the test product	
Would you buy the test product for home or personal use	
Would you buy your current product for home or personal use	
Would you switch to the test product (if less expensive , if more expensive)	
Could you clean adequately if you had only the test product	

User Comments

Manager Comments