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Analysis of IRTA Report on Water-Based Automotive Products

prepared for:

**Consumer Specialty Products Association
and
Automotive Specialty Products Alliance**

August 2006

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1. EXECUTIVE SUMMARY

The California Air Resources Board (CARB) has a well-established regulatory program for consumer products that is intended to reduce emissions of volatile organic compounds (VOC) from these products. In July 2001, CARB indicated that it planned to fund a research program to investigate alternatives to aerosol automotive products that use solvents containing VOCs and chlorinated organic compounds during the 2001-2002 fiscal year. On January 24, 2002, CARB issued Request for Proposal (RFP) #01-317 entitled "Alternatives to Automotive Consumer Products that use Volatile Organic Compounds (VOC) and/or Chlorinated Organic Compound Solvents."^{1*} According to the RFP, the objective of the project was as follows:

...to identify alternative water-based formulas for automotive products that do not contain chlorinated solvents and contain very low amounts of other toxic substances and VOC solvents. Aerosol formulations will be tested for efficacy and compared to currently used products. The ARB will use the information obtained from this research to assess the feasibility of achieving further VOC reductions from automotive products.

The contract for the study was awarded to the Institute for Research and Technical Assistance (IRTA), which submitted its Final Report to CARB in December 2004. The study included two primary tasks: (1) the identification and laboratory-based preliminary testing of water-based alternatives to solvent-based automotive aerosol cleaners and (2) field-testing of the most promising alternatives identified during the preliminary testing. Both preliminary and field-testing were to involve four cleaning applications: brake cleaning, general purpose degreasing, engine degreasing, and carburetor and fuel injection system cleaning.

IRTA's conclusions regarding the study, as stated in the final report, were as follows:

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 water-based cleaners, the VOC content of the alternative products would be near-zero.

* Superscripts denote references provided in Section 5.

CARB staff's characterization of the study was that:

The program demonstrated the technological feasibility of water-based aerosol automotive parts cleaners as well as the feasibility of using exempt solvents for the same purpose.

In apparent reliance on the IRTA study and the above finding, CARB staff has proposed VOC content limits of 10% by weight for engine degreasers, brake, fuel and carburetor cleaners and 15% by weight for general purpose aerosol degreasers.

At the request of the Consumer Specialty Products Association (CSPA) and the Automotive Specialty Products Alliance (ASPA), Sierra Research reviewed the study performed by IRTA in order to determine whether it supports the conclusions reported by IRTA as well as CARB staff's finding and current regulatory proposal.

The review documented in this report found that the results of the IRTA study do not support the conclusions that have been drawn by IRTA and CARB staff nor CARB's proposed VOC content regulations for the subject products. As summarized below, there are a number of issues associated with the design and execution of the study that led to this finding.

- IRTA is a non-profit organization whose stated goals include reducing and eliminating the use of ozone-depleting, chlorinated, and other solvents, and its mission is described as identifying, testing, and implementing low- and non-solvent alternatives to reduce or eliminate solvent use. While this doesn't mean that IRTA could not have conducted the study without introduction of bias, or necessarily that bias was introduced, the fact is that there is no evidence that IRTA took, or even considered, the affirmative steps necessary to ensure an independent evaluation.
- The technical feasibility of producing water-based aerosol cleaners with performance equal to that of existing cleaners was not proven by the study results. For example, IRTA noted that a key factor for a successful water-based aerosol cleaner used in brake and carburetor cleaning applications as well as general degreasing is that it should not foam on delivery. However, none of the existing 11 water-based aerosol cleaners or other 18 water-based cleaners originally identified and included in the preliminary testing by IRTA were ever successfully packaged as non-foaming aerosols. Further, the six water-based products that were ultimately reformulated and field tested in brake and general degreasing applications were rated as having inferior performance relative to existing solvent-based aerosol cleaners.
- IRTA failed to ensure that the field study participants that evaluated the alternative products were representative of California users of aerosol automotive cleaning products. For example, IRTA selected automotive

detailing and car wash facilities to rate the performance of alternative engine degreasers relative to solvent-based aerosol engine degreasers, despite the fact that those facilities don't even use solvent-based aerosol engine degreasers.

- IRTA performed no analysis of how much data would be required to successfully compare the alternative and solvent-based cleaners, and had no data analysis, data quality assurance, or data quality control plans. The study contained no means for quantitative testing and no means for achieving standard goals, such as determining the variability in individual evaluator responses by conducting multiple evaluations of the same cleaner or providing a control by blinding evaluators to the products being tested and then including some solvent-based aerosols along with the alternatives to be evaluated.
- The data actually collected by IRTA are incomplete. One would expect, especially given the lack of a statistically designed unbalanced sampling plan, that all of the evaluators in the study would have evaluated all of the alternative products. However, this was not the case, as only 30%, 31%, and 57% of the possible evaluations (based on the number of products and evaluators) for brake cleaning, general degreasing, and carburetor cleaning were actually performed. Further, no single evaluator or facility evaluated every one of the alternative brake cleaners or general degreasers.
- The data collected by IRTA were never analyzed in any meaningful fashion. Although each evaluation performed in the study required the evaluator to answer 18 questions posed by an IRTA representative, it appears that responses to only between one and three questions were actually used by IRTA in evaluating the performance of alternative cleaners. Further, it isn't clear how IRTA transformed the evaluators' verbal responses to questions into the numeric rating scales used by IRTA in reaching its conclusions. There was no statistical analysis of any kind performed on the collected data.

###

2. INTRODUCTION

The California Air Resources Board (CARB) has a well-established regulatory program for consumer products that is intended to reduce emissions of volatile organic compounds (VOC) from these products.² In July 2001, CARB indicated that it planned to fund a research program to investigate alternatives to aerosol automotive products that use solvents containing VOCs and chlorinated organic compounds during the 2001-2002 fiscal year.³ At this point, the stated objective of the project was “to develop, demonstrate, and evaluate water-based cleaning alternatives for automotive aerosol cleaning projects.” The project description indicated that the first step in the project would be the development of water-based formulations for cleaning engines, brakes, carburetors, fuel injectors, and other car parts, and laboratory testing of those formulations. In the second step, CARB said, “Auto repair shops, including small shops, chains, service stations, and dealerships will be converted to the water-based alternatives that worked best for their applications.”

On January 24, 2002, CARB issued Request for Proposal (RFP) #01-317 entitled “Alternatives to Automotive Consumer Products that use Volatile Organic Compounds (VOC) and/or Chlorinated Organic Compound Solvents.”¹ Proposals were required to be submitted by March 12, 2002, and the maximum budget for the project was set at \$200,000 and the project was to be completed in 18 months. According to the RFP, the objective of the project was as follows:

...to identify alternative water-based formulas for automotive products that do not contain chlorinated solvents and contain very low amounts of other toxic substances and VOC solvents. Aerosol formulations will be tested for efficacy and compared to currently used products. The ARB will use the information obtained from this research to assess the feasibility of achieving further VOC reductions from automotive products.

The RFP specified six tasks to be performed in pursuit of this objective, which included the following:

1. Development of a plan for preliminary testing of prospective near-zero-VOC cleaning products;
2. Procurement of candidate cleaning products and preliminary testing of those products;

3. Preparation of an Interim Report summarizing the results of the preliminary testing, identifying the most promising candidate cleaning products, and containing a plan for field-testing the most promising candidates to evaluate their performance relative to existing solvent-based products; and
4. Execution of the field-testing program and the collection and analysis of data from the field-testing program.

On April 26, 2002, CARB's Research Screening Committee approved a contract with the Institute for Research and Technical Assistance (IRTA) to perform the study specified by RFP #01-317.⁴ The budget approved for the study was \$189,966. It appears, however, that IRTA also received additional funding for the project from the State of California's Health and Human Services Agency under Agreement Number 01-16384, but the amount of this additional funding is not known. IRTA completed work on the project and submitted its Final Report in December 2004. The final report was approved by CARB's Research Screening Committee on February 28, 2005.⁵

IRTA's conclusions regarding the study, as documented in the final report, are restated below.

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 water-based cleaners, the VOC content of the alternative products would be near-zero.

In presenting the IRTA Final Report to the Research Screening Committee for approval, CARB staff characterized the result of the study as follows:⁶

The program demonstrated the technological feasibility of water-based aerosol automotive parts cleaners as well as the feasibility of using exempt solvents for the same purpose.

At the request of the Consumer Specialty Products Association and the Automotive Specialty Products Alliance, Sierra Research has reviewed and summarized the work performed by IRTA that underlies the above conclusions. The results of that review are presented in this report.

###

3. SUMMARY OF THE IRTA STUDY

In order to review the IRTA study, it was first necessary to review the original requirements for the study set forth in CARB RFP #01-317 and to review and summarize all available information related to the IRTA study. This summary is presented below and is referenced extensively in the next section of this report, which presents the findings of the review.

3.1 Summary of CARB RFP for the IRTA Study

The IRTA study was performed under contract to CARB. The request for proposal (RFP) for the study “Alternatives to Automotive Consumer Products that use Volatile Organic Compounds (VOC) and /or Chlorinated Organic Compound Solvents” was released by CARB on January 14, 2002.¹ The RFP provided a budget of up to \$200,000 for the study and 18 months for its completion. The budget approved by CARB for the IRTA was \$189,966.*

According to the RFP, the objective of the project was as follows:

...to identify alternative water-based formulas for automotive products that do not contain chlorinated solvents and contain very low amounts of other toxic substances and VOC solvents. Aerosol formulations will be tested for efficacy and compared to currently used products. The ARB will use the information obtained from this research to assess the feasibility of achieving further VOC reductions from automotive products.

The RFP also specified the performance of six tasks, as outlined below.

1. Development of a Plan for Preliminary Testing of Prospective Near-Zero-VOC Cleaning Products – This task required the development of a plan to identify prospective formulations for near-zero-VOC, water-based cleaning products for use as effective and cost-effective aerosol alternatives to conventional automotive cleaning products in each of the following four categories: (1) brake cleaners, (2) carburetor cleaners, (3) engine degreasers, and (4) general-purpose degreasers.

* It must be noted that IRTA appears to have received additional funding for this study from the State of California’s Health and Human Services Agency under Agreement Number 01-16384. The amount of this additional funding is unknown to us at this time.

In addition, the plan was to include a protocol for preliminary testing of prospective alternative formulations and a means for evaluating the cleaning effectiveness and cost effectiveness of these alternatives to conventional cleaners. Also included in this task was a requirement for the formation of a technical review committee (TRC) of interested stakeholders that was intended to provide technical input from industry and business interests.

2. Procurement of Candidate Cleaning Products and Preliminary Testing – Under this task, candidate water-based, near-zero-VOC, low-toxicity cleaning formulations were to be procured and subjected to preliminary laboratory testing following the protocol developed under the first task.
3. Interim Report and Development of Field-Testing Plan – This task entailed the preparation of a report documenting the results of the preliminary testing that was to be reviewed by CARB and the TRC. It was also to contain recommendations regarding specific near-zero-VOC aerosol formulations for field-testing at automotive maintenance and repair (AMR) facilities as well as development of a plan specifying how this field-testing was to be performed. The field-testing plan was to include a process for identifying AMR facilities where field-testing would occur and specify a minimum number of AMR facilities that would be required to participate for the duration of the study. Further, the AMR facilities used for field-testing were to include comparable numbers of general maintenance and repair shops, service stations, dealerships, and dedicated brake repair facilities already using these automotive products.

With respect to the actual testing, the plan required documentation of the types of cleaners being used, to which the candidates would be compared. It was further to include measures of the intensity of comparison, with metrics such as number of jobs or duration of comparison per product. Rating criteria were to be established for evaluating the efficacy of the candidate relative to the products that were currently being used. At a minimum, the criteria were to include volume used per product, residue, cleaning time, drying time (for brake cleaners), cleaning effectiveness, and cost.

4. Perform Field-Testing – Under this task, the field-testing plan developed under Task 3 was to be executed. This included providing candidate products to the selected AMRs as well as monitoring product usage and collecting data.
5. Final Report – The final task was the preparation of a report documenting all of the work performed under the study. More specifically, the direction was that:

The contractor shall prepare a final report that includes the findings from all preceding tasks and that compares the new aerosol products to currently used aerosol products at AMR facilities, based on technical feasibility, cost, cleaning effectiveness, cross-media impacts, and any other pertinent factors. The report shall also

provide basic information on the most promising low-VOC formulations, including the types and relative amounts of active ingredients, propellants, and toxic compounds. The contractor shall include an overall evaluation of each product tested, based on the objective rating criteria previously developed.

6. Seminar – The final task required that the contractor conduct a seminar for CARB to “disseminate the research results at the end of the project.”

3.2 Identification of Alternative Cleaners and Development of a Preliminary Testing Plan

Based on the RFP, the starting date of the IRTA project appears to have been around June 2002. By September 30, 2002, IRTA had completed the plan required under Task 1 of the CARB RFP.⁷ According to the plan document, IRTA used information provided by CARB, the South Coast Air Quality Management District (SCAQMD), and computerized information searches to arrive at a list of 19 existing water-based automotive aerosol products, which were apparently commercially available at that time.

This list of 19 products was reduced to 11 by eliminating products that did not meet a water or VOC content-based screening criterion. The water content criterion required that the product contain at least 70% water, while the VOC content criterion required that products contain less than 275 grams of VOC per liter.* IRTA reported that water and VOC content determinations were made based on examination of the Material Safety Data Sheets and that a determination of whether a product met either criterion was based on “IRTA’s judgment.”

Table 3-1, which is reproduced from IRTA’s Task 1 Plan, lists the 11 existing water-based aerosol products that, in IRTA’s judgment, met the water content or VOC content criterion, as well as their manufacturer and water and VOC content. As shown, only 7 of the 11 compounds clearly meet the criterion established by IRTA and the Task 1 plan provides no explanation as to how the 4 other compounds were determined to meet the quantitative IRTA selection criteria when the water and/or VOC content was characterized qualitatively by IRTA. As discussed below, these 11 products were included by IRTA in the preliminary testing performed under Task 2.

* IRTA represented that the 275 grams of VOC per liter of product criteria roughly translated to a 27.5% VOC content limit, apparently on a mass basis.

Table 3-1 Existing Aerosol Water-Based Cleaners Selected by IRTA for Preliminary Testing			
Manufacturer	Product	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
Berryman Products	All Purpose Clean-R	Unknown	Unknown
Berryman Products	New Engine Degreaser	30-50%	High
Drummond American Corp.	Zonk!	70-80%	264 g/l
Mirachem	Mirachem All Surface Safe Cleaner/Degreaser	Unknown	161 g/l
Radiator Specialty Co.	Foaming Wheel Cleaner	Unknown	Low
Radiator Specialty Co.	Foamy Engine Brite Degreaser	70-80%	Low
Sunshine Makers	Foaming Simple Green-Wheel Cleaner	90%	50 g/l
Sunshine Makers	Foaming Simple Green-Total Automotive Foaming Cleaner	90%	50g/l
Wynn's	Wynn's Engine Degreaser	80%	low

Despite having apparently identified 11 existing and commercially available low-VOC aerosol cleaning products, IRTA investigated existing non-aerosol water-based cleaners that reportedly complied with SCAQMD regulations that limit VOC content of automotive and industrial cleaners to no more than either 50 or 25 grams per liter. Although the Task 1 Plan presents absolutely no other information regarding what, if any, other criteria were used in selection, nor any indication of how many non-aerosol products were considered by IRTA, an additional 18 products produced by 6 manufacturers were selected for preliminary testing. These products are listed in Table 3-2.

Table 3-2 Non-Aerosol, Low-VOC Water-Based Automotive/Industrial Cleaners Selected by IRTA for Preliminary Testing	
Manufacturer	Product
Kyzen Corp.	Metalnox M6309
	Metalnox M6319
	Metalnox M6432
	Metalnox M6410MS
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 12
Mirachem	Mirachem 750

Finally, IRTA also decided to include acetone and a soy-based cleaner called Soy Gold, produced by AG Environmental Products, in the preliminary testing.

In addition to identifying the candidate cleaners described above, IRTA developed the required screening testing protocol for part of the Task 1 Plan. The protocol was based on comparative “laboratory” testing of existing solvent-based cleaners with the IRTA-selected alternatives in engine degreasing, general degreasing, brake cleaning, and carburetor and fuel injector cleaning. The testing protocol was as follows:

1. Select an appropriate part (e.g., brake component or carburetor) from a collection of used automotive parts acquired from auto repair shops;
2. Spray either the baseline or alternative cleaner on a portion of the selected component for 10 seconds;
3. Visually inspect the portion of the part upon which the cleaner was sprayed; and
4. Conduct a water-break test.

In addition, the Task 1 Plan included a second phase of preliminary testing that specified that the 10 “best” alternative cleaners from the laboratory would be subjected to additional testing at (1) a general auto repair shop, (2) a brake repair shop, and (3) a service station. This testing required that the cleaners be used by shop personnel who would be asked to “make judgments” about the alternative cleaners and to compare the cleaning capability of the alternatives with that of the cleaners currently being used in each shop.

Finally, IRTA also assembled the Technical Review Committee as required by Task 1.

3.3 Preliminary Testing

As discussed above, based on the Task 1 Plan, the first step under Task 2 was for IRTA to perform laboratory screening testing on the 29 aerosol and non-aerosol alternative cleaners that had been identified and listed in Tables 3-1 and 3-2 plus Soy Gold and acetone. This testing is described in an April 25, 2003 version of the Task 3 Interim Report⁸ and a subsequent version of the Task 3 Interim Report dated September 15, 2003,⁹ as well as in the IRTA Final Report¹⁰ dated December 2004. It should also be noted that IRTA prepared another report dated December 2004¹¹ for the State of California Health and Human Services Agency that is almost identical to the report submitted to CARB. In contrast to generally accepted principles, the Final Report submitted to CARB does not reference the report submitted to the Health and Human Services Agency nor does that report reference the final report submitted to CARB.

There were at least two changes in the products evaluated in the screening testing. First, Wynn’s Engine Degreaser, which was an existing aerosol cleaner, was not tested because the manufacturer “did not send a sample of the cleaner.” Second, IRTA added Hydrosol Non-Foaming Engine Degreaser. Further, there is confusion regarding whether AX-IT Immersion and/or AX-IT 3X Spray Cleaner was evaluated in the screening testing—both versions of the Task 3 interim report indicated that 3X Spray was evaluated, while the final report states that it was the Immersion product.

This testing, which IRTA refers to as the “first phase of the screening tests,” was reportedly performed using the laboratory protocol included in the Task 1 Plan where the effectiveness of alternative cleaners was compared to that of “baseline solvent cleaners” via visual inspection and water-break testing. The non-aerosol cleaners included in the screening test were tested using pesticide pump spray bottles. However, there was a deviation from the Task 1 Plan in that IRTA supplied the alternative cleaning products to three unidentified “auto repair facilities” and “requested that facility personnel evaluate the effectiveness of the alternatives.” No detail is provided regarding what types of repair facilities these were, nor is there any documentation regarding how alternative products were evaluated at the three unidentified repair facilities. Further, other than the completely qualitative and subjective summary provided by IRTA that is discussed below, there are no data documenting the results of the laboratory screening testing performed by IRTA or at the three repair facilities.

IRTA did report that of the 10 existing aerosol alternatives, 5 “performed well”:

1. Berryman - New Engine Degreaser;
2. Mirachem - All Surface Safe Cleaner/Degreaser;
3. Radiator Specialty Co. - Foamy Engine Brite Degreaser;
4. Sunshine Makers - Foaming Simple Green - Wheel Cleaner; and
5. Sunshine Makers - Foaming Simple Green - Total Automotive Foaming Cleaner.

Upon learning from Sunshine Makers that its two products listed above were identical in formulation, IRTA dropped the Total Automotive Foaming Cleaner from the study.

Of the 18 non-aerosol cleaners tested in pesticide spray bottles, IRTA reported that 14 “performed well enough to go on to the second phase of the screening testing.” These 14 cleaners are listed below.

1. Magnafluz Daraclean 200
2. Magnafluz Daraclean 236
3. Magnafluz Daraclean 238
4. Magnafluz Daraclean 257
5. Kyzen Metalnox 6432
6. Kyzen Metalnox 6319
7. Kyzen Metalnox 6410MS
8. Brulin GD-1990
9. Brulin GD-815
10. Applied Cleaning Technologies Spray Clean 12
11. Applied Cleaning Technologies Scrub Tub
12. AX-IT Spray
13. AX-IT 3X Spray Cleaner
14. Mirachem 750

IRTA also reported that acetone and Hydrosol Non-Foaming Engine Degreaser “compared well with the solvent aerosol products,” but that Soy Gold “did not perform well.”

The following is also reported by IRTA in the Task 3 report:

The solvent aerosol cleaners dissolve the contaminants but the aerosol pressure also imparts a significant mechanical action that helps to remove the contaminants. In fact, many of the auto repair technicians kept spraying the aerosols until they dissolved the contaminants and the contaminants/cleaner dripped off the part. Some of the alternative cleaners were already in aerosol form. Two of these, Mirachem All Surface Safe and Foamy Engine Bright, are delivered in a thick foam. The foamy state of these cleaners does not allow the aerosol pressure to help with the cleaning mechanically. Two of the other

cleaners, Simple Green Wheel Cleaner and Berryman B-33 Engine Degreaser, are delivered in a thin foam. In this case, the pressure imparted by the aerosol package is better but is not as good as for the solvent aerosols which do not foam at all. The other water-based cleaners which were tested in the spray bottles did not have the pressure of the aerosol package at all. None of them foamed when delivered with the spray bottles.

Given this, and apparently despite the fact that IRTA had already concluded that the 4 existing aerosol and 14 non-aerosol alternatives cleaned “well” compared to baseline solvent cleaners in the absence of the “mechanical action” due to a high pressure spray, IRTA’s next step was to repackage all 18 alternative cleaners into aerosol form using hydrocarbon propellants.

The repackaged alternative cleaners were then again evaluated relative to baseline solvent cleaners in two rounds of “laboratory” testing performed at the Applied Cleaning Technologies (ACT) facility.* The first round of this testing, which IRTA refers to as the “second phase” of screening testing, was reported to have been performed on March 3, 2003, and results were reported for all 18 existing aerosol (4) and non-aerosol (14) alternative cleaners selected based on the first phase of the screening testing. The performance of each of the alternative cleaners was compared to a baseline solvent cleaner in engine degreasing (baseline was CRC engine degreaser), general purpose degreasing (baseline was CRC engine degreaser), brake cleaning (baseline was CRC Brake Parts Cleaner), and carburetor and fuel injection system cleaning (baseline was Gumout Choke and Carb Cleaner).

Results from the second round of laboratory testing (which omitted an evaluation of engine degreasing performance) conducted on June 25 were reported for the same 18 alternative cleaners tested on March 3, as well as 7 additional alternative cleaners that were characterized as “new formulations.” It should be noted, however, that engine degreasing testing was not performed in June and that the same baseline solvent cleaners were used.

The results reported by IRTA for the March 3 and June 25, 2003 laboratory testing are summarized by cleaner in Table 3-3 for each application. Although this testing was intended as a means of prescreening alternative cleaners for use in later field-testing, the fact is that the second phase results are inconsistent. For example, in the March 3 testing, 9 of 18 alternatives tested gave different results for engine degreasing and general degreasing despite the fact that they were being compared to the same baseline solvent product. Also, while complicated by the introduction of the “close to baseline” rating in the June testing, there was a change in results in 15 of the 54 (18x3) comparisons possible between the March and June testing, again despite the fact that the comparisons were being made to the same baseline solvent products. These 15 result changes are highlighted by red text and italics in Table 3-3. The inconsistent results from the laboratory testing were not discussed or even noted by IRTA.

* No description of the ACT facility is provided.

Table 3-3 Summary of IRTA Laboratory Testing ^a							
	Eng. Degreasing March	Gen. Degreasing March June	Brakes March June	Carb/FI March June			
Existing Aerosols							
Mirachem All Surface Safe	N	N	N	N	N	S	S
Foamy Engine Brite Degreaser	S	S	S	S	S	S	S
Foaming Simple Green-Wheel Cleaner	S	<i>N</i>	<i>S</i>	N	N	S	S
New Engine Degreaser	S	N	N	S	S	S	S
Non-Aerosol Cleaners							
Daraclean 200	N	<i>S</i>	<i>C</i>	S	S	S	S
Daraclean 236	S	<i>N</i>	<i>C</i>	N	N	N	N
Daraclean 238	N	<i>S</i>	<i>N</i>	<i>S</i>	<i>C</i>	N	N
Daraclean 257	S	S	S	<i>S</i>	<i>C</i>	S	S
Metalnox 6319	N	N	S	S	S	S	S
Metalnox M6410MS	N	N	N	N	N	S	S
Metalnox 6432	S	<i>N</i>	<i>S</i>	S	S	N	N
GD-815	N	N	S	S	S	S	S
GD-1990	N	N	N	<i>N</i>	<i>S</i>	N	N
Spray Clean 12	S	<i>S</i>	<i>C</i>	<i>S</i>	<i>N</i>	S	S
Scrub Tub 8	S	N	N	N	N	<i>N</i>	<i>S</i>
AX-IT Spray	S	N	N	<i>N</i>	<i>C</i>	S	S
AX-IT Spray 3X	S	N	N	<i>N</i>	<i>C</i>	N	N
Mirachem 750	N	<i>N</i>	<i>C</i>	<i>S</i>	<i>C</i>	N	N
Kyzen DG-7 NF	-	-	N	-	S	-	S
Kyzen DG-9 NF	-	-	N	-	S	-	S
Kyzen DG-11 NF	-	-	S	-	N	-	S
Daraclean 200 NF	-	-	S	-	N	-	S
Daraclean 257 NF	-	-	C	-	S	-	S
Mirachem PR-726 NF	-	-	N	-	C	-	S
Mirachem PR-726 NF	-	-	C	-	S	-	S

^a S denotes “same as baseline,” N denotes “not as good as baseline,” and C denotes “close to baseline.”
Note: Inconsistent results are highlighted in red italics. See text for further discussion.

The final step in the second phase of preliminary testing involved IRTA providing *one* can of each of the 18 now-aerosol-packaged alternative cleaners to eight automotive repair facilities. There is no indication that the soy and acetone cleaners were further

evaluated during this final step of the second phase of preliminary testing. No information is provided by IRTA as to how these facilities were selected. All eight facilities were located in coastal southern California, with six of the eight being in Santa Monica, and the others in Costa Mesa and Santa Ana. The facilities included one service station, two brake repair shops, three general repair shops, and two dealerships. In the Final Report, IRTA notes that the results of this portion of the second phase of testing “were meaningful only for brake cleaning and general purpose degreasing.” However, in the Interim Task 3 report, it is stated that, despite the inclusion of two brake repair shops, “IRTA was able to test the alternative water-based cleaners during brake jobs at only two facilities, the dealerships” and “at all of the other facilities . . . IRTA used general purpose degreasing to judge the cleaners’ capabilities for brake cleaning.” Also in the Final Report, IRTA notes that it “participated in all of the testing and asked for the opinion of the technicians on the cleaning capabilities of the cleaners.” There is no discussion of what, if any, instructions the technicians were given with respect to the evaluation; of what, if anything, technicians were told about the alternatives; or of what IRTA “participation” in the process involved.

The results of this portion of the second phase of preliminary testing are summarized in Table 3-4, which is patterned after Table 3-4 in the IRTA Final Report. As shown, the best ratings for any of the alternatives were that they were judged to be the same or better than existing solvent-based cleaners with respect to general degreasing in six of the eight shops (4 of 18 cleaners received this rating), while the worst performance was that all of the eight shops found three alternatives to be not as good as current cleaners. On average, the acceptance rate (e.g., fraction of ratings that were same or better) for the alternative cleaners was less than 35%.

Based on the results of the screening testing, 12 of the 18 cleaners that were included in the field screening were selected for use in the actual field-testing performed under Task 4. These 12 cleaners are highlighted in yellow and italics in Table 3-4. As shown, the eight highest-rated cleaners were selected along with two cleaners rated at 25% and two rated at 0%. The two cleaners rated at 25% were included despite their poor performance because their manufacturers “agreed to send aerosol cleaners for the field-testing”; the two cleaners rated at 0% were included because they “performed well in the Phase 1 screening tests” although that doesn’t appear to be the case based on the data summarized in Table 3-3.

As discussed previously, comparative preliminary testing of existing non-aerosol alternative cleaners with existing aerosol solvent-based cleaners led IRTA to believe that the alternatives’ lack of high-pressure spray action lessened their efficacy in cleaning. As a result, as is also noted above, IRTA decided to package these alternatives as aerosols for the second phase of the preliminary testing. However, packaging the alternatives as aerosols failed to achieve IRTA’s objective of creating high-pressure spray action. This occurred because the water-based cleaners, which did not foam when sprayed from pesticide bottles, did foam in aerosol form. This in turn led IRTA to ask producers to reformulate selected cleaners so that non-foaming aerosol versions would be available for the field-testing.

Table 3-4 Results of IRTA Field Screening of 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 & Brake Service	% Close, Same or Better
Daraclean 200	N	S	S	N	S	N	S	S	62.5
Daraclean 236	N	N	B	S	N	N	N	N	25
Daraclean 238	N	N	S	S	S	S	N	N	50
Daraclean 257	S	S	B	S	N	S	N	N	62.5
Metalnox M6432	N	N	N	N	N	N	N	N	0
Metalnox M6319	N	S	N	S	N	N	N	N	25
Metalnox M6410MS	S	S	B	N	S	N	N	N	50
Brulin 1990GD	S	S	S	N	S	N	N	N	50
Brulin 815GD	N	N	N	N	N	N	N	S	12.5
ACT Sprayclean - 12	S	C	S	N	N	N	S	C	62.5
ACT Scrubtub	N	N	N	N	N	N	S	N	12.5
Ax-IT Spray Cleaner	N	B	B	S	N	S	N	S	62.5
Ax_IT 3X Spray Cleaner	N	N	N	N	N	N	N	N	0
Mirachem 750	N	N	N	N	N	N	N	N	0
Mirachem All Surface Safe	S	N	N	N	N	N	N	C	25
Foamy Engine Brite	N	N	N	S	N	S	N	C	37.5
Simple Green Wheel Cleaner	S	N	N	N	N	N	S	N	25
Berryman B-33 Engine Degreaser	N	N	N	N	N	N	N	C	12.5

Notes: Ratings are C = close in performance to current cleaner, S = same as or as good as current cleaner, B = better than current cleaner, N = not as good as current cleaner.
 Cleaners highlighted in yellow were selected for use in the field-testing performed under Task 4.

Another issue identified during the preliminary testing was that many auto repair technicians were reluctant to test water-based cleaners for carburetor and fuel injection system cleaning activities because they were concerned water would enter the fuel system. Because of this, IRTA stated that it would not field test water-based cleaners for this application.

As noted above, the CARB RFP specified that the Task 3 Interim Report include a Field Test Plan. According to the RFP, the Field Test Plan was to:

...include the process for identifying the participating AMR facilities, and shall specify a minimum number of AMR facilities to participate for the duration of the study. The test plan shall also identify the number of AMR facilities that will be enlisted to begin the field study, and provide assurance that the above specified “minimum number of AMR facilities” will be participating at the end of the study. The contractor shall include comparable numbers of general maintenance and repair shops, service stations, dealerships, and dedicated brake repair facilities already using these products. The contractor shall identify, by consumer product category and application technology, what types of automotive products are currently being used.

The field test plan shall include measures of the intensity of comparison with metrics such as the number of jobs or duration of comparison per product. The contractor shall provide rating criteria to evaluate the efficacy of the alternative near zero VOC, low-toxicity automotive products compared to current automotive products. As a minimum, the criteria shall include volume used per product, residue, cleaning time, and drying time (for brake cleaners), cleaning effectiveness and cost.

The Field-Testing Protocol included in the IRTA Task 3 Interim Report states that field-testing would be conducted in 12 facilities,* and identifies 8 of the facilities as being those that participated in the preliminary field screening, but provides no other information justifying 12 facilities as the appropriate minimum number or the mix of facilities selected. Interestingly, the Protocol indicates that 5 of the 8 facilities were currently using only one aerosol solvent product while the other 3 were using two products. Finally, the Field-Testing Protocol indicates that data regarding alternative cleaner performance would be collected by IRTA by asking a number of questions in weekly interviews. No other information is presented as to what, if any, information or instructions would be provided to technicians regarding the products; how alternative cleaners were to be labeled; whether controls (e.g., solvent-based cleaners labeled as alternatives) would be used; or how, if at all, technicians were to record observations regarding the different cleaners between weekly visits from IRTA personnel.

* Three service stations, two dealerships, two brake shops, four general automotive repair shops, and one municipal garage.

In addition, the IRTA Field Test Protocol fails to provide any discussion of how alternative cleaners would be compared with the solvent aerosols that were being used by the selected facilities.

3.4 Field-Testing

Based on the IRTA final report, the field-testing of alternative cleaners for evaluation of general degreasing, brake cleaning, and carburetor and fuel injector cleaning was performed at 13 automotive repair facilities “recruited by IRTA” while field-testing of engine degreasers was done by 3 automotive detail facilities, 1 car wash, and 3 “consumers” that were also “recruited” by IRTA. No information is provided by IRTA regarding how or why these particular facilities and individuals were identified or recruited, nor whether monetary or other incentives were used in recruitment.

With respect to the 13 automotive repair facilities, 8 of these were the same facilities involved in the second phase of the preliminary screening. The 5 additional facilities included two service stations, a dealer, a general repair facility, and a municipal bus garage. Three of the five were again located in Santa Monica, with the other two being in Orange County. The number of facilities is summarized by facility type in Table 3-5, as is the percentage of each type relative to the total facility population.

Table 3-5 Summary of AMR Facility Types Included in IRTA Field-Testing		
Type	Number	% of Total
New Car Dealer	3	23
General Repair	4	31
Brake Shops	2	15
Service Stations	3	23
Municipal Bus Garage	1	8

Although there is no description of the instructions provided by IRTA to the technicians who participated in the IRTA field test, a copy of the survey instrument is included in Appendix C of the final report. According to the final report, IRTA filled out the survey instrument by directly questioning participating technicians after they had “finished using the alternative cleaner.” Although there were a number of questions included in the survey instrument, only the results from two or three questions related to the relative efficacy of the alternative cleaners were directly reported. It appears that the first of the two questions was “did it (the alternative) clean sufficiently?” However, it may be that the response to the question, “could you clean adequately if you had only the test

product” were factored in somehow. A yes response to the first and perhaps both of these questions was assigned a numerical ranking of 1 and a no response was given a ranking of 0. The other question required comparing the cleaning performance of the alternative to that of the current cleaner being used by the technician. The subjective verbal responses of the field study participants to this question were transformed by IRTA using another numeric scale system. In this case, the scale or ranking system provided for 7 ratings between 0 and 3, as summarized in Table 3-6. Again, there is no discussion of what instructions, if any, participating technicians were given with respect to characterizing the relative efficacy of the alternative cleaners or the use of the rating scale in evaluating the alternative cleaners.

Despite the requirements set forth under Task 3 of the CARB RFP, none of the other metrics to be considered in comparing the performance of alternative and existing cleaners were used by IRTA.

Table 3-6 IRTA Field-Testing Ranking Scale	
Opinion of Alternatives Comparative Cleaning Efficacy	Value
Poor	0
Marginal	0.5
Almost as good as current cleaner	1.0
Nearly as good as current cleaner	1.5
As good as current cleaner	2.0
Somewhat better than current cleaner	2.5
Better than current cleaner	3.0

Field-testing of the alternative cleaners in brake cleaning and general degreasing applications was conducted at all 13 automotive repair facilities. However, IRTA does not appear to have tested any of the alternatives selected (and highlighted in Table 3-4) during the preliminary field screening.* Apparently the reason for abandoning the cleaners selected in the preliminary testing phase was that “IRTA needed non-foaming cleaners to test in these applications.” In any case, there were 10 alternative cleaners tested in the brake cleaning application and 11 in the general degreasing application. For each application, the same six water-based cleaners packed in aerosol form with hydrocarbon propellant were used along with five or six soy/acetone combinations ranging from a 50/50 mix to 100% acetone.

* It is not clear whether the AX-IT L-7769 is the same as any of the AX-IT products tested during the screening phase of the study nor is it clear if the Mirachem Automotive Cleaner is one of the products tested during the preliminary screening.

In addition to the abandonment of the selected alternative cleaners, there were several issues associated with testing. First, although testing was performed at all 13 facilities, there were different numbers of technicians involved at the different facilities. The number of technicians ranged from one to as many as seven at each facility. Second, each technician at a facility did not necessarily test the same products as the other technicians at that facility. Third, no technician at any facility tested all of the products. In fact, testing occurred in only 31% (92/300) of the potential technician-cleaner evaluations in the brake cleaning application and only 30% (104/352) of the potential evaluations in the general degreasing application. Finally, there were no facilities that tested all of the alternative cleaners.

The results of the brake and general degreasing testings are summarized in Tables 3-7 and 3-8, respectively. The tables show the actual number of tests for each cleaner; the percentage of the potential evaluations those tests represent; the number and percentage of technicians that actually tested the product who reported that it was “adequate,” however that was defined for them by IRTA; and the minimum, maximum, and average numeric scores reported for the cleaning ability of each alternative relative to the current cleaner being used.

Beginning with Table 3-7, the results show that while two cleaners were found to be “adequate” by those technicians that actually tested them, none of the alternatives received a ranking above 2 (“as good as current cleaner”) in any of individual evaluations. In addition, the only alternative that received an average ranking of 2 was the 100% acetone cleaner tested by only 2 of the 30 technicians involved in the evaluation. The results also show a contradiction between the determination of “adequacy” of cleaning and the comparative evaluation of cleaning efficacy relative to the existing cleaner. This is shown by the results for the Kyzen Aerosol Cleaner, where two of eight testing technicians found it to clean adequately, but all eight rated its relative cleaning performance as “poor.” This significance of this contradiction can be seen in the IRTA conclusions where, despite the fact that relative efficacy results indicate the cleaning performance of the alternatives to be inferior to that of the existing cleaners, IRTA states, with respect to the brake cleaning application:

... a majority of the shops found the AX-IT L7769 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 carbon dioxide propellant and the acetone cleaner found them adequate.

While this may be true, the average comparative rankings for the four products were less than 1.5 and three of the four had average rankings of less than 1. Turning to the conclusions regarding the performance of the soy/acetone blends, they were each tested by fewer than 20% of the participating technicians and, other than the 100% acetone product tested by only two technicians, the average rankings were 1.25 or less.

Table 3-7						
Summary of Results from IRTA Field-Testing of Alternative Brake Cleaners						
Alternative	No. of Testers	% of Total Testers	“Adequate”	Min	Rankings Max	Avg.
AX-IT L-7769	17	57	11 (65%)	0	2	0.76
Mirachem Automotive Cleaner	13	43	7 (54%)	0	2	0.73
Kyzen Cyber Solv 11	15	50	15 (100%)	0.5	2	1.33
Kyzen CyberSolv	15	50	12 (80%)	0	2	0.97
Kyzen Aerosol Cleaner	8	27	2 (25%)	0	0	0
Kyzen Aerosol Degreaser 11	10	33	2 (20%)	0	1	0.28
35% Soy/Acetone (CO ₂ propellant)	4	13	3 (75%)	0	2	1.25
25% Soy/Acetone (CO ₂ propellant)	3	10	2 (67%)	0	2	1.00
35% Soy/Acetone (HC propellant)	5	17	1 (20%)	0	1	0.40
Acetone (HC propellant)	2	7	2 (100%)	2	2	2

Turning to general degreasing results, shown in Table 3-8, two of the alternatives—the 25% and 35% soy/acetone blends—did receive individual evaluation ratings as high as 2.5 (“somewhat better than current cleaner”); however, the 25% percent soy/acetone cleaner also received an individual ranking of 0 (“poor”), the 35% blend had an individual rating of 1 (“almost as good as current cleaner”), and the average ranking for both was lower than 2 (“as good as current cleaner”). Further, only 19% and 31% of the potential evaluators used the 25% and 35% blends, respectively. Three of the other alternative cleaners had individual evaluation rankings as high as 2, but their average rankings were 1.11 or less and they were tested by no more than 56% of the potential evaluators.

Again, despite results indicating that the alternatives are generally inferior in their cleaning performance to existing solvent-based cleaners, IRTA concludes with respect to the general degreasing application:

... 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 3-8						
Summary of Results from IRTA Field-Testing of Alternative General Degreasers						
Alternative	No. of Testers	% of Total Testers	Adequacy	Min	Rankings Max	Avg.
AX-IT L-7769	9	28	1 (11%)	0	1	0.11
Mirachem Automotive Cleaner	8	25	1 (13%)	0	1	0.12
Kyzen Cyber Solv 11	18	56	17 (94%)	0	2	1.11
Kyzen CyberSolv	14	44	11 (79%)	0	2	0.82
Kyzen Aerosol Cleaner	16	50	0 (0)	0	0	0
Kyzen Aerosol Degreaser 11	14	44	2 (14%)	0	2	0.39
50% Soy/Acetone (CO ₂ propellant)	1	3	1 (100%)	1	1	1
35% Soy/Acetone (CO ₂ propellant)	6	19	6 (100%)	1	2.5	1.92
25% Soy/Acetone (CO ₂ propellant)	10	31	9 (90%)	0	2.5	1.65
35% Soy/Acetone (HC propellant)	6	19	5 (83%)	0	1	0.67
Acetone (HC propellant)	2	6	1 (50%)	0	0.5	0.25

Again, IRTA focuses mainly on the “adequacy” of the alternatives rather than their performance relative to the baseline cleaners and fails to note that the majority of mechanics never even tested the soy/acetone blends. Further, as was the case with the brake cleaning results, the results regarding the adequacy of the alternatives contradict the relative efficacy ratings, as shown with the Kyzen Cyber Solv products. As shown in Table 3-8, the adequacy ratings were 94% and 79% based on testing by roughly 50% of the mechanics involved in the testing, but their average efficacy rankings were only 1.11 and 0.82.

Moving to the carburetor and fuel injector cleaning application, as indicated in the Task 3 Interim Report, IRTA did not test any water-based alternatives. Instead, only the soy/acetone cleaners were to be tested. However, one technician did evaluate the Kyzen Cyber Solv 11 in this application. As shown in Table 3-9, again all products were not evaluated by all technicians, with only 57% of the possible 63 evaluations actually taking place. Further, only 4 of the 21 participating technicians evaluated all three of the soy/acetone blends. Virtually all of the technicians evaluating these cleaners found them to clean adequately, and the highest ranked cleaner—the 35% soy/acetone blend—received an average ranking of 2.4, indicating that it performed better than the existing cleaners being used by those technicians. However, IRTA did note one problem with the soy/acetone blends—they left an oily residue that required wiping in order to allow

Table 3-9 Summary of Results from IRTA Field-Testing of Alternative Carburetor and Fuel Injector Cleaners						
Alternative	No. of Testers	% of Total Testers	Adequacy	Min	Rankings Max	Avg.
50% Soy/Acetone	11	52	10 (91)	0.5	2.5	1.73
35% Soy/Acetone	13	62	13 (100)	2	3	2.42
25% Soy/Acetone	12	57	12 (100)	1	2.5	1.92
Kyzen Cyber Solv 11	1	5	1 (100)	2	2	2

proper seating of gaskets. Interestingly, IRTA also notes that commercially available high acetone products could be used on surfaces where gaskets were to be applied, but makes no mention of why it is that those products were not included in the test program.

Engine degreasing was the final application for which alternative cleaners were field tested by IRTA. Eight cleaners were tested, including three of the cleaners selected as the result of the screening testing, one cleaner that performed poorly in the screening testing and was not selected, and three Kyzen products that were not field tested during the screening. As noted above, these cleaners were evaluated by three commercial auto detail companies, one car wash, and three “consumers.” Again, there is no discussion in the IRTA final report regarding how any of these entities were selected for field-testing, something that would be of particular interest with respect to establishing the credentials of the three engine degreasing consumers.

While the evaluations performed for cleaners in this application might appear to be similar to those performed in the other three applications, there were some significant differences. First, as stated in the IRTA final report:

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 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 engine degreasers.

The above is important for two reasons. First, while the detailers and car washes might be able to evaluate the adequacy of the alternative cleaners, they clearly were unable to compare their performance to existing solvent-based cleaners since their existing cleaners are bulk water-based products and IRTA apparently did not provide them with solvent-based cleaners. Secondly, while IRTA states that consumers do use solvent-based cleaners, IRTA did not ask the consumers involved in the field-testing to answer the

question regarding the relative efficacy of the alternative cleaners. In explaining the rationale for this, IRTA states in the Final Report:

The feedback from the consumers was not included . . . because the consumers indicated that 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.*

Since only the detailers and car washes were asked to compare the performance of the alternatives to their existing cleaners—and those existing cleaners were water-based bulk cleaners, not solvent-based aerosols—the performance of the alternatives was never compared to the proper baseline.

The results of the field-testing of engine degreasers are presented in Table 3-10. In this application, only New Image and “consumer 2” evaluated each of the eight alternatives, but only five of the potential evaluations were not performed. Again, the table presents the number of testers, percentage of total testers, number and percentage of testers finding the alternatives to provide adequate cleaning, and the minimum, maximum, and average ratings of the comparative efficacy of the alternatives. Note, however, because consumers’ responses were not included in the comparative ratings, two sets of numbers are presented in the first two columns of Table 3-10. The first number reflects participation in the adequacy evaluation; the second reflects participation in the comparative ranking. Three of the alternatives received adequate designations from all evaluators, but the average comparative rankings for two of the alternative cleaners (Foamy Engine Brite and AX-IT 1-7768) relative to the water-based bulk cleaners were 1.25 and 1.00, respectively. The average efficacy ranking for the third (Scrub Tub) was 2 (same as the cleaner currently being used). As with the other applications, there was considerable variation in the efficacy ratings between evaluators. This can be seen from the results for the Kyzen products, where an individual product received poor or marginal ratings as well as ratings that indicated it was superior to existing cleaners. In this case, however, this variation may be due to the fact that performance is being compared to a variety of water-based bulk cleaners, rather than solvent-based aerosols.

3.5 Other Work by IRTA During the Study

As noted above, IRTA did prepare the Final Report specified in the RFP. Based on the RFP, however, the start date of the project should have been June 2002 and, given the project schedule, the Final Report should have been completed around the end of 2003. The actual date of the Final Report is December 2004 and was approved by CARB’s Research Screening Committee on February 28, 2005.

* i.e., the rankings of relative efficacy

Table 3-10						
Summary of Results from IRTA Field-Testing of Alternative Engine Degreasers						
Alternative	No. of Testers	% of Total Testers	Adequacy	Min	Rankings Max	Avg.
Foamy Engine Brite	7/4	100/100	7 (100)	1	2	1.25
Simple Green	7/4	100/100	5 (71)	0.5	2.5	1.50
Mirachem All Surface	7/4	100/100	5 (71)	1	2	1.25
AX-IT L-7768	7/4	100	7 (100)	1	1	1.00
Scrub Tub	4/3	57/75	4 (100)	2	2	2.00
Kyzen Aerosol Cleaner	7/4	100/100	4 (57)	0	2.5	1.12
Kyzen Aerosol Degreaser 11	5/2	71/50	4 (80)	0.5	2.5	1.50
Kyzen Engine Degreaser 2	7/4	100/100	6 (86)	0	2.5	1.50

In addition to the descriptions of the cleaner testing, the Final Report includes a chapter comparing the cost and toxicity of current and alternative cleaning products. We have not included the material in that chapter in our review.

Finally, the seminar specified in the RFP was conducted by Katy Wolf of IRTA at CARB's office in Sacramento in October 2005.^{12,13} There is nothing in the presentation materials used by Wolf that differs from the information contained in the IRTA reports.

3.6 IRTA and CARB Conclusions

The conclusions reached by IRTA are contained in the Executive Summary of the Final Report and in their entirety are as follows:

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 water-based cleaners, the VOC content of the alternative products would be near-zero.

In presenting the IRTA Final Report to the Research Screening Committee for approval on February 28, 2005 CARB staff¹⁴ stated:

The program demonstrated the technological feasibility of water-based aerosol automotive parts cleaners as well as the feasibility of using exempt solvents for the same purpose.

In apparent reliance on the IRTA study and the above finding, CARB staff has recently proposed VOC content limits of 10% by weight for engine degreasers and brake, fuel and carburetor cleaners and 15% by weight for general purpose aerosol degreasers.¹⁵ As noted to some extent above and in much greater detail in the following section of this report, the conclusions reached by IRTA and CARB are simply not supported by the IRTA study. It follows directly that the IRTA study provides an inadequate basis for any regulatory effort that would ban existing cleaners based on the presumption that equally efficacious low-VOC products have been demonstrated.

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4. FINDINGS FROM REVIEW OF THE IRTA STUDY

In this section, issues associated with the methodology, execution, and data analysis of the IRTA study are identified and discussed. As indicated below, there were a number of significant issues associated with the IRTA study, all of which adversely affected the veracity of IRTA's assessment of alternative cleaners and the conclusions drawn from the study by both IRTA and CARB.

4.1 Potential For Bias Favoring Alternative Cleaners

Although CARB staff clearly selected IRTA to perform this study, it isn't clear that IRTA represented an organization capable of performing an independent and unbiased evaluation of solvent-based and alternative automotive aerosol cleaners. Evidence of a bias toward alternative cleaners can be found on IRTA's website.¹⁶ That website indicates that IRTA is a non-profit organization whose stated goals include reducing and eliminating the use of ozone-depleting, chlorinated, and other solvents. In addition, IRTA sees its mission as identifying, testing, and implementing low- and non-solvent alternatives, as well as demonstrating existing and emerging technologies for reducing or eliminating solvent use. The website also contains a large number of publications related to projects where the project goal was to demonstrate that there was an alternative to existing solvent-based products. While there is no evidence that there was any intentional bias introduced into the study by IRTA, there are a number of areas where unintentional bias could have affected the study. This issue could have been precluded if IRTA had taken affirmative steps to prevent any such bias; however, there is no discussion of this issue in any of the IRTA documents related to this project, nor do the IRTA documents provide sufficient information to reach a conclusion regarding potential bias of the study toward alternative cleaners.

One area where bias could have occurred was in selecting facilities to participate in the study. As noted in Section 3, there is no information available regarding how the repair facilities, detailers, car wash, and consumers involved in the study were selected for participation in the study or "recruited." Although it appears that there were no financial incentives provided to participants, this is not clear. About all that is known are their names; the type of shop; and that they were all located in southern California, with most located in the Santa Monica area.

One may speculate that the lack of any description of the process for identifying facilities as potential evaluators in the IRTA report means that most, if not all, of the facilities were

already known to IRTA and perhaps had been involved in previous IRTA projects. This in turn leads to a key question that cannot be answered based on the information available from IRTA, which is whether any of the study participants had previous experience with and/or previously expressed a preference for alternative cleaners. If so, it would be difficult to claim that these participants were representative of automotive maintenance and repair facilities. Further, IRTA could have rendered this point moot simply by providing a description of how the participating facilities and the three individual consumers were selected.

Another area where bias could have been introduced into the study is through any briefings and instructions that were provided to the operators of the automotive maintenance and repair facilities that evaluated the alternative products and their technicians. There is no information in the IRTA reports regarding what the facility operators and technicians participating in the IRTA field-testing were told regarding the purpose of the IRTA study, the alternatives that they were testing, or the solvent aerosols they were currently using.

Obviously, what the technicians were told about the study and the alternatives could have biased their evaluation of the efficacy of the alternative cleaners both in terms of “adequacy” as well as performance relative to existing solvent cleaners. For example, if technicians were told that the alternatives were safer, less polluting, or more “environmentally friendly” than existing solvent-based cleaners, they might have been inclined to rate the performance of the alternatives more favorably than they would have if they had received neutral instructions and information. Again, this key question regarding the potential introduction of bias towards alternative cleaners into the study cannot be answered based on the information available in the IRTA reports. Also, once again, this issue could have been rendered moot by IRTA had details regarding the information and instructions provided to study participants been documented and included in the IRTA Final Report.

A third area where bias favoring alternative cleaners could have been introduced into the study is through the data collection process. As noted in the IRTA Final Report, except in one instance technicians participating in the study *did not* fill out the survey forms that represent the “results” of the study. Instead, these survey forms are reported to have been filled out by IRTA personnel through questioning of the technicians that was generally performed on a weekly basis. Once again, there is no information available in the IRTA reports about what instructions, if any, were given to the IRTA personnel performing the data collection.

As noted above, IRTA’s stated goal is essentially the elimination of solvent-based cleaners. One would expect that IRTA personnel involved in the data collection shared that goal and that their convictions may have unintentionally influenced data collection. This could have occurred in many ways during the conversations that had to take place given that IRTA personnel verbally collected data from the study participants. This issue could have been rendered moot by having the technicians evaluating the alternative cleaners fill out the survey forms themselves (even if it meant providing financial or other

incentives to do so) or could have been minimized if IRTA had documented that the persons collecting data were instructed not to engage in conversations with the participants beyond those required for data collection.

In summary, given IRTA's stated goal of reducing or eliminating the use of solvents and the historical fact that IRTA's primary activity is to demonstrate alternatives to solvents, a potential conflict existed that may have biased the results of the study to favor those alternatives. As described above, there were a number of steps that IRTA could have taken to ensure an independent and unbiased study, but did not.

4.2 Deviations from the CARB RFP, Stated IRTA Methodology, and Reasonable Practices Undermine the Study Results

While it is common for issues to arise in research programs that necessitate deviations from the original research plan—in this case, the CARB RFP or the methodology being used in the study—IRTA made a large number of such changes that have no apparent justification and that confuse and undermine the study results. These include those outlined below.

1. IRTA selected four existing aerosol cleaners for evaluation despite a lack of data indicating that they met IRTA's stated criteria for water content or VOC content.
2. IRTA failed to include an existing alternative aerosol cleaner (Wynn's Engine Degreaser) simply because the manufacturer wouldn't provide free samples.
3. IRTA included non-aerosol water-based cleaners for evaluation in the study without any evidence that the cleaners could be successfully aerosolized. While the CARB RFP allowed for evaluation of cleaners that were not available in aerosol form under Task 1, it also required that IRTA provide assurances that these cleaners could be successfully aerosolized while maintaining product efficacy. IRTA failed to successfully aerosolize the products originally listed in Table 3-2 of the Final Report for brake cleaning and general degreasing and ended up testing only a limited number of reformulated products. This issue is particularly important because, despite the clear failure of IRTA to successfully aerosolize the water-based cleaners it identified, CARB staff's presentation of the study to the Research Screening Committee stated that the study "*demonstrated the technological feasibility of water-based aerosol automotive parts cleaners.*" Rather, the study results are in direct contradiction of CARB staff's statement.
4. IRTA ignored its own stated criteria for selecting alternatives for field-testing by including four alternative cleaners that performed poorly in the laboratory and field screening.

5. IRTA generally abandoned the alternatives selected for use in the field-testing based on the results of the laboratory and field screening process.
6. Despite the requirement in the CARB RFP, IRTA failed to justify why 12 repair facilities was an appropriate minimum number for the study; did not explain why those facilities are representative of California automotive repair and maintenance facilities; failed to explain why it was appropriate for different numbers of technicians to be involved at different facilities; and failed to explain why it was appropriate that all of the products were not tested by all of the technicians, or even all of the facilities. Further, IRTA provided no rationale for the results of its evaluation of brake cleaners and general degreasers being either valid or reasonable given that fewer than 35% of the potential evaluations of those products actually occurred. Given these issues, results of the IRTA study simply do not form a reasonable basis upon which to compare the performance of those cleaners to solvent aerosol cleaners.
7. IRTA selected detailers and car washes for field-testing that don't use solvent or even aerosol engine degreasers to evaluate alternative aerosol degreasers. Although IRTA explained that these types of maintenance facilities frequently clean engines and understood that they did not use aerosol cleaners of any kind, IRTA provided no justification for why it made any sense to include them in an evaluation of aerosol cleaners.
8. IRTA enlisted only three consumers, using an undisclosed selection criteria, to evaluate aerosol engine degreasers and even then failed to have these consumers directly compare the performance of solvent and alternative engine degreasers.
9. IRTA performed limited testing with blended soy acetone cleaners and virtually no testing with straight acetone-based cleaners, yet claimed that they were viable alternatives for solvent-based aerosols used in carburetor and brake cleaning as well as general degreasing. In fact, as shown in Table 3-7 of this report, soy acetone blends were actually evaluated in less than 20% of the potential evaluations as brake cleaners and all were rated as less effective than existing cleaners. Acetone was rated in brake cleaning applications by only 2 of 31 technicians. Similar facts exist with respect to soy acetone and acetone in general degreasing applications, as was shown in Table 3-8. In the carburetor cleaning application, the soy acetone blends were actually evaluated in just over 50% of the potential evaluations and found to leave oily residues that required either wiping that would not have to be done with an aerosol solvent or recleaning of the surface with an existing commercial acetone product not included in the test program. Acetone itself was not evaluated in the carburetor cleaning application.
10. IRTA failed, as specified in Task 4 of the CARB RFP, to evaluate cleaner performance using rating criteria that included "volume used per product" in

cleaning, “residue,” “cleaning time,” or “drying time.” Although IRTA developed two numeric rating scales for the adequacy of the cleaning performance of alternatives and for use in comparing the performance of alternatives to aerosol solvents, both of these scales were merely attempts to quantify the subjective opinions of the evaluators regarding cleaning efficacy. IRTA’s failure in this regard could have been remedied by the use of standardized laboratory tests, and such testing was in fact suggested to IRTA.^{17,18} The suggested test protocols¹⁹ would have allowed the quantitative determination of the mass of baked-on oil and greasy oil soils removed by a known weight of cleaner during a 10-second application of the cleaner.

CARB staff apparently recognized the value of supplementing the field-testing with quantitative laboratory testing,²⁰ but also noted that the project had “budgetary constraints.” For its part, IRTA flatly rejected this laboratory testing, stating, among other things, that there were “no written standards or criteria for determining scoring of the test results for individual products in the test.” IRTA’s resistance to quantitative laboratory testing is curious as it does not appear that IRTA provided any written criteria or documentation to any of the technicians involved in the field-testing. In addition, knowing the mass of similar soils removed by known amounts of two different cleaners during a 10-second application seems to provide a better means of characterizing cleaner efficacy than asking technicians to differentiate, sometime after the fact, between performance that was “almost as good as current cleaner” or “nearly as good as current cleaner.”

Although the impacts of some of these issues are discussed in more detail below, the reliance of the IRTA study on subjective and incomplete evaluations, coupled with the fact that IRTA eschewed suggested quantitative laboratory tests, is a major flaw that seriously undermines the study and its conclusions. More specifically, items 7 and 8 above make it clear that there was never any testing performed that compared the performance of solvent-based engine degreasers relative to the alternatives. Therefore, no valid conclusions regarding the performance of alternative engine degreasers relative to solvent-based engine degreasers can be drawn from the study. Similarly, as is clear from item 9 above, the limited testing of soy acetone and acetone blends performed in the IRTA study falls far short of what would be required to deem them as technically feasible alternatives to solvent-based cleaners.

4.3 IRTA Failed to Properly Design the Field-Testing Program

The purpose of the field-testing program was to compare the efficacy of the alternative cleaners identified by IRTA with that of existing solvent-based aerosol cleaners. Given this, one would have expected that IRTA would have taken steps to develop a methodology for ensuring that shops and technicians selected to participate in the field test were representative of the shops and technicians who actually use aerosol automotive

cleaners. Secondly, one would have expected that IRTA would have developed a data collection and evaluation plan that included a data quality assurance and quality control component. These are basic steps in the general design of field-testing and survey programs, including programs intended to evaluate emission control programs at automotive repair facilities in California such as the California Smog Check Program.^{21,22}

With respect to ensuring the representativeness of field study participants, IRTA somehow selected 13 southern California automotive maintenance and repair facilities, 3 auto detailers, 1 car wash, and 3 consumers to participate in the field-testing; and apparently believed that these participants were representative of users of automotive aerosol cleaners in California. To put the population of automotive aerosol users of California into perspective, according to the California Bureau of Automotive Repair²³ there are 35,917 licensed automotive repair dealers, Smog Check Stations, lamp and brake stations, and tire shops in California. Of these 35,917 facilities, 7,528 were reported to have a Smog Check station and 2,018 had brake or lamp stations. While data on the number of government, private, and utility fleet vehicle maintenance and repair facilities do not appear to be available; we estimate that there are at least a few hundred such facilities in California. In addition, there are approximately 2,800 auto detailers and car washes in California²⁴ and, based on the 2000 U.S. Census, approximately 34,000,000 California consumers.²⁵

While it is obviously impossible for IRTA to have included all California users of aerosol automotive cleaners in the evaluation of alternative cleaners, it was important that the facilities and consumers involved in the testing be representative of the entire population of users of these products. In order to ensure this, IRTA's field test study design should have included, at a minimum, an assessment of the number of the four types of automotive maintenance and repair facilities in California specified in the RFP (i.e., general maintenance and repair shops, service stations, dealerships, and dedicated brake repair facilities), as well as the amounts of the four product types specified in the RFP (brake cleaners, carburetor cleaners, engine degreasers, and general purpose degreasers) used at each type of facility. In addition, to help ensure that participants were not biased toward or against alternatives, the design should have included a mechanism for soliciting the participation of randomly selected facilities of each type. While some sort of limitation on the geographic area in which selected facilities would be located may have been reasonable, it should have been explicitly stated and justified.

Turning to the issue of a data collection and analysis plan, IRTA's data collection and analysis plan for the field-testing as set forth in its entirety in the September 2003 Task 3 Interim Report was as follows:

Each of the facilities will test the alternative cleaners on their regular cleaning jobs. IRTA staff will visit the facilities weekly to ask about the performance of the cleaners and cleaner/propellant combinations. During the interviews, several different types of information for each of the cleaners tested in the field will be collected, including:

- *does the cleaner perform as well as, better than or not as well as your currently used product?*
- *does the cleaner perform differently for brake cleaning, engine degreasing or general purpose degreasing?*
- *was there a preference for the foaming or non-foaming version of the cleaner?*
- *which propellant performs the best?*
- *what are the advantages and disadvantages of the cleaner?*
- *which of the alternative cleaners did the technicians like the best and why?*
- *would you be willing to switch to the alternative cleaners?*

There was no further discussion of how these data would be analyzed to evaluate the viability of the alternative cleaners as substitutes for solvent-based cleaners. Ultimately, the IRTA “Automotive Aerosol Field-Testing Interview” form found in Appendix C of the IRTA final report included the following 18 questions that were asked only with regard to the performance of alternative cleaners:

1. Did it clean sufficiently?
2. Did you like the delivery rate?
3. Did you like the delivery pattern?
4. Did it dry sufficiently?
5. Did it adversely affect substrates? (metals, plastics, painted surfaces, etc)
6. Did the product have a smell?
7. Did it have an objectionable odor?
8. Did it leave an unacceptable residue?
9. Did it have too much foam?
10. Cleaning versus current product (terrible, almost as good, as good, better)
11. Did you use more volume than your current cleaner?
12. Did it take longer to clean?
13. Did you like the product?
14. Would you buy the test product?
15. Would you buy the test product for home or personal use?
16. Would you buy your current product for home or personal use?
17. Would you switch to the test product? (if less expensive, if more expensive)
18. Could you clean adequately if you had only the test product?

Although it appears that each “Automotive Aerosol Field-Testing Interview” form completed during the field-testing is included in the Addendum to the Final Report, it isn’t possible to determine from the Final Report how the data were used in evaluating the performance of alternative cleaners. For example, IRTA doesn’t indicate if the “adequacy” of the alternative cleaners—which is discussed in the Final Report in terms of a 0 or 1 rating based on whether the cleaner “did not work” or “was adequate”—was based on responses to question 1, question 18, both questions, or some combination of

these and other questions. Similarly, it isn't clear which question or combination of questions was used by IRTA to arrive at the rankings used to determine the relative performance of alternative cleaners to the current solvent cleaners that are listed in Table 3-6 of this report.

Normally, one would expect data of the type collected by IRTA to be input into a database or statistical software program and that the responses would be analyzed using some sort of statistical methods, with the results being evaluated in light of some sort of pre-established criteria for determining adequacy or relative efficacy. Furthermore, the relationship between the data actually collected and the numeric ratings in the tables of the Final Report cannot be established.

Returning to the data collection and analysis plan, such plans generally include an estimate of the amount of data that will be required in order to arrive at a robust conclusion. This type of estimate is what the CARB RFP appears to have been seeking in the "minimum number of AMR facilities" discussed under Task 3. Clearly there should have been some statistical basis for establishing the minimum number of facilities (i.e., the survey sample size) included in the study other than what appears to have been the number that IRTA could readily enlist. Similarly, the plan should have indicated, again relying on a statistical justification, whether it was necessary for all of the products to be tested by all of the evaluators and provided a means for establishing if the unbalanced evaluations that actually took place would render the results of the data analysis meaningless.

As also noted above, one would also expect the data collection and analysis plan to include a data quality assurance and quality control component. Two important aspects of this component of the plan would be to determine the variability of the evaluation of a given cleaner by an individual tester and to address the issue of whether or not a control should be used to establish the actual performance of solvent-based cleaners. The variability could have been assessed, for example, by blinding participants to the cleaners being evaluated (e.g., by labeling the cleaners generically as A, B, and C without disclosing their actual names), and including the same cleaner twice (e.g., labeled as A and C). Similarly, inclusion of solvent-based cleaners among the "alternatives" would have provided another means independent of the evaluators' perception of the performance of their existing cleaner for evaluating the comparative efficacy of the alternative and solvent-based cleaners.

Given that IRTA failed to ensure that the evaluators used in the field study were representative and that there is no analysis showing how the data collected support the conclusion reached by IRTA, those conclusions cannot be relied upon.

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5. REFERENCES

1. California Air Resources Board RFP #01-371, January 24, 2002.
2. See <http://www.arb.ca.gov/consprod/regs/regs.htm>
3. California Air Resources Board, Planned Air Pollution Research, Fiscal Year 2001-2002, July 2001.
4. See <http://www.arb.ca.gov/research/rsc/Apr02Act.htm>
5. See <http://www.arb.ca.gov/research/rsc/2-28-05/feb05act.pdf>
6. Advanced Agenda, CARB Research Screening Committee Meeting, February 28, 2005.
7. Morris, M. and Wolf, K., "Alternatives to Automotive Consumer Products that use Volatile Organic Compounds (VOC) and/or Chlorinated Organic Compound Solvents: Task 1 Plan," September 30, 2002.
8. Morris, M. Wolf K., and Zavadil, J., "Alternatives to Automotive Consumer Products that use Volatile Organic Compounds (VOC) and/or Chlorinated Organic Compound Solvents: Task 3 Interim Report," April 25, 2003.
9. Morris, M. Wolf K., and Zavadil, J., "Alternatives to Automotive Consumer Products that use Volatile Organic Compounds (VOC) and/or Chlorinated Organic Compound Solvents: Task 3 Interim Report," September 15, 2003.
10. Zavadil, J., Wolf, K., and Morris, M., "Alternatives to Automotive Consumer Products that use Volatile Organic Compounds (VOC) and/or Chlorinated Organic Compound Solvents," Prepared for California Air Resources Board and California Environmental Protection Agency Under Contract 01-317, December 2004.
11. Zavadil, J., Wolf, K., and Morris, M., "Safer Alternatives to Solvent Aerosol Automotive Cleaning Products," Prepared for State of California Health and Human Services Agency Under Agreement 01-16384, December 2004.
12. See <http://www.arb.ca.gov/research/seminars/wolf/wolf.htm>

13. See <ftp://ftp.arb.ca.gov/carbis/research/seminars/wolf/wolf.pdf>
14. Advanced Agenda, CARB Research Screening Committee Meeting, February 28, 2005.
15. See <http://www.arb.ca.gov/consprod/regact/cpwg2006/2cats.pdf>
16. See <http://www.irta.us/> and an older version of the website at <http://home.earthlink.net/~irta/>
17. Letter from D. Douglas Fratz of the Consumer Specialty Products Association and Andrew Hackman of the Automotive Specialty Products Alliance to Kevin Cleary of CARB's Research Division, August 26, 2003.
18. Letter from D. Douglas Fratz of the Consumer Specialty Products Association and Andrew Hackman of the Automotive Specialty Products Alliance to Kevin Cleary of CARB's Research Division, September 9, 2003.
19. "Engine, General Purpose, and Brake Cleaning Test Methods" transmitted by D. Douglas Fratz of the Consumer Specialty Products Association and Andrew Hackman of the Automotive Specialty Products Alliance to CARB, August 2003.
20. Letter from Kevin Cleary of CARB's Research Division to D. Douglas Fratz of the Consumer Specialty Products Association and Andrew Hackman of the Automotive Specialty Products Alliance, September 30, 2003.
21. Sierra Research, "Test Plan for the Second I/M Evaluation," Prepared for the California Air Resources Board, Mobile Source Division, December 6, 1990.
22. "Evaluation of the California Smog Check Program and Recommendations for Program Improvements: Fourth Report to the Legislature," February 16, 1993.
23. Letter from Julie Mellixa, California Bureau of Automotive Repair to Gabe McAuliffe, Sierra Research, August 4, 2006.
24. See <http://yellowpages.superpages.com/listings.jsp?C=auto+detailers&N=&STYPE=S&CID=&scale=&lng=&lat=&L=CA&search=Find+It>
25. See <http://www.census.gov/population/projections/PressTab1.xls>

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