RESEARCH
Fellowship

GreenEarth® Cleaning
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GREENEARTH® FELLOWSHIP

EXECUTIVE SUMMARY

IFI was contracted by GreenEarth® Cleaning for comprehensive testing and evaluation of its drycleaning system in comparison to perchloroethylene drycleaning.[1] The solvent system used in the GreenEarth® process was developed jointly with General Electric[2] and is a "siloxane"—that is, a solvent in the silicone family.

Any new cleaning process must not only prove itself independently but must show that it compares favorably to existing cleaning systems. Perc systems, of course, do an excellent job of cleaning clothes and are the most widely used systems today. In today's world, however, evaluation of a new process needs to go beyond just cleaning performance and affordability. Specifically, any proposed new process must get good marks on health and contamination issues, the two areas of greatest concern to our industry—and if an alternative cleaning system has problems in either of these areas, there would be no compelling reason to change.

As noted above, the GreenEarth® cleaning process was compared directly to a well-run perchloroethylene system and to IFI's cleaning performance ratings for more than 2,000 plants. To help members with this comparison, we have summarized all of our data and research work into ratings on six criteria and averaged the ratings for each solvent. In doing this, IFI assigned equal value to each criterion—but it was a subjective decision to weight each criterion evenly. You may feel that some criteria are more important based on your business needs and therefore, may wish to weight the criteria differently.

Based on our overall evaluations, IFI's findings are that GreenEarth® Cleaning is a viable alternative for the drycleaning industry, and while different in some respects, is comparable to a perc drycleaning process.

	GreenEarth®	Perc
A. Cleaning Performance	★★★★½	★★★★★
B. Handle Garments you currently process	★★★★★	★★★★½
C. Affordable/Operating Costs*	★★★½☆	★★★★★
D. Realistic Capital Costs	★★★★☆	★★★★★
E. Health Issues†	★★★★☆	★★☆☆☆
F. Contamination Issue†	★★★★☆	★★☆☆☆
Overall	★★★★½	★★★★½

* Reduced regulatory costs, depending on your state, could increase the rating for GreenEarth® to 4 stars or slightly higher—see Section C, pgs. 10–11.
† The GreenEarth® ratings could increase to 5 stars—see "E" and "F" on pg. 2.

A. Cleaning Performance

The GreenEarth® process with detergent J101 consistently received excellent or good ratings on IFI's Cleaning Performance Test (CPT). In terms of stain removal, the GreenEarth® process is not quite as effective as perchloroethylene but it is comparable, particularly in terms of water-soluble stain removal. Except for ballpoint ink and shoe polish stains, GreenEarth® and perc systems were directly comparable in terms of those stains where 100% removal was found.

[1] This Fellowship report is specific to GreenEarth® solvent and the J101 detergent as run in a Union Model HL850 machine. As with any drycleaning solvent system (including perchloroethylene) performance could be better, the same, or worse with another detergent or if used in a different cleaning machine.

[2] GreenEarth® Solutions, LLC is the owner of the GreenEarth registered trademark. GreenEarth® Solutions is a joint venture between GreenEarth® Cleaning, GE Silicones, and Procter & Gamble.

B. Will Handle Garments You Currently Dryclean

GreenEarth® can handle a wide variety of specialty items such as beads, sequins, metallics, etc., without causing damage, and that is the reason it received a higher rating than perchloroethylene drycleaning. It can expand the type and variety of garments a drycleaning plant can process.

C. Has Realistic/Affordable Labor and Operating Costs

One of the goals of the Fellowship was to look at how realistic labor and operating costs were with the GreenEarth® process. On the basis of solvent costs, detergent costs, and a licensing fee, the GreenEarth® process has a higher operating cost than perc but is still within a realistic range. At the same time, costs related to regulatory compliance will be lower. Other operating costs would be comparable to that of a perc operation since they are independent of the solvent used.

The type of work can vary considerably from plant to plant and will greatly affect your labor costs. IFI was able to do a side-by-side comparison and concluded that labor costs should be comparable between perchloroethylene and GreenEarth® processing. Labor components that would be affected by the solvent used are those involved in stain removal and finishing. As mentioned above, since the overall stain removal results are comparable, the labor should not increase in this area. In regards to finishing, there was a slight increase in finishing times, but again it was not significant and probably due to the garment type requiring a "hard" finish since the test was performed during the summer season. With heavier mid-season/winter garments, we would not expect any differences in finishing time. There is less lint and static electricity with garments processed in the GreenEarth® system, which facilitates finishing.

D. Has Realistic Capital Costs

In testing GreenEarth® we used a higher-end Union dry-to-dry Class IIIA drycleaning machine, which is normally higher in cost than dry-to-dry refrigerated perchloroethylene machines. However, less expensive Class IIIA machines are available.

E. Has No Known or Expected Health Issues

We all know the health issue surrounding perc. And, in this case, because of the negative "perception," not whether we agree with that perception, perc only receives a rating of 2. The data, studies, and current information on GreenEarth® solvent do not indicate any potential health issues. GreenEarth® and GE expect a favorable EPA review of a two-year cancer study in rats late this year. If this occurs as expected, then the rating would rise to a 5.

F. Will Not Create Water or Soil Contamination

Perchloroethylene drycleaning could and has resulted in soil and water contamination. If handled with today's safeguards, contamination may be greatly minimized, possibly even eliminated, but in some cases there is still some potential. GreenEarth® and GE also expect that EPA will classify GreenEarth® solvent as a benign contaminant that would not normally need to be cleaned up if it is found in soil or groundwater. If this occurs, the rating here would also raise to a 5.

Left: IFI evaulated GreenEarth® using a higher-end dry-to-dry Class IIIA drycleaning machine, a Union Model HL850.

Middle: The GreenEarth® solvent is a clear, odorless silicone-based liquid.

Right: J101, the detergent used in testing, was developed by GreenEarth® Cleaning in cooperation with Procter & Gamble.

THE GREENEARTH® PROCESS

Solvent: The GreenEarth® solvent (GE's designation is SB32) is a clear, odorless silicone-based liquid generally referred to as D5; the full chemical name is decamethylecyclopentasiloxane. IFI evaluated a number of solvent parameters according to ASTM standard test methods. All tested parameters conducted on GreenEarth® solvent meet ASTM specifications for a drycleaning grade Class IIIA solvent. Because there has been some question as to whether solvents with a flashpoint would exhibit a change in flashpoint after repeated use and distillation, IFI tested a sample at the end of the testing. The flashpoint did not change.

ASTM Test Methods	***GreenEarth® Solvent Parameters***
• Specific Gravity (ASTM D2111)	0.958 at 20°C (68°F)
• Flashpoint by Fisher Open Tag Tester (ASTM D56)	170°F
(Flashpoint of distilled solvent after 3,600 lbs. cleaned)	170°F
• Copper Corrosion Test according to ASTM D130 *Copper corrosion test determines if a solvent has the potential to corrode machine parts such as solvent tanks and condenser.*	1B (dark orange)
• Non-Volatile Residue (ASTM D2109) *Non-volatile residue (NVR) test determines how much the pure (no cleaning additive) solvent contributes to the total NVR of the working wash solvent.*	0.05 grams/liter
• Residual Odor Test (IFI Method as contained in ASTM D1296)	None
• Distillation Range (ASTM D86) *Distillation range is an excellent indicator of temperatures that will occur in the vacuum still during distillation.*	Initial boiling point: 386°F End point: 400°F

GREENEARTH® PROCESS CONDITIONS

Machine

A 50 lb. refrigerated dry-to-dry Class IIIA (hydrocarbon) machine was used. The machine is equipped with three filter housings. Housing No. 1 contains a spin disc filter with 39 filter discs. Housing No. 2 is smaller and contains two standard size carbon core cartridges. This filter serves as an after-filter for solvent leaving the disc filter. Housing No. 3 consists of three adsorptive split cartridges and is engaged only during the pre-wash and drying cycle after the solvent passes through the other two filter housings.

Detergent

GreenEarth® Cleaning, in cooperation with the Procter & Gamble Company (P&G), developed the J101 detergent that was used for the GreenEarth® process testing. J101 detergent is a pale yellow liquid of which the chemical composition is still confidential. According to P&G, the detergent is environmentally safe to workers, consumers, and the environment when used as intended.

The J101 drycleaning detergent is predominantly non-ionic, which means there is no simple in-plant test method for determining detergent concentration. The J101 detergent is automatically injected into each load in specified amounts to keep a 1% concentration by volume (that is, 1 gal. of detergent per 100 gals. of solvent).

Cycle

The cleaning cycle used in testing was as follows:

Total cycle length:	**53-58 minutes depending on load**
Pre-wash:	**4 minutes**
Wash cycle:	**16 minutes**
Dry cycle:	**approximately 30 minutes depending on load**
Detergent concentration:	**1.0% volume/volume by injection, no water addition**
Load size:	**40 lbs., 80% of machine capacity**

Solvent was pumped from the working tank into the wheel for the four-minute pre-wash cycle. At the end of the cycle, the load was lightly extracted and the solvent was pumped into the still. During the pre-wash cycle, all three filters are engaged. Then the main wash of 16 minutes begins followed by light and high extraction cycles followed by drying. During the main wash cycle, the solvent from the distilled solvent tank is pumped into the wheel and the pre-measured amount of detergent is injected. During the first eight minutes of the wash cycle, no filters are engaged. During the final eight minutes, the disc and carbon core filters are engaged.

PERCHLOROETHYLENE PROCESS CONDITIONS

Machine

A 35-pound dry-to-dry no-vent refrigerated Class IV (perchloroethylene) machine with disc filtration was used for the stain removal, colorfastness, dimensional stability, and hand and appearance tests.

Detergent

One of the most popular anionic detergents was used at a 1% concentration by volume.

Cycle

Total cycle length:	**45 minutes**
Wash cycle:	**15 minutes**
Dry cycle:	**approximately 25 minutes depending on load**
Detergent concentration:	**1% volume/volume charge**
Relative humidity:	**adjusted to approximately 75% RH**
Load size:	**28 pounds, 80% of machine**

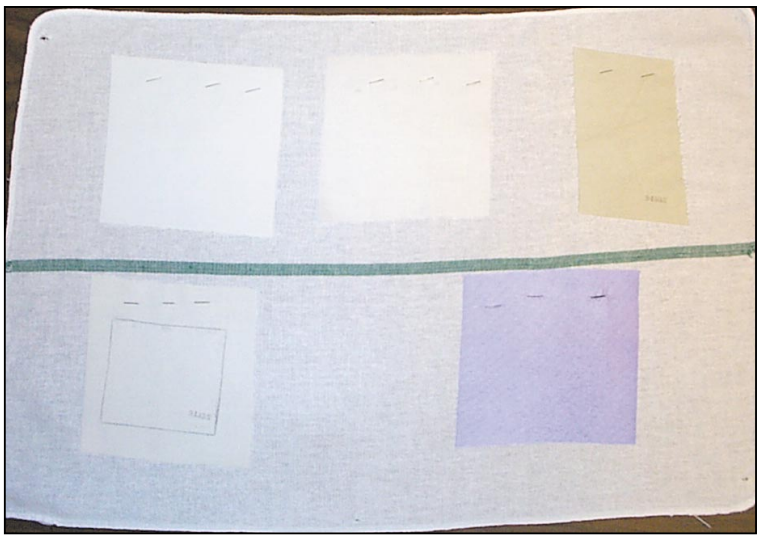
A single bath process was used, with continuous filtration over the entire 15-minute wash cycle.

A. DOES THE PROCESS CLEAN?

1. Cleaning Performance

IFI's Cleaning Performance Test (CPT) is designed to measure the degree of cleaning accomplished in a specific drycleaning system.

The CPT consists of five swatches (see picture at right). A 65/35 polyester/cotton swatch and a 100% cotton swatch measure graying, yellowing, and whiteness. A 100% cotton swatch containing rug soil evaluates solid insoluble soil removal. The remaining two swatches, a white acetate swatch treated with salt and a 100% polyester swatch treated with violet food dye, measure water-soluble soil removal.



The CPT swatches are run in light colored loads since dark fabrics carry more soil and dark lint has a disproportionate effect on the white CPT swatches. Also, dark fabrics are more apt to bleed dyes. Finally, the towels are pinned to garments, per IFI's procedure.

Results of the CPTs processed in the GreenEarth® system were evaluated against IFI's rating scale, which is based on more than 2,000 results from various drycleaning plants. Each category (Excellent, Good, Fair, and Poor) represents 25% of the test results.

IFI'S RATING SCALE FOR CLEANING PERFORMANCE TESTS									
Ranking	**% Graying**		**Yellowing**		**% Whiteness (Degree)**		**Water Soluble**		**Solid**
	Poly/Cotton	**Cotton**	**Poly/Cotton**	**Cotton**	**Poly/Cotton**	**Cotton**	**% Salt Removal**	**% Food Dye Removal**	**% Rug Soil Removal**
Excellent: Top 25%	0-4	0-3	Below 0	Below 0	91 or higher	95 or higher	33 or higher	91-100	87-100
Good: Upper Middle 25%	5	4-5	1	1	88-90	90-94	25-32	52-90	81-86
Fair: Lower Middle 25%	6	6	2	2	85-87	82-89	16-24	18-51	73-80
Poor: Bottom 25%	7 or higher	7 or higher	3 or higher	3 or higher	84 or lower	81 or lower	15 or lower	0-17	72 or lower

The first step was to look at how well the solvent cleans by itself.

CPT RESULTS: SOLVENT—NO DETERGENT			
Solvent	**Water-Soluble Soil Removal**		**Solid Soil Removal**
	% Salt Removal	*% Food Dye Removal*	*% Rug Soil Removal*
GreenEarth	11	0	76
Perc	8	0	80

There is no water-soluble soil removal and the only solid soil removal is that which is occurring because of mechanical action in the washwheel.

We then looked at how well GreenEarth® solvent and J101 detergent cleaned. IFI ran a total of 26 loads with three CPT swatches per load. The loads were comprised of customers' clothes from a Silver Spring, Maryland, cleaner.

CPT RESULTS: GREENEARTH® SOLVENT AND 1.0% J101 DETERGENT								
% Graying		**Yellowing**		**% Whiteness (Degree)**		**Water Soluble**		**Solid**
Poly/ Cotton	**Cotton**	**Poly/ Cotton**	**Cotton**	**Poly/ Cotton**	**Cotton**	**% Salt Removal**	**% Food Dye Removal**	**% Rug Soil Removal**
2.7	4.6	0.4	-1.3	96.3	101.2	24	86	89
Excellent	Good	Excellent	Excellent	Excellent	Excellent	Fair	Good	Excellent

HOW EACH OF THE INDIVIDUAL SWATCHES RANKS AMONG THE FOUR CATEGORIES FOR GREENEARTH® SOLVENT AND 1.0% J101 DETERGENT									
Ranking	**% Graying**		**Yellowing**		**% Whiteness (Degree)**		**Water Soluble**		**Solid**
	Poly/ Cotton	**Cotton**	**Poly/ Cotton**	**Cotton**	**Poly/ Cotton**	**Cotton**	**% Salt Removal**	**% Food Dye Removal**	**% Rug Soil Removal**
Excellent	26		14	26	26	26	4	11	26
Good		23	12				7	15	
Fair		3					10		
Poor							5		

Conclusion

The CPT results for the GreenEarth® process are very good. The results for all tests except % salt removal were in the excellent or good category. Just as important, the results from load to load were consistent. The salt swatch has high variability but has been retained in the IFI CPT only because of strong requests from members using the service.

2. Stain Removal Efficiency

The process's inherent ability to remove stains was evaluated using IFI stain swatches. The stains chosen to be evaluated represent the various classes of water-soluble, solvent-soluble, and combination stains that frequently appear on garments.

Water-Soluble		Solvent-Soluble	Insoluble	Combination
coffee	cola	ball point ink	pencil	chocolate
wine	blood	vegetable oil		lipstick
milk	ketchup	shoe polish		
grass	soy sauce			

The stains were applied to white or ivory-colored test fabrics of silk, wool, polyester, acetate, cotton, linen, and rayon. Multiple sets of stained fabrics were allowed to age at intervals of one day, three days, and three weeks. This represents ideal, typical, and extreme consumer behavior respectively. One set of fabrics was cleaned in the GreenEarth® process and the other set in perc drycleaning.

After cleaning, three independent evaluators compared the cleaned swatches to the original stained swatches and rated them using the following scale:

5: Stain completely removed (no visible trace)
4: Stain mostly removed
3: Stain slightly removed
2: Stain almost as original
1: Stain unchanged from original

Results

Table 1. Overall Stain Removal Ratings
(averaging the 14 stains on seven test fabrics together)

Solvent	1 Day	3 Days	3 Weeks	Overall Average
Perc	3.5	3.0	3.4	3.3
GreenEarth	3.0	3.1	2.9	3.0

Table 2. Average Individual Stains on All Fabrics

Aging Period	Solvent	Water-Soluble Stains									Solvent-Soluble Stains				Insoluble Stains	Combination Stains		
		Coffee	Wine	Milk	Grass	Cola	Blood	Ketchup	Soy Sauce	Average	Ball Point Ink	Veg. Oil	Shoe Polish	Average	Pencil	Chocolate	Lipstick	Average
1 Day	Perc	1.9	3.4	3.6	4.4	4.0	1.8	2.6	1.5	2.9	4.4	4.9	4.7	4.7	3.8	5.0	3.2	4.1
	GreenEarth	1.6	3.4	4.1	4.1	3.9	1.4	2.2	1.5	2.8	2.8	5.0	3.6	3.8	3.6	5.0	1.8	3.4
3 Day	Perc	1.6	3.2	2.7	2.9	3.9	1.4	1.4	1.2	2.3	4.3	5.0	4.6	4.6	2.3	4.7	2.5	3.6
	GreenEarth	2.2	3.9	3.6	2.6	4.0	2.6	2.0	1.8	2.8	1.6	5.0	3.9	3.5	2.6	5.0	2.3	3.7
3 Weeks	Perc	1.8	3.4	3.3	3.3	4.3	2.5	2.2	1.7	2.6	4.6	4.6	4.7	4.6	3.6	5.0	3.0	4.0
	GreenEarth	1.9	3.4	3.3	3.5	4.5	2.3	1.5	1.5	2.7	2.5	1.8	3.7	2.7	3.1	5.0	2.0	3.5

Table 3. Stains Completely Removed

Fabric	Perc			GreenEarth		
	1 Day	*3 Days*	*3 Weeks*	*1 Day*	*3 Days*	*3 Weeks*
Silk	Grass, lead pencil, veg. oil, shoe polish, chocolate Ink, veg. oil,	shoe polish, chocolate	Ink, chocolate	Grass, veg. oil, chocolate	Veg. oil, chocolate	Chocolate
Wool	Wine, grass, cola, ink, veg. oil, shoe polish, chocolate	Ink, veg. oil, shoe polish	Cola, ink, shoe polish, chocolate	Grass, veg. oil, shoe polish, chocolate	Veg. oil, shoe polish, chocolate	Grass, cola, chocolate
Polyester	Wine, grass, cola, veg. oil, chocolate	Wine, cola, ink, veg. oil, shoe polish, chocolate	Wine, cola, ink, shoe polish, chocolate	Wine, cola, veg. oil, chocolate	Wine, cola, veg. oil, chocolate	Wine, cola, chocolate
Acetate	Veg. oil, chocolate	Wine, veg. oil, chocolate	Cola, veg. oil, chocolate	Grass, veg. oil, chocolate	Wine, veg. oil, chocolate	Wine, cola, chocolate
Cotton	Milk, ink, shoe polish, veg. oil, chocolate	Veg. oil, shoe polish, chocolate	Ink, veg. oil, shoe polish, chocolate	Milk, veg. oil, chocolate	Veg. oil, chocolate	Milk, cola, chocolate
Linen	Ink, milk, veg. oil, chocolate	Milk, ink, veg. oil, chocolate	Veg. oil, shoe polish, chocolate	Milk, lead pencil, veg. oil, chocolate	Milk, veg. oil, chocolate	Shoe polish, chocolate
Rayon	Ink, veg. oil, shoe polish, chocolate	Ink, veg. oil, shoe polish	Ink, veg. oil, shoe polish, chocolate	Veg. oil, chocolate	Veg. oil, chocolate	Chocolate
Total	**32**	**26**	**25**	**23**	**19**	**16**
Without Shoe Polish & Ink	**24**	**16**	**15**	**22**	**18**	**15**

Conclusion

There is less than a 0.3 difference between the two processes when all the stain results are averaged (Table 1); differences less than 0.5 are not considered significant. Table 2 shows that the GreenEarth® process is comparable to a perc process in removing water-soluble stains but not as effective at removing solvent-soluble stains. With the differences in KB value, you would not expect GreenEarth® to be as effective as it is on solvent-soluble stains. (Perc's KB is 90 and GreenEarth's KB is less than 20. KB value is the measure of how well a solvent dissolves oils and other solvent-soluble materials.)

While we evaluated the degree of removal of each stain—and these are what make up our ratings—the key question in the real world is, "Were stains removed completely, or will I have to do additional spotting?" In Table 3, IFI shows which stains were completely removed. As we analyzed these results, we noted that two stains (ballpoint ink and shoe polish) essentially accounted for the entire difference between perc and GreenEarth®. In summary then, except for ballpoint ink (usually pre-spotted) and shoe polish (a relatively uncommon stain), perc and GreenEarth® were virtually identical in terms of the ability to remove stains completely.

B. WILL THE PROCESS HANDLE THE GARMENTS YOU CURRENTLY DRYCLEAN?

In order to answer this question colorfastness, dimensional change, appearance, and hand evaluations were done on a variety of fabrics and trims. Fabrics evaluated included wools, silks, cottons, rayons, acetates, linens, and lycra in a variety of colors, textures, and weaves. Trims evaluated included specialty buttons, sequins, fake fur, pearls, and rhinestones.

1. Colorfastness (shade change & dye bleeding)

Table 5. Shade Change Results
Average of 3 Evaluations
Standard: 4.0 Minimum
5.0: No Shade Change 1.0: Severe Shade Change

Fabric	Shade Change	
	Perc 3 Cycles	*GreenEarth 3 Cycles*
Blue acetate	5.0	5.0
Pink acetate	5.0	5.0
Green cashmere blend	5.0	5.0
Brown cashmere blend	5.0	5.0
Navy cashmere blend	5.0	5.0
Green cotton	4.8	4.7
Red cotton	5.0	5.0
Orange cotton	4.5	4.7
Light green cotton	4.3	4.7
Black fake fur	5.0	5.0
Brown fake fur	5.0	5.0
Light blue linen	4.8	5.0
Lavender linen	4.0	4.8
Olive green lycra	4.8	5.0
Light pink rayon	4.8	5.0
Light green rayon	5.0	5.0
Gold viscose rayon	5.0	4.8
Fuchsia rayon	5.0	5.0
Red print silk	5.0	5.0
Peach silk	5.0	5.0
Aqua silk	5.0	5.0
Fuchsia silk	5.0	5.0
Brown ultra suede	4.3	4.8
Green ultra suede	5.0	5.0
Green wool	5.0	5.0
Peach wool	5.0	5.0
Black wool with backing	*	5.0
Navy wool felt	5.0	5.0
Fuchsia wool	5.0	5.0

** Backing separated from face fabric after only one cycle so testing was discontinued.*

Shade Change

Shade change was visually evaluated by three independent evaluators using the American Association of Textile Chemists and Colorists Gray Scale of Shade Change. The AATCC Gray Scale evaluates the overall difference or contrast between the original fabric and the drycleaned fabric. The scale ranges from 1–5 with 5 being no shade change and 1, severe shade change.

Results

The minimum standard for most applications is a shade change of 4.0. After processing in either GreenEarth® or perc, none of the fabrics tested received a rating lower than 4.0. In fact, most of the fabrics tested showed no color loss after processing in either GreenEarth® or perchloroethylene.

Dye Bleeding

Another parameter of colorfastness evaluated was dye bleeding or dye staining. A multifiber swatch consisting of cotton, acetate, nylon, polyester, acrylic, and wool fiber strips was attached to the fabric. After processing in either GreenEarth® or perc, the swatch was visually evaluated against the AATCC Gray Scale for Staining. This scale ranges from Class 5 (no staining) to Class 1 (severe staining).

Results

Eight fabrics processed in GreenEarth® did receive a rating of 4.0 on at least one of the six sections of the multi-fibers bleeding swatch. In comparison, 15 of the fabrics processed in perc received at least one rating of 4.0. Additionally, four fabrics in perc received a rating of 3.5 on one of the sections of the multi-fiber swatch. The minimum standard for most applications is a rating of 4.0.

2. Dimensional Change

Dimensional change was assessed by measuring the fabric in inches prior to processing and again after three cycles in either GreenEarth® or perc drycleaning. The percentage difference is reported. An average of three measurements was assessed. A total of 26 different fabrics of various fiber contents was evaluated.

Table 6. Dimensional Change (%)
Standard: 2.0% Maximum

Fabric		Perc 3 Cycle	GreenEarth 3 Cycles
100% silk	Length	0.8	0.0
	Width	1.0	0.0
100% silk	Length	1.9	0.9
	Width	1.8	0.6
100% silk	Length	1.7	1.1
	Width	0.5	0.0
100% silk	Length	0.0	0.0
	Width	0.0	0.0
100% rayon	Length	1.0	0.0
	Width	1.5	0.0
100% rayon	Length	1.0	1.9
	Width	1.0	0.4
100% wool	Length	0.7	0.0
	Width	0.5	0.0
100% wool	Length	1.2	2.1
	Width	0.3	0.9
100% acetate	Length	0.5	0.8
	Width	0.7	0.7
100% acetate	Length	0.5	0.0
	Width	0.0	0.0
100% cotton	Length	1.7	1.5
	Width	2.1	1.0
100% cotton	Length	1.1	0.9
	Width	1.5	1.1
100% cotton	Length	0.4	1.0
	Width	0.1	0.4
100% cotton	Length	1.0	1.0
	Width	0.4	0.4
Lycra cotton blend	Length	3.1	2.3
	Width	+2.1	+1.1
100% lycra	Length	1.0	1.1
	Width	1.8	1.5
100% linen	Length	2.0	1.9
	Width	2.9	2.3
100% linen	Length	2.5	2.4
	Width	2.5	3.0
100% spandex	Length	2.3	0.0
	Width	0.7	0.0
100% rayon	Length	0.9	0.9
	Width	0.6	0.4
Ultrasuede	Length	1.7	1.4
	Width	0.9	0.9
Ultrasuede	Length	1.9	1.1
	Width	1.0	0.9
100% wool felt	Length	1.5	2.0
	Width	1.1	1.0
100% cashmere blend	Length	1.1	0.3
	Width	0.5	0.3
100% cashmere blend	Length	1.1	1.4
	Width	0.1	0.2
100% cotton	Length	0.4	1.0
	Width	0.1	0.4

Results

ASTM develops a variety of standards for textile products. ASTM D3778. A maximum shrinkage of 2.0% after three cleanings is acceptable for most garment applications.

Of the 26 fabrics tested, four fabrics exhibited slightly higher than 2.0% shrinkage after processing in GreenEarth® in either length or width. Five fabrics exhibited a change of slightly higher than 2.0% after processing in perc. In general, neither process is likely to result in excessive dimensional change of fabrics.

3. Hand and Appearance

Subjective evaluations of the appearance and hand or feel of the fabrics and trims were done by three independent evaluators. The evaluators compared the drycleaned samples, either perc or GreenEarth®, to the original fabric samples. Parameters looked for included stiffness, stickiness, slickness, softness, and damage.

Results

The majority of the fabrics tested had the same hand and appearance as the original fabric. The fabrics that exhibited any change after drycleaning in either solvent were those which contained a sizing. All of these fabrics had a softer (less stiff) hand after processing in perc or GreenEarth® and the change was to the same degree. A wool fabric with a urethane backing, was damaged after cleaning. The backing was softened after cleaning in GreenEarth® but after cleaning in perc, it was completely separated from the wool face fabric.

In all cases, the trims cleaned in GreenEarth® withstood processing better than those cleaned in the perc process. Some of the trims exhibited a slight loss of shine after several cleanings in GreenEarth® whereas in perc, the trim exhibited severe color and finish loss after only one cleaning.

In terms of zippers, while the zippers cleaned in perc exhibited very slight sticking, there was no change in the zippers processed in GreenEarth®.

A number of specialty fabrics identified to be more challenging for the cleaner were processed. These included fabrics with metallic yarns, applied glitter, rhinestones, coated fabrics, flocked fabrics, leather, and fake furs. Again, all of the specialty fabrics performed better in GreenEarth® processing than perchloroethylene. There was some loss of glitter on one fabric after three cycles in GreenEarth®, but perc drycleaning completely removed the glitter after only one cleaning. The leather sample lost excessive amounts of color after three cleanings in GreenEarth®, but this excessive color loss occurred with only one cleaning in perchloroethylene. After one cleaning in perc, the urethane fabric was completely stiff, while the fake fur was hard and the flocking was completely removed from another fabric. Some of the metallic fabrics exhibited a loss of color and/or finish and the laminated fabrics showed separation after one cleaning in perc. All of these fabrics withstood three cleanings in GreenEarth® without damage.

C. HAS REALISTIC/AFFORDABLE LABOR & OPERATING COSTS

When IFI looked at the total operating cost, we knew there were several factors in the process that could greatly affect the operating costs from one plant to another. Two of the greatest factors affecting operating cost are solvent mileage and supply expense. The type of equipment used, maintenance schedules, and the type of cleaning performed will have a great effect on solvent mileage, and this is true with the GreenEarth® process as well.

1. Labor Costs

There should not be significant differences in terms of labor between GreenEarth® processing and perchloroethylene processing. The only personnel that could be affected by the solvent used are the stain removal technician, the finishers, and machine maintenance personnel.

Although GreenEarth® is not quite as effective in removing some stains, the difference is not that significant that pre- or post-spotting should increase. GreenEarth's J101 detergent is effective at removing most water-soluble stains, which for most spotters are the more difficult stains to remove.

We compared the finishing times needed for 26 garments processed in perc vs. the same 26 garments processed in GreenEarth®.

The finishing times for garments processed in the two systems do not differ greatly. The plant's finishing personnel did comment that the garments that were processed in GreenEarth® took a little longer to finish, although as mentioned before these were primarily summer garments. With heavier mid-season/winter garments, we would not expect any differences in finishing time.

Combining the finishing times for all of the garments, we found the time for the garments processed in the perc system was 3.5 minutes faster than that for the GreenEarth® process. The garments processed in GreenEarth® are "softer" so those garments requiring a firmer finish may take a little extra time. Sizings are being developed for GreenEarth® but were unavailable at the time of testing.

The maintenance for the GreenEarth® machine is no different than that required for perc and/or petroleum machines; maintenance does not have to be done more frequently nor is it more difficult.

2. Operating Costs

Many factors figure into operating costs but we looked only at those parameters we decided could be different between the two processes—licensing fees, solvent and chemical costs, hazardous waste disposal, and regulatory costs.

Solvent & Chemical Costs

GreenEarth® solvent delivered is $15/gal., freight included. The average cost for perchloroethylene is $7/gal. in states where there is no solvent tax. In states where there is a solvent tax as part of the state drycleaning remediation program, a fee is added to the cost of perchloroethylene and could be as high as an additional $10/gal., or $17 total/gal. These are straight costs but a better way to look at solvent costs is to look at solvent mileage. The formula for solvent mileage is:

$$\text{Solvent Mileage} = \frac{\text{Lbs. clothes cleaned}}{\text{Gallons of solvent consumed}}$$

Solvent consumption occurs primarily because of 1) solvent lost as emission, and 2) solvent retained by the filters and still residue.

GreenEarth® solvent mileage during the IFI test was 38,902 lbs. cleaned/drum of solvent, or 707 lbs./gal. solvent. This solvent mileage is based on 3,600 lbs. cleaned and filter changes per the cleaning machine manufacturer's recommendation of 1,000 lbs. cleaned per split and 1,000 lbs. cleaned per carbon core. However, according to the filter pressure and solvent color, the filters did not have to be changed.

IFI's analysis found that after drying in the wheel the two carbon core cartridges retained a total of 0.045 gals. of solvent, and the three adsorptive split cartridges retained a total of 1.5 gals. of solvent. Still residue analysis shows that after 3,600 lbs. cleaned, there was a loss of 3.54 gals. of solvent. IFI found that the optimum frequency for still cleaning was at 400 lbs. cleaned. We attempted to run to 600 lbs., but distillation was slowed considerably and the still did not empty enough to allow the next wash cycle.

As we noted above, filter pressure had not increased indicating that we could have continued without changing the filters. GreenEarth® reports that in the field, operators are running three times longer before changing filters. Under those parameters, solvent mileage would increase to 48,601 lbs./drum or 884 lbs/gal. of solvent. Typical solvent mileage on a dry-to-dry refrigerated perc system will vary significantly depending on the type of filter wastes. For a perc system with the same type of filtration as our GreenEarth® system, we would expect the solvent mileages to be directly comparable.

Detergent costs are higher for the GreenEarth® process. For optimum cleaning, 15 oz. per cycle of detergent J101 is used, or 3.75 oz. per 10 lbs. The cost for J101 is $50-$55/gal., which works out to be a cost on average of $6.21 per load. In comparison, the average cost for a perc system using an injection detergent system, at 2 oz. per 10 lbs. at $30/gal., is $1.87 per load.

Other Costs

GreenEarth® charges an annual licensing fee of $2,500 for the first cleaning machine and $1,250 for any other additional cleaning machine at the same site. There is also a fee of $250 for any recovery dryers.

As described in Section F, GreenEarth® solvent itself and the still bottoms, cartridges, and separator water from the system are not hazardous wastes. GreenEarth® recommends that plants dispose of their waste in accordance with local regulations. If haz-

ardous waste disposal is *not* used, disposal costs would be virtually nothing. Even if a hazardous waste hauler is used, however, costs will be lower: GreenEarth® reports that haulers will handle the waste as non-hazardous at a 40% reduction in costs and that there is up to a 30% reduction in the quantity of still residue, with resulting savings.

Cost Summary

For a GreenEarth® operation similar to IFI's, detergent costs and the licensing fee would be higher than a perchloroethylene operation. Solvent costs would be higher with GreenEarth® in many states—but in those states with a solvent tax on perc but not GreenEarth®, the costs may be the same or lower for GreenEarth®.

On the other side of the ledger is an expected reduction in waste disposal costs, which will vary depending on your state. Additionally, there are other offsetting "soft" costs that are difficult to quantify. These would primarily be costs and fees associated with regulatory compliance that would no longer be needed with GreenEarth® as compared to a perc system. For example, with air regulations alone there would be an elimination of record keeping, testing, and of permit fees. Finally, there may be an elimination of other fees such as facility taxes or gross receipt taxes related to cleanup funds, depending on your state.

D. HAS FINANCIALLY REALISTIC CAPITAL COSTS

The machine used for GreenEarth® processing must be approved by GreenEarth®. The machines are a Class IIIA dry-to-dry machine and the cost is the same as that for petroleum solvent/hydrocarbon dry-to-dry machines. The cost for perc dry-to-dry machines is slightly lower.

The only other capital cost would be building requirements because of NFPA 32 requirements. Since GreenEarth® is a Class IIIA solvent with a flashpoint of 170°F, there may be some building code requirements, but this should be less than those required for petroleum solvent with a flashpoint of 140°F.

E. HAS NO KNOWN OR EXPECTED HEALTH ISSUES

Information in this section was provided by Bruce Frye, Manager of Product Stewardship, GE Silicones

General Toxicity

The toxicity of GreenEarth® solvent and related silicones have been extensively studied to ensure compliance with applicable federal regulations for use in hair conditioners, antiperspirants, and other personal care products. In the tests commonly used for such studies, it was non-irritating to skin, did not cause cell mutations, and has very low oral toxicity if swallowed (the same as pepper, sugar, or talc) and causes only mild eye irritation.

In extended "sub-chronic studies" in rats (that is, done at lower exposures than that which would produce immediate changes), the only effect seen has been an increase in rat liver size after long-term inhalation exposures of 160 ppm. However, there were no significant changes in liver chemistry or in the liver cells themselves, other than an increase in size. Additionally, these effects disappear once exposure is stopped.

Carcinogenicity

A very thorough two-year exposure study in rats is wrapping up now with the final report expected in early 2003. To date, no effects other than the reversible liver weight increase (discussed above) have been found.

Additionally, GreenEarth® solvent is not listed under the *California Safe Drinking Water and Toxic Enforcement Act (Proposition 65)* as a chemical known to the state of California to cause cancer or reproductive toxicity.

Safe Handling

As with polyethylene, mineral oil, and similar compounds (that is, compounds containing methyl groups), GreenEarth® solvent at high temperatures (>300°F) in the presence of air can generate small traces of formaldehyde. With drying temperatures at 158°F and vacuum distillation, these formations would not be expected in the drycleaning process. Finally, GreenEarth® vapors passing through an open flame (such as in a gas-fired boiler or laundry dryer) would burn, producing silicon dioxide (sand), water, and carbon dioxide.

Because GreenEarth® is a Class IIIA combustible liquid and can cause mild eye irritation, it falls under OSHA's hazardous classification according to 29 CFR 1910.1200, Hazard Communication Rules. During storage care should be taken to handle it below the flash point and bulk containers should be stored in a cool, well-ventilated area with adequate access to facilitate unobstructed movement of personnel and fire protection equipment.

Vapor Exposure

Good industrial hygiene practice minimizes inhalation exposure of any chemical. A time-weighted average (TWA) of 10 ppm is recommended by industry[3] for this substance. With average TWA exposures measured at <1 ppm (see below) and based on the No Observable Adverse Effect Level (NOAEL) in rats the safety factor is estimated to be greater than 160-fold.

To evaluate actual exposures in a drycleaning operation, California Industrial Hygienic Services tested air emissions and exposures at drycleaning facilities using the GreenEarth® solvent and a variety of detergents.

In these tests, employee exposures included those for machine operators, spotters, finishers, and counter personnel. Area sam-

[3] The American Conference of Government Industrial Hygienists (ACGIH) and the Occupational Safety and Health Administration (OSHA) determine government exposure limits as measured in Threshold Limits Values (TLV) or Permissible Exposure Limits (PEL). The safety limits as set by ACGIH TLV and OSAH PEL do not regulate solvent and no guidelines are set by them.

pling included the front and back of the drycleaning machine, the spotting area, the pressing area(s), the counter area, and outside the building.

Analysis included eight-hour time-weighted average (TWA) concentrations, short-term exposures during specific tasks (STEL), and concentrations during specific tasks such as transfer of load from the washer to a recovery dryer. Personnel sampling was performed according to OSHA and NIOSH methods that monitor the airborne concentration of the solvent in the employee's breathing zone.

The average employee exposure level was less than 1 ppm on an eight-hour time-weighted average (TWA). The maximum employee exposure level (peak) seen was 3.5 ppm at the point of transfer when clothes were moved from washer to a transfer recovery dryer. Even in the transfer plant, the eight-hour time-weighted average was less than 2 ppm.

F. WILL NOT CREATE FUTURE CONTAMINATION

Information in this section was provided by Bruce Frye, Manager of Product Stewardship, GE Silicones

Air

GreenEarth® solvent is a small, low molecular weight volatile compound, which will evaporate fairly easily into the air. However, it has been shown not to generate ozone (which leads to smog formation) and the U.S. EPA has therefore exempted it from volatile organic compound (VOC) rules. Additionally, EPA has found that GreenEarth® solvent is not a hazardous air pollutant (HAP) and the state of California has found it not to be a toxic air contaminant (TAC).

Water

GreenEarth® solvent has very low solubility in water (<100 ppb) and is very close in density to water, so if it is discharged to water, it will initially form a surface film and then will rapidly evaporate into the air. The aquatic half-life is estimated at between 1–5 days. Acute studies with trout, daphnia, and algae show no significant effects at the highest doses prescribed by the test methodology.

Soil and Hazardous Waste

If a small amount of GreenEarth® solvent is discharged into soil, 90% volatilizes in 1–2 days from soil at 100% humidity. If larger amounts of GreenEarth® solvent are kept in contact with soil, it will also be expected to decompose to carbon dioxide, silicon dioxide (sand), and water.

GreenEarth® solvent is not considered a hazardous waste under RCRA. Testing has previously been done on still bottoms, filter cartridges, and wastewater by Severn Trent Laboratories, one of the largest certified testing laboratories in the United States. These results are for GreenEarth® solvent and a variety of detergents. All the information that follows is taken directly from those reports and was provided to IFI by GreenEarth®. The Waste Stream Analysis evaluated the following criteria:

- Characterization of each of the three waste streams to determine regulatory classification for disposal (to federal requirements).
- Evaluate changes in characteristics, if any, over time.
- Determination of the presence of trace contaminants in each waste stream.

Severn Trent Laboratories found that wastewater generated from the use of GreenEarth® alone was determined to be nonhazardous. However, trichloroethane (1,1,1) appeared in the wastewater at a few sites. This was determined to be caused by the use of certain spotting chemicals at those sites.

The still bottoms and filter cartridge waste that result from the use of GreenEarth® alone were determined to be nonhazardous. It should be noted that the still bottoms and filter cartridges in some cases may be ignitable and should be disposed of in accordance with any applicable federal, state, and/or local requirements. ❑

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ABOUT IFI AND ITS FELLOWSHIP TESTING

The International Fabricare Institute has been the premier trade association for garment care professionals since 1883. A not-for-profit association, IFI supports its approximately 7,000 members through education, research, legislative representation, and other services.

IFI derives its "Institute" status from the various research, testing, and education services it performs, including quality control services, textile testing and analysis, and educational offerings. Fellowship Testing, which is paid for by the manufacturer contracting the testing, comprises IFI's most comprehensive, time-intensive research. Numerous equipment, garment, and chemical manufacturers have funded IFI Research Fellowships, enabling IFI to conduct extensive evaluations of product performance. IFI's Fellowship Testing benefits the drycleaning industry significantly because IFI approaches the evaluation of a manufacturer's product scientifically and objectively, as well as from a practical point of view in terms of how the product will fit into a drycleaner's day-to-day, real-world operations. Results of IFI laboratories testing are respected throughout the industry, worldwide.

IFI is dedicated to the highest standards of business ethics and professionalism, environmental responsibility, textile serviceability, and a positive public image. To learn more about IFI's Fellowship Testing contact IFI at (301) 622-1900.

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