

QUEST

Quality Environmental
Services & Technologies, Inc.

SUMMARY REPORT
November 1, 2006

Vacuum Cleaner Testing for Soil Removal Effectiveness and Airborne Particle Emissions

Quality Environmental Services & Technologies, Inc. (QUEST) is pleased to submit this summary report detailing the results of recent vacuum cleaner soil removal effectiveness and filtration efficiency testing. This research was conducted for the purchasing department of a major University. Since the University must avoid the potential appearance of endorsements, the data is provided by generic heading. Vacuum cleaner types tested are listed as "Backpack A, Backpack B," etc.

QUEST specializes in indoor air quality and particulate analysis. Our research and development capabilities include assessing the risks associated with environmental contaminants (biological, chemical, and particulate) as well as investigating and recommending remediation options for these contaminants.

For this study, QUEST has tested a total of thirteen vacuum cleaner units. The University and a janitorial supplier provided the vacuum cleaners, filters and tools. Twelve vacuum cleaner units were tested for both soil removal effectiveness and filtration efficiency, plus one for soil removal effectiveness only. QUEST used the floor-tools, adapters and filter-bags provided with each vacuum cleaner.

In the designing of testing procedures, the following test methods were reviewed and sections included as appropriate. Standard Laboratory Test Method for Evaluation of Carpet-Embedded Dirt Removal Effectiveness of Household Vacuum Cleaners (ASTM Method F 608-89); Standard Test Method for Measuring Air Performance Characteristics of Vacuum Cleaners (ASTM Method F 558-88); Specification for Air Performance Measurement Plenum Chamber for Vacuum Cleaners (ASTM Method F 431-87); Specification for Test Carpets and Pads for Vacuum Cleaner Testing (ASTM Method F 655-89); and ServiceMaster Vacuum Cleaner Testing Protocol.

The purpose of the requested testing was to develop and utilize testing protocols that were simple, reproducible, and accurate. Since no ASTM methods specifically address industrial type vacuum cleaners and their particulate emissions, we designed and utilized the following testing procedures:

SOIL REMOVAL EFFECTIVENESS PROTOCOL

Supplies:

- **Carpet test-section:** six foot by six foot, industrial short-nap
- **Test Soil:** 80% silica sand, 20% unscented, commercial grade talcum powder
- **Filter Bag Fill:** Louisiana-Pacific *Nature Guard* Cellulose Insulation (100% Recycled)

Test Method

- 1) Pre-weigh filter bag.
- 2) Deep extract/clean test carpet.
- 3) Evenly distribute 100 grams of test soil onto the carpet.
- 4) Work test soil into the carpet with a carpet rake.
- 5) Vacuum the test carpet for 60 seconds (entire carpet, both directions at an even rate).
- 6) Remove and weigh filter bag.
- 7) After three repetitions, fill filter-bags with 50 grams of Filter Bag Fill and conduct a minimum of three additional test runs.

FILTRATION EFFICIENCY TESTING PROTOCOL

Supplies:

- **Carpet Test-Section:** six foot by six foot, industrial short-nap
- **Test Soil:** 80% silica sand, 20% unscented, commercial grade talcum powder
- **Test Chamber:** Class 10 clean room, eight-foot by eight-foot by eight-foot, positively pressured HEPA filtered air
- **Particle Counter:** PMS Lasair Laser Particle Counter set to measure 0.2 to 5.0 micron particles.

Test Method

- 1) Deep extract/clean test carpet.
- 2) Evenly distribute 100 grams of test soil onto the carpet.

- 3) Work test soil into the carpet with a carpet rake.
- 4) With particle counter collecting data in one minute increments, vacuum carpet for five (5) minutes at a rate of two (2) seconds per stroke (stroke = six feet end to end) then back on the same path. Vacuum entire carpet, both directions at an even rate.
- 5) Discontinue vacuuming, exit test chamber and continue to collect particle counts for an additional three minutes.

These procedures were followed for each vacuum cleaner tested, as well as one run before and one run after the use of the test soils. The remainder of this report summarizes the results of this testing.

TEST RESULTS

Soil Removal Effectiveness

(Percent of soil picked up and retained in filter bag)

Vacuum Cleaner Brand	“Empty Filter-Bag”	“Full Filter-Bag”	Average
ProTeam MegaVac	99.9%	99.9%	99.9%
ProTeam SuperCoach	99.6%	99.9%	99.8%
ProTeam LineVacer	98.7%	99.9%	99.3%
Backpack A with HEPA filter	99.5%	99.0%	99.2%
ProTeam Tailvac	99.5%	96.5%	98.0%
Backpack H	97.7%	97.4%	97.6%
Backpack I	95.5%	94.9%	95.2%
Two-Motor Upright G	93.6%	92.7%	93.2%
Backpack F	93.3%	93.0%	93.2%
Backpack B	93.0%	93.0%	93.0%
Backpack E	92.5%	90.8%	91.6%
Backpack D	91.5%	91.3%	91.4%
Backpack C	90.2%	84.8%	87.5%

Filtration Efficiency

The following table shows the accumulated airborne particle counts (in thousands) during the five-minutes of vacuuming. For each vacuum cleaner tested, the accumulated counts of 0.2 micron, 2.0 micron, and 5.0 micron size particles are listed, and the sum of 0.2, 2.0, and 5.0 micron particles is provided.

Vacuum Cleaner Brand	0.2 Micron	2.0 Micron	5.0 Micron	Total of 0.2 + 2.0 + 5.0
Backpack A w/ HEPA Filter	6,798	1,391	304	8,493
ProTeam Linevacer	35,102	7,361	1,196	43,659
ProTeam Super Coach	548,572	918	158	549,648
Backpack B	674,765	1,891	291	676,947
ProTeam Mega-Vac	863,710	1,396	223	865,329
Backpack C	1,067,936	1,560	256	1,069,752
ProTeam TailVac #1	1,211,293	1,443	356	1,213,092
Backpack D	1,301,711	3,379	511	1,305,601
Backpack E	1,316,283	2,198	352	1,318,833
Backpack F	1,516,983	1,187	223	1,518,393
Two-Motor Upright G	1,648,439	6,276	839	1,655,554
Backpack H	2,602,073	4,288	642	2,607,003

If you have any questions or comments, please contact Robert Woellner at QUEST at (303) 935-1593.

Sincerely,

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