REC-01720, Rev. 1

HOMEDICS USA
TEST REPORT

SCOPE OF WORK
VOC Reduction by AP-T40

REPORT NUMBER
103640535GRR-001

ISSUE DATE
12-October-2018

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TEST REPORT FOR HOMEDICS USA, LLC

Report No.: 103640535GRR-001
Date: 12-October-2018
P.O.: N/A

SECTION 1

CLIENT INFORMATION

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SECTION 2
SUMMARY AND CONCLUSION

Date Received:	18-September-2018
Dates Tested:	01-October-2018 to 08-October-2018

DESCRIPTION OF SAMPLES

Part Name:	AP-T40
Model Number:	AP-T40
Manufacturer / Location:	HoMedics
Date of Manufacture:	Not Specified
Materials Submitted:	Two (2) Filtration Units
Condition of Samples:	Not Specified
Shipping Condition:	Good Condition

WORK REQUESTED/APPLICABLE DOCUMENTS

VOC Reduction Testing:	ISO 16000-3, ISO 16000-6 Referencing NRCC-54013
Intertek Quote:	Qu-00911231-5

TEST SUMMARY

The air purifier was challenged with Two VOCs representative of what are found in homes: formaldehyde and toluene. The clean air delivery rate, CADR, for the air purifier was measured to be 58.5, and 22.3 m3/h respectively for the two challenge VOCs.

SAMPLE DISPOSITION

At the completion of testing, samples were disposed of in a routine manner.

SECTION 3

ISO 16000-3, ISO 16000-6 REFERENCING NRCC-54013

Date Received:	18-September-2018
Dates Tested:	01-October-2018 to 08-October-2018

DESCRIPTION OF SAMPLES:

Part Name:	AP-T40
Model Number:	AP-T40
Manufacturer / Location:	HoMedics
Date of Manufacture:	Not Specified
Materials Submitted:	Two (2) Filtration Units
Condition of Samples:	Not Specified
Shipping Condition:	Good Condition

TEST PROCEDURE:

The purpose of this testing is to determine the efficacy of the HoMedics USA, LLC to remove challenge VOCs. VOC removal testing was performed referencing NRCC-54013 (April 2011): Method for Testing Portable Air Cleaners sections 3.2 and 5.1.2.

Natural system decay for the challenge chemicals is performed prior to the test. The unit was placed in the center of a chamber which was sealed and flushed with clean air for a minimum of one night. An additional enclosure fan was operated to ensure air mixing. The challenge chemicals (formaldehyde and toluene) were injected and allowed to circulate for 20 minutes during which an air sample was taken. Each challenge chemical was performed using a fresh filter. The system was then turned on using the highest fan speed beginning the test timing.

VOC samples were collected at 5, 10, 15, 20, 25, 30, 45, 60, 90, 120, 180, and 240 minutes after starting the system. Samples analyzed for toluene were collected on multi-sorbent tubes containing Tenax TA. These VOC samples were analyzed by thermal desorption-gas chromatography/mass-spectroscopy, TD-GC/MS. Samples analyzed for formaldehyde were collected on cartridges treated with 2,4-di-nitrophenylhydrazine (DNPH) and were analyzed using high performance liquid chromatography, HPLC. Individual VOCs were calculated using calibration curves based on pure standards.

TEST NOTES OR DEVIATIONS:

Testing performed without deviation unless noted below.

TEST PARAMETERS:

Table 1: Chamber Conditions During Test Period for Toluene

PARAMETER		SYMBOL	VALUE	UNITS
Chamber Volume		*V*	8.3	m^3
Testing Duration		t	4	h
Chamber Air Exchange Rate		K_n,V	0.0181	h^{-1}
Formaldehyde	Average Temperature (Range)	T	24.3 (23.3-25.1)	°C
Toluene	Average Temperature (Range)	T	24.6 (23.3 – 25.2)	°C

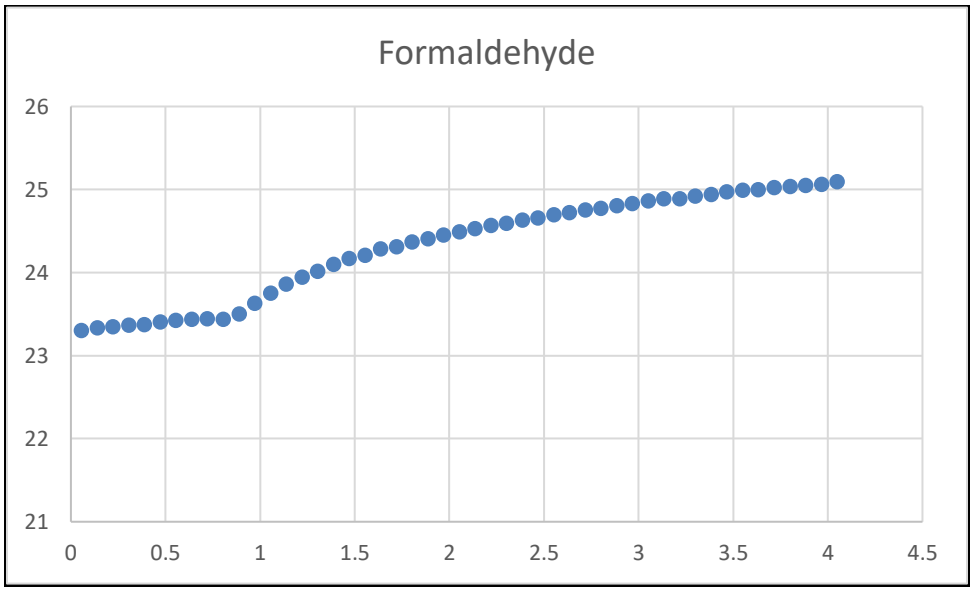

Figure 1: Chamber temperature during Formaldehyde test.

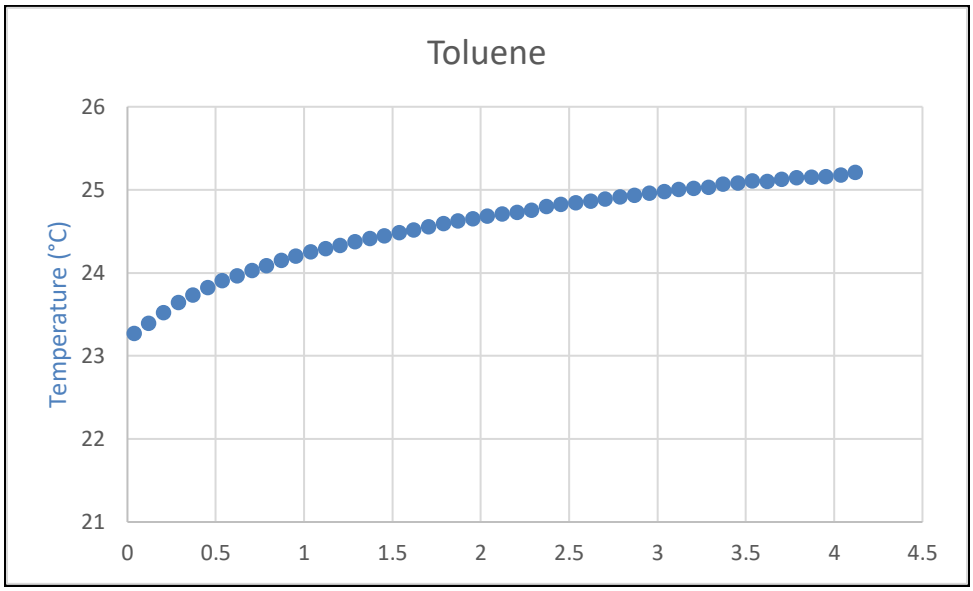

Figure 2: Chamber temperature during Toluene test.

Table 2: Concentration of challenge chemical at t_0.

	Initial Concentration	
Compound	Formaldehyde	Toluene
C_0 (µg/m^3)	118	748
C_0 (ppbv)	50	199

TEST RESULTS:

Table 3: Concentration of challenge chemical decay through test.

	Concentration	
Compound	Time (min)	C_0 (µg/m3)
Formaldehyde	0	117.7
	5	48.3
	10	26.2
	15	18.7
	20	7.6
	25	< 5.7
	30	< 5.7
	45	< 5.7
	60	< 5.7
	90	< 5.7
	120	< 5.7
	180	< 5.7
	240	< 5.7
Reduction Rate	-	> 94%
Toluene	0	747.8
	5	393.5
	10	287.5
	15	144.8
	20	106.1
	25	105.1
	30	59.4
	45	46.9
	60	30.4
	90	25.9
	120	22.8
	180	28.6
	240	25.0
Reduction Rate	-	97%

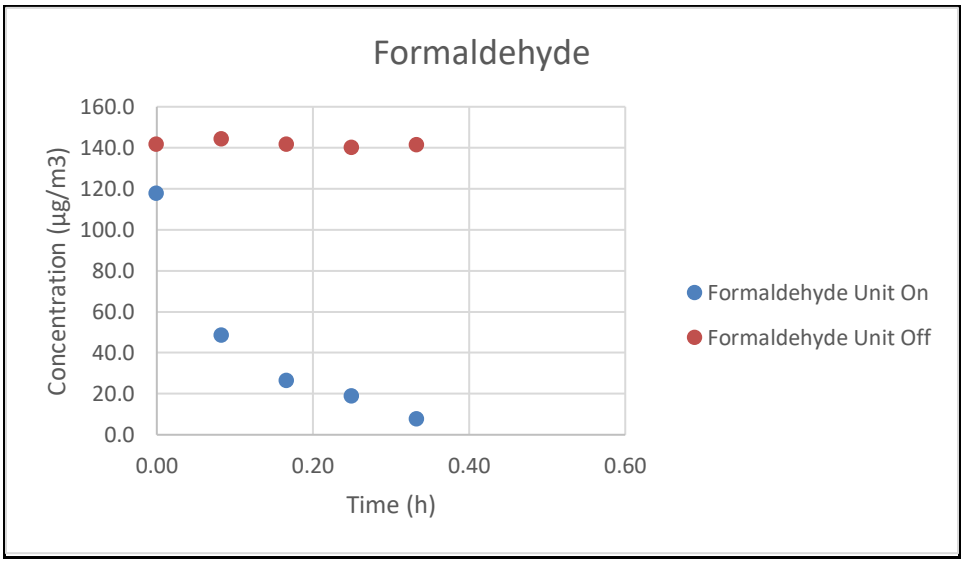

Figure 3: Concentration change throughout test for Formaldehyde.

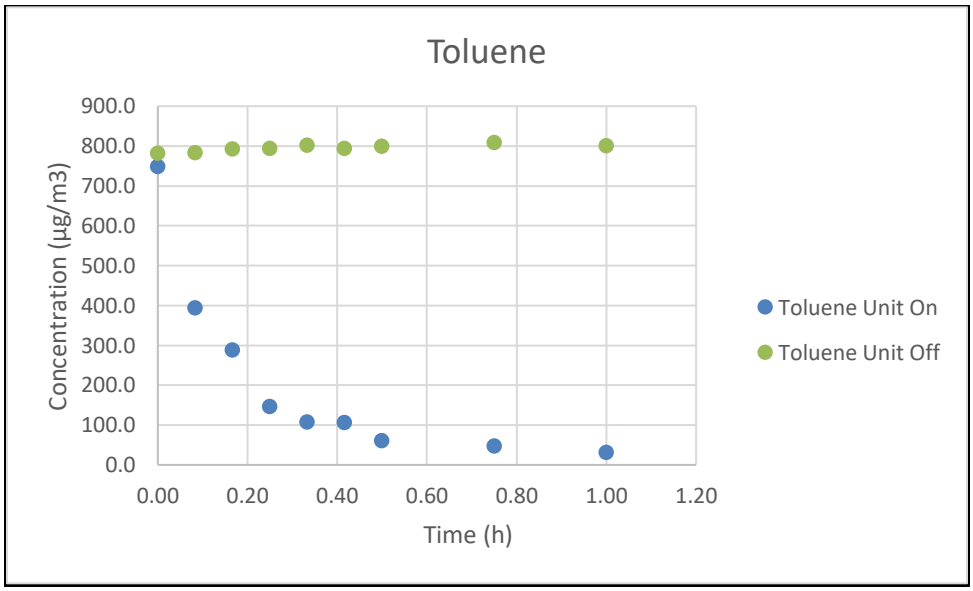

Figure 4: Concentration change throughout test for Toluene.

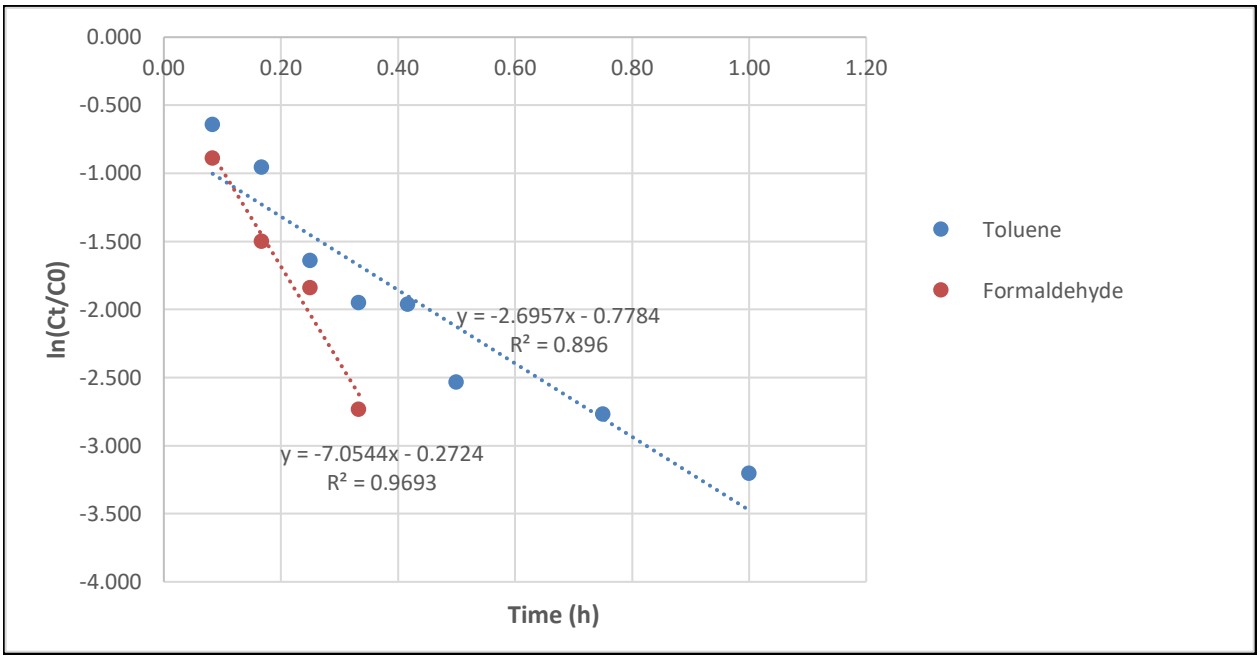

Figure 5: Removal rate of challenge chemicals.

The clean air delivery rate (CADR) is calculated according to equation 1:

$$ln\left(\frac{C_t}{C_0}\right) = -\left(k_n + \frac{CADR}{V}\right)t \quad \text{Eq. 1}$$

where:

C_t: chemical concentration at time t (µg/m^3)
C_0: chemical concentration at time t_0 (µg/m^3)
V: volume of the test chamber (m^3)
t: time (h)
$CADR$: Clean Air Delivery Rate (m^3/h)
k_n: first order decay constant with PAC turned off

The single pass efficiency (SPE) is calculated according to equation 2:

$$SPE = \frac{CADR}{Q} \quad \text{Eq. 2}$$

where:

Q: purifier flow rate (304 m^3/h).

Table 4: Purifier efficiency – calculation of clean air delivery rate and single pass efficiency.

VOC	CAS No.	CADR (m^3/h)	SPE (%)
Formaldehyde	50-00-0	58.5	19.2%*
Toluene	108-88-3	22.3	7.3%*

*CADR and SPE are calculated through the first hour only.

PHOTOGRAPHS:

Figure 6: Photograph of sample as received.

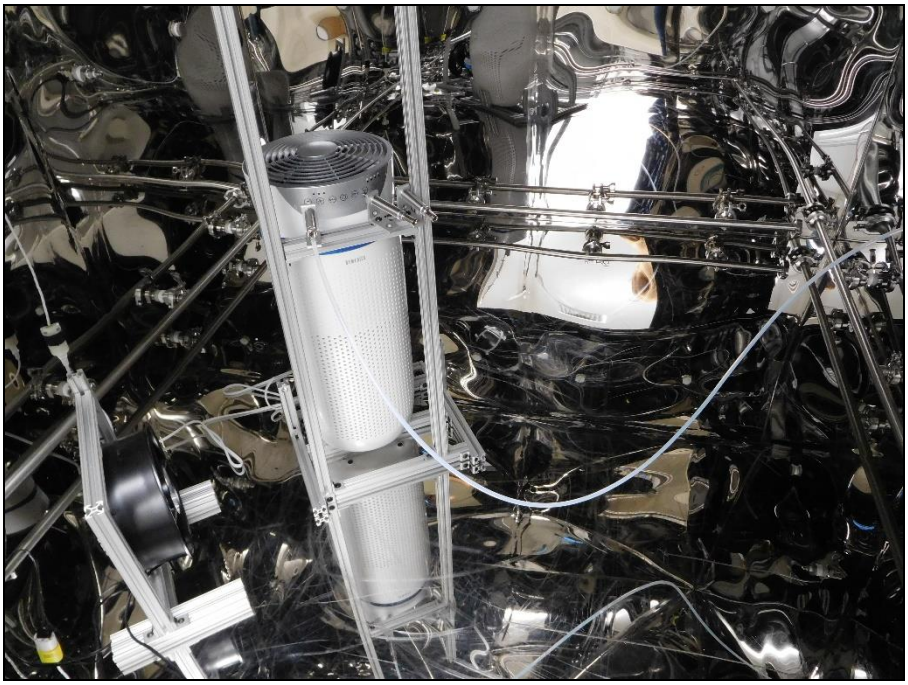

Figure 7: Photograph of sample in testing chamber.

SECTION 4

FACILITIES AND EQUIPMENT:

GCMS	
INSTRUMENTATION USED:	Markes TD-100 Thermal Desorption Agilent 7890A GC Agilent 5975C MS
COLUMN USED:	Agilent HP-Ultra 2 (GC)
HPLC	
INSTRUMENTATION USED:	Agilent 1260 Infinity Series
COLUMN USED:	Poroshell 120 EC-C18

St. Croix Sensory, Inc.

AP-T40 Air Purifier Efficacy Testing: Reduction of Household Malodors

Final Report – 7 November 2018

Data Report Nos.: **1827501**
1828101
1828902
1829902
1830301

Samples Received: 9/18/2018

Samples Evaluated: 10/2/2018
10/8/2018
10/16/2018
10/26/2018
10/30/2018

Report Prepared for:
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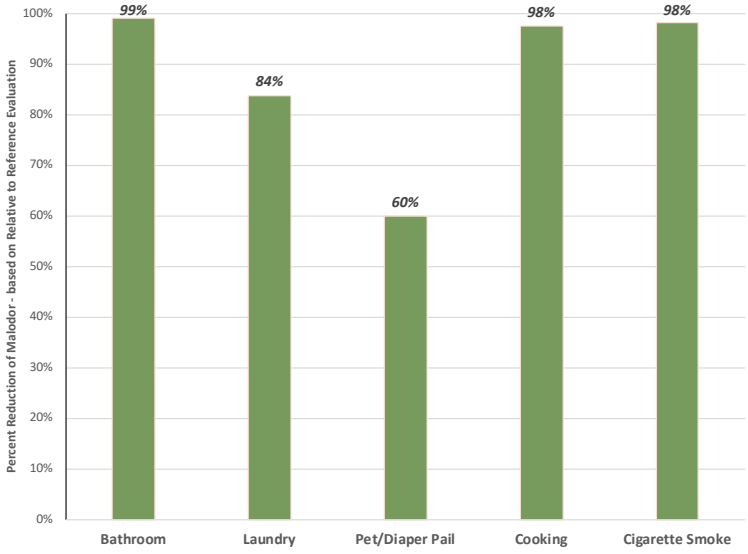
Michael McGinley, P.E.
Laboratory Director

Cooking malodor had significant malodor reduction at 30-minutes with 70% lower malodor scores compared to the reference. By 4-hours, 96-99% reduction in cooking malodor was achieved. The overall average odor intensity of 6.8 at test start, reduced to 1.4 at 4-hours. The grease/oil, sulfidic vegetable (garlic, onion), and spice malodor characters were also significantly reduced during the test.

The AP-T40 reduced cigarette smoke odors by 85% at 1-hour of operation. By 4-hours, the two test chambers showed malodor reduction of over 98%. The overall initial odor intensity of 6.6 reduced to 1.1 at 4-hours, while the unpleasant hedonic tone values of -6 at time zero improved to -1 in that same time. The intensity of cigarette smoke characters was also reported to be reduced throughout the test.

The test results show there was a perceived reduction of household malodors as soon as 30-minutes of operation for all malodors, with overall malodor reduction of 60-99% after 4-hours. Additionally, by 4-hours, all test chambers with malodor and the air purifier had reduced intensity results, improved (more pleasant) hedonic tone values, and reduced malodor descriptors. These results show the AP-T40 air purifier reduced household malodor odorants from the test chambers during these tests.



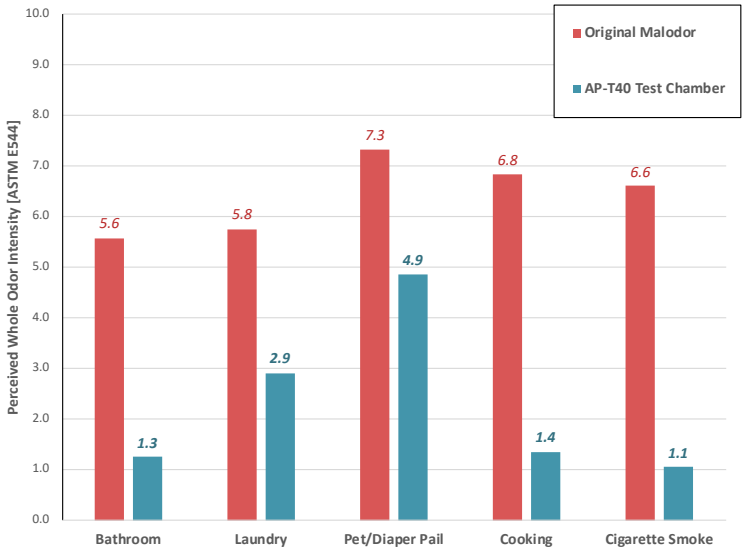


Figure 1. Four stainless steel chambers utilized for malodor reduction efficacy testing at St. Croix Sensory, Inc. The chambers are all identical 1.2x1.2x1.5m boxes with a sniffing port in the center on the front, multiple testing ports also on the front, two access and exhaust ports on the top, and an access hatch on the front. Power was provided to each air purifier through a top access port.

For the testing, a reference chamber was prepared with the specific household malodor. Two test chambers were also prepared with the malodor and an AP-T40 Air Purifier with the HEPA/carbon filters installed. Additionally, three controls were also prepared for each test, one malodor control with the malodor and no device, one blank control with no malodor and no device, and a third control with the AP-T40 operating with no malodor. The following was the chamber design for each test:

Chamber 1: Malodor Reference
Chamber 2: Malodor Control
Chamber 3: Blank Control
Chamber 4: Blank Control with AP-T40
Chamber 5: Malodor with AP-T40
Chamber 6: Malodor with AP-T40 replicate

The Malodors

The household malodors were each created with the following procedures. All malodor sources were removed from the test chambers at time zero.

Bathroom Malodor Preparation Summary: The bathroom malodor is generated with a surrogate chemical mixture known as GSA Bathroom malodor as originally published by the US General Services Administration as Specification FA200-5. This recipe includes: thioglycolic acid, n-caprioic acid, n-methylmorpholine, 4-methylphenyl 3-methylbutanoate, skatole, and 2-naphthalenethiol in dipropylene glycol solution. 3g of 6% diluted solution was placed on a cellulose pad and placed in the test chambers for 4-hours.

Figure 2 displays the Odor Character Descriptor Wheel developed by St. Croix Sensory and utilized during testing. Note that for cigarette smoke, the purple custom slice on the wheel includes cigarette smoke and ash odors. Likewise, for cooking this custom section included grease/oil odors. The gray section was listed as "No Odor" for the assessor to respond if they noticed no odors at all.

Figure 2. Odor character descriptor wheel utilized during this testing (©St. Croix Sensory).

Hedonic Tone

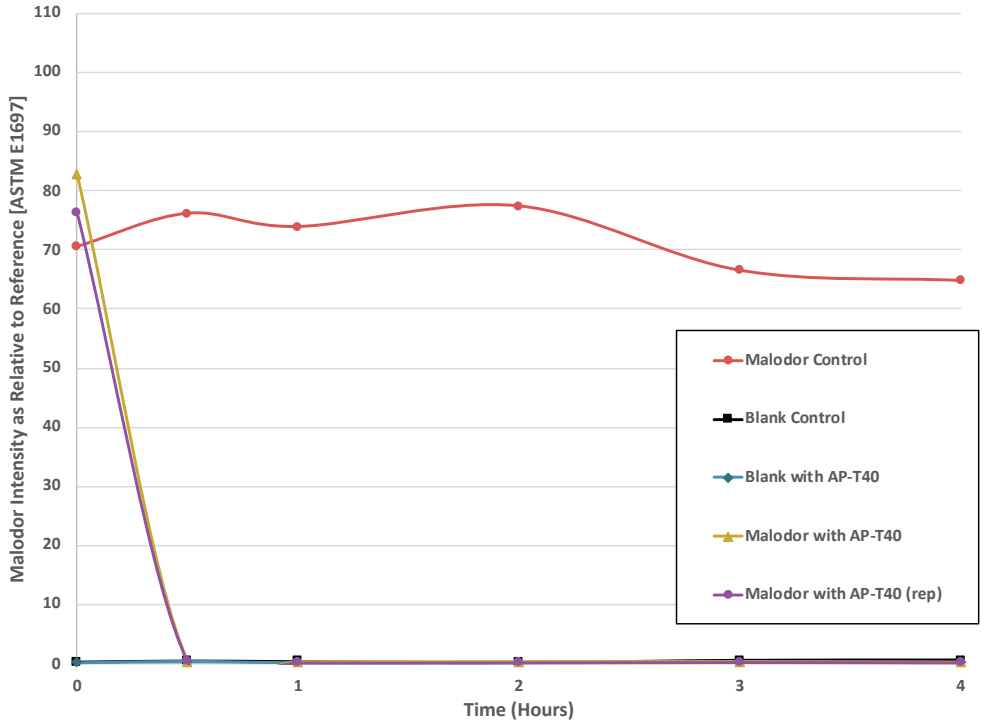
Hedonic Tone is a subjective parameter of odor evaluations. Assessors rate the pleasantness/unpleasantness of the odor sample based on a scale of –10 (most unpleasant odor they have experienced) to +10 (most pleasant odor they have experienced). A zero represents a neutral odor where the assessor has no opinion about the odor being either pleasant or unpleasant.

Table 1. Average assessor ratings of perceived malodor compared to reference chamber (100) for AP-T40 air purifier testing with bathroom malodor. Each time period was compared to the malodor reference at that time. Time zero is before the air purifier operation started.

	0-hour	*30-min*	*1-hour*	*2-hour*	*3-hour*	*4-hour*
Malodor Control	71 [a]	76 [a]	74 [a]	77 [a]	67 [a]	65 [a]
Blank Control	0.4 [b]	0.5 [b]	0.4 [b]	0.3 [b]	0.6 [b]	0.7 [b]
Blank with AP-T40	0.2 [b]	0.3 [b]	0.2 [c]	0.3 [b]	0.3 [c]	0.3 [c]
Malodor with AP-T40	83 [a]	0.3 [b]	0.2 [bc]	0.3 [b]	0.3 [c]	0.2 [c]
Malodor with AP-T40	76 [a]	0.4 [b]	0.2 [c]	0.3 [b]	0.3 [bc]	0.3 [c]

[abc] **the same letter superscript and color coding within a column are not significantly different as determined by a Fisher's least significant difference (LSD) test.**

Figure 3. Bathroom malodor reduction by AP-T40 air purifier based on magnitude estimation evaluation (ASTM E1697) over the 4-hour testing time. Each time period is compared to the malodor reference at that given time.



Whole Odor Intensity Results

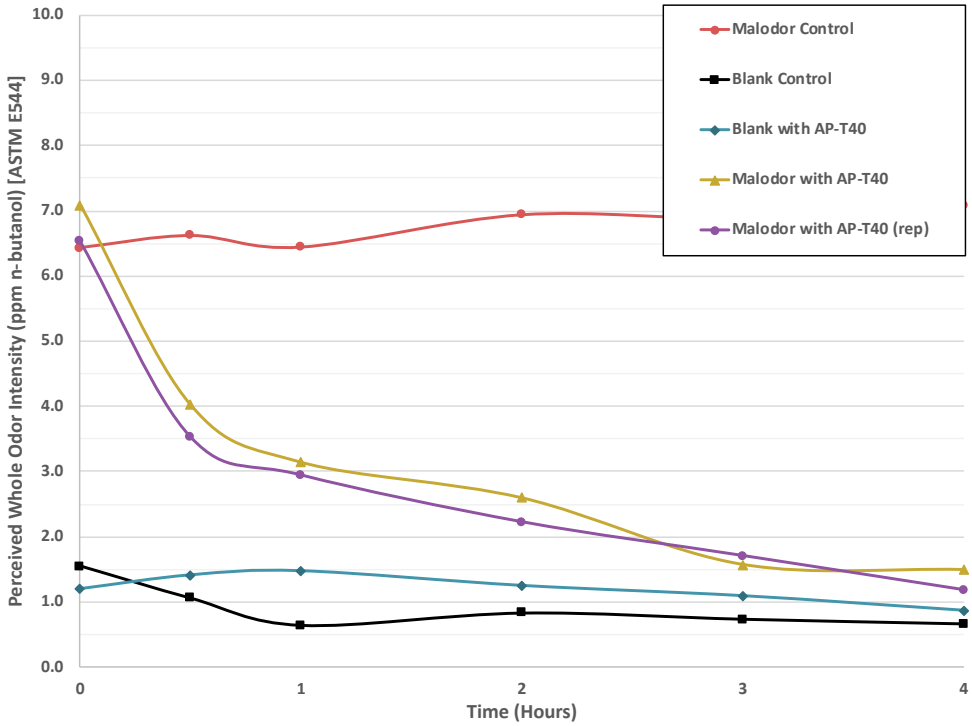
Table 2 provides the whole odor intensity ratings at time zero, 30-minutes, 1-hr, 2-hrs, 3-hrs, and 4-hrs. An analysis of variance (ANOVA) was run to compare performance along with a post-hoc Fisher's Least Significant Difference (LSD) test (α=0.05). Superscripts and color are used to display statistical significance within each time period. Figure 4 provides a graphical summary of the whole odor intensity evaluations over the 4-hour testing time.

Table 8. Average perceived whole odor intensity of testing with AP-T40 air purifier with cooking malodor.

	0-hour	*30-min*	*1-hour*	*2-hour*	*3-hour*	*4-hour*
Reference	7.2 [a]	7.4 [a]	6.9 [a]	7.4 [a]	7.3 [a]	7.4 [a]
Malodor Control	6.4 [a]	6.6 [a]	6.4 [a]	6.9 [a]	6.9 [a]	7.1 [a]
Blank Control	1.6 [b]	1.1 [c]	0.6 [c]	0.8 [c]	0.7 [c]	0.7 [b]
Blank with AP-T40	1.2 [b]	1.4 [c]	1.5 [c]	1.3 [c]	1.1 [bc]	0.9 [b]
Malodor with AP-T40	7.1 [a]	4.0 [b]	3.1 [b]	2.6 [b]	1.6 [bc]	1.5 [b]
Malodor with AP-T40	6.5 [a]	3.5 [b]	2.9 [b]	2.2 [b]	1.7 [b]	1.2 [b]

[abc] **the same letter superscript and color coding within a column are not significantly different as determined by a Fisher's least significant difference (LSD) test.**

Figure 31. Perceived whole odor intensity (ppm n-butanol) of test chambers during 4-hour test of AP-T40 air purifier reducing cooking malodor.



Hedonic Tone Results

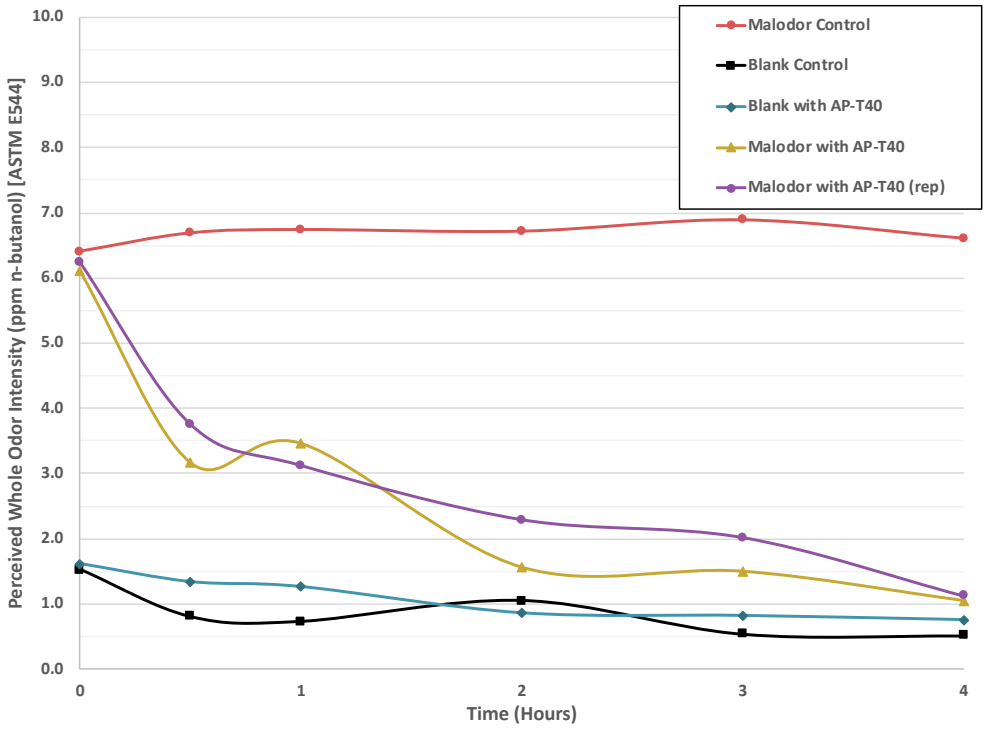
Figure 32 summarizes the hedonic tone results associated with the cooking malodor evaluations during the 4-hour test. Assessors tend to report more pleasant hedonic tone values for cooking malodors compared to other more disagreeable malodors. These cooking odors become unpleasant within the context of wanting less odors in a home. This is shown with all test chambers at neutral to -2 throughout the entire test.

Table 10. Average perceived whole odor intensity of testing with AP-T40 air purifier with cigarette smoke malodor.

	0-hour	*30-min*	*1-hour*	*2-hour*	*3-hour*	*4-hour*
Reference	7.7 [a]	7.6 [a]	7.3 [a]	7.0 [a]	7.4 [a]	7.3 [a]
Malodor Control	6.4 [a]	6.7 [a]	6.7 [a]	6.7 [a]	6.9 [a]	6.6 [a]
Blank Control	1.5 [b]	0.8 [c]	0.7 [c]	1.1 [c]	0.5 [d]	0.5 [b]
Blank with AP-T40	1.6 [b]	1.3 [c]	1.3 [c]	0.9 [c]	0.8 [cd]	0.8 [b]
Malodor with AP-T40	6.1 [a]	3.2 [b]	3.5 [b]	1.6 [bc]	1.5 [bc]	1.0 [b]
Malodor with AP-T40	6.2 [a]	3.8 [b]	3.1 [b]	2.3 [b]	2.0 [b]	1.1 [b]

[abc] **the same letter superscript and color coding within a column are not significantly different as determined by a Fisher's least significant difference (LSD) test.**

Figure 40. Perceived whole odor intensity (ppm n-butanol) of test chambers during 4-hour test of AP-T40 air purifier reducing cigarette smoke malodor.



Hedonic Tone Results

Figure 41 summarizes the hedonic tone results associated with the cigarette smoke malodor evaluations during the 4-hour test. The malodor control chamber had hedonic tone scores near -6 during the 4-hour test. The test chambers were also near -6 at time zero, but then improved to more pleasant hedonic tone scores of -4 at 1-hour and near -2 by 3-hours. The blank chambers had hedonic tone values near -2 at time zero and remained between -2 and neutral through 4-hours.

Summary and Conclusions

St. Croix Sensory, Inc. was contracted by HoMedics, Inc. to conduct a study to compare the performance of the AP-T40 Air Purifier reducing household malodors in controlled 4-hour tests following ASTM standards and guidelines. Five tests were run to document malodor reduction of 1) bathroom; 2) laundry (mold/mildew & sweat); 3) urine (pet and diaper); 4) cooking; and 5) cigarette smoke.

In each test, the malodor was prepared in a Reference Chamber, a malodor control chamber, and two test chambers with the AP-T40 air purifiers. In each case, the malodor was produced at a moderate to strong intensity level (5-8) with a very unpleasant hedonic tone (-4 to -6). These malodor levels are much stronger than what would be present in a common home, as odors of this intensity, character, and unpleasantness rating would cause most people to want to exit the area very quickly. Two blank control chambers were also prepared for each test with no malodors, one with an AP-T40 device operating.

Twenty assessors, trained and experienced at product and material sensory testing, evaluated the test chambers at the start of the test (time zero) as well as at 30-minutes, 1-hour, 2-hours, 3-hours, and 4-hours of air purifier operation. The assessors compared test chambers to the Reference malodor chamber and reported the degree of difference in malodor level utilizing magnitude estimation (ASTM E1697). The assessors also reported the overall odor intensity (ASTM E544), hedonic tone, and completed odor character profiles of the test chambers.

For all malodors, the malodor control chamber had consistent malodor, intensity, hedonic tone, and character descriptor ratings across the 4-hour testing time. Malodor relative to reference ratings for all malodor control chambers ranged from 65-98. Likewise, the blank control chambers had low ratings at all time points in all tests, with relative to reference malodor values of 0.2 to 6.0. At time zero, before air purifier operation began, the test chambers with malodor and the air purifier had malodor and intensity values that were not statistically different from the malodor control chamber. Further, the intensity and hedonic tone ratings and the character profile information show similar perception in all related malodor control and test chambers at the test start.

For bathroom malodor, the malodor ratings essentially showed malodor elimination (>99% reduction) by 30-minutes of the test, with relative to reference values that were not statistically different from the blank controls. The overall odor intensity of the reference, malodor control and test chambers at time zero were just over 5.5-6.5 with similar hedonic tone (-6) and malodor characters of sulfur and animal. The odor intensity had significant reduction by 30-minutes with values similar to the blank chambers. Hedonic tone likewise became less unpleasant to values near neutral. Sulfur and animal characters were immediately reduced in both AP-T40 test chambers.

For laundry malodor, reduction was greater than 80% by 2-hours and was a statistically significant difference from the malodor control. The initial overall average odor intensity of the laundry malodor was 5.8, with significant reduction in 30-minutes and reduction to an average intensity of 2.9 at 4-hours. The hedonic tone of the malodor was close to -5 at test start and

improved to -3 by 4-hours. The AP-T40 also reduced animal, medicinal, decay, and earth malodor characters during the 4-hours of device operation.

Urine malodors from cat litter and diaper pails were also reduced by the AP-T40 within 1-hour of operation with near 40% reduction. This reduction of perceived malodor was 60% at 4-hours. The overall odor intensity was an average of 7.3 for the malodor chambers at time zero and decreased in the AP-T40 test chambers to 4.9 at 4-hours. The hedonic tone became more pleasant, shifting from -6 to closer to -5 and animal (urine) and medicinal (ammonia) character levels decreased during the 4-hour test.

Cooking malodor had significant malodor reduction at 30-minutes with 70% lower malodor scores compared to the reference. By 4-hours, 96-99% reduction in cooking malodor was achieved. The overall average odor intensity of 6.8 at test start, reduced to 1.4 at 4-hours. The grease/oil, sulfidic vegetable (garlic, onion), and spice malodor characters were also significantly reduced during the test.

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The test results show there was a perceived reduction of household malodors as soon as 30-minutes of operation for all malodors, with overall malodor reduction of 60-99% after 4-hours. Additionally, by 4-hours, all test chambers with malodor and the air purifier had reduced intensity results, improved (more pleasant) hedonic tone values, and reduced malodor descriptors. These results show the AP-T40 air purifier reduced household malodor odorants from the test chambers during these tests.

This report is intended to provide results and interpretation of the pet related malodor reduction performance testing work performed by St. Croix Sensory in October 2018. Please contact St. Croix Sensory with any additional questions about testing and related results.

Michael A. McGinley, P.E.
Laboratory Director
St. Croix Sensory, Inc.

St. Croix Sensory is ISO/IEC 17025:2005 Accredited

Certificate of Accreditation issued by
Perry Johnson Laboratory Accreditation, Inc.
Accreditation No.: 81047
Certificate No.: L18-134
Initial Accreditation Date: 19 May 2014

Mission Statement:

St. Croix Sensory is a laboratory dedicated to practicing
state-of-the-art sensory evaluation
and to advancing the science of sensory perception.

We are a family owned and operated business
providing our clients with personal customer service,
flexible scheduling, and timely results.

Our focus is to provide the best professional services available
to make your project or product a success.

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