# A Nasal Chemosensory Performance Test for Odor Inspectors

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## ABSTRACT

Odors are the cause for most air pollution complaints by citizens. Common sources of community odors include the following types of facilities: wastewater treatment, composting, landfills and industry.

In communities across the country, odor issues are addressed in a variety of ways. Often odor regulations and ordinances place a limit on the strength of ambient odors. The strength of an odor in the ambient air is measurable using either a butanol intensity scale or a "scentometer" device. However, the odor inspector's olfactory sensitivity is a factor in measuring the odor strength in the ambient air.

"Sniffin' Sticks" is a commercially available test of nasal chemosensory performance based on pen-like odor dispensing devices. A modified version of the standard "Sniffin' Sticks" odor threshold test was developed and administered to 39 Odor Inspectors of a Regulation Enforcement Agency. The Odor Inspectors were assessed approximately once a month during the months of January to October, where the majority of individuals were tested eight times. A measure of central tendency and variation was calculated for each of the Regional Agency Offices (n=6). Also, the test was administered to 39 Trained Odor Assessors of an Odor Evaluation Laboratory. The Assessors were tested twice during a single month. It was found that the mean individual score from the Odor Inspector group was 7.33 ($s^2$=1.47). The mean individual score from the Odor Assessor group was 9.45 ($s^2$=1.17). A z-test of the comparison of population means ($\alpha$=0.05) showed that the mean group scores were statistically significant, thus the two sample populations could not have been drawn from the same statistical population.

The purpose of a standardized nasal chemosensory test method is to determine the olfactory threshold of an individual or a group and compare this olfactory sensitivity data with other published normative values. This paper presents the findings from an initial test cycle in an ongoing study that will establish a reliable method for olfactory screening, provide olfactory threshold data for odor inspectors and assessors, and generated recommended performance criteria for odor inspectors, assessors and monitors.

## INTRODUCTION

This paper presents a justification for a standardized method to test the nasal chemosensory performance of odor inspectors, odor investigators and odor monitors. A measurable element of an individual's chemosensory function is their odor detection threshold. An odor detection threshold is the point in which an observer becomes aware of an odorous substance (ASTM, 1997). Odor detection thresholds characterize an individual's and a group's sensitivity to odor. This characterization becomes essential in settings where individuals will be evaluating the strength of the odor in the ambient air and how it corresponds to the mandated acceptable levels of the odor. Thus, determining the sensitivity of the individual observing the odor is critical to support the accuracy of their assessment. A practice that describes a method of accurately obtaining the sensitivity of individuals and/or groups can be integrated into agencies with officers who serve as odor inspectors or into facilities with employees serving as odor monitors or complaint responders. Control of the test conditions and establishment of test criteria can generate data that is reliable and accurate. This data then serves as a reference for the reliability of the individual's ability to detect the odors they are observing. The test scores derived from olfactory screening are the most reliable when they are obtained following a standard test procedure.

"Sniffin' Sticks" (Burghart) as an instrument for determining nasal chemosensory performance has been previously investigated. Many authors have described the routine use of these devices in medical clinics to determine olfactory capacities of patients (Hummel et al, 1997). In these studies, they have been effective in the measurement of individual olfactory threshold levels (sensitivity), using n-butanol as the reference odor. A multicenter investigation provided normative olfactory threshold values a large population of healthy subjects (n=551) in relation to different age group using the "Sniffin' Sticks" as the test instrument (Kobal, et al 2000). This previously published research supports using the "Sniffin' Sticks" as the test instrument for routine screening of nasal chemosensory performance in individuals who will be monitoring facility odors or enforcing odor limits.

It is assumed that olfactory sensitivity varies as a result of random fluctuations in factors such as alertness, attention, fatigue, health status and variability of presentation techniques (ASTM, 1997). Thus, the precision of the results of an individual's olfactory threshold may be based on 1) the number of times that the individual takes the test and, 2) the clarity of directions under which the test is operated. It is recognized that the amount of training an individual receives influences their detection threshold. Establishing the necessary test criteria for the method of sample presentation for threshold determination was conducted in the present study. The current study attempts to obtain n-butanol thresholds for individuals in two test groups and the group scores based on an operating practice called the "Standard Procedure for Testing Individual Odor Sensitivity", utilizing "Sniffin' Sticks" as the test instrument.

## METHODOLOGY

Odor screening was conducted using the Odor Pen Kit (St. Croix Sensory, Inc), which is a commercially available method for measuring the olfactory sensitivity. The Odor Pen Kit contains one set of "Sniffin' Sticks", a blindfold for the test individual, and odorless non-latex gloves for the test administrator (Figure 1). The "Sniffin' Sticks" pens are felt tip markers in which the pen is impregnated with an odor agent. The odor agent used for olfactory threshold screening is n-butanol. Fourteen pens contain the n-butanol solution at different concentrations and two pens are odorless. The "Sniffin' Sticks" manufacturer performed the preparation of the test solutions of n-butanol.

**Figure 1. The St. Croix Sensory Odor Pen Kit. Included in the picture are the blindfold, non-latex gloves and the set of 14 n-butanol pens (red) and odorless blank pens.**

All test individuals were tested following the same procedure. The procedure is called the "Standard Procedure for Testing Individual Odor Sensitivity". The objective is to identify the detection threshold of the test individual by correct detection of the odor pen in a triad. The presentation method of the odor pens is a triangular force choice method, also known as 3-Alternative Forced Choice (ASTM, 1997). A pen triad is made up of three pens, two are blank pens and a third is an odor pen. The test individual is required to distinguish between the three pens by declaring which pen contains an odor. If no odor is perceived, the test individual is to assign a response of guess to one of the three odor pens. After a response is made, the test proceeds to the next pen triad. The next triad contains an odor pen with a greater n-butanol concentration than the previous series. The logic of the test is that the potential for the test individual to identify the odor pen increases as the test moves to the next concentration level. The increasing concentration levels will continue until the test individual correctly identifies the odor pen in a triad for two test levels. The level where a pen is first correctly identified as the odor pen is the score for the test individual and thus the odor threshold score of the individual. The odor sensitivity score for each of the participants was calculated by averaging the odor pen number (concentration level) associated with their first correct detection of the n-butanol

pen in the triad. The odor pens were sorted and presented in ascending concentrations of n-butanol. The concentration values of the odor pens is undetermined, therefore, quantitative n-butanol values are not available.

Olfactory sensitivity was determined in two study groups, the Odor Inspectors and the Trained Odor Assessors. The Standard Procedure and the Odor Pen Kit was the method of assessment used for both groups (Figure 2).

**Figure 2. A Test Individual being administered a n-butanol pen from the Odor Pen Kit.**

The Odor Inspector study group was made up of six Regional Agency Offices. Each of the Regional Offices received an Odor Pen Testing Kit and a copy of the "Standard Procedure". The testing period began in January and is on-going. However, this paper represents data collected between January and October, 2003. The same Odor Pen Testing Kits were used throughout the entire testing period. Minor revisions were made to the Standard Procedure twice between January and October. Each Regional Office designated one Odor Inspector to serve as test administrator throughout the study. The test administrator learned the test method as described by the Standard Procedure. There was no consideration given to the age or sex of the Odor Inspector tested in the study. The number of Odor Inspectors in each of the offices ranged from 4 to 12 (Table 1). A total of 39 Odor Inspectors were tested. The number of times each Inspector was tested ranged from 1 to 10. The most common number of times an Inspector was tested was 8 (n=12). A threshold average emerged for each of the individuals. The Inspector's odor detection threshold was the mean of their test scores.

The Trained Odor Assessor group was made up of 39 trained odor assessors. Participation in the study group was based on volunteerism. Age and gender were not considered as Assessor attributes for inclusion in the group. The testing occurred during September 2003. The number of times each assessor was tested was twice. The test

administrator for all of the evaluations used the same Odor Pen Testing Kit. The Assessor's odor detection threshold was the average of the thresholds from the two times they were screened.

**Table 1. Number of Odor Inspectors in each of the Regional Agency Offices.**

| Regional Agency Office | Number of Odor Inspectors |
|---|---|
| RO 1 | 4 |
| RO 2 | 7 |
| RO 3 | 12 |
| RO 4 | 6 |
| RO 5 | 6 |
| RO 6 | 4 |

## RESULTS

The olfactory detection threshold of the Odor Inspectors varied. The mean scores of the individuals ranged from 5.33 to 11.5, with a mean of 7.33 (n=39, $s^2$=1.47). Three Odor Inspectors had an olfactory sensitivity greater than 9.5. No mean scores were distributed between 13 thru 15. Three of the thirty-nine inspectors screened showed mean scores between 4.5 and 5.33. There were no detection thresholds below level 4.

The frequency of mean individual scores was dispersed towards the left of the threshold range (Figure 3). The majority of Inspectors reported scores in the lower pen number range and the reported pen scores spread across 8 pens (pen level=5-12). The mode of the Odor Inspector group was odor pen 7. The frequency of each pen was calculated by rounding individual mean scores up to the corresponding odor pen if the mean score was greater than 0.5 and down to the corresponding odor pen if less than 0.5.

The Odor Assessor group reported individual olfactory sensitivity mean scores between 7.0 and 12.25. Two assessors were shown to have mean threshold scores of 7.0, as well as two assessors having scores of 12.25. The mean threshold score of the group was 9.45 (n=39, $s^2$=1.17).

The frequency of detection scores followed a normal distribution and was dispersed roughly in the middle of the odor pen range and spread across six pens (pen level=7-12). The mode of the Odor Assessor group was odor pen 9 (Figure 4). Pen scores were generated following the same conversion as stated in the above paragraph.

A z-test of the comparison of means showed a significant difference in the mean odor detection thresholds of the Odor Assessor group and the Odor Inspector group ($\alpha$=0.05).

**Figure 3. The frequency of each odor pen was determined from the mean detection threshold score of an individual in the Odor Inspector Group (n=39, x=7.33, $s^2$=1.47). The mode of the group was odor pen number 7.**

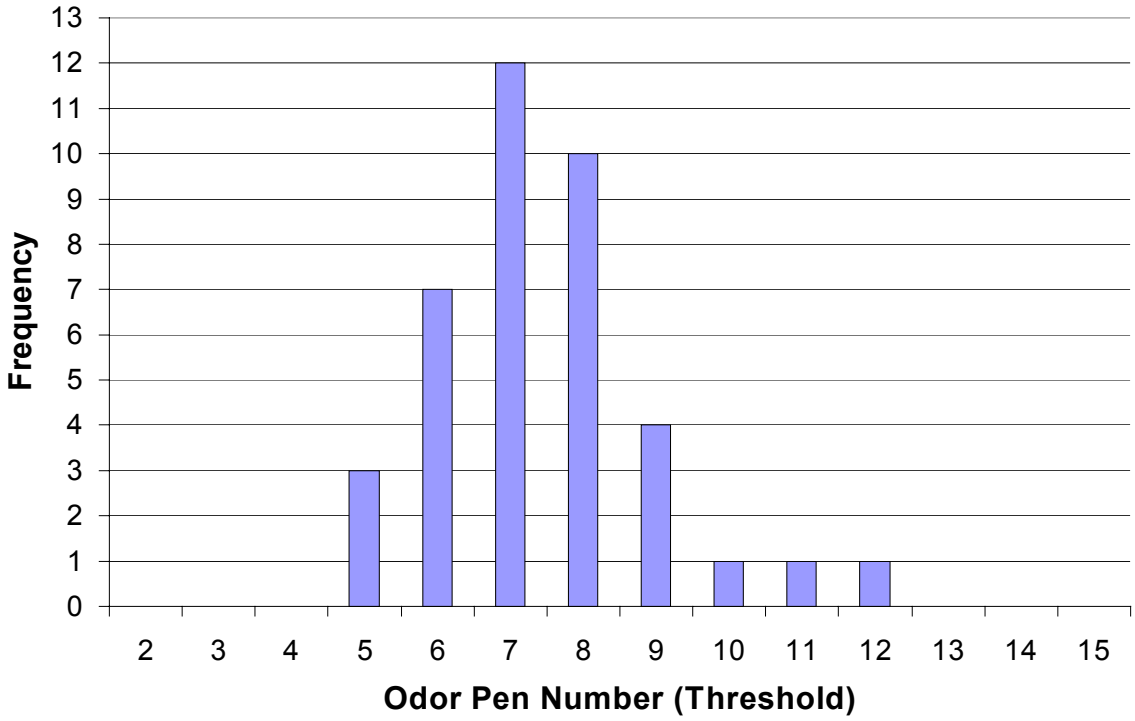



**Figure 4. The frequency of each odor pen was determined from the mean detection threshold score of an individual in the trained Odor Assessor Group (n=39, x=9.45, $s^2$=1.17). The mode of the group was odor pen number 9.**

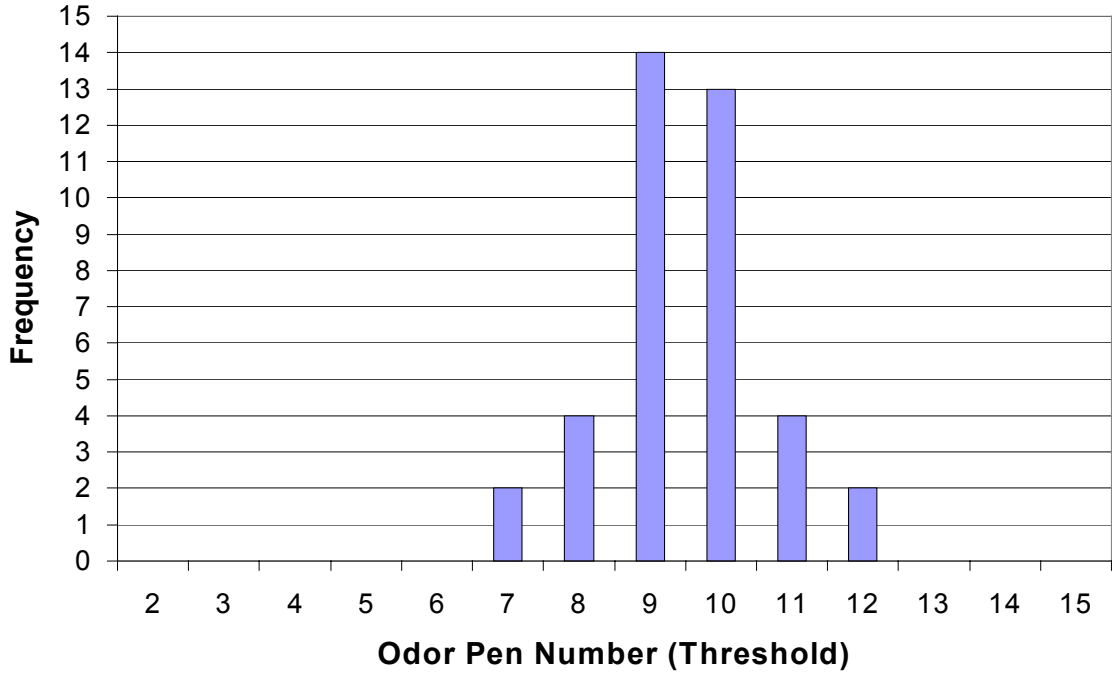
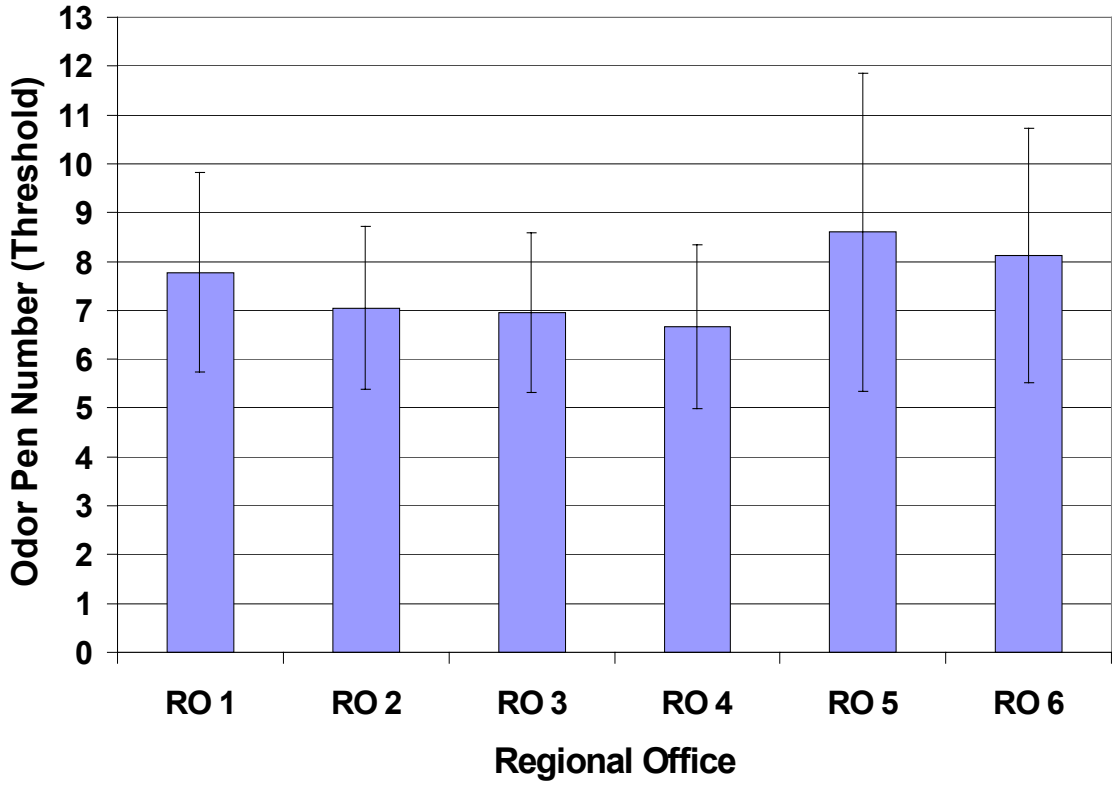


Figure 5 displays the mean scores for each of the Regional Offices. The odor sensitivity varied between each of the offices. The mean threshold scores for the six Regional Offices ranged from 6.66 to 8.45. Odor sensitivity varied within each of the Regional Offices as well. The standard deviation was the lowest at the Regional Office 3, which reported a standard deviation of 1.64. The highest standard deviation occurred at Regional Office 5, reporting a standard deviation of 3.26.

**Figure 5. Olfactory sensitivity mean detection thresholds for the six Regional Offices of the Odor Enforcement Group. (RO 1=2.05, RO 2=1.66, RO 3=1.64, RO 4=1.68, RO 5=3.26, RO 6=2.61)**




## DISCUSSION

This study provides olfactory sensitivity data in the form of odor detection thresholds from a commercially available test kit for two groups, the Odor Inspector group and the Odor Assessor group. The odor pen thresholds for these two groups both occurred within the middle range of possible odor pens. This suggests that there is a general sensitivity range within the population of individuals who will be assessing, enforcing or monitoring odors for industry, commercial and agency groups.

In an attempt to obtain normative odor threshold values in healthy subjects, a previous study with "Sniffin' Sticks" measured and compared the olfactory sensitivity (standard odorant n-butanol) in three age groups (Kobal et al, 2000). The age groups were 16-35

yrs (n=461), 36-55 yrs (n=60) and age greater than 55 yrs (n=30). The results showed that the odor detection thresholds for theses groups were 8.5 ($s^2$=3.12), 8.5 ($s^2$=2.08) and 7.6 ($s^2$=3.43), respectively. Post-hoc testing with ANOVA found differences for thresholds between subjects aged 36-55 yrs and greater than 55 yrs. Thus, these researchers concluded that odor sensitivity varies as a function of age.

The findings from this study are similar to the odor detection thresholds measured in this current study within the Inspector Group and Assessor Group, where mean group thresholds were 7.33 ($s^2$=1.47) and 9.45 ($s^2$=1.17), respectively. Furthermore, the published data from the Kobal et al study may provide an explanation for the difference group means between the Inspector Group and the Assessor Group. That study showed that an individual's olfactory function varies in relation to age, and it may be that the age categories of the individuals were aggregated within the two test groups in this current study. However, age was neither an examined attribute nor criterion for inclusion in either of the study groups. Therefore, further study of olfactory sensitivity as a function of age may be conducted in the forthcoming test cycle of this ongoing study.

The mean threshold scores of the two groups tested in this study are significantly different. It is important to consider the reasons for these differences. It is likely these two groups represented to distinctly different samples of the general population, and subset groups would not necessarily be expected to have an average equivalent to the population mean. For example, the Regional Office Odor Inspectors potentially represent a narrow age range and come from similar socio-economic backgrounds.

Likewise, the trained odor assessors also come from similar backgrounds and live in relatively close proximity in a few neighboring communities. Additionally, age of the assessors was not categorized and may contribute to the sensitivity profile of the assessor. Furthermore, the trained odor assessor group is familiar with the odor testing process, specifically the triangular forced choice approach, and they are familiar with the n-butanol odorant as used for assessor training and qualification and in intensity measurement procedures. This could explain why this specific sample of the population scored higher than the average reported by other studies.

This study is an ongoing investigation into the odor detection threshold of odor assessors and investigators. A greater understanding of necessary performance criteria is forthcoming from continuation of this study. Nonetheless, general recommendations that can be offered to groups or agencies who will be screening odor monitors are:

- Screen individuals an initial 5-6 times. This generates a profile of the individual's sensitivity.
- Screen individual's once a month after a profile of the individual's sensitivity has been established (mean threshold score). This will confirm their olfactory function by using pervious scores as the reference of function.

Continuation of the monitoring of these study groups and additional groups will provide additional information about the population average and variability of data sets within specific samples of individuals.

## CONCLUSIONS

Measuring the odor sensitivity of individuals who will be inspecting odors in the ambient air generates credibility for the agency or facility coordinating the monitoring. Odor detection thresholds provide credentials for the individual inspector, enforcer or assessor directing observing the odorous air. Furthermore, obtaining the threshold score of individuals who will be routinely observing odorous air is an important characterization of the individual's sensitivity to odor and therefore allows a reference for accurate assessment of the strength of the odor in waste water, landfill, composting and other industry environments.

The results of this study provide a basis for conducting assessments of olfactory sensitivity of odor inspectors, monitors and assessors with the St. Croix Sensory Odor Pen Kit ("Sniffin' Sticks") and the "Standard Procedure for Testing Individual Odor Sensitivity".

## ACKNOWLEDMENTS

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# Appendix

**Standard Procedure for**
## Testing Individual Odor Sensitivity

### Purpose

The purpose of this standard procedure is to determine the olfactory threshold (odor sensitivity) of an individual to a standard odorant.

### Materials and Resources

The testing method requires a Test Kit, approximate cost US$200, containing the following items

- "Sniffin' Sticks" odor pens--14 odor pens and 2 blank pen in a storage box with pen tips facing down. 12-month shelf life expected with refrigerated storage, 6-month shelf life with unrefrigerated storage.
- Blind fold (sleeping mask)
- Odor Sensitivity Test Data Sheets

Not included in the Test Kit but required are odorless cotton gloves or Nitrile exam gloves (single use, ambidextrous) that are to be worn by the test administrator during testing to minimize hand odor influence.

Pens are to be removed from refrigeration and placed in room temperature conditions two-hours before testing.

Thirty minutes of time is necessary for the administrator to complete the entire test procedure for one individual.

### Summary of Test Method

The testing procedure assesses an individual's olfactory sensitivity by using odor pens, devices like felt tip pens that contain 1-butanol (n-butanol), a standard odorant. 1-butanol is a common odorant used in felt tip marker pens thus tested individuals are familiar with its odor.

The practice combines two statistical procedures. First, the ascending concentration procedure utilizes 14 odor pens that contain an increasing concentration of 1-butanol in discrete steps (15=lowest and 2=highest). Second, the three-alternative forced choice (AFC) procedure requires the individual to indicate which pen contains the odorant out of

a triplet of pens, one of which is an odor pen and the other is an odorless pen, used twice as the blank pen. The individual will make three sniffing observations, one of each pen, and will be forced to make a choice, even if no difference is observed. When making a choice between pen one, two or three, the testing individual will indicate the selection as detect if a detectable odor difference is perceptible or will state guess if no difference is observed between the pens in the series. A response of detect is given even in the case that the odor is only observed in one of the two nostrils.

A detection threshold is the concentration of the odorant that has a 0.5 probability of being detected under test conditions. The probability of detection at any of the 14 concentrations is not a fixed attribute of the individual but a value, which assumes that olfactory sensitivity varies as a result of random fluctuation in factors such as alertness, attention, fatigue, health status, and possibility of variability presentation of the odor pen.

An individual's olfactory threshold is based on a series of judgments made by the individual. It is important to recognize that the determination of an individual's threshold is a definable task in which precision of the result is mainly a question of the number of times the individual takes the test. This test procedure requires a concentration series presentation Pretest, Test #1, to approximate the olfactory threshold of the individual and is followed by Test #2 and Test #3, two more concentration series presentations. These second and third presentations are averaged together to become the individual's olfactory threshold estimate.

The Test Data Sheet is used as a guide for presenting the odor pen and blanks. One of three Test Data Sheets will be randomly selected for recording the test individual's presentation observations. The three Test Data Sheets presentation columns are sequenced in unique predetermined random orders. The test administrator presents the pen triplet for a concentration level in the order that is coded on the Test Data Sheet. The presentation code sequence follows that the odor pen corresponds to the shaded box in the triplet row. The two unshaded boxes correspond to the blank pens. The red pens in the kit correspond to the 1-butanol pens and the blank pen is the green, blue or other than red colored pen.

The individual should wait one hour after any meal, snack or drink before testing and the meal or snack must not consist of spicy food items. During the one-hour period before testing, the individual may consume water. They should be free of cold, flu or allergy symptoms. A pregnant person should be excluded from testing. The test administrator should check that none of the pens in the kit smell like an odor other than 1-butanol or a blank. If a pen is malodorous, it should be discarded and replaced.

**Procedure for Testing Individual Odor Sensitivity**

1. Test administrator presents odor pen 4 to the test individual to familiarize the test individual with the odor of n-butanol. The sniffing technique used in the evaluation is to sniff as if naturally sniffing the end of a felt tip marker.

2. Test individual places blindfold over eyes to prevent visual detection of odor pens.

3. Test administrator is to complete the top portion of the Odor Sensitivity Test Data Sheet. Fill in the name of the testing individual and the date of the test.

4. Test administrator starts Pretest, Test #1, with odor pen 15 and will furthermore present every other odor pen dilution level (i.e. 15, 13, 11). Lay the pen triplets (odor containing pen, one blank used twice) on the table that will be presented for the beginning dilution series in the order corresponding to the sequence on the Test Data Sheet.

5. Test administrator states the first pen of the triplet verbally to the test individual as "Number One Pen." The test individual will smell each odor pen twice, once under each nostril. The administrator will remove the pen cap and the statement "Sniff" will be made when the pen is presented to the right and left nostril. The pen is to be held for three seconds, 1/4" below each nostril. **Note:** Test Administrator does not allow the odor pen to contact skin or facial hair on the individual.

6. Test individual will sniff the odor pen when directed and is required to remember the pen number that was presented (Number One Pen).

7. Test administrator replaces the cap on the odor pen. The second pen in the triplet sequence is verbally announced as "Number Two Pen". The administrator will remove the pen cap and the statement "Sniff" will be made when the pen is presented to the right and left nostril. The pen is to be held for three seconds, 1/4" below each nostril.

8. Test individual will sniff the odor pen when directed and is required to remember the pen number that is presented (Number Two Pen).

9. Test administrator replaces the cap on the odor pen. The third pen is verbally announced as "Number Three Pen". The administrator will remove the pen cap and the statement "Sniff" will be made when the pen is presented to the right and left nostril. The pen is to be held for three seconds, 1/4" below each nostril.

10. Test individual will sniff the odor pen when directed and is required to remember the pen number that is presented (Number Three Pen).

11. Test individual indicates which one pen of the three presented (One, Two, Three) is different from the other two pens. The test individual must indicate their response as a guess or detect.

12. Test administrator records the individual's observation in the first, second or third box in the dilution level row on the Test Data Sheet. The response is recorded as "G" for guess and "D" for detect.

13. Test administrator replaces the 15 odor pen in the "Sniffin Sticks" box and selects odor pen 13, the next odor pen dilution level to be observed. Lay the pen triplets (odor containing pen, two blanks) on the table in the order corresponding to the sequence on the Test Data Sheet.

14. Test administrator waits thirty seconds before proceeding to the presentation of the odor pen 13 and blank pen triplet, following the same procedure as used for the odor pen 15 (see above steps 3-11)

15. Test administrator concludes the Pretest, Test #1 when the test individual has indicated two correct consecutive detects. Correct guesses are not considered correct detects.

16. Test administrator waits three minutes before starting Test #2. Start Test #2 with the odor pen three dilution levels above the first correct detect of the Pretest, Test #1 [refer to attached example that indicates odor pen 5 as the first correct detect, odor pen 4 as the second correct detect (refer to step 15), therefore, select odor pen 8 to begin Test #2]. Proceed by laying the pen triplets (odor containing pen, two blanks, where one odor pen is used as both blanks) on the table in the presentation order corresponding to the sequence on the Test Data Sheet. **NOTE:** Test #2 requires the odor pen level to proceed in sequence, thus the test administrator will furthermore select the odor pen at the next dilution level lower than the preceding level. **Example:** In Test #2, the presentation following odor pen 8 will be odor pen 7.

17. Test administrator follows the Pretest, Test #1 procedure for Test #2 with the exception of not skipping every-other odor pen, as noted above.

18. Test individual continues to observe the pens when presented and indicates guess or detect for the different pen in the triplet.

19. Test administrator concludes Test #2 when the test individual has indicated two correct consecutive detects. Correct guesses are not considered correct detects.

20. Test administrator scores Test #2. The dilution level of the first of two consecutive correct detects is the score (refer to attached example that indicates a scored Test #2).

21. Test administrator waits five minutes before starting Test #3. Start Test #3 with the odor pen two dilution levels above the first correct detect of Test #2 (refer to attached example that indicates odor pen 6 as the first correct detect; therefore, select odor pen 8 to begin Test #3). Proceed by laying the pen triplets (odor containing pen, two blanks, where one blank pen is used twice) on the table in the presentation order corresponding to the sequence on the Test Data Sheet. **NOTE:** Test #3 requires the odor pen level to proceed in sequence, thus the test administrator will furthermore select the odor pen at the next dilution level lower than the preceding level. Example: the presentation following odor pen 8 will be odor pen 7.

22. Test administrator concludes Test #3 when the test individual indicated two correct consecutive detects. Correct guesses are not considered correct detects.

23. Test administrator scores Test #3. The dilution level of the first of two consecutive correct detects is the score (refer to attached example that indicates a scored
Test #3).

24. Test administrator averages the scores of Test #2 and Test #3 to generate the tested individual's olfactory (odor) threshold estimate (refer to attached example that indicates the tested individual's odor threshold).

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**St. Croix Sensory, Inc.**

## *Odor Sensitivity Test Data Sheet (I)*

Name : *Example* Date : Time :

Use shaded box for Numbered Red Pen (Indicate Guess "G" and Detect "D")

| | TEST #1 | TEST #2 | TEST #3 |
|---|---|---|---|
| 15 | G | | |
| 14 | | | |
| 13 | G | | |
| 12 | | | |
| 11 | G | | |
| 10 | | | |
| 9 | D | | |
| 8 | | G | G |
| 7 | G | G | G |
| 6 | | D | G |
| 5 | D | D | D |
| 4 | | | D |
| 3 | D | | |
| 2 | | | |
| | → 3 | → 2 | |
| | 2 | 1 | |
| | 1 | | |

The dilution level of the first of two consecutive correct detects is the Score

**SCORE:** 6 **SCORE:** 5

**Individual's Odor Threshold (average of the Scores):** 5.5

**Test Administrator :** *Signed*



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