The New European Olfactometry Standard: Implementation, Experience, and Perspectives

---

Authored by:

Michael A. McGinley
St. Croix Sensory, Inc.

Charles M. McGinley, P.E.
St. Croix Sensory, Inc.

Preprinted Manuscript of the
Air and Waste Management Association,
2001 Annual Conference Technical Program
Session No: EE-6b,
Session Title: Modeling, Analysis & Management of Odors

Copyright © 2001

St. Croix Sensory Inc. / McGinley Associates, P.A.
13701 - 30th Street Circle North
Stillwater, MN 55082 U.S.A.
800-879-9231
stcroix@fivesenses.com

ABSTRACT

With the global increase of environmental regulations in the 1970's, European countries, Australia, and the United States began to develop odor regulations. These regulations created the need to standardize the methods of odor measurement.

More recently, in the 1990's the European Committee for Standardization (CEN) formed a technical committee (TC264) which developed and is expected to release a final odor testing standard in late 2001, entitled EN 13725: "Air Quality-Determination of Odour Concentration by Dynamic Olfactometry." This standard, which will unify the olfactometry standards of 18 countries (Austria, Belgium, Denmark, Finland, France, Greece, Germany, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and the United Kingdom), follows ISO quality assurance and scientific testing protocols. Australia and New Zealand have combined to write a new standard essentially identical to the European Standard.

A consortium of odor laboratories in Canada and the United States initially approached the proposed European odor testing standard with skepticism. There were concerns regarding the presentation flow rate (20 lpm), the detailed statistical and procedural requirements, and the assessor screening and selection process that was based on only one standard odorant. However, the experience of adopting and applying the standard over the last five years has convinced these laboratories of the benefits of this one unifying olfactometry standard. While Universities and other laboratories are moving towards adopting the European olfactometry standard, there is also a trend towards state regulatory agencies in the U.S. also adopting the standard as an odor measurement tool for monitoring and compliance (e.g. Colorado, Minnesota). This new (draft) European olfactometry standard, due for official acceptance and publication in 2001, is poised to become a global standard of olfactometry for the testing of odours/odors.

This paper discusses implementing and utilizing the proposed (draft) European Olfactometry Standard (EN 13725) by a number of Canadian and US odor laboratories. Topics discussed include presentation air flow parameters, laboratory procedures, quality control statistics, and assessor screening and performance criteria.

INTRODUCTION

With the global increase of environmental regulations in the 1970's, European countries, Australia, and the United States began to develop odor regulations. These regulations created the need to standardize the methods of odor measurement. Some examples of these standards include: US - ASTM D-1391 (1978) and ASTM E679-91 (1991), Germany - VDI 3881 (1980), France - AFNOR - X-43-101 (1986), Netherlands - NVN2820 (1996).

More recently, in the 1990's the European Committee for Standardization (CEN) formed a technical committee (TC264) which developed and is expected to release a final odor testing standard in late 2001, entitled EN 13725: "Air Quality-Determination of Odour Concentration by Dynamic Olfactometry." This standard, which will unify the olfactometry standards of 18 countries (Austria, Belgium, Denmark, Finland, France, Greece, Germany, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and the United Kingdom), follows ISO quality assurance and scientific testing protocols. Australia and New Zealand have combined to write a new standard essentially identical to the European Standard.

A consortium of odor laboratories in Canada and the United States initially approached the proposed European odor testing standard with skepticism. These odor labs include:

- Agriculture Canada - Charlottetown, Prince Edward Island
- Alberta Research Council/University of Alberta - Edmonton, Alberta
- Duke University - Durham, North Carolina
- Iowa State University - Ames, Iowa
- Los Angeles County Sanitation Districts - Los Angeles, California
- Metropolitan Council, Environmental Services - St. Paul, Minnesota
- Purdue University - West Lafayette, Indiana
- St. Croix Sensory, Inc. - Stillwater, Minnesota
- University of Manitoba - Winnipeg, Manitoba
- University of Minnesota - St. Paul, Minnesota

There were concerns regarding the presentation flow rate (20 lpm), the detailed statistical and procedural requirements, and the assessor screening and selection process that was based on only one standard odorant. However, the experience of adopting and applying the standard over the last five years has convinced these laboratories of the benefits of this one unifying olfactometry standard. While Universities and other laboratories are moving towards adopting the European olfactometry standard, there is also a trend towards regulatory agencies in the U.S. also adopting the standard as an odor measurement tool for monitoring and compliance (e.g. Colorado, Minnesota). This new (draft) European olfactometry standard, due for official acceptance and publication in 2001, is poised to become a global standard of olfactometry for the testing of odours/odors.

DEVELOPMENT OF THE "EUROPEAN STANDARD"

In the United States and throughout Europe in the 1970's and 1980's there was a significant increase in public concern for odors from industrial, agricultural, and waste water treatment facilities. During this time, governments in many of these European countries implemented standards and regulations for odors. Many of the regulations required the measurement of odors through olfactometry, either to prove compliance or to measure and monitor odors.

Olfactometry has been used throughout the 20th century in the medical research community. However, there has existed variability of results due to differences in olfactometer design and operating performance as well as the lack of consistency in odor testing methods used.

In the 1980's countries in Europe began developing standards of olfactometry. Some of these standards developed and published include:

France	AFNOR X-43-101 (drafted in 1981 & revised in 1986)
Germany	VDI 3881, Parts 1-4 (drafted in 1980 & revised in 1989)
Netherlands	NVN 2820 (drafted in 1987 & issued in 1995)

Various inter-laboratory studies as well as collaborative projects involving multiple odor testing laboratories in the 80's showed that laboratory results still differed significantly even with these standards in practice.[1]

The development of a draft odor testing standard in the Netherlands led to an Inter-Laboratory Comparison study organized in 1989.[2] N-butanol and hydrogen sulfide were used as standard odorants for the study. Through 1990 to 1992 the results of this Dutch Inter-Laboratory study led to the development of strict assessor performance criteria. During the first year, the inter-laboratory repeatability was in the range of factors from 3 to 20. An analysis of the data from this first year showed the majority of variability was between assessors. Individual assessors were repeatable within a factor 3 to 5. The researchers found that the only way to meet agreed upon repeatability criteria was to control the instrument sensor, the human assessors, by selecting assessors who were all similar in sensitivity.

Standards were set for assessor performance to the standard odorant n-butanol. Only assessors who met predetermined repeatability and accuracy criteria were allowed to continue as assessors. Over the next two years, these new criteria were implemented within each of the labs involved in the study.

In 1993, a final round of testing yielded an inter-laboratory repeatability of a factor of only 2 to 3. The Dutch inter-laboratory study from 1989 to 1993 showed a convergence towards the agreed upon n-butanol reference threshold through the improved repeatability

of results. The results in March of 1993 showed the benefit of all laboratories implementing assessor selection criteria.[3]

The work of this inter-laboratory study led to the final Dutch standard released in 1995 and set the foundation for the development of the new European odor testing standard.

A working group was formed within the Committee European de Normalisation (CEN) Technical Committee 264 – "Air Quality" to develop a unified olfactometry standard. This working group saw a need to help industry and regulators develop a consistent basis for monitoring and testing odors, and, thus help determine the potential for odor nuisance. This was to be accomplished by developing a method that:

1. Improved consistency within each laboratory (repeatability);
2. Achieved comparable results among laboratories (reproducibility); and
3. Connect the results to a traceable reference material, e.g. n-butanol (accuracy)

In order to achieve these goals, the committee focused on the following issues: sampling procedures, sample containers, olfactometer construction and operation, the olfactometer and assessor interface, the odour testing room, methods of data processing, and assessor selection, training, and performance. This paper focuses on the olfactometer and assessor interface as well as assessor selection, training and performance.

The first complete draft of the European olfactometry standard was released in 1995. Then in the spring and summer of 1996, nineteen laboratories from five countries participated in an Inter-laboratory Comparison of Olfactometry (IOC) study. The purpose of this study was to validate the requirements, methods, and procedures outlined in the draft. The conclusions of this study were:

1. All quality requirements and performance criteria were attainable for all testing methods studied (Forced-Choice and Yes/No); and

2. Those following the standard for the longest period of time performed the best with regards to accuracy and repeatability.[4]

The CEN olfactometry standard was released to the public at the end of 1999 through the standard organizations of each participating country. The standard was released as Proposed CEN standard #13725 (prEN 13725) "Air Quality – Determination of odour concentration by dynamic olfactometry." A public comment period closed at the end of January 2000. Comments were submitted to each country's standardization body separately. These comments were reviewed in early 2000. The working group met in 2000 to review all comments and issue a final revision of the standard. The final revision will be sent to the CEN organization for official acknowledgement and approval in 2001.

The final CEN standard approval will obligate all countries of the European Union to adopt the standard and withdraw any conflicting or redundant national standards. These countries include: Austria, Belgium, Denmark, Finland, France, Greece, Germany,

Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and the United Kingdom.

The final standard will be published in three official languages: English, French, and German. The standards are distributed through the individual country standardization boards. For example, an English language copy can be obtained from the British Standards Institute (BSI).

COMPARISON OF US AND EUROPEAN ODOR TESTING

In simple terms, if a laboratory follows the European odor testing standard, prEN13725, using the "triangular presentation method", they will be meeting all elements of ASTM E679-91, "Determination of Odor and Taste Thresholds by a Forced-Choice Ascending Concentration Series of Limits." The ASTM standard is general in its description of procedures and operating requirements. Much of this is due to the fact that ASTM E679-91 pulls double duty, as the method for odor testing and taste testing.

The following discussion compares the ASTM E679-91 testing standard with the European Draft Odor Testing Standard, prEN13725, and the Air & Waste Management Association (A&WMA) Environmental Effects Committee #6 (EE-6) Draft Odor Testing Guidance Document, "Guidelines for Odor Sampling and Measurement by Dynamic Dilution Olfactometry" (1995).

Presentation Statistics

The CEN draft standard and the EE-6 committee draft guidelines agree that test odors should be presented to human assessors (panelists) utilizing dynamic dilution olfactometry following a "forced-choice" ascending concentration series method. The assessors are presented with a diluted odor sample and one or two blank samples of odor free air. The assessor must choose which sample contains the odor, even if they must guess. This approach is known as the "forced-choice" presentation method. After the assessor makes a selection, they are presented with the next odor sample and blank(s). However, this next odor sample is at a higher concentration (e.g. two times higher). The assessor continues to additional higher levels of sample presentation following these methods. This statistical approach of increasing levels of sample presentation is known as "ascending concentration series."

There are two minor differences between the European (CEN) and US testing methods regarding presentation statistics. The first difference is that the EE-6 committee stands behind the ASTM E679-91 method, which requires two blank presentations per diluted odor presentation. This approach is known as a triangular presentation method. The CEN standard agrees with the triangular approach, but also allows utilizing only one blank per dilute odor presentation (binary presentation). The second difference is in the dilution increase between dilution presentation levels. While the EE-6 committee recommends a constant increase of a factor of two, the CEN standard specifies an allowable step factor between 1.4 and 2.4.

The European Standard also allows the Yes/No Presentation Method and the Forced-Choice Probability Method. The Yes/No method is similar to audiometer protocol where dilute odors and blanks are randomly presented and the assessor identifies when they detect the odor. The Forced-Choice Probability Method is a complex Forced-Choice Method derived from the French standard AFNOR NF 43-101.

Presentation Method

Olfactometer Design. All standards developed to date have specified "odor free" dilution air. Further, the most recent drafts released by the EE-6 committee and the CEN have specified the olfactometer must be constructed of components made of glass, stainless steel, or polytetrafluoroethylene (PTFE - Teflon®). These standards also come relatively close to agreeing on an acceptable range of dilutions. The CEN has specified a minimum upper limit of 2^{14} and a maximum lower limit of 2^{7}. The EE-6 committee recommends a minimum upper limit of 10,000 ($\sim 2^{13}$) and a maximum lower limit of 10 ($\sim 2^{3}$).

Presentation Flow Rate. An olfactometer developed in the US by the Illinois Institute of Technology Research Institute (IITRI) in the 1970's was designed to simulate the static "syringe method" (ASTM D-1391) of odor testing with a dynamic presentation method. The IITRI olfactometer operated at 0.5-lpm.

ASTM E679-91 does not specify a presentation flow rate, but presents IITRI's 0.5-lpm as an example. In the Netherlands, a simulation study used tracer gas and an anatomical model of the nose to study the effects of presentation flow rate on the determined threshold. This study showed that at flow rates of 20-lpm and higher, there is only a minor decrease in the threshold value compared to higher flows.[5]

In the mid 1980's, Dr. David C. Laing of the CSIRO Division of Food Research, N.S.W., Australia, studied the variables of sniffing and concluded that the optimum operating flow rate for an olfactometer is between 30-lpm to 40-lpm.[6]

Konosuke Nishida, Yasuo Yanagibashi and Marahiro Osako of the Laboratory for Control of Environmental Micro Pollutants, Kyoto University, Otsu, Japan studied flow rates of 0.5-lpm to 5.0-lpm and concluded that "the optimum flow rate of test odor by dynamic sniffing test is 4-lpm."[7]

In 1995, Martha O'Brien, et al, of Odor Science & Engineering (OSE), Inc., Bloomfield, Connecticut, published their research which studied the flow rate phenomena over the flow range of 1-lpm to 20-lpm and concluded "that a flow rate between 5-lpm and 10-lpm…will produce repeatable measurements most characteristic of odor perception in the ambient air."[8] The OSE study utilized two mask sizes and three test odorants (hydrogen sulfide, p-xylene, and n-butanol).

prEN13725 specifies that the olfactometer must operate at a presentation flow rate of 20-lpm or higher. In 1995 the draft guideline of the EE-6 committee recommended an odor presentation flow rate of 8-lpm

A multiple laboratory olfactometer flow rate study began in 1996 with a number of university and sanitation district odor laboratories.[9,10] The odor laboratory participants included:

- Iowa State University, Ames, Iowa
- Metropolitan Council Environmental Services, St.Paul, Minnesota
- Purdue University, West Lafayette, Indiana
- St.Croix Sensory, Stillwater, Minnesota
- University of Minnesota, St.Paul, Minnesota

In April 2000, the multiple laboratory study found no statistical nor clinical difference between data produced from an olfactometer operating with an "odor presentation flow rate" of 10-LPM or 20-LPM. Furthermore, at the conclusion of the study, the participants elected to operate their olfactometers at the odor presentation flow rate of 20-liter per minute (LPM), following the tenets of the draft European standard, prEN13725.

Presentation Face Velocity. The EE-6 committee recommends a face velocity of between 0.02 - 0.05 m/s (6-10cm diameter mask @ 8-lpm). The CEN has specified a face velocity of no less than 0.2 m/s and recommends that it not exceed 0.5 m/s (3-5cm diameter mask @ 20-lpm). The laboratories that participated in the flow rate study, which began in 1996, all used the same sniffing mask (SWIFT™ nasal mask) with an equivalent diameter of four (4) centimeters, complying with CEN requirements.

Performance Criteria

Beyond the operating parameters, CEN and EE-6 discuss performance criteria and instrument calibration. The EE-6 guidelines only outline these topics generally, leaving specifics to each laboratory. The CEN standard goes one step further by creating the groundwork for a laboratory quality assurance plan. prEN13725 specifies laboratory accuracy and repeatability performance criteria (including instructions on how to test the criteria) for the olfactometer following the international standard ISO5725 *Accuracy (Trueness and Precision) of Measurement Methods and Results Parts 1-4*. The CEN standard also lists strict criteria for qualifying an assessor for olfactometry panels.

The CEN standard requires that the olfactometer must be periodically calibrated at each dilution level with a suitable tracer gas. Each level must be accurate to within 20%. For instrument performance, instability is used to represent repeatability. During simulated operation of the instrument, with a tracer gas as the odorant, multiple chemical measurements are taken to determine the instruments stability around each dilution ratio.

The laboratory must periodically test its performance using a reference gas at a defined concentration. prEN13725 gives detailed procedures and example calculations for testing and defining a laboratory's accuracy. For example, the standard contains specific criteria

for confirming that a laboratory can accurately assess standard reference odorants. For repeatability, the standard requires that "the difference between two single measurements, performed on the same testing material [gas] in one laboratory…will not be larger than a factor of 3 in 95% of the cases." If the laboratory meets these criteria, it is assumed that the quality level is transferable to other, environmental odorants.

Assessor Selection and Training

In the past, one major issue in the development of all odor testing standards has been the size of the statistical sample of assessors. Economics and practicality have traditionally limited panel size from six to twelve assessors. Past olfactometry standards have required the selection of a pool of assessors from the general population for these six to twelve assessors. This is how ASTM E679-91 and the EE-6 Guidance Document specify assessor selection.

The EE-6 guidelines state that individuals "representing 'normal' sensitivity are selected to serve as panelists." The guidelines do not go any further to define "normal sensitivity." Since odor sensitivity in the general population is normally distributed, it is implied that a laboratory should aim for assessors who lie near the center of the bell curve (i.e. within 1 to 2 standard deviations of the mean).

Through the review of past inter-laboratory odor testing studies and conducting the "inter-laboratory comparison of olfactometry" project in the 1990's, the CEN standard development working group concluded that selecting assessors from the general population does not provide sufficient repeatability and reproducibility when a small sample size is being used. Thus, "the notion that the panel should be representative for the general population was explicitly abandoned" and the committee moved towards developing a set of accuracy and repeatability criteria for assessor selection and qualification with the use of a standard odorant.[4]

prEN13725 states "assessors with a specific sensitivity to the reference odorant n-butanol are selected to be panel members." Each potential assessor must be tested to n-butanol on the olfactometer a minimum of 10 times. The individual's average threshold measurement of n-butanol must be in the range of 20 - 80 ppb. Further, the antilog of the standard deviation must be less than 2.3. Once the assessor is accepted as a panelist they must be continually checked to this n-butanol reference with a rolling average of twenty (20) measurements compared to the above criteria.

prEN13725 specifies that 8 responses are necessary for a "valid" testing result. The standard further suggests that this can be accomplished with five (5) assessors completing two rounds of sniffing. These ten (10) responses allow for retrospectively eliminating one assessor due to specific hypersensitivity or anosmia to the sample tested. Selecting assessors based on their performance to one standard odorant makes the assumption that their performance will be similar to other odorant mixtures (e.g. environmental odors). A footnote in prEN13725 states that the standard development

committee agrees that it would be ideal to eventually develop a series of standard odorants or a standard reference odorant mixture.

NORTH AMERICAN OLFACTOMETRY IN THE 90's

The proliferation of large scale animal confinement facilities (i.e. feedlots) throughout the United States, as well as the general trend of urban sprawl moving people closer to odorous industrial facilities, wastewater treatment facilities, and agricultural facilities has created a resurgence in funding for odor related research. In 1995, universities and research institutions in the United States and Canada began to develop and expand odor testing laboratories for conducting odor research in agricultural facilities, municipal solid waste facilities, and other odorous industries. Odor research laboratories founded or expanded in the past five years include:

- Agriculture Canada - Charlottetown, Prince Edward Island
- Alberta Research Council/University of Alberta - Edmonton, Alberta
- Duke University - Durham, North Carolina
- Iowa State University - Ames, Iowa
- Los Angeles County Sanitation Districts - Los Angeles, California
- Metropolitan Council, Environmental Services - St. Paul, Minnesota
- Purdue University - West Lafayette, Indiana
- University of Illinois – Urbana, Illinois
- University of Manitoba - Winnipeg, Manitoba
- University of Minnesota - St. Paul, Minnesota
- West Texas A&M University - Amarillo, Texas

These odor laboratories basically followed the ASTM E-679-91 practice with one exception, they adopted, for pragmatic reasons, the odor presentation flow rate of 20-lpm, a tenet of the draft European standard, prEN13725. However, the odor laboratories were skeptical of the extensive performance criteria and assessor selection requirements of prEN13725.

OLFACTOMETRY IN THE NEW MILLENIUM

Each of these laboratories has ongoing research that is funded through revenues and grants from various sources. It behooves them to coordinate, collaborate, and share databases that have a common test procedure, namely prEN13725. Likewise, these laboratories encounter European databases and published research, which they desire to correlate with their work. Only a common testing standard will allow this to be accomplished effectively.

At an America Society of Agricultural Engineers Specialty Conference held in Des Moines, Iowa in October 2000, many of the researchers and laboratory personnel from the above mentioned university laboratories met together for an "Odor Laboratory Workshop." This workshop was held to facilitate the sharing of experiences and ideas

between these laboratories. During this meeting, the university laboratories announced their commitment to implement the butanol screening assessor selection criteria. This element of prEN13725 was recognized as the laboratories' number one QA/QC priority.

Butanol screening for assessor selection must begin with specific training in "sniffing" technique and "force-choice" decision criteria. After more than five years of experience with butanol screening, several European odor laboratory managers have told U.S. laboratory managers that it is common to see only 40-60% of recruited assessors pass the butanol criteria. During initial training, potential assessors should take part in training sessions which should include information about: principles and objectives of odor testing, proper sniffing techniques, differentiation between the sample odorant and the blanks, definitions of required responses (i.e. "guess", "detection", and "recognition").

These laboratories have reported similar experiences with conducting butanol screening of assessors. All laboratories have started with testing current assessors for compliance. Initially, only about 20-30% of assessors pass the screening criteria. However, after training and repeated testing, laboratories are reporting 60-80% of current assessors meeting the butanol criteria. Figure 1 is an example of a butanol screening history report for one typical assessor. The report shows how the assessor's butanol threshold decreased after initial training and remained consistent over the remainder of the twenty tests displayed in this report.

It is important to continually test the assessors to n-butanol and then provide this feedback to them. If the assessor is performing well, they need to receive this reassurance. Likewise, if an assessor is not performing well, the assessor needs to be informed of this and laboratory management must consider corrective actions such as re-training. van Harreveld shared these same impression in a paper presented at the 1995 AWMA "Odors…" specialty conference:

> "The mere introduction of the idea of panel selection has apparently had, in itself, a clear influence on their responses…The moment panel selection as a concept was presented in June 1992, the level of the individual thresholds changed, to become 'more sensitive'. This would suggest that motivation determines the olfactometry characteristics of an individual to a considerable degree…[assessor selection] requires continuous monitoring and feedback…"[11]

There is clear momentum for the new European Odor Testing standard, prEN 13725, to become the standard of practice in the U.S. and Canada during the early part of this decade. Not only is the European standard currently being implemented in university and other research laboratories throughout North America, but state regulatory agencies are beginning to recognize this testing standard as superior to ASTM E679-91 and are specifying prEN13725 in permits and other management documents.

Figure 1. Butanol screening history report for a typical assessor. Reproduced from AC'SCENT DATASENSE™ Olfactometry Software.

Assessor History of Past 20 Individual Tests

McGinley , Michael **Assessor's Code No. :** 1002

Test Chemical : **N-Butanol**

Test Instrument : AC'SCENT International Olfactometer

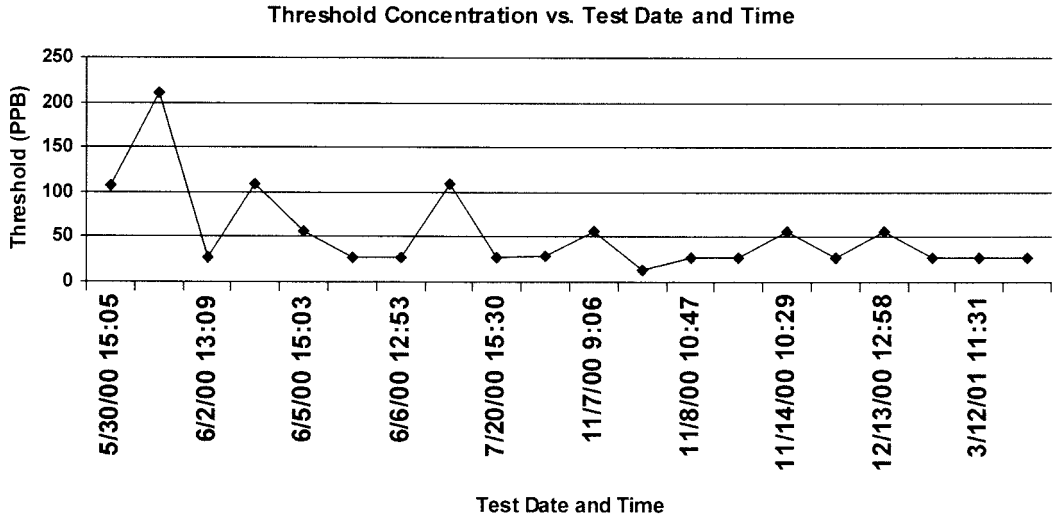
Test Method : Triangular Forced Choice

Test Date	Test Time	Test Chemical Reference	Flow Rate	Sniff Time	Concentration (PPM)	DT	Threshold (PPB)
5/30/00	3:05:02 PM	ML4891 - 020100	20	3	40	372.5	**107.4**
5/30/00	3:29:58 PM	ML4891 - 020100	20	3	40	189.0	**211.7**
6/2/00	1:09:02 PM	ML4891 - 020100	20	3	40	1,451.1	**27.6**
6/5/00	2:41:10 PM	ML4891 - 020100	20	3	40	363.7	**110.0**
6/5/00	3:03:32 PM	ML4891 - 020100	20	3	40	707.1	**56.6**
6/6/00	10:48:00 AM	ML4891 - 020100	20	3	40	1,414.2	**28.3**
6/6/00	12:53:31 PM	ML4891 - 020100	20	3	40	1,414.2	**28.3**
6/6/00	1:09:16 PM	ML4891 - 020100	20	3	40	363.7	**110.0**
7/20/00	3:30:48 PM	ML4891 - 020100	20	3	40	1,480.8	**27.0**
11/6/00	2:22:03 PM	ML4891 - 020100	20	3	40	1,407.8	**28.4**
11/7/00	9:06:18 AM	ML4891 - 020100	20	3	40	705.3	**56.7**
11/7/00	10:11:42 AM	ML4891 - 020100	20	3	40	2,832.9	**14.1**
11/8/00	10:47:02 AM	ML4891 - 020100	20	3	40	1,414.9	**28.3**
11/13/00	10:01:09 AM	ML4891 - 020100	20	3	40	1,414.9	**28.3**
11/14/00	10:29:43 AM	ML4891 - 020100	20	3	40	708.9	**56.4**
11/15/00	9:57:47 AM	ML4891 - 020100	20	3	40	1,414.9	**28.3**
12/13/00	12:58:33 PM	ML4891 - 020100	20	3	40	708.9	**56.4**
1/18/01	3:55:37 PM	ML4891 - 020100	20	3	40	1,414.9	**28.3**
3/12/01	11:31:10 AM	ML4891 - 020100	20	3	40	1,414.9	**28.3**
3/13/01	7:03:09 PM	ML4891 - 020100	20	3	40	1,414.9	**28.3**

Summary Statistics for Michael McGinley (n = 20 Records)

Average Threshold (PPB) = 54.4 **Minimum Threshold (PPB) =** 14.1

Standard Deviation of DT = 1.96 **aximum Threshold (PPB) =** 211.7



Thursday, 15 March 2001 Page 1 of 1

CONCLUSIONS

In the 1990's the European Committee for Standardization (CEN) formed a technical committee (TC264) which developed and is expected to release a final odor testing standard in 2001, entitled EN 13725: "Air Quality-Determination of Odour Concentration by Dynamic Olfactometry." The development of prEN13725 includes elements from the existing odor standards of Germany, The Netherlands, and France. An inter-laboratory testing program involving nineteen laboratories in Europe verified the standard is achievable and meets the original goals set forth by the technical working group. This new standard will unify the olfactometry standards of 18 countries. Australia and New Zealand have combined to write a new standard essentially identical to EN13725.

Odor laboratories in Canada and the United States initially approached the proposed European odor testing standard with skepticism. There were concerns regarding the presentation flow rate (20 lpm), the detailed statistical and procedural requirements, and the assessor screening and selection process that was based on only one standard odorant (i.e. n-butanol). However, the experience of several laboratories adopting and applying the standard over the last five years has convinced these laboratories of the benefits of this one unifying olfactometry standard.

prEN13725 provides essential criteria for QA/QC quality elements including:

1. Olfactometer design and operating procedures,
2. Olfactometer certification (calibration) requirements,
3. Ongoing assessor screening, training, and selection criteria,
4. Laboratory design and operation,
5. Assessor certification, and
6. Data processing procedures (including retrospective screening for data "outliers").

The published research from Europe in the 1990's showed that the butanol screening and selection criteria and all other laboratory QA/QC criteria of prEN13725 are achievable.

The following odor testing laboratories are embracing all quality elements of prEN 13725 and are working towards complete implementation of the new standard:

- Agriculture Canada - Charlottetown, Prince Edward Island
- Alberta Research Council/University of Alberta - Edmonton, Alberta
- Iowa State University - Ames, Iowa
- Los Angeles County Sanitation Districts - Los Angeles, California
- Metropolitan Council, Environmental Services - St. Paul, Minnesota
- Purdue University - West Lafayette, Indiana
- St. Croix Sensory, Inc. – Stillwater, Minnesota
- University of Illinois – Urbana, Illinois
- University of Manitoba - Winnipeg, Manitoba
- University of Minnesota - St. Paul, Minnesota
- West Texas A&M University - Amarillo, Texas

These laboratories represent over 50% of active commercial and research environmental odor testing laboratories in North America. The work of these laboratories from the late 1990's to present has created momentum in the U.S. and Canada for embracing prEN13725 through further validation that all elements of the standard are achievable.

The new European odor testing standard prEN13725 "Air Quality-Determination of Odour Concentration by Dynamic Olfactometry" is set to become the defacto international olfactometry standard for testing odors in the new millenium.

ACKNOWLEDGEMENTS

The authors of this paper would like to thank all university and research laboratory personnel who provided experience and other information utilized in this paper: Dr. A.J. Campbell & Lloyd Kerry (Agriculture Canada - Charlottetown, Prince Edward Island), Dr. John Feddes (University of Alberta/Alberta Research Council - Edmonton, Alberta), Dr. Susan Schiffman (Duke University - Durham, North Carolina), Dr. Dwaine Bundy & Peggy Lockhart (Iowa State University - Ames, Iowa), Solid Waste Engineering Staff of Los Angeles County Sanitation Districts (Los Angeles, California), Lisa Wolfert (Metropolitan Council, Environmental Services - St. Paul, Minnesota), Dr. Al Heber & Kate Fakhoury (Purdue University - West Lafayette, Indiana), Dr. Q. (Chong) Zhaing & Scott Melvin (University of Manitoba - Winnipeg, Manitoba), and Dr. Richard Nicolai, Dr. Larry Jacobson, Dr. Charles Clanton & David Schmidt (University of Minnesota - St. Paul, Minnesota).

STANDARD REFERENCES

ASTM D-1391. *Standard Test Method for Measurement of Odor in Atmospheres (dilution method)*. American Society for Testing and Materials, Philadelphia, PA, USA, 1978.

ASTM E679-91. *Standard Practice for Determination of Odor and Taste Thresholds by a Forced-Choice Ascending Concentration Series Method of Limits*. American Society for Testing and Materials, Philadelphia, PA, USA, 1991.

VDI 3881 Part 1-4. *Richtlinien, (draft) Olfactometry, Odour Threshold Determination, Fundamentals*. Verein Deutsche Ingenieure Verlag, Düsseldorf, Germany, 1980.

AFNOR X-43-101. *Method of the Measurement of the Odor of a Gaseous Effluent*. Bureau de Normalisation, Paris, France, 1981, 1986.

NVN 2820. *Provisional Standard: Air Quality. Sensory Odour Measurement using an Olfactometer*. Netherlands Normalization Institute, The Netherlands, March 1996.

prEN 13725. *Air Quality - Determination of Odour Concentration by Dynamic Olfactometry*. European Committee for Standardization (CEN), Technical Committee 267, Working Group 2, May 1997.

Draft: Guidelines for Odor Sampling and Measurement by Dynamic Dilution Olfactometry. Air & Waste Management Association, EE-6 Odor Committee, Chairman: Martha A. O'Brien, May 1993.

ISO5725. *Precision of Test Methods - Determination of Repeatability and Reproducibility for a Standard Test Method by Inter-laboratory tests*. International Organization for Standardization, 1986.

REFERENCES

1. Heeres, P. & H. Harssema. "Progress of the Standardization of Olfactometers in the Netherlans." Staub Reinh. Der Luft, 1990, vol. 50, pp 185-187.

2. Hermans, L. "Ringonderzoek Olfactometers." Publikatiereeks Lucht No. 80, 1989. Ministry of the Environment, Leidschendam, the Netherlands.

3. Klarenbeek, J.V., & A. Ph. (Ton) van Harreveld. "On the regulations, measurement and abatement of odours emanating from livestock housing in the Netherlands. International Livestock Conference 1995: pp. 16-21.

4. van Harreveld, A.Ph., Heeres, P., Harssema, H. "A Review of 20 Years of Standardization of Odor Concentration Measurement by Dynamic Olfactometry in Europe." Journal of the Air and Waste Management Association, June 1999. Vol. 49, No. 6: pp. 705-715.

5. Feenstra, L., "Onderzoek verdunning ruikbekers." Intern reprot MT-TNO. No. 80-04274. TNO, Apeldoorn, The Netherlands, 1980.

6. Laing, D.C., "Optimum Perception of Odours by Humans". The Seventh World Clean Air Congress, Sydney, NSW, Australia, 1986.

7. Nishida, K., Yasuo, Y., and Osako, M., "The Flow Rate of Test Odor Spouting into the Mask in the Dynamic Odor Test." International Journal of Environmental Studies, 1989.

8. O'Brien, M.A., Duffee, R.A., and Ostojic, N., "Effect of Sample Flow Rate in the Determination of Odor Thresholds." Air & Waste Management Association International Specialty Conference, Odors: Indoor and Environmental Air, Bloomington, MN, Sept. 1995.

9. McGinley, Charles M., Michael A. McGinley. “Olfactometry Flow Rate Criteria – A Multiple Laboratory Study, Part I”. WEF Specialty Conference: Control of Emissions of Odors and VOC’s. Houston, TX: 20-23 April 1997. pp 7.9 –7.16.

10. McGinley, Charles M., Richard Nicolia and Lisa Wolfert. “Olfactometry Flow Rate Criteria – A Multiple Laboratory Study, Part II”. WEF Specialty Conference: Odors and VOC Emissions 2000. Cincinnati, OH: 16-18 April 2000.

11. van Harreveld, A.Ph., "Main Features of the Final Draft European Standard 'Measurement of Odour Concentration Using Dynamic Olfactometry." Air & Waste Management Association International Specialty Conference, Odors: Indoor and Environmental Air, Bloomington, MN, Sept. 1995.

Keywords: odors, odours, olfactometry, standards, odor testing, prEN13725, E679-91, olfactometer.