Impact of the New European Odor Testing Standard on Wastewater Treatment Facilities

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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. 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).

In 1990 the European Committee for Standardization (CEN) formed a technical committee (TC264) which developed a draft odor sampling and testing standard. The draft standard, prEN13725 ("pr" means proposed) will be released as a final standard in early 2002, entitled EN13725: "Air Quality-Determination of Odour Concentration by Dynamic Olfactometry." EN13725 will unify the odor sampling and testing 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). EN13725 follows ISO 9000 quality assurance and scientific testing protocols. Australia and New Zealand have combined to write a new odor-testing standard essentially identical to the CEN draft.

A consortium of odor laboratories in Canada and the United States initially approached the proposed European odor-testing standard with caution and with a number of questions. There were concerns regarding the presentation flow rate (20-lpm), the detailed procedural requirements, and the assessor screening and selection processes. However, the experiences of adopting the proposed standard over the past five years has convinced the laboratories of the benefits of this one unifying odor testing standard.

While Universities and research laboratories are moving towards adopting the European odor-testing standard, there is also a trend of regulatory agencies, engineering firms, and sanitation district in the U.S. in adopting the European standard as an odor measurement tool for monitoring and compliance. This new European odor testing standard, due for official acceptance and publication in early 2002, is poised to become a global standard of odor testing; a de facto "International Standard".

This paper discusses implementing and utilizing the new European Odor Testing Standard, EN13725 for odor testing related to wastewater treatment processes and facilities.

KEYWORDS

Odor, olfactometry, standards, European, ASTM, quantification

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).

In 1990 the European Committee for Standardization (CEN) formed a technical committee (TC264) which developed a draft odor sampling and testing standard. The draft standard, prEN13725 ("pr" means proposed) will be released as a final standard in late 2001 or early 2002, entitled EN13725: "Air Quality-Determination of Odour Concentration by Dynamic Olfactometry." EN13725 will unify the odor sampling and testing 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). EN13725 follows ISO 9000 quality assurance and scientific testing protocols. Australia and New Zealand have combined to write a new odor-testing standard essentially identical to the CEN draft.

A consortium of odor laboratories in Canada and the United States initially approached the proposed European odor-testing standard with caution and with a number of questions. There were concerns regarding the presentation flow rate (20-lpm), the detailed statistical and procedural requirements, and the assessor screening and selection processes that were based on one standard odorant (i.e. n-butanol). However, the experiences of adopting the proposed standard over the past five years has convinced the laboratories of the benefits of this one unifying odor testing standard. The odor laboratories in the consortium are:

- Agriculture Canada - Charlottetown, Prince Edward Island
- Alberta Research Council - 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 Illinois, Urbana, Illinois
- University of Manitoba - Winnipeg, Manitoba
- University of Minnesota - St. Paul, Minnesota
- West Texas A&M University – Amarillo, Texas

ODOR AND ODORANTS

Of the five senses, the sense of smell is the most complex and unique in structure and organization. While human olfaction supplies 80% of flavor sensations during eating, the olfactory system plays a major role as a defense mechanism by creating an aversion response to malodors and irritants. This is accomplished with two main nerves. The olfactory nerve (first cranial nerve) processes the perception of chemical odorants. The trigeminal nerve (fifth cranial nerve) processes the irritation or pungency of chemicals, which may or may not be odorants.

During normal nose breathing only 10% of inhaled air passes up and under the olfactory receptors in the top, back of the nasal cavity. When a sniffing action is produced, either an involuntary sniff reflex or a voluntary sniff, more than 20% of inhaled air is carried to the area near the olfactory receptors due to turbulent action in front of the turbinates. These receptors, in both nasal cavities, are ten to twenty-five million olfactory cells making up the olfactory epithelium. Cilia on the surface of this epithelium have a receptor contact surface area of approximately five square centimeters due to the presence of many microvilli on their surface. Supporting cells surrounding these cilia secrete mucus, which acts as a trap for chemical odorants. Chemical odorants pass by the olfactory epithelium and are dissolved (transferred) into the mucus at a rate dependent on their water solubility and other mass transfer factors. The more water-soluble the chemical, the more easily it is dissolved into the mucus layer. A "matching" site on the olfactory cells then receives the chemical odorant. The response created by the reception of a chemical odorant depends on the mass concentration or the number of molecules present. Each reception creates an electrical response in the olfactory nerves. A summation of these electrical signals leads to an "action potential." If this action potential has high enough amplitude (a threshold potential), then the signal is propagated along the nerve, through the ethmoidal bone between the nasal cavity and the brain compartment where it synapses with the olfactory bulb.

All olfactory signals meet in the olfactory bulb where the information is distributed to two different parts of the brain. One major pathway of information is to the limbic system, which processes emotion and memory response of the body. This area also influences the signals of the hypothalamus and the pituitary gland, the two main hormone control centers of the human body. The second major information pathway is to the frontal cortex. This is where conscious sensations take place as information is processed with other sensations and is compared with cumulative life experiences for the individual to possibly recognize the odor and make some decision about the experience. The entire trip from the nostril to the brain takes as little as 500 milliseconds.

Frequently the terms **odor** and **odorant** are used interchangeably and, often incorrectly. There is a distinct difference between these two terms, which is fundamental to the discussion of odor and odor nuisance related to wastewater treatment facilities. The term **"odor"** refers to the perception experienced when one or more chemicals come in contact with receptors on the olfactory nerves (a human response). The term **"odorant"** refers to any chemical in the air that is part of the perception of odor by a human.

The best analogy to understand what is happening with odor perception in the olfactory system is that the receptor nerves are like keys on a piano. As a chemical **odorant** "hits" the piano keyboard (the olfactory epithelium) a tone is played. When multiple chemical **odorants** are present the result is a cord or perception. For example, if keys 1, 3, and 7 are "hit" by three odorants, the brain perceives "banana." Likewise, if keys 4, 6, and 12 are "hit" by three odorants, the brain perceives "sewer." The greater the number of **odorant** molecules present (higher concentrations), the louder the cord is played. The loudness of the cord is analogous to the intensity of the **odor** perception.

WASTEWATER TREATMENT ODORS

Odors from a wastewater treatment facility can affect the surrounding community. Estimating the effects from a facility's odorous air emissions requires field and laboratory testing. Some odorants can be testing in the field using portable instrumentation and other odorants need to be sampled in the field and subsequently analyzed in a laboratory .

On the property of the wastewater treatment facility, at the property line, and in the surrounding community, odorous ambient air (mixtures of odorants in the ambient air) can be quantified using a field olfactometer (portable odor measuring device, e.g. "Scentometer-like-device"). Odor intensity can also be quantified by a trained and calibrated nose (i.e. human assessor) utilizing the methods in ASTM E544-99, Standard Practice for Suprathreshold Odor Intensity Measurement.

Odorous air sample collection from wastewater treatment processes and related odor control systems can be accomplished using standard sampling techniques. Vacuum chambers (sampling lungs) with Tedlar gas sample bags comprise the standard sampling methods. Odorous air samples are then sent to an odor-testing laboratory. Odor testing (evaluation by human assessors) in the odor laboratory includes the determination of odor thresholds (detection and recognition), odor intensity, odor character, odor pleasantness vs unpleasantness (Hedonic Tone), and odor persistency (dose-response function).

Managers and engineer use odor-testing results from a wastewater treatment facility for decision-making. The quantification of odors from wastewater treatment facilities is typically required for the following purposes:

1. Compliance monitoring (compliance assurance)
2. Determination of compliance (permit renewal)
3. Determination of status (base line data for expansion planning)
4. Determination of specific odor sources (investigation of complaints)
5. Monitoring operations (management performance evaluation)
6. Comparison of operating practices (evaluating alternatives)
7. Monitoring specific events or episodes (defensible credible evidence)
8. Determination of an odor control system's performance (warranty)
9. Comparison of odor mitigation measures (scientific testing)

10. Estimation of odor impacts (dispersion modeling)

Each of these purposes dictates a need for dependable and reproducible methods and practices for odor testing. The trend internationally and in the United States is toward using one unifying odor testing standard.

THE "EUROPEAN ODOUR TESTING 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 wastewater 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 (testing) of odors through olfactometry, either to prove compliance or to measure and monitor odors.

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

Countries in Europe began developing standards of olfactometry in the 1980's. 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 showed that laboratory results differed even with these standards in place.

The development of a draft odor testing standard in the Netherlands led to an Inter-Laboratory Comparison study organized in 1989. 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 (human panelist) 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 (humans). 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 more similar in sensitivity and repeatability.

Standards were set for assessor performance using 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.

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, olfactometer operation, olfactometer calibration, assessor interface (sniffing port), odor testing room, methods of data processing, and 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.

The CEN olfactometry standard was released to the public for comment 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." The 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 issued a final revision of the standard. The final

revision was sent to the CEN organization for official acknowledgement in 2001. Final approval is expected in 2002.
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. In 2000 Australia and New Zealand jointly wrote a new odor-testing standard essentially identical to the European Standard.

The final standard, EN13725, "Air Quality – Determination of Odour Concentration by Dynamic Olfactometry", will be published in three official languages: English, French, and German. The standards are distributed through the individual country standardization boards. For example, the British Standards Institute (BSI) will distribute an English language copy.

THE IMPACT OF EN 13725

The odor parameter measured by olfactometry is "odor concentration" (odor strength). "Odor concentration" (detection threshold or recognition threshold) is a dimensionless dilution ratio, which is commonly reported as "Odor Units" or "Odor Units per Cubic Foot (or Meter)". This determination is made using an instrument called an "olfactometer." In the United States the standard that has been followed for olfactometry is ASTM Standard of Practice E679-91, "Determination of Odor and Taste Threshold by a Forced-Choice Ascending Concentration Series Method of Limits." The European Union, Canada, Australia, New Zealand, and much of the Pacific Rim (i.e. Singapore) will be following the new standard, prEN 13725 – "Air Quality – Determination of Odour Concentration by Dynamic Olfactometry"

In simple terms, if a laboratory follows the European odor-testing standard, prEN13725, they will be meeting and exceeding 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.

EN13725 standardizes the following elements of odor testing (olfactometry):

1. Ascending concentration series sample presentation (same as ASTM E679-91)
2. Binary or triangular forced-choice selection (ASTM requires triangular)
3. Dilution ratio of "2" for the presentation series (ASTM allows 3)
4. "Odor free" dilution and blank air (same as ASTM)
5. Olfactometer materials of Teflon, stainless steel, or glass (same as ASTM)
6. Presentation flow rate of 20-liters per minute (ASTM does not specify)
7. ISO 5725 Accuracy of Measurement and Results (exceeds ASTM)
8. Requires periodic olfactometer calibration (exceeds ASTM)

9. Requires assessor certification (exceeds ASTM)
10. Uses the traceable reference odorant n-butanol (exceeds ASTM)

EN13725 is a unifying olfactometry standard that will help wastewater treatment facilities, engineers, and regulators to develop a consistent basis for odor testing. To that end, EN13725 will help determine the potential for odor nuisance, help set odor control performance criteria, and help develop overall facility odor mitigation measures.

CONCLUSIONS

Managers and engineer use odor-testing results from a wastewater treatment facility for decision-making. The measurement of odors is often a requirement for compliance monitoring, planning, site expansion and review of operational practices. Additional purposes for quantification of odors includes chemical trials, process tests, and odor control equipment performance tests. Each of these purposes dictates a need for dependable and reproducible methods and practices for odor testing. The trend internationally and in the United States is toward using one unifying odor testing standard, i.e. EN13725.

EN13725, "Air Quality – Determination of Odour Concentration by Dynamic Olfactometry" (DRAFT as prEN13725), impacts the wastewater treatment industry by providing reliability and repeatability to odor testing results. As the wastewater treatment industry incorporates EN13725 into their investigations, odor studies, and management reporting systems; engineers, managers, and regulators will build confidence in their decision making with odor testing results.

For a wastewater treatment facility, EN13725 means repeatable, reproducible, and accurate odor testing results. EN13725, as a unifying testing standard, will produce confidence in using odor testing for performance measures (control equipment guaranties) and for comparing performance of different facilities, industry wide.

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