American Industrial Hygiene Association Journal

ISSN: 0002-8894 (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/aiha20

The NIOSH Detector Tube Certification Program

PAUL ROPER

To cite this article: PAUL ROPER (1974) The NIOSH Detector Tube Certification Program, American Industrial Hygiene Association Journal, 35:7, 438-442, DOI: 10.1080/0002889748507057

To link to this article: https://doi.org/10.1080/0002889748507057

Published online: 04 Jun 2010.

The NIOSH Detector Tube Certification Program

PAUL ROPER

National Institute for Occupational Safety and Health, DHEW,
1014 Broadway, Cincinnati, Ohio 45202

Because NIOSH evaluations of commercial gas detector tubes in past years had indicated widespread inaccuracy and other serious problems with these devices, NIOSH adopted a set of performance and quality control standards for gas detector tubes which commercial tubes must meet in order to be considered acceptable for NIOSH and OSHA use. NIOSH has also established a testing program in Morgantown, West Virginia, for evaluating commercial detector tubes and certifying those brands of tubes which meet NIOSH standards. Some of the most important of these standards are presented in this report.

Introduction

GAS DETECTOR TUBE UNITS are widely used by industrial hygienists and by others in measuring concentrations of toxic gas and vapor contaminants in the air of working environments. The proper use of such devices can be both desirable and beneficial to industrial hygiene activities. However, the results from extensive evaluation of gas detector tube performance by the National Institute for Occupational Safety and Health (NIOSH) in recent years have indicated widespread inaccuracy and other serious problems associated with commercial detector tubes sold in the United States.[1-5] Several concerned organizations, including the International Union of Pure and Applied Chemists (IUPAC) and the Joint ACGIH-AIHA Committee on Direct Reading Gas Detecting Systems, have recommended the adoption and enforcement of uniform performance standards for gas detector tubes. The Joint ACGIH-AIHA Committee stated in its August, 1965 report, "The Committee believes that a reasonable uniformity of performance is necessary, if use of a gas detecting tube system is to be acceptable, and that such uniformity can be fostered by the recommendation of performance specifications for these tubes."[6]

NIOSH agrees substantially with the recommendations of both the Joint ACGIH-AIHA Committee and the IUPAC, and has incorporated most of their recommendations into a newly-developed program at NIOSH for testing and certifying gas detector tube units. NIOSH has adopted performance and quality control requirements which are designed to insure uniform and acceptable performance of the tube units without imposing any design or production restrictions on the manufacturers of the devices. The requirements are also designed to bring about an optimum balance between the needs of the users and the state of the art in the manufacture and calibration of the tube units. The requirements which have been adopted can be met using existing technological capabilities.

Certification Program

The certification program is designed to insure the compliance of commercial detector tube units with the established performance specifications. One production batch of detector tubes submitted by a manufacturer is tested for each particular contaminant of interest to ascertain the compliance of the tubes with the performance specifications. At the time of submission of the test batch, the applicant for certification must also submit a quality control plan whereby he intends to routinely inspect each batch of

tubes produced for compliance with NIOSH performance specifications. NIOSH must approve the applicant's quality control plan prior to issuing him any certificate. If the batch of tubes submitted to NIOSH for testing is found to meet the performance requirements and if the manufacturer's quality control plan is acceptable, then NIOSH issues a certificate to the manufacturer covering the tubes for that particular gas or vapor. Thereafter, the manufacturer must affix the NIOSH certification seal to each box of tubes which is to be marketed for the measurement of that particular contaminant.

NIOSH is authorized to make inspections of the applicant's plant without prior notice to inspect quality control procedures and records. As a further control, NIOSH plans to purchase small quantities of tubes from local suppliers to spot check for continued quality. Should NIOSH find evidence that a previously certified tube brand is no longer meeting performance specifications, NIOSH is authorized to withdraw certification. The certification program is described in Title 42, Code of Federal Regulations, Part 84, and is conducted by the NIOSH Testing and Certification Laboratory at Morgantown, West Virginia.[7]

Part 84 details the performance and quality control requirements for certified detector tube units. The apparatuses used for producing known concentrations of gases and vapors in air for testing the instruments were designed and evaluated by the Analytical Chemistry Division of the National Bureau of Standards.[8]

Certification Standards

The certification standards for gas dector tube units are based on NIOSH's extensive past experience in testing and using these devices.[1-5] The standards combine the performance requirements which NIOSH deems necessary for acceptable accuracy with past results which indicate the levels of performance which are feasible.

Some of the most important requirements for certification are:

1. Each box of certified detector tubes to be marketed must be labeled with the following information:
   a. Manufacturer's batch number.
   b. The expiration date of the tubes.
   c. Storage instructions.
2. Each box of certified detector tubes to be marketed must be accompanied by the following printed information:
   a. Instructions for obtaining contaminant concentration values from tube readings.
   b. Temperature, pressure, and humidity corrections necessitated by use of the tubes under conditions unlike those under which the tubes were calibrated.
   c. Operating instructions for the tubes.
   d. A list of known interfering substances and the amount of each that can be tolerated without adversely affecting the accuracy of the measurement.
3. Accuracy of the gas detector tubes must be such that measurements made by the tubes, when used in accordance with the manufacturer's instructions, produce readings that are within ± 25% of the true contaminant concentration at concentrations of 1, 2, and 5 times the test standard for the contaminant, and within ± 35% of the true value at one-half the test standard. (The test standard is a concentration level set by NIOSH for the purpose of defining the range of measurement for the tube. This value is normally the same as the 8-hour time-weighted average standard for the contaminant.)
4. The manufacturer must test the accuracy of each batch of certified tubes to be marketed by comparing tube readings with known concentrations of contaminants generated in his plant or laboratory. Tubes must be tested at four concentrations, corresponding to one-half, one, two, and five times the test stand-

ard. The known concentrations used for the tests must be produced by a method previously approved by NIOSH, and must be verified by independent chemical analysis except in certain cases where no reliable method of independent analysis is known.

5. For length-of-stain type detector tubes only, a minimum stain length of 15 mm must be produced when measuring a concentration equal to the test standard. The objective of this requirement is to insure that the error associated with the uncertainty in reading a tube with a poor, unclear end of stain is small, since the length of the gradually fading end-of-stain region is small in comparison with the overall stain length.

   Detector tubes with clear, sharp stain end points are exempt from the minimum stain length requirement if they can meet the following requirement (at a concentration equal to the test standard):

$$\frac{\sigma}{\overline{X}} \leqslant 0.10$$

where: σ = the standard deviation of the tube readings obtained from three or more independent readers when reading an individual stained tube.

$\overline{X}$ = mean reading for a given tube.

6. The channeling of air flow, and thus stain, down a given side of the tube must be eliminated to the extent that the maximum variation of stain length around the circumference of the tube at the interface between stained and unstained reagent is expressed as:

$$\frac{\triangle L}{M} \leqslant 0.20$$

where: $\triangle L = L_2 - L_1$

L_2 = the concentration value indicated by the length of stain at the side of the tube where the stain is farthest extended along the tube's longitudinal axis.

L_1 = the concentration value indicated by the length of stain at the side of the tube where the stain is least extended along the tube's longitudinal axis.

M = the median value of L_1 and L_2.

This requirement is illustrated in Figure 1.

7. For length-of-stain type detector tubes only, the unevenness of the interface between the end packing materials and the reagent layer at the stained end of the tube must not exceed 2 mm.

   The term "unevenness" is used to describe the variability in the distance along the tube's longitudinal axis from the point at which the packing is farthest extended into the reagent to the point at which the packing is least extended into the reagent.

8. Color-intensity type detector tubes must meet the same accuracy standards as length-of-stain tubes and, essentially, an equivalent person-to-person reading reproducibility standard.
9. The maximum permissible leakage per minute for a detector tube pump, when the pump has been evacuated and its inlet plugged, is 3% of the pump's single-stroke volume.
10. If a flow control device is built into the detector tube pump, it must regulate the flow rate to within ± 10% of the optimum rate.
11. The pump volume accuracy must be

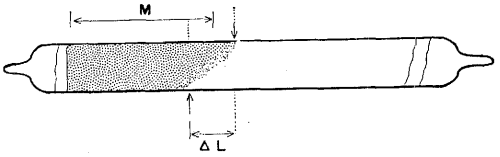

Figure 1. Illustrating the uneven stain resulting from channeling and showing the measurements used in the measurement of variation.

within ± 5% of the manufacturer's stated volume.

Accuracy Standards

To some people the ± 25% and ± 35% accuracy standards appear to be unduly lenient. However, the difficulty of meeting these standards is illustrated in Table I by a typical set of data obtained from a past evaluation by NIOSH of five commercial tube brands for chlorine. Only brand D met the proposed NIOSH accuracy standards. The percentages given in Table I represent the observed accuracies at the 95% confidence level.

TABLE I

Accuracy Limits of All Tube Brands in Measurement of Chlorine

Tube Brand	Concentration of Test Gas (ppm) 0.5	1.0	2.0	5.0
A	±70%	±25%	±25%	±25%
B	±35%	±40%	±35%	±50%
C	±40%	±50%	±30%	±30%
D	±35%	±25%	±25%	±25%
E	±105%	±40%	±85%	±90%

A further illustration of the stringency of these standards is given by Figure 2. This figure shows the distribution of the readings obtained from one brand of detector tube at a concentration of 50 ppm of the contaminant. The average tube reading was 55 ppm, which represents only a 10% systematic calibration error. The ± 25% accuracy standard allows readings to fall within the range of 37.5 to 62.5 ppm. However, because the standard deviation of the tube readings was 10 ppm, over 25% of the tube readings fell outside of the acceptable range. It should be noted that this problem is caused by random error, not systematic calibration error, and is much more difficult for the manufacturer to control. For a batch size of 2,000 to 3,000 tubes and a 95% confidence limit, only 13% of the tube readings are allowed to fall outside of the acceptable range.

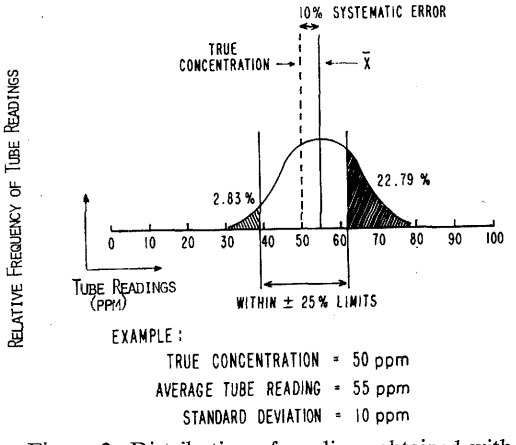

Figure 2. Distribution of readings obtained with one brand of detector tube when measuring a concentration of 50 ppm of the contaminant.

At a contaminant concentration of one-half the test standard, the stain length is generally quite short. The end point boundary region comprises a large percentage of the total stain length and causes the relative standard deviation to be high. This makes it very dificult, if not impossible, for even a tube with a very small systematic calibration error to meet the ± 25% accuracy criterion. Therefore, a ± 35% accuracy criterion is set for this concentration range.

Summary

In conducting the certification program, NIOSH furnishes useful services to both the suppliers and the consumers of gas detector tube units. NIOSH provides for the development of generation systems to produce known concentrations of contaminants in the air. These methods are available to tube suppliers for calibration purposes. NIOSH also reviews the suppliers' quality control programs and makes suggestions for improvements. The test results obtained from the NIOSH testing program serve to inform the consumer about the particular tube brands which meet NIOSH certification criteria. Tube units which have received NIOSH certification can be identified by the NIOSH certification seal which must be

affixed by the tube unit manufacturer to each box of certified tubes.

References

1. Brown, C. H., Jr.: *The Evaluation of Gas Detector Tube Systems: Nitrogen Dioxide,* NIOSH Research Report—20 (June 1972).
2. Johnson, B. A. and C. P. Roper: *The Evaluation of Gas Detector Tube Systems: Chlorine,* NIOSH Research Report—19 (June 1972).
3. Johnson, B. A.: *The Evaluation of Gas Detector Tube Systems: Hydrogen Sulfide,* NIOSH Research Report—18 (March 1972).
4. Johnson, B. A.: *The Evaluation of Gas Detector Tube Systems: Ozone,* NIOSH Research Report—21 (July 1972).
5. Roper, P.: *The Evaluation of Gas Detector Tube Systems: Trichloroethylene,* NIOSH Research Report—22 (July 1972).
6. American Conference of Governmental Industrial Hygienists-American Industrial Hygiene Association Committee on Direct Reading Gas Detecting Tube Systems. *Amer. Ind. Hyg. Assoc. J. 32:*488 (July 1971).
7. Title 42, Code of Federal Regulations, Part 84: Certification of Gas Detector Tube Units. *Federal Register 38:*11458 (May 8, 1973).
8. Hughes, E. E., and J. K. Taylor: Gas Generating Systems for Calibration of Gas Detector Tubes. Presented at the *Amer. Ind. Hyg. Conference, Boston, Massachusetts* (May 1973).
9. Lynch, J. R.: Uses and Misuses of Detector Tubes. *Transactions of the Thirty-Second Annual Meeting of the American Conference of Governmental Industrial Hygienists,* Detroit, Michigan, p. 142, (May 1970).

Occupational Health Hazards

A course on recognition, evaluation and control of occupational health hazards will be offered by Northwestern University starting October 1, 1974. The study material is intended for engineers, physicians, environmental scientists and others in industry, government, casualty insurance, or consulting. It should be of significance to all who have responsibilities in occupational health protection.

Participants should have an undergraduate or professional degree in engineering, science or medicine. Sessions will be held from 6:30 to 9:30 p.m. Tuesday, October 1-December 10, 1974 at The Technological Institute in Evanston. Director of the course is Edward R. Hermann, C.E., Ph.D., Professor of Environmental Health Engineering. Tuition is $350. For further information write to: Continuing Engineering Studies, 2806 Technological Institute, Northwestern University, Evanston, Illinois 60201. Telephone: (312) 492-3365.

Southeastern Occupational Health Conference

The annual Southeastern Occupational Health Conference will take place in Winston-Salem, South Carolina, at the new Hyatt House on October 3, 4 and 5, 1974. The theme of the meeting will be "Rehabilitation of the Injured Worker." There will be special half-day sessions for nurses and physicians. For additional information write to D. H. Robinson, M.D., Bureau of Occupational Health and Safety, South Carolina Department of Health and Environmental Control, Sims Building, 2600 Bull Street, Columbia, SC 29201.