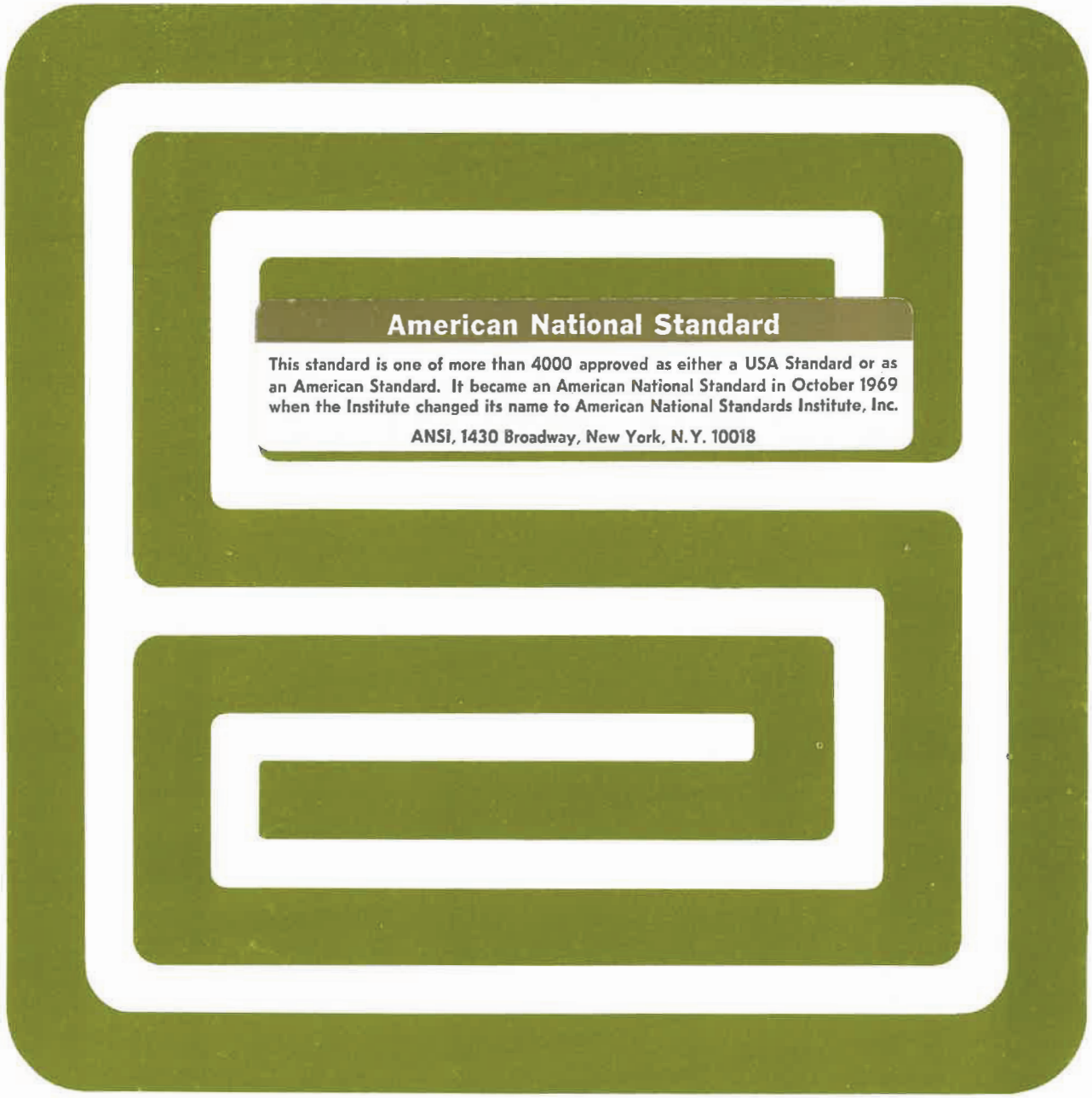
USAS
Z37.4-1969
Revision of
Z37.4-1960

USA Standard

Acceptable Concentrations of Benzene



Z37.4-1969

USAS
Z37.4-1969
Revision of
Z37.4-1960

USA Standard
Acceptable Concentrations of Benzene

Sponsor

American Industrial Hygiene Association

Approved September 5, 1969

United States of America Standards Institute, Inc

USA Standard

A USA Standard implies a consensus of those substantially concerned with its scope and provisions. A USA Standard is intended as a guide to aid the manufacturer, the consumer, and the general public. The existence of a USA Standard does not in any respect preclude anyone, whether he has approved the standard or not, from manufacturing, marketing, purchasing, or using products, processes, or procedures not conforming to the standard. USA Standards are subject to periodic review and users are cautioned to obtain the latest editions.

CAUTION NOTICE: This USA Standard may be revised or withdrawn at any time. The procedures of the United States of America Standards Institute require that action be taken to reaffirm, revise, or withdraw this standard no later than five (5) years from the date of publication. Purchasers of USA Standards may receive current information on all standards by calling or writing the USA Standards Institute, 10 East 40th Street, New York, N. Y. 10016, (212) 683-3058.

Published by

United States of America Standards Institute

Printed in USA
A2M969/225

Foreword

(This Foreword is not a part of USA Standard Acceptable Concentrations of Benzene, Z37.4-1969.)

This USA Standard Acceptable Concentrations of Benzene, Z37.4-1969, has been developed by a committee, national in scope, functioning under the procedures of the United States of America Standards Institute.

This committee was organized to coordinate all available information on the various air contaminants and to establish acceptable concentrations which could be used in the development of means for controlling such contamination.

For many years the need for standard acceptable concentrations of toxic dusts, gases, mists, vapors, and fumes in the air of work places has been recognized. A great deal of information on such concentrations has been published but it frequently differs, due largely to the varying conditions under which observations and tests were made.

While research on the toxic effects of many dusts, fumes, mists, vapors, and gases is continuing in industry, governmental institutions, universities and elsewhere, the concentrations set forth in this standard reflect information obtained from all authoritative published data and the experience of the members of the committee. The first draft of this revision was prepared by Dr. Horace W. Gerarde.

Suggestions for improvement in the use of this standard will be welcome. They should be sent to the United States of America Standards Institute.

The Sectional Committee on Acceptable Concentrations of Toxic Dusts and Gases, Z37, which developed this standard had the following personnel at the time of approval:

Don D. Irish, *Chairman* Henry F. Smyth, Jr, *Vice-Chairman*
Henry G. Lamb, *Secretary*

Organization Represented	*Name of Representative*
American Conference of Governmental Industrial Hygienists	H. E. Stokinger
American Industrial Hygiene Association	J. F. Treon
American Institute of Chemical Engineers	W. J. Smith
American Insurance Association	W. G. Meade
	G. K. Hogan *(Alt)*
American Mutual Insurance Alliance	W. R. LaRoque
	R. H. Deibert *(Alt)*
American Petroleum Institute	A. E. Dooley
	H. H. Golz *(Alt)*
American Public Health Association	E. D. Palmes
American Society of Safety Engineers	W. A. Cook
	J. C. Radcliffe *(Alt)*
American Society for Testing and Materials	P. M. Giever
	M. D. Huber *(Alt)*
Canadian Standards Association *(Liaison)*	K. Kay
Conference of State and Provincial Health Authorities of North America	F. M. Foote
	J. J. Stapor *(Alt)*
Industrial Medical Association	J. H. Lede
International Association of Governmental Labor Officials	H. B. Elkins
Manufacturing Chemists' Association	J. A. Zapp, Jr
	J. F. Morgan *(Alt)*
National Safety Council	W. G. Hazard
	J. B. Olishifski *(Alt)*
Society of Toxicology	H. N. MacFarland
	N. G. White *(Alt)*
U.S. Department of the Army *(Liaison)*	L. P. Devlin
	J. Foderaro *(Alt)*
U.S. Department of Health, Education, and Welfare — Public Health Service *(Liaison)*	H. E. Stokinger
	D. H. Byers *(Alt)*
U.S. Department of the Interior, Bureau of Mines	H. A. Watson
U.S. Department of Labor — Bureau of Labor Standards	G. Walker Daubenspeck
	J. P. O'Neill *(Alt)*

Organization Represented	*Name of Representative*
Individual Members	E. E. Campbell B. Dinman H. W. Gerarde D. D. Irish W. H. Jones W. Machle N. Nelson S. J. Pearce S. Pinto H. H. Schrenk H. F. Smyth, Jr

Contents

SECTION PAGE

The Meaning of Acceptable Concentrations 5

1. Scope and Purpose 6
   1.1 Scope 6
   1.2 Purpose 6
2. Properties of Benzene 6
   2.1 Physical and Chemical Properties 6
   2.2 Toxic Properties: Acute Toxicity 6
   2.3 Toxic Properties: Chronic Toxicity 6
3. Acceptable Concentrations 7
   3.1 Acceptable Maximum for Peaks 7
   3.2 Acceptable Ceiling Concentration 7
   3.3 Acceptable Time-Weighted Average 7
4. Sampling Procedure and Analytical Methods 7
   4.1 Sampling Procedure 7
   4.2 Analytical Methods 7
   4.3 Biochemical Analysis 7
5. References to the Text 7
6. General References 8

The Meaning of Acceptable Concentrations

It is generally recognized that there are concentrations of air contaminants to which a person may be exposed without discomfort or ill effects. This standard defines such concentrations in light of best present day knowledge.

The immediate use of a USA Standard for acceptable concentrations is for guidance in establishing engineering procedures to prevent objectionable concentrations of materials in the air of work places. These concentrations in themselves do not represent a scale of relative toxicity; they represent concentrations below which ill effects are unlikely under the specified conditions.

The term, acceptable concentration, is not defined as a single concept but is related to the duration and pattern of the exposure as set forth in the USA Standard for the individual substance.

In the application of an acceptable concentration established as a USA Standard, it is important to understand the criteria upon which the standard is established. These criteria are avoidance of:

(1) Undesirable changes in body structures or biochemistry

(2) Undesirable functional reactions that may have no discernible effects on health

(3) Irritation or other adverse sensory effects

A purpose for establishing acceptable concentrations is to provide a basis for interpretation of the results of air analysis as an indication of the severity of potential exposure, but not as a means of establishing the presence of occupational disease. Comparison of air analysis results with acceptable concentrations indicates either acceptable conditions or otherwise the need, extent, and urgency of control measures. Sampling and analysis should be performed by competent personnel using a standard method if available, and one that will provide a reliable indication of potential exposure.

It should be kept in mind that:

(1) The acceptable concentrations are the highest concentrations which can currently be justified consistent with the objective of maintaining unimpaired health or comfort of workers or both. It is good practice to maintain lower concentrations when this does not render industrial operations inefficient.

(2) Acceptable concentrations are not precise values sharply dividing what is hazardous from what is safe under the particular circumstances and therefore are not appropriate for use as legal requirements.

(3) These standards are considered to be guides for good industrial hygiene practices and should be applied and interpreted by persons with a full understanding of the basis and limitations of the information from which the standard has been developed.

(4) The levels are applicable only to a single substance and to the exposure pattern as detailed in the standard. Unless specified, acceptable concentrations should not be assumed to apply under conditions of abnormal physical stress. Judgment must be exercised when gross deviations from normal environments are encountered.

(5) Exposure to mixtures is the rule. When more than one of the components is of hygienic significance, acceptable concentrations of the components should be based on the given mixture and situation.

(6) Routes of absorption other than inhalation, such as through the skin, should be considered in the evaluation of the exposure.

(7) These standards do not apply to community atmospheric pollution as related to general populations.

USA Standard
Acceptable Concentrations of Benzene

1. Scope and Purpose

1.1 Scope. This standard of acceptable concentrations of benzene applies to all work places where the duration and circumstances of potential contacts are similar to those described in the standard.

1.2 Purpose. The purpose of this standard is to provide useful information for the control of benzene exposures and to aid in the design and operation of equipment, so as to protect the health of workers.

2. Properties of Benzene

2.1 Physical and Chemical Properties. Benzene is a colorless liquid with a distinctive odor. The odor gives some warning of exposure above acceptable concentrations. Since olfactory fatigue develops rapidly, the sense of smell cannot be relied on to warn of the presence of benzene.

Chemical formula:	C_6H_6
Molecular Weight:	78.11
Boiling point:	80.1°C at 760 mm of Hg
Melting point:	5.4°C to 5.5°C
Vapor pressure:	74.6 mm of Hg at 20°C
Vapor density:	2.77 (air = 1)
Density of air saturated with benzene vapors:	1.22 (air = 1) 26°C at 760 mm of Hg
Concentration in saturated air:	13.15 percent 26°C at 760 mm of Hg
Liquid density:	0.8787 (15/4°C)
Index of refraction:	1.5016 at 20°C
Solubility:	Water—1 part in 1430 parts; miscible with alcohol, chloroform, ether, carbon disulfide, carbon tetrachloride, glacial acetic acid, and acetone
Flash point:	12°F (C.C.)
Flammable limits:	1.35 to 6.75 percent by vol in air[1][1]
Conversion factors:	1 mg/l of vapor = 313 ppm (at 25°C and 760 mm Hg). 1 ppm of vapor = 0.00319 mg/l

2.2 Toxic Properties: Acute Toxicity. Liquid benzene on direct contact with the skin may cause erythema and blistering. Benzene is poorly absorbed through the intact skin so that systemic intoxication from the percutaneous absorption of benzene is unlikely to occur. The direct aspiration of liquid benzene into the lungs causes immediate pulmonary edema and hemorrhage.

The ingestion of liquid benzene causes local irritation of the mucous membranes of the mouth, throat, esophagus, and stomach. The ingestion of a tablespoonful (about 15 ml) of benzene has been known to cause collapse, bronchitis and pneumonia.

High concentrations of benzene vapor are irritating to the mucous membranes of the eyes, nose, and respiratory tract. The inhalation of high concentrations of benzene vapor may cause exhilaration followed by drowsiness, fatigue, dizziness, headache, and nasuea. The pulse rate increases; there may be a sensation of tightness in the chest accompanied by breathlessness and ultimately the victim may lose consciousness. Convulsions and tremor occur frequently and death may follow in a few minutes or several hours following severe exposure.

2.3 Toxic Properties: Chronic Toxicity. The effects of inhaling small quantities of benzene vapor over a prolonged period of time may be serious in industrial exposures to this hydrocarbon. These effects are due to the insidious injury to the blood-forming tissue at atmos-

[1]Numbers in brackets refer to references in Section 5.

pheric concentrations which may not cause irritation of mucous membranes or any unpleasant sensory effects.

The most common abnormalities in the blood of workers exposed to benzene are anemia and leukopenia, the latter believed by many authorities to be the earliest sign of chronic benzene intoxication. The classical picture of severe anemia, leukopenia, and thrombocytopenia is found in the severe and fatal cases of aplastic anemia following benzene exposure.

3. Acceptable Concentrations
[2, 3, 4, 5, and 6]

3.1 Acceptable Maximum for Peaks above the acceptable ceiling for an eight-hour work day: A concentration of *50 ppm* for a duration of not more than ten minutes is acceptable if encountered not more than once during an eight-hour work day. This requires that other exposures be within the concentrations indicated in sections 3.2 and 3.3.

3.2 Acceptable Ceiling Concentration for protection of health assuming an eight-hour work day: A ceiling of *25 ppm* is acceptable for avoiding injury to blood-forming tissues.

3.3 Acceptable Time-Weighted Average for protection of health assuming an eight-hour work day: A time-weighted average of *10 ppm* is acceptable for avoidance of injury to the blood-forming tissue. This is based on the information now available concerning exposures at this level.

4. Sampling Procedure and Analytical Methods

4.1 Sampling Procedure. Air samples taken continuously in accordance with good industrial hygiene practice should be adequate to define the potential exposure to benzene in a particular work operation. In major operations continuous analyzing and recording equipment is desirable with an alarm device to indicate concentrations above 25 ppm.

4.2 Analytical Methods. [7 and 8] The method depends on the sample. Most used would be ultraviolet absorption, infrared absorption, gas chromatography, or nitration, and determination by colorimeter. Concentration in air may be determined directly by infrared or gas chromatography.

Any method used should be carefully verified and the apparatus calibrated by the industrial hygienist to be sure it is appropriate to the particular operation under study.

4.3 Biochemical Analysis. Analysis of exhaled air may be used as an indicator of recent past exposures, inasmuch as benzene is excreted partly unchanged in exhaled air. Useful methods for qualitative and quantitative analysis of exhaled air are infrared spectroscopy and gas-liquid chromatography. Benzene is metabolized, in part, to phenol which is excreted in conjugated form in the urine. A total phenol content (both free and combined) of more than 10 mg/liter of urine as a group average (even in small groups) may be an indication of benzene exposure [9]. The normal phenol level of 10 mg per liter is based on a highly specific analytical method. This method should determine phenol but should exclude other phenolic substances. Phenol values exceeding 200 mg/liter of urine taken as a spot sample at the end of a work day may indicate exposure to 25 ppm or more of benzene for eight hours. Certain drugs are metabolized to phenolic compounds and excreted in the urine. For example, one tablet of phenacetin will double the normal level of phenol in urine.

5. References to the Text

[1] COWARD, H. F.; JONES, G. W. Limits of flammability of gases and vapors. *U.S. Bureau of Mines Bulletin No. 503,* 1952.

[2] BOWDITCH, M.; ELKINS, H. B. Chronic exposure to benzene (benzol). I. The industrial aspects. *Journal of Industrial Hygiene and Toxicology,* vol 21, 1939, p 321.

[3] HEIMANN, H. Chronic benzol poisoning in plastics industry; note on liver damage. *New York Industrial Bulletin,* Nov 1940, p 224.

[4] WILSON, R. H. Benzene poisoning in industry. *Journal of Laboratory and Clinical Medicine,* vol 27, 1942, p 1517.

[5] HARDY, H. L.; ELKINS, H. B. Medical aspects of maximum allowable concentrations: Benzene. *Journal of Industrial Hygiene and Toxicology,* vol 30, 1948, p 196.

[6] GERARDE, H. W. *Toxicology and Biochemistry of Aromatic Hydrocarbons.* New York: Elsevier Publishing Co, 1960.
[7] SCHRENK, H. H.; PEARCE, S. J.; YANT, W. P. A microcolorimetric method for the determination of benzene. *U.S. Bureau of Mines Reports of Investigations No. 3287,* 1935.
[8] SIEGEL, J.; BURKE, W. J. A modified method for the determination of benzol in air. *New York Industrial Bulletin,* vol 17, 1939.
[9] VAN HAAFTEN, A. B.; SIE, S. T. The measurement of phenol in urine by gas chromatography as a check on benzene exposure. *American Industrial Hygiene Association Journal,* vol 26, Jan-Feb 1965, pp 52-58.

6. General References

DAVIS, P. A. Present status of benzene. *Journal of the American Medical Association,* vol 114, 1940, pp 553-557.

FAIRHALL, L. T. *Industrial Toxicology.* Baltimore: The Williams and Wilkins Co, 1957, 2nd ed.

GREENBURG, L.; MAYERS, M. R.; GOLDWATER, L.; SMITH, A. R. Benzene (benzol) poisoning in the rotogravure printing industry in New York City. *Journal of Industrial Hygiene and Toxicology,* 1939, p 395.

GREENBURG, L. Benzol poisoning as an industrial hazard. *Reprint No. 1096, Public Health Reports,* July 2, 9, 23, 1926, pp 1357, 1410 and 1516.

YANT, W. P.; SCHRENK, H. H.; SAYERS, R. R.; HORVATH, A. A.; REINHART, W. A. Urine sulfate determinations as a measure of benzene exposure. *Journal of Industrial Hygiene and Toxicology,* vol 18, 1936, p 69.

USA Standard

Allowable Concentrations of Toxic Dusts and Gases

Z37.1-1941	Carbon Monoxide
Z37.2-1966	Hydrogen Sulfide
Z37.3-1968	Carbon Disulfide
Z37.4-1969	Benzene
Z37.6-1948	Manganese
Z37.7-1943	Chromic Acid and Chromates
Z37.8-1943	Mercury
Z37.10-1960	Xylene
Z37.11-1969	Lead and Its Inorganic Compounds
Z37.12-1967	Toluene
Z37.13-1962	Nitrogen Dioxide
Z37.14-1944	Methanol
Z37.15-1969	Styrene
Z37.16-1967	Formaldehyde
Z37.17-1967	Carbon Tetrachloride
Z37.18-1969	Methyl Chloride
Z37.19-1967	Trichloroethylene
Z37.21-1969	Ethylene Dichloride
Z37.22-1967	Tetrachloroethylene
Z37.23-1969	Methylene Chloride (Dichloro Methane)
Z37.27-1961	p-Dichlorobenzene
Z37.28-1966	Hydrogen Fluoride and Inorganic Fluoride Dusts
Z37.29-1969	Beryllium and Beryllium Compounds
Z37.30-1969	Organo (Alkyl) Mercury

For a free and complete list of the available USA Standards write to:

United States of America Standards Institute
10 East 40th Street **New York, N. Y. 10016**