



Standard Test Method for Determination of Ethyl Mercaptan in LP-Gas Vapor¹

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1. Scope

1.1 This test method covers a rapid and simple procedure using length of stain tubes for field measurement of ethyl mercaptan in the vapor phase of LP-gas systems. Although length-of-stain tubes are available to detect ethyl mercaptan concentrations in the range of 0.5 to 120 parts per million volume (ppmv), this test method is specifically applicable to systems containing 5 ppmv or more of ethyl mercaptan in LP-gas vapors.

NOTE 1—A chromatographic technique can be used for more precise, quantitative determination of ethyl mercaptan in LP-gas.

1.2 The values stated in SI (metric) units are to be regarded as the standard.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *NFPA Standard:*²

NFPA 58 Standard for the Storage and Handling of Liquefied Petroleum Gases

3. Summary of Test Method

3.1 Using a manually-operated vacuum pump, a sample of LP-gas is drawn through a detector tube made specifically for detection of mercaptans. The length of stain (color change) produced in the detector tube when exposed to a measured volume of sample is directly proportional to the amount of ethyl mercaptan present in the sample being tested. The length of stain produced in the detector tube is converted to concentration, in parts per million volume (ppmv), by comparison with a calibration scale provided by the manufacturer of the stain tubes.

¹ This test method is under the jurisdiction of ASTM Committee D02 on Petroleum Products and Lubricants and is the direct responsibility of Subcommittee D02.H0 on Liquefied Petroleum Gas.

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² Available from National Fire Protection Association (NFPA), 1 Batterymarch Park, Quincy, MA 02169-7471, <http://www.nfpa.org>.

4. Significance and Use

4.1 LP-gas is colorless and odorless, and not detectable by normal human senses. To provide an olfactory warning in the event of a leak, LP-gas intended for domestic or commercial use is intentionally odorized so as to be readily detectable well below flammable or suffocating concentration levels of LP-gas in air. (See [Appendix X1.](#)) The most common odorant for LP-gas is ethyl mercaptan. The field use of this test method will rapidly determine the presence and concentration of ethyl mercaptan in LP-gas vapor without the necessity for complex laboratory equipment.

5. Interferences

5.1 Detector tubes can be subject to interferences from materials other than the target substance. Methyl mercaptan will likely interfere with tubes designed to measure ethyl mercaptan. Because of different detection chemistry by different manufacturers, interferences can vary. Consult the manufacturer's instructions for specific interference information and observe any instructions given.

5.2 Propylene (propene) will cause an interfering (gray) discoloration with some tubes designed for ethyl mercaptan. LP-gas from natural gas sources usually does not contain propylene (propene). However, LP-gas produced in refinery operations often does contain propylene (propene). Detector tubes calibrated for *t*-butyl mercaptan eliminate this interference, and should be used if the presence of propylene (propene) is suspected. Some tubes designed for measurement of *t*-butyl mercaptan are calibrated in milligrams per cubic metre (mg/m^3) and should be converted to ppmv ethyl mercaptan as shown in [Annex A1.](#)

6. Apparatus

6.1 *Pump*—A manually-operated vacuum pump, capable of drawing 100 mL per stroke of sample through the detector tube with an accuracy of ± 2.0 mL.

6.2 *Detector Tubes*—Sealed tubes, made of glass with break-off tips sized to fit the orifice of the pump used (tubes and pumps from different manufacturers should not be interchanged). The tube used must be appropriate for the determination of ethyl mercaptan and must produce a distinct color change when exposed to a sample of LP-gas containing ethyl mercaptan. Any substance known to interfere must be listed in

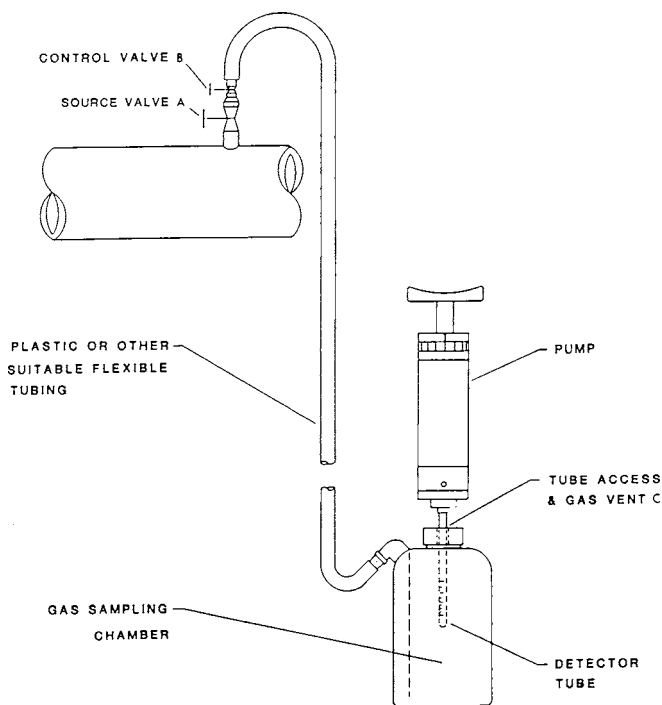


FIG. 1 Half Litre Polyethylene Bottle

instructions accompanying the tubes (see 5.2). A calibration scale or other markings referenced to a scale must be etched directly on the tube to allow direct interpretation of ethyl mercaptan concentration.³

6.2.1 Detector tubes must be calibrated for a tube temperature of approximately 20°C and normal atmospheric pressure. Shelf life of the detector tubes must be a minimum of two years when stored according to the manufacturer's recommendations.

6.2.2 Detector tubes and pumps form an integrally designed unit, that must be used as a unit. Each manufacturer calibrates detector tubes to match the flow characteristics of its pump, and the use of one brand of tube with another brand of pump will give unreliable results.

6.3 A suitable container can be devised from a half-litre polyethylene bottle (see Fig. 1). A 6 mm outside diameter polyethylene tubing sealed into the bottle and discharging near the bottom of the bottle provides for flow into the sampling container. A 12 mm hole cut into the cap of the bottle provides both access for the detector tube and a vent for the excess gas flow.

6.3.1 *Gas Sampling Container*—Any container of a material that is not reactive with mercaptan and that provides for access of the detector tube into a uniform flow of sample gas at atmospheric pressure and isolated from the surrounding atmosphere.

6.4 *Needle Valve and Tubing*—A stainless steel needle valve that can be adjusted to control the flow of gas into the sample container. Although a stainless steel needle valve is preferred, a pressure regulator can be used in lieu of a needle valve to control the flow of gas into the sample container. Polyethylene or TFE-fluorocarbon tubing can be used to connect the needle valve or pressure regulator to the gas sampling container.

7. Sampling

7.1 Select a sampling point that provides access to a representative sample of LP-gas vapor from the container to be sampled.

7.1.1 Open the source valve (Valve A in Fig. 1) and blow down vigorously to clear foreign material from the source valve and connecting nipple. Close the source valve.

7.1.2 Install the control valve (Valve B in Fig. 1) or pressure regulator on the outlet of the source valve. Connect outlet of the control valve to the gas sampling container using the shortest length practicable of suitable tubing.

7.1.3 Open the source valve and then the control valve to obtain a slight positive flow through the gas sample container, venting to atmosphere through the tube access and vent (Vent C in Fig. 1). Purged gas must be vented at a sufficient rate so that pressure does not build up in the sampling container and increase the flow rate through the detector tube.

7.1.4 Purge the gas sample container for at least 3 min to displace air.

7.1.5 Maintain flow of LP-gas during the test procedure in Section 9.

8. Preparation of Apparatus

8.1 Before sampling, all sampling equipment should be thoroughly clean and dry.

8.2 Immediately before each series of tests, test the pump for tightness in accordance with manufacturer's instructions. A loss in vacuum on the pump within 60 s indicates a leak. If a leak occurs, follow the pump manufacturer's instructions for re-sealing the pump and retest. If the pump vacuum cannot be maintained, do not use the pump for testing.

9. Procedure

9.1 Select the tube range that includes the expected concentration of ethyl mercaptan present in the sample. Reading accuracy is improved when the stain extends at least one-half of the tube length. Consider multiple strokes or a lower range tube, or both, to achieve this length of stain.

9.2 Break off both tips of the glass stain tube and insert the outlet of the tube (indicated by arrow in direction of flow) snugly into the pump head. Temperature of tube must be maintained in the 0 to 40°C range throughout the test.

9.3 Insert the detector tube well into the gas sampling container through the tube access and vent (Vent C).

9.4 Operate the pump to draw a measured amount of sample through the detector tube. Within any limits set by the manufacturer's instructions, use multiple strokes to achieve a stain extending to approximately one-half the tube length.

9.5 Remove the tube from the pump and follow the manufacturer's instructions if further handling of the tube is necessary.

³ Detector tube No. 72, manufactured by Gastec Corporation, based on the palladium sulfate detection principle, is calibrated for ethyl mercaptan; Gastec detector tubes No. 75 and 75L, using mercuric chloride detection chemistry, are calibrated for *t*-butyl mercaptan. Other manufacturer's tubes may be based on other detection chemistry.

9.6 Immediately (within 30 s), read the concentration of ethyl mercaptan from graduations on the tube or from charts supplied with the tubes. The scale reading nearest the end of the stain is the measured concentration of ethyl mercaptan.

10. Interpretation of Results

10.1 If the number of pump strokes used is different from the number specified by the manufacturer, a correction must be made as follows:

$$\text{corrected ethyl mercaptan concentration} = \text{scale reading} \quad (1)$$

$$\times (\text{specified strokes/actual strokes})$$

10.2 Some detector tubes that can be used in this test method may be calibrated for other mercaptans in milligrams per cubic metre (mg/m³). The conversion from mg/m³ of *t*-butyl mercaptan to ppmv of ethyl mercaptan shall be performed as documented in **Annex A1**.

10.3 Correct the reading for barometric pressure, especially at high altitudes. For details of this correction, see **Annex A1**.

10.4 Readings of concentrations below 5 ppmv may not be reliable, and may warrant further investigation. (See **Appendix X2**.)

NOTE 2—This test method is a direct measure of the concentration of ethyl mercaptan in the vapor phase of LP-gas. If the temperature of the system is known, results can be used to obtain an approximation of the concentration of ethyl mercaptan in the liquid phase. (See **Appendix X1**.)

11. Report

11.1 Report the observed tube reading and corrected concentration of ethyl mercaptan in parts per million by volume (ppmv) to the nearest 0.5 ppm.

12. Precision and Bias

12.1 *Precision:*

12.1.1 The precision of this test method as determined by statistical analysis of interlaboratory test results is as follows:

12.1.1.1 *Repeatability*—The difference between successive test results, obtained by the same operator using the same apparatus under constant operating conditions on identical test material, would, in the long run, in the normal and correct operation of the test method, exceed the following values only in one case in twenty: from 5 to 20 ppmv, the larger of 1 ppm or ±15 % of the mean of the two results; above 20 ppmv, ±20 % of the mean of the two results.

12.1.1.2 *Reproducibility*—The difference between two single and independent results, obtained by different operators working in different laboratories on identical test material, would, in the normal and correct operation of the test method, exceed the following value only in one case in twenty: the larger of 1.5 ppmv or ±20 % of the mean of the two results.

NOTE 3—The preceding repeatability and reproducibility were obtained from statistical analysis of results submitted by twelve testers who cooperatively tested five samples of propane with ethyl mercaptan concentrations ranging from 3.3 to 32 ppmv in the vapor phase.

12.2 *Bias*—Within the precision limits defined in 12.1.1.1 and 12.1.1.2, this test method has no bias.

13. Keywords

13.1 ethyl mercaptan; liquefied petroleum gases; odorant; stain tube

ANNEX

(Mandatory Information)

A1. CONVERSION AND CORRECTION INFORMATION

A1.1 Conversion of mg/m³ *t*-butyl mercaptan (TBM) to mg/m³ ethyl mercaptan (EM):

$$\text{mg/m}^3 \text{ EM} = \text{mg/m}^3 \text{ TBM} \quad (A1.1)$$

$$\times (\text{mol weight EM/mol weight TBM})$$

Therefore:

$$1 \text{ mg/m}^3 \text{ TBM} = 1 \quad (A1.2)$$

$$\times (62.14/90.19) = 0.689 \text{ mg/m}^3 \text{ EM}$$

A1.2 Conversion of mg/m³ EM to ppmv EM at approximately 25°C:

$$\text{ppmv} = ((\text{mg/m}^3) \times (24.45))/(\text{mol weight EM}) \quad (A1.3)$$

Therefore:

$$1 \text{ mg/m}^3 \text{ EM} = ((1) \times (24.45))/(62.14) = 0.393 \text{ ppmv EM} \quad (A1.4)$$

NOTE A1.1—1 g mol = 22.4 L at 0° = 24.45 L at 25°C.

A1.3 A convenient tabulation of conversions:

mg/m ³ TBM	mg/m ³ × 0.689 = EM × 0.393 =	ppmv EM
2.5	1.72	0.68
5.0	3.45	1.36
10	6.89	2.71
15	10.34	4.06
20	13.78	5.42
25	17.23	6.77
30	20.67	8.12

A1.4 Correction for barometric pressure:

$$\text{ppmv (corrected)} = \text{ppmv} \times (760 \text{ mm Hg/barometric pressure, mm Hg}) \quad (A1.5)$$

Atmospheric Pressure, kPa (mm Hg)	Elevation in metres (feet)	ppm Reading	ppm Corrected
101.325 (760)	0 (0)	10	10.0
97.709 (733)	305 (1000)	10	10.4
93.977 (705)	610 (2000)	10	10.8
90.644 (680)	915 (3000)	10	11.2

Atmospheric Pressure, kPa (mm Hg)	Elevation in metres (feet)	ppm Reading	ppm Corrected	Atmospheric Pressure, kPa (mm Hg)	Elevation in metres (feet)	ppm Reading	ppm Corrected
87.312 (655)	1220 (4000)	10	11.6	81.313 (610)	1829 (6000)	10	12.5
84.246 (632)	1524 (5000)	10	12.0				

APPENDIXES

(Nonmandatory Information)

X1. RELATIONSHIP OF VAPOR-LIQUID CONCENTRATIONS

X1.1 Published data on vapor-liquid equilibria (k-ratios) of the ethyl mercaptan/propane system are as follows:

Temperature, °C	-30	-20	-10	0	10	20	30
Temperature, °F	-22	-4	14	32	50	68	86
K-ratio ⁴	0.12	0.15	0.18	0.21	0.24	0.27	0.31

NOTE X1.1—The K-ratios given herein are for a pure propane/ethyl

⁴ Heng-Joo, Ng and Robinson, Donald B., “Vapor Liquid Equilibrium in Propane Odorant Systems,” Gas Processors Assoc. Research Report, No. 113, 1989,. Available from Gas Processors Assoc., 6526 E. 60th St., Tulsa, OK 74145.

mercaptan system and may vary for commercial propane/ethyl mercaptan systems.

X1.2 Assuming system equilibrium and accurate data on the temperature of the system, the liquid-phase concentration of ethyl mercaptan can be approximated, based on the following relationship:

$$\frac{\text{liquid-phase concentration, ppmv}}{\text{K-ratio (at system temperature)}} = \frac{\text{vapor-phase concentration, ppmv}}{\text{K-ratio (at system temperature)}} \quad (\text{X1.1})$$

X2. ODORIZATION REQUIREMENTS

X2.1 **NFPA 58** is the basis for most regulatory requirements for odorization of LP-gas. This standard stipulates, in part:

“1-4.1.1 All LP-gases shall be odorized prior to the delivery to a distributing plant by the addition of a warning agent of such character that they are detectable, by a distinct odor, down to a concentration in air of not over 1/5 the lower limit of flammability.

“Exception: Odorization, however, is not required if harmful in the use or further processing of LP-gas, or if such odorization will serve no useful purpose as a warning agent in such further use or processing.

“1-4.4.2 If odorization is required, the presence of such odorants shall be determined by sniff testing or other means and the results documented:

a) whenever LP-gas is delivered to a distributing plant, and
b) when shipments of LP-gas by-pass the distributing plant.”

X2.2 An informational appendix to **NFPA 58** states the following:

“A-1-4.1.1 It is recognized that no odorant will be completely effective as a warning agent in every circumstance.

“It is recommended that odorants be qualified as to compliance with 1-4.1.1 by tests or experience. Where qualifying is by tests, such tests should be certified by an approved laboratory not associated with the odorant manufacturer. Experience has shown that ethyl mercaptan in the ratio of 1.0 lb (0.45 kg)/10 000 gallons (37.9 m³) of liquid LP-gas has been recognized as an effective odorant.”

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