



Designation: D4443 – 19

Standard Test Method for Determining Residual Vinyl Chloride Monomer Content in PPB Range in Vinyl Chloride Homo- and Co-Polymers by Headspace Gas Chromatography¹

This standard is issued under the fixed designation D4443; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope*

1.1 This test method is suitable for determining the residual vinyl chloride monomer (RVM) content of homopolymer and copolymers of vinyl chloride down to a concentration of ~ 5 $\mu\text{g/kg}$ (ppb).

1.2 This test method is applicable to any polymer form, such as resin, compound, film, bottle wall, etc. that can be dissolved in a suitable solvent.

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, health, and environmental practices and determine the applicability of regulatory limitations prior to use. Specific hazard statements are given in Section 9 and Note 10.*

NOTE 1—This standard is equivalent to ISO 6401.

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 ISO Standard:

ISO 6401 Plastics—Homopolymer and Copolymer Resins of Vinyl Chloride—Determination of Residual Vinyl Chloride Monomer—Gas Chromatographic Method²

2.2 OSHA Standard:

29 CFR 1919.1017 Vinyl Chloride³

3. Terminology

3.1 Abbreviations:

3.1.1 DMAc—N,N-dimethylacetamide.

3.1.2 VCM—Vinyl chloride monomer.

4. Summary of Test Method

4.1 Samples of vinyl chloride-containing polymers are dissolved in a suitable solvent in a closed system.

4.2 The polymer solution and headspace are equilibrated at an elevated temperature.

4.3 Aliquots of headspace gas are injected into a gas chromatograph and the vinyl chloride monomer is separated. The response of vinyl chloride monomer is determined by the use of one of several suggested detectors.

4.4 Calibration is accomplished using either (a) vinyl chloride monomer in nitrogen gas standards, (b) standard solutions containing known amounts of vinyl chloride monomer, or (c) a method of standard addition.

5. Significance and Use

5.1 Vinyl chloride-containing polymers are widely used to package a variety of materials, including foods.

5.2 Vinyl chloride monomer has been shown to be a human carcinogen. Threshold toxicity value has not been established.

5.3 Plastic manufacturers, food packagers, government agencies, etc. have a need to know the residual vinyl chloride monomer content of vinyl chloride-containing polymers.

6. Interferences

6.1 N,N-dimethylacetamide should be analyzed under identical conditions to determine the absence of interferences at the vinyl chloride monomer gas chromatography (GC) retention time.

6.2 Other solvents, monomers, or compounding aids may cause interference at the vinyl chloride monomer GC retention time.

¹ This test method is under the jurisdiction of ASTM Committee D20 on Plastics and is the direct responsibility of Subcommittee D20.70 on Analytical Methods.

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² Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, <http://www.ansi.org>.

³ Available from Superintendent of Documents, US Government Printing Office, Washington, DC 20402, <https://bookstore.gpo.gov>.

*A Summary of Changes section appears at the end of this standard

7. Apparatus

7.1 *Gas Chromatography*, equipped with either, a mass spectrometric detector, flame ionization detector (FID), a photo ionization detector (PID), or a Hall electroconductivity detector (HED), backflushing valve, and either automatic capability or manual sampling (**Note 2**) and ability to analyze the headspace vapors contained in a sealed vial.

NOTE 2—If the analyses are to be performed manually (that is, by syringe injection), then the following equipment will also be needed:

(1) Constant-temperature bath or oven capable of maintaining a temperature of $90 \pm 1^\circ\text{C}$.

(2) Gas-tight GC syringes for sampling and injection.

(3) Sample bottles with fluoropolymer faces septa and caps (size optional).

(4) Gloves for handling hot syringes.

7.2 *Chromatographic Column*, 3 % OV-101 on 80/100 mesh Chromosorb WHP, $\frac{1}{8}$ -in. (3.2-mm) outside diameter by 2 ft (0.6 m), stainless steel connected through $\frac{1}{8}$ -in. “tee” to 0.19 % picric acid on 80/100 mesh Carbowack C, $\frac{1}{8}$ -in. outside diameter by 8 ft (2.4 m), stainless steel.

NOTE 3—Any column packing that will resolve VCM from interferences and elute VCM in a reasonable length of time (1 to 5 min) is satisfactory. For example, a 3-ft (0.9-m) by $\frac{1}{8}$ -in. (3.2-mm) outside diameter column containing 0.19 % picric acid on 80/100 mesh Carbowack C can replace the recommended 3 % OV – 101 column. Settings recommended in 11.3.1 may have to be modified to suit the packing material being used.

7.3 *Detector Output Filter/Amplifier*—The extreme sensitivity of this test method is best realized when the detector (usually operated at the maximum sensitivity) output is (1) filtered to remove the high-frequency noise and (2) amplified to give a visible or measurable signal.

7.4 *Sample Headspace Vials*, glass, 23 mL, with fluoropolymer-lined septa and aluminum caps.

7.5 *Vial Sealer*.

7.6 *Analytical Balance*, capable of weighing to ± 0.001 g.

8. Reagents and Materials

8.1 *Vinyl Chloride Monomer (neat)*, pure, preferably in small cylinder.

8.2 *Standard Cylinders*, vinyl chloride monomer in nitrogen at 1 and 10 mg/L by volume.

8.3 *Hydrogen Cylinder*, prepurified gas.

8.4 *Nitrogen*, oxygen-free.

NOTE 4—Helium may replace nitrogen as the carrier gas.

8.5 *Air*, breathing or water-pumped.

8.6 *N,N-Dimethylacetamide (DMAc)*, sparged with nitrogen gas for up to a week at room temperature to remove chromatographic interferences.

9. Hazards

9.1 *Safety Precautions*:

9.1.1 Vinyl chloride monomer is a carcinogen and exposure by inhalation or dermal contact, or both, is to be avoided. Refer to OSHA Standard 29 CFR 1919.1017 for regulated levels of exposure. *N,N*-dimethylacetamide is a teratogen. The use of a

properly functioning hood and septum-sealed sample containers are recommended.

9.1.2 Avoid all contact with heated parts of the gas chromatograph, hot syringes, and sample bottles. Handle all electrical connections with care.

9.1.3 Once heated, sample vials are under pressure. After analysis, relieve the pressure with a hypodermic syringe needle vented into a charcoal slug or vent tube leading to a hood *before* removing vials from the water bath.

10. Sampling and Storage

10.1 Keep all polymer samples in tightly sealed jars or tightly wrapped aluminum foil prior to analysis. Dissolved polymer samples must be kept in septum-sealed vials or bottles until analyzed. Polymer solutions stored longer than 24 h should be maintained under refrigeration.

11. Preparation of Gas Chromatograph

NOTE 5—All conditions in this section refer to a Headspace Analyzer. If analyses are performed manually, alter the operating procedures as required by the instrumentation.

11.1 Install the chromatographic column and condition overnight at 100°C , using normal carrier flow. Do not connect the exit end of the column to the detector *or* turn on detector gases during column conditioning.

11.2 Set the flow of detector gases as follows:

Detector	Gas	Flow
FID	Hydrogen	30 to 40 cm^3/min
	Air	300 to 400 cm^3/min
PID	Not required	
HED	Hydrogen	30 cm^3/min

11.3 Set other parameters as follows:

11.3.1 *Oven Temperature*—50 to 60°C .

NOTE 6—Higher oven temperatures may be required when other chromatographic columns are used, or when high-boiling solvents and late-eluting materials are being driven from the column.

11.3.2 *Dosing Needle*— 150°C .

11.3.3 *Injection Block Temperature*— 200°C .

11.3.4 *Constant-Temperature Bath*— $90 \pm 1.0^\circ\text{C}$.

11.3.5 *Carrier-Gas Flow Rate*—30 cm^3/min .

NOTE 7—Backflushing the carrier gas after VCM elutes can considerably shorten analysis time. After backflushing, allow adequate time for chromatographic conditions to stabilize before making another injection.

11.3.6 *Detector Temperature*:

11.3.6.1 *FID*— 250°C .

11.3.6.2 *PID*— 150°C .

11.3.6.3 *HED*— 880°C .

11.3.7 *Filter/Amplifier*—Adjust as needed to remove high frequency noise and to provide adequate amplification of VCM signal. Typical settings: filter – 0.05 Hz and amplifier – 2 $\times$.

12. Calibration by Standard Addition

NOTE 8—The gas chromatograph is calibrated using either procedure: (1) VCM in nitrogen gas standards and a previously determined partition coefficient for VCM between DMAc and headspace, (2) VCM solution standards, or (3) a method of standard addition of VCM to polymer solutions. Procedure (3) is preferred to correct for any contribution the polymer makes to partitioning of VCM. Therefore, only procedure (3) is described.