



Designation: D 7203 – 05

Standard Test Method for Screening Trichloroethylene (TCE)-Contaminated Soil Using a Heated Diode Sensor¹

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1. Scope

1.1 This test method describes a procedure for screening soil known to contain the halogenated volatile organic compound (HVOC), trichloroethylene (TCE), by measuring the TCE concentration in the headspace above a sample of the soil using a heated diode sensor device. From this measurement, an estimated concentration of TCE in the soil can be determined. Any TCE remaining in the soil sample is not measured by this test method. Any other HVOC present in the soil will be reported as TCE.

1.2 This test method can also be used for screening the headspace above a soil suspected of containing HVOC contamination to indicate the presence or absence of HVOC contamination in the soil. Any HVOC contamination remaining in the soil is not detected by this test method.

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 application of regulatory limitations prior to use.*

NOTE 1—The diode sensor is heated to temperatures ranging between approximately 600 and 1000 °C (see 6.6) and as a result could be a source of ignition.

2. Referenced Documents

2.1 *ASTM Standards:*²

D 4547 Guide for Sampling Waste and Soils for Volatile Organic Compounds

E 131 Terminology Relating to Molecular Spectroscopy

3. Terminology

3.1 *Definitions*—For definitions of terms used in this screening test method, refer to Terminology E 131.

¹ This test method is under the jurisdiction of ASTM Committee D34 on Waste Management and is the direct responsibility of Subcommittee D 34.01.05 on Screening Methods.

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² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

4. Summary of Test Method

4.1 To estimate the concentration of TCE in a soil known to contain TCE contamination, a sample of the soil is added to a glass jar having an open-top cap with a PTFE-bonded silicone septum. At the time of screening, the temperature of the soil in the jar should be approximately 50 to 120 °F (10 to 49 °C). The soil in the jar is shaken and allowed to settle for 10 min, so the TCE can partition into the headspace above the soil. After 10 min, the TCE concentration in the headspace is measured using a heated diode sensor device, which gives a numerical voltage reading. The voltage reading from the device is converted to a mg/m³ value of TCE in the headspace in the container. Using this value, an estimated concentration of TCE in the soil in mg/Kg can be calculated. Any TCE remaining in the soil sample is not measured by this test method. Any other HVOC present in the soil will be reported as TCE.

4.2 To use this test method to screen a soil suspected of containing HVOC contamination, a sample of the soil is added to a glass jar having an open-top cap with a PTFE-bonded silicone septum. At the time of screening, the temperature of the soil in the jar should be approximately 50 to 120 °F (10 to 49 °C). The soil in the jar is shaken and allowed to settle for 10 min, so the HVOC can partition into the headspace above the soil. After 10 min, the heated diode sensor device is used to screen the headspace in the container. The numerical voltage reading from the device indicates the presence or absence of HVOC contamination in the soil. Any HVOC contamination remaining in the soil is not detected by this test method.

5. Significance and Use

5.1 The heated diode sensor device used in this test method is selective for HVOCs. Other electronegative compounds, such as alcohols, ketones, nitrates, and sulfides, may cause a positive interference with the performance of the heated diode sensor to detect HVOCs, but to do so, they must be present at much higher concentrations than the HVOCs.

NOTE 2—For volatile organic compound (VOC) screening purposes, a flame ionization detector (FID) selectively responds to flammable VOCs; a photoionization detector (PID) selectively responds to VOCs having a double bond; and a heated diode sensor selectively responds to halogenated VOCs.

5.2 This test method can be used for screening soil known to contain TCE to estimate the concentration of TCE in the soil. The test method measures the TCE concentration in the headspace above a sample of the TCE-contaminated soil. An estimated concentration of TCE in the soil can be determined. Any TCE remaining in the soil sample is not measured by this test method. Any other HVOC present in the soil will be reported as TCE.

5.3 This test method can also be used for screening the headspace above a soil suspected of containing HVOC contamination to indicate the presence or absence of HVOC contamination in the soil. Any HVOC contamination remaining in the soil is not detected by this test method.

5.4 The quantitation limit of the screening test method is dependent on the soil-to-headspace ratio in the sample container and the HVOC in the soil. For a 25-g TCE-contaminated soil sample in a 250-mL container, the quantitation limit for TCE is 0.005 mg/Kg, based on a signal-to-noise ratio of 10.

5.5 The detection limit of the heated diode sensor for TCE is 0.1 mg/m³ in air, based on a signal-to-noise ratio of 2. For a 25-g TCE-contaminated soil sample in a 250-mL container, the detection limit of the screening test method for TCE is 0.001 mg/Kg, assuming complete partitioning of TCE into the headspace.

5.6 This test method can be used to screen moist soil samples. Water vapor does not interfere with the performance of the heated diode sensor.

5.7 Hydrocarbon fuels, including fuels containing aromatic compounds, such as gasoline, are not detected by the test method.

6. Apparatus

6.1 *Metal or Rigid Plastic Coring Tools*, designed for collecting and transferring a 25-g soil VOC sample (see Guide D 4547 and 8.1).

6.2 *Glass Jars*, 250-mL (8-oz), approximately 14 cm (5½ in.) tall, with open-top caps having PTFE-bonded silicone septa.

6.3 *Scale*, capable of weighing to 0.1 g.

6.4 *Thermometer*, with temperature given in divisions of 0.1 °C

6.5 *Barometer*, such that pressure in atmospheres can be determined to 0.001 atm.

6.6 *Heated Diode Sensor Device*, a device having a diode sensor that is heated between temperatures ranging from approximately 600 to 1000 °C generating an alkali metal vapor stream that selectively reacts with halogens present in HVOC molecules, creating ionized product species that cause a current to flow between a cathode and an anode. The numerical output from the sensor in volts is proportional to a microamp current from the diode and ranges from 0.001 to 20 V with a resolution of 0.001 V. The HVOC molecules in the headspace above the soil sample are drawn through a probe to the heated diode sensor by a pump in the device. The heated diode sensor device should have a needle attached to the probe of the device so the septum in the cap of the sample jar can be pierced and the needle can be inserted into the headspace above the sample. This needle must be designed to allow make-up air to enter the sample jar from the top so that back pressure will not build up

within the jar. Back pressure in the jar will change the air flow rate of the device and in turn affect the voltage reading.

6.7 *Tedlar Bags*, 1-L in volume and having a stainless steel valve with a nipple fitting that can be opened and closed.

6.8 *Gas Regulators*, for use with the TCE standard gas cylinders (see 7.1). Each regulator should have a short length, about 1¼-in., of ¼-in. inner diameter fluoroelastomer tubing attached to the nipple fitting.

7. Reagents and Materials

7.1 *TCE Standard Gas Cylinders*—These are transportable cylinders containing certified concentrations of TCE in air pressurized to about 320 psi. If the test method is being used to screen a TCE-contaminated soil to estimate the concentration of TCE in the soil, two concentrations of TCE are required. One concentration is 220 ± 10 vapor part per million (ppmv) TCE in air. This is the high concentration TCE standard gas. The other concentration is 22 ± 1 ppmv TCE in air, which is the mid concentration TCE standard gas. These concentrations correlate with the upper and mid range of sensor response for the device. A 220 ppmv TCE standard gas at 25 °C corresponds to about 890 mg/m³ TCE in air at 0.75 atm of pressure and to about 1200 mg/m³ TCE in air at 1 atm of pressure. A 22 ppmv TCE standard gas at 25 °C corresponds to about 90 mg/m³ TCE in air at 0.75 atm of pressure and to about 120 mg/m³ TCE in air at 1 atm of pressure. See Note 3 and Note 4. If the test method is being used to screen a soil suspected of containing HVOC contamination to indicate the presence or absence of HVOC contamination, only the high concentration TCE standard gas, 220 ± 10 ppmv TCE in air, is required.

NOTE 3—For HVOC concentrations in air that are greater than 10 mg/m³, the current that is generated by the reaction between the halogen and the alkali metal vapor when the sensor is exposed to the HVOC is a function of the log of the concentration of the halogen in air. The log of 890 is 2.9, and the log of 1200 is 3.1, showing that the log values of these concentrations vary only slightly. Similarly, the log of 90 is 1.9, and the log of 120 is 2.1. These values show that the log of the TCE concentration in air varies only slightly at different elevations (atmosphere of pressure).

NOTE 4—The mg/m³ concentrations of the TCE in the standard gas cylinders can be calculated using the ppmv concentrations of TCE in the cylinders, the atmospheric pressure, the temperature, and Eq 5 and Eq 6, which are given in 13.6.

7.1.1 Transportation of the TCE gas cylinders must comply with current Department of Transportation (DOT) regulations.

8. Sample Collection and Preparation

8.1 Collect a soil sample of approximately 25 g using a metal or rigid plastic coring tool. See Guide D 4547 for recommended devices. If the sample will be stored in the coring tool prior to screening, it should be collected using a coring tool designed for sample storage as described in Guide D 4547 and should be stored as specified in Guide D 4547.

8.2 Preweigh a 250-mL glass jar with an open-top cap having a PTFE-bonded silicone septum. Record the mass of the jar with the cap to ±0.1 g.

8.3 Extrude the soil sample from the coring tool into the pre-weighed 250-mL glass jar and immediately seal the jar making sure that there are no soil particles on the sealing surfaces.



8.4 Weigh the jar-plus-soil sample and record the mass of the jar-plus-soil sample to ± 0.1 g.

8.5 Determine the mass of soil added to the jar, and record the mass of the soil sample to ± 0.1 g.

8.6 The temperature of the soil in the sample jar should be approximately 50 to 120 °F (10 to 49 °C) prior to screening the sample using the heated diode sensor, so that HVOC partitioning into the headspace above the sample will occur (see **Note 5**). The sample jar should not be opened to determine the soil temperature. The ambient temperature where the screening is to be performed should be in the range of 50 to 120 °F (10 to 49 °C), and the soil sample should be allowed to come to approximately that temperature prior to screening (Section 12).

NOTE 5—The temperature at which the screening is performed may affect the HVOC concentration in the headspace. For example, the vapor pressure of TCE at 120°F (49°C) is about seven times greater than the vapor pressure of TCE at 50°F (10°C). Therefore, more TCE would be expected in the headspace at higher temperatures.

NOTE 6—The ambient temperature where the screening is to be performed will be recorded as specified in 11.3

9. Operation of the Heated Diode Sensor Device

9.1 The heated diode sensor device used to perform this test method should be calibrated and operated according to the manufacturer's instructions.

9.2 After a sample or standard gas has been screened using the heated diode sensor device, the voltage reading of the device must be allowed to return to zero, indicating that the sensor has been flushed with intake air so that any contamination from the previous sample or standard gas has been removed from the system.

10. Preparation of Tedlar Bags Containing the TCE Standard Gases

10.1 If the test method is being used to screen a TCE-contaminated soil to estimate the concentration of TCE in the soil, a 1-L Tedlar bag containing each of the TCE standard gases (7.1) should be prepared. If the test method is being used to screen a soil suspected of containing HVOC contamination to indicate the presence or absence of HVOC contamination, a 1-L Tedlar bag containing the high concentration TCE standard gas, 220 ± 10 ppmv TCE in air, (7.1) should be prepared.

10.1.1 To prepare a Tedlar bag containing the TCE standard gas, attach a regulator (see 6.8) to the TCE standard gas cylinder.

10.1.2 Open the valve on a 1-L Tedlar bag. Press the bag against a flat, hard surface to make sure the bag is empty.

10.1.3 With the valve on the Tedlar bag in the open position, attach the bag to the regulator by connecting the nipple fitting on the valve with the tubing on the regulator. Carefully fill the Tedlar bag with the standard gas. Remove the bag from the regulator. With the valve on the Tedlar bag in the open position, once again press the bag against a flat, hard surface to empty the bag. After the bag has been flushed with the standard gas, it should be refilled with the standard gas, as described above, and the valve on the bag should be closed.

11. Heated Diode Sensor Device Calibration Check and Voltage Measurement of TCE Standard Gases

11.1 After the heated diode sensor device has been calibrated (see 9.1), open the valve on the Tedlar bag containing the high concentration TCE standard gas and connect the nipple fitting on the bag to the probe of the heated diode sensor device. The device is calibrated if the voltage reading for the high concentration TCE standard gas is between 9 and 12 V. If the voltage reading is 9 V or less or 12 V or greater, the device should be re-calibrated until the reading for the high concentration TCE standard gas is between 9 and 12 V. Record this voltage reading from the device for the high concentration TCE standard gas as $V_{\text{HighTCEStd}}$.

11.2 If the test method is being used to screen a TCE-contaminated soil to estimate the concentration of TCE in the soil, a voltage reading for the mid concentration TCE standard gas is required. This reading is made after it is determined that the heated diode sensor device is calibrated (11.1), the voltage reading from the device for the high concentration TCE standard gas ($V_{\text{HighTCEStd}}$) has been recorded, and the voltage reading of the heated diode sensor device has returned to zero. The valve on the Tedlar bag containing the mid concentration TCE standard gas (Section 10) should be opened and the nipple fitting on the bag should be connected to the probe of the heated diode sensor device. The voltage reading from the device for the mid concentration TCE standard gas should be recorded as $V_{\text{MidTCEStd}}$. If the test method is being used to screen a soil suspected of containing HVOC contamination to indicate the presence or absence of HVOC contamination, a voltage reading for the mid concentration TCE standard gas is not required.

11.3 If the test method is being used to screen a TCE-contaminated soil to estimate the concentration of TCE in the soil, record the temperature in °C to 0.1°C and pressure in atmospheres to 0.001 atm at the time that the voltage readings for the high concentration and mid concentration TCE standard gases are recorded. If the test method is being used to screen a soil suspected of containing HVOC contamination to indicate the presence or absence of HVOC contamination, record the temperature in °C to 0.1°C at the time that the voltage reading for the high concentration TCE standard gas is recorded.

11.4 The voltage reading of the high concentration TCE standard gas should be checked after 10 samples have been screened, or if the sensor is exposed to a sample that gives a voltage reading above the reading for the high concentration TCE standard gas, $V_{\text{HighTCEStd}}$, recorded in 11.1 (see **Note 7**). If during this check, the reading for the high concentration TCE standard gas is not within 10 % of the value recorded for the standard gas during the previous check, the device must be re-calibrated.

NOTE 7—If a sensor is exposed to a sample that gives a voltage reading above the reading for the high concentration TCE standard gas, $V_{\text{HighTCEStd}}$, indicating that the concentration of TCE in the headspace above the sample is greater than the TCE concentration in the high concentration standard gas, the sensor response may become unstable.