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Standard Guide for Vapor Encroachment Screening on Property Involved in Real Estate Transactions¹

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1. Scope

1.1 Purpose—The purpose of this guide is to provide practical guidance and a useful process for conducting a *vapor encroachment screen (VES)* on a property parcel involved in a *real estate transaction* in the United States of America with respect to *chemicals of concern (COC)* that may migrate as vapors into the vadose zone of a property as a result of contaminated soil and/or groundwater on or near the property. This guide may be used in conjunction with E1527 but does not alter or in any way define the scope of that practice. In addition, performance of this guide is not a requirement of and does not constitute, expand, or in any way define “all appropriate inquiry” as defined and approved by the U.S. Environmental Protection Agency (EPA) under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the regulations there under, including 40 CFR Sec. 312.11.

1.1.1 Vapor Encroachment Condition (VEC)—The goal of conducting a VES, as established by this guide, on a parcel of property is to identify a *vapor encroachment condition (VEC)*, which is the presence or likely presence of COC vapors in the vadose zone of the *target property (TP)* caused by the release of vapors from contaminated soil and/or groundwater either on or near the TP as identified by Tier 1 (see Section 8) or Tier 2 (see Section 9) procedures.

1.1.2 Federal, State, and Local Environmental Laws—This guide does not address requirements of any federal, state, or local laws with respect to vapor intrusion. Users are cautioned that federal, state, and local laws, regulations, or policy may impose vapor encroachment screening or vapor intrusion assessment obligations that are beyond the scope of this guide (information is provided in Appendix X5 and Appendix X9). Users should also be aware that there may be other legal obligations, for example, disclosure, with regard to COC or COC vapors discovered on the TP that are not addressed in this guide. This ASTM practice does not supersede existing federal, state and local statutes and regulations.

¹ This guide is under the jurisdiction of ASTM Committee E50 on Environmental Assessment, Risk Management and Corrective Action and is the direct responsibility of Subcommittee E50.02 on Real Estate Assessment and Management.

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1.1.3 Documentation—The scope of this guide includes investigation and reporting actions. Sufficient documentation of all sources, records, and resources used in the investigation procedures that are set out in this guide should be provided in the VES report (refer to Section 10).

1.2 Objectives—Objectives guiding the development of this guide are: (1) to synthesize and put into writing a practical guide for conducting a VES on a property involved in a *real estate transaction* and (2) to provide that the process to screen for a VEC is practical and reasonable.

1.3 Considerations Outside the Scope—The use of this guide is strictly limited to the scope set forth in this section. Section 11 of this guide identifies, for informational purposes, certain tasks (not an all-inclusive list) that may be conducted on a property that are beyond the scope of this guide but that may warrant consideration by parties to a *real estate transaction*. Whether to include an investigation of any such conditions in the *environmental professional's* scope of services should be evaluated by the user and should be agreed upon between the user and *environmental professional* as additional services beyond the scope of this guide before initiation of a Phase I ESA conducted in conjunction with a VES or initiation of an independent VES.

1.4 Units—The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.5 Organization of this Guide—This guide has eleven sections and nine appendices. The appendices are included for informational purposes and are not part of the procedures prescribed in this guide.

Section 1	contains the scope of the guide.
Section 2	includes the referenced documents.
Section 3	has definitions of terms pertinent to this guide, terms used in this guide but defined in E1527, and acronyms.
Section 4	is directed at the significance and use of this guide.
Section 5	discusses the relationship between this guide and E1527.
Section 6	describes the user's responsibilities under this guide.
Sections 7 – 10	consist of the main body of the VES process, including evaluation and report preparation.
Section 11	provides information regarding non-scope considerations (see 1.3).
Appendix X1	provides legal background for vapor encroachment screening.

Appendix X2	provides guidance on suggested qualifications for the <i>environmental professional</i> conducting the VES.
Appendix X3	provides a sample questionnaire for the <i>environmental professional</i> to obtain pertinent information for the VES from the <i>property owner/operator/occupants</i> .
Appendix X4	provides a recommended table of contents and report format for the VES investigation when not incorporated into a <i>Phase I ESA</i> report.
Appendix X5	includes a listing of federal and state agency web sites that discuss vapor intrusion assessment policies and guidance.
Appendix X6	includes a list of <i>chemicals of potential concern</i> .
Appendix X7	provides general guidance for vapor intrusion assessment and mitigation.
Appendix X8	provides general guidance and references for data collection in the conduct of vapor intrusion investigations.
Appendix X9	provides a supplemental bibliography of federal and state vapor intrusion guidance and other publications that may assist the <i>environmental professional</i> conducting a VES or vapor intrusion assessment.

1.6 *This guide 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.*

1.7 *This guide cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this guide may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this guide be applied without consideration of a project's many unique aspects. The word "Standard" in the title means only that the guide has been approved through the ASTM consensus process.*

1.8 *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 ASTM Standards:²

E1527 Practice for Environmental Site Assessments: Phase I Environmental Site Assessment Process

E1903 Practice for Environmental Site Assessments: Phase II Environmental Site Assessment Process

2.2 Federal Statutes:

42 U.S.C. U.S. Code, Title 42, The Public Health and Welfare, Solid Waste Disposal, Identification and Listing of Hazardous Wastes, §6901, 6903, 6921; 42 U.S.C. U.S. Code, Title 42, Comprehensive Environmental Response, Compensation and Liability Act, 9605, 9601, *et seq.*

2.3 USEPA Documents:

40 CFR Title 40, Protection of Environment, Chapter 1, Environmental Protection Agency, Parts 300, 302, 312, 355, *et seq.*

OSWER Publication 9200.2-154, OSWER Technical Guide for Assessing and Mitigating the Vapor Intrusion Pathway

from Subsurface Vapor Sources to Indoor Air, June 2015
EPA 510-R-15-001, Technical Guide for Addressing Petroleum Vapor Intrusion at Leaking Underground Storage Tank Sites, June 2015

2.4 Other Documents:

NTP National Toxicology Program, "Annual Report on Carcinogens," (latest edition)

IARC International Agency for Research on Cancer "Monographs" (latest editions)

Pubchem, "Database of Toxic Effects of Chemical Substances" (<https://pubchem.ncbi.nlm.nih.gov>)

Vapor Intrusion Regulatory Guidance, <https://www.protect-environmental.com/vapor-intrusion-regulatory-guidance-by-state/>

3. Terminology

3.1 This section provides definitions and descriptions of terms used in this guide, terms used in this guide extracted from E1527 (some of which have been modified to be consistent with this guide), and a list of acronyms for keywords used in this guide. The terms are an integral part of this guide and are critical to an understanding of the guide and its use.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *approximate minimum search distance, n*—defined in subsection 8.1.3 and also defines the default *area of concern (AOC)*.

3.2.2 *aquifer, n*—rock or sediment in a formation, a group of formations, or part of a formation that is saturated and sufficiently permeable to transmit water to wells or springs.

3.2.3 *area of concern (AOC), n*—defined in subsections 8.1.2, 8.1.3 and 8.1.4 and is defined by the *approximate minimum search distance* adjusted as appropriate. When the AOC is defined by the *approximate minimum search distance* without adjustment, the AOC is the default AOC.

3.2.4 *biodegradation, n*—process by which microbial organisms transform or alter (through metabolic, enzymatic, or other action) the structure of chemicals present in the environment.

3.2.5 *chemical(s) of concern, COC, n*—chemical that is present in the subsurface environment, has a vapor pressure greater than 1 mm of mercury, or a Henry's Law Constant greater than 1×10^{-5} atm m³/mole at ambient temperature and pressure, and can potentially migrate as a vapor into the vadose zone of the TP.

3.2.5.1 *Discussion*—COC generally meet specific criteria for *volatility* (see 3.2.39) and *toxicity* (see 3.2.34) and include volatile organic compounds, semi-volatile organic compounds, petroleum hydrocarbons, and volatile inorganic analytes (such as mercury). A list of COC is presented in Appendix X6. A chemical's molecular weight has also been suggested as a criterion for volatility (with a threshold of 200 g/mole). However, EPA indicated in its June 2015 Vapor Intrusion Guidance that it is not considering a chemical's molecular weight because molecular weight is only a weak predictor of volatility. Those chemicals with a molecular weight greater than 200 g/mole are identified with an asterisk in Appendix X6.

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.

3.2.6 *conduit*, *n*—preferential pathway along which vapors released from contaminated soil and/or groundwater may migrate onto the *TP* or away from the *TP*.

3.2.7 *contaminant*, *n*—any physical, chemical, biological, or radiological substance or matter that has an adverse effect on air, water, or soil.

3.2.8 *contaminated plume*, *n*—plume in which concentrations of *COC* are known to be present in the soil or groundwater or both at concentrations exceeding levels that generally would be the subject of an enforcement action if brought to the attention of appropriate governmental agencies.

3.2.8.1 *Discussion*—A *contaminated plume* can take the form of a groundwater *contaminated plume* or a soil *contaminated plume*. In a groundwater *contaminated plume*, *COC* may be conveyed as *solutes* away from the point at which they were introduced into groundwater. They move with the migrating groundwater mass in the direction of groundwater flow. When dispersion within the groundwater *contaminated plume* brings a dissolved *COC* to the groundwater-soil gas interface, the *COC* may transition from the dissolved state to the vapor state and migrate from groundwater into soil gas in the vadose zone. Once a *COC* migrates into soil gas in the vadose zone, its migration may no longer be dependent on or related to groundwater movement. In a soil *contaminated plume*, *COC* volatilized from the soil mix freely with soil gas that exists within soil voids in the vadose zone. *COC* in the soil gas can also be introduced from underlying contaminated groundwater, as a result of a liquid spill into vadose zone soils, or by the direct release of vapors from a leaking underground source. Migration of *COC* contaminated soil gas through the vadose zone may be in any direction; however, it preferentially follows the path of least resistance. Fluctuations in barometric pressure may cause movement of air and vapors into and out of the vadose zone through preferential pathways.

3.2.9 *contaminated property*, *n*—property on which soil or groundwater or both contains *chemicals of concern (COC)* or otherwise hazardous substances at concentrations exceeding levels that generally would be the subject of an enforcement action if brought to the attention of appropriate governmental agencies.

3.2.10 *critical distance*, *n*—defined in subsection 9.2.

3.2.11 *dwelling*, *n*—structure or portion thereof used for residential habitation.

3.2.12 *environmental professional*, *n*—person meeting the education, training, and experience requirements as set forth in 40 CFR 312.10(b), which is the requirement set forth in E1527 (see subsection 3.3.5).

3.2.13 *findings*, *n*—defined in subsection 10.2.2.

3.2.14 *fracture*, *n*—break in a rock formation.

3.2.14.1 *Discussion*—Faults, shears, joints, and planes of fracture cleavage are types of fractures. The presence of fractures may accelerate migration of *COCs* along the fracture.

3.2.15 *groundwater*, *n*—water contained in the pore spaces of saturated geologic media.

3.2.16 *Henry's law*, *n*—relationship between the partial pressure of a compound in air and the concentration of that

compound in water under equilibrium conditions; *Henry's law* constants are temperature dependent.

3.2.17 *hydrocarbon*, *n*—chemical compound composed only of carbon and hydrogen atoms.

3.2.18 *moisture content (of soil)*, *n*—amount of water lost from soil upon drying to a constant weight expressed as the weight per unit weight of dry soil or as the volume of water per unit bulk volume of the soil.

3.2.18.1 *Discussion*—For a fully saturated medium, moisture content expressed as a volume fraction equals the porosity.

3.2.19 *nonaqueous phase liquid, NAPL*, *n*—substances that do not dissolve readily in water and that remain in the original bulk liquid form in the subsurface.

3.2.19.1 *Discussion*—Light NAPL (LNAPL), such as gasoline, is less dense than water and can accumulate above the water table, while dense NAPL (DNAPL), such as many chlorinated solvents, including trichloroethylene and perchloroethylene, are more dense than water and can penetrate into the water table.

3.2.20 *permeability*, *n*—qualitative description of the relative ease with which rock, soil, or sediment will transmit a fluid (that is, a liquid or gas).

3.2.21 *petroleum*, *n*—crude oil or any fraction thereof that is liquid at standard conditions of temperature and pressure (60°F at 14.7 psia).

3.2.21.1 *Discussion*—The term includes substances comprised of a complex blend of hydrocarbons derived from crude oil through the process of separation, conversion, upgrading, and finishing, such as motor fuels, jet oils, lubricants, and petroleum solvents, and also includes used oils.

3.2.22 *petroleum hydrocarbon chemicals of concern*, *n*—for the purpose of this guide, those volatile petroleum hydrocarbon compounds are a subset of *COC* and readily biodegrade to carbon dioxide and water by soil microbes in aerated environments.

3.2.22.1 *Discussion*—*Petroleum hydrocarbon chemicals of concern* may be present in several forms in environmental media, including adsorbed to soil, as constituents of LNAPL above the water table, as dissolved solutes in groundwater, or as vapors in soil gas.

3.2.23 *Phase I environmental site assessment, ESA*, *n*—process described in E1527.

3.2.24 *porosity*, *n*—volume fraction of a rock or unconsolidated sediment not occupied by solid material but usually occupied by liquids, gas, and/or air.

3.2.25 *preferential pathway*, *n*—pathway that has the least amount of constraint on the migration of *COC* vapors.

3.2.25.1 *Discussion*—Preferential pathways are natural or man-made and may provide direct contact between the subsurface of a property and the vapor contaminant source (that is, the location on a property where the contaminated vapor intersects the preferential pathway). Natural preferential pathways may include, for example, vertically fractured bedrock where the fractures are interconnected and in direct contact with the subsurface of a property and the vapor contaminant source. Man-made preferential pathways may include, for

example, utility conduits and sewers. The presence of preferential pathways may also direct migrating *COC* vapors away from a *TP*.

3.2.26 *real estate, n*—undeveloped real property, real property used for industrial, retail, office, agricultural, other commercial, medical, or educational purposes, or property used as a single family or multi-family residential *dwelling*.

3.2.27 *real estate transaction, n*—transfer of title to or possession of real property or receipt of a security interest in real property.

3.2.28 *report, n*—document prepared by an *environmental professional* pursuant to Section 10.

3.2.29 *saturated zone, n*—zone in which all of the voids in the rock or soil are filled with water at a pressure that is greater than atmospheric.

3.2.29.1 *Discussion*—The *water table* is the top of the *saturated zone* in an unconfined *aquifer*.

3.2.30 *semi-volatile organic compound, n*—general term for an organic compound that has sufficient vapor pressure at standard temperature (20°C) and pressure (1 atm) to vaporize (albeit at a slower rate than *volatile organic compounds*) and enter the atmosphere.

3.2.31 *solute, n*—substance such as a contaminant that is dissolved in another substance such as groundwater.

3.2.32 *target property, TP, n*—property involved in the *real estate transaction* that is the subject of the *VES* defined by this guide.

3.2.33 *toxic chemical, n*—chemical whose vapor concentration of the pure component poses either an incremental lifetime cancer risk (ILCR) or a non-cancer hazard quotient greater than acceptable values established by applicable federal, state, or local regulatory agencies.

3.2.34 *toxicity, n*—effect on human health that is exhibited by a *toxic chemical*; for the purposes of this guide, toxicity is defined as a chemical exhibiting an incremental lifetime cancer risk greater than 10^{-6} or a non-cancer Hazard Index greater than 1.

3.2.35 *user, n*—party who commissions the performance of a *VES* pursuant to this guide.

3.2.35.1 *Discussion*—Commonly, the *user* is the prospective purchaser of a parcel of property.

3.2.36 *vadose zone (or unsaturated zone), n*—zone between the land surface and the water table within which moisture content is less than saturation (except in the capillary fringe) and pressure is less than atmospheric.

3.2.36.1 *Discussion*—Soil pore space typically contains air or other gases. The capillary fringe is included in the *vadose zone*.

3.2.37 *vapor encroachment condition, VEC, n*—presence or likely presence of *COC* vapors in the vadose zone of the *TP* caused by the release of vapors from contaminated soil and/or groundwater either on or near the *TP* as identified by the Tier 1 (see Section 8) or Tier 2 (see Section 9) procedures in this guide.

3.2.37.1 *Discussion*—Conditions may exist where there

could be no vadose zone, such as the case of a building foundation sitting below the water table. In this case, it may be possible for *COC* vapors to adversely impact the indoor air without migrating through a vadose zone.

3.2.38 *volatile organic compound, VOC, n*—general term for an organic compound that has sufficient vapor pressure (for example, greater than 1 mm Hg) at standard temperature (20°C) and pressure (1 atm) to significantly vaporize and enter the atmosphere.

3.2.39 *volatility, n*—chemical is considered to be sufficiently *volatile* if its *Henry's law* constant is greater than 10^{-5} atm·m³·mol⁻¹ and its vapor pressure is greater than 1 mm Hg at room temperature.

3.2.39.1 *Discussion*—A chemical's molecular weight has also been used as an indicator of volatility, with the threshold molecular weight being approximately 200 g/mole. EPA in its June 2015 Vapor Intrusion Guidance does not use the molecular weight criterion because this criterion is believed to be only a weak predictor of volatility.

3.2.40 *water table, n*—top of the *saturated zone* in an unconfined *aquifer*.

3.3 *Terms Used in This Guide*—Some terms have been modified to be consistent with this guide.

3.3.1 *adjoining properties, n*—any real property or properties the border of which is contiguous or partially contiguous with that of the *target property*, or that would be contiguous or partially contiguous with that of the *target property* but for a street, road, or other public thoroughfare separating them.

3.3.2 *business environmental risk, n*—risk that can have a material environmental or environmentally driven impact on the transaction or the business associated with the current or planned use of a parcel of *real estate*, not limited to environmental issues that are investigated pursuant to this guide. Consideration of *business environmental risk* issues may involve addressing one or more non-scope considerations, some of which are identified in Section 11 of this guide.

3.3.3 *Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS), n*—list of sites compiled by EPA that EPA has investigated or is currently investigating for potential *hazardous substance* contamination and for possible inclusion on the *National Priorities List* (the CERCLIS information system supporting CERCLA has been retired by EPA and replaced by SEMS, the Superfund Enterprise Management System).

3.3.4 *CORRACTS list, n*—list of *hazardous waste* treatment, storage, or disposal facilities and other RCRA-regulated facilities (because of past interim status or storage of *hazardous waste* beyond 90 days) that have been notified by the EPA to undertake corrective action under RCRA. The *CORRACTS list* can be derived from the EPA database that manages RCRA data.

3.3.5 *environmental professional, n*—person meeting the education, training, and experience requirements as set forth in 40 CFR 312.10(b). The person may be an independent contractor or an employee of the *user*.