

# NRT Quick Reference Guide: VX

For References, Please See: Key References Cited/Used\* in National Response Team (NRT) Quick Reference Guides (QRGs) for Chemical Warfare Agents. QRGs are intended for Federal OSC/RPMs

Agent Characteristics	<b>Agent Classification:</b> Schedule 1 Chemical Warfare Nerve Agent CAS: 50782-69-9, <b>Formula:</b> C <sub>11</sub> H <sub>26</sub> NO <sub>2</sub> PS <b>Molecular Weight:</b> 267.38 g/mol <b>Description:</b> Odorless, oily, yellow/amber colored liquid when pure. VX is a lethal cholinesterase inhibitor having a similar mechanism of toxicity as organophosphate insecticides though it is much more potent. VX is more potent than the G-agents. However, VX has a very low vapor pressure and is difficult to maintain or disperse as vapor in air. <b>VX aqueous breakdown can result in the formation of compound EA-2192, which is considered almost as toxic as VX by ingestion exposure route.</b> EA-2192 formation is maximized between pH 7-10, but can be formed in potentially significant amounts outside this range. <b>Persistence:</b> VX is considered a persistent agent. Vapor: hours-day; liquid: hours-months. Persistence will depend upon the amount and purity of the agent, method of release, environmental conditions, and the types of surfaces and materials impacted. Porous, permeable, organic or polymeric materials such as carpets & vinyl tiles can act as sinks for absorbing VX vapors & liquids, prolonging persistence.						
	<b>Physical properties are listed at/near STP unless otherwise indicated.</b> Conversion Factors: ppm = mg/m <sup>3</sup> x 0.09144; mg/m <sup>3</sup> = ppm x 10.936 Vapor Pressure: 7x10 <sup>-4</sup> mm Hg						

Sampling	<p><b>Note: This section on sampling contains general guidelines &amp; does not replace the need for a site-specific sampling plan (See reference list for specifics)</b></p> <p><b>Sampling Concerns:</b> Detection, sampling equipment and procedures, and analytical techniques will be highly site-specific and depend on: 1) physical state of the agent; 2) type of surfaces contaminated (e.g., porous vs. nonporous); 3) the purpose of sampling (e.g., characterization, decon efficacy and clearance); and 4) specific laboratory requirements. Few laboratories have capability to determine VX (or its breakdown product EA-2192), in all types of media. The EPA is in the process of setting up analytical assets for chemical agent analysis of environmental samples, see LABORATORY ANALYSIS below. For sampling questions, call the EPA/HQ-EOC at 202-564-3850.</p> <p><b>Sample Locations and Planning:</b> Initially consider atmospheric sampling to ensure worker safety and to determine if there is a vapor plume. Characterization sampling is initiated by targeted sampling and analysis to identify "hot spots", potential agent flow paths, and media or objects potentially acting as sinks. Additional biased or random sampling can be used to determine the extent of potential contamination or to verify efficacy of decon. More thorough sampling (e.g., grid, statistical approach) will be required for the clearance phase or if there are large uncertainties about the area impacted or the amount released. Because VX is a persistent liquid, sample priorities should include surfaces that are potentially contaminated with aerosol/liquid (e.g., release site, low lying areas) and which humans are likely to contact or where vegetation is used as food.</p> <p><b>Note: Under specific reaction conditions breakdown products, including EA-2192, may form in many sample types.</b> Samples should be analyzed for the presence of agent &amp; its breakdown products. To ensure using sampling procedures compatible with all analytes, see ANALYSIS section below.</p> <p><b>Types of Samples: Air (Vapors are heavier than air):</b> Samples are collected using appropriate solid phase absorbent (tubes) at breathing zone level (5 ft.) to assess inhalation exposure and at ground levels (~ 6 in.) to assess off gassing at surfaces.</p> <p><b>Water:</b> Water should be collected in appropriate containers with addition of appropriate de-chlorinating agents and preservatives. In large volumes of water, VX is expected to dissipate via breakdown, hydrolysis and dilution. To rule out contamination concerns, particularly in small bodies of water, analyses should include EA-2192.</p> <p><b>Soil:</b> For localized "hot spot" areas where soil deposition may occur (i.e., aerosol or liquid droplets), surface soil samples should be taken from a non-vegetated area to a depth of less than one inch. Sub-surface soil samples are typically not necessary unless a large amount of liquid was poured on ground or if an underlying aquifer is endangered.</p> <p><b>Surface Wipes:</b> Wipe samples are often desired to indicate absence of VX on non-porous surfaces. Concurrent air monitoring is recommended.</p> <p><b>Bulk:</b> For hot spot areas where VX deposition may occur on porous surfaces (e.g., concrete, asphalt), actual pieces or cores of contaminated surface may be obtained using appropriate tools (scabbling or drills) for subsequent laboratory extraction analysis.</p> <p><b>Other Sample Matrices:</b> Contact EPA/HQ-EOC at 202-564-3850 for sampling instructions.</p> <p><b>Sample Packaging &amp; Shipping:</b> The packaging &amp; shipping of samples are subject to strict regulations established by DOT, CDC, USPS, OSHA, &amp; IATA. Contact the sample-receiving laboratory to determine if they have additional packaging, shipping or labeling requirements.</p>
	<p><b>CAUTION: Many labs may not be able to perform analysis on all matrices (e.g., wipes &amp; soil).</b> The Environmental Response Laboratory Network (ERLN) will use uniform, compatible sample prep &amp; analytical methods. (See <a href="http://www.epa.gov/sam">http://www.epa.gov/sam</a>). For access to the nearest ERLN lab specially trained and equipped for in VX analysis, contact the EPA/HQ-EOC at 202-564-3850.</p>
	<p><b>Decon/Cleanup Planning:</b> Once site controls are in place, develop a site specific decon/cleanup plan. Decontamination may require a "tiered approach" using a variety of techniques and products. Call the EPA/HQ-EOC at 202-564-3850 for more information.</p> <p><b>General Considerations:</b> A cost vs. benefit evaluation should be undertaken for each decon strategy and approach which considers: public safety, total cost, impact on the facility, wastes generated, as well as the time the facility or item will be out of service and any socio-economic, psychological, and/or security impacts that may result. Large volumes of decon wastes may be generated which will need to be collected, treated and disposed of properly. Waste handling and disposal must be addressed as early in the decon and cleanup process as possible, see WASTE DISPOSAL section.</p> <p><b>Disposal Option:</b> The urgency to restore a facility as quickly as possible may result in the outright and timely removal and disposal of contaminated materials. Certain materials may be resistant to decon formulations, or may be cheaper to discard and replace then to decon and restore.</p> <p><b>Monitored Natural Attenuation:</b> VX is degraded via natural processes. Environmental monitoring must be maintained during decon and recovery phases. Monitored natural attenuation may require institutional controls (e.g. access restriction and contaminant containment measures). The time to achieve clearance must be considered in the overall cost/benefit evaluation. This option is more passive than other options but is nondestructive to materials. Potential formation of EA-2192 must be considered and addressed.</p> <p><b>Fix-in-Place Option:</b> The contaminated area may be resistant to decontamination products or may be unable or impractical to be treated. Physical barriers can be used to separate and immobilize the agent contamination from coming into contact with the environment or the public. This can be a temporary or permanent solution.</p> <p><b>Decon Strategy:</b> A decon strategy can be developed by designating contaminated areas into 3 broad categories: 1) surfaces or hot-spots, 2) large volumetric spaces, and 3) sensitive equipment or items. Areas in each category may be treated using one or more unique decon processes in a tiered approach to overall site specific decon strategy.</p> <p><b>CAUTION: VX hydrolyzes and forms the toxic breakdown product EA-2192, with greatest yields between pH levels 7 and 10. For decon and EA-2192 info, contact the EPA/HQ-EOC at 202-564-3850. It is advisable to choose a decon solution containing a strong oxidant, such as chlorine or peroxide, which will help prevent EA-2192 formation regardless of pH. Presence of EA-2192 may present significant challenges in waste disposal.</b></p> <p><b>Surfaces/Hot Spots:</b> This category is for areas smaller in size but with higher levels of agent contamination. They may require more rigorous decontamination products and methods. 1) Hypochlorite Solutions: Hypochlorite can be very damaging (corrosive) to certain surfaces and materials and should be rinsed thoroughly afterwards. Household bleach solutions (5.0% sodium hypochlorite) are very effective for VX with efficacy achieved with contact time of 15-60 minutes depending on surface material. Calcium hypochlorite, present in commercial products, such as HTH (10% hypochlorite solution), and is better for surfaces with high concentrations of liquids in localized areas. 2) Aqueous peroxide solutions may be effective in breaking down VX without the formation of the EA-2192 species.</p> <p><b>Large Volumetric Spaces:</b> This category is for areas larger in size but with lower levels of agent contamination. 1) Monitored Natural Attenuation is more passive than other decon options and is non destructive to materials. This option may be preferable given the scope and severity of contamination; 2) Forced or Hot Air ventilation methods are recommended for vapor plume contamination or low concentration of VX in large volumetric spaces or open areas; efficacy typically can be achieved in days to weeks with less waste and adverse impacts to materials; 3) Fumigation with modified vaporous hydrogen peroxide (VHP®) may be effective against VX, however requires long exposure times (up to 24 hours). HVAC systems in large indoor spaces may require a separate decon strategy which could include the use of hot air ventilation or fumigation.</p> <p><b>Sensitive Equipment and Items:</b> 1) Forced or Hot Air ventilation may be used for VX and can be used either in-situ or ex-situ to decon these items. The low volatility of VX may necessitate high operating temperatures; 2) mVHP fumigation can be used on these items with less corrosion to electronics than dilute hypochlorite solutions, however requires long exposure times (up to 24 hours).</p> <p><b>CAUTION:</b> Decon products may have unique safety/PPE requirements due to their own toxicity or that of breakdown products during use (e.g., bleach results in chlorine vapors). Strong oxidizers, such as hypochlorite, may react violently with organics. Proprietary decon foams and gels such as DF-200®, CASCAD®, Decon Green®, or L-Gel® have been shown to be effective against VX on the order of minutes to hours, but not all have been thoroughly tested. Formulations should be chosen that do not allow the formation of toxic byproducts such as EA-2192. Availability, cost and the need for specialized equipment may limit their use early in the response. Dirt, grime, and other coatings can reduce the efficacy of decon; pre-cleaning surfaces with soap and water may be needed before the application of decon formulations <b>but resulting pre-cleaning rinsates may contain and spread agent and toxic byproducts.</b></p> <p><b>Verification of Decon:</b> Site &amp; situation specific. Please contact NRC for initial notification (1-800-424-8802) and EPA/HQ-EOC (202-564-3850) post notification.</p>
Waste Disposal	<p><b>CAUTION:</b> Hazardous waste transportation &amp; disposal are regulated federally; however more stringent regulations may exist under state authority. These regulations differ from state-to-state. Detailed state regulations can be found at <a href="http://www.envcap.org">www.envcap.org</a>.</p>
	<p><b>Waste Disposal Planning:</b> Waste disposal for agent-contaminated wastes generated from the decontamination &amp; disposal activities will be problematic. Landfills willing to take these wastes may be limited &amp; incineration may be prohibitively expensive or impractical. All waste disposal options should be investigated as early into the response process as possible. Transportation of the agent contaminated wastes from the site to the landfill or incinerator may be problematic as well. First, agreements must be reached between the waste sender &amp; acceptor BEFORE transport, followed by timely public notification of the transport &amp; disposal phases. Transportation of hazardous waste may cross several states and localities, which may exceed federal regulations. Requirements for transporting hazardous materials, &amp; procedure for exemption, are specified in <a href="http://www.fmcsa.dot.gov/safety-security/hazmat/complyhmrregs.htm#hmp">http://www.fmcsa.dot.gov/safety-security/hazmat/complyhmrregs.htm#hmp</a>. VX is classified as a Division 6.1 material &amp; is shipped as Hazard Zone A. The U.S. EPA has developed a web-based Incident Waste Management Planning &amp; Response Tool which contains links to guidance related to waste transportation, contact information for potential treatment, disposal facilities, &amp; state regulatory offices, packaging guidance to minimize risk to workers, &amp; guidance to minimize the potential for contaminating the treatment or disposal facility. Access to the EPA's web based disposal tool requires pre-registration (<a href="http://www2.ergweb.com/bdrtool/login.asp">http://www2.ergweb.com/bdrtool/login.asp</a>).</p>