

**NRT Quick Reference Guide:
Lewisite (L)**

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	<p>Agent Classification: Schedule 1 Blister (Vesicant) Agent CAS: 541-25-3; Formula: C₂H₂AsCl₃; Molecular Weight: 207.35 g/mol Description: Pure lewisite is referred to as L-1 and is oily, colorless and odorless. When impure, it is yellow brown through violet black liquid with strong penetrating geranium odor. The manufacturing process affects physical properties, appearance, persistence, & analytical detection limits. When sulfur mustard (HD) is added, the mixture ("Agent Yellow", HL) has a strong garlic odor. Common impurities include two related compounds, lewisite 2 (L-2) and lewisite 3 (L-3). This QRG is based on L-1 but includes aspects of L-2 and L-3, and will use the collective abbreviation "L". L is a blister (vesicant) agent that produces immediate burning pain with blistering starting within a few hours. L is less volatile than sarin (GB); it is much more volatile than persistent agents VX or HD. Environmental breakdown products of Lewisite include highly toxic, arsenic (III) compounds, such as arsenites, lewisite oxide, and 2-chlorovinyl arsenous acid (CVAA); some cause similar blistering as Lewisite. Decon by-products include arsenic (V) compounds, which are generally less toxic than arsenic (III) compounds, but may be considered hazardous. Persistence: Lewisite is considered to have low persistence. Vapor: minutes to hours; liquid: hours to days. Persistence will depend upon the amount and purity of the agent, method of release, environmental conditions, and types of surfaces and materials impacted. Porous, permeable, organic or polymeric materials such as carpets & vinyl tiles can act as sinks for absorbing Lewisite vapors & liquids, prolonging persistence. Many toxic environmental and decon byproducts are persistent. Under certain conditions, when protected from environmental degradation processes, lewisite and/or lewisite oxide could persist in soil for decades.</p>																													
	<p>Physical properties are listed at/near STP unless otherwise indicated and represent the most conservative values reported for various L manufacturing processes. Reported values vary significantly. Conversion Factors: ppm = mg/m³ x 0.1179; mg/m³ = ppm x 8.481 Vapor Pressure: 0.58 mm Hg (68°F/20°C) Vapor Density: 7.1 (air = 1) Aqueous Solubility: 0.5 g/L Volatility: 4,480 mg/m³ (68°F/20°C) Boiling Point: 374°F/190°C Soluble: organic solvents, oils and alcohol Freezing Point: 32°F/0.1°C Flash Point: Does not flash. Liquid Density: 1.89 (68°F/20°C)</p>																													
Release Scenarios	<p>AIR RELEASE SCENARIOS ARE ASSUMED MOST PROBABLE; HOWEVER OTHER RELEASE SCENARIOS & EXPOSURE ROUTES SHOULD BE CONSIDERED. Open Areas: Due to its volatility, L could be dispersed as a vapor, and the primary release/attack scenario is an airborne release. L is expected to degrade in the environment fairly rapidly; however, liquid on surfaces generally persists for days. Environmental conditions will affect the degradation & evaporation rates of L with cooler & drier conditions enhancing persistence. L vapors are heavier than air, so vapors can accumulate in lower terrains. Lewisite has a freezing point at 0°C (32°F), so the reaerosolization of liquids & solids, as ambient temperatures rise, may present a real hazard. Water/Water Systems: L released into water will likely degrade within a few days; however toxic L breakdown products may persist from days to weeks. If released into water systems such as reservoirs, treatment plants, distribution systems, public fountains or pools, treatment processes can further break down agent. Water systems, plumbing, surfaces, and equipment that have contacted contaminated water must be evaluated for decon along with the bulk water. Indoor Facility: Due to its volatility, L could potentially be dispersed inside a building or facility; HVAC systems could be impacted. L vapors are heavier than air so vapors can accumulate in lower levels or utility corridors inside the buildings.</p>																													
	<p>Onset Onset & severity of effects depend on dose, duration, & route of exposure (not all signs/symptoms may develop). The effects caused by L are not typically fatal immediately. THERE IS AN ANTIDOTE but secondary infections from blisters/tissue damage may be fatal. L can cause immediate eye pain and eye/skin/respiratory tract irritation, and skin redness within 15-30 min. Blister formation and deep skin burns are approximately 12 hours post exposure. This is unlike HD, which has delayed effects.</p>																													
Health Effects	<p>Signs/Symptoms Information below is exposure route specific. Regardless of route the following range of effects may occur depending on dose. Mild to Moderate: Immediate stinging and burning pain and strong irritation, tear production, spasmodic blinking, and swelling and fluid accumulation in the membranes and eyelids. Irritation of the nose and lower airways, immediate burning pain, violent sneezing, nosebleed, sinus pain, inflammation of the voice box, cough, and difficulty breathing or shortness of breath. Immediate stinging and burning pain or irritation of skin, redness, blistering with pain, and itching. Severe: Blistering and scarring of the cornea, rupture of the eye, and blindness. Inflammation of the lungs, accumulation of fluid in the lungs, respiratory failure, and death. Severe blistering and severe burns on skin.</p>																													
	<p>Exposure Routes Inhalation: Vapor is absorbed through mucous membranes (eyes, throat, and lungs). Skin: Direct contact with liquid or vapor causes symptoms. Eyes (sensitive organ): Vapors are absorbed through mucous membranes. Symptoms occur immediately. Ingestion: Consumption of food or drink contaminated with L or L breakdown products could cause local and systemic effects.</p>																													
Effect Levels	<p>Air: Acute Exposure Guideline Levels (AEGs) for general population one-time exposure emergency scenarios for L-1 (complete definitions are available in Key References Cited/Used* in NRT Quick Reference Guides for Chemical Warfare Agents). NA = not available.</p> <table border="1"> <thead> <tr> <th>AEGL Level in mg/m³, at exposure duration →</th> <th>10 min.</th> <th>30 min.</th> <th>1 hr.</th> <th>4 hr.</th> <th>8 hr.</th> </tr> </thead> <tbody> <tr> <td>AEGL 1: threshold mild effects</td> <td>NA</td> <td>NA</td> <td>NA</td> <td>NA</td> <td>NA</td> </tr> <tr> <td>AEGL 2: potentially irreversible effects or impaired ability to escape</td> <td>0.65</td> <td>0.23</td> <td>0.12</td> <td>0.035</td> <td>0.018</td> </tr> <tr> <td>AEGL 3: threshold for severe effects/medical needs/increasing potential for lethality</td> <td>3.9</td> <td>1.4</td> <td>0.74</td> <td>0.21</td> <td>0.11</td> </tr> </tbody> </table> <p>Exposure Guidelines: IDLH: None; STEL: None; Worker Population Limit (WPL) [an 8-hour time-weighted average occupational value] = 0.003 mg/m³ General Population Limit (GPL) [a 24-hour time-weighted average] = 0.003 mg/m³ WPL and GPL based on detection limit and are not health-based. Soil: Industrial Exposure Scenario = 3.7 mg/kg. Residential Exposure Scenario = 0.3 mg/kg. Drinking Water: Army field standard at 15L/day, for 7 days = 27 µg/L; Provisional Advisory Levels (PAL-1) for general public at 2L/day, for 1, 30, and 90 days = NA.</p>						AEGL Level in mg/m ³ , at exposure duration →	10 min.	30 min.	1 hr.	4 hr.	8 hr.	AEGL 1: threshold mild effects	NA	NA	NA	NA	NA	AEGL 2: potentially irreversible effects or impaired ability to escape	0.65	0.23	0.12	0.035	0.018	AEGL 3: threshold for severe effects/medical needs/increasing potential for lethality	3.9	1.4	0.74	0.21	0.11
	AEGL Level in mg/m ³ , at exposure duration →	10 min.	30 min.	1 hr.	4 hr.	8 hr.																								
AEGL 1: threshold mild effects	NA	NA	NA	NA	NA																									
AEGL 2: potentially irreversible effects or impaired ability to escape	0.65	0.23	0.12	0.035	0.018																									
AEGL 3: threshold for severe effects/medical needs/increasing potential for lethality	3.9	1.4	0.74	0.21	0.11																									
<p>Note Personal Protective Equipment (PPE) selection (levels A-D), medical surveillance requirements, First Aid options and personnel decon may vary depending upon the agent, site & the release scenario. Additional information on personnel safety and PPE selection criteria can be found at: www.cdc.gov/niosh/ershdb. We also recommend that responders check their own internal procedures (SOPs) if they have them.</p>																														
Personnel Safety	<p>Medical Pre-incident: Annual physical, respiratory function exams and a baseline cholinesterase activity. During Incident: Conduct periodic on-site medical monitoring, observe for any signs & symptoms as per Health Effects section above and treat accordingly as per First Aid section below.</p>																													
	<p>First Aid Immediately remove person from affected area, remove contaminated articles. Wash bare skin with warm soapy water, and rinse eyes with plain water for 10-15 minutes if exposed to liquid agent. Antidote: Dimercaprol (a.k.a. British Anti-Lewisite, 2,3-dimercaptopropanol). Antidote should only be administered as per pre-incident training. Send person for follow up medical attention and evaluation. If cleared to resume work, continue to monitor for signs/symptoms & treat accordingly.</p>																													
	<p>PPE GENERAL INFORMATION: NIOSH-certified Chemical, Biological, Radiological, Nuclear (CBRN) Self Contained Breathing Apparatus (SCBA), Air Purifying Respirators (APR) or Powered Air Purifying Respirators (PAPR), full-face masks, & protective clothing should be used. Pre-incident training & exercises on the proper use of PPE is recommended. Per NIOSH guidance - LEVEL A: Recommended for the initial response to an L incident. Level A provides the greatest level of skin (fully encapsulating suit), respiratory (SCBA), & eye protection when the contaminant identity or concentration is unknown. Select Level A when the L concentration is unknown or above the IDLH or AEGL-2, & when there is a potential of ocular or dermal exposure. LEVEL B: Provides the highest level of respiratory protection (SCBA) when a lesser level of skin protection is required. Select Level B when the L concentration is unknown or above the IDLH or AEGL-2 & dermal exposure is less of a risk. Level B differs from Level A in that it incorporates a non-encapsulating, splash-protective, chemical-resistant outer suit that provides protection against most liquids but is not airtight. LEVEL C: Select Level C when the contaminant identity & concentration are known & the respiratory protection criteria factors for the use of APR or PAPR (i.e.: < IDLH, warning properties) are met. Level C may be appropriate when decontaminating personnel or equipment. LEVEL D: Select Level D when the contaminant is known & the concentration is below the appropriate occupational exposure limit or less than AEGL-1 for the stated duration times. Downgrading PPE levels can be considered only when the identity & concentration of the contaminant & the risks of dermal exposure are known, & must be accompanied by on-site monitoring.</p>																													

Field Detection	Real-time field screening tools (results not confirmatory or quantitative): Caution should be given to equipment that has not been properly evaluated. False positive & false negatives may occur in the presence of interferences common in the environment. The following is a summary of minimum screening levels for equipment procured by most EPA response teams. Other screening tools may be used by other agencies & responders; some with similar capabilities & limitations.						
	NOTE: Detection equipment does not measure contaminant levels. Rather they detect the presence of a nerve agent at levels as low as listed below.						
	Minimum Screening Levels	CAM/ICAM	AP4C	APD-2000	Dräger	M256	M272 (water)
	ppm	N/A	0.15 (as Arsenic)	0.24	0.1	1.06	0.1 mg/L
mg/m ³	N/A	0.5 (as Arsenic)	2.04	0.85	9	NA	
Sampling	Note: This section on sampling contains general guidelines & does not replace the need for a site-specific sampling plan. See reference list for specifics. Sampling Concerns: Detection, sampling equipment & procedures, & analytical techniques will be highly site-specific & 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 & clearance); & 4) specific laboratory requirements. Few laboratories currently have capability to determine L and breakdown products, particularly for large numbers of samples & in all types of media. The EPA is in the process setting up analytical assets for chemical agent analysis of environmental samples, see ANALYSIS below. For sampling questions, call the EPA/HQ-EOC at 202-564-3850						
	Sample Locations & Planning: Initially consider air sampling to ensure worker safety & to determine if there is a vapor plume which could impact other areas. Characterization sampling is initiated by targeted or judgmental sampling to identify "hot spots", potential agent flow paths, & 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 the efficacy of decon. More thorough probabilistic sampling (e.g., grid, statistical approach) will be required for the clearance phase or if there are large areas of uncertainties. Because lewisite is generally not persistent, air sampling to "clear areas" should be included in the sampling plan.						
	Note: L breaks down in most environmental and decon conditions to numerous persistent toxic products, such as arsenites, lewisite oxide, and 2-chlorovinyl arsenous acid (CVAA); some cause similar blistering as L. Because of low capacity for analysis specific for L and L related compounds, total arsenic (As) may be used as marker for contamination in air, surfaces, soils and water matrices. Arsenic is prevalent in many environments therefore determining background As levels is recommended. See ANALYSIS sections below to ensure sampling procedures are compatible with all analytes. Types of Samples: Air (Vapors are heavier than air): Samples are collected using appropriate media at breathing zone level (~5 ft.) to assess inhalation exposure. Determination of total As in particulates in air via high-volume air samplers is recommended. Water: Water should be collected in appropriate containers with addition of appropriate de-chlorinating agents and preservatives. Soil: For localized "hot spot" areas where soil deposition may occur, surface soil samples should be taken from a non-vegetated area to a depth of less than one inch. Sub-surface soil samples may not be necessary unless a large amount of liquid L was poured on the ground, or if an underlying aquifer is endangered. Surface Wipes: Wipe samples are often desired to indicate absence of L contamination on non-porous surfaces. Concurrent air monitoring is recommended. Bulk: For hot spot areas where liquid L deposition may occur on porous surfaces (e.g., concrete, asphalt), actual pieces or cores of contaminated surface may be obtained using appropriate tools (scabbling, coring or drills) for subsequent laboratory extraction analysis. Other Sample Matrices: Contact EPA/HQ-EOC at 202-564-3850 for sampling instructions.						
	Sample Packaging & Shipping: The packaging & shipping of samples are subject to strict regulations established by DOT, CDC, USPS, OSHA, & IATA. Contact the sample-receiving laboratory to determine if they have additional packaging, shipping or labeling requirements.						
	Anal-ysis CAUTION: Many labs may not be able to perform analysis on all matrices (e.g., wipes & soil). The Environmental Response Laboratory Network (ERLN) will use uniform, compatible sample prep & analytical methods. (See http://www.epa.gov/sam). For access to the nearest ERLN laboratory specially trained and equipped for in lewisite analysis, contact the EPA/HQ-EOC at 202-564-3850.						
Decontamination/Cleanup	Decon/Cleanup Planning: 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, including disposal of arsenic contaminated waste. CAUTION – SEE NOTE ABOVE CONCERNING TOXIC BYPRODUCTS. General Considerations: 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. Disposal Option: 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 than to decon and restore. Monitored Natural Attenuation: 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. Fix-in-Place Option: 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. Decon Strategy: 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 the overall site specific strategy. Surfaces/Hot Spots: This category is for areas smaller in size but with higher levels of agent contamination. They may require more rigorous decontamination products and methods. 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 expected to be effective for L with contact time of 15-60 minutes depending on surface material. Large Volumetric Spaces: This category is for areas larger in size but with lower levels of agent contamination. They may require less aggressive but more broadly applied decon products and methods. 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 Air ventilation methods are recommended for vapor plume contamination or low concentration of Lewisite in large volumetric spaces or open areas; Lewisite may be removed in hours to days with less waste and adverse impacts to materials. Sensitive Equipment and Items: Forced ventilation may be used for Lewisite and can be used either in-situ or ex-situ to decon these items. CAUTION: 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). The use of other products (oxidizers, gelling/foam-making blends) for decon of L has not been tested, such as DF-200®, Decon Green®, CASCAD® or L-Gel®. 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 but resulting pre-cleaning rinsates may contain and spread agent. Verification of Decon: Site & situation specific. Please contact NRC for initial notification (1-800-424-8802) and EPA/HQ-EOC (202-564-3850) post notification.						
	Waste Disposal CAUTION: Hazardous waste transportation & 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 www.envcap.org . Waste Disposal Planning: Waste disposal for agent-contaminated wastes generated from the decontamination & disposal activities will be problematic. Landfills willing to take these wastes may be limited & 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 & acceptor BEFORE transport, followed by timely public notification of the transport & disposal phases. Transportation of hazardous waste may cross several states and localities, which may exceed federal regulations. Requirements for transporting hazardous materials, & procedure for exemption, are specified in http://www.fmcsa.dot.gov/safety-security/hazmat/complyhmrregs.htm#hmp . L is classified as a Division 6.1 material & is shipped as Hazard Zone A. The L contains Arsenic (As), state and local authorities may have specific regulations regarding the disposal of As containing wastes. The U.S. EPA has developed a web-based Incident Waste Management Planning & Response Tool which contains links to guidance related to waste transportation, contact information for potential treatment, disposal facilities, & state regulatory offices, packaging guidance to minimize risk to workers, & guidance to minimize the potential for contaminating the treatment or disposal facility. Access to the EPA's web based disposal tool requires pre-registration (http://www2.ergweb.com/bdrtool/login.asp).						