

Agent Characteristics	<p>Agent Classification: Schedule 1 Chemical Warfare Blister (Vesicant) Agent; CAS: 541-25-3; Formula: C₂H₂AsCl₃; Molecular Weight: 207.35 g/mol.</p> <p>Description: Lewisite is referred to as L-1 and is oily, colorless and odorless. When pure, it is a yellow brown through violet black liquid with a strong penetrating geranium odor. The manufacturing process affects physical properties, appearance, persistence, and analytical detection limits. 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 "L" as the collective abbreviation. 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 L are easily formed and include highly toxic arsenic (III) compounds, such as arsenites, lewisite oxide, and 2-chlorovinyl arsenous acid (CVAA); some cause similar blistering as L. Decontamination by-products of L include arsenic (V) compounds, which are generally less toxic than arsenic (III) compounds, but may be considered hazardous.</p> <p>Persistence: L is considered a "low to moderate persistent" chemical warfare agent. Vapor: minutes to hours; liquid: hours to days. Persistence will depend upon 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 and vinyl tiles can accumulate agent by absorbing L vapors and liquids, acting as "sinks," thereby prolonging persistence. Many vesicant and toxic environmental breakdown products and decontamination by-products are persistent. Under certain conditions, when protected from environmental degradation processes, L breakdown products may persist in soils for decades.</p> <p>Physical properties are listed at/near STP unless otherwise indicated. Conversion Factors: ppm = mg/m³ x 0.1179; mg/m³ = ppm x 8.481</p>																																
	<table border="1"> <thead> <tr> <th>Vapor Density</th> <th>Vapor Pressure</th> <th>Volatility</th> <th>Boiling Point</th> <th>Freezing Point</th> <th>Flash Point</th> <th>Liquid Density</th> <th>Aqueous Solubility</th> <th>Non-aqueous Solubility</th> </tr> </thead> <tbody> <tr> <td>7.1 (air = 1)</td> <td>0.58 mm Hg (77°F/25°C)</td> <td>4,480 mg/m³ (68°F/20°C)</td> <td>374°F/190°C</td> <td>32.2°F/0.1°C</td> <td>Does not flash</td> <td>1.89 g/mL (68°F/20°C)</td> <td>0.5 g/L (temp not reported)</td> <td>Common solvents, alcohols, gasoline, oils, fats</td> </tr> </tbody> </table>									Vapor Density	Vapor Pressure	Volatility	Boiling Point	Freezing Point	Flash Point	Liquid Density	Aqueous Solubility	Non-aqueous Solubility	7.1 (air = 1)	0.58 mm Hg (77°F/25°C)	4,480 mg/m ³ (68°F/20°C)	374°F/190°C	32.2°F/0.1°C	Does not flash	1.89 g/mL (68°F/20°C)	0.5 g/L (temp not reported)	Common solvents, alcohols, gasoline, oils, fats						
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<p>AIR RELEASE SCENARIOS ARE ASSUMED MOST PROBABLE; HOWEVER, OTHER RELEASE SCENARIOS AND EXPOSURE ROUTES SHOULD BE CONSIDERED.</p> <p>Open Areas: Due to its volatility, L could be dispersed as a vapor or aerosol, and the primary release/attack scenario is an airborne release. L is expected to degrade in the environment fairly rapidly; however, liquid L on surfaces generally persists for hours to days. Environmental conditions will affect the degradation and evaporation rates of L with cooler and drier conditions enhancing persistence. L has a freezing point at 0.1°C (32.2°F), so the re-aerosolization of liquids and solids, as ambient temperatures rise, may present a real hazard. L vapors are heavier than air, so vapors can accumulate in lower terrains.</p> <p>Water/Water Systems: L released into water will likely hydrolyze within a few hours into vesicant and toxic compounds, which may persist for days to weeks. If released into water systems such as reservoirs, treatment plants, distribution systems, public fountains or pools, their treatment processes may result in further reaction with L. Water systems, plumbing, surfaces and equipment that have contacted contaminated water must be evaluated for decontamination along with the bulk water.</p> <p>Indoor Facility: Due to its volatility, L could potentially be dispersed as a vapor or aerosol 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>																																	
Release Scenarios	<p>Onset Onset and severity of effects depend on dose, duration and route of exposure (not all signs/symptoms may develop). The effects caused by L are immediate but are not typically fatal; however, secondary infections from blisters/tissue damage may be fatal and can require substantial supportive medical care. L can cause immediate eye pain and eye/skin/respiratory tract irritation, and skin redness within 15-30 minutes. Blister formation and deep skin burns are approximately 12 hours post exposure. Eye lesions are very serious resulting in blindness unless decontamination is very prompt.</p>																																
	<p>Signs/Symptoms Symptoms will vary depending on exposure route; however, the following is a general list of all possible symptoms. The severity of effects depends upon the dosage. Mild to Moderate: Immediate stinging and burning pain and strong irritation of eyes, 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 (mouth, throat and lungs). Skin: Direct contact with liquid or vapor causes symptoms. Eyes: Eyes are the most sensitive to L injury. Vapors are absorbed through mucous membranes. Symptoms occur immediately. Ingestion: Consumption of contaminated food or drink could cause local and systemic effects.</p>																																
Health Effects	<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 various exposure durations</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>1.3</td> <td>0.47</td> <td>0.25</td> <td>0.070</td> <td>0.037</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: 0.36 mg/m³; proposed value that is toxicologically derived. STEL: NA; Worker Population Limit (WPL) [an 8-hr time-weighted average occupational value] = 0.003 mg/m³; General Population Limit (GPL) [a 24-hr 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: Provisional Advisory Levels (PAL-1) for L are not available. In the absence of PALs, the U.S. Army's Military Exposure Guidelines (MEGs) may be used; the MEG at 5 L/day, for 7 days = 80 µg/L.</p>									AEGL Level in mg/m ³ , at various exposure durations	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	1.3	0.47	0.25	0.070	0.037	AEGL 3: Threshold for severe effects/medical needs/increasing potential for lethality	3.9	1.4	0.74	0.21	0.11
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<p>Note Personal Protective Equipment (PPE) selection (levels A-D), medical surveillance requirements, First Aid options and personnel decontamination may vary depending upon the amount and purity of agent, site conditions and 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 (i.e., SOPs), if they have them.</p>																																	
<p>Medical Pre-incident: Annual physical and respiratory function exams. During Incident: Conduct periodic on-site medical monitoring, observe for any signs and symptoms as per Health Effects section above and treat accordingly as per First Aid section below.</p>																																	
Personnel Safety	<p>First Aid Immediately remove person from affected area and remove contaminated clothing and articles. Wash bare skin immediately with water, or warm, soapy water if available, at normal household pressures (~50-60 psi) for three minutes, ensure thorough soaking. Rinse eyes exposed to liquid agent with potable water for 15 minutes. Antidote: Dimercaprol (a.k.a. British Anti-Lewisite, 2,3-dimercaptopropanol). Antidote should only be administered in hospital setting. Send person for follow-up medical attention and evaluation. If cleared to resume work, continue to monitor for signs/symptoms and 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, and protective clothing should be used. Pre-incident training and exercises on the proper use of PPE are 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), and 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, and when there is a potential of ocular or dermal exposure. LEVEL B (modified): 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 and dermal exposure is less of a risk. Level B differs from Level A in that it typically incorporates a non-encapsulating, splash-protective, chemical-resistant outer suit that provides protection against most liquids but is not vapor tight. The Level B PPE dress-out for L should be modified to ensure there is no exposed skin or potential for ocular exposure. LEVEL C (modified): Level C may not be appropriate for an L response since there are insufficient warning properties for L inhalation exposures to permit the appropriate use of an APR/PAPR in most L contamination scenarios. LEVEL D: Select Level D when the contaminant is known and the concentration is below the appropriate occupational exposure limit for the stated duration times. Downgrading PPE levels can be considered only when the identity and concentration of the contaminant and the risks of dermal exposure are known, and must be accompanied by on-site monitoring.</p>																																
	<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 and false negatives may occur in the presence of interferents common in the environment. The following is a summary of minimum screening concentration ranges for equipment procured by many EPA and HAZMAT response teams. Other screening tools may be used by these teams and other agencies and responders, some with similar capabilities and limitations. NA = not available.</p>																																

	NOTE: Detection equipment does not measure contaminant levels. Rather, they detect the presence of L at levels as listed below.						
	Minimum Screening Ranges	CAM/CAM	AP2C/AP4C	APD-2000	Dräger (CDS Kit)	M256/M256A1	M272 (water)
	ppm	NA	0.15-1.5 (as Arsenic)	0.2-0.24	0.1 (Arsine)	1.1	0.1-2 mg/L
	mg/m ³	NA	0.5-13 (as Arsenic)	1.7-2.0	3.0 (organic Arsenic)	9-14	NA
Sampling	Note: This section on sampling contains general guidelines and does not replace the need for a site-specific sampling plan (See Key References Cited/Used)						
	Sampling Concerns: Detection, sampling equipment and procedures, and analytical techniques will be site-specific and depend on: 1) physical state of the agent; 2) type of surfaces contaminated (e.g., porous vs. non-porous); 3) the purpose of sampling (e.g., characterization, decontamination efficacy and clearance); and 4) specific laboratory requirements. Few laboratories currently have capability to determine L, particularly for large numbers of samples and in all types of media. The U.S. Environmental Protection Agency (EPA) has set up mobile and fixed labs and analytical assets for chemical agent analysis of environmental samples under their Environmental Response Laboratory Network (ERLN), see ANALYSIS section below (www2.epa.gov/emergency-response/environmental-response-laboratory-network). For sampling questions, call the EPA/HQ-EOC at 202-564-3850.						
	Sample Locations and Planning: Initially consider air monitoring to ensure worker safety and to determine if there is a vapor plume that could impact other areas. Characterization sampling is initiated by targeted or judgmental sampling 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 the efficacy of decontamination. More thorough probabilistic sampling (e.g., grid, statistical approach) may be required for the clearance phase or if there are large uncertainties about the area impacted or the amount released. Because L is generally not persistent, air sampling to help to "clear areas" should be included in the sampling plan.						
	Note: L breaks down in most environmental and decontamination conditions to numerous persistent toxic products, such as arsenites, lewisite oxide, and CVAA; some cause similar blistering as L. Because of low capacity for analysis that is specific for L and L-related compounds, total arsenic (As) may be used as a marker to determine the extent of contamination of the parent L. Arsenic is prevalent in many environments therefore determining background As levels is recommended. See ANALYSIS section below to ensure sampling procedures are compatible with all analytes. Types of Samples: Air (Vapors are heavier than air): Samples are collected using appropriate solid phase absorbent media (tubes) or air sampler (e.g., SUMMA canister) at breathing zone level (~5 ft.) to assess inhalation exposure and at ground levels (~6 in.) to assess off gassing at surfaces. 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 was poured on the ground, or if an underlying aquifer is endangered. Surface Wipes: Wipe samples are often desired to indicate absence of L 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. Bulk samples of suspected sink materials may be recommended to rule out secondary vapor phase disposition or absorption of L into these materials. Other Sample Matrices: Contact EPA/HQ-EOC at 202-564-3850 for sampling instructions.						
	Sample Packaging and Shipping: The packaging and shipping of samples are subject to strict regulations established by DOT, CDC, USPS, OSHA and 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 and soil). The ERLN will use uniform, compatible sample prep and analytical methods. (See www2.epa.gov/emergency-response/environmental-response-laboratory-network). For access to the nearest ERLN laboratory specially trained and equipped for L analysis, contact the EPA/HQ-EOC at 202-564-3850.						
Decontamination/Cleanup	Decontamination/Cleanup Planning: Once site controls are in place, develop a site-specific decontamination/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.						
	General Considerations: A cost vs. benefit evaluation should be undertaken for each decontamination strategy and approach that 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 decontamination wastes may be generated that will need to be collected, treated and disposed of properly. Waste handling and disposal must be addressed as early in the decontamination and cleanup process as possible (see Waste Management section below). 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 decontamination formulations, or may be cheaper to discard and replace than to decontaminate and restore. Monitored Natural Attenuation: L degrades via natural processes. Environmental monitoring must be maintained during decontamination 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 non-destructive to materials. Porous or permeable materials can adsorb L thereby prolonging persistence. 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. Decontamination Strategy: A decon strategy can be developed by designating contaminated areas into three 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 decon 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 corrosive to certain surfaces and materials and should be rinsed thoroughly afterwards. Household bleach solutions (≥5% sodium hypochlorite) are effective for decontamination of surfaces contaminated with L with efficacy expected to be achieved with contact time of 30-60 minutes depending on surface material. Calcium hypochlorite, present in commercial products, such as HTH (10% hypochlorite solution), is better for surfaces with high concentrations of liquids in localized areas. DF-200® is effective against surfaces contaminated with L with a contact time of at least 30 minutes. Other proprietary decontamination foams and gels such as CASCAD®, Decon Green®, or L-Gel® have not been tested for decontamination of surfaces contaminated with L. 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 decontamination products and methods. 1) Monitored Natural Attenuation is more passive than other decontamination 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 L in large volumetric spaces or open areas; efficacy may be typically achieved in hours to days with less waste and adverse impacts to materials. Sensitive Equipment and Items: Forced or Hot Air ventilation may be used for L and can be used either in-situ or ex-situ to decontaminate these items. CAUTION: Decontamination 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). Dirt, grime and other coatings can reduce the efficacy of decontamination; pre-cleaning surfaces with soap and water may be needed before the application of decontamination formulations but resulting pre-cleaning rinsates may contain and spread agent. Verification of Decontamination: Site and situation specific. Please contact EPA/HQ-EOC at 202-564-3850 for further assistance.						
Waste Management	CAUTION: Federal requirements for transporting hazardous materials and procedures for exemptions are specified in www.fmcsa.dot.gov/safety-security/hazmat/complyhmqrgs.htm#hmp . These regulations differ from state-to-state. Detailed state regulations can be found at www.envcap.org . Current resources on packaging, labeling and shipping are available at www.phmsa.dot.gov/hazmat .						
	Waste Management: Under the Resource Conservation and Recovery Act (RCRA), waste generally is classified as hazardous waste (subtitle C) or solid waste (subtitle D). Under RCRA's statutory authority, a waste is considered hazardous if it: (A) causes or significantly contributes to an increase in mortality or an increase in serious, irreversible or incapacitating reversible illness or (B) poses a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported or disposed of or otherwise managed. The RCRA regulations generally define a waste as hazardous if it is: (1) a listed waste (40 CFR §261.31, §261.32), (2) exhibits specific characteristics (40 CFR §261.21-261.24) or (3) is a discarded commercial chemical product, off-speciation species, container residue, or spill residue thereof (40 CFR §261.33). The States (except for Alaska and Iowa) have the primary responsibility to implement the hazardous waste regulations and can impose more stringent requirements than the Federal program, so it is critical to open a dialogue with regulators as early as possible. Several states (CO, IN, KY, MD, OR, UT) have their own waste designations for CWA, which may be applicable for the cleanup of contaminated residues. L is not a hazardous waste under the Federal regulations, but state codes may apply for L-contaminated residues, soils and debris. Because L contains As, state and local authorities may have specific regulations regarding disposal of As-contaminated wastes. Management of toxic decomposition products, associated residual decontamination solutions, local waste acceptance criteria, and transportation and handling requirements should be considered. The EPA has developed I-WASTE, a web-based tool that contains links to waste transportation guidance, treatment and disposal facilities, state regulatory offices, packaging guidance, and guidance to minimize the potential for contaminating the treatment or disposal facility. Access to this decision support tool requires pre-registration (www2.ergweb.com/bdrtool/login.asp).						