

**Agent Characteristics**

**Agent Classification:** Toxic Industrial Chemical, proposed Chemical Warfare Agent; **CAS:** 7784-42-1; **Formula:** AsH<sub>3</sub>; **Molecular Weight:** 77.95 g/mol.  
**Description:** Arsenic (SA) is a colorless gas which produces no immediate symptoms. It has a garlic odor, but its high odor threshold diminishes this safeguard. SA is typically transported as a liquefied compressed gas, but can be formed by the reaction of arsenic-containing substances with hydrogen in water or acids. Environmental breakdown products of SA include highly toxic arsenic compounds. Decontamination by-products include arsenic (V) compounds, which are generally less toxic than arsenic (III) compounds, but may be considered hazardous. SA is highly flammable, having a wide explosive range, with the Lower Explosive Limit (LEL) = 5.1% and the Upper Explosive Limit (UEL) = 78%. Vapors may travel to the source of ignition and flash back. SA fires will produce irritating, corrosive, and/or toxic gases.

**Persistence:** SA is considered “non-persistent.” Vapor: minutes to hours; liquid: rapidly evaporates at ambient temperatures and pressures. Persistence will depend upon amount and purity of the agent, method of release, environmental conditions, and the types of surfaces and materials impacted.

**Physical Properties**

Physical properties are listed at/near STP unless otherwise indicated. Conversion Factors: ppm = mg/m<sup>3</sup> x 0.3143; mg/m<sup>3</sup> = ppm x 3.182.

<b>Vapor Density:</b> 2.7 (air = 1)	<b>Boiling Point:</b> -80°F/-63°C	<b>Density/Specific Gravity:</b> 3.186 g/L (gas)
<b>Vapor Pressure:</b> 11,000 mm Hg (68°F/20°C)	<b>Freezing Point:</b> -177°F/-116°C	<b>Aqueous Solubility:</b> Slightly soluble
<b>Volatility:</b> 30,900,000 mg/m <sup>3</sup> (32°F/0°C)	<b>Flash Point:</b> decomposes when heated, but is highly flammable; LEL=5.1%, UEL=78%	<b>Non-aqueous Solubility:</b> alcohols, alkalies, chloroform, benzene

**Release Scenarios**

**AIR RELEASE SCENARIOS ARE ASSUMED MOST PROBABLE; HOWEVER, OTHER RELEASE SCENARIOS AND EXPOSURE ROUTES SHOULD BE CONSIDERED.**

**Open Areas:** Due to its volatility, SA is relatively easy to disperse as a gas, and the primary release/attack scenario is an airborne release. SA is expected to degrade by reaction with moisture and encountered surfaces/materials, with toxic arsenic compounds likely formed. SA is reactive, extremely flammable, and may ignite forming toxic arsenic fumes. An unreacted cloud of SA can migrate several miles from the site of release by the wind while maintaining very dangerous concentrations. SA is heavier than air and can accumulate in lower terrains.

**Water/Water Systems:** SA released into or over natural waters or water systems can form arsenic compounds, which may exert toxic effects if present in high concentrations. If a large cloud of SA is released, not all SA may dissolve or react before the SA cloud leaves the vicinity of the water. For water systems, plumbing, surfaces, and equipment that have contacted contaminated water must be evaluated for toxic arsenic compounds along with the bulk water.

**Indoor Facility:** Due to its volatility, SA could potentially be dispersed as a gas inside a building or facility; HVAC systems could be impacted. Explosive vapors can be formed with oxidants. Toxic vapors can be formed as SA decomposes in the presence of heat, moisture, and light. SA is heavier than air and can accumulate in lower levels or utility corridors inside the building.

**Health Effects**

**Onset:** Onset of symptoms is dose and route dependent. Symptoms may occur within 1-24 hours of exposure. Late effects from acute exposure have been reported to occur days to months post exposure.

**Signs/Symptoms:** Appearance and severity of symptoms will vary depending upon exposure route, concentration and duration. However, the following is a general list of possible symptoms.

**Mild to Moderate:** Inhalation: Weakness, headache, drowsiness, disorientation, confusion, chills, rapid breathing, rapid heart rate, nausea, vomiting, abdominal pain, and/or muscle cramps. Some effects may occur days to months post exposure and include hemolytic anemia (fatigue, shortness of breath), red or dark urine, yellow skin and eyes (jaundice), irritation, memory losses, and agitation.

**Severe:** Inhalation: Loss of consciousness, convulsions, paralysis, respiratory failure, acute circulatory failure, possibly leading to death.

**Exposure Routes:**

**Inhalation:** The primary route of SA exposure is in gaseous form. SA is absorbed into the body by inhalation. SA destroys red blood cells and leads to increased levels of hemoglobin and subsequent kidney damage. SA is broken down to different forms of arsenic compounds known to present a cancer hazard.

**Skin:** Absorption into the body through the skin has not been known to occur. Contact with SA as liquefied compressed gas can cause frostbite.

**Eyes:** Absorption into the body through the eyes has not been known to occur.

**Ingestion:** SA is a gas at room temperature, making ingestion an unlikely exposure route.

**Effect Levels**

**Air: Acute Exposure Guideline Levels (AEGLs)** for general population one-time exposure emergency scenarios for SA (complete definitions are available in Key References Cited/Used in NRT Quick Reference Guides for Toxic Industrial Chemicals). It should be noted that AEGL-1 values are not recommended (NR) for SA due to insufficient data.

AEGL Level in ppm, at various exposure durations	10 min.	30 min.	1 hr.	4 hr.	8 hr.
<b>AEGL 1:</b> Threshold mild effects	NR	NR	NR	NR	NR
<b>AEGL 2:</b> Potentially irreversible effects or impaired ability to escape	0.30	0.21	0.17	0.040	0.020
<b>AEGL 3:</b> Threshold for severe effects/medical needs/increasing potential for lethality	0.91	0.63	0.50	0.13	0.060

**Exposure Guidelines**

<b>NIOSH IDLH</b> = 3 ppm	<b>STEL</b> = NA (not available)	<b>Worker Population Limit (WPL)</b> = NA
<b>NIOSH REL</b> = 0.002 mg/m <sup>3</sup> [15-minute ceiling]	<b>OSHA PEL</b> = 0.05 ppm [an 8-hour time-weighted average occupational value]	<b>General Population Limit (GPL)</b> = NA
<b>ACGIH TLV-TWA</b> = 0.005 ppm [an 8-hr time-weighted average occupational value]	<b>RfC</b> = 0.00005 mg/m <sup>3</sup>	<b>Soil: Industrial Exposure Scenario</b> = 3.97 mg/kg
<b>Ingestion Provisional Advisory Levels</b> = NA		<b>Soil: Residential Exposure Scenario</b> = 2.74 mg/kg
<b>Inhalation Provisional Advisory Level (PAL-1)</b> = for general public for 1 day = 0.013; for 30 days = 0.0028 mg/m <sup>3</sup> ; and for 90 days = 0.00048 mg/m <sup>3</sup>		<b>Drinking Water</b> = NA; see values for arsenic

### Personnel Safety

**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](http://www.cdc.gov/niosh/ershdb). We also recommend that responders check their own internal procedures (i.e., SOPs), if applicable.

**Medical: Pre-incident:** Annual physical and respiratory function exam. **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.

**First Aid:** Immediately remove person from affected area and remove contaminated clothing and articles. **Compressed liquid:** Observe and treat for frostbite. 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. **Gas:** Observe and treat for respiratory distress and maintain clear airway, *initial effects may be delayed up to 24 hours*. Administer oxygen if respiratory distress develops. **Antidote: THERE IS NO ANTIDOTE.** Send person for follow-up medical attention and evaluation. If cleared to resume work, continue to monitor for signs/symptoms and treat accordingly.

**Post Incident:** Due to delayed effects, ensure suspected or confirmed exposed persons are aware of symptoms listed in the Health Effects section of this QRG, and to immediately seek medical attention if any of these symptoms occur. Post-incident medical surveillance is highly recommended.

**Personal Protective Equipment (PPE):**

**GENERAL INFORMATION:** NIOSH-certified Chemical, Biological, Radiological, Nuclear (CBRN) Self Contained Breathing Apparatus (SCBA), NIOSH-approved 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 SA 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 SA concentration is unknown or above the IDLH or AEGL-2, and 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 SA 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.

**LEVEL C:** Select Level C when the contaminant identity and concentration are known and 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. **Note: SA has limited inhalation warning properties; use APR/PAPR with caution.**

**LEVEL D:** Select Level D when the contaminant is known and the concentration is below the appropriate occupational exposure limits for the stated duration times. **Note:** AEGL-1 values are not available for SA; therefore, other exposure values such as PEL, REL must be used.

**Downgrading PPE levels can be considered only when the identity and concentration of the contaminant and risks of dermal exposure are known, and must be accompanied by on-site monitoring.**

### 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 or levels 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.

**NOTE: Detection equipment does not measure contaminant levels. Rather, they detect the presence of SA at levels as listed below.**

Minimum Screening Ranges/ Levels for Air	AP4C (as Arsenic)	Honeywell – SPM	Dräger Arsine tube	Dräger CDS Kit (tubes)	Dräger XS/XXS (sensors)	MultiRAE*	ppbRAE*	Screening Levels for Water	HACH (as Arsenic)
ppm	0.15	0.015-0.150	0.05	0.10	0.02	1	0.001		0.005-0.010
mg/m <sup>3</sup>	0.47	0.047-0.47	0.16	0.32	0.06	3.2	0.003		μg/L

\*RAE instruments detect SA with standard photoionization detector (PID) using 10.6 eV lamp; if calibrating with isobutylene, correction factor = 1.9 with PID

### 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. **Because SA is reactive and volatile, field detection instead of laboratory analysis of samples for SA and/or arsenic may suffice and sometimes be necessary to achieve many goals of sampling.** 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](http://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 an SA cloud 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 SA is reactive and generally not persistent, sampling for a variety of arsenic-containing compounds along with SA to help to “clear areas” should be included in the sampling plan.

**Note:** SA is highly volatile and reactive, forming a variety of arsenic breakdown and reaction by-products. Laboratory analysis may need to include these additional breakdown and reaction by-products. See ANALYSIS section below to ensure sampling procedures are compatible with all analytes. Concurrent air monitoring for SA is recommended for all matrices.

**Types of Samples:**

**Air:** On-site SA monitors may provide sufficiently accurate real-time results. For lab analysis, samples are collected using appropriate solid phase absorbent media at breathing zone level (~5 ft.) to assess inhalation exposure and at ground levels (~6 in.) to assess off gassing at surfaces.

**Water:** SA is soluble in aqueous solutions but is expected to diffuse out of the bulk water phase or decompose to arsenical compounds. Arsenic is easy to analyze in the field by colorimetric/titrimetric methods and can be used as a marker for SA contamination.

**Soil:** For localized “hot spot” areas where soil deposition may occur, surface soil samples may be analyzed for SA and arsenic-containing breakdown and reaction by-products and should be taken from a non-vegetated area to a depth of less than one inch.

**Surface Wipes:** Although SA is very volatile, wipe samples are often desired to indicate SA and arsenic-containing breakdown and reaction by-products, on non-porous surfaces.

**Bulk:** Although SA is very volatile, for hot spot areas where liquid SA 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 for SA and any arsenic-containing breakdown and reaction by-products.

**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.

### Analysis

**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](http://www2.epa.gov/emergency-response/environmental-response-laboratory-network)). SA and arsenic-compounds such as total arsenic may be accurately determined in the field using available meters and field kits. For access to the nearest ERLN laboratory specially trained and equipped for analysis of SA and its reaction by-products, contact the EPA/HQ-EOC at 202-564-3850.

### Decontamination/Cleanup

**DO NOT USE WATER DIRECTLY ON LIQUID SA. Use water spray to knock down vapors or to divert vapor cloud drift. Vapor can react explosively with air and oxidizing materials. Prevent wastewater from further contaminating the environment. Avoid use of acids, oxidizers, or heating as they release toxic arsenic fumes.**

SA is so volatile that it will dissipate quickly. As a gas, SA does not persist in the environment. SA gas can be stable for days in air and will only slowly degrade in air by UV light into nonvolatile, oxidized compounds. Moist environments will enhance SA gas decomposition. Most decontamination efforts will not necessarily be for SA itself, but for decomposition by-products such as the toxic arsenic (III) compounds or somewhat less toxic arsenic (V) compounds. Separate, long-term decontamination strategies will need to be developed if those decomposition by-products are of concern in a particular situation. This decontamination/cleanup section refers to the SA itself.

**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:** SA dissipates 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.

**Fix-in-Place Option:** SA dissipates rapidly via natural processes, as such a “Fix-in-Place Option” may not be required or feasible. 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. Solid or liquid SA decomposition residues or wastes may require a separate decontamination evaluation process.

**Decontamination Strategy:** A decontamination strategy can be developed by designating contaminated areas based on presence of: 1) liquid SA, 2) gaseous SA, or 3) aqueous solutions of SA.

**Strategy for Liquid SA:** Do not allow direct contact with water. Actions that promote safe volatilization of liquid SA may be useful since SA in gaseous form can be allowed to dissipate; volatilization may be a slow process depending on site conditions.

**Strategy for Gaseous SA:** Aerate spaces where gaseous SA may be present. Forced air ventilation methods are recommended for SA cloud contamination or low concentration of SA gas in large volumetric spaces or open areas.

**Strategy for Aqueous Solutions of SA:** If SA is present in solution, hydrolysis will occur to produce arsenic compounds. Decontamination may be necessary for those decomposition by-products.

**Sensitive Equipment and Items:** For difficult-to-clean equipment thought to be contaminated with small amounts of SA, additional options for consideration include aeration followed by flushing with water.

**CAUTION:** Decontamination/neutralization products may have unique safety/PPE requirements due to their own toxicity or that of breakdown products during use.

**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/complyhregs.htm#hmp](http://www.fmcsa.dot.gov/safety-security/hazmat/complyhregs.htm#hmp). These regulations differ from state-to-state. Detailed state regulations can be found at [www.envcap.org/](http://www.envcap.org/). Current resources on packaging, labeling and shipping are available at [www.phmsa.dot.gov/hazmat](http://www.phmsa.dot.gov/hazmat).

**Waste Management:** Under the Resource Conservation and Recovery Act (RCRA), solid waste can be classified as hazardous (subtitle C) or non-hazardous (subtitle D). 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-specification species, container residue, or spill residue thereof (40 CFR §261.33). Wastes containing arsenic compounds are likely to be characterized as hazardous due to toxicity, waste code D004 (§261.24). Arsenic-containing waste is approved for land disposal only if the concentration in the waste or treatment residual does not exceed 1.4 mg/L for wastewaters or 5 mg/L by TCLP for non-wastewaters (§268.40). 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. 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](http://www2.ergweb.com/bdrtool/login.asp)).