

**NRT Quick Reference Guide:  
Tabun (GA)**

*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><b>Agent Classification:</b> Schedule 1 Chemical Warfare Nerve Agent CAS: 77-81-6; <b>Formula:</b> C<sub>5</sub>H<sub>11</sub> N<sub>2</sub>O<sub>2</sub>P ; <b>Molecular Weight:</b> 162.13 g/mol  <b>Description:</b> Colorless to brown liquid; generally odorless, though possibly fruity or almond-like. GA is a lethal cholinesterase inhibitor with a mechanism of toxicity similar to organophosphate insecticides, though it is much more potent. GA is less volatile than GB (Sarin), has similar volatility to HD (sulfur mustard), and it is more volatile than the persistent agent VX. Environmental breakdown products of GA, including cyanide compounds, may be present.  <b>Persistence:</b> GA is considered to have moderately low persistence. Vapor: minutes to hours; liquid: hours to days. Persistence will depend upon the amount and purity of agent, method of release, environmental conditions, and the types of surfaces and materials impacted. Porous, permeable, organic or polymeric materials such as carpets &amp; vinyl tiles can act as sinks for absorbing GA vapors &amp; liquids, prolonging persistence.</p>																													
	<p><b>Physical properties are listed at/near STP unless otherwise indicated.</b> Conversion Factors: ppm = mg/m<sup>3</sup> x 0.1508; mg/m<sup>3</sup> = ppm x 6.631  Vapor Pressure: 0.07 mm Hg (68°F/20°C)      Vapor Density: 5.63 (air = 1)      Aqueous Solubility: 73 g/L (68°F/20°C)  Volatility: 610 mg/m<sup>3</sup>      Boiling Point: 446-473°F/230-245°C      Soluble: organic solvents  Freezing Point: -58°F/-50°C      Flash Point: 172°F/78°C      Liquid Density: 1.08 g/ml</p>																													
Release Scenarios	<p><b>AIR RELEASE SCENARIOS ARE ASSUMED MOST PROBABLE; HOWEVER OTHER RELEASE SCENARIOS &amp; EXPOSURE ROUTES SHOULD BE CONSIDERED.</b>  <b>Open Areas:</b> Because GA is so volatile, it is relatively easy to disperse as a vapor and the primary release/attack scenario is an airborne release. GA is expected to degrade in the environment fairly rapidly; however, liquid on surfaces generally persist for hours to days. Environmental conditions will affect the degradation &amp; evaporation rates of GA with cooler &amp; drier conditions enhancing persistence. GA vapors are heavier than air, so vapors can accumulate in lower terrains.  <b>Water/Water Systems:</b> GA is not typically considered a water hazard. If released into natural waters or water systems, GA will likely degrade rapidly (less than 2 days) depending on GA volume and other environmental conditions.  <b>Indoor Facility:</b> Due to its volatility, GA could potentially be dispersed inside a building or facility; HVAC systems could be impacted. GA vapors are heavier than air so vapors can accumulate in lower levels or utility corridors inside the buildings.</p>																													
Health Effects	Onset	Symptoms and onset are dose and route dependent and may occur within seconds after exposure to vapors and within minutes or hours from exposure to liquid forms. Even relatively low dose exposure to GA can be fatal, although immediate administration of an antidote can be lifesaving (see First Aid below).																												
	Signs/ Symptoms	<p><b>Information below is exposure route specific. Regardless of route the following range of effects may occur depending on dose.</b>  <b>Mild:</b> Runny nose, reduction in pupil size (miosis), dimness of vision, tightness of chest, difficult breathing.  <b>Moderate:</b> Increased miosis (to level of pinpointing of pupils), headaches, confusion, drowsiness, nasal congestion, tightness of chest, nausea, vomiting, diarrhea, cramps, generalized weakness, twitching of large muscle groups.  <b>Severe:</b> Involuntary defecation and urination, drooling, twitching, staggering, convulsions, cessation of breathing, loss of consciousness, coma, and death.</p>																												
	Exposure Routes	<p><b>Inhalation:</b> A primary exposure route; inhalation of very small concentrations can produce health effects.  <b>Skin:</b> Especially toxic from contact with liquid agent. Moderate to severe signs/symptoms occur at but are NOT limited to the site of contact. Exposure can also result from absorption of vapors via skin.  <b>Eyes:</b> Eyes are the most sensitive target organs of nerve agent exposure: miosis (reduction in pupil size) will typically be the first sign of exposure. Eyes are particularly sensitive receptors and can act as an indicator to the presence of GA.  <b>Ingestion:</b> Nausea, vomiting, diarrhea, abdominal pain, and cramping. Contamination of foods is the most likely route for ingestion of agent.  <b>Other:</b> Females appear to be more susceptible to nerve agent effects. Certain genetic traits may increase susceptibility.</p>																												
Effect Levels	<p><b>Air: Acute Exposure Guideline Levels (AEGs)</b> for general population one-time exposure emergency scenarios for GA (complete definitions are available in Key References Cited/Used* in NRT Quick Reference Guides for Chemical Warfare Agents):</p> <table border="1"> <thead> <tr> <th>AEGL Level in mg/m<sup>3</sup>, 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>0.0069</td> <td>0.0040</td> <td>0.0028</td> <td>0.0014</td> <td>0.0010</td> </tr> <tr> <td>AEGL 2: potentially irreversible effects or impaired ability to escape</td> <td>0.087</td> <td>0.050</td> <td>0.035</td> <td>0.017</td> <td>0.013</td> </tr> <tr> <td>AEGL 3: threshold for severe effects/medical needs/increasing potential for lethality</td> <td>0.76</td> <td>0.38</td> <td>0.26</td> <td>0.14</td> <td>0.10</td> </tr> </tbody> </table> <p><b>Exposure Guidelines:</b> IDLH = 0.1 mg/m<sup>3</sup>; STEL = 1.0 x 10<sup>-4</sup> mg/m<sup>3</sup>; <b>Worker Population Limit (WPL)</b> [an 8-hour time-weighted average occupational value] = 3.0 x 10<sup>-5</sup> mg/m<sup>3</sup>. <b>General Population Limit (GPL)</b> [a 24-hour time weighted average] = 1.0 x 10<sup>-6</sup> mg/m<sup>3</sup>. <b>Soil: Industrial Exposure Scenario</b> = 68 mg/kg; <b>Residential Exposure Scenario</b> = 2.8 mg/kg. <b>Drinking Water:</b> Army field standard at 15L/day, for 7 days = 4 µg/L; Provisional Advisory Levels (PAL-1) for general public at 2L/day, for 1, 30, and 90 days = 74, 16 and 4 µg/L, respectively.</p>						AEGL Level in mg/m <sup>3</sup> , at exposure duration →	10 min.	30 min.	1 hr.	4 hr.	8 hr.	AEGL 1: threshold mild effects	0.0069	0.0040	0.0028	0.0014	0.0010	AEGL 2: potentially irreversible effects or impaired ability to escape	0.087	0.050	0.035	0.017	0.013	AEGL 3: threshold for severe effects/medical needs/increasing potential for lethality	0.76	0.38	0.26	0.14	0.10
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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: <a href="http://www.cdc.gov/niosh/ershdb">www.cdc.gov/niosh/ershdb</a> . We also recommend that responders check their own internal procedures (SOPs) if they have them.																													
Medical	<b>Pre-incident:</b> Annual physical, respiratory function exams and a baseline cholinesterase activity. <b>During Incident:</b> 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.																													
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. <b>Antidote: Atropine, 2-PAM Chloride injections (Duo Dote/Mark II kits). Antidote kit should only be administered as per pre-incident training.</b> Send person for follow up medical attention and evaluation. If cleared to resume work, continue to monitor for signs/symptoms & treat accordingly.																													
PPE	<p><b>GENERAL INFORMATION:</b> 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, &amp; protective clothing should be used. Pre-incident training &amp; exercises on the proper use of PPE is recommended. Per NIOSH guidance - <b>LEVEL A:</b> Recommended for the initial response to a GA incident. Level A provides the greatest level of skin (fully encapsulating suit), respiratory (SCBA), &amp; eye protection when the contaminant identity or concentration is unknown. Select Level A when the GA concentration is unknown or above the IDLH or AEGL-2, &amp; when there is a potential of ocular or dermal exposure. <b>LEVEL B:</b> Provides the highest level of respiratory protection (SCBA) when a lesser level of skin protection is required. Select Level B when the GA concentration is unknown or above the IDLH or AEGL-2 &amp; 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. <b>LEVEL C:</b> Select Level C when the contaminant identity &amp; concentration are known &amp; the respiratory protection criteria factors for the use of APR or PAPR (i.e.: &lt; IDLH, warning properties) are met. Level C may be appropriate when decontaminating personnel or equipment. <b>LEVEL D:</b> Select Level D when the contaminant is known &amp; the concentration is below the appropriate occupational exposure limit or less than AEGL-1 for the stated duration times. <b>Downgrading PPE levels can be considered only when the identity &amp; concentration of the contaminant &amp; the risks of dermal exposure are known, &amp; must be accompanied by on-site monitoring.</b></p>																													
Field Detection	<p>Real-time field screening tools (results not confirmatory or quantitative): Caution should be given to equipment that has not been properly evaluated. False positive &amp; false negatives may occur in the presence of interferents 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 &amp; responders; some with similar capabilities &amp; limitations.</p>																													
	<b>NOTE: Detection equipment does not measure contaminant levels. Rather they detect the presence of a nerve agent at levels as low as listed below.</b>																													
	Minimum Screening Levels	CAM/CAM	AP2C/AP4C	APD-2000	Dräger	M256	M272 (water)																							
ppm	0.015	0.0015	0.015	0.025	0.0008	0.02 mg/L																								
mg/m <sup>3</sup>	0.1	0.01	0.27	0.17	0.005	N/A																								

Sampling	<p><b>Note:</b> This section on sampling contains general guidelines &amp; does not replace the need for a site-specific sampling plan. See reference list for specifics.</p> <p><b>Sampling Concerns:</b> Detection, sampling equipment &amp; procedures, &amp; analytical techniques will be highly site-specific &amp; 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 &amp; clearance); &amp; 4) specific laboratory requirements. Few laboratories currently have capability to determine GA, particularly for large numbers of samples &amp; 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</p>
	<p><b>Sample Locations &amp; Planning:</b> Initially consider air sampling to ensure worker safety &amp; 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, &amp; 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 GA is generally not persistent, air sampling to "clear areas" should be included in the sampling plan.</p>
	<p><b>Note:</b> GA breaks down in most environmental conditions to numerous breakdown products, especially cyanide compounds, which may be used as a marker to determine the extent of contamination of the parent GA. See ANALYSIS section below to ensure sampling procedures are compatible with all analytes.</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; G-agents are unlikely to persist in water.</p> <p><b>Soil:</b> 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.</p> <p><b>Surface Wipes:</b> Wipe samples are often desired to indicate absence of G-agents on non-porous surfaces. Concurrent air monitoring is recommended.</p> <p><b>Bulk:</b> For hot spot areas where liquid G-agent 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 GA into these materials.</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>
Anal- ysis	<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 laboratory specially trained and equipped for in GA analysis, contact the EPA/HQ-EOC at 202-564-3850.</p>
Decontamination/Cleanup	<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 than to decon and restore.</p> <p><b>Monitored Natural Attenuation:</b> GA is likely 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.</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 the overall site specific decon strategy. <b>All statements about decontamination efficacy are based upon GB and have not been verified for GA. Because hydrolysis has been identified as a major degradation pathway for both GA and GB and because the hydrolysis rate of GA is around 5 times that of GB, the limited data available for GA suggest at least equal or perhaps greater efficacy.</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. Decontamination of GA occurs mainly through hydrolysis, which may be catalyzed (sped up), by hypochlorites. 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) may be very effective for GA with efficacy expected to be achieved with contact time of 15-60 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. 2) Hydroxide (e.g. sodium, potassium – 10 % solution) is expected to react rapidly with GA but solutions are very damaging to many surfaces and should be rinsed thoroughly after use. 3) Other high pH solutions, such as sodium carbonate (10% solution), are expected to decon GA but slower than decon with sodium or potassium hydroxide.</p> <p><b>Large Volumetric Spaces:</b> 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 or Hot Air ventilation methods are recommended for vapor plume contamination or low concentration of GA in large volumetric spaces or open areas; efficacy may be typically achieved in hours to days with less waste and adverse impacts to materials.</p> <p><b>Sensitive Equipment and Items:</b> Forced or Hot Air ventilation may be used for GA and can be used either in-situ or ex-situ to decon these items.</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). Proprietary decon foams and gels such as DF-200®, CASCAD®, Decon Green®, or L-Gel® may be effective against GA, but not all have been thoroughly tested. 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.</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/complyhmr.htm#hmp">http://www.fmcsa.dot.gov/safety-security/hazmat/complyhmr.htm#hmp</a>. GA 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>