Cyclosarin (GF)

**Cyclosarin (GF)**

**Drinking Water:**
- Real
- Medical

**Medical Symptoms**

- Mild: Headache, nausea, vomiting, diarrhea, cramps, generalized weakness, twitching of large muscle groups.
- Moderate: Involuntary defecation and urination, drooling, twitching, staggering, convulsions, cessation of breathing, loss of consciousness, coma, death.
- Severe: Involuntary defecation and urination, drooling, twitching, staggering, convulsions, cessation of breathing, loss of consciousness, coma, death.

**Signs/Symptoms**

- Onset: Runny nose, reduction in pupil size, miosis, diminuendo of vision, tightness of chest, difficulty in breathing.
- Moderate: Increased miosis (to level of pinpointing of pupils), headache, confusion, drowsiness, nasal congestion, tightness of chest, nausea, vomiting, diarrhea, cramps, generalized weakness, twitching of large muscle groups.
- Severe: Involuntary defecation and urination, drooling, twitching, staggering, convulsions, cessation of breathing, loss of consciousness, coma, death.

**Air Release Scenarios** are assumed most probable; however, other release scenarios and exposure routes to be considered are:

- **Open Areas:** GF has low volatility but may still be present as a vapor or aerosol, and the primary release/attack scenario is an airborne release. GF is expected to degrade in the environment fairly rapidly; however, liquid GF on surfaces generally persists for hours to days. Environmental conditions will affect the degradation and evaporation rates of GF with cooler and drier conditions enhancing persistence. GF vapors are heavier than air, so vapors can accumulate in lower areas.

- **Water/Water Systems:** GF is not typically considered a water release hazard. If released into natural waters or water systems, GF will likely hydrolyze with a half-life estimated at 19 hours at pH 7, with persistence depending on released amount and environmental conditions.

**Indoor Facilities:** GF could potentially be dispersed as a vapor or aerosol inside a building or facility; HVAC systems could be impacted. GF vapors are heavier than air so vapors can accumulate in lower areas or utility corridors inside the buildings.

**Health Effects**

**Personal Protective Equipment (PPE) selection (levels A-D):**

- 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 B: follows a general list of all possible symptoms. The severity of effects depends upon the dosage.
- Level C: should only be administered as per pre-incident training. Send person for follow-up medical attention and evaluation. If resume to work, continue to monitor for signs/symptoms and treat accordingly.

- Level D: in vapor form.

**Effect Levels**

**Air:**

- **Acute Exposure Guideline Levels (AEGLs) for general population one-time emergency scenarios for GF** (complete definitions are available in Key References Cited/Used in NRT Quick Reference Guides for Chemical Warfare Agents):

<table>
<thead>
<tr>
<th>AEGL 1</th>
<th>AEGL 2</th>
<th>AEGL 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Threshold mild effects</td>
<td>Threshold potentially reversible effects/irreversible potential to escape</td>
<td>Threshold for severe effects/mnopotential for lethality</td>
</tr>
<tr>
<td>0.0035</td>
<td>0.044</td>
<td>0.38</td>
</tr>
<tr>
<td>0.0020</td>
<td>0.025</td>
<td>0.19</td>
</tr>
<tr>
<td>0.0014</td>
<td>0.018</td>
<td>0.013</td>
</tr>
<tr>
<td>0.00070</td>
<td>0.0085</td>
<td>0.070</td>
</tr>
<tr>
<td>0.0050</td>
<td>0.0065</td>
<td>0.061</td>
</tr>
</tbody>
</table>

**Drinking Water:**

- Provisional Advisory Levels (PAL-1) for general public at 2 L/day, for 1, 30, and 90 days = 7.4, 1.6, and 0.44 mg/L, respectively.

**Personnel Safety**

**GREAT 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. Recommended training and exercises on the proper use of PPE are recommended. Per NIOSH guidance - LEVEL A: Recommended for the initial response to a GF 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 GF 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 GF 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 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 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. LEVEL D: Select Level D when the contaminant is known and 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 and concentration of the contaminant and the risks of dermal exposure are known, and must be accompanied by on-site monitoring.

**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.

**Field Detection**

**NOTE:** Detection equipment may not measure contaminant levels. Rather, they detect the presence of a nerve agent at levels as listed below.

<table>
<thead>
<tr>
<th>Minimum Screening Ranges</th>
<th>CAMICAN</th>
<th>AP2CA/AP4C</th>
<th>APD-2000</th>
<th>Dräger (CDS Kit)</th>
<th>M256/M256A1</th>
<th>M272 (water)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ppm</td>
<td>0.014-0.02</td>
<td>0.0015-0.0017</td>
<td>0.015</td>
<td>0.025</td>
<td>0.002-0.009</td>
<td>0.02 mg/L</td>
</tr>
<tr>
<td>mg/mL</td>
<td>0.03-0.1</td>
<td>0.01-0.03</td>
<td>0.1-0.11</td>
<td>0.18</td>
<td>0.005-0.007</td>
<td>NA</td>
</tr>
</tbody>
</table>

Updated January 2015 (replaced previous version dated 2011)
Sampling: Collection of environmental samples includes solid, liquid, and gaseous matrices for chemical analysis. Air and water samples are collected using appropriate solid phase absorbent (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. Water should be collected in appropriate containers with adequate information about the water source and characteristics.

Decontamination/Cleanup Planning: Once site conditions 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-EQC at 202-564-3850 for more information.

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 decontamination.

Decontamination Strategy: Decontamination strategy should be based on the type and level of contamination, the type of equipment, and the surface to be treated. For example, if the surface is non-porous, a specific decontamination strategy may be needed. All statements about decontamination efficacy are based upon GB and have not been verified for GF. However, because hydrolysis has been identified as a major degradation pathway for both GF and GB and because reports of hydrolysis rates for GF are similar to GB, the limited data available suggest similar efficacy for GF as GB.

Large Volumes Spaces: This category is for large areas in size but with lower levels of agent contamination. They may require less aggressive decontamination products and methods. Decontamination of GF occurs mainly through hydrolysis, which may be catalyzed (sped up) by hypochlorites. 1) Hypochlorite Solutions: Hypochlorite can be very corrosive to certain surfaces and materials and should be rinsed thoroughly afterwards. Household bleach solutions (≥5% sodium hypochlorite) may be very effective for GF 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 quickly with GF, but solutions are very damaging to porous surfaces and should be used as directed and contaminant containment measures (e.g., access restriction and decontamination of areas nearby). 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: The contaminated area may be resistant to decontamination processes 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.

Vapor/Water Spills: Spilled or discarded commercial chemical product (§261.33). The States (except for Alaska and Iowa) have the primary responsibility to implement the hazardous waste regulations. 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. For access to the nearest ERLN laboratory specially trained and equipped for GF analysis, contact the EPA/HQ-EQC at 202-564-3850 for sampling instructions.

CAUTION: Decontamination/cleanup planning must 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. Wasteland disposal and handling 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.

Decontamination Strategy: A decontamination 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 decontamination processes in a tiered approach to the overall site-specific decontamination strategy. All statements about decontamination efficacy are based upon GB and have not been verified for GF. However, because hydrolysis has been identified as a major degradation pathway for both GF and GB and because reports of hydrolysis rates for GF are similar to GB, the limited data available suggest similar efficacy for GF as GB.

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. Decontamination of GF occurs mainly through hydrolysis, which may be catalyzed (sped up) by hypochlorites. 1) Hypochlorite Solutions: Hypochlorite can be very corrosive to certain surfaces and materials and should be rinsed thoroughly afterwards. Household bleach solutions (≥5% sodium hypochlorite) may be very effective for GF 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 quickly with GF, but solutions are very damaging to porous surfaces and should be used as directed and contaminant containment measures (e.g., access restriction and decontamination of areas nearby). 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: The contaminated area may be resistant to decontamination processes 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.

Large Volumes Spaces: This category is for large areas in size but with lower levels of agent contamination. They may require less aggressive 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 GF in large volumetric spaces or open areas; efficacy may be typically achieved in hours to days with less waste and adverse impacts to materials. Sensitivity can be influenced by other conditions: Forced or Hot Air ventilation may be used for GF 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-EQC at 202-564-3850 for further assistance.

Waste Management: Under the Resource Conservation and Recovery Act (RCRA), waste generally is classified as hazardous waste (subtle C) or solid waste (subtle D). Under RCRA’s statutory authority, a waste is considered hazardous if: (A) it 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 §261.21, §261.32), (2) exhibits specific characteristics (§261.21-261.24) or (3) is spilled or discarded commercial chemical product (§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. GF is not a hazardous waste under the Federal regulations, but state codes for contaminated materials may be applicable. 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/bdtool/login.asp).