

Agent Characteristics

Agent Classification: Toxic Industrial Chemical, Schedule 3 Chemical Warfare Agent; **CAS:** 75-44-5; **Formula:** CCl_2O ; **Molecular Weight:** 98.92 g/mol.
Description: Phosgene (CG) is a colorless gas above boiling point. Fog-like when concentrated. CG is a colorless, fuming liquid below boiling point. May have the appearance of a white cloud. When refrigerated or compressed, CG is a light yellow liquid. CG is shipped as a liquefied compressed gas. Depending on concentration, odor is of new mown hay or fresh corn, or suffocating and unpleasant; however, olfactory fatigue onsets rapidly, diminishing this safeguard. CG causes lung damage when it reacts with water in the lungs to form corrosive hydrochloric acid (HCl). CG will also react with environmental moisture to form HCl and carbon dioxide (CO_2). CG can be formed during the combustion of certain plastics materials (i.e., PVC) or other chlorinated organic compounds.
Persistence: CG 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. The HCl produced when CG reacts with water will corrode many materials resulting in damage that greatly shortens their usable life (e.g., reduction of metal corrosion resistance).

Physical Properties

Physical properties are listed at/near STP unless otherwise indicated. Conversion Factors: ppm = $\text{mg}/\text{m}^3 \times 0.2477$; $\text{mg}/\text{m}^3 = \text{ppm} \times 4.038$. NA = not applicable.		
Vapor Density: 3.48 (air = 1)	Boiling Point: 47°F/8.2°C	Liquid Density: 1.43 g/ml (108°F/40°C) Vapor above 47°F/8.2°C
Vapor Pressure: 1,215 mm Hg (68°F/20°C)	Freezing Point: -180°F / -118°C	Aqueous Solubility: reacts with H_2O , alcohols, and ammonia
Volatility: 4,300,000 mg/m^3 (46°F/7.6°C)	Flash Point: NA, not combustible	Non-aqueous Solubility: most hydrocarbons, chloroform, carbon tetrachloride

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, CG is relatively easy to disperse as a gas, and the primary release/attack scenario is an airborne release. CG is expected to disperse or to degrade by reaction with encountered surfaces/materials. However, an unreacted cloud of CG can migrate several miles from the site of release by the wind while maintaining very dangerous concentrations. CG is heavier than air and can accumulate in lower terrains. CG decomposes in the presence of moisture to HCl and CO_2 .

Water/Water Systems: CG released into or over natural waters or water systems can decompose to form HCl, which is corrosive and may exert toxic effects if present in high concentration. If a large cloud of CG is released, not all CG may dissolve before the CG cloud leaves the vicinity of the water.

Indoor Facility: Due to its volatility, CG could potentially be dispersed as a gas inside a building; HVAC systems could be impacted. Corrosive vapors can be formed as CG decomposes in the presence of moisture. CG is heavier than air and can accumulate in lower levels or utility corridors inside the building.

Other: CG can be formed during the combustion of chlorinated building materials and other chlorinated organic compounds.

Health Effects

Onset: Onset of symptoms is dose and route dependent. Following CG exposure, victim may be free of symptoms for 30 minutes to 72 hours before respiratory damage becomes evident; the more severe the exposure, the shorter the latency. Physical exertion may shorten the symptom-free period. Victims inhaling low concentrations of CG gas may experience no irritation or only mild irritation of the upper airway, allowing them to inhale CG gas more deeply into the lungs for prolonged periods. Victims inhaling initial high concentrations of CG gas may experience rapid onset of direct toxicity (see Signs/ Symptoms below).

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. CG may have latency period anywhere from 30 minutes to 72 hours, depending upon the level of exposure.

Mild: No adverse health effects or mild upper airway irritation; effects may improve when the victim is removed from exposure. More severe adverse health effects are possible after a delay period. Severe damage to lower airways and lungs can occur even while upper airway irritation is mild.

Moderate: After a symptom-free interval (latency period), irritation of the upper airway, dryness and burning of the throat, painful cough, choking, sense of chest discomfort, difficulty breathing, spasmodic narrowing of the large airways, and possible nausea and vomiting.

Severe: Rapid accumulation of fluid in the lungs (pulmonary edema); shallow rapid respirations; severe, painful coughing fits producing frothy liquid; possible upper airway closure that may result in sudden death. Shock, difficulty breathing, cardiovascular collapse due to low blood oxygen, low blood pressure secondary to pulmonary edema.

Exposure Routes:

Inhalation: The primary route of CG exposure is in gaseous form. Vapor exposure is absorbed in mucous membranes (mouth, throat, and lungs).

Skin: Direct contact with moist skin may cause irritation and redness. Contact with CG as liquefied compressed gas can cause frostbite and severe skin burns.

Eyes: High concentrations can cause tearing, accumulation of blood, corneal inflammation and opacity.

Ingestion: CG 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 CG (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 CG due to insufficient data.

AEGL Level in ppm, at various exposure durations	10 min.	30 min.	1 hr.	4 hr.	8 hr.
AEGL 1: Threshold mild effects	NR	NR	NR	NR	NR
AEGL 2: Potentially irreversible effects or impaired ability to escape	0.60	0.60	0.30	0.080	0.040
AEGL 3: Threshold for severe effects/medical needs/increasing potential for lethality	3.6	1.5	0.75	0.20	0.090

Exposure Guidelines

NIOSH IDLH = 2 ppm	STEL = 0.2 ppm	Worker Population Limit (WPL) = 0.4 mg/m^3
NIOSH REL = 0.1 ppm TWA, 0.2 ppm [15-minute ceiling]	OSHA PEL = 0.1 ppm [an 8-hour time-weighted average occupational value]	General Population Limit (GPL) = 0.0025 mg/m^3
ACGIH TLV-TWA = 0.1 ppm [an 8-hr time-weighted average occupational value]	RFI = 0.0004 mg/m^3	Soil: Industrial Exposure Scenario = 1.4 mg/kg
Ingestion Provisional Advisory Levels = none recommended for oral exposures		Soil: Residential Exposure Scenario = 0.33 mg/kg
Inhalation Provisional Advisory Level (PAL-1) = for general public for one day = 0.0017 ppm; for 30, 90 days and 2 years = 0.0006 ppm		Drinking Water: none (decomposes to HCl and CO_2 in water)

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. 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. Keep the affected person warm and at rest.

Compressed liquid: Observe and treat for frostbite and chemical burns. 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, *effects may be delayed from 30 minutes up to 72 hours*. Administer oxygen if respiratory distress develops. **Antidote: THERE IS NO ANTIDOTE.** In cases of ingestion, do not induce vomiting or drink fluids. 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 up to 24 hours, or even a few days, particularly in low CG exposures, ensure suspected or confirmed exposed persons are aware of symptoms of CG exposure and to immediately seek medical attention if 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 a CG 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 CG 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 CG 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:** CG may have limited inhalation warning properties due to olfactory fatigue; in addition, the odor threshold for CG is 0.4 ppm, 4 times greater than OSHA PEL, providing insufficient warning of hazardous concentrations. CG symptoms can be delayed due a latency period of 0.5-72 hours, which may result in a greater potential for exposures.

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 CG; 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. Note: CG decomposes in the presence of moisture to form HCl, which will present a contact hazard to exposed skin as well as inhalation hazard; monitoring for CG along with HCl or pH may be required.

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. **CAUTION: CG reacts with water and moisture in air to form HCl; monitoring for HCl and changes in pH as well as CG is therefore recommended.**

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

Minimum Screening Ranges/ Levels for Air	Miran SapphIRe	Honeywell – SPM	Dräger CDS Kit (tubes)	Dräger XS/XXS (sensors)	MultiRAE	TVA 1000B	Screening Levels for Water	pH meter / pH paper	Colorimetric field test kits
ppm	0.5	0.011	0.02	0.01	0.02	0.5		pH range	pH range
mg/m ³	2	0.044	0.08	0.04	0.08	2		1-14	1-14

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 CG is reactive and volatile, field detection instead of laboratory analysis of samples 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). For sampling questions, call 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 CG 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 CG is reactive and generally not persistent, sampling for CG and HCl (air), and pH (surfaces, water, and soil) determination to help to “clear areas” should be included in the sampling plan.

Note: CG is highly reactive, so reaction by-products, mainly HCl and organochlorine reaction by-products, may be detected in the field and used as markers to determine the extent of contamination of the parent CG. Laboratory analysis will be necessary for organochlorine reaction by-products. See ANALYSIS section below to ensure sampling procedures are compatible with all analytes.

Types of Samples:

Air: On-site CG 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. Concurrent air monitoring is recommended for CG and HCl.

Water: Dissolved CG decomposes to form HCl which may not be easily analyzed in the field. Measuring the pH of the water may be sufficient. Concurrent air monitoring is recommended for CG and HCl.

Soil: For localized “hot spot” areas where soil deposition may occur, surface soil samples may be analyzed for pH and organochlorine reaction by-products and should be taken from a non-vegetated area to a depth of less than one inch. Measuring the pH of the soils may be sufficient. Concurrent air monitoring is recommended for CG and HCl.

Surface Wipes: Wipe samples are often desired to indicate CG and breakdown products, mainly HCl and organochlorine reaction by-products, on non-porous surfaces. Measuring the pH of collected wipes may be sufficient. Concurrent air monitoring is recommended for CG and HCl.

Bulk: For hot spot areas where liquid CG 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 CG and any organochlorine reaction by-products. Measuring the pH of bulk samples may be sufficient. Concurrent air monitoring is recommended for CG and HCl.

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). Reactive compounds such as CG and HCl 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 CG and its reaction by-products, contact the EPA/HQ-EOC at 202-564-3850.

Decontamination/Cleanup

DO NOT USE WATER DIRECTLY ON LIQUID CG. Use water spray to knock down vapors or to divert vapor cloud drift. If using water spray, plan for HCl formation. pH adjustment of spillages and decontamination runoff may be necessary before discharge to receiving waters and wastewater systems. Avoid allowing water runoff to contact liquid CG.

CG is so volatile and reactive that it will either dissipate and/or be consumed by reaction with moisture it encounters. Hence, most decon will not necessarily be for the CG itself, but for reaction by-products, such as HCl, most of which have lower toxicity. Separate, long-term decon strategies will need to be developed if those by-products are of concern in a particular situation. This decontamination/cleanup section refers to the CG itself.

Decontamination/Cleanup Planning: Once site controls are in place, develop a site-specific decon/cleanup plan. Decon 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 decon 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 decon 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 decon 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 decon formulations, or may be cheaper to discard and replace than to decontaminate and restore.

Monitored Natural Attenuation: CG dissipates 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 non-destructive to materials.

Fix-in-Place Option: CG 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 CG decomposition residues or wastes may require a separate decon evaluation process.

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

Strategy for Liquid CG: Do not allow direct contact with water. Actions that promote safe volatilization of liquid CG may be useful since CG in gaseous form is easier to decontaminate or allow to dissipate; volatilization may be a slow process depending on site conditions. Liquid can be covered with sodium hydrogen carbonate or equal mixture of soda ash and slaked lime or crystallized urea. After mixing, spray carefully with water and transfer to a larger volume of water.

Strategy for Gaseous CG: Aerate spaces where gaseous CG may be present. Hydrolysis of CG results in HCl which is highly corrosive. Impact on materials should be assessed for mitigation efforts. Mechanical, electrolytic, or chemical cleaning of corroded products may be needed. Forced or Hot Air ventilation methods are recommended for CG cloud contamination or low concentration of CG in large volumetric spaces or open areas.

Strategy for Aqueous Solutions of CG: If CG is present in solution, it will completely decompose in a matter of minutes, if sufficient water is present. Decon may be necessary for HCl.

Sensitive Equipment and Items: For difficult-to-clean equipment thought to be contaminated with small amounts of CG, additional options for consideration include dissipation with monitored natural attenuation or flushing with water or mild to moderate alkaline solutions.

CAUTION: Decon/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. 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), 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). Phosgene (carbonic dichloride) is listed under RCRA chemical code P095 for discarded commercial chemical products (40 CFR §261.33). Compressed gas cylinders of phosgene and other phosgene waste can also be reactive hazardous waste, chemical code D003, if it generates toxic gases when mixed with water (40 CFR §261.23). 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).