

# NRT Quick Reference Guide: Phosgene (CG)

For References, Please See: Key References Cited/Used\* in National Response Team (NRT) Quick Reference Guides (QRGs) for Toxic Industrial Chemicals. QRGs are intended for Federal OSC/RPMs

Agent Characteristics	<b>Agent Classification:</b> Toxic Industrial Chemical, Schedule 3 Chemical Warfare Agent <b>CAS:</b> 75-44-5; <b>Formula:</b> CCl <sub>2</sub> O; <b>Molecular Weight:</b> 98.92 g/mol <b>Description:</b> Colorless gas above boiling point; fuming, colorless liquid below. CG is shipped as compressed gas. Depending on concentration, odor is of new mown hay, fresh corn, or 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 <sub>2</sub> ) <b>Persistence:</b> CG is considered "non-persistent". Vapor: minutes-hours; liquid: rapidly evaporates at ambient temperatures and pressures. Persistence will depend upon the amount & purity of the agent, method of release, environmental conditions & the types of surfaces & materials impacted. The HCl produced when CG reacts with water will corrode many materials resulting in damage which greatly shortens their usable life (e.g. reduction of metal corrosion resistance).							
	<b>Physical properties are listed at/near STP unless otherwise indicated.</b> Conversion Factors: ppm = mg/m <sup>3</sup> x 0.2477; mg/m <sup>3</sup> = ppm x 4.038 <b>Vapor Pressure:</b> 1,215 mm Hg (68°F/20°C) <b>Vapor Density:</b> 3.48 (air = 1) <b>Aqueous Solubility:</b> reacts with H <sub>2</sub> O, alcohols, and ammonia <b>Volatility:</b> 4,300,000 mg/m <sup>3</sup> (46°F/7.6°C) <b>Boiling Point:</b> 47°F/8.2°C <b>Soluble:</b> most hydrocarbons, chloroform, carbon tetrachloride <b>Freezing Point:</b> -180°F/-118°C <b>Flash Point:</b> not flammable <b>Liquid Density:</b> 1.43 g/ml (108°F/40°C)							
Release Scenarios	<b>AIR RELEASE SCENARIOS ARE ASSUMED MOST PROBABLE; HOWEVER OTHER RELEASE SCENARIOS &amp; EXPOSURE ROUTES SHOULD BE CONSIDERED.</b> <b>Open Areas:</b> 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. However, unreacted CG clouds can migrate several miles from the release site 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 <sub>2</sub> . <b>Liquid CG can easily volatilize at ambient temperatures.</b> <b>Water/Water Systems:</b> CG is not typically considered a water hazard. When CG is released into water, it decomposes to form HCl which may exert toxic effects if present in high concentration. If a large cloud of CG is released, not all CG may dissolve before the cloud leaves the vicinity of the water. <b>Indoor Facility:</b> Due to its volatility, CG could potentially be dispersed as a gas inside a building or facility; 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.							
Health Effects	Onset	Following phosgene exposure, victim may be free of symptoms for 30 min to 48 hours before respiratory damage becomes evident; the more severe the exposure, the shorter the latency. Victims inhaling low concentrations of phosgene gas may experience no irritation or only mild irritation of the upper airway. Lack of irritation allows victims to inhale the gas more deeply into the lungs for prolonged periods. If the initial concentration of inhaled phosgene is high, rapid onset of direct toxicity may ensue, resulting in massive hemolysis and pulmonary edema.						
	Signs/ Symptoms	<b>Odor threshold is 5 times greater than OSHA PEL. Thus, odor provides insufficient warning of hazardous concentrations. Phosgene's irritating quality can be mild and delayed, which may result in lack of avoidance leading to greater exposures. The odor threshold for phosgene is about 0.5 to 1 ppm. This level will vary with the individual and is usually higher following exposure because of olfactory fatigue.</b> <b>Mild:</b> 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. <b>Moderate:</b> 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. <b>Severe:</b> Rapid accumulation of fluid in the lungs; shallow rapid respirations; severe, painful coughing fits producing frothy liquid; possible upper airway closure that may result in sudden death. Difficulty breathing, cardiovascular collapse due to low blood oxygen, low blood pressure secondary to fluid in the lungs (pulmonary edema).						
	Exposure Routes	<b>Inhalation:</b> Vapor exposure is absorbed in mucous membranes (mouth, throat, & lungs). <b>Skin:</b> Direct contact with moist skin may cause irritation and redness. High concentrations can cause frostbite and corrosion. <b>Eyes:</b> High concentrations can cause tearing, accumulation of blood, corneal inflammation and opacity. <b>Ingestion:</b> Ingestion unlikely because phosgene is gas at room temperature.						
Effect Levels	<b>Air: Acute Exposure Guideline Levels (AEGs)</b> for general population one-time exposure emergency scenarios for phosgene (complete definitions are available in Key References Cited/Used* in NRT Quick Reference Guides for Chemical Warfare Agents). It should be noted that AEGL-1 values are not recommended (NR) for phosgene. Odor cannot be used as a warning of potential exposure.							
	<b>AEGL Level in mg/m<sup>3</sup>, at exposure duration →</b>		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		0.60	0.60	0.30	0.080	0.040	
		<b>AEGL 3:</b> threshold for severe effects/medical needs/increasing potential for lethality		3.6	1.5	0.75	.020	0.090
<b>Exposure Guidelines:</b> IDLH = 8.1 mg/m <sup>3</sup> ; STEL = 0.8 mg/m <sup>3</sup> ; OSHA PEL [an 8-hour time-weighted average occupational value] = 0.4 mg/m <sup>3</sup> ; <b>Worker Population Limit (WPL)</b> = none; <b>General Population Limit (GPL)</b> = none; <b>RfC</b> = 0.0004 mg/m <sup>3</sup> . <b>Soil: Industrial Exposure Scenario</b> = 1.4 mg/kg; <b>Residential Exposure Scenario</b> = 0.33 mg/kg; <b>Drinking Water:</b> none; <b>Provisional Advisory Levels</b> = none recommended for oral exposures.								
Personnel Safety	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>						
	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: NO ANTIDOTE IS AVAILABLE.</b> Send person for follow up medical attention and evaluation. If cleared to resume work, continue to monitor for signs/symptoms & treat accordingly.						
	PPE	<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, & protective clothing should be used. Pre-incident training & exercises on the proper use of PPE is recommended. Per NIOSH guidance - <b>LEVEL A:</b> Recommended for the initial response to a CG incident. Level A provides the greatest level of skin (fully encapsulating suit), respiratory (SCBA), & 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, & 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 CG concentration is unknown or above the IDLH or AEGL-2 & 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 & concentration are known & 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. <b>Note: CG has limited warning properties (i.e. rapid odor fatigue); use APR/PAPR with caution.</b> <b>LEVEL D:</b> Select Level D when the contaminant is known & the concentration is below the selected appropriate occupational exposure limit (e.g., OSHA PEL) for the stated duration times. <b>Note: AEGL-1 values are not recommended for CG. 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. CG decomposes in presence of moisture to form HCl which will present a contact hazard to exposed skin as well as inhalation hazard.</b>						
Field Detect	<b>Real-time field screening tools (results not confirmatory or quantitative):</b> Caution should be given to equipment that has not been properly evaluated. False positive & 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 & responders; some with similar capabilities & limitations.							

	Minimum Screening Levels	Miran SaphIRe	Honeywell - SPM	Dräger tube	MultiRAE	TVA 1000B	Field test kits
	ppm	0.5	0.011	0.02	0.02	0.5	Use pH as indicator of CG
	mg/m <sup>3</sup>	2	0.044	0.08	0.08	2	breakdown to HCl in water
Sampling	<p><b>Note: This section on sampling contains general guidelines &amp; does not replace the need for a site-specific sampling plan. See reference list for specifics.</b></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. <b>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.</b> 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 CG is reactive and generally not persistent, sampling/monitoring for HCl (air) and pH (surfaces, water, and soil) along with CG should be included in the sampling plan to "clear areas".</p>						
	<p><b>Note:</b> CG is highly reactive; breakdown products include HCl, organochlorine reaction products and CO<sub>2</sub>. pH can be detected in the field and used as markers to determine the extent of contamination of the parent CG (via HCl breakdown product). Laboratory analysis may need to include additional organochlorine reaction products. See ANALYSIS section below to ensure sampling procedures is compatible with all analytes.</p> <p><b>Types of Samples: Air:</b> 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.</p> <p><b>Water:</b> Dissolved CG decomposes to form HCl which may not be easily analyzed in the field. Measuring the pH in water may be sufficient. Concurrent air monitoring is recommended for CG and HCl.</p> <p><b>Soil:</b> For localized "hot spot" areas where soil deposition may occur, surface soil samples may be analyzed for CG and organochlorine reaction 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.</p> <p><b>Surface Wipes:</b> Wipe samples are often desired to indicate CG and breakdown products, mainly HCl and organochlorine reaction products, on non-porous surfaces. Measuring the pH of collected wipes may be sufficient. Concurrent air monitoring is recommended for CG and HCl.</p> <p><b>Bulk:</b> 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 products. Measuring the pH of bulk samples may be sufficient. Concurrent air monitoring is recommended for CG and HCl.</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>						
	<p><b>CAUTION:</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>). Reactive compounds such as CG &amp; HCl may be accurately determined in the field using available meters and field kits. Many laboratories are available for analysis of CG and reaction compounds; contact the EPA/HQ-EOC at 202-564-3850.</p>						
Decontamination/Cleanup	<p><b>DO NOT USE WATER DIRECTLY ON LIQUID PHOSGENE. USE WATER SPRAY OR GASEOUS AMMONIA 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 run-off may be necessary before discharge to receiving waters and wastewater systems.</b></p> <p>CG is so volatile and reactive that it will either dissipate and/or be consumed by reaction with moisture it encounters. Hence, most decontamination will not necessarily be for the phosgene itself, but for reaction byproducts, such as hydrochloric acid, most of which have lower toxicity. Separate, long-term decon strategies will need to be developed if those byproducts are of concern in a particular situation. This decon section refers to the CG itself.</p> <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> 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 nondestructive to materials.</p> <p><b>Decon Strategy:</b> Decon strategy can be developed by designating contaminated areas based on presence of 1) liquid CG, 2) gaseous CG or 3) aqueous solution of CG.</p> <p><b>Strategy for Liquid Phosgene:</b> Do not allow direct contact with water. 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 mixture to a larger volume of water. Actions that promote safe volatilization of liquid CG may be useful since CG in gaseous form is easier to decon or allow to dissipate; volatilization may be a slow process depending on site conditions.</p> <p><b>Strategy for Gaseous Phosgene:</b> Aerate spaces where gaseous CG may be present. Hydrolysis of CG results in hydrochloric acid which is highly corrosive. Impact on materials should be assessed for mitigation efforts. Cleaning of corroded products may be needed. Forced or hot air ventilation methods are recommended for vapor plume contamination or low concentration of phosgene in large volumetric spaces or open areas.</p> <p><b>Strategy for Aqueous Solutions of Phosgene:</b> If CG is present in aqueous solution; it will completely decompose in a matter of minutes, if sufficient water is present. Decon may be necessary for hydrochloric acid.</p> <p><b>Sensitive Equipment &amp; Items:</b> For difficult-to-clean equipment thought to be contaminated with small amounts of CG, additional options for consideration include flushing with water, weak aqueous ammonia, caustic or anhydrous ammonia.</p> <p><b>Verification of Decon:</b> Site &amp; situation specific. Please contact ERT (732-321-6660) and/or NDT (513-487-2420) for further assistance.</p>						
	<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>						
Waste Disposal	<p><b>Waste Disposal Planning:</b> The U.S. EPA considers a waste to be hazardous if it exhibits any of the following characteristics: ignitability, corrosivity, reactivity, or toxicity as defined in 40 CFR 261.21-261.24. Under the Resource Conservation and Recovery Act (RCRA) (40 USC 6901 et seq.), U.S. EPA has specifically listed many chemical wastes as hazardous. Although phosgene (CG) is not specifically listed as a hazardous waste under RCRA, U.S. EPA treats waste as hazardous if it exhibits any of the previously mentioned characteristics. Current resources on packaging, labeling, and shipping are available at <a href="http://www.phmsa.dot.gov/hazmat">http://www.phmsa.dot.gov/hazmat</a>. A material known to contain or suspected of containing chlorine must be classed as a U.S. Department of Transportation (DOT) Division (also known as Hazard Class) 2.3, Subsidiary Division 8, material and shipped as a poisonous substance (49 CFR 173.115). 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>						