NRT Quick Reference Guide:
Methyl isocyanate (MIC)
[July 2015 Update]

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

Agent Classification: Toxic Industrial Chemical; CAS: 624-83-9; Formula: CH_3NCO; Molecular Weight: 57.1 g/mol.

Description: Methyl isocyanate (MIC) is a volatile colorless liquid with a sharp, unpleasant odor that causes eyes to tear. MIC reacts with moist tissues (e.g., lungs, eyes) causing immediate symptoms; if tissues are drier (e.g., drier skin) symptoms may be delayed. MIC is an industrial intermediate in the production of various pesticides. Environmental breakdown products include N-carboxymethylamine, methylamine, hydrogen cyanide (HCN), and N,N'-dimethylurea, some of which are toxic.

Persistence: MIC is considered "very low persistent." Vapor: minutes to hours; liquid: 2-24 hours. Persistence will depend upon amount and purity of the agent, method of release, environmental conditions, and the types of surfaces and materials impacted.

Caution: MIC is extremely flammable; reacts violently with water; and is incompatible with oxidizers, acids, alkalis, amines, and metals. MIC can polymerize in the presence of heat, metals, or catalysts. MIC can release toxic gases, including HCN, when ignited or during rapid decomposition with reactive materials.

Physical properties are listed at/near STP unless otherwise indicated. Conversion Factors: ppm = mg/m³ x 0.427; mg/m³ = ppm x 2.34. NA = not available.

Vapor Density	Vapor Pressure	Volatility	Boiling Point	Freezing Point	Flash Point	Liquid Density	Aqueous Solubility	Non-aqueous Solubility
1.44 (air = 1)	348 mm Hg (68°F/20°C)	very high, limited by mass transfer	102°F/39°C	-49°F/-45°C	-7°C (flammable)	0.96 g/mL (68°F/20°C)	6.7% (68°F/20°C) (decomposes)	NA (reactive)

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, MIC is relatively easy to disperse as a vapor, and the primary release/attack scenario is an airborne release. MIC is expected to disperse or to degrade by reaction with moist or reactive surfaces/materials. However, an unreacted cloud of MIC can migrate several miles from the site of release by the wind while maintaining very dangerous, toxic, and potentially flammable concentrations of MIC. MIC vapors are heavier than air, so vapors can accumulate in lower terrains.

Water/Water Systems: MIC released into or over natural waters or water systems can dissolve and hydrolyze with a half-life of about 9 minutes at 25°C (77°F) into compounds that may exert toxic effects if present in high concentrations. If a large cloud of MIC is released, not all MIC may dissolve before the MIC cloud leaves the vicinity of the water.

Indoor Facility: Due to its volatility, MIC could potentially be dispersed as a vapor or aerosol inside a building or facility; HVAC systems could be impacted. MIC is heavier than air so vapors can accumulate in lower levels or utility corridors inside the buildings.

Health Effects

Onset	Onset of symptoms is dose and route dependent. Symptoms may occur within seconds after exposure to vapors. Even a relatively low dose exposure to MIC can be fatal. Skin and eye irritation can occur below odor threshold. MIC corrodes moist tissues (e.g., lungs, eyes) causing immediate symptoms; if tissues are drier (e.g., drier skin) symptoms may be delayed. Cyanide poisoning does not occur.
Signs/ Symptoms	Symptoms will vary depending on exposure route; however, the following is a general list of all possible symptoms. The severity of effects depends upon the dosage. Mild: Eye and throat irritation begin to occur below odor threshold. Moderate: Shortness of breath, disorientation, coughing, and swollen eyelids. Severe: Chronic breathing difficulties, scarring of the cornea, and death from pulmonary edema.
Exposure Routes	Inhalation: Severely irritating and corrosive to the respiratory tract–pulmonary edema and bronchial spasms leading to pneumonia. Symptoms may include cough, chest pain, shortness of breath, coma, and death. Skin: Irritation of mucous membranes and chemical burns of the skin at high concentrations. Eyes: Immediate eye pain, tearing, photophobia, profuse lid edema, and corneal ulcerations. Ocular exposure may result in long-term or permanent eye damage. Ingestion: Cyanosis, nausea, vomiting, and gastric irritation.

Effect Levels

Air: Acute Exposure Guideline Levels (AEGLs) for general population one-time exposure emergency scenarios for MIC (complete definitions are available in Key References Cited/Used in NRT Quick Reference Guides for Toxic Industrial Chemicals). NA = not available.

AEGL Level in mg/m³, at various exposure durations	10 min.	30 min.	1 hr.	4 hr.	8 hr.
AEGL 1: Threshold mild effects	NA	NA	NA	NA	NA
AEGL 2: Potentially irreversible effects or impaired ability to escape	0.936	0.304	0.157	0.04	0.019
AEGL 3: Threshold for severe effects/medical needs/increasing potential for lethality	2.808	0.936	0.468	0.117	0.059

Exposure Guidelines: IDLH = 7 mg/m³; OSHA PEL = 0.05 mg/m³; ACGIH TLV-TWA = 0.047 mg/m³ [an 8-hr time-weighted average occupational value]. Regional Screening Level (RSL) for Residential Soil = 4.6 mg/kg; RSL for Industrial Soil = 190 mg/kg. Drinking Water RSL = 2.1 µg/L.

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 they have them.
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. 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. Antidote: THERE IS NO ANTIDOTE. In cases of ingestion, do not induce vomiting. Monitor for respiratory distress. If cough or difficulty breathing develops, administer oxygen and assist ventilation as required. Treat bronchospasm with an inhaled beta-2 adrenergic agonist. Consider systemic corticosteroids if significant bronchospasm develops. Send person for follow-up medical attention and evaluation. If cleared to resume work, continue to monitor for signs/symptoms and treat accordingly.
PPE	GENERAL INFORMATION: 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 MIC 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 MIC 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 MIC 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. LEVEL D: Select Level D when the contaminant is known and the concentration is below the appropriate occupational exposure limit such as PEL or TWA 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.

Field Detection

Real-time field screening tools (results not confirmatory or quantitative): Currently no field detection equipment specifically for MIC exists. HCN, isocyanates, amines, or volatile organic compounds (VOCs) may have to be monitored as markers for the presence of MIC. 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. NA = not available.

Minimum Screening Ranges/Levels for Air	Honeywell – SPM (diisocyantes / HCN / amines)	MultiRAE/ ppb (VOCs)	MultiRAE (HCN)	Dräger (isocyanates / amines)
ppm	0.002 / 1.0 / 0.002 - 1.1	0.02	1.0	0.02 / qualitative
mg/m³	0.005 / 2.3 / 0.005 - 2.6	0.05	2.34	0.05 / qualitative

Minimum Screening Levels for Surfaces and Water	SKC – SWYPES, PERMEA-TEC surface wipes:	HACH Kits (HCN) Water
	3-5 µg/wipe for aromatic amines and aromatic and aliphate isocyanates. Wipes for aliphatic amines are available, minimum screening levels are NA.	0.002 mg/L (in H_2O)

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. Few laboratories currently have capability to determine MIC, particularly for large numbers of samples and in all types of media. 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 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 MIC 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 MIC is generally not persistent, air sampling to help to "clear areas" should be included in the sampling plan.
	Note: MIC breaks down in most environmental conditions to numerous breakdown products, including N-carboxymethylamine, methylamine, HCN, and N,N'-dimethylurea, which are less toxic than MIC and may be used as markers to determine the extent of contamination of the parent MIC. See ANALYSIS section below to ensure sampling procedures are compatible with all analytes. Types of Samples: Air (Vapors are heavier than air): Samples are collected using appropriate solid phase absorbent media (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: Water should be collected in appropriate containers with addition of appropriate de-chlorinating agents and preservatives. Soil: 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. Surface Wipes: Wipe samples are often desired to indicate absence of MIC (degradates) on non-porous surfaces. Concurrent air monitoring is recommended. Bulk: For hot spot areas where liquid MIC 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 MIC into these materials. 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). For access to the nearest ERLN laboratory specially trained and equipped for MIC analysis, contact the EPA/HQ-EOC at 202-564-3850.
Decontamination/Cleanup	CAUTION: USE WATER SPRAY ONLY TO REDUCE VAPORS OR DIVERT VAPOR CLOUD DRIFT; DO NOT PUT WATER IN DIRECT CONTACT WITH LIQUID MIC. AVOID ALLOWING WATER RUNOFF TO CONTACT REMAINING MIC LIQUID. MIC is so volatile and reactive that it will either dissipate and/or be consumed by reaction with materials it encounters. Hence, most decontamination will not necessarily be for MIC itself, but for reaction by-products, most of which have low toxicity, except for HCN, which is only produced by reaction of MIC with acids and bases. Separate, long-term decontamination strategies will need to be developed if those by-products are of concern in a particular situation. This decontamination section refers to MIC 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: MIC degrades or 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: The contaminated area 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. Decontamination Strategy: A decontamination strategy can be developed by designating contaminated areas based on presence of: 1) liquid MIC, 2) gaseous MIC, or 3) aqueous solutions of MIC. Strategy for Liquid MIC: If in gaseous form, MIC is easier to decontaminate or allow to dissipate; actions that promote safe volatilization may be useful. Volatilization may be a slow process depending on site conditions. Strategy for Gaseous MIC: Aerate spaces where gaseous MIC may be present. MIC has corrosive properties and attacks plastic, rubber, and coatings. Impact on materials should be assessed for mitigation efforts. Cleaning of corroded products may be needed. Forced ventilation methods are recommended for MIC cloud contamination or low concentration of MIC in large volumetric spaces or open areas. Due to low flash point, Hot Air ventilation is not advised. Strategy for Aqueous Solutions of MIC: If MIC is present in aqueous solution, it will completely decompose in a matter of hours, although the reaction between MIC and water can be violent. 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/complyhmregs.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), waste generally is classified as hazardous waste (subtitle C) or solid waste (subtitle D). Under RCRA's statutory authority, a waste is considered hazardous if it: (A) 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 §261.31, §261.32), (2) exhibits specific characteristics (40 CFR §261.21-261.24) or (3) is a discarded commercial chemical product, off-speciation species, container residue, or spill residue thereof (40 CFR §261.33). MIC is listed under RCRA, chemical code P064. MIC is also regulated under CERCLA with a reportable quantity threshold of 10 pounds. 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).