ENV-ON-SUD-Environmental Emergency Response Plan (E2 Plan) Copper Cliff Nickel Refinery

PGS-005914, Rev.00-1/1/2023

Issuer Area: Sudbury Operations – Environment Department
Technician Responsible: Name: Natalie Jones, Registration: LDD5373, Area: Environment Department.
Target Audience: Site Operators, Site Supervisors, Site Manager, Sudbury Environmental personnel
Need of training: (X)YES ( )NO

Expected results:

- ✓ To define roles and responsibilities, resources, equipment, and training requirements related to the emergency response plan.
- ✓ To summarize the site risk analysis by defining specific risk factors, including risk analysis, preparedness, prevention, and response.
- ✓ To define emergency response equipment and alerting/notification procedures.

This document applies to the following Vale facilities and jurisdictions:

Ontario: Copper Cliff Nickel Refinery Complex

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1 PURPOSE

Facilities or responsible persons who own or have the charge, management or control of a substance that is included in Schedule 1 of the *Environmental Emergency Regulations, 2019* (herein the Regulations) and in a quantity greater than that listed in column 4 of Schedule 1 are required to prepare an environmental emergency response plan (an E2 Plan) that identifies potential environmental emergencies as defined in Section 193 of the *Canadian Environmental Protection Act, 1999* (CEPA, 1999). Part 8 of CEPA, 1999 states the requirement to address the "prevention of, preparedness for, response to and recovery from environmental emergencies caused by uncontrolled, unplanned or accidental releases, and to reduce any foreseeable likelihood of releases of toxic or other hazardous substances listed in Schedule 1 of the Regulations" (Technical Guidelines for the *Environmental Emergency Regulations, 2019*).

These plans may be prepared in accordance with existing emergency response documents and systems (i.e. Emergency Preparedness or Crisis Management Plans) provided that they meet the requirements of subsection 4(2) of the Regulations or have been amended so that they meet all requirements.

A key pillar in E2 planning is the consideration of the risks present in the overall management of hazardous substances from movement, storage and disposal perspectives. Addressing key risks contributes to the overall reduction of risk severity through the implementation of critical controls and is an effective way to minimize potential catastrophic events.

2 FACILITY DESCRIPTION

2.1 Copper Cliff Nickel Refinery

Vale Canada Limited (Vale) owns and operates the Copper Cliff Nickel Refinery Complex (CCNR) in Copper Cliff, Ontario, which acts as the final stage of the refining process to produce high quality nickel products. The CCNR is comprised of three main facilities:

- The Nickel Refinery Converter (NRC) Plant
- The Inco Pressure Carbonyl (IPC) Plant; and
- The Electrowinning Plant

The regulated substances described in this Plan meeting the thresholds defined in the Regulations are located at the NRC and IPC plants within the CCNR Complex. As such, we will focus on the substances and their use at these plants only.

2.2 Nickel Refinery Converter Plant

The NRC Plant receives feed materials (nickel sulphides, metallics from Matte Processing, nickel oxides, precious metal bearing intermediates, refinery intermediates, tolls and reverts, Clydach residues etc.) that are added to two top blown rotary converters (TBRCs) and are melted down with natural gas-oxygen lance burners. Once melted, the hot metal is transferred to ladles where it undergoes granulation by passing through high-velocity water jets. The resulting granules are dried in a gas-fired kiln dryer and are sent to the IPC plant for further refining.

2.3 Inco Pressure Carbonyl Plant

The IPC Plant consists of three reactors where dry, metallic granules are batch-reacted with carbon monoxide. Nickel, with some iron, is extracted as a carbonyl vapour, while copper, cobalt, precious metals and impurities are retained in the residue (IPC residue) that are pumped to Electrowinning. The carbonyl vapour is liquified, then purified in two parallel distillation columns. It is then sent for thermal decomposition in the pellet decomposers. Nickel deposition takes place on a circulating stream of preheated nickel pellets and the remaining pure nickel carbonyl vapour is decomposed in electrically heated decomposers to produce pure nickel powder. The distillation process produces a liquid residue consisting of a mixture of nickel and iron carbonyls. The iron/nickel carbonyl is vapourized and then decomposed to ferro-nickel pellets.

2.4 Surrounding Area

Sensitive receptors are places which would be significantly impacted by the adverse effects caused by a release. The following resources have been used to determine sensitive receptors that must be considered during the implementation of this Plan:

- The City of Greater Sudbury's Official Plan (2008)
- Land Use Map used to identify land uses near the property;

- Natural Heritage Map used to identify ecological, cultural and First Nation values;
- Hazard Lands Map used to identify flood plains;
- Groundwater Protection Area used to identify potable water wells and groundwater protection areas situated within 1 km of the CCNR;
- Watershed Map (Nickel District Conservation Authority)

All maps and figures are included in the CCNR Spill Response and Contingency Plan that is located on the Vale Intranet site (http://intranet.valepub.net/en/canada/Pages/Sudbury-Safety-Health-Environment/Emergency-Management.aspx).

The Land Use Map indicates that all land extending north from the north shore of Kelly Lake (and including a portion of the southern shore) is zoned as "Mining/Mineral Reserve" while the shoreline is also designated as "Parks and Open Space". The nearest residential/commercial use is found along Fielding Road which is adjacent to the western boundary of the CCNR. The nearest institutional use is in the town of Copper Cliff approximately 2 km from the CCNR. Land used for commercial, residential and institutional purposes, including nearby transportation corridors, may be considered as potentially vulnerable to a release to atmosphere of nickel carbonyl, iron pentacarbonyl, carbon monoxide or ammonia. In the context of a catastrophic spill to atmosphere, these features are considered sensitive receptors.

The Natural Heritage map identifies two mapped wetlands near the CCNR: one oval feature near the western property (west of Fielding Road) and a second south of the refinery complex on the shore of Kelly Lake. Kelly Lake itself contains fish and wildlife habitat and, along with the wetlands, is considered a sensitive receptor for the purposes of this Plan.

The Official Plan's Groundwater Protection Area map was reviewed. Kelly Lake is not considered a groundwater protection area. However, there are several groundwater wells located in the area of Fielding Road (within 1 km of the CCNR) that must be considered as sensitive receptors. Narrow floodplains are shown along the north shore of Kelly Lake on the Hazard Lands Map.

Table 1 summarizes all sensitive receptors that have been considered in the Plan, their distance to the facility and the type of potential impact a release could have. Their physical location relative to the CCNR is indicated in Figure 1.

Table 1 Summary of sensitive receptors that could be impacted by a release of materials at CCNR

Receptor	Distance to Facility	Potential Impact
Health care facilities	Copper Cliff (2km)	Public Safety
Senior citizens' residences	Copper Cliff (2km)	Public Safety
Child care facilities	Copper Cliff (2km)	Public Safety
Educational facilities	Copper Cliff (2km)	Public Safety
Residential	Lively (3km) + Copper Cliff (2km)	Public Safety
Places of business	CCNR Plant Facilities Adjacent (Fielding Rd)	Public & Personnel Safety
Transportation corridors	Adjacent (Route 55)	Transportation & Infrastructure
Groundwater Wells	Adjacent (Fielding Road; 1km)	Environmental
Flood plain areas	Adjacent (Kelly Lake)	Environmental
Fish and wildlife habitat areas	Adjacent (wetlands, Kelly Lake)	Environmental

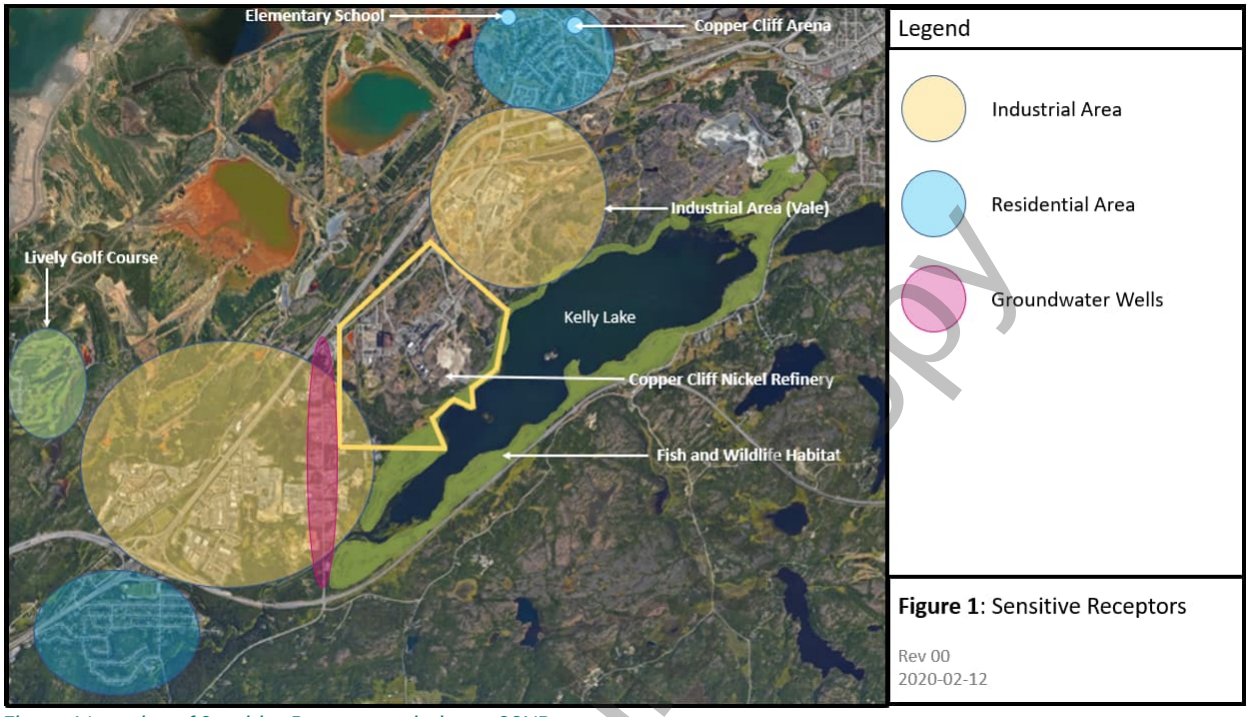

Figure 1 Location of Sensitive Receptors relative to CCNR

3 SCHEDULE 1 SUBSTANCES

The CCNR Complex has five Schedule 1 substances that are in quantities greater than the quantity listed in column 4, minimum quantity, that requires a substance specific emergency response plan. The substances are: nickel oxide, nickel carbonyl, iron pentacarbonyl, anhydrous ammonia and carbon monoxide. Safety Date Sheets (SDS) for each substance are attached in Appendix A. A summary of physical and chemical properties for each substance is included in Table 2.

Table 2 Summary of Physical and Chemical Properties for Substances at CCNR

Physical/Chemical Properties	Nickel Oxide	Nickel Carbonyl	Iron Pentacarbonyl	Anhydrous Ammonia	Carbon Monoxide
CAS Number	1313-99-1	13463-39-3	13463-40-6	7664-41-7	630-08-0
UN Number	Not regulated	UN1259	UN1994	UN1005	UN1016
Physical State	Solid	Liquid	Liquid	Gas/Liquid	Gas
Colour	granular, dark grey	Colourless/Yellow	Brown	Colourless	Colourless
Odour	Not provided	Musty	Not Available	Pungent	Odourless
pH	Not Available	Not Available	Not Available	10.6-11.6	Not Available
Melting Point	>1900°C	-19.3°C	-20°C	-77°C	-199°C
Boiling Point	Not Applicable	43°C	103°C	-33.4°C	-191.52°C
Flash Point (closed cup)	Not Applicable	-20°C	-15°C	Not Available	608°C
Lower Explosive Limit	Not Applicable	2%	3.7 vol%	16% (volume in air)	12.50%
Upper Explosive Limit	Not Applicable	34%	12.5 vol%	25% (volume in air)	74.20%
Vapour Density	Not Applicable	5.9 (air = 1)	6.74 (air = 1)	0.597 (air = 1)	0.97 (air = 1)
Auto-ignition Temperature	>400°C	60°C	49°C	651°C	607°C
Soluble in Water?	3.52 E-5 g/l at 20°C	Not Available	Insoluble	YES	2 g/l
E2 Hazard Category	Aquatically Toxic	Inhalation	Inhalation	Inhalation	Inhalation

3.1 Nickel Oxide

Nickel oxide is a dark grey, granular, non-flammable solid that may cause irritation to skin upon contact. Symptoms of allergic reaction or asthma may present upon inhalation of the substance. The substance is considered insoluble in water. As such, limited environmental mobility in water is expected. However, it is classified as being aquatically toxic and may cause long lasting effects to aquatic life.

Nickel oxide is considered stable under normal conditions and there are no known incompatible substances for storage.

3.2 Nickel Carbonyl

Nickel carbonyl is one of the most hazardous substances encountered in nickel chemistry due to its high toxicity, compounded with high volatility and rapid skin absorption. The vapour is much heavier than air and has an autoignition temperature of 60°C. It also decomposes very quickly in air, with a half-life of under one minute at 23°C. High atmospheric temperatures lead to a quicker decomposition rate, while cooler temperatures will slow the rate of decomposition.

The National Institute for Occupational Safety and Health (NIOSH) classifies nickel carbonyl as a potential human carcinogen and exposure to the substance can lead to nickel poisoning, that without treatment, can be fatal. Poisoning is characterized in two stages. Stage one consists of headaches and chest pain

lasting a few hours with a short remission. Stage two consists of chemical pneumonitis (typically after 16 hours) with symptoms of cough, breathlessness and extreme fatigue, reaching the greatest severity after four days. Death may result due to cardiorespiratory and/or renal failure. An individual exposed to carbonyl must be assessed by a medical professional regardless of the duration of exposure. Antabuse is the only known treatment.

3.3 Iron Pentacarbonyl

Iron pentacarbonyl is considerably less toxic than nickel carbonyl, though exposure can still result in lung irritation, toxic pneumonitis and/or pulmonary edema. Immediate medical attention is needed following an exposure of any duration. Exposed individuals may be treated with Deferoxamine if iron levels are elevated to a toxic concentration. In the event that the exposed individual develops pneumonitis, they are also prescribed Cortisone to help prevent permanent scarring of lung tissue.

Iron pentacarbonyl is stable under normal conditions. However, precautions must be taken to ensure there is no contact with incompatible products such as strong oxidizing agents, strong bases, halogens, amines as wells as excessive heat. Iron pentacarbonyl is a highly flammable liquid and vapour.

3.4 Anhydrous Ammonia

Anhydrous ammonia is characterized by its pungent odour that is often described as being suffocating upon inhalation. As a 0.02-1.7% solution, ammonia has a pH of 10.6-11.6, which can be corrosive and may cause burns upon contact with skin. Anhydrous ammonia is a hygroscopic compound, meaning that it will seek moisture from the nearest available source. When inhaled, the reaction between the moisture laden tissues of the human throat and the substance can have immediate consequences including swelling of the airway leading to suffocation. Immediate medical assessment is mandatory following exposure.

Incompatible materials include, but are not limited to metals, chlorine, calcium hypochlorite and other halogens. Fire and explosions may result from contact with strong oxidizers. Anhydrous ammonia as a gas is highly flammable and in a concentration of 16-25% in air can be ignited if the autoignition temperature is reached. Special consideration is needed to ensure that ammonia vapours do not accumulate in confined areas where ignition may occur due to risk of explosion.

3.5 Carbon Monoxide

Carbon monoxide is a colourless, odourless, toxic gas that is extremely flammable and a tank containing the gas under pressure that is heated may explode. All sources of ignition must be avoided.

Exposure to and inhalation of carbon monoxide can be fatal as it more favourably binds to hemoglobin in the blood than pure oxygen but does not have the ability to provide oxygen to organs and tissues. Symptoms of exposure to carbon monoxide typically include headache, nausea, vomiting, dizziness, fatigue and weakness. Severe exposure can cause seizure, arrhythmias, loss of consciousness and death. Immediate medical attention is required following exposure.

3.6 Maximum Expected Quantities

Table 3 summarizes the maximum expected quantity of nickel oxide, nickel carbonyl, iron pentacarbonyl, anhydrous ammonia and carbon monoxide on site at the CCNR and the largest means of containment for each substance.

Table 3 Maximum Quantity of Substances at CCNR

Onsite Volumes and Containment	Nickel Oxide	Nickel Carbonyl	Iron Pentacarbonyl	Anhydrous Ammonia	Carbon Monoxide
Max Expected Quantity	373 Tonnes	554 Tonnes	209 Tonnes	39 Tonnes	131 Tonnes
Largest Container Capacity	250 Tonnes	250 Tonnes	250 Tonnes	45 Tonnes	18 Tonnes
Are all quantities contained?	YES	YES	YES	YES	YES
Details of Containment:	Contained within the NRC plant in a storage bin, contains nickel oxide feed <10 microns	Contained in storage tank with water containment if spill occurs (IPC)	Contained in storage tank with water containment if spill occurs (IPC)	Contained in a storage tank	Contained in a large low-pressure tank - Process Gas Storage Tank (PGST)

3.7 Use of Substances at the Facility

The location of each substance is identified in Figure 2 below.

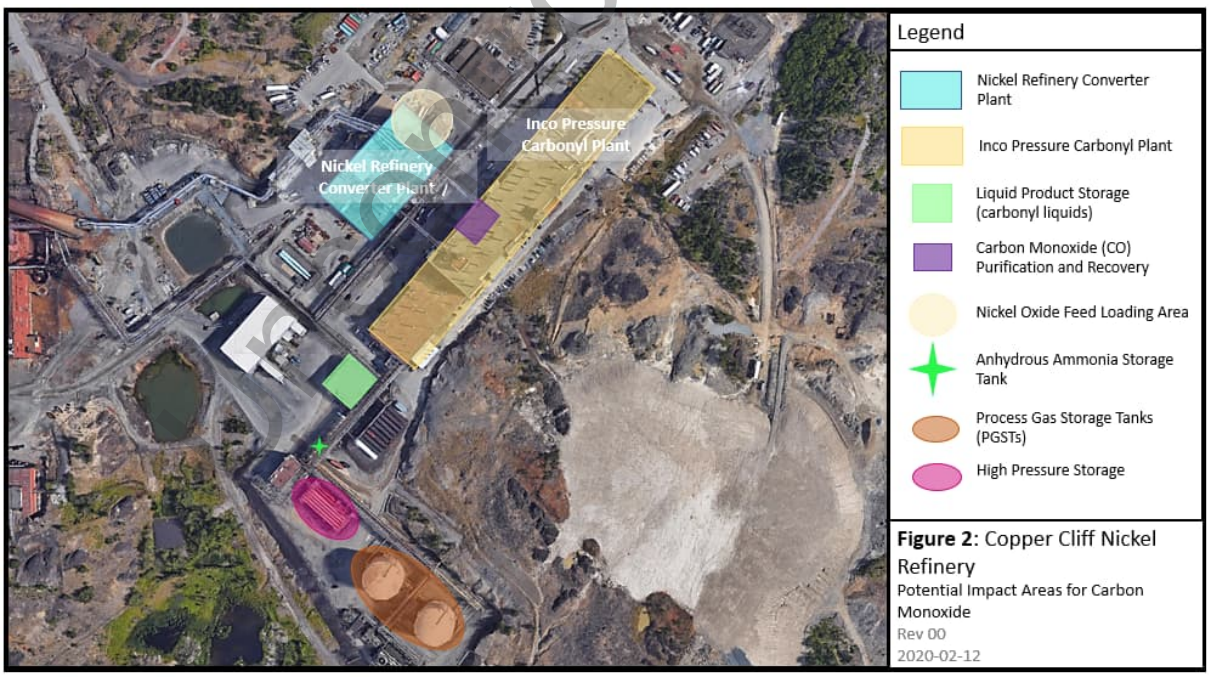

Figure 2 Location of Each Substance at CCNR

3.7.1 Nickel Oxide

Nickel oxide, NiO, is generated at the Copper Cliff Smelter Complex Matte Processing Plant. It is transported to the CCNR Complex NRC plant where it is used as a feed material for further processing. The feed materials are charged in two top-blown rotary converters (TBRCs) and are melted using natural gas-oxygen lance burners. The molten metal is transferred to a teeming ladle where it is poured through high velocity water jets in a process called granulation. The resulting granules are dewatered and dried in a gas-fired kiln which are then sent to the IPC plant.

3.7.2 Nickel Carbonyl

In the IPC plant, nickel carbonyl, $Ni(CO)_4$, in the form of a crude carbonyl vapour (with some iron pentacarbonyl), is created when pure carbon monoxide gas is batch-reacted in the high-pressure reactor system with metallic granules received from the NRC plant. The carbonyl vapour is liquified and purified in two distillation columns which is then sent to the decomposers to create a final nickel pellet product that goes to market.

3.7.3 Iron Pentacarbonyl

Similar to nickel carbonyl, iron pentacarbonyl, $Fe(CO)_5$, is created in the IPC plant when pure carbon monoxide is reacted in the high-pressure reactor system with metallic granules received from the NRC plant. The same process that nickel carbonyl undergoes occurs with iron pentacarbonyl. However, in this case, the iron pentacarbonyl stream is condensed, stored, re-vapourized and decomposed to form ferronickel pellets.

3.7.4 Anhydrous Ammonia

Anhydrous Ammonia, NH3, is used to form cupric ammonium acetate (CAA), a reagent used in the purification of carbon monoxide in the Carbon Monoxide Purification and Recovery system (CO P&R) in the IPC plant. CAA absorbs carbon monoxide/carbon dioxide (CO/CO_2) from reaction and bleed gas streams as the first step in the purification of CO for reuse.

3.7.5 Carbon Monoxide

Carbon monoxide, CO, is reacted in the high-pressure reactor system with metallic granules from the NRC plant as part of the nickel refining process. The resulting carbonyl vapours and any remaining, uncondensed CO gas is sent to the gas condensing and recycling system. Some of the CO gas contains carbonyl that is removed in the Alumina Adsorption system. The remaining CO is then transferred to the CO Purification and Recovery (CO P & R) system where residual impurities are removed. Clean CO is then recycled back to the plant's high-pressure reactor system for subsequent use.

4 POTENTIAL ENVIRONMENTAL EMERGENCIES

The potential for small or large releases of each of the five substances at the CCNR exists and each has its own specific set of associated hazards. In the presence of an ignition source, some of the defined releases may result in fire or explosion at the site. Table 4 summarizes worst case and alternate scenarios as prescribe by the Regulations. These scenarios are further described and assessed in subsequent plan sections.

Table 4 Summary of Release Scenarios at CCNR

Plant	Substance (Hazard Category)	Description of Emergency Scenario	Worst Case Scenario?[1]	Alternate scenario?[2]
NRC	Nickel Oxide (Aquatically Toxic)	Small release of nickel oxide due to baghouse line rupture		X
NRC	Nickel Oxide (Aquatically Toxic)	Large release of nickel oxide due to failure of largest container (11 tonnes)	X	
IPC	Nickel Carbonyl (Inhalation)	Small release of nickel carbonyl due to a leak in the process gas storage tank (PGST)		X
IPC	Nickel Carbonyl (Inhalation)	Large Release of nickel carbonyl due to failure of the reactor system (7000 m3)	X	
IPC	Iron Pentacarbonyl (Inhalation)	Small release due to rupture of the #9 pellet decomposer		X
IPC	Iron Pentacarbonyl (Inhalation)	Large release due to failure of the B vapourizer	X	
IPC	Anhydrous Ammonia (Inhalation)	Small release of anhydrous ammonia during the filling of the storage tank		X
IPC	Anhydrous Ammonia (Inhalation)	Large release of anhydrous ammonia due to tank rupture on south side	X	
IPC	Carbon Monoxide (Inhalation)	Small release of carbon monoxide due to process gas storage tank (PGST) failure		X
IPC	Carbon Monoxide (Inhalation)	Large release of carbon monoxide due to high pressure storage failure	X	

[1]Release of the maximum quantity of the substance that could be contained in the container system that has the largest maximum capacity

[2]Environmental emergency that is more likely to occur than the release of the maximum quantity of the substance in the largest container at the facility and that would have the longest impact distance outside the boundary of the facility

4.1 Assessment of Possible Events

The *2016 Emergency Response Guidebook* (ERG2016) issued by Transport Canada provides several emergency response guides for various hazardous material classes. The guides provide initial isolation distances that are protective of public health and safety in the event of a release. In addition, the guides provide downwind protection distances to consider. Wind speed and ambient air temperature should also be considered when assessing the severity of a release of any toxic substance. Table 5 below provides a reference to each guide that has been considered in the assessment of possible events for each substance and the corresponding Table 1 protection/isolation distances that are recommended. Ammonia is classified as a Toxic Inhalation Hazard (TIH) and has its own set of additional protection distances that factor in wind speed at the time of the release (Table 6). Nickel oxide is not a regulated substance and as such, protection and isolation distances are not defined by ERG2016.

In addition to ERG2016, Vale also utilizes SAFER Systems to model potential releases of chemical substances. Case numbers are provided in the following sections where releases have been modeled to date and the details of each case are included in Appendix B.

Table 5 Emergency Response Guidebook 2016 Reference Table

Name of Substance	Guide #	Small Spills (<208 L)			Large Spills (>208 L)		
		Isolation Distance (m)	Protection Distance (m)		Isolation Distance (m)	Protection Distance (m)	
			Daytime	Nighttime		Daytime	Nighttime
Nickel Carbonyl	131	100	1400	4900	1000	11000+	11000+
Iron Pentacarbonyl	131	100	900	2000	400	4500	7400
Anhydrous Ammonia	125	Use Table 3 from 2016 Emergency Response Guidebook					
Carbon Monoxide	119	30	100	200	200	1200	4400
Nickel Oxide	N/A	Not Regulated					

Table 6 Emergency Response Guidebook 2016 Table 3 Ammonia Isolation and Downwind Protection Distances

Anhydrous Ammonia			
Isolation Distance (m)	Daytime Downwind Protection Distance (m)		
	Low Wind	Moderate Wind	High Wind
300	1700	1300	1000
Low wind <10 km/h; Moderate wind 10-20 km/h; High wind >20 km/h			

As prescribed by the Regulation, the worst-case scenario is defined as a release of the maximum quantity of the substance that could be contained in the container system that has the largest maximum capacity. The alternate scenario is an environmental emergency that is more likely to occur than the release of the maximum quantity of the substance in the largest container at the facility and that would have the longest

impact distance outside the boundary of the facility. A representative group of Vale employees from the CCNR, as well as the Health and Safety, Environment and Emergency Preparedness departments met to discuss all possible scenarios and determine which scenarios should be included in this Plan. The subsequent sections below provide a detailed description for each scenario and each substance located at the facility. In addition, the corresponding level of emergency is identified for each scenario.

Level I Emergency – confined to a building within a mine or plant complex, with no effect to other parts of the mine, plant or public. The public is not notified for a Level I Emergency.

Level II Emergency – confined to a mine or plant complex but has no effect to the public. The public is not notified for a Level II Emergency.

Level III Emergency – any situation which could pose a significant hazard to personnel at other locations and/or to the public. Air horns are activated and the public is notified for a Level III Emergency.

4.2 Nickel Oxide

4.2.1 Worst-Case Scenario and Resulting Harm

The largest container system of nickel oxide at the CCNR is an 11 tonne bin located in the NRC building. Nickel oxide is offloaded from a tanker truck into #3 FEN storage bin on the second floor using a blower that is located on the ground level. The worst-case scenario would result in a complete failure of the storage bin, causing a release of 11 tonnes of nickel oxide into the NRC building, with the potential for dust to escape to atmosphere through building ventilation. In this scenario, a Level I Emergency would be called for the site. Figure 3 identifies the location of the Level I Emergency with an estimated impact distance outside of the NRC plant. There is no modeled SAFER case for a release of nickel oxide.

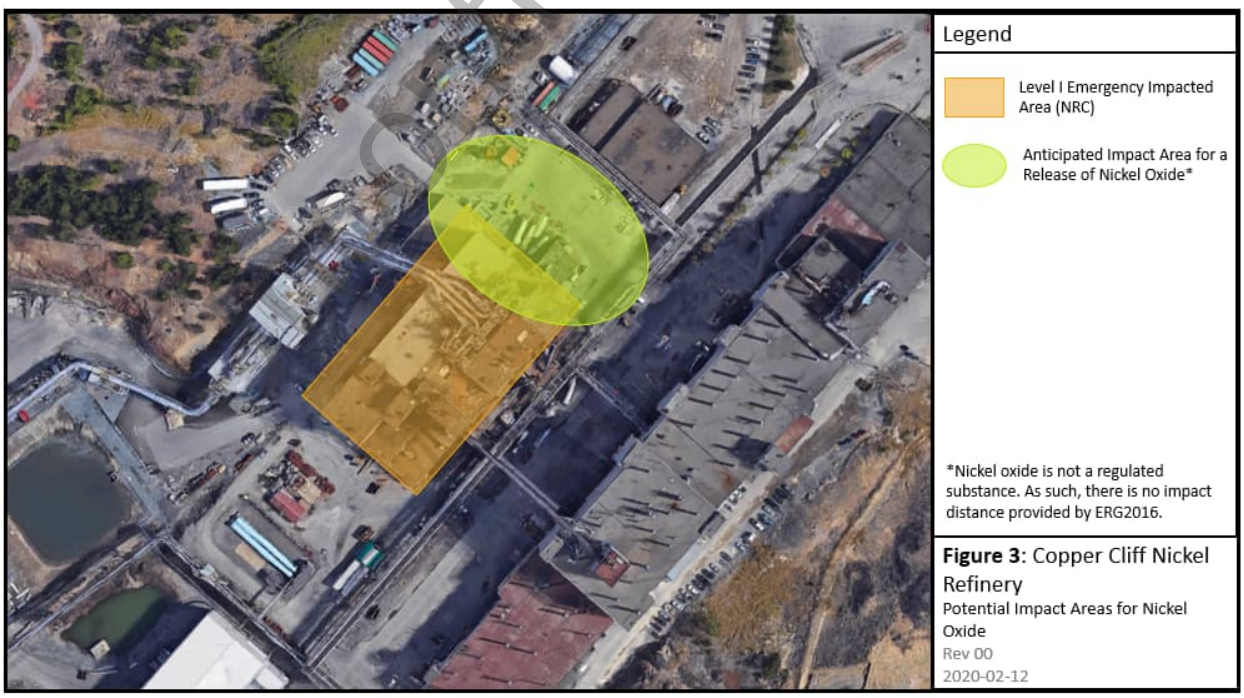

Figure 3: Copper Cliff Nickel Refinery
Potential Impact Areas for Nickel Oxide
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Figure 3 Estimated Impact Distance for a Release of Nickel Oxide

The hazard category assigned by the Regulation identifies nickel oxide as being aquatically toxic. If the spilled nickel oxide enters a water way, there is the potential for contamination and exposure to aquatic organisms. This can cause interference with cell growth and development as well as impair photosynthetic capability in aquatic plants[1]. Following a release of this nature, a preliminary assessment of the site would be conducted to determine the level of contamination present, if any. If metals were shown to be elevated, proper clean up and disposal of released materials would be coordinated through the Environment Department.

4.2.2 Alternate Scenario and Resulting Harm

The NRC receives some feed material from Vale's Clydach refinery that contains nickel oxide. The feed comes in bags that are loaded into a receiving and storage system where they are unloaded into a charge bin on the third floor of the NRC building for blending with other feed materials for processing. The system utilizes a baghouse to collect dust generated during the unloading process. As an alternative to the worst-case scenario, a baghouse dust transfer system line rupture could cause a release of nickel oxide into the plant that would require immediate response. A pressure drop in the line would be a key indicator that there was an issue requiring investigation. The alternate scenario would not result in a level emergency being called for the site.

As in the case of the worst-case scenario, a release that contaminates a water body has the potential to harm local aquatic organisms. As such, the impacts follow a release of this nature would be investigated by the Environment Department.

4.3 Nickel Carbonyl

4.3.1 Worst-Case Scenario and Resulting Harm

The worst-case scenario involving the release of nickel carbonyl would result from the complete failure of a reactor tank where carbon monoxide is reacted with metallic granules to form crude carbonyl vapour. The reactor has a pressurized volume (1,000 pounds per square inch) of 7,000 m^3 of nickel carbonyl that could be released to the building and the surrounding atmosphere through building vents. In addition, due to the high pressure in the reactor tank, the force of a release at that magnitude would have substantial consequences. ERG2016 references Guide 131 for a release of nickel carbonyl and indicates a minimum isolation distance in the event of a large spill (>208L) of 1,000 m and an additional downwind daytime protection distance of 11,000+ m (Figure 4). Considerations were made to determine if a scenario including fire would be worse than the case provided. It was determined that combustion would increase the rate of dissipation of nickel carbonyl, and while the immediate impact from explosion at the reactor would be of greatest consequence, it would substantially reduce how far the impacts would reach if no fire or explosion were to occur. In the event that the worst-case scenario occurs, a Level III emergency would be called and is discussed in subsequent sections. SAFER Case 115 has modeled a release of this nature and identifies a downwind travel distance of approximately 6,700 m.

[1] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5394891/

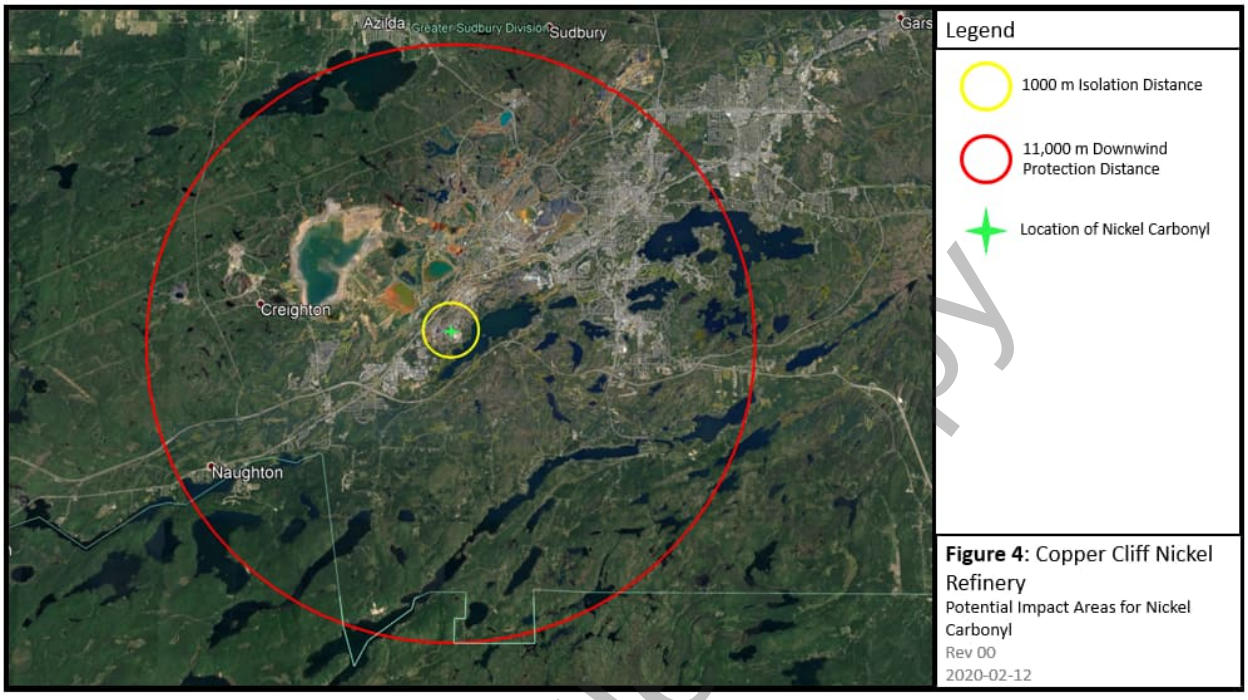


Figure 4 Emergency Response Guidebook 2016 Isolation and Downwind Protection Distance for a Release of Nickel Carbonyl

A release of nickel carbonyl will dissipate in the atmosphere, making any potential environmental impact negligible. However, due to the toxicity of nickel carbonyl, any personnel or offsite receptor that is exposed to a concentration of nickel carbonyl must seek immediate medical attention. Failure to do so may result in severe health complications or death. CCNR has a detailed Carbonyl Health Surveillance Program that identifies what to do if an individual has been exposed to carbonyl (http://intranet.valepub.net/en/canada/Pages/Sudbury-Safety-Health-Environment/Health%20Programs.aspx).

4.3.2 Alternate Scenario and Resulting Harm

A release of carbonyl gas containing carbon monoxide could potentially occur due to a leak in the process gas storage tank (PGST) located in the outside environment. These tanks receive all the high concentration carbonyl gas vents from the IPC process and provide surge capacity for the main gas compressors. Under low wind speeds and a cold ambient air temperature, dispersion and breakdown of nickel carbonyl would be much slower compared with fast winds and high temperature. As such, the impacts have a higher potential to reach off site receptors under this scenario. A Level III emergency would be called and is discussed in subsequent sections. SAFER Case 157 has modeled a release of this nature and indicates a downwind travel distance of approximately 4,000 m.

As indicated above, all individuals exposed to nickel carbonyl are at risk for serious injury or death if not treated by medical personnel.

4.4 Iron Pentacarbonyl

4.4.1 Worst-Case Scenario and Resulting Harm

Liquid iron/nickel carbonyl is received from the Crude Liquid Handling and Distillation system where it is stored in the "B" Material Storage Tank. From there, the liquid is pumped to the "B" vapourizer in a continuous process for further refinement. The worst-case scenario would result from the complete failure of the "B" vapourizer, yielding a release of 1,500 gallons of iron pentacarbonyl into the environment. As with nickel carbonyl, ERG2016 references Guide 131 in the event of a release to the environment, with an initial isolation distance of 400 m and a subsequent downwind, daytime protection distance of 4,500 m (Figure 5). The worst-case scenario also assumes slow wind speed and cold ambient temperatures, slowing the rate of decomposition and potentially resulting in the greatest amount of harm. A level III emergency would result from this situation. There is no current SAFER model for a release of iron pentacarbonyl.

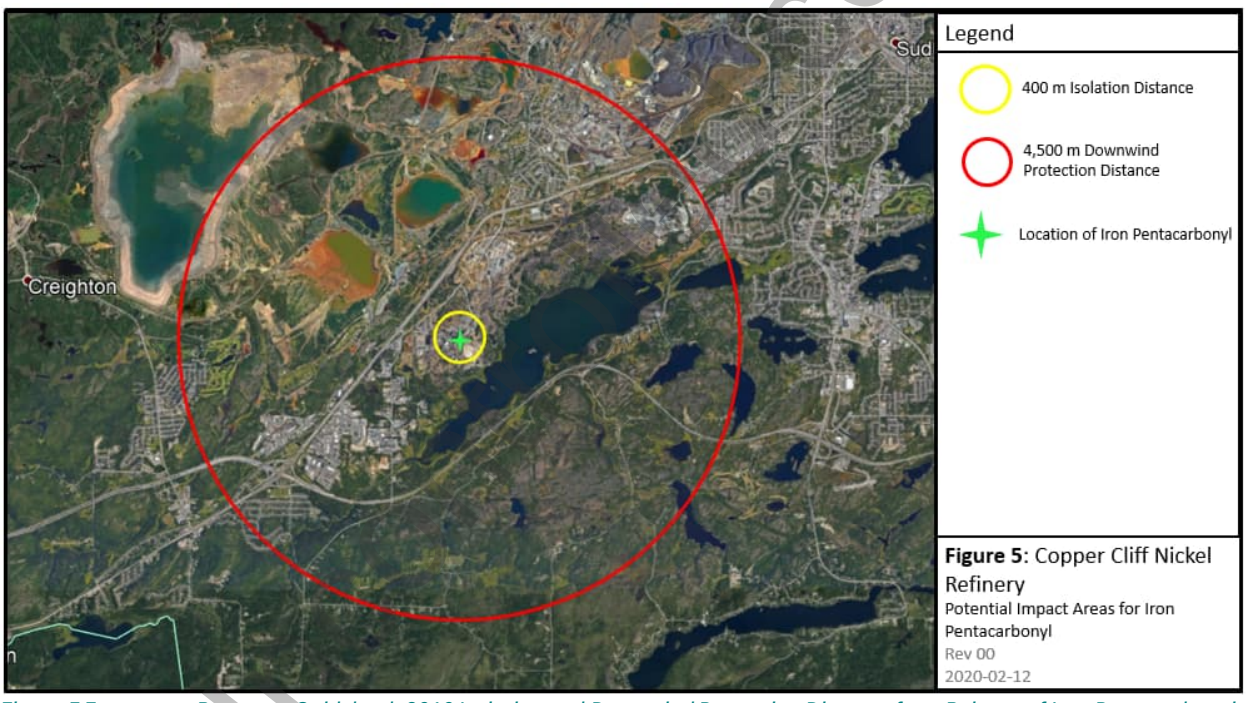


Figure 5 Emergency Response Guidebook 2016 Isolation and Downwind Protection Distance for a Release of Iron Pentacarbonyl

Though considerably less toxic than nickel carbonyl, inhalation of iron pentacarbonyl can cause irritation and requires immediate medical assessment. Respiratory illness or distress may result from exposure. The CCNR Carbonyl Surveillance Program includes exposure to iron pentacarbonyl. Minimal environmental impacts are anticipated from a release of iron pentacarbonyl due the dissipation of the substance in the atmosphere.

4.4.2 Alternate Scenario and Resulting Harm

The #9 pellet decomposer extends from the first to the fifth floor of the Decomposer area within the IPC plant. The unit receives iron/nickel carbonyl vapour from the "B" vapourizer and the iron/nickel is deposited onto circulating pellets, with carbon monoxide produced as an off gas. The alternate scenario yielding in a release of iron pentacarbonyl would result from a rupture of the #9 pellet decomposer. Slow winds and colder temperatures would slow down the decomposition of iron pentacarbonyl and would create a greater risk to sensitive receptors in the area. However, the impacts would be less than nickel

carbonyl, due to its lower toxicity. As above, a release of iron pentacarbonyl has not been modeled by SAFER.

Exposure to iron pentacarbonyl requires immediate medical attention. Monitoring individuals who have been exposed for signs of respiratory impairment is necessary.

4.5 Anhydrous Ammonia

4.5.1 Worst-Case Scenario and Resulting Harm

The ammonia tank has a capacity of 45 tonnes and is stored in the outside environment. The worst-case scenario would be a large leak on the bottom of the tank on the south side, causing a complete release of both liquid and gaseous ammonia. Because dispersion of ammonia is heavily dependent on temperature, wind conditions and relative humidity, the worst-case release would occur under cold temperatures, high relative humidity and low wind speeds. Under these conditions, the vapour has a much higher likelihood of hovering near the ground. The liquid portion would be at risk for running off the site and into waterways. This would result in a Level III emergency. ERG20165 references Guide 125 and in the event of a spill, further references Table 3 for isolation and downwind protection distances. Because anhydrous ammonia is a toxic inhalation hazard, Table 3 also factors in wind speed when determining distances. An initial isolation distance of 300 m is suggested, with an additional downwind protection distance of 1,000 m, 1,300 m and 1,700 m for fast (>20km/h), moderate (10-20 km/h) and slow (<10 km/h) winds, respectively (Figure 6). SAFER Case 134 models this scenario and provides a downwind travel distance of approximately 800 m.

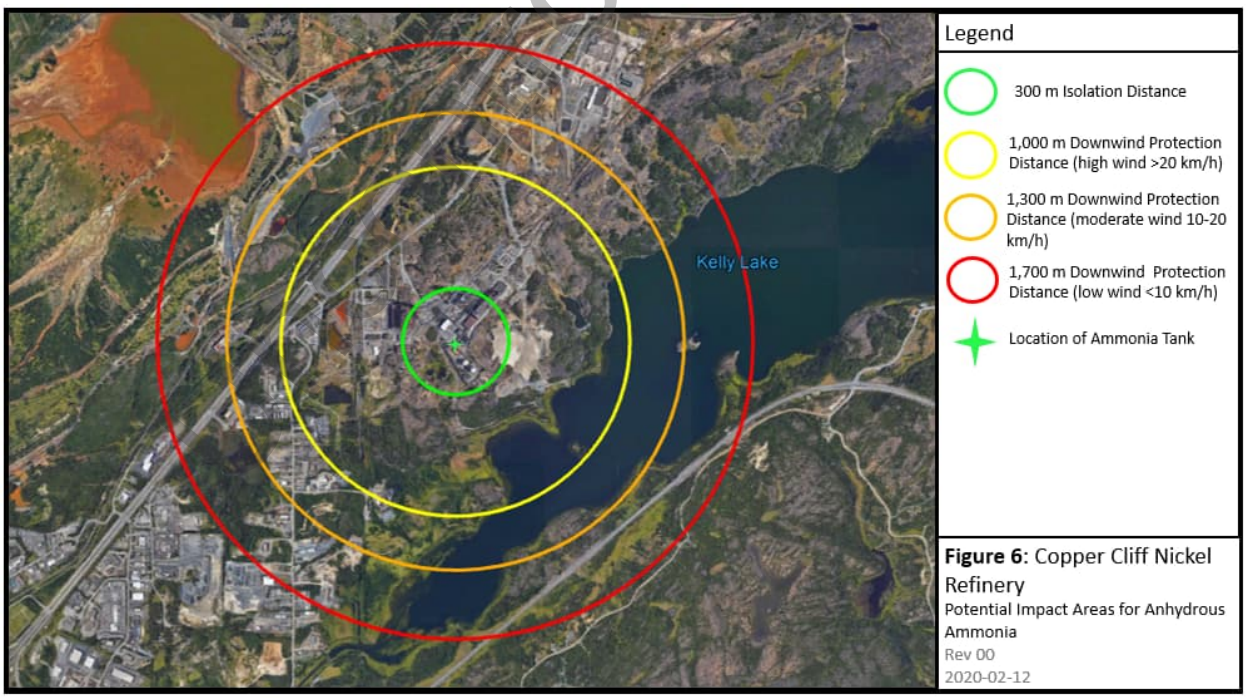


Figure 6 Emergency Response Guidebook 2016 Isolation and Downwind Protection Distances for a Release of Anhydrous Ammonia

Because of its hygroscopic nature, inhalation of anhydrous ammonia gas can cause irritation to the airways of individuals who are exposed. Immediate medical assistance is necessary to assess respiratory function. Direct skin contact with liquid ammonia may result in burns to individuals who are exposed. In addition,

ammonia that contaminates water ways can build up in the tissues and blood of aquatic organisms and can potentially cause death. In the event that ammonia is released to the environment, the site will contact a third-party contractor to isolate the scene and clean up any materials contaminated by the spill.

4.5.2 Alternate Scenario and Resulting Harm

The alternate scenario that is more likely to occur would be the release of ammonia during the filling of the ammonia storage tank, resulting from a leak in the pipe connection. In addition to the isolation and protection distances provided by ERG2016, SAFER Case 128 models a release of this nature that indicates a downwind travel distance of approximately 60 m. This could result in a Level II or Level III Emergency, depending on the leak duration, volume released and whether the ammonia is released into a watercourse. As indicated above, Individuals exposed to anhydrous ammonia are at risk for serious medical complications (i.e. respiratory distress, burns) and should seek medical attention.

4.6 Carbon Monoxide

4.6.1 Worst-Case Scenario and Resulting Harm

The Carbon Monoxide Gas Handling System receives, stores and provides surge capacity for high and low concentration carbonyl CO gases from the IPC process. Compressed high pressure CO is stored in the high-pressure gas storage tanks. A release of carbon monoxide from a complete failure of the high-pressure storage tank would constitute the worst-case scenario as prescribed by the Regulations. A Level III emergency would result. Weather conditions that limit the dispersion of the gas in the atmosphere would delay resolution of the emergency. ERG2016 Table 1 suggests an initial isolation distance of 200 m for a large release and a daytime downwind protection distance of 1,200 m (Figure 7). SAFER Case 159 also models a release of this nature and indicates a downwind travel distance of approximately 620 m.

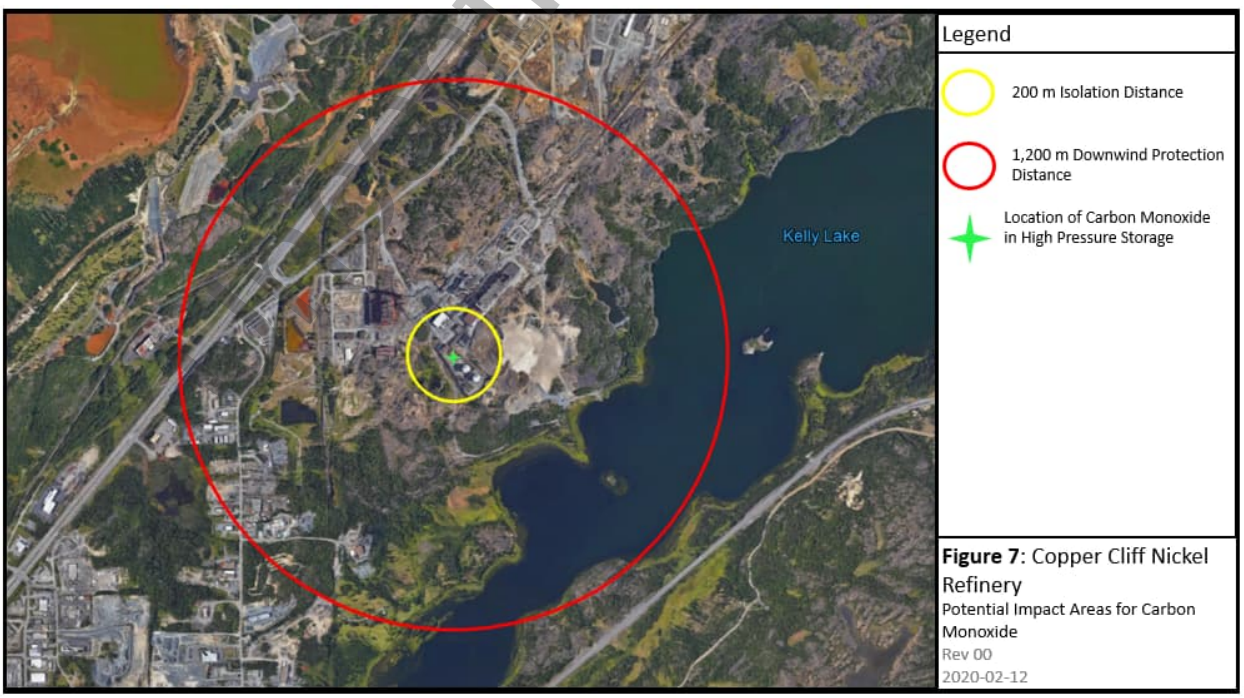


Figure 7: Copper Cliff Nickel Refinery
Potential Impact Areas for Carbon Monoxide
Rev 00
2020-02-12

Figure 7 Emergency Response Guidebook 2016 Isolation and Downwind Protection Distance for a Release of Carbon Monoxide

Since CO more readily binds to hemoglobin in the blood, it displaces oxygen and can cause death in exposed individuals if they are not brought to fresh air in time. All individuals exposed to CO must seek immediate medical attention. Due to the dissipation of CO in the atmosphere, environmental impacts are negligible.

4.6.2 Alternate Scenario and Resulting Harm

Process Gas Surge Tanks (PGSTs) receive high concentration carbonyl CO gas vents from the IPC process and provide surge capacity for the main gas compressors. There are two PGSTs located in the outside environment. The alternate scenario involving a release of carbon monoxide would result from a PGST vessel failure. This scenario would result in the site calling at Level III Emergency. SAFER Case 157 models a release of this nature and identifies a downwind travel distance of approximately 4,000 m.

As indicated above, CO displaces oxygen when inhaled by an exposed individual. Immediate medical attention is required following an exposure.

5 ENVIRONMENTAL EMERGENCY ACTIONS

5.1 Prevention

To prevent the release of any hazardous substance to the environment, there are several written documents that outline standard operations for the plants at the CCNR and the preventative controls in place to reduce the risk of a release and potential harm to people and the environment. Table 7 summarizes the list of relevant training manuals that discuss this information in detail and the corresponding sections where pertinent information can be found for each substance included in this Plan. Each manual provides information on good plant operations, implemented controls, alarms, interlocks and shutdowns, operating procedures, historical problems and potential causes as well as a summary of safety requirements that must be followed. Manuals can be accessed on Vale's Intranet at http://cator2valeas738:81/NR%20Navigation%20output/story_flash.html. The plants were also developed with several engineering design safeguards, use risk assessments, process hazard reviews and mandate substantial training for all areas of the site. Training requirements are detailed in section 7.0. In addition, rigorous preventative maintenance programs are implemented at the site to ensure all components of the plants are in proper working condition.

Table 7 CCNR Training Manuals

Substance	Title of Manual	Relevant Sections
Nickel Oxide	75NRCSO02.0 - MYN/FEN Receiving Mixing and Storage System	4.00 Evidence of Good Operation 5.00 Controlling the Step 5.50 Alarms, Interlocks and Shutdowns 6.00 Operating Procedure 8.00 Historical Problems 9.00 Safety
Nickel Carbonyl	75RCTSO03.0 - High Pressure Reactor System 75RCTSO11.0 - CO Gas Handling System	
Iron Pentacarbonyl	75RCTSO10.0 - B Liquid Handling and Vaporization System 75DECSO09.0 - Fe/Ni Pellet Production and Handling System	
Anhydrous Ammonia	75RCTSO13.0 - Carbon Monoxide Purification and Recovery System	
Carbon Monoxide	75RCTSO11.0 - CO Gas Handling System	

5.2 Preparedness

An emergency resulting from the release of any of the five substances included in this Plan may cause substantial harm to people and/or the environment. As such, Vale has several means of preparing for such an emergency. They include, but are not limited to:

- Copper Cliff Nickel Refinery Emergency Preparedness Manual (http://intranet.valepub.net/en/canada/Pages/Sudbury-Safety-Health-Environment/Emergency-Management.aspx)
- Copper Cliff Nickel Refinery Spill Prevention and Contingency Plan (http://intranet.valepub.net/en/canada/Pages/Sudbury-Safety-Health-Environment/Emergency-Management.aspx)
- Annual testing of emergency response plans

- Carbonyl monitors
- Ammonia sensor
- Training for all operators

In addition, the CCNR ensures that emergency and protective equipment is available if emergency response is required (Table 8).

Table 8 Emergency and Protective Equipment and Location

Emergency Equipment	Location	Quantity
SCBA (MSA MMR Firehawk 4500s)	3rd floor IPC Emergency Response area IPC Control Room Utilities Lunch room Utilities Maintenance & West Corner IPC Process Tech 5th Floor Lab Incinerator IPC Cooling Tower NRC Lab NRC Control Room MSA Shop (spares)	14 2 2 4 2 2 1 4 2 2
MSA MMR PremAires	3rd floor IPC Emergency Response area Utilities Maintenance & West Corner NRC Control Room	3 7 1
High Pressure Jumbo Cylinder Cascade Systems (for recharging SCBA cylinders)	3rd floor of IPC Emergency Response area Incinerator NRC Lab SCBA Service Shop 1st floor maintenance aisle 1st floor by Utilities (Maintenance aisle side)	1 1 1 1 1 1
Gas Analyzers	All Surface Safe Assembly Areas (Draeger pumps with associated tubes)	5

5.3 Response

The response that is required in the event of an emergency is outlined in detail in the Copper Cliff Nickel Refinery Emergency Preparation Manual. Table 9 indicates each emergency scenario defined in this Plan and the corresponding level of emergency that will be called. In addition to the emergency response procedures listed below, the site also maintains several standard procedures (SPs) for both the NRC and IPC that can be referenced in the event of a site emergency. A complete list of SPs can be found at http://cator2valeas732/CCSWeb/JobProcTestCCNR/ by searching from the List of Procedures by Job Class drop down menu.

Table 9 Summary of Emergency Scenarios and their Corresponding Level of Emergency

Substance	Scenario Type	Level of Emergency Called	Site Location
Nickel Oxide	Worst-Case	Level I	NRC Plant
	Alternate	No Level Called	
Nickel Carbonyl	Worst-Case	Level III	IPC Plant
	Alternate	Level III	
Iron Pentacarbonyl	Worst-Case	Level III	

Substance	Scenario Type	Level of Emergency Called	Site Location
	Alternate	Level I	
Anhydrous Ammonia	Worst-Case	Level III	
	Alternate	Level II or III	
Carbon Monoxide	Worst-Case	Level III	
	Alternate	Level III	

5.3.1 Nickel Refinery Converter Plant Emergency Response

5.3.1.1 Nickel Oxide

The worst-case scenario for the release of nickel oxide would result in the site calling a Level I Emergency. Because the substance is located at the NRC plant, the response would follow the Level I – NRC Emergency Procedure indicated in the Copper Cliff Nickel Refinery Emergency Preparedness Manual:

1. All CCNR personnel are notified of alert and wind direction by the plant Communication Centre. Notification is initiated by a 10 second sounding of the Emergency P.A. Tone Alert, followed by a message using the P.A. announcement and radio Emergency Channel.
2. Confined Space work will cease.
3. Personnel in the affected area will attempt to control the source, if safe to do so. The On-Scene Coordinator will assess the situation and direct the appropriate response.
4. Operational personnel will do the following:
   - The NRC Aisle Operator will notify the FEN truck drivers of the emergency and tell them to report to the Assembly Area.
   - The NRC operations personnel will remain on the job. (Refer to SOP C-01, Emergency Shutdown of Hot Metal Handling Systems during a Level I, II, III)
   - The Converter Operator will report to the Control Room.
   - Plant operation continues as required.
   - The Area Work Permit Book is to be sent to the Administration Building Assembly Area. The book may be used to help determine the location of any missing personnel.
5. All other personnel will report immediately to their designated Assembly Areas in the Administration Building. Personnel are accounted for and reported to the Accounting Centre. In a Level I event only, if work area is unaffected, employees may return to work after being accounted for. This is at the discretion of the On-Scene Coordinator.
6. The On-Scene Coordinator may call upon any NRC First Response personnel who are available. They should prepare for the possibility of being dispatched to the Main Gate with an SCBA and radio.
7. Once the emergency situation has been rectified, the Communications Centre will issue the “All Clear” message using the P.A. announcement and radio Emergency Channel.

The alternate scenario for a release of nickel oxide would be minor and as a result, there would be no level emergency called. Standard spill response would be followed and is outlined in the Copper Cliff Nickel Refinery Spill Prevention and Contingency Plan on the Vale Intranet site.

5.3.2 Inco Pressure Carbonyl Plant Emergency Response

5.3.2.1 Nickel Carbonyl

Both the worst-case and alternate scenario for the release of nickel carbonyl would result in the site calling a Level III Emergency. The response would follow the Level III – IPC Emergency Response Procedure that is outlined in the Copper Cliff Nickel Refinery Emergency Preparedness Manual as follows:

1. All CCNR personnel are notified of alert and wind direction by the plant Communication Centre. Notification is initiated by a 10 second sounding of the Emergency P.A. Tone Alert, followed by a message over the PA and the radio Emergency Channel. For a Level III event, the IPC "roof top" Emergency Air Horn and NRC Emergency Siren will run continuously during the event.
2. Flashing red lights and intermittent blasts of the evacuation horns may be initiated for IPC centered events.
3. Breathing air compressors, H&V's and auxiliary equipment may be shut down at the discretion of the Control Room Supervisor or On-Scene Emergency Coordinator or Supervisor.
4. Operating personnel (Emergency Responders: Reactor, Decomposer and Utilities operators) will:
   - Place any work-in–progress in a safe state.
   - Safely control the source of the emergency for an IPC centred event, otherwise report to respective Assembly Areas: Reactor and Decomposer operators to IPC Control Room; Utilities operators to Utilities Lunchroom.
5. Non-operating Emergency Responders (Shift Electrician, Shift Instrument Tech) will:
   - Place any work-in-progress in a safe state
   - Report to the IPC Control Room
6. All other personnel will place any work-in-progress in a safe state and report immediately to their designated Assembly Areas in the Administration Building. Packaging and Shipping employees will escort truck drivers to the Administration Dry Assembly Area. Personnel are accounted for and reported to the Accounting Centre. Personnel will remain in Assembly Area until the all clear is given.
7. Once the emergency situation has been rectified, the Communications Centre will issue the "All Clear" message over the PA and the radio Emergency Channel.

5.3.2.2 Iron Pentacarbonyl

The worst-case scenario for the release of nickel carbonyl would result in the site calling a Level III Emergency. The response would follow the Level III – IPC Emergency Procedure that is outlined in section 5.2.2.2 of the Copper Cliff Nickel Refinery Emergency Preparedness Manual as follows:

1. All CCNR personnel are notified of alert and wind direction by the plant Communication Centre. Notification is initiated by a 10 second sounding of the Emergency P.A. Tone Alert, followed by a message over the PA and the radio Emergency Channel. For a Level III event, the IPC "roof top" Emergency Air Horn and NRC Emergency Siren will run continuously during the event.
2. Flashing red lights and intermittent blasts of the evacuation horns may be initiated for IPC centered events.
3. Breathing air compressors, H&V's and auxiliary equipment may be shut down at the discretion of the Control Room Supervisor or On-Scene Emergency Coordinator or Supervisor.
4. Operating personnel (Emergency Responders: Reactor, Decomposer and Utilities operators) will:
   - Place any work-in–progress in a safe state.

- Safely control the source of the emergency for an IPC centred event, otherwise report to respective Assembly Areas: Reactor and Decomposer operators to IPC Control Room; Utilities operators to Utilities Lunchroom.

5. Non-operating Emergency Responders (Shift Electrician, Shift Instrument Tech) will:
   - Place any work-in-progress in a safe state
   - Report to the IPC Control Room
6. All other personnel will place any work-in-progress in a safe state and report immediately to their designated Assembly Areas in the Administration Building. Packaging and Shipping employees will escort truck drivers to the Administration Dry Assembly Area. Personnel are accounted for and reported to the Accounting Centre. Personnel will remain in Assembly Area until the all clear is given.
7. Once the emergency situation has been rectified, the Communications Centre will issue the "All Clear" message over the PA and the radio Emergency Channel.

The alternate scenario release would result in a Level I Emergency. The response would follow the steps outlined in section 5.2.2.1 under the Level I – IPC Emergency Procedure as follows:

1. All CCNR personnel are notified of alert and wind direction by the plant Communication Centre. Notification is initiated by a 10 second sounding of the Emergency P.A. Tone Alert, followed by a message and communication on the radio Emergency Channel.
2. Flashing red lights and intermittent blasts of the evacuation horns may be initiated for IPC centered events.
3. Breathing air compressors, H&V's and auxiliary equipment may be shut down at the discretion of the Control Room Supervisor or On-Scene Emergency Coordinator or Supervisor.
4. Operating personnel (Emergency Responders: Reactor, Decomposer and Utilities operators) will:
   - Place any work-in–progress in a safe state.
   - Safely control the source of the emergency for an IPC centred event, otherwise report to respective Assembly Areas: Reactor and Decomposer operators to IPC Control Room; Utilities operators to Utilities Lunchroom.
5. Non-operating Emergency Responders (Shift Electrician, Shift Instrument Tech) will:
   - Place any work-in-progress in a safe state
   - Report to the IPC Control Room
6. All other personnel will place any work-in-progress in a safe state and report immediately to their designated Assembly Areas in the Administration Building. Packaging and Shipping employees will escort truck drivers to the Administration Dry Assembly Area. Personnel are accounted for and reported to the Accounting Centre. In a Level I event only, if work area is unaffected, employees may return to work after being accounted for. This is at the discretion of the On-Scene Coordinator.
7. Once the emergency situation has been rectified, the Communications Centre will issue the "All Clear" message over the PA System and the radio Emergency Channel.

5.3.2.3 Anhydrous Ammonia

Both the worst-case and alternate scenario for the release of anhydrous ammonia would result in a Level III Emergency for the site. The response would follow the Level III – IPC Emergency Procedure that is outlined in section 5.2.2.2 of the Copper Cliff Nickel Refinery Emergency Preparedness Manual as follows:

1. All CCNR personnel are notified of alert and wind direction by the plant Communication Centre. Notification is initiated by a 10 second sounding of the Emergency P.A. Tone Alert, followed by a message over the PA and the radio Emergency Channel. For a Level III event, the IPC "roof top" Emergency Air Horn and NRC Emergency Siren will run continuously during the event.
2. Flashing red lights and intermittent blasts of the evacuation horns may be initiated for IPC centered events.
3. Breathing air compressors, H&V's and auxiliary equipment may be shut down at the discretion of the Control Room Supervisor or On-Scene Emergency Coordinator or Supervisor.
4. Operating personnel (Emergency Responders: Reactor, Decomposer and Utilities operators) will:
   - Place any work-in–progress in a safe state.
   - Safely control the source of the emergency for an IPC centred event, otherwise report to respective Assembly Areas: Reactor and Decomposer operators to IPC Control Room; Utilities operators to Utilities Lunchroom.
5. Non-operating Emergency Responders (Shift Electrician, Shift Instrument Tech) will:
   - Place any work-in-progress in a safe state
   - Report to the IPC Control Room
6. All other personnel will place any work-in-progress in a safe state and report immediately to their designated Assembly Areas in the Administration Building. Packaging and Shipping employees will escort truck drivers to the Administration Dry Assembly Area. Personnel are accounted for and reported to the Accounting Centre. Personnel will remain in Assembly Area until the all clear is given.
7. Once the emergency situation has been rectified, the Communications Centre will issue the "All Clear" message over the PA and the radio Emergency Channel.

In addition, the Site has a third-party contractor on standby at all times that is equipped to respond to any release of anhydrous ammonia.

5.3.2.4 Carbon Monoxide

Both the worst-case and alternate scenario for a release of carbon monoxide would result in a Level III Emergency for the site. The response would follow the Level III – IPC Emergency Response Procedure that is outlined in section 5.2.2.2 of the Copper Cliff Nickel Refinery Emergency Preparedness Manual as follows:

1. All CCNR personnel are notified of alert and wind direction by the plant Communication Centre. Notification is initiated by a 10 second sounding of the Emergency P.A. Tone Alert, followed by a message over the PA and the radio Emergency Channel. For a Level III event, the IPC "roof top" Emergency Air Horn and NRC Emergency Siren will run continuously during the event.
2. Flashing red lights and intermittent blasts of the evacuation horns may be initiated for IPC centered events.
3. Breathing air compressors, H&V's and auxiliary equipment may be shut down at the discretion of the Control Room Supervisor or On-Scene Emergency Coordinator or Supervisor.
4. Operating personnel (Emergency Responders: Reactor, Decomposer and Utilities operators) will:
   - Place any work-in–progress in a safe state.

- Safely control the source of the emergency for an IPC centred event, otherwise report to respective Assembly Areas: Reactor and Decomposer operators to IPC Control Room; Utilities operators to Utilities Lunchroom.

5. Non-operating Emergency Responders (Shift Electrician, Shift Instrument Tech) will:
   - Place any work-in-progress in a safe state
   - Report to the IPC Control Room
6. All other personnel will place any work-in-progress in a safe state and report immediately to their designated Assembly Areas in the Administration Building. Packaging and Shipping employees will escort truck drivers to the Administration Dry Assembly Area. Personnel are accounted for and reported to the Accounting Centre. Personnel will remain in Assembly Area until the all clear is given.
7. Once the emergency situation has been rectified, the Communications Centre will issue the "All Clear" message over the PA and the radio Emergency Channel.

5.4 Recovery

The Emergency Preparedness Manual outlines several components of recovery following the release of a hazardous material. Below is a summarized list of steps that should be considered following such a release.

5.4.1 Clean Up

An assessment of the impacts following the release of materials will be conducted to investigate areas that require clean up. Clean up is coordinated between the CCNR and the Environment department. A third-party contractor may be brought in to assist in remediating the site as required.

5.4.2 Post-Emergency Response Review

A thorough review of all aspects of response to an emergency will be conducted as soon as possible after the conclusion of operations. The post emergency review will examine:

- Activation of First Response team
- Activation of Emergency Response teams
- Communications
- Resource allocation
- Alert Call Centre response

A written report of the review findings will be produced after each Emergency Response and is to be forwarded to the Plant Manager and area OSHE Committee for review. Qualified company personnel will carry out all investigations. Where applicable, a member of the Emergency Preparation Committee should participant in the post review. Alternatively, Vale may decide that it may be appropriate to retain the services of qualified consultants and other service providers to conduct investigations of behalf of the company. The Emergency Preparation Committee will continue to audit the progress of the investigation's recommended actions once findings are made.

5.4.3 Repair of Damaged Equipment

All equipment damaged in an emergency will be repaired or replaced as required, including any emergency response equipment that was used to respond to the emergency.

5.4.4 Vale Internal Joint Investigations

Investigations are required to identify causes and ways to prevent future incidents. They are also required to satisfy company policy requirements. Investigations by Vale into the emergency are distinct and separate from the Post Emergency Response Review referred to in section 5.4.2 noted above. The Operating Superintendent in conjunction with the Worker Safety Representative ensures that investigations are initiated and followed through to completion.

- Root cause analysis of the emergency
- Safety investigation
- Environment investigation

The Operating Superintendent will continue to audit the progress of the investigation's recommended actions once findings are made.

5.4.5 Preliminary Reporting

For a LEVEL I, II, or III the CCNR On-Call person, with the On-Scene Co-ordinator, will collect and record all relevant information regarding the emergency event. A concise report will be prepared for review so that pertinent information is captured for the Plant Manager and Joint Safety Investigation Team, as required.

5.4.6 Post Level Event Emergency Response Debriefing Protocol

To continuously improve the response process, it is of particular importance that all CCNR services involved hold debriefing sessions where applicable for responders and plant management. Thus an inter-organizational debriefing session should be held in order to learn from the event in question and enhance the safety of people, environment, operation assets and property. Debriefing should strive to:

- Define the situation to which the Company has been exposed more accurately;
- Identify prevention and mitigation measures which could have been useful for that particular situation;
- Identify difficulties encountered;
- Gather necessary information for entries in the response log records and chronology;
- Measure the efficiency of the response and identify potential improvements;
- Gather necessary information for completion of the final report.

6 ROLES AND RESPONSIBILITIES

The roles and responsibilities are the same as those identified in the Copper Cliff Nickel Refinery Emergency Preparedness Manual.

6.1 Copper Cliff Nickel Refinery Manager

The CCNR Manager is accountable for the Nickel Refinery during an emergency situation. The CCNR Plant On-Call assumes this accountability outside of regular office hours or in the Manager's absence. The responsibility to manage an emergency situation has been delegated to the On-Scene Emergency Coordinator.

6.2 On-Scene Emergency Coordinator

The On-Scene Emergency Coordinator is the on-site person designated to manage an emergency event. By default, the role is held by the IPC Shift Supervisor for IPC centered events or the NRC Shift Supervisor for NRC centered events. The Shift Supervisor may also delegate the role during day-shift weekdays. Responsibilities include:

- Declaring emergency and level classification.
- Assuming responsibility over the emergency situation and activating emergency procedures.
- Assessing the situation and communicating the nature and level of the emergency and the chemicals involved to the Communication Centre.
- Directing personnel to shut down the operation and control the source of the emergency.
- Directing Emergency Response and/or First Response operations as required.
- Summoning external assistance and conveying notifications as required.
- Determining whether an emergency vehicle may drive through the red flashing warning light located at the IORP entrance. This decision must be relayed from the Alert Call Centre to the emergency vehicle dispatcher at the time of the request for emergency services.
- Executing the established procedures outlined in Section 5 as required by the situation.
- Determining changes to the level of emergency as the situation evolves (reductions and escalations).
- Communicating changes via the Communication Centre.
- Declaring the ALL CLEAR
- Ensuring the workplace is secure for re-entry.

6.3 IPC Emergency Response Team

The IPC Emergency Response Team is comprised of reactor operators, decomposer operators, utilities operators, shift electricians and Instrumentation personnel. IPC Emergency Responder Responsibilities include:

- Assembling in the Control Rooms (IPC and Utilities)
- Participating in any Emergency Response under the guidance of the On-Scene Coordinator.
- Removal of personnel located in harm's way.
- Serving as a knowledgeable guide for external emergency services (fire, police, EMS, HazMat responders) and meet them at a specified location, directing them to the scene.

- Obtain First Responder training (VES Course SSS500.75) qualification. Maintain associated Qualifications for SCBA use.

6.4 Protection Services Personnel

In an emergency Plant Services Personnel (PSPs) provide First Aid and accounting support for the plant during an emergency (Level I, II, III). Protection Services Personnel responsibilities include:

- Secure site.
- Convey Gatehouse Sign-in List names to the Plant-Wide Personnel Accountant:
  - Copy the list and hand it to the Main Dry Accountant (at Dry entrance) on dayshift.
  - Phone the names over to the Communication Centre on the backshift.
- Shutdown Administration building H&V's.
- Prepare to provide first aid, or urinalysis as may be required.
- Communicate whether an emergency vehicle may or may not drive through the red flashing warning light located at the IORP entrance. This will be communicated to the PSP by the Alert Call Centre or Control Room.

6.5 Communication Centre (IPC/NRC Control Room Supervisor)

The Control Room Supervisor runs the Communication Centre (IPC Control Room for IPC Events or NRC Control Room for NRC Events – Each control room is back up to the other). Communication Centre responsibilities include:

- Receiving calls advising of an emergency.
- Providing clearance to Alert Call Centre for Emergency Vehicles to travel past red light at IORP entrance.
- Declaring emergency and level classification
- Assisting/directing in operational shut downs and control of the emergency situation.
- Assisting in the assessment of the situation and communicating the nature and level of the emergency and the chemicals involved.
- Making the initial communications:
  - P.A. announcements
  - In-Plant Group Calls
  - Alert Call Center
  - Contact Sudbury Fire for Emergency Response
  - Contacts KRT (for Ammonia related events) for remediation requirements
- Activating local evacuation lights and horns.
- Activating the emergency air horns (Level III only),
- Summoning external assistance and conveying notifications as required.
- Executing the established procedures outlined in Section 5 as required by the situation.
- Communicating changes of emergency level classifications.
- On weekdays-dayshift, conducting/delegating local Assembly Area personnel accounting.
- On the backshift, conducting/delegating plant-wide personnel accounting.
- Communicating the ALL CLEAR when notified by the On-Scene Coordinator.
- Completing (or delegating) and returning documentation to the Emergency Management Coordinator for post emergency/drill evaluation
- Emergency Response Report (prepare for P.A. announcement)

- Emergency Response Checklist (prepare to call Alert Call Center)
- Personnel accounting

6.6 NRC First Response Team

The NRC First Response Team is comprised of NRC operators. NRC First Responder responsibilities include:

- One First Responder will assemble in control room others will assemble in the Administration Building.
  - If required they will be dispatched to Gatehouse for escorting emergency services; If not required they will remain in the CCNR Administration Dry Assembly Area.
- Removal of personnel located in harm's way under the guidance of the On-Scene Coordinator.
- Follow instructions by Control Room Supervisor and On-Scene Coordinator.
- Serve as a knowledgeable guide for external emergency services (fire, police, EMS). Meet them at a specified location and direct them to the scene.
- Obtain First Responder training (VES Course SSS500.75) qualification. Maintain associated qualifications SCBA use.

6.7 Plant-Wide Personnel Accountant

Plant-wide Personnel Accountants have been selected (and back-up individuals designated) to cross-reference the information obtained from Assembly Area Coordinators in order to determine who may be missing. In the absence of a designated individual, someone else must assume this responsibility. Instructions are on the prepared plant personnel list. Plant-wide Personnel Accountant responsibilities include:

- Obtaining the names of those who are suspected "missing" and those who are in "addition" to the expected occupants (contractors, visitors) of all Assembly Areas:
  - Dayshift weekdays (Administration Conference Room #1):
    - Phones remote Assembly Area Coordinators.
    - Distributes accounting lists to be passed along each Main Dry Assembly Area aisle and collects them.
    - The Main Dry Contractor Assembly Coordinator does all Gatehouse Sign-in List cross-referencing. Expect to receive final results.
  - Backshift (Communication Centre):
    - Receives calls from remote Assembly Area Coordinators.
    - Contacts the Admin Dry Assembly Area with IPC Control Room direct line telephone, if necessary.
    - Receives a call from the Plant Security Officer who conveys the Gatehouse Sign-in List names.
    - Cross-references all plant personnel to determine who is missing.
    - Cross-references any additional Gatehouse Sign-in List names.
    - Assesses the likelihood of those individuals who are suspected to be missing as actually missing and conveys that information to the On-Scene Coordinator.
    - Completes and returns all personnel accounting documentation to the Emergency Management Coordinator for post emergency/drill evaluation.

6.8 Assembly Area Coordinator

Assembly Area Coordinators (and back-up individuals) have been selected to take charge of Assembly Areas. In the absence of a designated individual, someone else must assume this responsibility. Instructions are on the prepared plant personnel list. Assembly Area Coordinator responsibilities include:

- Accounting for all plant personnel arriving at the Assembly Area with the use of the prepared accounting list.
- Cross references and highlights on Assembly Area listing any missing personnel.
- Conveys above information to the Plant-wide Accountant:
  - Dayshift weekdays:
    - Expect Administration Conference Room #1 to call. (For Main Dry, deliver it upstairs)
  - Backshift:
    - Calls the Communication Centre
- Designates someone to take the required action to secure the Assembly Area (i.e. seal trailer, shut down H&Vs or use Drager air samplers).
- Carries out any additional duties assigned by the Communication Centre.
- Completes and returns documentation to the Emergency Management Coordinator for post emergency/drill evaluation:
- Personnel accounting lists
- Emergency Incident Report (Admin Conf. Rm. #1 only).

6.9 Non-Essential Personnel

Non-essential personnel consist of CCNR personnel who are not directly involved in the emergency as well as those on the Gatehouse Sign-in List (contractors, delivery people, non-CCNR VALE personnel, salesmen, consultants, etc.). Non-Essential Personnel Responsibilities:

- Go to your designated Assembly Area. Ensure that you get yourself checked off the prepared list
- Go to another designated Assembly Area, only if necessary. Declare yourself as an “additional” to the Assembly Area Coordinator.
- Special case: If you are in the Administration building during an event, recognize that there are two possible Assembly Areas:
  - If you are normally accounted for in the Admin building (Dry or #1 Conference Rm.), go there - this simplifies the accounting task.
  - If you are not normally accounted for in the Admin building, go to #1 Conference Rm. and declare yourself as "Additional". Do not go into the plant.
- Proper behaviour is required - stay quiet and do not create unnecessary distractions.
- Follow instructions given by the Assembly Area Coordinator.
- Be prepared if called upon to provide any expertise that the Emergency On-Scene Coordinator may require.

6.10 Reporting the Release to the Spills Action Centre

Following a release of any of the substances included in this plan, the Plant On-Call employee is required to contact Environment On-Call. Environment On-Call will determine if the release or spill of materials is reportable. If deemed reportable, the Environment Manager, Environment On-Call, or their designate will report the release to the Spills Action Centre (SAC).

7 TRAINING

All CCNR employees receive annual emergency and fire safety training. Individuals who are part of the emergency response teams for the NRC plant and IPC plant are required to annually complete the First Response Review (SSS500.75) for their respective plant as well as complete the MSA SCBA (SRP 4500) Operation and Full-Face Mask Fit Test.

In addition, NRC and IPC operators are required to complete extensive field training before they are permitted to operate in the plant. This training includes approximately 50-60 weeks of in-class and in-field training for reactor/decomposer operators that is outlined in the course syllabi and can be accessed at Z:\Environmental Reporting\E2 2019\CCNR - Working Folder E2 Plan\Supporting Documentation.

8 NOTIFICATIONS AND ALERTS

8.1 Potential Environmental Emergencies

Vale utilizes several different means of communicating with the public. Examples include, but are not limited to:

- Vale Open Houses (i.e. during Emergency Preparation Week)
- Information Pamphlets
- Posters

Information on potential environmental emergencies, as defined in the Regulations and applicable to the CCNR Complex, will be provided to the community using one of the above means of communication and will specifically address the hazards associated with each substance included in this Plan. In addition, it will identify all scenarios that are most likely to occur at the site and the corresponding potential effects that could be anticipated. The public will be made aware of the emergency response procedures outlined in this Plan (section 5.3 Response) and will be advised of how Vale will communicate an emergency should it occur. All information contained in this plan will be communicated by the Corporate and Indigenous Affairs Specialist.

8.2 Actual Environmental Emergencies

The public will be notified only in the event of a Level III Emergency for a release of hazardous substances included in this Plan. Once the site has determined that a Level III Emergency has been called, the Communication Centre (IPC Control Room) will notify the Alert Call Centre (Smelter #1 First Aid). The Alert Call Centre is responsible for contacting all other plants using the Vale Notification System. The Alert Call Centre also notifies the Sudbury 911 Communication Centre which in turn activates Sudbury Alerts. It is through Sudbury Alerts that the public is notified of the Level III emergency (Figure 8).

This Plan is available on the Vale Emergency Management Intranet site (http://intranet.valepub.net/en/canada/Pages/Sudbury-Safety-Health-Environment/Emergency-Management.aspx) and any environmental emergency involving the scenarios included in this Plan that have the potential to impact the public will require notifications to be made.

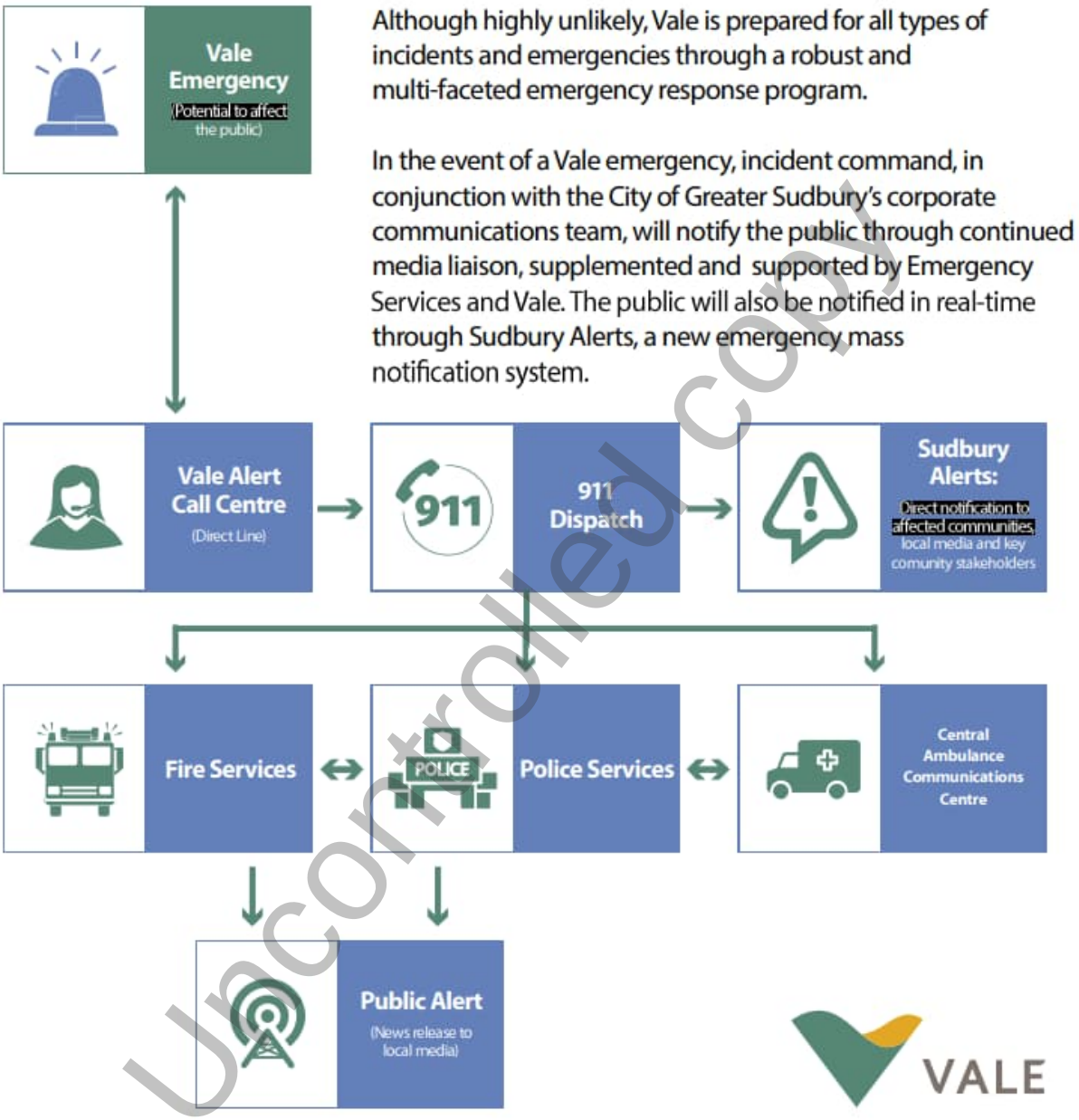
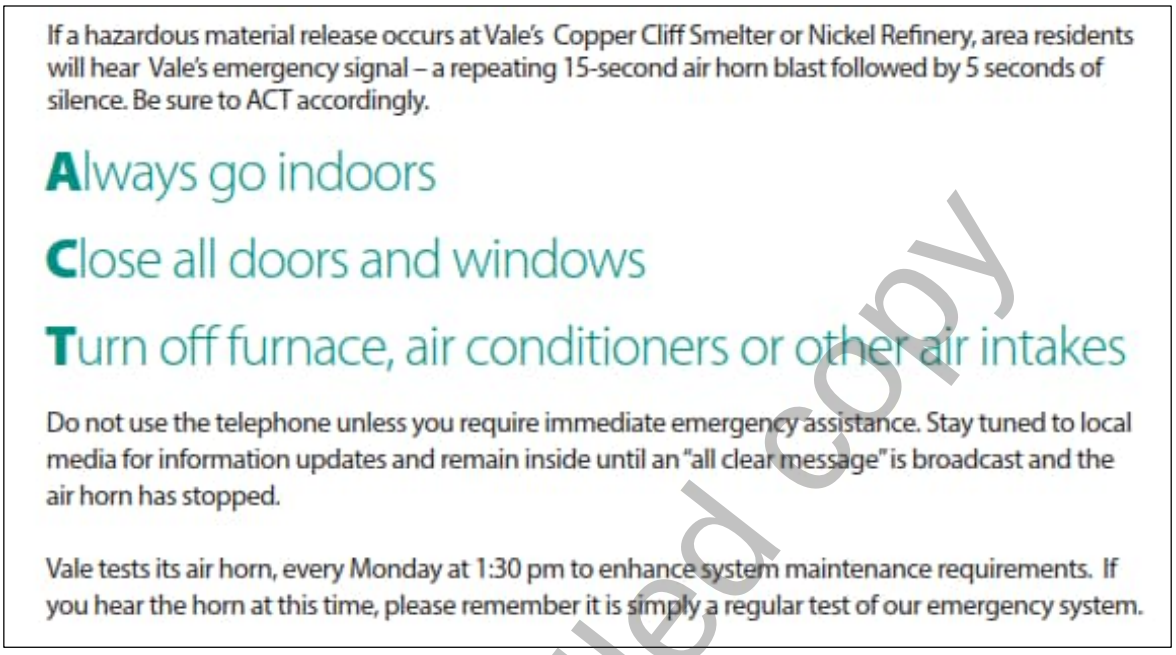


Figure 8 Vale Emergency Notification Protocol

In addition, the air horn at CCNR will be activated, and the ACT message (Figure 9) will be made available on the Vale public website at:

http://www.vale.com/canada/EN/aboutvale/communities/sudbury/health-and-safety/Pages/default.aspx



If a hazardous material release occurs at Vale's Copper Cliff Smelter or Nickel Refinery, area residents will hear Vale's emergency signal – a repeating 15-second air horn blast followed by 5 seconds of silence. Be sure to ACT accordingly.

Always go indoors

Close all doors and windows

Turn off furnace, air conditioners or other air intakes

Do not use the telephone unless you require immediate emergency assistance. Stay tuned to local media for information updates and remain inside until an "all clear message" is broadcast and the air horn has stopped.

Vale tests its air horn, every Monday at 1:30 pm to enhance system maintenance requirements. If you hear the horn at this time, please remember it is simply a regular test of our emergency system.

Figure 9 ACT - What to Do in the Event of a Hazardous Materials Release (Level III Emergency)

External notification to regulators will be completed by Environment On-Call or their designate and all required follow up will be coordinated through the Environment Department.

8.3 Consultation with Local Authorities

The contents of this plan have not been directly communicated to local authorities. However, Vale has a notification system that is initiated in the event of a Level III emergency that contacts the Sudbury 911 Communication Centre. In the event that the public could be affected following the release of hazardous materials, local police and emergency services will be deployed to set up road closures and other means of protecting the public as required.

9 REVISION HISTORY

Version Number	Date	Revision Type	Content	Reason for Edit	Name	Approver
—	21 Feb 2020	Original	E2 Plan	Plan preparation; first draft	—	—
—	19 Apr 2021	Review	E2 Plan	No updates required	—	—
—	29 Nov 2022	Update	E2 Plan	Update Emergency Response Procedure to contact Sudbury Fire for Emergency Response.	—	—
00	1 Jan 2023	Uploaded to SISPAV	E2 Plan	Integration into ISO 14001	A. Corson	N. Jones; L. Lanteigne

*If no changes come out of annual plan review, a revision record must still be entered. Include the date of revision and a note that no changes resulted from annual plan review

Appendix A – Safety Data Sheets

Distributed by:
Vale Canada Limited
200 Bay St., Royal Bank Plaza
Suite 1600, South Tower, PO Box 70
Toronto, Ontario
Canada, M5J 2K2
Email: msds@vale.com

Imported by:

In North & South America
Vale Americas Inc.
140 E. Ridgewood Avenue
Suite 415, South Tower
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Route de Pallatex 29
1162 Saint-Prex
Switzerland

EU REACH Contact
Vale Europe Limited
Clydach,
Swansea
SA6 5QR
Telephone number: +44 (0) 1792 8412501
Email: REACH@vale.com

For Fire, Spill, or chemical emergency call CHEMTREC: +1 703 527-3887
for Europe call CHEMTREC: +(44) 870 8200418

Section 2. Hazards Identification

2.1 Classification of the Substance:

Acute toxicity inhalation – Category 4
Skin Sensitization – Category 1
Respiratory Sensitization – Category 1
Carcinogenicity – Category 1A
Specific Target Organ Toxicity, Repeated exposure – Category 1
Aquatic Chronic – Category 3

Hazard Pictograms:	GHS07 - Exclamation mark, GHS08 - Health Hazard,
Signal Word:	Danger
Hazard Statements:	H332 – Harmful if inhaled H317 - May cause an allergic skin reaction H334 – May cause allergy or asthma symptoms or breathing difficulties if inhaled H350 - May cause cancer by inhalation

H372 - Causes damage to lungs through prolonged or repeated inhalation exposure
H412 –Harmful to aquatic life with long lasting effects.

Precautionary Statements: P201, P202, P260, P261, P264, P270, P271, P272, P273, P280, P284, P302+P352, P304+P340, P308+P313, P333+P313, P314, P321, P342+P311, P362+P364, P405, P501

2.2: Label elements

Product identifier: Nickel Oxide
CAS #: 1313-99-1 / 11099-02-8
Symbols:

GHS07 - Exclamation mark

GHS08 - Health Hazard

Signal Word: Danger

Hazard Statements:
H332 – Harmful if inhaled
H317 - May cause an allergic skin reaction
H334 – May cause allergy or asthma symptoms or breathing difficulties if inhaled
H350 - May cause cancer by inhalation
H372 - Causes damage to lungs through prolonged or repeated inhalation exposure
H412 –Harmful to aquatic life with long lasting effects.

Precautionary Statements:
P202 – Do not handle until all safety precautions have been read and understood
P261 - Avoid breathing dust or fume; Wear respiratory protective equipment if fine dusts are generated
P273 - Avoid release to the environment.
P302+P352 - If on skin: Wash with plenty of soap and water.
P501 - Dispose of contents/container in accordance to local/regional/national/international regulations

(Note: P-statements have been reduced)
For full text of Precautionary statements see section 15.

Section 3. Composition

☒ **Substance** ☐ **Mixture**

Typical Analysis:

Hazardous Ingredients	Typical Composition (%)	C.A.S. Number	EINECS/EC Label No.
Nickel Oxide (NiO)	90-96	1313-99-1	215-215-7
Copper Oxide (CuO)	0.2-9.0	1317-38-0	215-269-1
Cobaltous Oxide (CoO)	0.5- 1.5	1307-96-6	215-154-6
Nickel hydroxide	0 – 0.5	12054-48-7	235-008-05

Section 4. First Aid Measures

Ingestion: No specific first aid required.

Inhalation: No specific first aid required.

Skin: Remove contaminated clothing, and wash affected areas thoroughly with soap and water. If skin irritation or rash occurs: Get medical advice/attention. Show label if possible.

Eyes: Irrigate eyeball thoroughly with water for at least 10 minutes. If discomfort persists seek medical attention.

Most important symptoms and affects, both acute and delayed Skin contact: Rash
Eye contact: Redness

Indication of immediate medical attention and special treatment needed No special requirements

Section 5. Fire Fighting Measures

Suitable extinguishing media: Any, type to be selected according to materials stored in the immediate neighbourhood.

Special risks: Non-flammable. Extinguish surrounding fires with appropriate methods.

Special protective equipment for fire fighting: None needed. Wear protective equipment if required for other materials within the immediate vicinity.

Section 6. Accidental Release Measures

Person related precautionary measures:	Avoid generation of dusty atmospheres. Do not inhale dusts. Contaminated work clothing should not be allowed out of the workplace. Use personal protective equipment as required. Wash hands, and face thoroughly after handling.
Environmental Protection measures:	Spillages and uncontrolled discharges must be prevented from entering waterways.
Procedures for cleaning/absorption:	Pick up and replace in original container. Nickel-containing material is normally collected to recover nickel values.

Section 7. Handling And Storage

Precautions for Safe Handling:	Prevent the generation of inhalable dusts e.g. by the use of suitable ventilation. Do not inhale dust. Wear appropriate nationally approved respirators if handling is likely to cause the concentration limits of airborne nickel to exceed the locally prescribed exposure limits. Wear suitable protective clothing and gloves. Contaminated work clothing should not be allowed out of the workplace
Conditions for Safe Storage:	Keep in the container supplied, and keep container closed when not in use. Local regulations should be followed regarding the storage of this product.

Section 8. Exposure Controls / Personal Protection

8.1.1 Exposure Limits:

Nickel Oxide (NiO) – CAS 1313-99-1		
	Exposure Limit (mg/m^3)	Year
ACGIH TLV-TWA [1]	0.2 * ‡ as Ni	2008
UK WEL [2]	0.5 as Ni	2011
Japan	1 as Ni	2012
Korea	0.1 as Ni	2006
China	1 as Ni	2007

* Inhalable fraction
‡ Insoluble inorganic fraction

DNEL's

	Unit	DNEL
Dermal		
Long-term local	mgNi/cm^2/day	0.035
Inhalation		
Acute local	mgNi/m^3	11.9
Long-term systemic	mgNi/m^3	0.05

Long-term local	mgNi/m^3	0.05

8.1.2 Environmental Limits:

PNEC's

Compartment	Unit	PNEC
Freshwater	µg Ni/L (bioavailable)	7.1
Sediment (freshwater)	mg Ni/kg	109
Marine water	µg Ni/L	8.6
Sediment (marine	mg Ni/kg	109
Agricultural soil	mg Ni/kg	29.9

8.2.1 Occupational exposure controls:

Do not inhale dust. Mechanical extraction ventilation may be required if user operations change it to other physical or chemical forms, whether as end products, intermediates or fugitive emissions, which are inhalable. Maintain airborne nickel levels as low as possible. Avoid repeated skin contact.

PPE

Respiratory protection: If required, use an approved respirator with particulate filters.

Eye protection: None

Hand & Skin Protection: Wear suitable protective clothing and gloves, which should be selected specifically for the working place, depending on concentration and quantity of the hazardous material (overalls and leather/rubber gloves). Wash skin thoroughly after handling and before eating, drinking or smoking. Change contaminated clothing frequently. Launder clothing and gloves as needed. Use of skin-protective barrier cream advised.

Section 9. Physical And Chemical Properties

Solid, granular dark grey material.

Physical state at 20°C and 101.3 kPa	Solid
Melting / freezing point	>1900°C
Boiling point	Not applicable
Decomposition temperature	Not applicable
Relative density	6.75g/cm^3 at 20°C
Vapour pressure	Not applicable
Vapour density	Not applicable
Surface tension	Not applicable

Water solubility	3.52x10^{-5} g/l at 20°C (typical for green nickel oxide)
pH	Not applicable
Evaporation rate	Not applicable
Partition coefficient n-octanol/water (log value)	Not applicable
Flash point	Not applicable
Flammability	Non-flammable
Explosive properties	Not applicable
Self-ignition temperature	>400°C
Oxidising properties	Non-oxidising
Granulometry	<0.1% of particles with a diameter <100µm
Stability in organic solvents and identity of relevant degradation products	Not applicable
Dissociation constant	Not applicable
Viscosity	Not applicable
Packaged density	See relative density

Section 10. Stability And Reactivity

Reactivity:	Stable under normal conditions.
Chemical stability:	Stable under normal conditions.
Possibility of hazardous reactions:	Stable under normal conditions.
Conditions to avoid:	None.
Incompatible materials:	None.
Hazardous Decomposition Product(s):	No information available

Section 11. Toxicological Information[3]

As a mixture the toxicological properties of this product are unknown. The toxicology of the reported ingredients are summarized below.

Nickel Oxide

Acute Toxicity:

a) Oral: Non toxic - LD_{50} ORAL RAT >11,000 mg/kg (green); 9,990 (black)

b) Inhalation: Non toxic - LD_{50} INHAL RAT >5.08 mg/m^3 (green); >5.15 mg/m^3 (black)

c) Dermal: No information available.

Corrosivity/Irritation:
a) Respiratory Tract: No classification

b) Skin: Not corrosive/irritating.

c) Eyes: Mildly irritating.

Sensitization:
a) Respiratory tract: Nickel metal induced asthma is very rare. 3 case reports are available; the data is not sufficient to conclude that nickel metal is classified as a respiratory sensitizer.

b) Skin: Nickel oxide is currently classified as a dermal sensitizer according to the 1st ATP to the CLP Regulation. Recent studies evaluating the bioaccessibility of a series of nickel compounds in synthetic sweat indicated very low nickel ion release from nickel oxide suggesting very low or no sensitization potency. Early Guinea pig maximization and Beuhler test results show low potential for nickel oxide to act as a dermal sensitizer.

c) Pre-existing conditions: Individuals known to be allergic to nickel should avoid contact with nickel whenever possible to reduce the likelihood of nickel allergic contact dermatitis reactions (skin rashes). Repeated contact may result in persistent chronic palmar/hand dermatitis in a smaller number of individuals, despite efforts to reduce or avoid nickel exposure.

Chronic toxicity:
a) Oral: No information available

b) Inhalation: Exposure related toxicities were noted following 13 weeks and two years of exposure to nickel oxide in both rats and mice in the US NTP chronic rat inhalation study. Adverse effects in rodents were primarily limited to the lung (*e.g.*, increased tissue weight, inflammation, macrophage hyperplasia). The LOAEC from the chronic study in rats was 0.6 mg NiO/m^3 or 0.5 mg Ni/m^3.

c) Dermal: No information available.

Mutagenicity / Reproductive toxicity: Not classified for reproductive/developmental toxicity. Not classified for mutagenicity.

Carcinogenicity:
a) Ingestion: No information available. Not classified
b) Inhalation: Cat. 1A; Human epidemiological and animal data suggest that at least some forms of nickel oxide can be carcinogenic to the respiratory tract of humans after inhalation.

Cobaltous Oxide (CoO)

Acute toxicity oral: LD_{50} ORAL RAT: 202 mg/kg

Inhalation: Causes irritation to the respiratory tract, symptoms may include coughing, shortness of

breath, and nausea. Respiratory hypersensitivity, asthma may appear. Inhalation of cobalt dust and fumes is associated with an increased incidence of lung disease.

Ingestion: Causes abdominal pain, nausea, vomiting, flushing of the face and ears, mild hypotension, rash, and ringing in the ears. May have cumulative toxic action where elimination cannot keep pace with absorption. Large amounts depress erythrocyte production.

Skin Contact: May cause dermatitis. Cause irritation to skin. Symptoms include redness, itching, and pain.

Eye Contact: Causes irritation, redness, and pain.

Chronic Exposure: Repeated oral administration may produce goitre and reduced thyroid activity. Prolonged or repeated skin exposure may cause dermatitis. Chronic exposure associated with kidney, heart and lung damage.

Pre-existing Conditions: Persons with pre-existing skin disorders or eye problems, or impaired liver, kidney or respiratory function may be more susceptible to the effects of the substance. Persons with allergies or sensitivity to cobalt may also be more susceptible to the effects of the substance.

Nickel Hydroxide
No information currently available.

Copper Oxide
Acute toxicity oral: LD_{50} ORAL RAT: >2500 mg/kg

Inhalation: Copper fume, dusts and mists from copper ore smelting and related metallurgical operations have been associated with irritations of the respiratory tract and metal fume fever. Symptoms of metal fume fever include chills, fever and sweating.

Ingestion: No data available

Skin Contact: Not classified for skin irritation or corrosion

Eye Contact: Causes immediate irritation and conjunctival inflammation, which will subside without permanent damage soon after the eye is cleansed by irrigation

Pre-existing Conditions: Wilson's disease can occur in certain individuals with a rare, inherited metabolic disorder characterized by retention of excessive amounts of copper in the liver, brain, kidneys and corneas. These deposits eventually lead to tissue necrosis and fibrosis, causing a variety of clinical effects, especially liver (i.e. hepatic) disease and neurologic changes. Wilson's disease is progressive and, if untreated, leads to fatal liver (i.e. hepatic) failure.

Section 12. Ecological Information

Toxicity	Aquatic Chronic 3. May cause long lasting harmful effects to aquatic life.
Persistence and degradability	The PBT and vPvB criteria of Annex XIII to the Regulation do not apply to inorganic substances, such as nickel oxide. The methods for determining the biological degradability are not applicable to inorganic substances.
Bioaccumuative potential	Nickel does not tend to bioaccumulate or biomagnify in aquatic or terrestrial systems.
Mobility in soil	The substance is essentially insoluble in water.
Results of PBT and vPvB assessment	Not classified as PBT or vPvB.
Other adverse effects	None anticipated.

Section 13. Disposal Considerations

Waste treatment methods	Recover or recycle if possible. Dispose of contents in accordance with local, state or national legislation.
Additional Information	No information available.

Section 14. Transport Information

International Maritime Dangerous Goods Code	Not regulated.
International Civil Aviation Organization Technical Instructions for the Carriage of Dangerous Goods by Air	Not regulated.
U.S. Dept. of Transportation Regulations	Not regulated.
Canadian Transportation of Dangerous Goods Act	Not regulated.
European Agreement Concerning the International Carriage of Dangerous Goods by Road	Not regulated.

MARPOL Annex V
Under the 7 Criteria contained within the MARPOL Annex V, This material is classified as:

	Harmful to the Marine Environment (HME)
X	**Not Harmful to the Marine Environment (non-HME)**

Section 15. Regulatory Information

Europe:
REACH Registration #'s:
01-2119467172-41-XXXX – Vale Europe Limited
01-2119467172-41-XXXX – Vale Japan Limited (Vale Europe Limited acting as Only Representative)

Exposure Scenarios: See Annex 1

Classification according to Part 3 of Annex VI of EU Regulation No. 1272/2008
Acute toxicity inhalation – Category 4
Skin Sensitization – Category 1
Respiratory Sensitization – Category 1
Carcinogenicity – Category 1A
Specific Target Organ Toxicity, Repeated exposure – Category 1
Aquatic Chronic – Category 3

Symbols:
GHS07 - Exclamation mark GHS08 - Health Hazard


Signal Word: Danger

Hazard Statements:
H332 – Harmful if inhaled
H317 - May cause an allergic skin reaction
H334 – May cause allergy or asthma symptoms or breathing difficulties if inhaled
H350 - May cause cancer by inhalation
H372 - Causes damage to lungs through prolonged or repeated inhalation exposure
H412 –Harmful to aquatic life with long lasting effects.

Precautionary Statements:
Prevention:
P201 - Obtain special instructions before use
P202 - Do not handle until all safety precautions have been read and understood

P260 - Do not breathe dust or fume
P261 - Avoid breathing dust or fume; Wear respiratory protective equipment if fine dusts are generated.
P264 - Wash hands, and face thoroughly after handling.
P270 - Do not eat, drink or smoke when using this product.
P271 – Use only outdoors or in a well-ventilated area
P272 - Contaminated work clothing should not be allowed out of the workplace.
P273 - Avoid release to the environment.
P280 - Wear protective gloves and protective clothing
P284 – [In case of inadequate ventilation] wear respiratory protection

Response:
P302+P352 - If on skin: Wash with plenty of soap and water.
P308+P313 - If exposed or concerned: Get medical advice/attention
P304+P340 – IF INHALED: remove person to fresh air and keep comfortable for breathing
P333+P313 - If skin irritation or rash occurs: Get medical advice/attention.
P314 - Get medical advice/attention if you feel unwell.
P321 - See Safety Data Sheet for specific treatment
P342+P311 – If experiencing respiratory symptoms: Call a POISON CENTER/doctor
P362+P364 – Take off contaminated clothing and wash it before reuse

Storage:
P405 - store locked up

Disposal:
P501 - Dispose of contents/container in accordance to local/regional/national/international regulations

Canada:
WHMIS 2015 Classification:
Acute toxicity inhalation – Category 4
Skin Sensitization – Category 1
Respiratory Sensitization – Category 1
Carcinogenicity – Category 1A
Specific Target Organ Toxicity, Repeated exposure – Category 1

United States of America:
Hazardous by definition of Hazard Communication Standard (29 CFR 1910.1200)
This product contains *NICKEL* which is subject to the reporting requirements of Section 313 of the Emergency Planning and Community Right-to-Know Act of 1986 and of 40 CFR 372. Refer to the Hazardous Ingredients section of this MSDS for the appropriate CAS numbers and percent by weight.
All components are listed on the US Toxic Substances Control Act (TSCA) inventory

Australia:
Classified as Hazardous according to ASCC criteria
All components are listed on the Australian Inventory of Chemical Substances (AICS)

P.R. Korea:
All components are listed in the Korean Toxic Substances Control Act inventory; KE-25818

Philippines:
All components are listed in the Philippine Inventory of Chemicals and Chemical Substances (PICCS)

Japan:
All components are listed in the Japanese Handbook of Existing and New Chemical Substances.

P.R. China:
All components are listed in the Inventory of Existing Substances in China (IECSC).

Section 16. Other Information

Indications of Change

1.0 – Original Document
2.2 – Formatting Changes
3.0 – Added new GES title to Annex I, Update P-Statements
4.0 – Removal of classification according to Directive 67/538/EEC, update of DNELs
4.1 – Corrections in DNEL table
5.0 – Updated exposure scenarios and for compliance with EU CLP/WHMIS 2015
6.0 – Classification update for cobalt oxide impurity for acute toxicity and respiratory sensitisation

The following acronyms may be found in this document:

ACGIH	American Conference of Governmental Industrial Hygienists
DNEL	Derived No Effect Level
LTEL	Long Term Exposure Limit
LR	Lead Registrant
MMAD	Mass Median Aerodynamic Diameter
NIOSH	National Institute of Occupational Safety and Health
OEL	Occupational Exposure Limits
OR	Only Representative
OSHA	Occupational Safety and Health Administration
PBT	PBT: Persistent, Bioaccumulative and Toxic

PNEC	Predicted No Effect Concentration
STEL	Short Term Exposure Limit
STOT	Specific Target Organ Toxicity
TLV-TWA	Threshold Limit Value – Time Weighted Average
vPvB	very Persistent and very Bioaccumulative
WEL	Workplace Exposure Limit (UK HSE EH40)

Safety Data Sheet prepared by:
Vale Canada Limited
200 Bay St., Royal Bank Plaza
Suite 1600, South Tower, PO Box 70
Toronto, ON
Canada, M5J 2K2
msds@vale.com

SDS available online at http://www.vale.com/canada/en/business/mining/nickel/pages/default.aspx

Note:
Vale Canada believes that the information in this Safety Data Sheet is accurate. However, Vale Canada makes no express or implied warranty as to the accuracy of such information and expressly disclaims any liability resulting from reliance on such information.

1. Threshold Limit Values of the American Conference of Governmental Industrial Hygienists. 2016
2. Maximum Exposure Limit of the Health and Safety Executive in the U.K. in EH40/2005.
3. Describes possible health hazards of the product supplied. If user operations change it to other chemical forms, whether as end products, intermediates or fugitive emissions, the possible health hazards of such forms must be determined by the user.

ANNEX 1 – Exposure Scenarios

Exposure Scenarios can be obtained by clicking on the following link: Vale Nickel Oxide Exposure Scenarios. Exposure Scenarios are listed on the page according to GES # and by language.

If you are unable to retrieve the document or have difficulties, please contact one of the following email addresses for assistance: REACH@vale.com or msds@vale.com

ES2-F1 - Use of nickel oxide for the formulation of nickel oxide-containing catalysts and catalyst precursors
ES3-Is1 - Use of nickel oxide-containing catalysts
ES4-Is2 - Industrial use of nickel oxide-containing catalyst precursors for the manufacture of other nickel substances in catalysts
ES5-IS3 - Use of nickel oxide for the manufacture of nickel-containing powders
ES6-IS4 - Use of nickel oxide for the manufacture of nickel-containing frits
ES7- IS5 - Use of nickel oxide for the manufacture of nickel-containing inorganic pigments
ES8- IS6 - Use of nickel oxide for the manufacture of nickel-containing glass
ES9- IS7 - Use of nickel oxide sinter in the production of stainless, special steels and special alloys
ES11- IS9 - Use of nickel oxide for the production of nickel-containing electronics and thermally functioning ceramics
ES12 – IS10 - Use of nickel oxide for the production of nickel-zinc ferrite cores
ES13 – SL-IS1 - Service life of nickel-containing electronics/ferrite cores in industrial settings
ES14- SL-PW1 - Service life of nickel-containing electronics/ferrite cores in professional settings
ES15-SL-C1 - Service life of nickel-containing electronics/ferrite cores (consumers)
ES16_IS12 - Production of nickel oxide-containing automotive catalysts
ES17-SL-IS2 - Service life of manufacture of vehicle exhaust system in industrial settings
ES18-SL-PW2 - Service life of manufacture of vehicle exhaust system in professional settings
ES19-SL-C2 - Catalyst application in vehicles

SAFETY DATA SHEET

CCNR - IPC Pure Carbonyl

Section 1. Identification

Product identifier : CCNR - IPC Pure Carbonyl

Product code : 1989-1084

Chemical name : tetracarbonylnickel

Other means of identification : nickel tetracarbonyl; Nickel carbonyl, (T-4)-; Nickel carbonyl (Ni(CO)4), (beta-4)-; Nickel carbonyl (as Ni); Nickel carbonyl; Nickel carbonyl (Ni(CO)4), (T-4)-; NICKEL CARBONYL Ni(CO)4, (T-4)-; Nickel carbonyl (tetracarbonylnickel); Nikel tetracarbonyl; Tetracarbonyl nickel(0); Carbonyl nickel

Product type : Liquid.

Relevant identified uses of the substance or mixture and uses advised against

Identified uses
Not available.

Uses advised against

Supplier's details : Vale Canada Limited - Ontario Operations
Copper Cliff, Ontario
P0M 1N0

Emergency telephone number (with hours of operation) : (705) 682-6622 - Number 1 First Aid, 24 hr contact

Section 2. Hazard identification

Classification of the substance or mixture : FLAMMABLE LIQUIDS - Category 2
ACUTE TOXICITY (inhalation) - Category 1
RESPIRATORY SENSITIZATION - Category 1
CARCINOGENICITY - Category 1A
TOXIC TO REPRODUCTION (Fertility) - Category 2
TOXIC TO REPRODUCTION (Unborn child) - Category 2
SPECIFIC TARGET ORGAN TOXICITY (SINGLE EXPOSURE) (lungs) - Category 1
SPECIFIC TARGET ORGAN TOXICITY (REPEATED EXPOSURE) - Category 1

GHS label elements

Hazard pictograms :

Signal word : Danger

Hazard statements : Highly flammable liquid and vapor.
Fatal if inhaled.
May cause allergy or asthma symptoms or breathing difficulties if inhaled.
May cause cancer.
Suspected of damaging fertility or the unborn child.
Causes damage to organs. (lungs)
Causes damage to organs through prolonged or repeated exposure.

Precautionary statements

Section 2. Hazard identification

Prevention : Follow plant nickel carbonyl protocol.Follow plant protocals for use/handling/contact with this product.Obtain special instructions before use.Wear respiratory protection. Product to be contained to a sealed vessel, pipe or equivalent means of process enclosure Do not handle until all safety precautions have been read and understood. Wear protective gloves. Wear protective clothing. Wear eye or face protection. Keep away from heat, hot surfaces, sparks, open flames and other ignition sources. No smoking. Use only outdoors or in a well-ventilated area. Do not breathe vapor. Do not eat, drink or smoke when using this product. Wash hands thoroughly after handling.

Response : Follow plant nickel carbonyl protocol. Get medical attention if you feel unwell. IF exposed or concerned: Call a POISON CENTER or physician. IF INHALED: Remove person to fresh air and keep comfortable for breathing. Immediately call a POISON CENTER or physician. If experiencing respiratory symptoms: Call a POISON CENTER or physician. IF ON SKIN (or hair): Take off immediately all contaminated clothing. Rinse skin with water.

Storage : See Section 7 - Handling and Storage

Disposal : Dispose of contents and container in accordance with all local, regional, national and international regulations. See section 13

Section 3. Composition/information on ingredients

Substance/mixture : Substance

Chemical name : tetracarbonylnickel

Other means of identification : nickel tetracarbonyl; Nickel carbonyl, (T-4)-; Nickel carbonyl (Ni(CO)4), (beta-4)-; Nickel carbonyl (as Ni); Nickel carbonyl; Nickel carbonyl (Ni(CO)4), (T-4)-; NICKEL CARBONYL Ni(CO)4, (T-4)-; Nickel carbonyl (tetracarbonylnickel); Nikel tetracarbonyl; Tetracarbonyl nickel(0); Carbonyl nickel

CAS number/other identifiers

CAS number : 13463-39-3

Ingredient name	% (w/w)	CAS number
Nickel carbonyl	98 - 100	13463-39-3

There are no additional ingredients present which, within the current knowledge of the supplier and in the concentrations applicable, are classified as hazardous to health or the environment and hence require reporting in this section.

Occupational exposure limits, if available, are listed in Section 8.

Section 4. First-aid measures

Description of necessary first aid measures

Eye contact : Immediately flush eyes with plenty of water, occasionally lifting the upper and lower eyelids. Check for and remove any contact lenses. Continue to rinse for at least 10 minutes. Get medical attention. If necessary, call a poison center or physician.

Inhalation : Get medical attention immediately. Call a poison center or physician. Remove victim to fresh air and keep at rest in a position comfortable for breathing. If it is suspected that fumes are still present, the rescuer should wear an appropriate mask or self-contained breathing apparatus. If not breathing, if breathing is irregular or if respiratory arrest occurs, provide artificial respiration or oxygen by trained personnel. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation. If unconscious, place in recovery position and get medical attention immediately. Maintain an open airway. Loosen tight clothing such as a collar, tie, belt or waistband. In the event of any complaints or symptoms, avoid further exposure.

Section 4. First-aid measures

Skin contact : Flush contaminated skin with plenty of water. Remove contaminated clothing and shoes. Wash contaminated clothing thoroughly with water before removing it, or wear gloves. Continue to rinse for at least 10 minutes. Get medical attention. If necessary, call a poison center or physician. Wash clothing before reuse. Clean shoes thoroughly before reuse.

Ingestion : Wash out mouth with water. Remove dentures if any. Remove victim to fresh air and keep at rest in a position comfortable for breathing. If material has been swallowed and the exposed person is conscious, give small quantities of water to drink. Stop if the exposed person feels sick as vomiting may be dangerous. Do not induce vomiting unless directed to do so by medical personnel. If vomiting occurs, the head should be kept low so that vomit does not enter the lungs. Get medical attention. If necessary, call a poison center or physician. Never give anything by mouth to an unconscious person. If unconscious, place in recovery position and get medical attention immediately. Maintain an open airway. Loosen tight clothing such as a collar, tie, belt or waistband.

Most important symptoms/effects, acute and delayed

Potential acute health effects

Eye contact : No known significant effects or critical hazards.

Inhalation : Fatal if inhaled. May cause allergy or asthma symptoms or breathing difficulties if inhaled.

Skin contact : No known significant effects or critical hazards.

Ingestion : No known significant effects or critical hazards.

Over-exposure signs/symptoms

Eye contact : No specific data.

Inhalation : Adverse symptoms may include the following:
wheezing and breathing difficulties
asthma
reduced fetal weight
increase in fetal deaths
skeletal malformations

Skin contact : Adverse symptoms may include the following:
reduced fetal weight
increase in fetal deaths
skeletal malformations

Ingestion : Adverse symptoms may include the following:
reduced fetal weight
increase in fetal deaths
skeletal malformations

Indication of immediate medical attention and special treatment needed, if necessary

Notes to physician : Treat symptomatically. Contact poison treatment specialist immediately if large quantities have been ingested or inhaled.

Specific treatments : No specific treatment.

Protection of first-aiders : No action shall be taken involving any personal risk or without suitable training. If it is suspected that fumes are still present, the rescuer should wear an appropriate mask or self-contained breathing apparatus. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation. Wash contaminated clothing thoroughly with water before removing it, or wear gloves.

See toxicological information (Section 11)

Section 5. Fire-fighting measures

Extinguishing media

Suitable extinguishing media : Use dry chemical, CO_2, water spray (fog) or foam.

Unsuitable extinguishing media : Do not use water jet.

Specific hazards arising from the chemical : Highly flammable liquid and vapor. Runoff to sewer may create fire or explosion hazard. In a fire or if heated, a pressure increase will occur and the container may burst, with the risk of a subsequent explosion. The vapor/gas is heavier than air and will spread along the ground. Vapors may accumulate in low or confined areas or travel a considerable distance to a source of ignition and flash back.

Hazardous thermal decomposition products : Decomposition products may include the following materials:
carbon dioxide
carbon monoxide
metal oxide/oxides

Special protective actions for fire-fighters : Promptly isolate the scene by removing all persons from the vicinity of the incident if there is a fire. No action shall be taken involving any personal risk or without suitable training. Move containers from fire area if this can be done without risk. Use water spray to keep fire-exposed containers cool.

Special protective equipment for fire-fighters : Fire-fighters should wear appropriate protective equipment and self-contained breathing apparatus (SCBA) with a full face-piece operated in positive pressure mode.

Section 6. Accidental release measures

Personal precautions, protective equipment and emergency procedures

For non-emergency personnel : No action shall be taken involving any personal risk or without suitable training. Evacuate surrounding areas. Keep unnecessary and unprotected personnel from entering. Do not touch or walk through spilled material. Shut off all ignition sources. No flares, smoking or flames in hazard area. Do not breathe vapor or mist. Provide adequate ventilation. Wear appropriate respirator when ventilation is inadequate. Put on appropriate personal protective equipment.

For emergency responders : If specialized clothing is required to deal with the spillage, take note of any information in Section 8 on suitable and unsuitable materials. See also the information in "For non-emergency personnel".

Environmental precautions : Avoid dispersal of spilled material and runoff and contact with soil, waterways, drains and sewers. Inform the relevant authorities if the product has caused environmental pollution (sewers, waterways, soil or air). Note : **At Vale sites where applicable, direct all spills to the assigned drains for metal recovery.**

Methods and materials for containment and cleaning up

Small spill : Stop leak if without risk. Follow plant specific spill procedures in the event of a spill.

Large spill : Stop leak if without risk. Follow plant specific spill procedures in the event of a spill. Note: see Section 1 for emergency contact information and Section 13 for waste disposal.

Section 7. Handling and storage

Precautions for safe handling

Protective measures : Put on appropriate personal protective equipment (see Section 8). Avoid exposure - obtain special instructions before use. Persons with a history of skin sensitization problems or asthma, allergies or chronic or recurrent respiratory disease should be evaluated for fit for work, any restrictions would be applied as per this process. Avoid exposure during pregnancy. Do not handle until all safety precautions have been read and understood. Do not get in eyes or on skin or clothing. Do not breathe vapor or mist. Do not ingest. Use only with adequate ventilation. Wear appropriate respirator when ventilation is inadequate. Do not enter storage areas

Section 7. Handling and storage

and confined spaces unless adequately ventilated. Keep in the original container or an approved alternative made from a compatible material, kept tightly closed when not in use. Store and use away from heat, sparks, open flame or any other ignition source. Use explosion-proof electrical (ventilating, lighting and material handling) equipment. Use only non-sparking tools. Take precautionary measures against electrostatic discharges. Empty containers retain product residue and can be hazardous. Do not reuse container.

Advice on general occupational hygiene : Eating, drinking and smoking should be prohibited in areas where this material is handled, stored and processed. Workers should wash hands and face before eating, drinking and smoking. Remove contaminated clothing and protective equipment before entering eating areas. See also Section 8 for additional information on hygiene measures.

Conditions for safe storage, including any incompatibilities : Store in accordance with local regulations. Store in a segregated and approved area. Store in original container protected from direct sunlight in a dry, cool and well-ventilated area, away from incompatible materials (see Section 10) and food and drink. Eliminate all ignition sources. Separate from oxidizing materials. Keep container tightly closed and sealed until ready for use. Containers that have been opened must be carefully resealed and kept upright to prevent leakage. Do not store in unlabeled containers. Use appropriate containment to avoid environmental contamination. See Section 10 for incompatible materials before handling or use.

Section 8. Exposure controls/personal protection

Control parameters

Occupational exposure limits

Ingredient name	Exposure limits
Nickel carbonyl	**CA Alberta Provincial (Canada, 4/2009).** 8 hrs OEL: 0.3 mg/m³, (as Ni) 8 hours. 8 hrs OEL: 0.05 ppm, (as Ni) 8 hours. **CA British Columbia Provincial (Canada, 6/2017).** TWA: 0.001 ppm, (as Ni) 8 hours. **CA Quebec Provincial (Canada, 1/2014).** TWAEV: 0.001 ppm, (as Ni) 8 hours. TWAEV: 0.007 mg/m³, (as Ni) 8 hours. **CA Saskatchewan Provincial (Canada, 7/2013).** STEL: 0.15 ppm, (measured as Ni) 15 minutes. TWA: 0.05 ppm, (measured as Ni) 8 hours. **CA Ontario Provincial (Canada, 1/2018).** C: 0.05 ppm, (as Ni)

ACGIH

Ingredient name	Exposure limits
tetracarbonylnickel	**ACGIH TLV (United States, 3/2017).** C: 0.05 ppm, (as Ni)

Appropriate engineering controls : Use only with adequate ventilation. Use process enclosures, local exhaust ventilation or other engineering controls to keep worker exposure to airborne contaminants below any recommended or statutory limits. The engineering controls also need to keep gas, vapor or dust concentrations below any lower explosive limits. Use explosion-proof ventilation equipment.

Environmental exposure controls : Emissions from ventilation or work process equipment should be checked to ensure they comply with the requirements of environmental protection legislation. In some cases, fume scrubbers, filters or engineering modifications to the process equipment will be necessary to reduce emissions to acceptable levels.

Individual protection measures

Section 8. Exposure controls/personal protection

Hygiene measures : Wash hands, forearms and face thoroughly after handling chemical products, before eating, smoking and using the lavatory and at the end of the working period. Appropriate techniques should be used to remove potentially contaminated clothing. Wash contaminated clothing before reusing. Ensure that eyewash stations and safety showers are close to the workstation location.

Eye/face protection : Safety eyewear complying with an approved standard should be used when a risk assessment indicates this is necessary to avoid exposure to liquid splashes, mists, gases or dusts. If contact is possible, the following protection should be worn, unless the assessment indicates a higher degree of protection: safety glasses with side-shields.

Skin protection

Hand protection : Chemical-resistant, impervious gloves complying with an approved standard should be worn at all times when handling chemical products if a risk assessment indicates this is necessary. Considering the parameters specified by the glove manufacturer, check during use that the gloves are still retaining their protective properties. It should be noted that the time to breakthrough for any glove material may be different for different glove manufacturers. In the case of mixtures, consisting of several substances, the protection time of the gloves cannot be accurately estimated.

Body protection : Personal protective equipment for the body should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product. When there is a risk of ignition from static electricity, wear anti-static protective clothing. For the greatest protection from static discharges, clothing should include anti-static overalls, boots and gloves.

Other skin protection : Appropriate footwear and any additional skin protection measures should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product.

Respiratory protection : Based on the hazard and potential for exposure, select a respirator that meets the appropriate standard or certification. Respirators must be used according to a respiratory protection program to ensure proper fitting, training, and other important aspects of use.

Section 9. Physical and chemical properties

Appearance

Physical state : Liquid.

Color : Colorless. Yellow.

Odor : Musty

Odor threshold : Not available.

pH : Not available.

Melting point : -19.3°C (-2.7°F)

Boiling point : 43°C (109.4°F)

Flash point : Closed cup: -20°C (-4°F)

Evaporation rate : Not available.

Flammability (solid, gas) : Not available.

Lower and upper explosive (flammable) limits : Lower: 2%
Upper: 34%

Vapor pressure : 42 kPa (315 mm Hg) [room temperature]

Vapor density : 5.9 [Air = 1]

Relative density : 1.3

Solubility : Not available.

Solubility in water : Not available.

Partition coefficient: n-octanol/water :

Auto-ignition temperature : 60°C (140°F)

Decomposition temperature : Not available.

Section 9. Physical and chemical properties

Viscosity : Not available.

Flow time (ISO 2431) : Not available.

Aerosol product

Heat of combustion : -6908220 J/kg

Section 10. Stability and reactivity

Reactivity : No specific test data related to reactivity available for this product or its ingredients.

Chemical stability : The product is stable.

Possibility of hazardous reactions : Under normal conditions of storage and use, hazardous reactions will not occur.

Conditions to avoid : Avoid all possible sources of ignition (spark or flame). Do not pressurize, cut, weld, braze, solder, drill, grind or expose containers to heat or sources of ignition. Do not allow vapor to accumulate in low or confined areas.

Incompatible materials : Reactive or incompatible with the following materials:
oxidizing materials

Hazardous decomposition products : Under normal conditions of storage and use, hazardous decomposition products should not be produced.

Section 11. Toxicological information

Information on toxicological effects

Acute toxicity

Product/ingredient name	Result	Species	Dose	Exposure
Nickel carbonyl	LC50 Inhalation Gas. LC50 Inhalation Vapor	Rat Rat	35 ppm 81.5 mg/m³	30 minutes 4 hours

Irritation/Corrosion

Not available.

Sensitization

Not available.

Mutagenicity

Not available.

Carcinogenicity

Not available.

Classification

Product/ingredient name	OSHA	IARC	NTP
tetracarbonylnickel	None.	1	Known to be a human carcinogen.

Reproductive toxicity

Not available.

Teratogenicity

Not available.

Specific target organ toxicity (single exposure)

Section 11. Toxicological information

Name	Category	Route of exposure	Target organs
Nickel carbonyl	Category 1	Inhalation	lungs

Specific target organ toxicity (repeated exposure)

Name	Category	Route of exposure	Target organs
Nickel carbonyl	Category 1	Not determined	Not determined

Aspiration hazard

Not available.

Information on the likely routes of exposure : Not available.

Potential acute health effects

Eye contact : No known significant effects or critical hazards.

Inhalation : Fatal if inhaled. May cause allergy or asthma symptoms or breathing difficulties if inhaled.

Skin contact : No known significant effects or critical hazards.

Ingestion : No known significant effects or critical hazards.

Symptoms related to the physical, chemical and toxicological characteristics

Eye contact : No specific data.

Inhalation : Adverse symptoms may include the following:
wheezing and breathing difficulties
asthma
reduced fetal weight
increase in fetal deaths
skeletal malformations

Skin contact : Adverse symptoms may include the following:
reduced fetal weight
increase in fetal deaths
skeletal malformations

Ingestion : Adverse symptoms may include the following:
reduced fetal weight
increase in fetal deaths
skeletal malformations

Delayed and immediate effects and also chronic effects from short and long term exposure

Short term exposure

Potential immediate effects : Not available.

Potential delayed effects : Not available.

Long term exposure

Potential immediate effects : Not available.

Potential delayed effects : Not available.

Potential chronic health effects

Not available.

General : Causes damage to organs through prolonged or repeated exposure. Once sensitized, a severe allergic reaction may occur when subsequently exposed to very low levels.

Carcinogenicity : May cause cancer. Risk of cancer depends on duration and level of exposure.

Section 11. Toxicological information

Mutagenicity : No known significant effects or critical hazards.

Teratogenicity : Suspected of damaging the unborn child.

Developmental effects : No known significant effects or critical hazards.

Fertility effects : Suspected of damaging fertility.

Numerical measures of toxicity

Acute toxicity estimates

N/A

Section 12. Ecological information

Toxicity

Not available.

Persistence and degradability

Not available.

Bioaccumulative potential

Not available.

Mobility in soil

Soil/water partition coefficient (K_{OC}) : Not available.

Other adverse effects : No known significant effects or critical hazards.

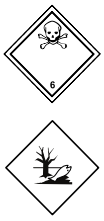
Section 13. Disposal considerations

Disposal methods : The generation of waste should be avoided or minimized wherever possible. Disposal of this product must comply with all local, provincial and federal regulations. Please contact the Waste Management Coordinator within Vale's Environmental Department for additional information regarding proper disposal of this product. This material and its container must be disposed of in a safe way. Care should be taken when handling emptied containers that have not been cleaned or rinsed out. Empty containers or liners may retain some product residues. Vapor from product residues may create a highly flammable or explosive atmosphere inside the container. Do not cut, weld or grind used containers unless they have been cleaned thoroughly internally. Follow plant specific spill procedures in the event of a spill.

Section 14. Transport information

	TDG Classification	DOT Classification	ADR/RID	IMDG	IATA
UN number	UN 1259	UN 1259	UN 1259	UN 1259	PROHIBITED
UN proper shipping name	Not available.	Not available.	Not available.	Not available.	Not available.

Section 14. Transport information

Transport hazard class(es)	6.1 	6.1 	6.1 	6.1 	6.1 
Packing group	I	I	I	I	I
Environmental hazards	No.	No.	Yes.	No.	No.

Additional information

TDG Classification : Product classified as per the following sections of the Transportation of Dangerous Goods Regulations: 2.26-2.36 (Class 6).

DOT Classification : **Reportable quantity** 10 lbs / 4.54 kg [0.92257 gal / 3.4923 L]. Package sizes shipped in quantities less than the product reportable quantity are not subject to the RQ (reportable quantity) transportation requirements.

ADR/RID : The environmentally hazardous substance mark is not required when transported in sizes of ≤5 L or ≤5 kg.

IATA : The environmentally hazardous substance mark may appear if required by other transportation regulations.

Special precautions for user : **Transport within user's premises:** always transport in closed containers that are upright and secure. Ensure that persons transporting the product know what to do in the event of an accident or spillage.

Transport in bulk according to Annex II of MARPOL and the IBC Code : Not available.

Section 15. Regulatory information

Canadian lists

Canadian NPRI : The following components are listed: Nickel (and its compounds)

CEPA Toxic substances : The following components are listed: tetracarbonylnickel

International regulations

Chemical Weapon Convention List Schedules I, II & III Chemicals

Not listed.

Montreal Protocol

Not listed.

Stockholm Convention on Persistent Organic Pollutants

Not listed.

Rotterdam Convention on Prior Informed Consent (PIC)

Not listed.

UNECE Aarhus Protocol on POPs and Heavy Metals

Not listed.

Inventory list

Australia : Not determined.

Canada : All components are listed or exempted.

China : Not determined.

Europe : All components are listed or exempted.

Section 15. Regulatory information

Japan : **Japan inventory (ENCS)**: All components are listed or exempted.
Japan inventory (ISHL): Not determined.

New Zealand : Not determined.

Philippines : All components are listed or exempted.

Republic of Korea : All components are listed or exempted.

Taiwan : All components are listed or exempted.

Thailand : Not determined.

Turkey : Not determined.

United States : All components are listed or exempted.

Viet Nam : Not determined.

Section 16. Other information

History

Date of printing : 4/8/2019

Date of issue/Date of revision : 4/8/2019

Date of previous issue : 12/3/2018

Version : 2

Prepared by : Contact your plant Occupational Health contact for additional information regarding this product or SDS.

Key to abbreviations :
ATE = Acute Toxicity Estimate
BCF = Bioconcentration Factor
GHS = Globally Harmonized System of Classification and Labelling of Chemicals
HPR = Hazardous Products Regulations
IATA = International Air Transport Association
IBC = Intermediate Bulk Container
IMDG = International Maritime Dangerous Goods
LogPow = logarithm of the octanol/water partition coefficient
MARPOL = International Convention for the Prevention of Pollution From Ships, 1973 as modified by the Protocol of 1978. ("Marpol" = marine pollution)
N/A = Not available
SGG = Segregation Group
UN = United Nations

Procedure used to derive the classification

Classification	Justification
FLAMMABLE LIQUIDS - Category 2	Regulatory data
ACUTE TOXICITY (inhalation) - Category 1	On basis of test data
RESPIRATORY SENSITIZATION - Category 1	Calculation method
CARCINOGENICITY - Category 1A	Regulatory data
TOXIC TO REPRODUCTION (Fertility) - Category 2	Regulatory data
TOXIC TO REPRODUCTION (Unborn child) - Category 2	Regulatory data
SPECIFIC TARGET ORGAN TOXICITY (SINGLE EXPOSURE) (lungs) - Category 1	Calculation method
SPECIFIC TARGET ORGAN TOXICITY (REPEATED EXPOSURE) - Category 1	Regulatory data

References : Not available.

Indicates information that has changed from previously issued version.

Notice to reader

Vale Canada believes that the information in this Safety Data Sheet is accurate. However, Vale Canada makes no express or implied warranty as to the accuracy of such information and expressly disclaims any liability resulting from reliance on such information.

SAFETY DATA SHEET

Creation Date 25-Jan-2011 **Revision Date** 25-Apr-2019 **Revision Number** 5

1. Identification

Product Name **Iron pentacarbonyl**

Cat No. : **AC412600000; AC412600010; AC412600250; AC412601000**

CAS-No 13463-40-6
Synonyms Pentacarbonyl iron

Recommended Use Laboratory chemicals.
Uses advised against Food, drug, pesticide or biocidal product use

Details of the supplier of the safety data sheet

Company
Fisher Scientific
One Reagent Lane
Fair Lawn, NJ 07410
Tel: (201) 796-7100

Acros Organics
One Reagent Lane
Fair Lawn, NJ 07410

Emergency Telephone Number
For information **US** call: 001-800-ACROS-01 / **Europe** call: +32 14 57 52 11
Emergency Number **US:**001-201-796-7100 / **Europe:** +32 14 57 52 99
CHEMTREC Tel. No.**US:**001-800-424-9300 / **Europe:**001-703-527-3887

2. Hazard(s) identification

Classification
This chemical is considered hazardous by the 2012 OSHA Hazard Communication Standard (29 CFR 1910.1200)

Flammable liquids	Category 2
Acute oral toxicity	Category 2
Acute dermal toxicity	Category 2
Acute Inhalation Toxicity - Vapors	Category 1
Specific target organ toxicity - (repeated exposure)	Category 1
Target Organs - Lungs, Liver, Kidney, Blood.	

Label Elements

Signal Word
Danger

Hazard Statements
Highly flammable liquid and vapor
Fatal if swallowed
Fatal in contact with skin

Fatal if inhaled
Causes damage to organs through prolonged or repeated exposure

Precautionary Statements
Prevention
Wash face, hands and any exposed skin thoroughly after handling
Do not eat, drink or smoke when using this product
Do not get in eyes, on skin, or on clothing
Wear protective gloves/protective clothing/eye protection/face protection
Do not breathe dust/fume/gas/mist/vapors/spray
Use only outdoors or in a well-ventilated area
Wear respiratory protection
Keep away from heat/sparks/open flames/hot surfaces. - No smoking
Keep container tightly closed
Ground/bond container and receiving equipment
Use explosion-proof electrical/ventilating/lighting/equipment
Use only non-sparking tools
Take precautionary measures against static discharge
Keep cool
Response
Get medical attention/advice if you feel unwell
Inhalation
IF INHALED: Remove victim to fresh air and keep at rest in a position comfortable for breathing
Immediately call a POISON CENTER or doctor/physician
Call a POISON CENTER or doctor/physician if you feel unwell
Skin
Immediately call a POISON CENTER or doctor/physician
Wash contaminated clothing before reuse
IF ON SKIN (or hair): Take off immediately all contaminated clothing. Rinse skin with water/shower
Ingestion
IF SWALLOWED: Immediately call a POISON CENTER or doctor/physician
Rinse mouth
Fire
In case of fire: Use CO2, dry chemical, or foam for extinction
Storage
Store locked up
Store in a well-ventilated place. Keep container tightly closed
Disposal
Dispose of contents/container to an approved waste disposal plant
Hazards not otherwise classified (HNOC)
None identified

3. Composition/Information on Ingredients

Component	CAS-No	Weight %
Iron, pentacarbonyl-	13463-40-6	>95

4. First-aid measures

General Advice	Immediate medical attention is required. Show this safety data sheet to the doctor in attendance.
Eye Contact	Rinse immediately with plenty of water, also under the eyelids, for at least 15 minutes. In the case of contact with eyes, rinse immediately with plenty of water and seek medical advice.
Skin Contact	Wash off immediately with plenty of water for at least 15 minutes. Immediate medical attention is required.
Inhalation	Move to fresh air. Do not use mouth-to-mouth method if victim ingested or inhaled the substance; give artificial respiration with the aid of a pocket mask equipped with a one-way valve or other proper respiratory medical device. Immediate medical attention is required. If not breathing, give artificial respiration.
Ingestion	Do not induce vomiting. Call a physician or Poison Control Center immediately.
Most important symptoms and effects	Breathing difficulties. Inhalation of high vapor concentrations may cause symptoms like headache, dizziness, tiredness, nausea and vomiting
Notes to Physician	Treat symptomatically

5. Fire-fighting measures

Suitable Extinguishing Media	Cool closed containers exposed to fire with water spray.
Unsuitable Extinguishing Media	Do not use a solid water stream as it may scatter and spread fire
Flash Point	-15 °C / 5 °F
Method -	No information available
Autoignition Temperature	49 °C / 120.2 °F
Explosion Limits	
Upper	12.5 vol %
Lower	3.7 vol %
Sensitivity to Mechanical Impact	No information available
Sensitivity to Static Discharge	No information available

Specific Hazards Arising from the Chemical
Containers may explode when heated. Vapors may form explosive mixtures with air. Vapors may travel to source of ignition and flash back. Extremely flammable.

Hazardous Combustion Products
None known
Protective Equipment and Precautions for Firefighters
As in any fire, wear self-contained breathing apparatus pressure-demand, MSHA/NIOSH (approved or equivalent) and full protective gear. Thermal decomposition can lead to release of irritating gases and vapors.

NFPA

Health	Flammability	Instability	Physical hazards
4	3	1	N/A

6. Accidental release measures

Personal Precautions	Use personal protective equipment. Keep people away from and upwind of spill/leak. Evacuate personnel to safe areas. Ensure adequate ventilation. Remove all sources of ignition. Take precautionary measures against static discharges.
Environmental Precautions	Should not be released into the environment. See Section 12 for additional ecological information.

Methods for Containment and Clean Up Soak up with inert absorbent material. Keep in suitable, closed containers for disposal. Remove all sources of ignition. Use spark-proof tools and explosion-proof equipment.

7. Handling and storage

Handling Use only under a chemical fume hood. Wear personal protective equipment. Do not get in eyes, on skin, or on clothing. Do not ingest. Do not breathe vapors or spray mist. Keep away from open flames, hot surfaces and sources of ignition. Use only non-sparking tools. To avoid ignition of vapors by static electricity discharge, all metal parts of the equipment must be grounded. Take precautionary measures against static discharges.

Storage Keep containers tightly closed in a dry, cool and well-ventilated place. Keep away from heat and sources of ignition.

8. Exposure controls / personal protection

Exposure Guidelines

Component	ACGIH TLV	OSHA PEL	NIOSH IDLH	Mexico OEL (TWA)
Iron, pentacarbonyl-	TWA: 0.1 ppm TWA: 1 mg/m³ STEL: 0.2 ppm	(Vacated) TWA: 0.1 ppm (Vacated) TWA: 0.8 mg/m³ (Vacated) TWA: 1 mg/m³ (Vacated) STEL: 0.2 ppm (Vacated) STEL: 1.6 mg/m³	IDLH: 0.4 ppm TWA: 0.1 ppm TWA: 0.23 mg/m³ TWA: 1 mg/m³ STEL: 0.2 ppm STEL: 0.45 mg/m³	TWA: 0.1 ppm TWA: 1 mg/m³ STEL: 0.2 ppm

Legend

ACGIH - American Conference of Governmental Industrial Hygienists
OSHA - Occupational Safety and Health Administration
NIOSH IDLH: The National Institute for Occupational Safety and Health Immediately Dangerous to Life or Health

Engineering Measures Use only under a chemical fume hood. Ensure that eyewash stations and safety showers are close to the workstation location. Use explosion-proof electrical/ventilating/lighting/equipment. Ensure adequate ventilation, especially in confined areas.

Personal Protective Equipment

Eye/face Protection Wear appropriate protective eyeglasses or chemical safety goggles as described by OSHA's eye and face protection regulations in 29 CFR 1910.133 or European Standard EN166.

Skin and body protection Long sleeved clothing.

Respiratory Protection Follow the OSHA respirator regulations found in 29 CFR 1910.134 or European Standard EN 149. Use a NIOSH/MSHA or European Standard EN 149 approved respirator if exposure limits are exceeded or if irritation or other symptoms are experienced.

Hygiene Measures Handle in accordance with good industrial hygiene and safety practice.

9. Physical and chemical properties

Physical State	Liquid
Appearance	Brown
Odor	No information available
Odor Threshold	No information available
pH	No information available
Melting Point/Range	-20 °C / -4 °F
Boiling Point/Range	103 °C / 217.4 °F @ 760 mmHg
Flash Point	-15 °C / 5 °F

Evaporation Rate	No information available
Flammability (solid,gas)	Not applicable
Flammability or explosive limits	
Upper	12.5 vol %
Lower	3.7 vol %
Vapor Pressure	35 hPa (20°C)
Vapor Density	6.74 (Air = 1.0)
Specific Gravity	1.490
Solubility	insoluble
Partition coefficient; n-octanol/water	No data available
Autoignition Temperature	49 °C / 120.2 °F
Decomposition Temperature	No information available
Viscosity	No information available
Molecular Formula	C5 Fe O5
Molecular Weight	195.9

10. Stability and reactivity

Reactive Hazard None known, based on information available

Stability Stable under normal conditions.

Conditions to Avoid Incompatible products. Excess heat. Keep away from open flames, hot surfaces and sources of ignition.

Incompatible Materials Strong oxidizing agents, Strong bases, Halogens, Amines

Hazardous Decomposition Products None under normal use conditions

Hazardous Polymerization Hazardous polymerization does not occur.

Hazardous Reactions None under normal processing.

11. Toxicological information

Acute Toxicity

Product Information

Oral LD50 Category 2.

Dermal LD50 Category 2.

Component Information

Component	LD50 Oral	LD50 Dermal	LC50 Inhalation
Iron, pentacarbonyl-	LD50 = 40 mg/kg (Rat)	LD50 = 56 mg/kg (Rabbit)	LC50 = 0.32 mg/L (Rat) 4 h LC50 = 10 ppm (Rat) 4 h

Toxicologically Synergistic Products No information available

Delayed and immediate effects as well as chronic effects from short and long-term exposure

Irritation No information available

Sensitization No information available

Carcinogenicity The table below indicates whether each agency has listed any ingredient as a carcinogen.

Component	CAS-No	IARC	NTP	ACGIH	OSHA	Mexico
Iron, pentacarbonyl-	13463-40-6	Not listed	Not listed	Not listed	Not listed	Not listed

Mutagenic Effects No information available

Reproductive Effects No information available.

Developmental Effects No information available.

Teratogenicity No information available.

STOT - single exposure None known
STOT - repeated exposure Lungs Liver Kidney Blood

Aspiration hazard No information available

Symptoms / effects,both acute and delayed Inhalation of high vapor concentrations may cause symptoms like headache, dizziness, tiredness, nausea and vomiting

Endocrine Disruptor Information No information available

Other Adverse Effects The toxicological properties have not been fully investigated.

12. Ecological information

Ecotoxicity

.

Component	Freshwater Algae	Freshwater Fish	Microtox	Water Flea
Iron, pentacarbonyl-	EC50: = 150 mg/L, 72h (Desmodesmus subspicatus)	LC50: = 990 mg/L, 96h static (Leuciscus idus)	EC50 > 10000 mg/L 30 min	EC50: = 130 mg/L, 48h (Daphnia magna)

Persistence and Degradability Persistence is unlikely

Bioaccumulation/ Accumulation No information available.

Mobility . Is not likely mobile in the environment due its low water solubility. Will likely be mobile in the environment due to its volatility.

Component	log Pow
Iron, pentacarbonyl-	3

13. Disposal considerations

Waste Disposal Methods Chemical waste generators must determine whether a discarded chemical is classified as a hazardous waste. Chemical waste generators must also consult local, regional, and national hazardous waste regulations to ensure complete and accurate classification.

14. Transport information

DOT

UN-No UN1994
Proper Shipping Name IRON PENTACARBONYL
Hazard Class 6.1
Subsidiary Hazard Class 3
Packing Group I

TDG

UN-No UN1994
Proper Shipping Name IRON PENTACARBONYL
Hazard Class 6.1
Subsidiary Hazard Class 3
Packing Group I

IATA Forbidden

IMDG/IMO

UN-No UN1994
Proper Shipping Name IRON PENTACARBONYL
Hazard Class 6.1
Subsidiary Hazard Class 3

Packing Group I

15. Regulatory information

United States of America Inventory

Component	CAS-No	TSCA	TSCA Inventory notification - Active/Inactive	TSCA - EPA Regulatory Flags
Iron, pentacarbonyl-	13463-40-6	X	ACTIVE	-

Legend:
TSCA - Toxic Substances Control Act, (40 CFR Part 710)
X - Listed
'-' - Not Listed

TSCA 12(b) - Notices of Export Not applicable

International Inventories
Canada (DSL/NDSL), Europe (EINECS/ELINCS/NLP), Philippines (PICCS), Japan (ENCS), Australia (AICS), China (IECSC), Korea (ECL).

Component	CAS-No	DSL	NDSL	EINECS	PICCS	ENCS	AICS	IECSC	KECL
Iron, pentacarbonyl-	13463-40-6	X	-	236-670-8	X	X	X	-	KE-27863

U.S. Federal Regulations

SARA 313

Component	CAS-No	Weight %	SARA 313 - Threshold Values %
Iron, pentacarbonyl-	13463-40-6	>95	1.0

SARA 311/312 Hazard Categories See section 2 for more information

CWA (Clean Water Act) Not applicable

Clean Air Act Not applicable

OSHA - Occupational Safety and Health Administration Not applicable

Component	Specifically Regulated Chemicals	Highly Hazardous Chemicals
Iron, pentacarbonyl-	-	TQ: 250 lb

CERCLA This material, as supplied, contains one or more substances regulated as a hazardous substance under the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) (40 CFR 302)

Component	Hazardous Substances RQs	CERCLA EHS RQs
Iron, pentacarbonyl-	-	100 lb

California Proposition 65 This product does not contain any Proposition 65 chemicals

U.S. State Right-to-Know Regulations

Component	Massachusetts	New Jersey	Pennsylvania	Illinois	Rhode Island
Iron, pentacarbonyl-	X	X	X	-	X

U.S. Department of Transportation
Reportable Quantity (RQ): N
DOT Marine Pollutant N
DOT Severe Marine Pollutant N

U.S. Department of Homeland This product contains the following DHS chemicals:

Security **Legend** - STQs = Screening Threshold Quantities, APA = A placarded amount

Component	DHS Chemical Facility Anti-Terrorism Standard
Iron, pentacarbonyl-	Release STQs - 10000lb

Other International Regulations

Mexico - Grade Serious risk, Grade 3

16. Other information

Prepared By
Regulatory Affairs
Thermo Fisher Scientific
Email: EMSDS.RA@thermofisher.com

Creation Date 25-Jan-2011
Revision Date 25-Apr-2019
Print Date 25-Apr-2019
Revision Summary This document has been updated to comply with the US OSHA HazCom 2012 Standard replacing the current legislation under 29 CFR 1910.1200 to align with the Globally Harmonized System of Classification and Labeling of Chemicals (GHS).

Disclaimer
The information provided in this Safety Data Sheet is correct to the best of our knowledge, information and belief at the date of its publication. The information given is designed only as a guidance for safe handling, use, processing, storage, transportation, disposal and release and is not to be considered a warranty or quality specification. The information relates only to the specific material designated and may not be valid for such material used in combination with any other materials or in any process, unless specified in the text

End of SDS

SAFETY DATA SHEET

A N C O C H E M I C A L S I N C.
85 Malmo Court, Maple Ontario, L6A 1R4, Ph: 905-832-2276 www.ancochemicals.com

ANHYDROUS AMMONIA

SECTION 1: PRODUCT AND COMPANY INFORMATION

Supplier Information: Anco Chemicals
85 Malmo Court
Maple, Ontario
L6A 1R4
Ph: (905) 832-2276
Fax: (905) 832-3701

Product Name: **Anhydrous Ammonia**

CAS No: 7664-41-7

Synonyms: Liquid Ammonia, Ammonia

Product Use: Fertilizers, Manufacture of Chemicals, Manufacture of synthetic fibers, Refrigerant, Cleaning solutions, Pollution Control, Other Industrial Uses

24 HOUR EMERGENCY TELEPHONE NUMBER

1-888-CANUTEC (226-8832) or (613) 996-6666(collect) or *666 cellular

SECTION 2: HAZARDOUS IDENTIFICATION

Classification of the Substance or Mixture

Classification

Flam. Gas 2	H221
Liquefied gas	H280
Acute Tox. 3 (Inhalation: gas)	H331
Skin Corr. 1B	H314
Eye Dam. 1	H318
STOT SE 3	H335
Aquatic Acute 1	H400
Aquatic Chronic 2	H411

Hazard Pictograms:

Signal Word: Danger

Hazard Statements (GHS):

H221 - Flammable gas.
H280 - Contains gas under pressure; may explode if heated.
H314 - Causes severe skin burns and eye damage.
H318 - Causes serious eye damage.
H331 - Toxic if inhaled. H335 - May cause respiratory irritation.
H400 - Very toxic to aquatic life.
H411 - Toxic to aquatic life with long lasting effects.

Precautionary Statements (GHS) :

P210 - Keep away from heat, hot surfaces, open flames, sparks. - No smoking.
P260 - Do not breathe mist, spray, vapors, and gas.
P261 - Avoid breathing vapors, mist, or spray.
P264 - Wash hands, forearms, and exposed areas thoroughly after handling.

P271 - Use only outdoors or in a well-ventilated area.
P273 - Avoid release to the environment.
P280 - Wear eye protection, protective clothing, and protective gloves.

P301+P330+P331 - If swallowed: rinse mouth. Do NOT induce vomiting.
P303+P361+P353 - If on skin (or hair): Take off immediately all contaminated clothing. Rinse skin with water/shower.
P304+P340 - If inhaled: Remove person to fresh air and keep at rest in a position comfortable for breathing.
P305+P351+P338 - If in eyes: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.
P310 - Immediately call a poison center or doctor.
P311 - Call a poison center or doctor.
P312 - Call a poison center or doctor if you feel unwell.
P321 - Specific treatment (see Section 4 on this SDS).
P363 - Wash contaminated clothing before reuse.
P377 - Leaking gas fire: Do not extinguish, unless leak can be stopped safely.
P381 - Eliminate all ignition sources if safe to do so. P391 - Collect spillage.
P403 - Store in a well-ventilated place.
P403+P233 - Store in a well-ventilated place. Keep container tightly closed.
P405 - Store locked up.
P410+P403 - Protect from sunlight.

Other Hazards

Ammonia vapor, in concentrations of 16-25% volume by weight in air, is flammable, toxic by inhalation and corrosive. Take all appropriate precautions.

Unknown Acute Toxicity

No data available

SECTION 3: COMPOSITION / INFORMATION ON INGREDIENTS

Hazardous Ingredients:	**%**	**ACGIH TLV**	**CAS. No.**
Anhydrous Ammonia	>99.5	25 PPM as NH3	7664-41-7
Other Ingredients			
Deionized Water	<0.5		007732-18-5

SECTION 4: FIRST AID MEASURE

Description of First Aid Measures

General: Never give anything by mouth to an unconscious person. If you feel unwell, seek medical advice (show the label where possible). If frostbite or freezing occurs, immediately flush with plenty of lukewarm water to GENTLY warm the affected area. Do not use hot water. Do not rub affected area. Get immediate medical attention.

Inhalation: When symptoms occur: go into open air and ventilate suspected area. Immediately call a POISON CENTER or doctor/physician.

Skin Contact: Immediately flush skin with plenty of water for at least 60 minutes. Remove contaminated clothing. Immediately call a POISON CENTER or doctor/physician. Wash contaminated clothing before reuse.
Eye Contact: Rinse cautiously with water for at least 60 minutes. Remove contact lenses, if present and easy to do. Continue rinsing. Obtain medical attention.
Ingestion: Rinse mouth. Do NOT induce vomiting. Immediately call a POISON CENTER or doctor/physician.

Most Important Symptoms and Effects Both Acute and Delayed General: Toxic if inhaled. Corrosive to eyes, respiratory system and skin.
Inhalation: Toxic if inhaled.
Skin Contact: Corrosive. Causes burns. Symptoms may include: Redness. Pain. Serious skin burns. Blisters.
Eye Contact: Causes permanent damage to the cornea, iris, or conjunctiva. Redness. Pain. Blurred vision. Severe burns.
Ingestion: Ingestion is an unlikely route of exposure for a gas.
Chronic Symptoms: Not available

SECTION 5: FIRE FIGHTING MEASURES

Extinguishing Media
Suitable Extinguishing Media: Water spray, fog.

Unsuitable Extinguishing Media: Do not use a heavy water stream. Use of heavy stream of water may spread fire. Do not use water directly on liquid ammonia as this will increase formation of ammonia vapors

Special Hazards Arising From the Substance or Mixture

Fire Hazard: Flammable gas. Ammonia concentrations in the range of 16-25% by volume in air can be ignited if heated to the auto-ignition temperature. Oil or other combustible materials increases the fire hazard.

Explosion Hazard: Forms explosive compounds with calcium hypochlorite, bleaches, gold, mercury, silver, chlorine and other halogens. Contact with strong oxidizers can result in fires and explosions.

Reactivity: Corrosive to copper, brass, silver, zinc and galvanized steel.

Advice for Firefighters Precautionary Measures Fire: Exercise caution when fighting any chemical fire. Do not allow ammonia vapors to accumulate in confined areas where ignition may occur.

Firefighting Instructions: Stop leak if safe to do so. For a serious leak, use fire hose with fog nozzle and plant of water to absorb ammonia vapors. Isolate immediate hazard area and keep unauthorized personnel out. Stop spill/release if it can be done with minimal risk. Move undamaged containers from immediate hazard area if it can be done with minimal risk. Water spray may be useful in minimizing or dispersing vapors and to protect persons shutting off flow. Cool equipment exposed to fire with water, if it can be done with minimal risk. In case of major fire and large quantities: Evacuate area. Fight fire remotely due to the risk of explosion.

Protection During Firefighting: Do not enter fire area without proper protective equipment, including respiratory protection. Firefighters must use full bunker gear including NIOSH-approved positive-pressure self-contained breathing apparatus to protect against potential hazardous combustion and decomposition products.

Hazardous Combustion Products: Nitrogen oxides.
Other Information: Compressed gas or refrigerated liquid. Intense heating particularly in contact with hot metallic surfaces may cause decomposition of ammonia generating hydrogen, a flammable gas. Note that many materials, particularly plastics, become brittle upon contact with liquid ammonia.

SECTION 6: ACCIDENTAL RELEASE MEASURES

Personal Precautions, Protective Equipment and Emergency Procedures General Measures: Cleanup workers should stay upwind and keep out of low areas where ammonia vapors can accumulate. Keep away from open flames, hot surfaces and sources of ignition. Use special care to avoid static electric charges. No smoking. Do not get in eyes, on skin, or on clothing. Do not breathe gas. If small spill, allow to vaporize or absorb vapor in water. For a large spill refer to section 5 for advice. Neutralization with acid is NOT recommended.

For Non-Emergency Personnel Protective Equipment: Use appropriate personal protection equipment (PPE). Persons without proper PPE should be restricted from the spill area until cleanup has been completed.

Emergency Procedures: Evacuate unnecessary personnel. Eliminate ignition sources.

For Emergency Personnel Protective Equipment: Equip cleanup crew with proper protection.
Emergency Procedures: Stop leak if safe to do so. Ventilate area.

Environmental Precautions
Prevent entry to sewers and public waters.

Methods and Material for Containment and Cleaning Up For Containment: Stop the flow of material, if this is without risk. Ventilate area.

Methods for Cleaning Up: Clean up spills immediately and dispose of waste safely. Allow to vaporize or absorb the vapor in water. Use only non-sparking tools.

Reference to Other Sections: See heading 8, Exposure Controls and Personal Protection. See Section 13, Disposal Considerations

SECTION 7: HANDLING AND STORAGE

Precautions for Safe Handling Additional Hazards When Processed: Do NOT enter (storage areas, confined spaces) unless adequately ventilated. Emits ammonia vapors. Flammable gas. Ammonium hydroxide reacts with many heavy metals and their salts forming explosive compounds. It may attack metals forming flammable/explosive gas. The solution in water is a strong base, it reacts violently with acids.

Hygiene Measures: Handle in accordance with good industrial hygiene and safety procedures. Wash hands and other exposed areas with mild soap and water before eating, drinking, or smoking and again when leaving work.

For Safe Storage, Including Any Incompatibilities Technical Measures: Contents under pressure. The use of explosion proof equipment is recommended. Anhydrous ammonia is a product which must be handled in approved equipment and by trained personnel. Any proposed use of this product in elevated-temperature processes should be thoroughly evaluated to assure that safe operating conditions are established and maintained. Ensure adequate ventilation. Proper grounding procedures to avoid static electricity should be followed. System design and training programs must comply with applicable regulations and in addition to good engineering practices. Pressure vessels, piping and appurtenances should be regularly inspected and tested using methods designed to reveal external and internal deterioration or defects that may impair integrity of the equipment such that an unintended release of anhydrous ammonia may result. Consult with State Department of Agriculture and other experts, as applicable, concerning methods that would be appropriate given the particular circumstances. Refer the current ANSI/CGA G-2.1-2014 standard, Requirements for the Storage and Handling of Anhydrous Ammonia for additional information.

Storage Conditions: Store in a dry, cool and well-ventilated place. Keep in fireproof place. Store locked up. Storage containers should have safety relief valves. Note that many materials,

particularly plastics, become brittle upon contact with liquid ammonia.

Incompatible Materials: Forms explosive compounds with calcium hypochlorite, bleaches, gold, mercury, silver, chlorine and other halogens. Contact with strong oxidizers can result in fires and explosions. Corrosive to copper, brass, silver, zinc and galvanized steel.

Area: Post readily visible warning signs in the storage area listing emergency measures. Water hoses should be readily available to disperse vapors in case of a spill.

Specific End Use(s)
Fertilizers, Manufacture of Chemicals, Manufacture of synthetic fibers, Refrigerant, Cleaning solutions, Pollution Control, Other Industrial Uses

SECTION 8: EXPOSURE CONTROLS AND PERSONAL PROTECTION

ACGIH	TWA	25ppm
ACGIH	STEL	35ppm

Exposure Controls Appropriate Engineering Controls: Gas detectors should be used when flammable gases/vapors may be released. Gas detectors should be used when toxic gases may be released. Emergency eye wash fountains and safety showers should be available in the immediate vicinity of any potential exposure. Use explosion-proof equipment. Ensure all national/local regulations are observed.

Personal Protective Equipment: Protective goggles. Gloves. Protective clothing. Insufficient ventilation: wear respiratory protection. Face shield.

Materials for Protective Clothing: Chemically resistant materials and fabrics.
Hand Protection: Wear chemically resistant protective gloves.
Eye Protection: Chemical safety goggles.
Skin and Body Protection: Wear suitable protective clothing.
Respiratory Protection: If exposure limits are exceeded or irritation is experienced, approved respiratory protection should be worn.

Thermal Hazard Protection: Wear cold insulating gloves.
Other Information: When using, do not eat, drink or smoke.

SECTION 9: PHYSICAL AND CHEMICAL PROPERTIES

Information on Basic Physical and Chemical Properties

Physical State:	Gas
Appearance:	Colorless liquid or gas
Odor:	Pungent odor considered suffocating
Odor Threshold :	1 - 50 ppm in humans
pH :	10.6 - 11.6 (0.02-1.7% aqueous ammonia solution)
Evaporation Rate :	Not available
Melting Point :	-108 °F (- 77 °C)
Freezing Point :	Not available
Boiling Point :	-28.1 °F (- 33.4 °C)
Flash Point :	Not available
Auto-ignition Temperature:	1,204 °F (651 °C)
Decomposition Temperature:	Not available
Flammability (solid, gas):	Not available
Lower Flammable Limit :	16 % (by volume in air)
Upper Flammable Limit :	25 % (by volume in air)
Vapor Pressure:	8.5 atm at 68°F (20°C)
Relative Vapor Density at 20 °C:	0.597 (at 32°F and 760 mmHg) (lighter than air)
Relative Density :	Not available
Specific Gravity:	0.62 at 60°F (16°C)
Solubility:	Soluble in water.
Water:	51 g at 68°F (20°C)
Partition Coefficient:	
N-Octanol/Water :	- 1.14 at 68°F (25°C)
Viscosity:	0.475 cP at -92°F (-69°C)
Explosion Data – Sensitivity to Mechanical Impact:	Not expected to present an explosion hazard due to mechanical impact.
Explosion Data – Sensitivity to Static Discharge:	Not expected to present an explosion hazard due to static discharge.

SECTION 10: STABILITY AND REACTIVITY

Reactivity
Forms explosive compounds with calcium hypochlorite, bleaches, gold, mercury, silver,

chlorine and other halogens. Contact with strong oxidizers can result in fires and explosions. Corrosive to copper, brass, silver, zinc and galvanized steel.

Chemical Stability

Flammable gas. Contains gas under pressure; may explode if heated. Can form explosive mixture with air.

Possibility of Hazardous Reactions

Hazardous polymerization will not occur.

Conditions to Avoid

Extremely high or low temperatures. Open flame. Overheating. Heat. Sparks.

Incompatible Materials

Strong acids. Strong bases. Strong oxidizers.Hypochlorites.

Hazardous Decomposition Products

Nitrogen oxides.

SECTION 11: TOXICOLOGICAL INFORMATION

Information on Toxicological Effects - Product

LD50 and LC50 Data: Anhydrous Ammonia (7664-41-7)

ATE US (gases) 2,000.10 ppmV/4h

Skin Corrosion/Irritation: Causes severe skin burns and eye damage.

pH: 10.6 - 11.6 (0.02-1.7% aqueous ammonia solution)

Serious Eye Damage/Irritation: Causes serious eye damage.

pH: 10.6 - 11.6 (0.02-1.7% aqueous ammonia solution)

Respiratory or Skin Sensitization: Not classified

Germ Cell Mutagenicity: Not classified

Teratogenicity: Not classified

Carcinogenicity: Not classified

Specific Target Organ Toxicity (Repeated Exposure): Not classified

Reproductive Toxicity: Not classified

Specific Target Organ Toxicity (Single Exposure): May cause respiratory irritation.

Aspiration Hazard: Not classified

Symptoms/Injuries After Inhalation: Toxic if inhaled.

Symptoms/Injuries After Skin Contact: Corrosive. Causes burns. Symptoms may include: Redness. Pain. Serious skin burns. Blisters.

Symptoms/Injuries After Eye Contact: Causes permanent damage to the cornea, iris, or conjunctiva. Redness. Pain. Blurred vision. Severe burns.

Symptoms/Injuries After Ingestion: Ingestion is an unlikely route of exposure for a gas.

Information on Toxicological Effects - Ingredient(s)

SECTION 12: ECOLOGICAL INFORMATION

Toxicity Ecology - General:
Toxic to aquatic life with long lasting effects. Very toxic to aquatic life.

Ammonia (7664-41-7)

LC50 Fish 1	0.44 mg/l (Exposure time: 96 h - Species: Cyprinus carpio)
EC50 Daphnia 1	25.4 mg/l (Exposure time: 48 h - Species: Daphnia magna)
LC 50 Fish 2	0.26 - 4.6 mg/l (Exposure time: 96 h - Species: Lepomis macrochirus)

Ammonia Solution (Aqua ammonia) (1336-21-6)

LC50 Fish 1	8.2 mg/l (Exposure time: 96 h - Species: Pimephales promelas)
EC50 Daphnia 1	0.66 mg/l (Exposure time: 48 h - Species: water flea)
EC50 Daphnia 2	0.66 mg/l (Exposure time: 48 h - Species: Daphnia pulex)

Other Adverse Effects Other Information:
Avoid release to the environment.

SECTION 13: DISPOSAL CONSIDERATIONS

Waste treatment methods
Waste Disposal Recommendations: Dispose of waste material in accordance with all local, regional, national, provincial, territorial and international regulations.
Additional Information: Handle empty containers with care because residual vapors are flammable. Prevent runoff from entering drains, sewers or waterways.
Ecology – Waste Materials: This material is hazardous to the aquatic environment. Keep out of sewers and waterways.

SECTION 14: TRANSPORTATION INFORMATION

Classified in Accordance with TDG Proper Shipping Name: ANHYDROUS AMMONIA

Hazard Class	2.3 (8)
Identification Number	UN1005
Label Codes:	2.3, 8
Special Provision	23
ERP	>3000L

Additional Information: Marine Pollutant

SECTION 15: REGULATORY INFORMATION

Canadian Regulations Anhydrous Ammonia (7664-41-7)
WHMIS Classification Class E - Corrosive Material Class B - Flammable Gas Class A - Compressed Gas Class D Division 1 Subdivision A - Very toxic material causing immediate and serious toxic effects

Ammonia (7664-41-7)
Listed on the Canadian DSL (Domestic Substances List) Listed on the Canadian IDL (Ingredient Disclosure List)
IDL Concentration 1 %

This product has been classified in accordance with the hazard criteria of the Controlled Products Regulations (CPR) and the SDS contains all of the information required by CPR.

SECTION 16: OTHER INFORMATION

Prepared by: Anco Chemicals Inc., Quality Department,
Tel : 1-905-832-2276 ext 233 by Sat Anand

Date of Preparation: Jan. 20, 2017
Date of Revision: Jan. 20, 2017

The information contained herein is offered only as a guide to the handling of this specific material and has been prepared in good faith by technically knowledgeable personnel. It is not intended to be all inclusive and the manner and conditions of use and handling may involve other and additional considerations, no warranty of any kind is given or implied and Anco Chemicals Inc. will not be liable for any damages, losses, injuries or consequential damages which may result from the use or reliance on any information contained herein.

SAFETY DATA SHEET

CCNR - Carbon Monoxide

Section 1. Identification

Product identifier : CCNR - Carbon Monoxide

Product code : 1989-1173

Other means of identification : CO

Product type : Gas.

Relevant identified uses of the substance or mixture and uses advised against

Identified uses
Not available.

Uses advised against

Supplier's details : Vale Canada Limited - Ontario Operations
Copper Cliff, Ontario
P0M 1N0

Emergency telephone number (with hours of operation) : (705) 682-6622 - Number 1 First Aid, 24 hr contact

Section 2. Hazard identification

Classification of the substance or mixture : FLAMMABLE GASES - Category 1
GASES UNDER PRESSURE - Compressed gas
ACUTE TOXICITY (inhalation) - Category 2
TOXIC TO REPRODUCTION (Unborn child) - Category 1
SPECIFIC TARGET ORGAN TOXICITY (REPEATED EXPOSURE) - Category 1

GHS label elements

Hazard pictograms :

Signal word : Danger

Hazard statements : Extremely flammable gas.
Contains gas under pressure; may explode if heated.
Fatal if inhaled.
May damage the unborn child.
Causes damage to organs through prolonged or repeated exposure.

Precautionary statements

Prevention : Obtain special instructions before use. Do not handle until all safety precautions have been read and understood. Wear protective gloves. Wear protective clothing. Wear eye or face protection. Keep away from heat, hot surfaces, sparks, open flames and other ignition sources. No smoking. Use only outdoors or in a well-ventilated area. Do not breathe gas. Do not eat, drink or smoke when using this product. Wash hands thoroughly after handling. Respiratory protection may be required

Section 2. Hazard identification

Response : Get medical attention if you feel unwell. IF exposed or concerned: Get medical attention. IF INHALED: Remove person to fresh air and keep comfortable for breathing. Immediately call a POISON CENTER or physician. Leaking gas fire: Do not extinguish, unless leak can be stopped safely. In case of leakage, eliminate all ignition sources.

Storage : Store in a well-ventilated place. See Section 7 - Handling and Storage

Disposal : See section 13

Supplemental label elements : Percentage of the mixture consisting of ingredient(s) of unknown oral toxicity: 100%
Percentage of the mixture consisting of ingredient(s) of unknown dermal toxicity: 100%
Percentage of the mixture consisting of ingredient(s) of unknown inhalation toxicity: 2.1%

Section 3. Composition/information on ingredients

Substance/mixture : Mixture

Other means of identification : CO

Ingredient name	% (v/v)	CAS number
carbon monoxide	98 - 100	630-08-0
nitrogen	0.1 - 2	7727-37-9
Carbon dioxide, gas	0.1 - 2	124-38-9

There are no additional ingredients present which, within the current knowledge of the supplier and in the concentrations applicable, are classified as hazardous to health or the environment and hence require reporting in this section.

Occupational exposure limits, if available, are listed in Section 8.

Section 4. First-aid measures

Description of necessary first aid measures

Eye contact : Immediately flush eyes with plenty of water, occasionally lifting the upper and lower eyelids. Check for and remove any contact lenses. Continue to rinse for at least 10 minutes. Get medical attention.

Inhalation : Get medical attention immediately. Call a poison center or physician. Remove victim to fresh air and keep at rest in a position comfortable for breathing. If it is suspected that fumes are still present, the rescuer should wear an appropriate mask or self-contained breathing apparatus. If not breathing, if breathing is irregular or if respiratory arrest occurs, provide artificial respiration or oxygen by trained personnel. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation. If unconscious, place in recovery position and get medical attention immediately. Maintain an open airway. Loosen tight clothing such as a collar, tie, belt or waistband. In case of inhalation of decomposition products in a fire, symptoms may be delayed. The exposed person may need to be kept under medical surveillance for 48 hours.

Skin contact : Flush contaminated skin with plenty of water. Remove contaminated clothing and shoes. To avoid the risk of static discharges and gas ignition, soak contaminated clothing thoroughly with water before removing it. Continue to rinse for at least 10 minutes. Get medical attention. Wash clothing before reuse. Clean shoes thoroughly before reuse.

Ingestion : As this product is a gas, refer to the inhalation section.

Most important symptoms/effects, acute and delayed

Potential acute health effects

Eye contact : Contact with rapidly expanding gas may cause burns or frostbite.

Inhalation : Fatal if inhaled.

Section 4. First-aid measures

Skin contact : Contact with rapidly expanding gas may cause burns or frostbite.

Ingestion : As this product is a gas, refer to the inhalation section.

Over-exposure signs/symptoms

Eye contact : No specific data.

Inhalation : Adverse symptoms may include the following:
reduced fetal weight
increase in fetal deaths
skeletal malformations

Skin contact : Adverse symptoms may include the following:
reduced fetal weight
increase in fetal deaths
skeletal malformations

Ingestion : Adverse symptoms may include the following:
reduced fetal weight
increase in fetal deaths
skeletal malformations

Indication of immediate medical attention and special treatment needed, if necessary

Notes to physician : In case of inhalation of decomposition products in a fire, symptoms may be delayed. The exposed person may need to be kept under medical surveillance for 48 hours.

Specific treatments : No specific treatment.

Protection of first-aiders : No action shall be taken involving any personal risk or without suitable training. If it is suspected that fumes are still present, the rescuer should wear an appropriate mask or self-contained breathing apparatus. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation. Wash contaminated clothing thoroughly with water before removing it, or wear gloves.

See toxicological information (Section 11)

Section 5. Fire-fighting measures

Extinguishing media

Suitable extinguishing media : Use an extinguishing agent suitable for the surrounding fire.

Unsuitable extinguishing media : None known.

Specific hazards arising from the chemical : Contains gas under pressure. Extremely flammable gas. In a fire or if heated, a pressure increase will occur and the container may burst, with the risk of a subsequent explosion.

Hazardous thermal decomposition products : Decomposition products may include the following materials:
carbon dioxide
carbon monoxide
nitrogen oxides

Special protective actions for fire-fighters : Promptly isolate the scene by removing all persons from the vicinity of the incident if there is a fire. No action shall be taken involving any personal risk or without suitable training. Contact supplier immediately for specialist advice. Move containers from fire area if this can be done without risk. Use water spray to keep fire-exposed containers cool. If involved in fire, shut off flow immediately if it can be done without risk. If this is impossible, withdraw from area and allow fire to burn. Fight fire from protected location or maximum possible distance. Eliminate all ignition sources if safe to do so.

Special protective equipment for fire-fighters : Fire-fighters should wear appropriate protective equipment and self-contained breathing apparatus (SCBA) with a full face-piece operated in positive pressure mode.

Section 6. Accidental release measures

Personal precautions, protective equipment and emergency procedures

For non-emergency personnel : Accidental releases pose a serious fire or explosion hazard. No action shall be taken involving any personal risk or without suitable training. Evacuate surrounding areas. Keep unnecessary and unprotected personnel from entering. Shut off all ignition sources. No flares, smoking or flames in hazard area. Do not breathe gas. Provide adequate ventilation. Wear appropriate respirator when ventilation is inadequate. Put on appropriate personal protective equipment.

For emergency responders : If specialized clothing is required to deal with the spillage, take note of any information in Section 8 on suitable and unsuitable materials. See also the information in "For non-emergency personnel".

Environmental precautions : Ensure emergency procedures to deal with accidental gas releases are in place to avoid contamination of the environment. Inform the relevant authorities if the product has caused environmental pollution (sewers, waterways, soil or air).

Methods and materials for containment and cleaning up

Small spill : Immediately contact emergency personnel. Stop leak if without risk. Use spark-proof tools and explosion-proof equipment.

Large spill : Immediately contact emergency personnel. Stop leak if without risk. Use spark-proof tools and explosion-proof equipment. Note: see Section 1 for emergency contact information and Section 13 for waste disposal.

Section 7. Handling and storage

Precautions for safe handling

Protective measures : Put on appropriate personal protective equipment (see Section 8). Contains gas under pressure. Avoid exposure - obtain special instructions before use. Avoid exposure during pregnancy. Do not handle until all safety precautions have been read and understood. Do not get in eyes or on skin or clothing. Do not breathe gas. Use only with adequate ventilation. Respirator selection must be based on known or anticipated exposure levels, the hazards of the product and the safe working limits of the selected respirator. Do not enter storage areas and confined spaces unless adequately ventilated. Store and use away from heat, sparks, open flame or any other ignition source. Use explosion-proof electrical (ventilating, lighting and material handling) equipment. Use only non-sparking tools. Empty containers retain product residue and can be hazardous. Do not puncture or incinerate container.

Advice on general occupational hygiene : Eating, drinking and smoking should be prohibited in areas where this material is handled, stored and processed. Workers should wash hands and face before eating, drinking and smoking. Remove contaminated clothing and protective equipment before entering eating areas. See also Section 8 for additional information on hygiene measures.

Conditions for safe storage, including any incompatibilities : Store in accordance with local regulations. Store in a segregated and approved area. Store away from direct sunlight in a dry, cool and well-ventilated area, away from incompatible materials (see Section 10). Eliminate all ignition sources. Keep container tightly closed and sealed until ready for use. See Section 10 for incompatible materials before handling or use.

Section 8. Exposure controls/personal protection

Control parameters

Occupational exposure limits

Section 8. Exposure controls/personal protection

Ingredient name	Exposure limits
carbon monoxide	**CA Alberta Provincial (Canada, 4/2009).** 8 hrs OEL: 25 ppm 8 hours. 8 hrs OEL: 29 mg/m³ 8 hours. **CA British Columbia Provincial (Canada, 7/2016).** TWA: 25 ppm 8 hours. STEL: 100 ppm 15 minutes. **CA Ontario Provincial (Canada, 7/2015).** TWA: 25 ppm 8 hours. **CA Quebec Provincial (Canada, 1/2014).** TWAEV: 35 ppm 8 hours. TWAEV: 40 mg/m³ 8 hours. STEV: 200 ppm 15 minutes. STEV: 230 mg/m³ 15 minutes. **CA Saskatchewan Provincial (Canada, 7/2013).** STEL: 190 ppm 15 minutes. TWA: 25 ppm 8 hours.
nitrogen	**CA Alberta Provincial (Canada, 4/2009). Oxygen Depletion [Asphyxiant].** **CA British Columbia Provincial (Canada, 7/2016). Oxygen Depletion [Asphyxiant].** **CA Ontario Provincial (Canada, 7/2015). Oxygen Depletion [Asphyxiant].** **CA Quebec Provincial (Canada, 1/2014). Oxygen Depletion [Asphyxiant].**
Carbon dioxide, gas	**CA Alberta Provincial (Canada, 4/2009).** 15 min OEL: 54000 mg/m³ 15 minutes. 8 hrs OEL: 5000 ppm 8 hours. 15 min OEL: 30000 ppm 15 minutes. 8 hrs OEL: 9000 mg/m³ 8 hours. **CA British Columbia Provincial (Canada, 7/2016).** TWA: 5000 ppm 8 hours. STEL: 15000 ppm 15 minutes. **CA Ontario Provincial (Canada, 7/2015).** TWA: 5000 ppm 8 hours. STEL: 30000 ppm 15 minutes. **CA Quebec Provincial (Canada, 1/2014).** TWAEV: 5000 ppm 8 hours. TWAEV: 9000 mg/m³ 8 hours. STEV: 30000 ppm 15 minutes. STEV: 54000 mg/m³ 15 minutes. **CA Saskatchewan Provincial (Canada, 7/2013).** STEL: 30000 ppm 15 minutes. TWA: 5000 ppm 8 hours.

ACGIH

Ingredient name	Exposure limits
carbon monoxide	**ACGIH TLV (United States, 3/2017).** TWA: 25 ppm 8 hours. TWA: 29 mg/m³ 8 hours.
nitrogen	**ACGIH TLV (United States, 3/2017). Oxygen Depletion [Asphyxiant].**
Carbon dioxide, gas	**ACGIH TLV (United States, 3/2017).** TWA: 5000 ppm 8 hours. TWA: 9000 mg/m³ 8 hours. STEL: 30000 ppm 15 minutes. STEL: 54000 mg/m³ 15 minutes.

Section 8. Exposure controls/personal protection

Appropriate engineering controls : Use only with adequate ventilation. Use process enclosures, local exhaust ventilation or other engineering controls to keep worker exposure to airborne contaminants below any recommended or statutory limits. The engineering controls also need to keep gas, vapor or dust concentrations below any lower explosive limits. Use explosion-proof ventilation equipment.

Environmental exposure controls : Emissions from ventilation or work process equipment should be checked to ensure they comply with the requirements of environmental protection legislation. In some cases, fume scrubbers, filters or engineering modifications to the process equipment will be necessary to reduce emissions to acceptable levels.

Individual protection measures

Hygiene measures : Wash hands, forearms and face thoroughly after handling chemical products, before eating, smoking and using the lavatory and at the end of the working period. Appropriate techniques should be used to remove potentially contaminated clothing. Wash contaminated clothing before reusing. Ensure that eyewash stations and safety showers are close to the workstation location.

Eye/face protection : Safety eyewear complying with an approved standard should be used when a risk assessment indicates this is necessary to avoid exposure to liquid splashes, mists, gases or dusts. If contact is possible, the following protection should be worn, unless the assessment indicates a higher degree of protection: safety glasses with side-shields.

Skin protection

Hand protection : Chemical-resistant, impervious gloves complying with an approved standard should be worn at all times when handling chemical products if a risk assessment indicates this is necessary. Considering the parameters specified by the glove manufacturer, check during use that the gloves are still retaining their protective properties. It should be noted that the time to breakthrough for any glove material may be different for different glove manufacturers. In the case of mixtures, consisting of several substances, the protection time of the gloves cannot be accurately estimated.

Body protection : Personal protective equipment for the body should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product. When there is a risk of ignition from static electricity, wear anti-static protective clothing. For the greatest protection from static discharges, clothing should include anti-static overalls, boots and gloves.

Other skin protection : Appropriate footwear and any additional skin protection measures should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product.

Respiratory protection : Based on the hazard and potential for exposure, select a respirator that meets the appropriate standard or certification. Respirators must be used according to a respiratory protection program to ensure proper fitting, training, and other important aspects of use. Respirator selection must be based on known or anticipated exposure levels, the hazards of the product and the safe working limits of the selected respirator.

Section 9. Physical and chemical properties

Appearance

Physical state : Gas.

Color : Colorless.

Odor : Odorless.

Odor threshold : Not available.

pH : Not available.

Melting point : -199°C (-326.2°F)

Boiling point : -191.52°C (-312.7°F)

Flash point : Closed cup: 608°C (1126.4°F)

Section 9. Physical and chemical properties

Evaporation rate : Not available.

Flammability (solid, gas) : Not available.

Lower and upper explosive (flammable) limits : Lower: 12.5%
Upper: 74.2%

Vapor pressure : Not available.

Vapor density : 0.97 [Air = 1]

Relative density : Not available.

Solubility : Not available.

Solubility in water : 2 g/l

Partition coefficient: n-octanol/water : Not available.

Auto-ignition temperature : 607°C (1124.6°F)

Decomposition temperature : Not available.

Viscosity : Dynamic (room temperature): 0 mPa·s (0 cP)

Flow time (ISO 2431) : Not available.

Aerosol product

Heat of combustion : -10101818 J/kg

Section 10. Stability and reactivity

Reactivity : No specific test data related to reactivity available for this product or its ingredients.

Chemical stability : The product is stable.

Possibility of hazardous reactions : Under normal conditions of storage and use, hazardous reactions will not occur.

Conditions to avoid : Avoid all possible sources of ignition (spark or flame). Do not pressurize, cut, weld, braze, solder, drill, grind or expose containers to heat or sources of ignition.

Incompatible materials : No specific data.

Hazardous decomposition products : Under normal conditions of storage and use, hazardous decomposition products should not be produced.

Section 11. Toxicological information

Information on toxicological effects

Acute toxicity

Product/ingredient name	Result	Species	Dose	Exposure
carbon monoxide	LC50 Inhalation Gas. LC50 Inhalation Vapor	Rat Rat	1807 ppm 1900 mg/m³	4 hours 4 hours

Irritation/Corrosion

Not available.

Sensitization

Not available.

Mutagenicity

Not available.

Carcinogenicity

Not available.

Section 11. Toxicological information

Reproductive toxicity

Not available.

Teratogenicity

Not available.

Specific target organ toxicity (single exposure)

Not available.

Specific target organ toxicity (repeated exposure)

Name	Category	Route of exposure	Target organs
carbon monoxide	Category 1	Not determined	Not determined

Aspiration hazard

Not available.

Information on the likely routes of exposure : Not available.

Potential acute health effects

Eye contact : Contact with rapidly expanding gas may cause burns or frostbite.

Inhalation : Fatal if inhaled.

Skin contact : Contact with rapidly expanding gas may cause burns or frostbite.

Ingestion : As this product is a gas, refer to the inhalation section.

Symptoms related to the physical, chemical and toxicological characteristics

Eye contact : No specific data.

Inhalation : Adverse symptoms may include the following:
reduced fetal weight
increase in fetal deaths
skeletal malformations

Skin contact : Adverse symptoms may include the following:
reduced fetal weight
increase in fetal deaths
skeletal malformations

Ingestion : Adverse symptoms may include the following:
reduced fetal weight
increase in fetal deaths
skeletal malformations

Delayed and immediate effects and also chronic effects from short and long term exposure

Short term exposure

Potential immediate effects : Not available.

Potential delayed effects : Not available.

Long term exposure

Potential immediate effects : Not available.

Potential delayed effects : Not available.

Potential chronic health effects

Not available.

General : Causes damage to organs through prolonged or repeated exposure.

Carcinogenicity : No known significant effects or critical hazards.

Section 11. Toxicological information

Mutagenicity : No known significant effects or critical hazards.

Teratogenicity : May damage the unborn child.

Developmental effects : No known significant effects or critical hazards.

Fertility effects : No known significant effects or critical hazards.

Numerical measures of toxicity

Acute toxicity estimates

Route	ATE value
Inhalation (gases) Inhalation (vapors)	1845.3 ppm 1.94 mg/l

Section 12. Ecological information

Toxicity

Not available.

Persistence and degradability

Not available.

Bioaccumulative potential

Not available.

Mobility in soil

Soil/water partition coefficient (K_{OC}) : Not available.

Other adverse effects : No known significant effects or critical hazards.

Section 13. Disposal considerations

Disposal methods : Disposal of this product must comply with all local, provincial and federal regulations. Please contact the Waste Management Coordinator within Vale's Environmental Department for additional information regarding proper disposal of this product. Recycle to process, if possible. Follow plant specific spill procedures in the event of a spill.

Section 14. Transport information

	TDG Classification	DOT Classification	ADR/RID	IMDG	IATA
UN number	UN1953	UN1953	UN1953	UN1953	UN1953
UN proper shipping name	COMPRESSED GAS, TOXIC, FLAMMABLE, N. O.S. (carbon monoxide, nitrogen)	COMPRESSED GAS, TOXIC, FLAMMABLE, N. O.S. (carbon monoxide, nitrogen)	COMPRESSED GAS, TOXIC, FLAMMABLE, N. O.S. (carbon monoxide, nitrogen)	COMPRESSED GAS, TOXIC, FLAMMABLE, N. O.S. (carbon monoxide, nitrogen)	COMPRESSED GAS, TOXIC, FLAMMABLE, N. O.S. (carbon monoxide, nitrogen)

Section 14. Transport information

Transport hazard class(es)	2.3 (2.1) 	2.3 (2.1) 	2 (2) 	2.3 (2.1) 	2.3 (2.1) 
Packing group	-	-	-	-	-
Environmental hazards	No.	No.	No.	No.	No.

Additional information

TDG Classification : Product classified as per the following sections of the Transportation of Dangerous Goods Regulations: 2.13-2.17 (Class 2), 2.13-2.17 (Class 2).

DOT Classification : Toxic - Inhalation hazard Zone D

ADR/RID : **Tunnel code** (B/D)

Special precautions for user : **Transport within user's premises:** always transport in closed containers that are upright and secure. Ensure that persons transporting the product know what to do in the event of an accident or spillage.

Transport in bulk according to Annex II of MARPOL and the IBC Code : Not available.

Section 15. Regulatory information

Canadian lists

Canadian NPRI : The following components are listed: Carbon monoxide

CEPA Toxic substances : The following components are listed: Carbon dioxide

International regulations

Chemical Weapon Convention List Schedules I, II & III Chemicals

Not listed.

Montreal Protocol (Annexes A, B, C, E)

Not listed.

Stockholm Convention on Persistent Organic Pollutants

Not listed.

Rotterdam Convention on Prior Informed Consent (PIC)

Not listed.

UNECE Aarhus Protocol on POPs and Heavy Metals

Not listed.

Inventory list

Australia : All components are listed or exempted.

Canada : All components are listed or exempted.

China : All components are listed or exempted.

Europe : All components are listed or exempted.

Japan : **Japan inventory (ENCS)**: Not determined.
Japan inventory (ISHL): Not determined.

Malaysia : Not determined.

New Zealand : All components are listed or exempted.

Section 15. Regulatory information

Philippines : All components are listed or exempted.

Republic of Korea : All components are listed or exempted.

Taiwan : All components are listed or exempted.

Thailand : Not determined.

Turkey : Not determined.

United States : All components are listed or exempted.

Viet Nam : Not determined.

Section 16. Other information

History

Date of printing : 11/30/2018

Date of issue/Date of revision : 11/30/2018

Date of previous issue : 6/25/2018

Version : 2

Prepared by : Contact your plant Occupational Health contact for additional information regarding this product or SDS.

Key to abbreviations : ATE = Acute Toxicity Estimate
BCF = Bioconcentration Factor
GHS = Globally Harmonized System of Classification and Labelling of Chemicals
IATA = International Air Transport Association
IBC = Intermediate Bulk Container
IMDG = International Maritime Dangerous Goods
LogPow = logarithm of the octanol/water partition coefficient
MARPOL = International Convention for the Prevention of Pollution From Ships, 1973 as modified by the Protocol of 1978. ("Marpol" = marine pollution)
UN = United Nations
HPR = Hazardous Products Regulations

Procedure used to derive the classification

Classification	Justification
FLAMMABLE GASES - Category 1	On basis of test data
GASES UNDER PRESSURE - Compressed gas	On basis of test data
ACUTE TOXICITY (inhalation) - Category 2	Calculation method
TOXIC TO REPRODUCTION (Unborn child) - Category 1	Calculation method
SPECIFIC TARGET ORGAN TOXICITY (REPEATED EXPOSURE) - Category 1	Calculation method

References : Not available.

Indicates information that has changed from previously issued version.

Notice to reader

Vale Canada believes that the information in this Safety Data Sheet is accurate. However, Vale Canada makes no express or implied warranty as to the accuracy of such information and expressly disclaims any liability resulting from reliance on such information.

Appendix B – SAFER Case

Chemical Release Report

Study

General

Description	CASE - 115
Notes	Reactor Pressure Control Valve Bonnet failure Fresh gas to Reactor at 1000 psig Gas Strength 20 gm Ni/m3 (0.26 mole % Ni(CO)4) Estimated time to empty reactor - 45 min 80% depressurized to PGST Mass release based ib 20% released: 1334.2 kg/min Ni(CO)4 + CO Release through roof exhaust accounts for dilution by building ventilation Fresh gas to IPC HP Reactor: new chemical established in SAFER database
Release time	2/20/2012 10:18:13 AM

Release Scenario

General

Chemical	Fresh Gas to IPC HP Reactor

Steady state

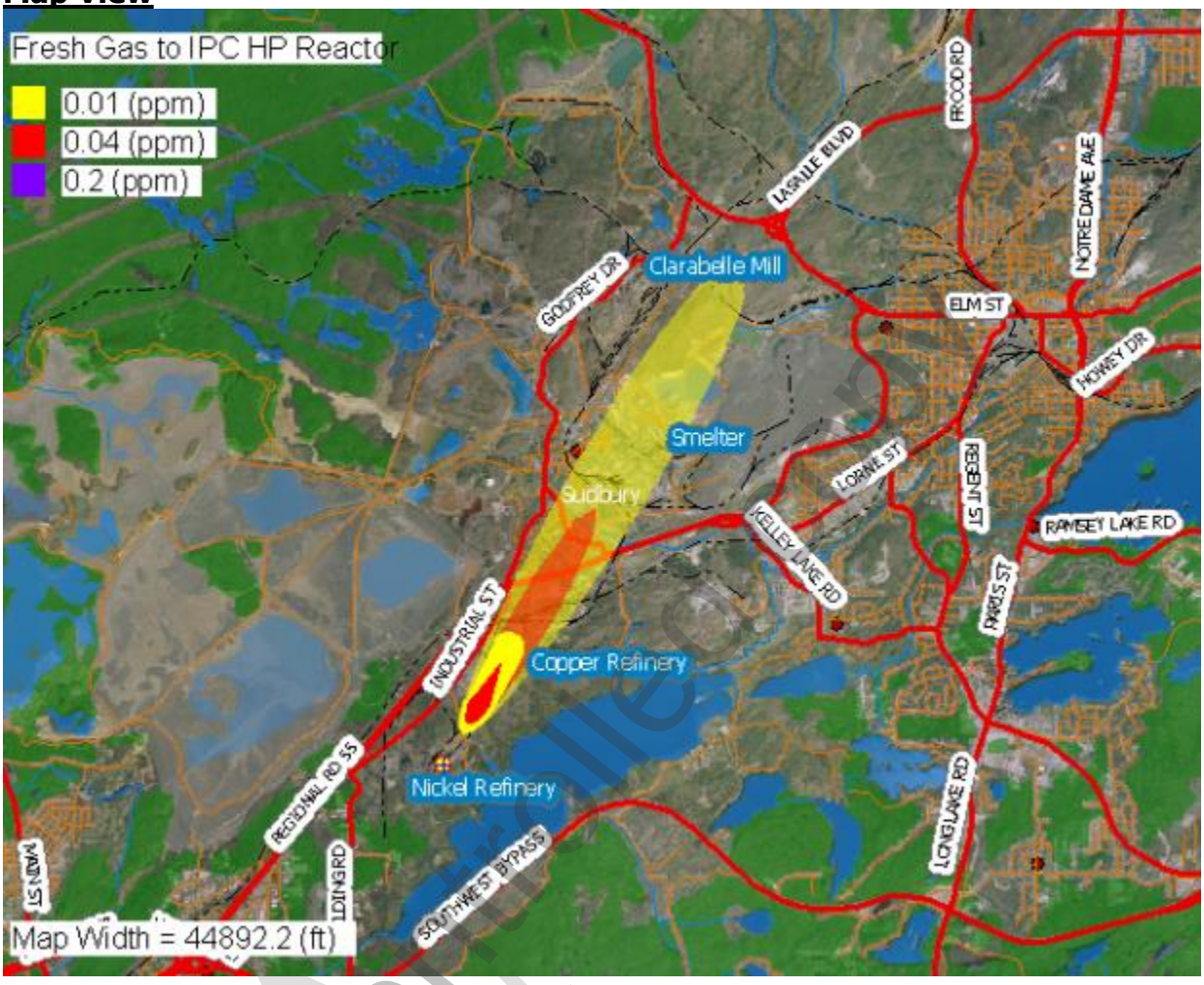
The release stream contains	Gas
The release type is	Continuous
Release temperature	165.6 (deg C)
Release height	0.0 (m)
Total release rate (mass)	1334.2 (kg/min)
Release duration	20.0 (min)
Percent chemical (dilution)	100.0 (%)

Building data

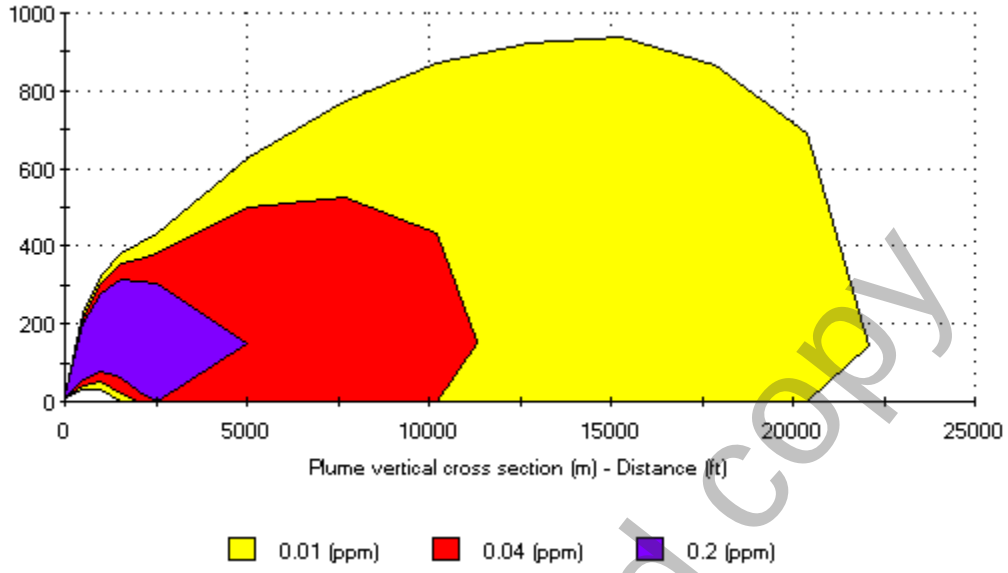
Building Length	69.5 (m)
Building Width	38.7 (m)
Building Height	45.7 (m)
Building Temperature	20.0 (deg C)
Velocity of Air inside the building	0.0 (m/s)
Exhaust Rate from building	237.1 (m^3/s)
Vent Height	13.9 (m)
Vent Radius	3.4 (m)

Release site on map -81.083889, 46.446907

Map View



Plume Vertical Cross-section



Meteorology

Surface roughness 0.1 (ft)
Ceiling height 10000.0 (m)
Upper stability class 4.0

Interval (min)	Ambient Temperature (deg C)	Horizontal Stability	Vertical Stability	Solar Radiation (W/m^2)	Humidity (%)
5.0	-7.4	4.0	2.0	359	82.0
10.0	-7.1	4.0	2.0	368	81.9
15.0	-7.1	4.0	2.0	368	81.9
20.0	-7.1	4.0	2.0	368	81.9
25.0	-7.1	4.0	2.0	368	81.9
30.0	-7.1	4.0	2.0	368	81.9
35.0	-7.1	4.0	2.0	368	81.9
40.0	-7.1	4.0	2.0	368	81.9
45.0	-7.1	4.0	2.0	368	81.9
50.0	-7.1	4.0	2.0	368	81.9
55.0	-7.1	4.0	2.0	368	81.9
60.0	-7.1	4.0	2.0	368	81.9
65.0	-7.1	4.0	2.0	368	81.9
70.0	-7.1	4.0	2.0	368	81.9
75.0	-7.1	4.0	2.0	368	81.9
80.0	-7.1	4.0	2.0	368	81.9
85.0	-7.1	4.0	2.0	368	81.9
90.0	-7.1	4.0	2.0	368	81.9

Interval	Ambient Temperature	Horizontal Stability	Vertical Stability	Solar Radiation	Humidity
(min)	(deg C)			(W/m^2)	(%)
95.0	-7.1	4.0	2.0	368	81.9
100.0	-7.1	4.0	2.0	368	81.9
105.0	-7.1	4.0	2.0	368	81.9
110.0	-7.1	4.0	2.0	368	81.9
115.0	-7.1	4.0	2.0	368	81.9
120.0	-7.1	4.0	2.0	368	81.9

SPD TOWER

Reference Height 107.6 (ft)

Interval	Wind Speed	Wind Direction
(min)	(km/h)	(deg [from])
5.0	8.0	SSW
10.0	8.3	SSW
15.0	8.3	SSW
20.0	8.3	SSW
25.0	8.3	SSW
30.0	8.3	SSW
35.0	8.3	SSW
40.0	8.3	SSW
45.0	8.3	SSW
50.0	8.3	SSW
55.0	8.3	SSW
60.0	8.3	SSW
65.0	8.3	SSW
70.0	8.3	SSW
75.0	8.3	SSW
80.0	8.3	SSW
85.0	8.3	SSW
90.0	8.3	SSW
95.0	8.3	SSW
100.0	8.3	SSW
105.0	8.3	SSW
110.0	8.3	SSW
115.0	8.3	SSW
120.0	8.3	SSW

Summary of source characteristics

Occurance of flash	No
Pool formation	No

Downwind Distance Report

Isopleth Limits (ppm)	Downwind distance (ft)
0.01	22012.3
0.04	11036.6
0.2	3407.9

Receptor Dosage Report

Receptors sorted by Impact Level(Ascending) Then by Name(Ascending)

Receptor	Impact Level (ppm)	First Impact	Duration (min)	Dosage (ppm-min)
Copper Refinery	Low	10:28:13 AM	20.0	0.4
Smelter	Low	10:48:13 AM	20.0	0.4
C.C. MILL	Low	10:48:13 AM	25.0	0.6
Copper Cliff	Low	10:38:13 AM	20.0	0.4
Copper Cliff	Low	10:38:13 AM	20.0	0.4
COPPER CLIFF GARDENS	Low	10:33:13 AM	20.0	0.4
CURLING CLUB	Low	10:38:13 AM	30.0	0.8
FIRST AID	Low	10:33:13 AM	20.0	0.6
GENERAL OFFICE	Low	10:48:13 AM	10.0	0.3
Matte Test Reference	Low	10:53:13 AM	20.0	0.4
NO. 1 DRY	Low	10:43:13 AM	25.0	0.7
NO. 3 DRY	Low	10:43:13 AM	25.0	0.6
OXYGEN CONTROL ROOM	Low	10:43:13 AM	30.0	0.7
SHOPS	Low	10:28:13 AM	25.0	0.5
ACID PLANT	Low	10:28:13 AM	40.0	2.9
ACID PLANT	Medium	10:28:13 AM	30.0	2.9
CASTING	Low	10:23:13 AM	40.0	2.0
CASTING	Medium	10:28:13 AM	20.0	2.0
ELECTROWINNING	Low	10:23:13 AM	45.0	3.3
ELECTROWINNING	Medium	10:28:13 AM	25.0	3.3
ENGINEERING BLDG	Low	10:33:13 AM	35.0	1.6
ENGINEERING BLDG	Medium	10:38:13 AM	20.0	1.6
SILVER REFINERY	Low	10:28:13 AM	40.0	2.4
SILVER REFINERY	Medium	10:33:13 AM	20.0	2.4

Receptor report

Receptors sorted by Impact Level(Ascending) Then by Name(Ascending)

Receptor - Copper Refinery

Distance 4069.6 (ft)

Dosage 0.4 (ppm-min)
Peak concentration 0.02 (ppm)
Time of peak concentration 25.0 (min)

Contact phone numbers -

Important Information

Impact Level	First Impact	Duration (min)
Low	10:28:13 AM	20.0

Receptor - Smelter

Distance 13925.1 (ft)
Dosage 0.4 (ppm-min)
Peak concentration 0.02 (ppm)
Time of peak concentration 45.0 (min)

Contact phone numbers -

Important Information

Impact Level	First Impact	Duration (min)
Low	10:48:13 AM	20.0

Receptor - C.C. MILL

Distance 14339.3 (ft)
Dosage 0.6 (ppm-min)
Peak concentration 0.02 (ppm)
Time of peak concentration 45.0 (min)

ACH

Low 1.0
Medium 2.0
High 3.0

Contact phone numbers -

Important Information

Impact Level	First Impact	Duration
		(min)
Low	10:48:13 AM	25.0

Receptor - Copper Cliff

Distance	9474.3 (ft)
Dosage	0.4 (ppm-min)
Peak concentration	0.02 (ppm)
Time of peak concentration	35.0 (min)

Contact phone numbers -

Important Information

Impact Level	First Impact	Duration
		(min)
Low	10:38:13 AM	20.0

Receptor - Copper Cliff

Distance	10122.2 (ft)
Dosage	0.4 (ppm-min)
Peak concentration	0.02 (ppm)
Time of peak concentration	35.0 (min)

ACH

Low	0.5
Medium	1.0
High	1.5

Contact phone numbers -

Important Information

Impact Level	First Impact	Duration
		(min)
Low	10:38:13 AM	20.0

Receptor - COPPER CLIFF GARDENS

Distance	7468.8 (ft)
Dosage	0.4 (ppm-min)
Peak concentration	0.02 (ppm)

Time of peak concentration 30.0 (min)

ACH

Low 0.3
Medium 0.5
High 1.0

Contact phone numbers -

Important Information

Impact Level	First Impact	Duration (min)
Low	10:33:13 AM	20.0

Receptor - CURLING CLUB

Distance 11159.5 (ft)
Dosage 0.8 (ppm-min)
Peak concentration 0.03 (ppm)
Time of peak concentration 40.0 (min)

ACH

Low 0.5
Medium 1.0
High 2.0

Contact phone numbers -

Important Information

Impact Level	First Impact	Duration (min)
Low	10:38:13 AM	30.0

Receptor - FIRST AID

Distance 5482.2 (ft)
Dosage 0.6 (ppm-min)
Peak concentration 0.02 (ppm)
Time of peak concentration 30.0 (min)

ACH

Low	0.5
Medium	1.0
High	2.0

Contact phone numbers -

Important Information

Impact Level	First Impact	Duration (min)
Low	10:33:13 AM	20.0

Receptor - GENERAL OFFICE

Distance	12258.6 (ft)
Dosage	0.3 (ppm-min)
Peak concentration	0.01 (ppm)
Time of peak concentration	40.0 (min)

ACH

Low	0.5
Medium	1.0
High	2.0

Contact phone numbers -

Important Information

Impact Level	First Impact	Duration (min)
Low	10:48:13 AM	10.0

Receptor - Matte Test Reference

Distance	16670.3 (ft)
Dosage	0.4 (ppm-min)
Peak concentration	0.02 (ppm)
Time of peak concentration	50.0 (min)

Contact phone numbers -

Important Information

3700 feet from dump site for the matte test

Impact Level	First Impact	Duration
		(min)
Low	10:53:13 AM	20.0

Receptor - NO. 1 DRY

Distance	12207.6 (ft)
Dosage	0.7 (ppm-min)
Peak concentration	0.03 (ppm)
Time of peak concentration	40.0 (min)

ACH

Low	0.5
Medium	1.0
High	2.0

Contact phone numbers -

Important Information

Impact Level	First Impact	Duration
		(min)
Low	10:43:13 AM	25.0

Receptor - NO. 3 DRY

Distance	13381.3 (ft)
Dosage	0.6 (ppm-min)
Peak concentration	0.02 (ppm)
Time of peak concentration	45.0 (min)

ACH

Low	1.0
Medium	2.0
High	3.0

Contact phone numbers -

Important Information

Impact Level	First Impact	Duration

		(min)
Low	10:43:13 AM	25.0

Receptor - OXYGEN CONTROL ROOM

Distance	13406.0 (ft)
Dosage	0.7 (ppm-min)
Peak concentration	0.03 (ppm)
Time of peak concentration	45.0 (min)

ACH

Low	0.5
Medium	1.0
High	2.0

Contact phone numbers -

Important Information

Impact Level	First Impact	Duration (min)
Low	10:43:13 AM	30.0

Receptor - SHOPS

Distance	5401.6 (ft)
Dosage	0.5 (ppm-min)
Peak concentration	0.02 (ppm)
Time of peak concentration	30.0 (min)

ACH

Low	0.5
Medium	1.0
High	2.0

Contact phone numbers -

Important Information

Impact Level	First Impact	Duration (min)
Low	10:28:13 AM	25.0

Receptor - ACID PLANT

Distance	5768.8 (ft)
Dosage	2.9 (ppm-min)
Peak concentration	0.1 (ppm)
Time of peak concentration	30.0 (min)

ACH

Low	0.5
Medium	1.0
High	2.0

Contact phone numbers -

Important Information

Impact Level	First Impact	Duration (min)
Low	10:28:13 AM	40.0
Medium	10:28:13 AM	30.0

Receptor - CASTING

Distance	4972.6 (ft)
Dosage	2.0 (ppm-min)
Peak concentration	0.1 (ppm)
Time of peak concentration	25.0 (min)

ACH

Low	1.0
Medium	2.0
High	3.0

Contact phone numbers -

Important Information

Impact Level	First Impact	Duration (min)
Low	10:23:13 AM	40.0
Medium	10:28:13 AM	20.0

Receptor - ELECTROWINNING

Distance	4680.9 (ft)
Dosage	3.3 (ppm-min)
Peak concentration	0.2 (ppm)
Time of peak concentration	25.0 (min)

ACH

Low	0.5
Medium	1.0
High	2.0

Contact phone numbers -

Important Information

Impact Level	First Impact	Duration (min)
Low	10:23:13 AM	45.0
Medium	10:28:13 AM	25.0

Receptor - ENGINEERING BLDG

Distance	8020.6 (ft)
Dosage	1.6 (ppm-min)
Peak concentration	0.1 (ppm)
Time of peak concentration	35.0 (min)

ACH

Low	0.3
Medium	0.5
High	1.0

Contact phone numbers -

Important Information

Impact Level	First Impact	Duration (min)
Low	10:33:13 AM	35.0
Medium	10:38:13 AM	20.0

Receptor - SILVER REFINERY

Distance	5600.4 (ft)
Dosage	2.4 (ppm-min)
Peak concentration	0.1 (ppm)
Time of peak concentration	30.0 (min)

ACH

Low	0.5
Medium	1.0
High	2.0

Contact phone numbers -

Important Information

Impact Level	First Impact	Duration
		(min)
Low	10:28:13 AM	40.0
Medium	10:33:13 AM	20.0

Infiltration Report

Receptors sorted by Impact Level(Ascending) Then by Name(Ascending)

Receptor	ACH	Max. Outside Conc.	Max. Inside Conc.	Outside Dosage	Inside Dosage (2-hours)	Inside Dosage, Evacuation
		(ppm)	(ppm)	(ppm-min)	(ppm-min)	(ppm-min)
C.C. MILL	3.0	0.02	0.01	0.6	0.6	0.4
Copper Cliff	1.5	0.02	0.01	0.4	0.3	0.1
COPPER CLIFF GARDENS	1.0	0.02	0.005	0.4	0.3	0.1
CURLING CLUB	2.0	0.03	0.01	0.8	0.7	0.4
FIRST AID	2.0	0.02	0.01	0.6	0.6	0.3
GENERAL OFFICE	2.0	0.01	0.01	0.3	0.2	0.1
NO. 1 DRY	2.0	0.03	0.01	0.7	0.7	0.4
NO. 3 DRY	3.0	0.02	0.01	0.6	0.6	0.4
OXYGEN CONTROL ROOM	2.0	0.03	0.01	0.7	0.7	0.4
SHOPS	2.0	0.02	0.01	0.5	0.5	0.2
ACID PLANT	2.0	0.1	0.1	2.9	2.8	2.0
CASTING	3.0	0.1	0.05	2.0	2.0	1.5
ELECTROWINNING	2.0	0.2	0.1	3.3	3.2	2.3

Receptor	ACH	Max. Outside Conc.	Max. Inside Conc.	Outside Dosage	Inside Dosage (2-hours)	Inside Dosage, Evacuation
		(ppm)	(ppm)	(ppm-min)	(ppm-min)	(ppm-min)
ENGINEERING BLDG	1.0	0.1	0.02	1.6	1.3	0.6
SILVER REFINERY	2.0	0.1	0.05	2.4	2.3	1.6

Chemical properties

General

Description	Fresh Gas to IPC HP Reactor
Category	GAS MIXTURE
Formula	
CAS Number	
U.N. or Dot Number	
Ref. Number	

Gas Mixture Setup

Component	Composition amount	Key component
	(Mole %)	
CARBON MONOXIDE	99.7	No
NI(CO)4	0.3	Yes

Gas Properties

Critical Temperature	-139.2 (deg C)
Critical Pressure	34.5 (atm)
Critical Volume	93.9 (cm^3/mol)
Molecular Weight	28.4 (gm/mol)
Ideal gas heat capacity (Cp) = A + B*T + C*T^2 + D*T^3	J/(kmol.deg K)
A	31056.4
B	-12.6
C	0.03
D	0.0

Liquid Properties

Normal boiling point (NBP)	-190.7 (deg C)
Surface tension at NBP	9.4 (dyne/cm)
Viscosity at NBP	0.17 (centipoise)
Enthalpy at NBP	6.2 (cal/mol)
Enthalpy at NBP + 10 degK	154.7 (cal/mol)
Enthalpy at NBP + 20 degK	307.1 (cal/mol)
Density at NBP	0.78 (gm/cm^3)
Density at NBP - 5 degK	0.80 (gm/cm^3)

Temperature at 400 mm Hg vapor pressure	-196.0 (deg C)

F/E Properties

Heat of formation	-110203.1 (J/mol)
Heat of combustion	67397.2 (cal/mol)
Heat of vaporization	1439.8 (cal/mol)
Reactivity	2.0
Upper explosive limit (UEL)	738834.6 (ppm)
Lower explosive limit (LEL)	123061.8 (ppm)
Carbon	1.0
Hydrogen	0.0
Oxygen	1.0
Nitrogen	0.0
Halogen	0.0
Sulfur	0.0

Chemical Release Report

Study

General

Description	CASE - 157
Notes	Catastrophic PGST Tank Release PGST_CO Carbonyl Mixture Equivalent to 30 mole% Ni(CO)4 [after reactor blowdown] 20 cm long x 0.25 cm wide tear in rubber liner Tank pressure during reactor blowdown - ~40 ins w.g. Absolute pressure: 16.14 psi Tank temperature: Ambient Efforts to reduce pressure in PGST will be modeled when tank pressure is updated
Release time	2/15/2012 12:56:52 PM

Release Scenario

General

Chemical	PGST_CO Carbonyl Mixture

Tank Info.

Tank geometry & dimensions	Vertical cylinder
Tank height	24.5 (m)
Tank diameter	34.0 (m)
Tank wall thickness	0.6 (cm)
Tank temperature	-0.1 (deg C)
Tank contents	Gas pressure
Gas pressure	16.1 (psi)
Tank padding	Off

Leak Info.

Tank leak type	Orifice - Rectangular
Hole length	20.0 (cm)
Hole width	0.3 (cm)
Hole elevation	24.5 (m)
Angle (0=Horizontal, 90 deg =Vertical)	90.0 (deg)

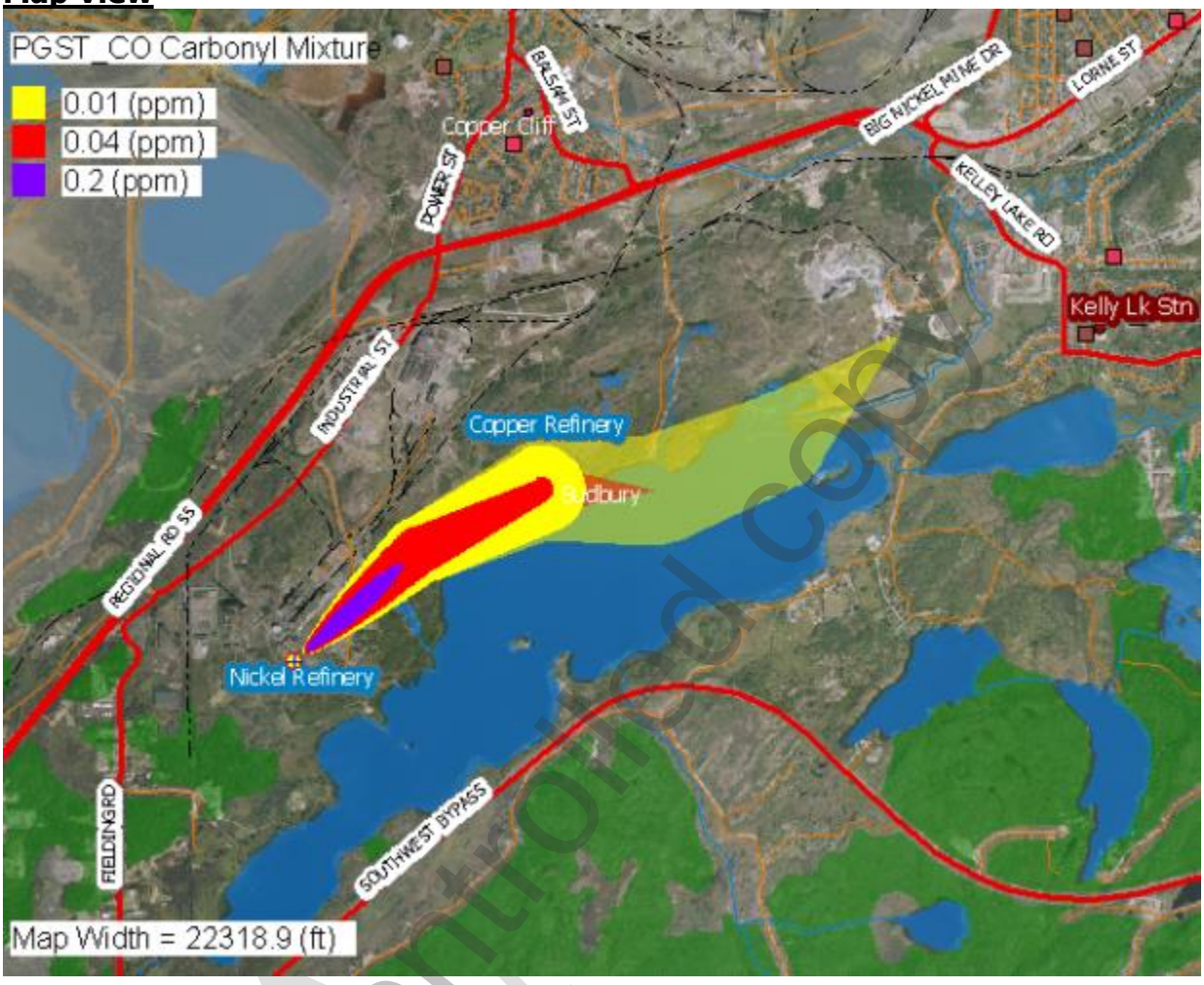
Pool Info.

Substrate type	Concrete

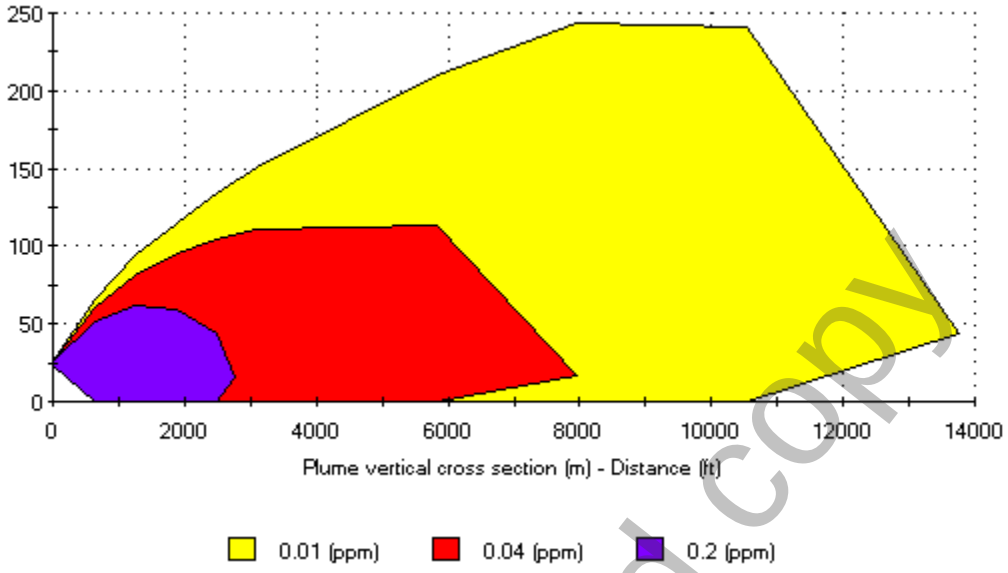
Substrate temperature	-0.1 (deg C)
Pool area	Unconfined
Minimum pool depth	Unconfined
Aerosol formation	Let model decide
Aerosol/Flash ratio	0.0
Initial air entrainment	Don't evaporate any aerosol
Air/Chemical ratio	0.0

Release site on map	-81.084909, 46.444285

Map View



Plume Vertical Cross-section



Meteorology

Surface roughness 0.1 (ft)
Ceiling height 10000.0 (m)
Upper stability class 4.0

Interval	Ambient Temperature	Horizontal Stability	Vertical Stability	Solar Radiation	Humidity
(min)	(deg C)			(W/m^2)	(%)
5.0	-0.1	4.0	3.0	275	90.0
10.0	-0.1	4.0	3.0	270	90.3
15.0	-0.1	4.0	3.0	270	90.3
20.0	-0.1	4.0	3.0	270	90.3
25.0	-0.1	4.0	3.0	270	90.3
30.0	-0.1	4.0	3.0	270	90.3
35.0	-0.1	4.0	3.0	270	90.3
40.0	-0.1	4.0	3.0	270	90.3
45.0	-0.1	4.0	3.0	270	90.3
50.0	-0.1	4.0	3.0	270	90.3
55.0	-0.1	4.0	3.0	270	90.3
60.0	-0.1	4.0	3.0	270	90.3
65.0	-0.1	4.0	3.0	270	90.3
70.0	-0.1	4.0	3.0	270	90.3
75.0	-0.1	4.0	3.0	270	90.3
80.0	-0.1	4.0	3.0	270	90.3
85.0	-0.1	4.0	3.0	270	90.3
90.0	-0.1	4.0	3.0	270	90.3

Interval	Ambient Temperature	Horizontal Stability	Vertical Stability	Solar Radiation	Humidity
(min)	(deg C)			(W/m^2)	(%)
95.0	-0.1	4.0	3.0	270	90.3
100.0	-0.1	4.0	3.0	270	90.3
105.0	-0.1	4.0	3.0	270	90.3
110.0	-0.1	4.0	3.0	270	90.3
115.0	-0.1	4.0	3.0	270	90.3
120.0	-0.1	4.0	3.0	270	90.3

SPD TOWER

Reference Height 107.6 (ft)

Interval	Wind Speed	Wind Direction
(min)	(km/h)	(deg [from])
5.0	10.8	SW
10.0	11.2	SW
15.0	11.2	SW
20.0	11.2	SW
25.0	11.2	SW
30.0	11.2	SW
35.0	11.2	SW
40.0	11.2	SW
45.0	11.2	SW
50.0	11.2	SW
55.0	11.2	SW
60.0	11.2	SW
65.0	11.2	SW
70.0	11.2	SW
75.0	11.2	SW
80.0	11.2	SW
85.0	11.2	SW
90.0	11.2	SW
95.0	11.2	SW
100.0	11.2	SW
105.0	11.2	SW
110.0	11.2	SW
115.0	11.2	SW
120.0	11.2	SW

Summary of source characteristics

Maximum release rate	4.8 (kg/min)
Release duration	1949.7 (min)
Occurance of flash	No
Pool formation	No

Downwind Distance Report

Isopleth Limits (ppm)	Downwind distance (ft)
0.01	12876.9
0.04	7422.1
0.2	2691.4

Source status after 2 hours

Tank contents

Mass	170415.6 (lb)
Pressure	16.0 (psi)
Temperature	-0.1 (deg C)
Liquid level	0.0 (ft)

Receptor Dosage Report

Receptors sorted by Impact Level(Ascending) Then by Name(Ascending)

Receptor	Impact Level (ppm)	First Impact	Duration (min)	Dosage (ppm-min)
Fielding Bird Sanctuary	Low	1:01:52 PM	115.0	7.1
Fielding Bird Sanctuary	Medium	1:01:52 PM	115.0	7.1
Refuge d'oiseaux de Fielding	Low	1:01:52 PM	115.0	7.1
Refuge d'oiseaux de Fielding	Medium	1:01:52 PM	115.0	7.1

Receptor report

Receptors sorted by Impact Level(Ascending) Then by Name(Ascending)

Receptor - Fielding Bird Sanctuary

Distance	5658.4 (ft)
Dosage	7.1 (ppm-min)
Peak concentration	0.1 (ppm)
Time of peak concentration	15.0 (min)

Contact phone numbers - (000)000-0000

Important Information

Impact Level	First Impact	Duration

		(min)
Low	1:01:52 PM	115.0
Medium	1:01:52 PM	115.0

Receptor - Refuge d'oiseaux de Fielding

Distance	5658.4 (ft)
Dosage	7.1 (ppm-min)
Peak concentration	0.1 (ppm)
Time of peak concentration	15.0 (min)

Contact phone numbers - (000)000-0000

Important Information

Impact Level	First Impact	Duration
		(min)
Low	1:01:52 PM	115.0
Medium	1:01:52 PM	115.0

Chemical properties

General

Description	PGST_CO Carbonyl Mixture
Category	GAS MIXTURE
Formula	
CAS Number	
U.N. or Dot Number	
Ref. Number	

Gas Mixture Setup

Component	Composition amount	Key component
	(Mole %)	
CARBON MONOXIDE	70.0	No
NI(CO)4	30.0	Yes

Gas Properties

Critical Temperature	-39.7 (deg C)
Critical Pressure	33.1 (atm)
Critical Volume	176.5 (cm^3/mol)
Molecular Weight	70.8 (gm/mol)
Ideal gas heat capacity (Cp) = A + B*T + C*T^2 + D*T^3	J/(kmol.deg K)
A	49584.7

B	13.9
C	0.3
D	0.0

Liquid Properties

Normal boiling point (NBP)	-121.3 (deg C)
Surface tension at NBP	10.6 (dyne/cm)
Viscosity at NBP	0.21 (centipoise)
Enthalpy at NBP	618.0 (cal/mol)
Enthalpy at NBP + 10 degK	871.3 (cal/mol)
Enthalpy at NBP + 20 degK	1127.2 (cal/mol)
Density at NBP	0.95 (gm/cm^3)
Density at NBP - 5 degK	0.97 (gm/cm^3)
Temperature at 400 mm Hg vapor pressure	-130.0 (deg C)

F/E Properties

Heat of formation	-77835.4 (J/mol)
Heat of combustion	47320.0 (cal/mol)
Heat of vaporization	1023.4 (cal/mol)
Reactivity	2.0
Upper explosive limit (UEL)	639180.8 (ppm)
Lower explosive limit (LEL)	48543.7 (ppm)
Carbon	1.0
Hydrogen	0.0
Oxygen	1.0
Nitrogen	0.0
Halogen	0.0
Sulfur	0.0

Chemical Release Report

Study

General

Description	CASE - 134
Notes	NH3 Tank Release No pad pressure applied Tank Temperature: 0 deg C 0.8 cm dia hole at 20% level from the bottom Liquid NH3 level at 50% Dia: 5.5 ft Length: 28.6 ft Assume 3/8 - inch wall thickness Substrate temp - Ambient Temp Gravel substrate
Release time	2/15/2012 12:01:58 PM

Release Scenario

General

Chemical	AMMONIA

Tank Info.

Tank geometry & dimensions	Horizontal cylinder
Tank length	8.7 (m)
Tank diameter	1.7 (m)
Tank wall thickness	1.0 (cm)
Tank temperature	0.0 (deg C)
Tank contents	Liquid level
Liquid level	2.8 (ft)
Tank padding	Off

Leak Info.

Tank leak type	Orifice - Circular
Hole diameter	0.8 (cm)
Hole elevation	0.3 (m)
Angle (0=Horizontal, 90 deg =Vertical)	0.0 (deg)

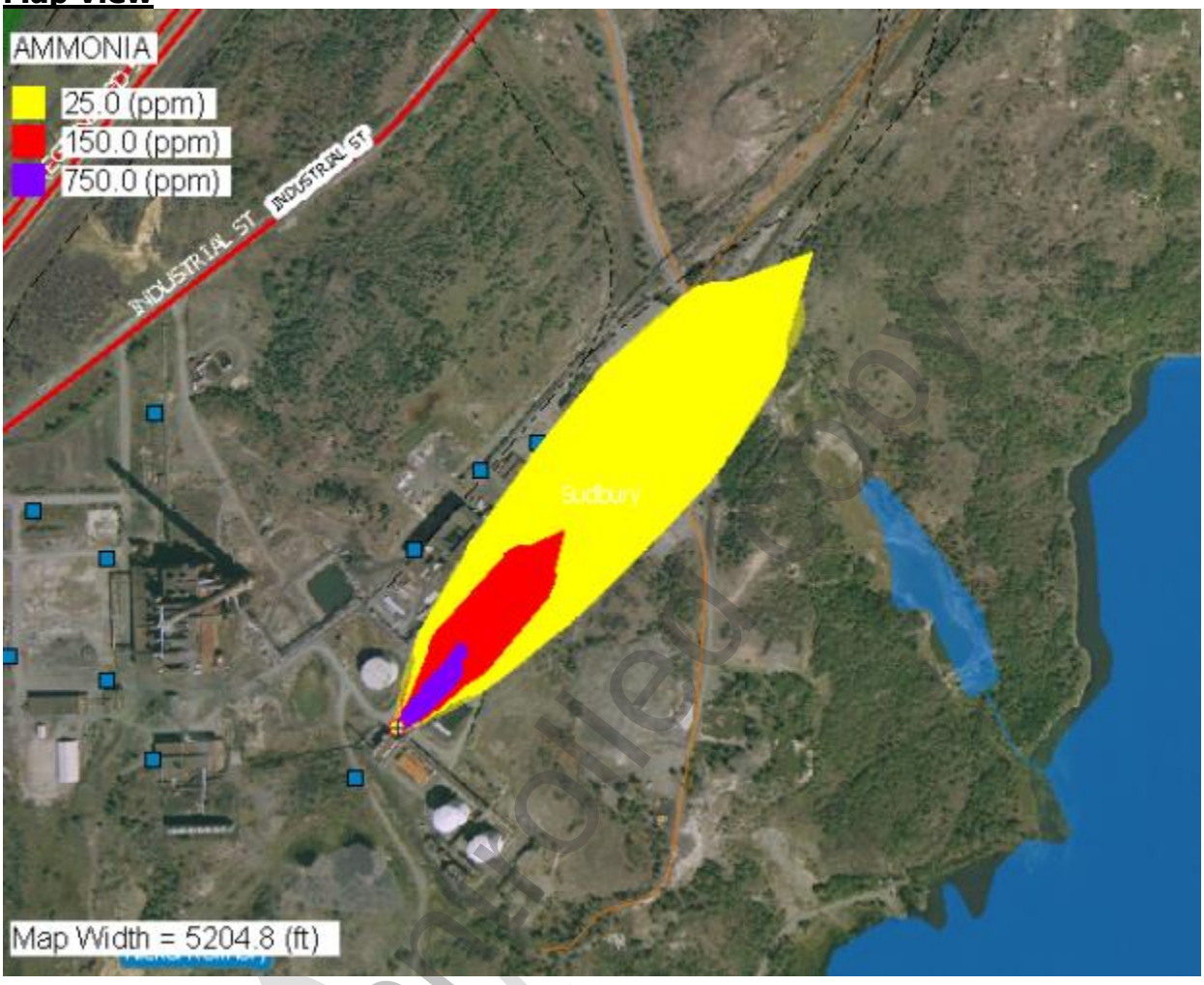
Pool Info.

Substrate type	Gravel
Substrate temperature	-0.8 (deg C)
Pool area	Unconfined
Minimum pool depth	Unconfined

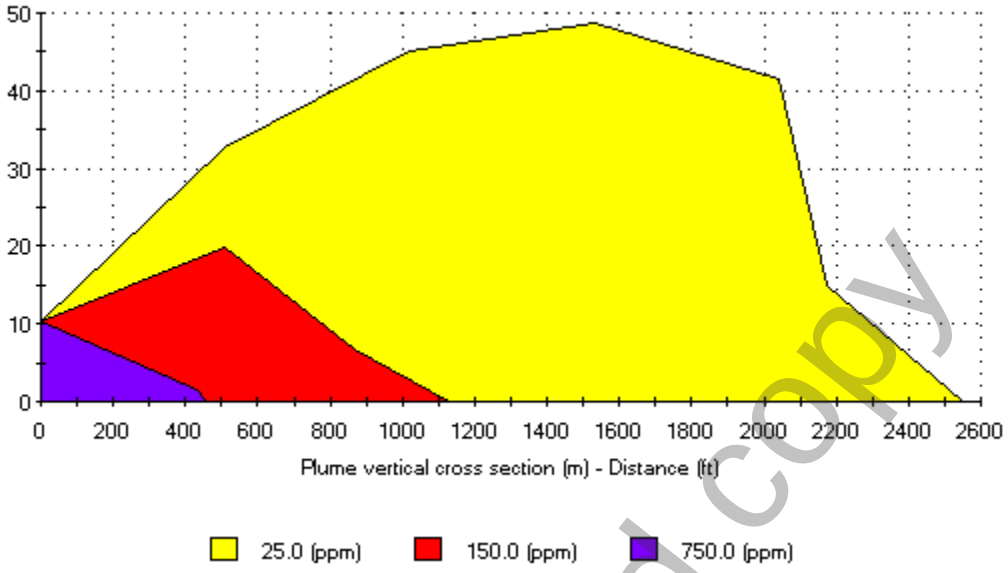
Aerosol formation	Let model decide
Aerosol/Flash ratio	0.0
Initial air entrainment	Don't evaporate any aerosol
Air/Chemical ratio	0.0

Release site on map	-81.085938, 46.445303

Map View



Plume Vertical Cross-section



Meteorology

Surface roughness 0.1 (ft)
Ceiling height 10000.0 (m)
Upper stability class 4.0

Interval	Ambient Temperature	Horizontal Stability	Vertical Stability	Solar Radiation	Humidity
(min)	(deg C)			(W/m^2)	(%)
5.0	-0.8	4.0	3.0	186	91.0
10.0	-0.7	4.0	3.0	206	91.1
15.0	-0.7	4.0	3.0	206	91.1
20.0	-0.7	4.0	3.0	206	91.1
25.0	-0.7	4.0	3.0	206	91.1
30.0	-0.7	4.0	3.0	206	91.1
35.0	-0.7	4.0	3.0	206	91.1
40.0	-0.7	4.0	3.0	206	91.1
45.0	-0.7	4.0	3.0	206	91.1
50.0	-0.7	4.0	3.0	206	91.1
55.0	-0.7	4.0	3.0	206	91.1
60.0	-0.7	4.0	3.0	206	91.1
65.0	-0.7	4.0	3.0	206	91.1
70.0	-0.7	4.0	3.0	206	91.1
75.0	-0.7	4.0	3.0	206	91.1
80.0	-0.7	4.0	3.0	206	91.1
85.0	-0.7	4.0	3.0	206	91.1
90.0	-0.7	4.0	3.0	206	91.1

Interval	Ambient Temperature	Horizontal Stability	Vertical Stability	Solar Radiation	Humidity
(min)	(deg C)			(W/m^2)	(%)
95.0	-0.7	4.0	3.0	206	91.1
100.0	-0.7	4.0	3.0	206	91.1
105.0	-0.7	4.0	3.0	206	91.1
110.0	-0.7	4.0	3.0	206	91.1
115.0	-0.7	4.0	3.0	206	91.1
120.0	-0.7	4.0	3.0	206	91.1

SPD TOWER

Reference Height 107.6 (ft)

Interval	Wind Speed	Wind Direction
(min)	(km/h)	(deg [from])
5.0	7.9	SW
10.0	9.2	SW
15.0	9.2	SW
20.0	9.2	SW
25.0	9.2	SW
30.0	9.2	SW
35.0	9.2	SW
40.0	9.2	SW
45.0	9.2	SW
50.0	9.2	SW
55.0	9.2	SW
60.0	9.2	SW
65.0	9.2	SW
70.0	9.2	SW
75.0	9.2	SW
80.0	9.2	SW
85.0	9.2	SW
90.0	9.2	SW
95.0	9.2	SW
100.0	9.2	SW
105.0	9.2	SW
110.0	9.2	SW
115.0	9.2	SW
120.0	9.2	SW

Summary of source characteristics

Maximum release rate	40.2 (kg/min)
Release duration	296.2 (min)
Occurance of flash	Yes
Pool formation	Yes

Maximum pool area	631.6 (ft^2)
Maximum evaporation rate	27.4 (kg/min)
Total pool evaporation time	132.5 (min)

Downwind Distance Report

Isopleth Limits (ppm)	Downwind distance (ft)
25.0	> 2558.4
150.0	> 1129.0
750.0	> 465.7

Source status after 2 hours

Tank contents

Mass	3968.3 (lb)
Pressure	54.8 (psi)
Temperature	-3.1 (deg C)
Liquid level	1.1 (ft)

Pool contents

Mass	370.4 (lb)
Volume	0.3 (m^3)
Temperature	-33.1 (deg C)
Diameter	19.9 (ft)
Depth	0.4 (in)

Receptor report

Receptors sorted by Impact Level(Ascending) Then by Name(Ascending)

Receptor - CCNR GATE

Distance	1575.0 (ft)
Dosage	712.0 (ppm-min)
Peak concentration	46.6 (ppm)
Time of peak concentration	5.0 (min)

ACH

Low	0.3
Medium	0.5
High	1.0

Contact phone numbers -

Important Information

Impact Level	First Impact	Duration (min)
Low	12:01:58 PM	5.0

Receptor - PACK AND SHIP

Distance	1382.9 (ft)
Dosage	6423.2 (ppm-min)
Peak concentration	69.4 (ppm)
Time of peak concentration	5.0 (min)

ACH

Low	0.5
Medium	1.0
High	2.0

Contact phone numbers -

Important Information

Impact Level	First Impact	Duration (min)
Low	12:01:58 PM	120.0

Receptor - LIQUID PROD STOR

Distance	97.2 (ft)
Dosage	891571.7 (ppm-min)
Peak concentration	8613.1 (ppm)
Time of peak concentration	5.0 (min)

ACH

Low	0.5
Medium	1.0
High	2.0

Contact phone numbers -

Important Information

Impact Level	First Impact	Duration
		(min)
Low	12:01:58 PM	120.0
Medium	12:01:58 PM	120.0
High	12:01:58 PM	120.0

Chemical properties

General

Description	AMMONIA
Category	NORMAL
Formula	NH3
CAS Number	
U.N. or Dot Number	
Ref. Number	

Gas Properties

Critical Temperature	132.5 (deg C)
Critical Pressure	111.3 (atm)
Critical Volume	72.5 (cm^3/mol)
Molecular Weight	17.0 (gm/mol)
Ideal gas heat capacity (Cp) = A + B*T + C*T^2 + D*T^3	J/(kmol.deg K)
A	27314.7
B	23.8
C	0.02
D	0.0

Liquid Properties

Normal boiling point (NBP)	-33.5 (deg C)
Surface tension at NBP	34.4 (dyne/cm)
Viscosity at NBP	0.25 (centipoise)
Enthalpy at NBP	0.0 (cal/mol)
Enthalpy at NBP + 10 degK	178.0 (cal/mol)
Enthalpy at NBP + 20 degK	356.0 (cal/mol)
Density at NBP	0.68 (gm/cm^3)
Density at NBP - 5 degK	0.69 (gm/cm^3)
Temperature at 400 mm Hg vapor pressure	-45.5 (deg C)

Chemical Release Report

Study

General

Description	CASE - 128
Notes	Ammonia liquid leak during the filling of the storage tank 3 drips/sec from the hose connection Equivalent release rate: .041 kg/min [based on liquid density: 0.68 g/cm3]
Release time	2/15/2012 12:00:39 PM

Release Scenario

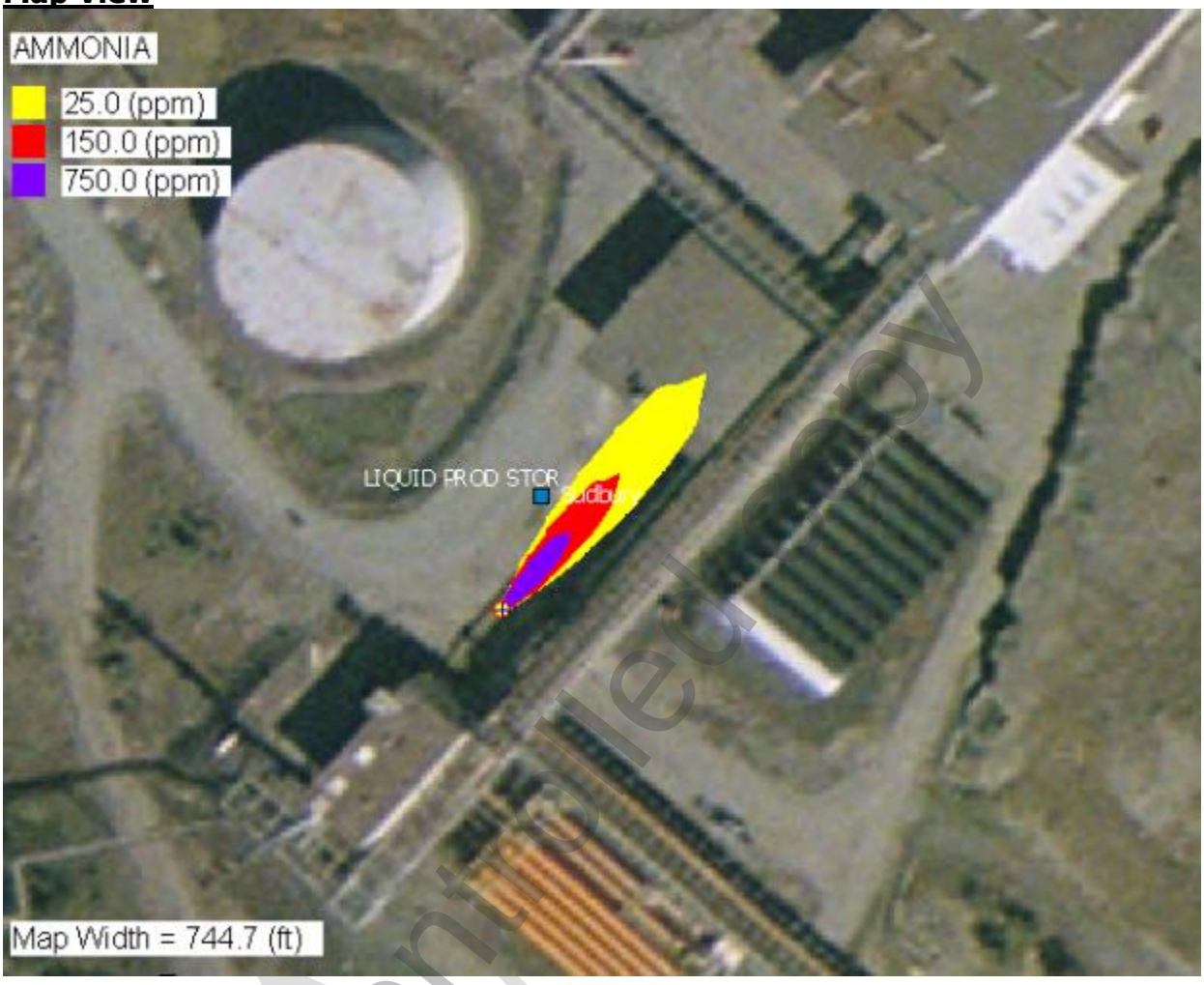
General

Chemical	AMMONIA

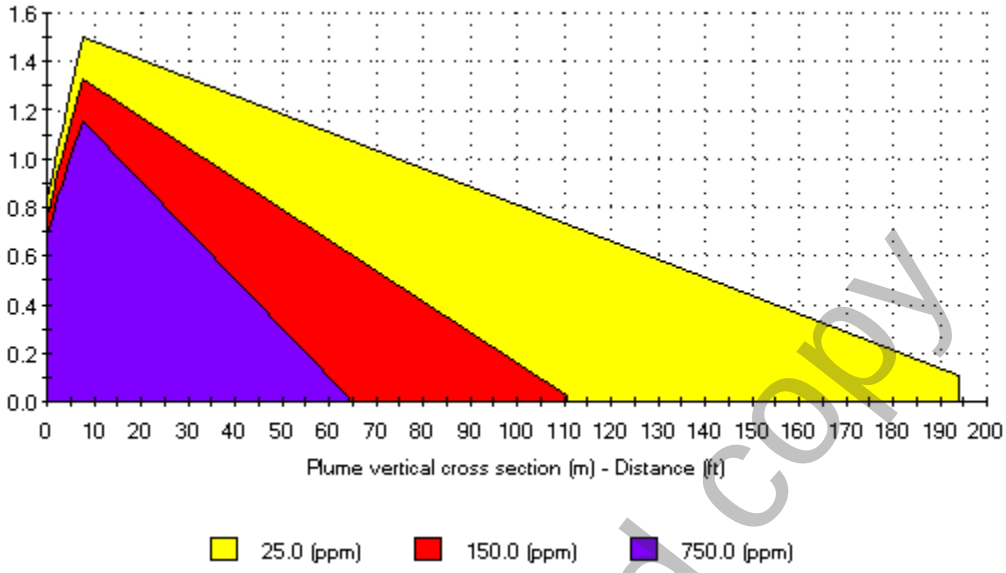
Steady state

The release stream contains	Gas
The release type is	Continuous
Release temperature	-45.0 (deg C)
Release height	0.0 (m)
Total release rate (mass)	0.04 (kg/min)
Release duration	30.0 (min)
Percent chemical (dilution)	100.0 (%)
Release site on map	-81.085866, 46.445351

Map View



Plume Vertical Cross-section



Meteorology

Surface roughness 0.1 (ft)
Ceiling height 10000.0 (m)
Upper stability class 4.0

Interval	Ambient Temperature	Horizontal Stability	Vertical Stability	Solar Radiation	Humidity
(min)	(deg C)			(W/m^2)	(%)
5.0	-0.8	4.0	3.0	186	91.0
10.0	-0.7	4.0	3.0	199	91.1
15.0	-0.7	4.0	3.0	199	91.1
20.0	-0.7	4.0	3.0	199	91.1
25.0	-0.7	4.0	3.0	199	91.1
30.0	-0.7	4.0	3.0	199	91.1
35.0	-0.7	4.0	3.0	199	91.1
40.0	-0.7	4.0	3.0	199	91.1
45.0	-0.7	4.0	3.0	199	91.1
50.0	-0.7	4.0	3.0	199	91.1
55.0	-0.7	4.0	3.0	199	91.1
60.0	-0.7	4.0	3.0	199	91.1
65.0	-0.7	4.0	3.0	199	91.1
70.0	-0.7	4.0	3.0	199	91.1
75.0	-0.7	4.0	3.0	199	91.1
80.0	-0.7	4.0	3.0	199	91.1
85.0	-0.7	4.0	3.0	199	91.1
90.0	-0.7	4.0	3.0	199	91.1

Interval	Ambient Temperature	Horizontal Stability	Vertical Stability	Solar Radiation	Humidity
(min)	(deg C)			(W/m^2)	(%)
95.0	-0.7	4.0	3.0	199	91.1
100.0	-0.7	4.0	3.0	199	91.1
105.0	-0.7	4.0	3.0	199	91.1
110.0	-0.7	4.0	3.0	199	91.1
115.0	-0.7	4.0	3.0	199	91.1
120.0	-0.7	4.0	3.0	199	91.1

SPD TOWER

Reference Height 107.6 (ft)

Interval	Wind Speed	Wind Direction
(min)	(km/h)	(deg [from])
5.0	7.9	SW
10.0	8.8	SW
15.0	8.8	SW
20.0	8.8	SW
25.0	8.8	SW
30.0	8.8	SW
35.0	8.8	SW
40.0	8.8	SW
45.0	8.8	SW
50.0	8.8	SW
55.0	8.8	SW
60.0	8.8	SW
65.0	8.8	SW
70.0	8.8	SW
75.0	8.8	SW
80.0	8.8	SW
85.0	8.8	SW
90.0	8.8	SW
95.0	8.8	SW
100.0	8.8	SW
105.0	8.8	SW
110.0	8.8	SW
115.0	8.8	SW
120.0	8.8	SW

Summary of source characteristics

Occurance of flash	No
Pool formation	No

Downwind Distance Report

Isopleth Limits (ppm)	Downwind distance (ft)
25.0	194.1
150.0	110.9
750.0	64.2

Receptor report

No receptors are impacted

Chemical properties

General

Description	AMMONIA
Category	NORMAL
Formula	NH3
CAS Number	
U.N. or Dot Number	
Ref. Number	

Gas Properties

Critical Temperature	132.5 (deg C)
Critical Pressure	111.3 (atm)
Critical Volume	72.5 (cm^3/mol)
Molecular Weight	17.0 (gm/mol)
Ideal gas heat capacity (Cp) = A + B*T + C*T^2 + D*T^3	J/(kmol.deg K)
A	27314.7
B	23.8
C	0.02
D	0.0

Liquid Properties

Normal boiling point (NBP)	-33.5 (deg C)
Surface tension at NBP	34.4 (dyne/cm)
Viscosity at NBP	0.25 (centipoise)
Enthalpy at NBP	0.0 (cal/mol)
Enthalpy at NBP + 10 degK	178.0 (cal/mol)
Enthalpy at NBP + 20 degK	356.0 (cal/mol)
Density at NBP	0.68 (gm/cm^3)
Density at NBP - 5 degK	0.69 (gm/cm^3)
Temperature at 400 mm Hg vapor pressure	-45.5 (deg C)

Chemical Release Report

Study

General

Description	CASE - 159
Notes	Tank release of HP Storage Process Gas Leak through gasket 10% up from bottom of tank 1 cm long x .05 cm wide Tank pressure @ 20 kg/cm2 (gauge) - Equiv to 299.2 psia Tank pressure can be adjusted as C/R takes remedial action to isolate and reduce pressure (Use 'Update Scenario') HP Storage_Process Gas new chemical in SAFER database 1 mole% Ni(CO)4 Ambient temperature
Release time	2/15/2012 12:17:04 PM

Release Scenario

General

Chemical	HP Storage_Process Gas

Tank Info.

Tank geometry & dimensions	Horizontal cylinder
Tank length	43.6 (m)
Tank diameter	1.6 (m)
Tank wall thickness	5.4 (cm)
Tank temperature	-0.6 (deg C)
Tank contents	Gas pressure
Gas pressure	299.2 (psi)
Tank padding	Off

Leak Info.

Tank leak type	Orifice - Rectangular
Hole length	1.0 (cm)
Hole width	0.1 (cm)
Hole elevation	0.2 (m)
Angle (0=Horizontal, 90 deg =Vertical)	90.0 (deg)

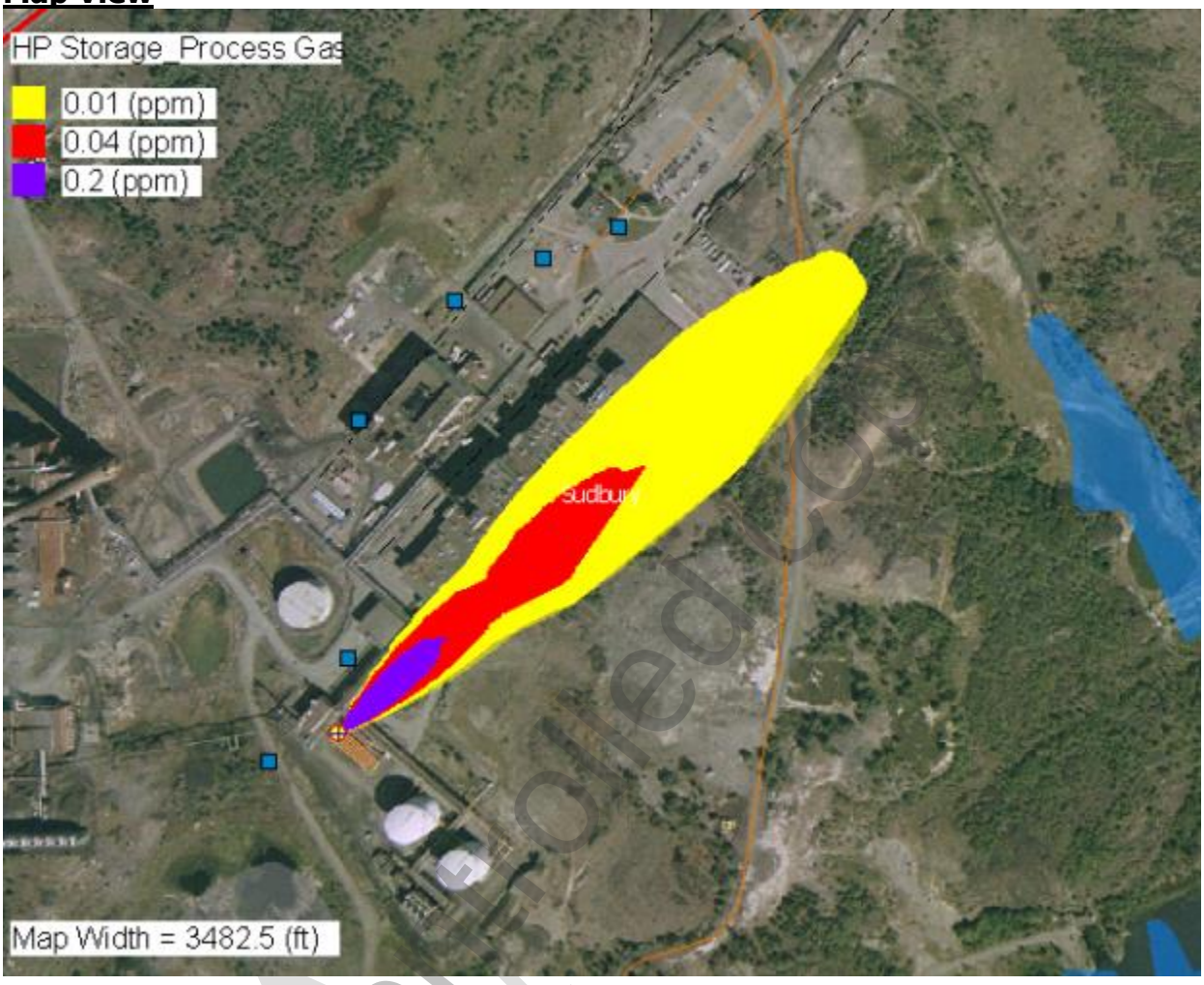
Pool Info.

Substrate type	Concrete

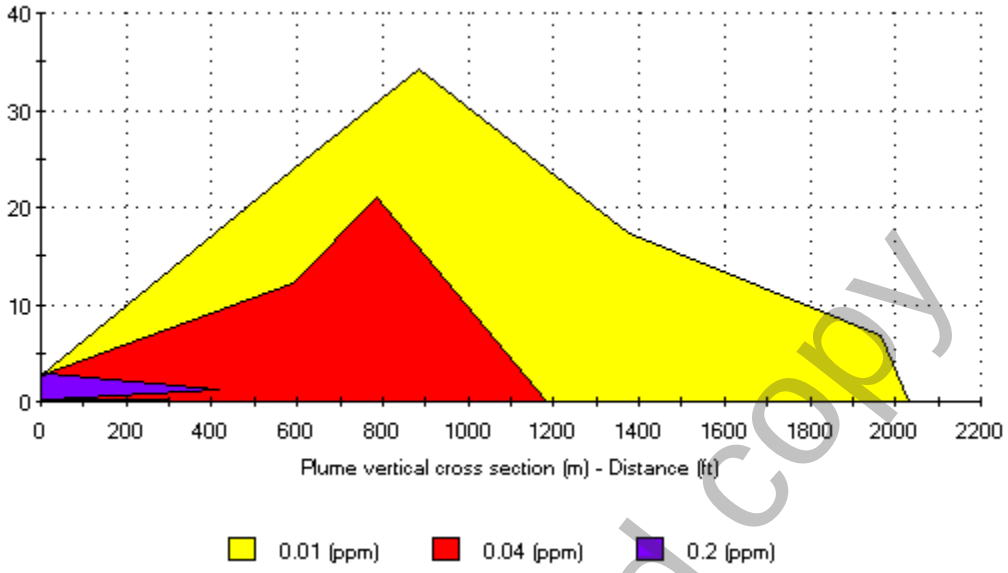
Substrate temperature	-0.6 (deg C)
Pool area	Unconfined
Minimum pool depth	Unconfined
Aerosol formation	Let model decide
Aerosol/Flash ratio	0.0
Initial air entrainment	Don't evaporate any aerosol
Air/Chemical ratio	0.0

Release site on map	-81.085873, 46.444945

Map View



Plume Vertical Cross-section



Meteorology

Surface roughness 0.1 (ft)
Ceiling height 10000.0 (m)
Upper stability class 4.0

Interval	Ambient Temperature	Horizontal Stability	Vertical Stability	Solar Radiation	Humidity
(min)	(deg C)			(W/m^2)	(%)
5.0	-0.6	4.0	3.0	271	91.0
10.0	-0.6	4.0	3.0	280	91.1
15.0	-0.6	4.0	3.0	280	91.1
20.0	-0.6	4.0	3.0	280	91.1
25.0	-0.6	4.0	3.0	280	91.1
30.0	-0.6	4.0	3.0	280	91.1
35.0	-0.6	4.0	3.0	280	91.1
40.0	-0.6	4.0	3.0	280	91.1
45.0	-0.6	4.0	3.0	280	91.1
50.0	-0.6	4.0	3.0	280	91.1
55.0	-0.6	4.0	3.0	280	91.1
60.0	-0.6	4.0	3.0	280	91.1
65.0	-0.6	4.0	3.0	280	91.1
70.0	-0.6	4.0	3.0	280	91.1
75.0	-0.6	4.0	3.0	280	91.1
80.0	-0.6	4.0	3.0	280	91.1
85.0	-0.6	4.0	3.0	280	91.1
90.0	-0.6	4.0	3.0	280	91.1

Interval	Ambient Temperature	Horizontal Stability	Vertical Stability	Solar Radiation	Humidity
(min)	(deg C)			(W/m^2)	(%)
95.0	-0.6	4.0	3.0	280	91.1
100.0	-0.6	4.0	3.0	280	91.1
105.0	-0.6	4.0	3.0	280	91.1
110.0	-0.6	4.0	3.0	280	91.1
115.0	-0.6	4.0	3.0	280	91.1
120.0	-0.6	4.0	3.0	280	91.1

SPD TOWER

Reference Height 107.6 (ft)

Interval	Wind Speed	Wind Direction
(min)	(km/h)	(deg [from])
5.0	10.7	SW
10.0	11.1	SW
15.0	11.1	SW
20.0	11.1	SW
25.0	11.1	SW
30.0	11.1	SW
35.0	11.1	SW
40.0	11.1	SW
45.0	11.1	SW
50.0	11.1	SW
55.0	11.1	SW
60.0	11.1	SW
65.0	11.1	SW
70.0	11.1	SW
75.0	11.1	SW
80.0	11.1	SW
85.0	11.1	SW
90.0	11.1	SW
95.0	11.1	SW
100.0	11.1	SW
105.0	11.1	SW
110.0	11.1	SW
115.0	11.1	SW
120.0	11.1	SW

Summary of source characteristics

Maximum release rate	1.0 (kg/min)
Release duration	7205.4 (min)
Occurance of flash	No
Pool formation	No

Downwind Distance Report

Isopleth Limits (ppm)	Downwind distance (ft)
0.01	> 2031.2
0.04	> 1183.7
0.2	> 415.1

Source status after 2 hours

Tank contents

Mass	5004.4 (lb)
Pressure	285.1 (psi)
Temperature	-0.1 (deg C)
Liquid level	0.0 (ft)

Receptor report

Receptors sorted by Impact Level(Ascending) Then by Name(Ascending)

Receptor - PACK AND SHIP

Distance	1463.2 (ft)
Dosage	2.1 (ppm-min)
Peak concentration	0.02 (ppm)
Time of peak concentration	10.0 (min)

ACH

Low	0.5
Medium	1.0
High	2.0

Contact phone numbers -

Important Information

Impact Level	First Impact	Duration (min)
Low	12:17:04 PM	120.0

Chemical properties

General

Description HP Storage_Process Gas

Category	GAS MIXTURE
Formula	
CAS Number	
U.N. or Dot Number	
Ref. Number	

Gas Mixture Setup

Component	Composition amount (Mole %)	Key component
NI(CO)4	1.0	Yes
CARBON MONOXIDE	99.0	No

Gas Properties

Critical Temperature	-136.9 (deg C)
Critical Pressure	34.5 (atm)
Critical Volume	95.9 (cm^3/mol)
Molecular Weight	29.4 (gm/mol)
Ideal gas heat capacity (Cp) = A + B*T + C*T^2 + D*T^3	J/(kmol.deg K)
A	31493.1
B	-12.0
C	0.04
D	0.0

Liquid Properties

Normal boiling point (NBP)	-189.1 (deg C)
Surface tension at NBP	9.4 (dyne/cm)
Viscosity at NBP	0.17 (centipoise)
Enthalpy at NBP	20.6 (cal/mol)
Enthalpy at NBP + 10 degK	171.6 (cal/mol)
Enthalpy at NBP + 20 degK	326.4 (cal/mol)
Density at NBP	0.79 (gm/cm^3)
Density at NBP - 5 degK	0.81 (gm/cm^3)
Temperature at 400 mm Hg vapor pressure	-194.5 (deg C)

F/E Properties

Heat of formation	-109440.2 (J/mol)
Heat of combustion	66924.0 (cal/mol)
Heat of vaporization	1430.0 (cal/mol)
Reactivity	2.0
Upper explosive limit (UEL)	736129.6 (ppm)
Lower explosive limit (LEL)	118764.8 (ppm)
Carbon	1.0
Hydrogen	0.0
Oxygen	1.0

Nitrogen	0.0
Halogen	0.0
Sulfur	0.0