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Guide 154

Initial Isolation and Protective Action Distances (Metric)

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		Small Spills			Large Spills		
		First Isolate in all directions	Then Protect persons Downwind during		First Isolate in all directions	Then Protect persons Downwind during	
			Day	Night		Day	Night
ID	Name of Material	m	km	km	m	km	km
1744	Bromine	60	0.6	1.9	300	2.8	6.5

Name of Material

Bromine

GUIDE 154

SUBSTANCES - TOXIC and/or CORROSIVE (Non-Combustible)

POTENTIAL HAZARDS

HEALTH

- **TOXIC**; inhalation, ingestion or skin contact with material may cause severe injury or death.
- Contact with molten substance may cause severe burns to skin and eyes.
- Avoid any skin contact.
- Effects of contact or inhalation may be delayed.
- Fire may produce irritating, corrosive and/or toxic gases.
- Runoff from fire control or dilution water may be corrosive and/or toxic and cause pollution.

FIRE OR EXPLOSION

- Non-combustible, substance itself does not burn but may decompose upon heating to produce corrosive and/or toxic fumes.
- Some are oxidizers and may ignite combustibles (wood, paper, oil, clothing, etc.).
- Contact with metals may evolve flammable hydrogen gas.
- Containers may explode when heated.

- For UN3171, if Lithium ion batteries are involved, also consult GUIDE 147.

PUBLIC SAFETY

- **CALL Emergency Response Telephone Number on Shipping Paper first. If Shipping Paper not available or no answer, refer to appropriate telephone number listed on the inside back cover.**
- As an immediate precautionary measure, isolate spill or leak area in all directions for at least 50 meters (150 feet) for liquids and at least 25 meters (75 feet) for solids.
- Keep unauthorized personnel away.
- Stay upwind.
- Keep out of low areas.
- Ventilate enclosed areas.

PROTECTIVE CLOTHING

- Wear positive pressure self-contained breathing apparatus (SCBA).
- Wear chemical protective clothing that is specifically recommended by the manufacturer. It may provide little or no thermal protection.
- Structural firefighters' protective clothing provides limited protection in fire situations ONLY; it is not effective in spill situations where direct contact with the substance is possible.

EVACUATION

Spill

- See Table 1 - Initial Isolation and Protective Action Distances for highlighted materials. For non-highlighted materials, increase, in the downwind direction, as necessary, the isolation distance shown under "PUBLIC SAFETY".

Fire

- If tank, rail car or tank truck is involved in a fire, ISOLATE for 800 meters (1/2 mile) in all directions; also, consider initial evacuation for 800 meters (1/2 mile) in all directions.

EMERGENCY RESPONSE

FIRE

Small Fire

- Dry chemical, CO₂ or water spray.

Large Fire

- Dry chemical, CO₂, alcohol-resistant foam or water spray.
- Move containers from fire area if you can do it without risk.
- Dike fire-control water for later disposal; do not scatter the material.

Fire involving Tanks or Car/Trailer Loads

- Fight fire from maximum distance or use unmanned hose holders or monitor nozzles.
- Do not get water inside containers.
- Cool containers with flooding quantities of water until well after fire is out.
- Withdraw immediately in case of rising sound from venting safety devices or discoloration of tank.
- ALWAYS stay away from tanks engulfed in fire.

SPILL OR LEAK

- ELIMINATE all ignition sources (no smoking, flares, sparks or flames in immediate area).
- Do not touch damaged containers or spilled material unless wearing appropriate protective clothing.
- Stop leak if you can do it without risk.
- Prevent entry into waterways, sewers, basements or confined areas.
- Absorb or cover with dry earth, sand or other non-combustible material and transfer to containers.
- DO NOT GET WATER INSIDE CONTAINERS.

FIRST AID

- Move victim to fresh air.
- Call 911 or emergency medical service.

- Give artificial respiration if victim is not breathing.
- **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.**
- Administer oxygen if breathing is difficult.
- Remove and isolate contaminated clothing and shoes.
- In case of contact with substance, immediately flush skin or eyes with running water for at least 20 minutes.
- For minor skin contact, avoid spreading material on unaffected skin.
- Keep victim warm and quiet.
- Effects of exposure (inhalation, ingestion or skin contact) to substance may be delayed.
- Ensure that medical personnel are aware of the material(s) involved and take precautions to protect themselves.

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Guide 139

Initial Isolation and Protective Action Distances (Metric)

[Change to Imperial Units](#)

		Small Spills			Large Spills		
		First Isolate in all directions	Then Protect persons Downwind during		First Isolate in all directions	Then Protect persons Downwind during	
			Day	Night		Day	Night
ID	Name of Material	m	km	km	m	km	km
1360	Calcium phosphide (when spilled in water)	30	0.2	0.7	300	1.1	3.8

Name of Material

Calcium phosphide

GUIDE 139

SUBSTANCES - WATER-REACTIVE (Emitting Flammable and Toxic Gases)

POTENTIAL HAZARDS

FIRE OR EXPLOSION

- Produce flammable and toxic gases on contact with water.
- May ignite on contact with water or moist air.
- Some react vigorously or explosively on contact with water.
- May be ignited by heat, sparks or flames.
- May re-ignite after fire is extinguished.
- Some are transported in highly flammable liquids.
- Containers may explode when heated.
- Runoff may create fire or explosion hazard.

HEALTH

- Highly toxic: contact with water produces toxic gas, may be fatal if inhaled.
- Inhalation or contact with vapors, substance or decomposition products may cause severe injury or death.
- May produce corrosive solutions on contact with water.
- Fire will produce irritating, corrosive and/or toxic gases.
- Runoff from fire control may cause pollution.

PUBLIC SAFETY

- **CALL Emergency Response Telephone Number on Shipping Paper first. If Shipping Paper not available or no answer, refer to appropriate telephone number listed on the inside back cover.**
- As an immediate precautionary measure, isolate spill or leak area in all directions for at least 50 meters (150 feet) for liquids and at least 25 meters (75 feet) for solids.
- Keep unauthorized personnel away.
- Stay upwind.
- Keep out of low areas.
- Ventilate the area before entry.

PROTECTIVE CLOTHING

- Wear positive pressure self-contained breathing apparatus (SCBA).
- Wear chemical protective clothing that is specifically recommended by the manufacturer. It may provide little or no thermal protection.
- Structural firefighters' protective clothing provides limited protection in fire situations ONLY; it is not effective in spill situations where direct contact with the substance is possible.

EVACUATION

Spill

- See Table 1 - Initial Isolation and Protective Action Distances for highlighted materials. For non-highlighted materials, increase, in the downwind direction, as necessary, the isolation distance shown under "PUBLIC SAFETY".

Fire

- If tank, rail car or tank truck is involved in a fire, ISOLATE for 800 meters (1/2 mile) in all directions; also, consider initial evacuation for 800 meters (1/2 mile) in all directions.

EMERGENCY RESPONSE

FIRE

- **DO NOT USE WATER OR FOAM. (FOAM MAY BE USED FOR CHLOROSILANES, SEE BELOW)**

Small Fire

- Dry chemical, soda ash, lime or sand.

Large Fire

- DRY sand, dry chemical, soda ash or lime or withdraw from area and let fire burn.
- **FOR CHLOROSILANES, DO NOT USE WATER;** use AFFF alcohol-resistant medium expansion foam; **DO NOT USE** dry chemicals, soda ash or lime on chlorosilane fires (large or small) as they may release large quantities of hydrogen gas that may explode.
- Move containers from fire area if you can do it without risk.

Fire involving Tanks or Car/Trailer Loads

- Fight fire from maximum distance or use unmanned hose holders or monitor nozzles.
- Cool containers with flooding quantities of water until well after fire is out.
- Do not get water inside containers.
- Withdraw immediately in case of rising sound from venting safety devices or discoloration of tank.
- ALWAYS stay away from tanks engulfed in fire.

SPILL OR LEAK

- Fully encapsulating, vapor protective clothing should be worn for spills and leaks with no fire.

- ELIMINATE all ignition sources (no smoking, flares, sparks or flames in immediate area).
- Do not touch or walk through spilled material.
- Stop leak if you can do it without risk.
- **DO NOT GET WATER on spilled substance or inside containers.**
- Use water spray to reduce vapors or divert vapor cloud drift. Avoid allowing water runoff to contact spilled material.
- **FOR CHLOROSILANES**, use AFFF alcohol-resistant medium expansion foam to reduce vapors.

Small Spill

- Cover with DRY earth, DRY sand or other non-combustible material followed with plastic sheet to minimize spreading or contact with rain.
- Dike for later disposal; do not apply water unless directed to do so.

Powder Spill

- Cover powder spill with plastic sheet or tarp to minimize spreading and keep powder dry.
- **DO NOT CLEAN-UP OR DISPOSE OF, EXCEPT UNDER SUPERVISION OF A SPECIALIST.**

FIRST AID

- Move victim to fresh air.
- Call 911 or emergency medical service.
- Give artificial respiration if victim is not breathing.
- **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.**
- Administer oxygen if breathing is difficult.
- Remove and isolate contaminated clothing and shoes.
- In case of contact with substance, wipe from skin immediately; flush skin or eyes with running water for at least 20 minutes.
- Keep victim warm and quiet.
- Ensure that medical personnel are aware of the material(s) involved and take precautions to protect themselves.

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Guide 124

Initial Isolation and Protective Action Distances (Metric)

[Change to Imperial Units](#)

		Small Spills			Large Spills		
		First Isolate in all directions	Then Protect persons Downwind during		First Isolate in all directions	Then Protect persons Downwind during	
			Day	Night		Day	Night
ID	Name of Material	m	km	km	m	km	km
1017	Chlorine	60	0.4	1.5	500	3	7.9

[View Common TIH Table entry](#)

Name of Material

Chlorine

GUIDE 124

GASES - TOXIC and/or CORROSIVE - OXIDIZING

POTENTIAL HAZARDS

HEALTH

- **TOXIC; may be fatal if inhaled or absorbed through skin.**
- Fire will produce irritating, corrosive and/or toxic gases.
- Contact with gas or liquefied gas may cause burns, severe injury and/or frostbite.
- Runoff from fire control may cause pollution.

FIRE OR EXPLOSION

- Substance does not burn but will support combustion.
- Vapors from liquefied gas are initially heavier than air and spread along ground.
- These are strong oxidizers and will react vigorously or explosively with many materials including fuels.
- May ignite combustibles (wood, paper, oil, clothing, etc.).

- Some will react violently with air, moist air and/or water.
- Cylinders exposed to fire may vent and release toxic and/or corrosive gas through pressure relief devices.
- Containers may explode when heated.
- Ruptured cylinders may rocket.

PUBLIC SAFETY

- **CALL Emergency Response Telephone Number on Shipping Paper first. If Shipping Paper not available or no answer, refer to appropriate telephone number listed on the inside back cover.**
- As an immediate precautionary measure, isolate spill or leak area for at least 100 meters (330 feet) in all directions.
- Keep unauthorized personnel away.
- Stay upwind.
- Many gases are heavier than air and will spread along ground and collect in low or confined areas (sewers, basements, tanks).
- Keep out of low areas.
- Ventilate closed spaces before entering.

PROTECTIVE CLOTHING

- Wear positive pressure self-contained breathing apparatus (SCBA).
- Wear chemical protective clothing that is specifically recommended by the manufacturer. It may provide little or no thermal protection.
- Structural firefighters' protective clothing provides limited protection in fire situations ONLY; it is not effective in spill situations where direct contact with the substance is possible.

EVACUATION

Spill

- See Table 1 - Initial Isolation and Protective Action Distances.

Fire

- If tank, rail car or tank truck is involved in a fire, ISOLATE for 800 meters (1/2 mile) in all directions; also, consider initial evacuation for 800 meters (1/2 mile) in all directions.

EMERGENCY RESPONSE

FIRE

Small Fire

CAUTION: These materials do not burn but will support combustion. Some will react violently with water.

- Contain fire and let burn. If fire must be fought, water spray or fog is recommended.
- **Water only; no dry chemical, CO₂ or Halon®.**
- Do not get water inside containers.
- Move containers from fire area if you can do it without risk.
- Damaged cylinders should be handled only by specialists.

Fire involving Tanks

- Fight fire from maximum distance or use unmanned hose holders or monitor nozzles.
- Cool containers with flooding quantities of water until well after fire is out.
- Do not direct water at source of leak or safety devices; icing may occur.
- Withdraw immediately in case of rising sound from venting safety devices or discoloration of tank.
- ALWAYS stay away from tanks engulfed in fire.
- For massive fire, use unmanned hose holders or monitor nozzles; if this is impossible, withdraw from area and let fire burn.

SPILL OR LEAK

- Fully encapsulating, vapor protective clothing should be worn for spills and leaks with no fire.
- Do not touch or walk through spilled material.

- Keep combustibles (wood, paper, oil, etc.) away from spilled material.
- Stop leak if you can do it without risk.
- Use water spray to reduce vapors or divert vapor cloud drift. Avoid allowing water runoff to contact spilled material.
- Do not direct water at spill or source of leak.
- If possible, turn leaking containers so that gas escapes rather than liquid.
- Prevent entry into waterways, sewers, basements or confined areas.
- Isolate area until gas has dispersed.
- Ventilate the area.

FIRST AID

- Move victim to fresh air.
- Call 911 or emergency medical service.
- Give artificial respiration if victim is not breathing.
- **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.**
- Administer oxygen if breathing is difficult.
- Clothing frozen to the skin should be thawed before being removed.
- Remove and isolate contaminated clothing and shoes.
- In case of contact with substance, immediately flush skin or eyes with running water for at least 20 minutes.
- Keep victim warm and quiet.
- Keep victim under observation.
- Effects of contact or inhalation may be delayed.
- Ensure that medical personnel are aware of the material(s) involved and take precautions to protect themselves.

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Guide 157

Name of Material

Muriatic acid

GUIDE 157

SUBSTANCES - TOXIC and/or CORROSIVE (Non-Combustible / Water-Sensitive)

POTENTIAL HAZARDS

HEALTH

- **TOXIC**; inhalation, ingestion or contact (skin, eyes) with vapors, dusts or substance may cause severe injury, burns or death.
- Reaction with water or moist air may release toxic, corrosive or flammable gases.
- Reaction with water may generate much heat that will increase the concentration of fumes in the air.
- Fire will produce irritating, corrosive and/or toxic gases.
- Runoff from fire control or dilution water may be corrosive and/or toxic and cause pollution.

FIRE OR EXPLOSION

- Non-combustible, substance itself does not burn but may decompose upon heating to produce corrosive and/or toxic fumes.
- For UN1796, UN1826, UN2031 at high concentrations and for UN2032, these may act as oxidizers, also consult GUIDE 140.
- Vapors may accumulate in confined areas (basement, tanks, hopper/tank cars etc.).
- Substance may react with water (some violently), releasing corrosive and/or toxic gases and runoff.
- Contact with metals may evolve flammable hydrogen gas.
- Containers may explode when heated or if contaminated with water.

PUBLIC SAFETY

- **CALL Emergency Response Telephone Number on Shipping Paper first. If Shipping Paper not available or no answer, refer to appropriate telephone number listed on the inside back cover.**
- As an immediate precautionary measure, isolate spill or leak area in all directions for at least 50 meters (150 feet) for liquids and at least 25 meters (75 feet) for solids.
- Keep unauthorized personnel away.
- Stay upwind.
- Keep out of low areas.
- Ventilate enclosed areas.

PROTECTIVE CLOTHING

- Wear positive pressure self-contained breathing apparatus (SCBA).
- Wear chemical protective clothing that is specifically recommended by the manufacturer. It may provide little or no thermal protection.
- Structural firefighters' protective clothing provides limited protection in fire situations ONLY; it is not effective in spill situations where direct contact with the substance is possible.

EVACUATION

Spill

- See Table 1 - Initial Isolation and Protective Action Distances for highlighted materials. For non-highlighted materials, increase, in the downwind direction, as necessary, the isolation distance shown under "PUBLIC SAFETY".

Fire

- If tank, rail car or tank truck is involved in a fire, ISOLATE for 800 meters (1/2 mile) in all directions; also, consider initial evacuation for 800 meters (1/2 mile) in all directions.

EMERGENCY RESPONSE

FIRE

- Note: Some foams will react with the material and release corrosive/toxic gases.

Small Fire

- CO₂ (except for Cyanides), dry chemical, dry sand, alcohol-resistant foam.

Large Fire

- Water spray, fog or alcohol-resistant foam.
- Move containers from fire area if you can do it without risk.
- Use water spray or fog; do not use straight streams.
- Dike fire-control water for later disposal; do not scatter the material.

Fire involving Tanks or Car/Trailer Loads

- Fight fire from maximum distance or use unmanned hose holders or monitor nozzles.
- Do not get water inside containers.
- Cool containers with flooding quantities of water until well after fire is out.
- Withdraw immediately in case of rising sound from venting safety devices or discoloration of tank.
- ALWAYS stay away from tanks engulfed in fire.

SPILL OR LEAK

- ELIMINATE all ignition sources (no smoking, flares, sparks or flames in immediate area).
- All equipment used when handling the product must be grounded.
- Do not touch damaged containers or spilled material unless wearing appropriate protective clothing.
- Stop leak if you can do it without risk.
- A vapor suppressing foam may be used to reduce vapors.
- DO NOT GET WATER INSIDE CONTAINERS.
- Use water spray to reduce vapors or divert vapor cloud drift. Avoid allowing water runoff to contact spilled material.
- Prevent entry into waterways, sewers, basements or confined areas.

Small Spill

- Cover with DRY earth, DRY sand or other non-combustible material followed with plastic sheet to minimize spreading or contact with rain.
- Use clean non-sparking tools to collect material and place it into loosely covered plastic containers for later disposal.

FIRST AID

- Move victim to fresh air.
- Call 911 or emergency medical service.
- Give artificial respiration if victim is not breathing.

- **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.**
- Administer oxygen if breathing is difficult.
- Remove and isolate contaminated clothing and shoes.
- In case of contact with substance, immediately flush skin or eyes with running water for at least 20 minutes.
- In case of contact with Hydrofluoric acid (UN1790), flush skin and eyes with water for 5 minutes; then, for skin exposures rub on a calcium/gel combination; for eyes flush with a water/calcium solution if available, otherwise continue with water for 15 minutes.
- For minor skin contact, avoid spreading material on unaffected skin.
- Keep victim warm and quiet.
- Effects of exposure (inhalation, ingestion or skin contact) to substance may be delayed.
- Ensure that medical personnel are aware of the material(s) involved and take precautions to protect themselves.

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Chemical Reactivity Report

Hazard Summary

Mix

Chlorine

Strong Oxidizing Agent

Bromine


Strong Oxidizing Agent, Air-Reactive

Water


Hazards

Exothermic 


Exothermic reaction. May generate heat and/or cause pressurization.

Explosive 

Heat generated from chemical reaction may initiate explosion.

Flammable 

Spontaneous ignition of reactants or products due to reaction heat.

Pressurization 

Combination liberates gaseous products, at least one of which is toxic. May cause pressurization.

Combination liberates combustion-enhancing gas (e.g., oxygen). May cause pressurization.

Exothermic, generation of toxic and corrosive fumes.

Generation of corrosive liquid.

Violent Reaction 

Reaction may be intense or violent.

Gases Produced

Halogen Oxides

Oxygen

Mixed Halogenated Oxides

Halogen Gas

Corrosive Fumes

Nitrogen Oxides

Acid Halogens

Sulfur Oxides

Full Reaction List

Inorganic Oxidizing Agents + Halogenating Agents, Strong

Materials

Chlorine + Bromine

Hazards

Heat generated from chemical reaction may initiate explosion.

Spontaneous ignition of reactants or products due to reaction heat.

Exothermic reaction. May generate heat and/or cause pressurization.

Combination liberates gaseous products, at least one of which is toxic. May cause pressurization.

Hazard Notes

SF₄ explodes on contact with F₂O₂, even at cryogenic temperatures (Streng, A.G. 1963. Chemical Reviews 63:615.). Thionyl chloride explodes on contact with chloryl perchlorate (Schmeisser, M. 1955. Agnew. Chem. 67:499). BrF₃ ignites or explodes on contact with inorganic oxidants, including CrO₃, IO₅, MgO, Mo₂O₃, P₄O₁₀, W₂O₃, and SO₂ (Mellor. 1956. Volume 2, Supplemental 1. pp. 172). PBr₃ ignites on contact with chromyl chloride (Pascal. 1959. Volume 14. pp. 153.). ClF₃ reacts violently or ignites on contact with many inorganic oxidants (Urben, P.G. 1995. Bretherick's Handbook of Reactive Chemical Hazards, 5th Edition. Oxford: Butterworth-Heinemann. pp. 1237.). ClF₃ reacts incandescently with CrO₃ (Mellor. 1943. Volume 1. pp. 181.). BrF₃ incandesces with bromine or iodine (Mellor. 1941. Volume 2. pp. 113; 1956. Volume 2, Supplemental 1. pp. 164-167.). BrF₃ reacts violently with Sb₂O₃ or tin hypochlorite (Mellor. 1956. Volume 2, Supplemental 1. pp. 166.).

Gases Produced

Halogen Oxides

Oxygen

Mixed Halogenated Oxides

Gas Reference

Mercuric oxide reacts with chlorine to form toxic and flammable chlorine dioxide (Masschelein, W. J. Chlorine Dioxide. Ann Arbor, MI: Ann Arbor Science Publishers Inc., 1979 pp. 9) As does sodium chlorate with chlorine (Ibid, pp. 10). The reaction of ozone with chlorine dioxide liberates combustion-enhancing O₂ gas (Masschelein, W. J. Chlorine Dioxide. Ann Arbor, MI: Ann Arbor Science Publishers Inc., 1979 pp. 11). A similar reaction occurs between hydrogen peroxide and chlorine dioxide (Ibid, pp. 13). Fluorine reacts with chlorine

dioxide to liberate toxic and flammable chloryl fluoride gas (Ibid, pp. 38). The reaction between potassium chlorate and fluorine is similar, liberating ClO₃ gas which decomposes to ClO₂ and O₂ gasses at 30C (Ibid, pp. 39).

Halogenating Agents, Strong + Inorganic Oxidizing Agents

Materials

⊗ Chlorine + Bromine

Hazards

⚠ Heat generated from chemical reaction may initiate explosion.

⚠ Spontaneous ignition of reactants or products due to reaction heat.

☀ Exothermic reaction. May generate heat and/or cause pressurization.

⚠ Combination liberates gaseous products, at least one of which is toxic. May cause pressurization.

Hazard Notes

SF₄ explodes on contact with F₂O₂, even at cryogenic temperatures (Streng, A.G. 1963. Chemical Reviews 63:615.). Thionyl chloride explodes on contact with chloryl perchlorate (Schmeisser, M. 1955. Agnew. Chem. 67:499). BrF₃ ignites or explodes on contact with inorganic oxidants, including CrO₃, IO₅, MgO, Mo₂O₃, P₄O₁₀, W₂O₃, and SO₂ (Mellor. 1956. Volume 2, Supplemental 1. pp. 172). PBr₃ ignites on contact with chromyl chloride (Pascal. 1959. Volume 14. pp. 153.). ClF₃ reacts violently or ignites on contact with many inorganic oxidants (Urban, P.G. 1995. Bretherick's Handbook of Reactive Chemical Hazards, 5th Edition. Oxford: Butterworth-Heinemann. pp. 1237.). ClF₃ reacts incandescently with CrO₃ (Mellor. 1943. Volume 1. pp. 181.). BrF₃ incandesces with bromine or iodine (Mellor. 1941. Volume 2. pp. 113; 1956. Volume 2, Supplemental 1. pp. 164-167.). BrF₃ reacts violently with Sb₂O₃ or tin hypochlorite (Mellor. 1956. Volume 2, Supplemental 1. pp. 166.).

Gases Produced

- ⊗ Halogen Oxides
- ⊗ Oxygen
- ⊗ Mixed Halogenated Oxides

Gas Reference

Mercuric oxide reacts with chlorine to form toxic and flammable chlorine dioxide (Masschelein, W. J.

Chlorine Dioxide. Ann Arbor, MI: Ann Arbor Science Publishers Inc., 1979 pp. 9) As does sodium chlorate with chlorine (Ibid, pp. 10). The reaction of ozone with chlorine dioxide liberates combustion-enhancing O₂ gas (Masschelein, W. J. Chlorine Dioxide. Ann Arbor, MI: Ann Arbor Science Publishers Inc., 1979 pp. 11). A similar reaction occurs between hydrogen peroxide and chlorine dioxide (Ibid, pp. 13). Fluorine reacts with chlorine dioxide to liberate toxic and flammable chloryl fluoride gas (Ibid, pp. 38). The reaction between potassium chlorate and fluorine is similar, liberating ClO₃ gas which decomposes to ClO₂ and O₂ gasses at 30C (Ibid, pp. 39).

Inorganic Oxidizing Agents + Water

Materials

⊗ Chlorine + Water

⊗ Bromine + Water

Hazards

☀ Exothermic reaction. May generate heat and/or cause pressurization.

⚠ Combination liberates gaseous products, at least one of which is toxic. May cause pressurization.

⚠ Combination liberates combustion-enhancing gas (e.g., oxygen). May cause pressurization.

⚠ Exothermic, generation of toxic and corrosive fumes.

⚠ Generation of corrosive liquid.

🔥 Reaction may be intense or violent.

Gases Produced

- ⊗ Halogen Gas
- ⊗ Corrosive Fumes
- ⊗ Nitrogen Oxides
- ⊗ Oxygen

Gas Reference

CALCIUM HYPOCHLORITE is slowly decomposed by water with the evolution of gaseous chlorine and heat. Experimental work at Argonne National Laboratory has determined that there is essentially no Cl₂ gas formation; the substance is quite unreactive in water. This does not prevent Cl₂ formation by a catalytic mechanism, but under normal conditions calcium hypochlorite is quite unreactive. The hydration reaction was rapid and quite exothermic. The small change in gas volume was attributed to this heating. (Argonne Report ANL/DIS-00-1, October 2000). CHROMIUM OXYCHLORIDE fumes in moist air. The compound

hydrolyzes exothermically and vigorously on contact with water to generate chromic acid, hydrochloric acid and some chlorine [Merck, 11th ed., 1989]. In experiments at Argonne National Laboratory, in which it was mixed with water and stirred at room conditions, about 8 percent of the theoretical yield of HCl evolved as a gas in the first 40 minutes [Brown, D. F., et al. (2000) Development of the Table of Initial Isolation and Protective Action Distances for the 2000 Emergency Response Guidebook, ANL-DIS-00-1, Argonne National Laboratory, Argonne IL].

CYANURIC CHLORIDE reacts exothermically with water, especially if catalyzed or heated, to generate fumes of hydrochloric acid. DICHLOROISOCYANURIC ACID, DRY may vigorously react with small quantities of water releasing chlorine gas. Water vapor will react combustibly with Fluorine; an explosive reaction occurs between liquid fluorine and ice, after an intermediate induction period, [NASA SP-3037: 52 (1967)]: If liquid air, which has stood for some time is treated with Fluorine, a precipitate is formed which is likely to explode. Explosive material is thought to be Fluorine Hydrate, [Mellor 2:11 (1946-1947)].

LITHIUM HYPOCHLORITE is soluble in water and decomposes slowly in water with the evolution of chlorine gas. (MONO)-(TRICHLORO)-TETRA-(MONOPOTASSIUM DICHLORO)-PENTA-S-TRIAZINETRIONE is soluble in water. It may vigorously react with water releasing chlorine gas. . Material containing less than 39% available chlorine will undergo reactions as described herein, but may take longer to initiate, and the resulting reaction may not be as vigorous [AAR 1992].

NITRIC OXIDE combines very rapidly with oxygen in the air to form nitrogen dioxide. Nitrogen dioxide reacts with water to form nitric acid and nitric oxide, reacts with alkalis to form nitrates and nitrites [Merck 11th ed. 1989].

NITROGEN DIOXIDE reacts with water to form nitric acid and nitric oxide, it reacts with alkalis to form nitrate and nitrites [Merck 11th ed. 1989]. The liquid nitrogen oxide is very sensitive to detonation, in the presence of water.

NITROGEN TETROXIDE reacts with water to form nitric acid and nitric oxide.

SODIUM DICHLORO-S-TRIAZINETRIONE may vigorously react with water releasing chlorine gas. Material containing less than 39% available chlorine will undergo reactions as described herein, but may take longer to initiate, and the resulting reaction may not be as vigorous [AAR 1992].

SODIUM PERBORATE, in the presence of moist air or water, rapidly evolves oxygen,

especially in the presence of base. This presents a severe fire/explosion risk in enhancing combustion process. SODIUM SUPEROXIDE reacts with moisture and carbon dioxide in the air. The compound reacts vigorously with water to give oxygen and sodium hydroxide. TRICHLORO-S-TRIAZINETRIONE may react with water releasing gaseous chlorine. If mixed with a small amount of water, the concentrated solution (with pH at about 2.0) may explode due to the evolution of unstable nitrogen trichloride. (Bretherick 5th ed.).

Halogenating Agents, Strong + Water

Materials

- ⊗ Chlorine + Water
- ⊗ Bromine + Water

Hazards

- ☀ Exothermic reaction. May generate heat and/or cause pressurization.
- ☉ Combination liberates gaseous products, at least one of which is toxic. May cause pressurization.

Gases Produced

- ⊗ Halogen Oxides
- ⊗ Halogen Gas
- ⊗ Acid Halogens
- ⊗ Sulfur Oxides
- ⊗ Oxygen

Gas Reference

ANTIMONY PENTAFLUORIDE fumes in air to form hydrogen fluoride (reacts with moisture in air). May React with water to give hydrofluoric acid (HF) [Merck 11th ed. 1989]. Experimental work at Argonne National Laboratory has determined that there is essentially very little HF formation; the substance was quite unreactive in water. This does not prevent HF formation by a catalytic mechanism, but under normal conditions antimony pentafluoride is quite unreactive. The hydration reaction was rapid and quite exothermic. The small change in gas volume was attributed to this heating. (Argonne Report ANL/DIS-00-1, October 2000).

BORON TRIFLUORIDE fumes in air. Soluble in water and slowly hydrolyzed by cold water to give hydrofluoric acid. The compound reacts more rapidly with hot water.

BROMINE PENTAFLUORIDE produces corrosive fumes in moist air. The compound reacts explosively upon contact with water. Very reactive, usually with conflagration [Merck, 11th ed. 1989]. Its' reaction with water is violent, oxygen being

evolved, [Mellor 2 Supp. 1:172 1956].BROMINE TRIFLUORIDE fumes in air. The compound reacts with water with explosive force, oxygen being evolved [Handbook of Chemistry and Physics].CHLORINE MONOXIDE decomposes in water forming chlorine and oxygen gases.CHLORINE PENTAFLUORIDE reacts with water or moisture in the air to produce corrosive hydrofluoric acid and toxic chloride gas. Interaction with ice at -100°C, or with water vapor above 0°C is extremely vigorous (Christe, K.O. Inorg. Chem. 1972 11, 1220).CHLORINE TRIFLUORIDE violently reacts with water or ice generating acidic HF and chlorine, [Sidgwick, 1156(1950)]. The release of Chlorine Trifluoride to the atmosphere rapidly generates two toxic reaction products: HF and Chlorine Dioxide, [Lombardi, D.A. and M.D. Cheng 1996. "Modeling Accidental Releases of Chlorine Trifluoride to the Atmosphere," Paper No. 96-WP66B.02, presented at the 89th Annual Meeting of the Air and Waste Management Association, Nashville, Tennessee, June 23-26].Molybdenum pentachloride may react with water to produce corrosive hydrochloric acid and toxic fumes.OXYGEN DIFLUORIDE violently exploded when a spark was discharged in a 25-70% mixture of oxygen difluoride with oxygen over water [Mellor 2, Supp. 1:191. 1956].PHOSPHORUS PENTABROMIDE fumes in air. The compound decomposed in water or moist air to form corrosive hydrogen bromide fumes. [Merck 11th ed. 1989]. Phosphorus Pentabromide reacts vigorously with water to generate gaseous HBr. In experiments at Argonne National Laboratory, in which it was mixed with water and stirred at room conditions, about 35 percent of the theoretical yield of HBr evolved as a gas in the first 1 minute [Brown, D. F., et al. (2000) Development of the Table of Initial Isolation and Protective Action Distances for the 2000 Emergency Response Guidebook, ANL-DIS-00-1, Argonne National Laboratory, Argonne IL].PHOSPHORUS PENTACHLORIDE fumes in air, reacts violently with water to form phosphoric acid and hydrochloric acid [Oldbury Chemicals year/ p.9]. Phosphorus Pentachloride reacts vigorously with water to generate gaseous HCl. In experiments at Argonne National Laboratory, in which it was mixed with water and stirred at room conditions, about 21 percent of the theoretical yield of HCl evolved as a gas in the first 0.5 minutes [Brown, D. F., et al. (2000) Development of the Table of Initial Isolation and Protective Action Distances for the 2000

Emergency Response Guidebook, ANL-DIS-00-1, Argonne National Laboratory, Argonne IL].SILICON TETRAFLUORIDE fumes in air. The compound decomposed exothermically by water or moisture in the air to hydrofluoric acid and silicic acid [Merck 11th ed. 1989; Handling Chemicals Safely 1980 p. 821].SULFUR MONOCHLORIDE is decomposed by water yields hydrogen sulfide, hydrochloric acid, sulfur dioxide, sulfite, hydrogen sulfide, and thiosulfate [Merck 11th ed. 1989]. Very corrosive in the presence of water; reacts violently with water and strong oxidants to form toxic and corrosive gas; on contact with air, it gives off HCl. [Handling Chemicals Safely 1980 p.874].SULFUR TETRAFLUORIDE reacts violently with water. It reacts vigorously with water and acids to yield toxic fluoride and sulfur oxide fumes and an acidic solution.Tellurium Hexafluoride reacts with water to yield toxic hydrogen fluoride vapors. It emits very toxic fumes of fluoride and tellurium. Decomposes in water, acid, and alkali. [EPA, 1998].

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