Material Safety Data Sheet for:
Enriched Germanium Tetrafluoride ($^{72}$GeF$_4$)

In an emergency, call CHEMTREC at 800-424-9300 or 703-527-3887.

**Section 1: Chemical Product and Company Identification**

<table>
<thead>
<tr>
<th>Material Name:</th>
<th>Enriched Germanium tetrafluoride</th>
</tr>
</thead>
<tbody>
<tr>
<td>Synonyms:</td>
<td>Tetrafluorogermane; germanium fluoride; Isotopic Germanium tetrafluoride</td>
</tr>
<tr>
<td>Manufacturer:</td>
<td>Voltaix, LLC Post Office Box 5357, North Branch, New Jersey 08876-5357, USA</td>
</tr>
<tr>
<td></td>
<td>Voice: 908-231-9060 or 800-VOLTAIX, Facsimile: 908-231-9063</td>
</tr>
</tbody>
</table>

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**Section 2: Composition/Information on Ingredients**

<table>
<thead>
<tr>
<th>Component</th>
<th>CAS Registry Number</th>
<th>Concentration</th>
<th>Exposure Guidelines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germanium tetrafluoride, Enriched</td>
<td>848094-33-7</td>
<td>100%</td>
<td>0.8 ppm TLV-TWA, as GeF$_4$</td>
</tr>
</tbody>
</table>

**Section 3: Hazards Identification**

**EMERGENCY OVERVIEW**

DANGER! TOXIC, CORROSIVE.

Enriched germanium tetrafluoride is a colorless gas with a pungent, garlic odor. It fumes to form a dense white cloud in moist air. Enriched germanium tetrafluoride’s immediate health hazard is that it is a poison gas. It reacts with water vapor in the air to form other corrosive, toxic substances. Contents of cylinder may be combination of gas and liquefied gas. (See Section 4: Note to Physicians.)

**NFPA 704 Rating (NFPA 49-1991):** Health 4, Fire 0, Reactivity 1, Special None

**Potential Health Effects**

**Routes of Exposure:**
- Inhalation, skin, eye and mucous membrane contact.

**Lengths of Exposure:**
- No data are available on exposure to this material. Exposure to hydrogen fluoride has been found toxic in acute and chronic exposures.

**Severity of Effect:**
- Corrosive. May be fatal if inhaled.

**Target Organs:**
- Lungs, kidneys, liver, blood, bones and teeth.

**Type of Effect:**
- Acute, high concentration exposures produce pulmonary irritation. Subchronic, low concentration exposures also produce generalized effects of fluorine exposure, including hypocalcemia.

**Signs and Symptoms of Exposure:**
- Acute exposure: coughing, shortness of breath, headache, vertigo, chills and nausea. Subchronic: dental fluorosis, increased bone, serum and urinary fluoride levels, hypocalcemia.
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In an emergency, call CHEMTREC at 800-424-9300 or 703-527-3887.

Medical Conditions that may be Aggravated by Exposure:
None identified.

Reported Carcinogenic and Reproductive Effects:
NTP has not reported genetic or long-term toxicology and carcinogenesis effects studies.

Section 4: First Aid Measures

Inhalation
This is the primary route of exposure.
1) Remove the affected person from the gas source or contaminated area. Note: Personal Protective Equipment (PPE), including positive pressure, self contained breathing apparatus, may be required to assure the safety of the rescuer.
2) Give the victim 6 calcium gluconate tablets with water, if conscious. Follow up immediately with medical attention at a medical facility at which the treatment protocol for HF inhalation is to be followed.
3) If the affected person is not breathing spontaneously, administer rescue breathing.
4) If the affected person does not have a pulse, administer CPR.
5) If medical oxygen and appropriately trained personnel are available, administer 100% oxygen to the affected person.
6) Summon an emergency ambulance. If an ambulance is not available, contact a physician, hospital, or poison control center for instruction.
7) Keep the affected person warm, comfortable, and at rest while awaiting professional medical care. Monitor the breathing and pulse continuously. Administer rescue breathing or CPR if necessary.

Skin Contact
Flush with a copious stream of water while removing contaminated clothing. Continue flushing until the professional medical assistance arrives, but for no less than fifteen minutes. Apply calcium gluconate gel to the affected area. Assume the patient has also been exposed by inhalation and obtain professional medical assistance immediately. The effects of skin exposure may be delayed.

Eye Contact
Flush continuously with clean water until the professional medical assistance arrives, but for no less than thirty minutes. Continuation of flushing until patient is transferred to an ophthalmologist or emergency physician is recommended. Assume that the airway may also have been injured and obtain professional medical assistance immediately.

Ingestion
Ingestion is not an observed route of exposure to gaseous hazardous materials.

Chronic Effects
Dental fluorosis, increased bone, serum and urinary fluoride levels, kidney and liver disease, hypocalcemia.

Note to Physicians:
The possible reaction products of germanium tetrafluoride and moist air or water are germanium oxide and hydrofluoric and fluorogermanic acids; the composition of the material to which a patient has been exposed depends on the conditions of the release. Therefore, skin and eye contact should be treated as exposures to acidic fluorine compounds, e.g., hydrofluoric acid. Consider the use of such agents as benzalkonium chloride, magnesium sulfate, and calcium gluconate. Keep under medical observation for 72 hours for delayed onset of pulmonary edema.

Section 5: Fire Fighting Measures

Flammability and Explosivity

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Flash Point:
Not applicable, this material is a nonflammable gas.

Flammability Limits in Air (% by volume):
Upper: Not applicable  Lower: Not applicable
This material is a nonflammable gas

Autoignition Temperature:
Not applicable, this material is a nonflammable gas

Flammability Classification (per 29 CFR 1910.1200):
Nonflammable gas.

Known or Anticipated Hazardous Products of Combustion:
Not applicable, this material is a nonflammable gas

Properties that may Initiate or Intensify Fire:
Heating cylinder to the point of activating the pressure relief device.

Reactions that Release Flammable Gases:
None.

**Extinguishing Media**
None.

**Fire Fighting Instructions**
Cool the cylinder and surroundings with water from a suitable distance. Excessive pressure may develop in gas cylinders exposed to fire, which may result in explosion, regardless of the cylinder's content. Cylinders with pressure relief devices (PRD's) may release their contents through such devices if the cylinder is exposed to fire. Cylinders without PRD's have no provision for controlled release and are therefore more likely to explode if exposed to fire.

*Note: If germanium tetrafluoride is released, the water used for fire suppression and cooling may be contaminated with fluorine compounds. The discharge of such compounds to the sewer system or the environment may be restricted, requiring the containment and proper disposal of the water.*

Positive pressure, self contained breathing apparatus is required for all fire fighting involving hazardous materials. Full structural fire fighting (bunker) gear is the minimum acceptable attire. The need for proximity, entry, and flashover protection and special protective clothing should be determined for each incident by a competent fire fighting safety professional.

**Section 6: Accidental Release Measures**

**Containment**
This material is a gas at atmospheric conditions. The only means of containment is the enclosure of the space into which the material is released. Such containment is described in Section 7.

**Clean Up**
Clean up consists of passing the entire gas volume of the enclosure through appropriate exhaust gas treatment equipment (EGTE). Purge the enclosure with a non-reactive gas, such as nitrogen, through the EGTE until an acceptably low level of contamination remains. Equipment contaminated by this material must then be cleaned or decommissioned appropriately.

**Evacuation**
If the release is not contained in an appropriate device or system, all personnel not appropriately protected (see Section 8) must evacuate the contaminated spaces. Consider evacuation of additional areas, as a precaution against the spread of the release.

**Special Instructions**
The water used for cleanup may be contaminated with fluorine compounds. The discharge of such compounds to the sewer system or the environment may be restricted, requiring the containment and proper disposal of the water.

**Section 7: Handling and Storage**

**Handling**
Handle this material only in sealed, purged systems. The design of handling systems for hazardous materials is beyond the scope of this MSDS, and should be performed by a competent, experienced professional. Consider the use of doubly-contained piping; diaphragm or bellows sealed, soft seat valves; backflow prevention devices; flash arrestors; and flow monitoring or limiting devices. Gas cabinets, with appropriate exhaust treatment, are recommended, as is automatic monitoring of the secondary enclosures and work areas for release.

Handle sealed gas cylinders in accordance with CGA P-1, *Safe Handling of Compressed Gases in Containers*.

Some material may have accumulated behind the outlet plug. Face the outlet away from you and wear appropriate protective equipment when removing the plug to connect the cylinder to your system.

Never introduce any substance into a gas cylinder. If you believe your cylinder may have been contaminated, notify Voltaix immediately. Provide as much information as possible on the nature and quantity of contamination.

**Storage**
Store cylinders in accordance with CGA P-1, *Safe Handling of Compressed Gases in Containers*, local building and fire codes and other relevant regulations. Materials should be segregated, by the hazards they comprise, for storage.

Protect the cylinders from direct sunlight, precipitation, mechanical damage, and temperatures above 55 °C (130 °F).

Ship and store cylinders with the outlet plug and valve protective cap in place.

**Section 8: Exposure Control/Personal Protection**

**Engineering Controls**
Local exhaust is required. Secondary containment, with appropriate exhaust gas treatment, is strongly encouraged and is required in some jurisdictions.

Monitor the work area and the secondary containment continuously for release of the material. Automatic alerting of personnel and automatic shutdown of flow are appropriate in most applications and are required in some jurisdictions.

Purge all primary containment systems with a nonreactive gas, such as nitrogen, before introducing germanium tetrafluoride.

**Personal Protective Equipment (PPE)**

**Respiratory Protection:**
Positive pressure, full face, air supplied breathing apparatus should be used for work within the secondary containment equipment if a leak is suspected or the primary containment is to be opened, *e.g.*, for a cylinder change. Air supplied breathing apparatus is required for response to demonstrated or suspected releases from the primary containment.

**Eye/Face Protection:**
When using respiratory protection as described above, use a face mask that provides splash and impact protection for the face and eyes. For handling sealed cylinders, wear safety glasses.

**Skin Protection:**
Wear appropriate gloves when handling sealed cylinders. Use gloves and other skin protection, as assigned by a competent safety professional, when working within the secondary enclosure with the primary enclosure compromised, *e.g.*, cylinder changing, to protect from exposure to the material. For response to demonstrated or
suspected releases from the primary containment, the need for whole-body exposure protection should be
determined by a competent safety professional.

Other Protection:
Wear appropriate protective footwear when moving cylinders. Select per OSHA 29CFR1901.132 and 1910.133.

Exposure Guidelines

<table>
<thead>
<tr>
<th>Property</th>
<th>ACGIH</th>
<th>OSHA</th>
<th>NIOSH</th>
</tr>
</thead>
<tbody>
<tr>
<td>TLV-TWA</td>
<td>0.8 ppm</td>
<td>0.8 ppm</td>
<td>0.8 ppm</td>
</tr>
<tr>
<td>PEL-TWA</td>
<td>0.8 ppm</td>
<td>0.8 ppm</td>
<td>NE</td>
</tr>
</tbody>
</table>

Based on ACGIH TLV TWA for Fluorine, which is 2.5 mg/m$^3$ that is equivalent to 3.2 ppm for HF or 0.8 ppm for GeF$_4$.

Section 9: Physical and Chemical Properties

Notes: 1) "N/A" means not applicable.
2) Unless otherwise specified, properties are reported at 0 °C (32 °F) and 1 atmosphere (1.0 bar, 14.7 psia).

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appearance</td>
<td>colorless</td>
</tr>
<tr>
<td>Odor</td>
<td>pungent, garlic</td>
</tr>
<tr>
<td>Physical state at atmospheric conditions</td>
<td>gas</td>
</tr>
<tr>
<td>pH</td>
<td>not applicable</td>
</tr>
<tr>
<td>Vapor Pressure</td>
<td>4.04 bar (58.6 psia) at -15 ºC (5 ºF)</td>
</tr>
<tr>
<td>Vapor Density</td>
<td>unknown</td>
</tr>
<tr>
<td>Boiling point (at 1 atm)</td>
<td>-37 ºC (-34 ºF)</td>
</tr>
<tr>
<td>Melting point</td>
<td>-15 ºC (5 ºF)</td>
</tr>
<tr>
<td>Solubility in water (v/v)</td>
<td>not applicable, reacts with water</td>
</tr>
<tr>
<td>Specific gravity of liquid (water = 1)</td>
<td>unknown</td>
</tr>
<tr>
<td>Molecular weight</td>
<td>148.6</td>
</tr>
</tbody>
</table>

Section 10: Stability and Reactivity

Chemical Stability: Not known to decompose thermally.

Conditions to Avoid: Exposure to air.

Incompatibility with Other Materials:
Water, alkali metals, alkaline earth metals (except magnesium), alkyl nitrates, polymerizable materials.

Hazardous Decomposition, Reaction and Oxidation (other than burning) Products:
Reaction with water, including water vapor in air, produces enriched fluorogermanic acid and hydrofluoric acid.

Hazardous Polymerization: Not known to polymerize.

Section 11: Toxicological Information

Acute Data (by route):
No data exists for enriched germanium tetrafluoride. Based on natural germanium tetrafluoride, currently, there is no LD$_{50}$ Oral, Skin or LC$_{50}$ Inhalation data for Germanium Tetrafluoride. By analogy to hydrogen fluoride, under ISO 10298:2010, LC$_{50}$ (Inhalation-Rat) 1307 ppm/1 hour for hydrogen fluoride, which is the main decomposition product. Therefore, the LC$_{50}$ for Germanium Tetrafluoride is estimated to be 319 ppm.
Additionally, germanium tetrafluoride is expected to produce irritation of the skin, eyes and upper respiratory system. The effects of skin exposure may be delayed; this may make it difficult to associate the injury with the exposure.

**Chronic and Subchronic Data:**
No data for enriched or natural germanium tetrafluoride are available. Prolonged exposure to hydrogen fluoride produces systemic increase in fluoride, which may result in diseases of bones, liver, and kidneys and in hypocalcemia. Enriched or natural germanium tetrafluoride is not listed in the *Registry of Toxic Effects of Chemical Substances* (RTECS); no information on its carcinogenicity is available.

**Special Studies:**
None known to Voltaix

**Section 12: Ecological Information**

**Ecotoxicity:**
None known to Voltaix.

**Environmental Fate:**
Hydrolyzes to enriched fluorogermanic acid and hydrofluoric acid.

**Section 13: Disposal Considerations**

**Classification under RCRA, 40 CFR 261:**
Not listed

**US EPA waste number and descriptions:**
D003 (reactivity characteristic)

**Special Instructions and Limitations:**
Treat process and other exhaust streams appropriately before release to the atmosphere.

**Notice:**
The information above is derived from Voltaix’s interpretation of the US federal laws, regulations and policies concerning the material, as shipped by Voltaix, at the time this MSDS was prepared. Federal controls are subject to change and state and local controls may also apply. Proper waste disposal is the responsibility of the owner of the waste. The user is encouraged to consult with appropriate experts in developing a disposal plan.

**Section 14: Transport Information**

**Basic Description:**
Compressed Gas, Toxic, Corrosive, n.o.s. (Enriched Germanium Tetrafluoride), Division 2.3 (8), UN 3304. If Liquefied Gas Present: Liquefied Gas, Toxic, Corrosive, n.o.s. (Enriched Germanium Tetrafluoride), Division 2.3 (8), UN 3308

Toxic - Inhalation Hazard, Hazard Zone B.

**Additional Information for shipment by water:**
IMDG Page Number 2125-1 for UN 3304 and 2155-2 for UN 3308.

**Additional Information for shipment by air:**
Air transportation is not permitted.

**Section 15: Regulatory Information**

**TSCA Status:**
This material is not listed on the Inventory of Chemical Substances. This material is supplied under the "Exemption for Research and Development" (40 CFR 720.36) of the Toxic Substances Control Act. As such, its use is restricted to R&D purposes and must be "by, or directly under the supervision of, a technically qualified individual," as defined by 40 CFR 720.3(ee). Use for "commercial purposes", which EPA defines, in part, as "the purpose of obtaining an immediate or eventual commercial advantage" (40 CFR 720.3(r)), is prohibited.

**CERCLA Reportable Quantity (40CFR302.4):**
This material is not listed.

**SARA Title III Status (Section 302 (40CFR355), Section 311/312, Section 313 (40CFR372)):**
This material is not listed. The Reportable Quantity (RQ) for "Unlisted Hazardous Wastes Characteristic of Reactivity" (D003) of 45.4 kg (100 lbs.) therefore applies.

*Note:* State and local requirements may be more stringent.

### Section 16: Other Information

#### References
- Vakhirin, A. A. and Yushkov, G. G.; "Hygienic Standardization of Chemical Substances as an Aspect of Environmental restrictions in Design of environmentally Safe Processes (as Illustrated by Germanium Tetrafluoride)"; 2004

#### Revision Indication
- 21 July 2006: Revise to reflect company name change.
- 02 October 2007: Corrected CAS number.
- 23 November 2011: Revise transportation, toxicological information and TSCA status.

#### Disclaimer
Voltaix cannot guarantee that these are the only hazards that exist. Users are solely responsible for the safe storage, handling, use and disposal of this material, and for compliance with the applicable laws, regulations and accepted practices.

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