NEW BRUNSWICK LABORATORY

SAFETY DATA SHEET

URANIUM HEXAFLUORIDE (UF6)

SECTION 1: CHEMICAL PRODUCTS & COMPANY IDENTIFICATION

New Brunswick Laboratory
U. S. Department of Energy
9800 South Cass Avenue
Argonne, IL 60439
1-630-252-CRMS

Off Hours Emergency Numbers:
1-630-252-6131 or 1-630-252-5731

Substance: Uranium Hexafluoride (UF6)

Trade Names/Synonyms:
CRM 113-A (normal enrichment uranium), CRM 113-B (low-enriched uranium)
Uranium Hexafluoride for Safeguards Measurement Evaluation (SME) Program

Chemical Family:
Inorganic salt

Radioactive

SECTION 2: HAZARDS IDENTIFICATION

OSHA Hazards
Highly toxic by inhalation, Highly toxic by ingestion. Corrosive.

Target Organs
Kidney, Liver, Lungs, Brain, Skin, Eyes.

GHS Classification
Acute toxicity, Oral (Category 1)
Acute toxicity, Inhalation (Category 1)
Specific target organ toxicity - repeated exposure (Category 2)
Skin Corrosion (Category 1A)
Serious eye damage (Category 1)
Acute aquatic toxicity (Category 2)

Chronic aquatic toxicity (Category 2)

GHS Label elements, including precautionary statements

Pictogram

Signal Word: Danger

Hazard statement(s)
H300 + H330 Fatal if swallowed or if inhaled
H314 Causes severe skin burns and eye damage
H373 May cause damage to organs through prolonged or repeated exposure.
H411 Toxic to aquatic life with long lasting effects.

Precautionary statement(s)
P260 Do not breathe dust/ fume/ gas/ mist/ vapors/ spray.
P262 Do not get in eyes, on skin, or on clothing.
P264 Wash skin thoroughly after handling.
P273 Avoid release to the environment.
P280 Wear protective gloves/protective clothing/eye protection/face protection
P310 Immediately call a POISON CENTER or doctor/ physician if swallowed or inhaled.

Other Hazard(s): Radioactive

CERCLA Ratings (SCALE 0-3): HEALTH=3 FIRE=0 REACTIVITY=1
PERSISTENCE = 3

NFPA RATINGS (SCALE 0-4); HEALTH=4 FIRE=0 REACTIVITY=1

EMERGENCY OVERVIEW: Volatile, colorless or white, deliquescent monoclinic crystal solid.

May be fatal if inhaled. May cause blood disorders. May cause convulsions. May damage kidneys. May affect the central nervous system. May cause adverse reproductive effects.

May affect respiration. May cause eye damage. May affect the liver. May cause burns. May react with water.

Poison. Do not breathe fumes. Do not get in eyes, on skin, or on clothing. Do not allow water to get in container. Keep container tightly closed. Wash thoroughly after handling. Use only with adequate ventilation. Handle with caution.

POTENTIAL HEALTH EFFECTS:

INHALATION:
Short Term Exposure: May cause lack of appetite, nausea, vomiting, diarrhea, dehydration, kidney damage, blood in the urine, jaundice, weakness, drowsiness, incoordination, twitching, sterility, blood disorders, convulsions and shock. May also cause death. Exposure to radioactive substances increases one's risk of developing cancer.

Long Term Effects: In addition to effects from short-term exposure, anemia, cataracts and lung damage may occur.

SKIN CONTACT:
Short Term Exposure: May cause skin irritation. May cause kidney damage.

Long Term Effects: In addition to effects from short-term exposure, liver damage may occur.

EYE CONTACT:
Short Term Exposure: May cause irritation. Additionally, eye damage, including ulcerations, may occur.

Long Term Effects: It is unlikely that long term eye contact would occur as the effects of short term exposure, over a period of time, would result in serious eye damage. However, if long term exposure did occur, cataracts may also occur.

INGESTION:
Short Term Exposure: May cause drooling, nausea, vomiting, diarrhea, stomach pain, weakness, twitching, kidney damage and convulsions. May cause increased cancer risk.
Long Term Effects: No information available on significant adverse effects. Prolonged exposure to uranium compounds may cause kidney damage and elevated cancer risk.

CARCINOGEN STATUS:

OSHA: N
NTP: N
IARC: N

SECTION 3: COMPOSITION/INFORMATION ON INGREDIENTS

Component: Uranium Hexafluoride
CAS Number: 7783-81-5
Percentage: 100.0
Other Contaminants: None

SECTION 4: FIRST AID MEASURES

UF6 upon exposure to air will generate hydrogen fluoride and uranyl fluoride. Hydrofluoric acid burns require immediate and specialized first aid and medical treatment. Symptoms may be delayed for up to 24 hours. Skin exposures can be treated with calcium gluconate. Conditions such as hypocalcemia, hypomagnesemia and cardiac arrhythmias should be monitored for.

INHALATION: Remove from exposure area to a restricted area with fresh air as quickly as possible. If breathing has stopped, perform artificial respiration, preferably by administering oxygen. Get medical attention immediately. Medical problems take priority over radiological concerns. The victim may be contaminated with radioactive particles.

SKIN CONTACT: Remove victim to a suitable area for decontamination as quickly as possible. Remove clothing and shoes immediately. Thoroughly wash the victim with soap and water. Medical problems take priority over radiological concerns. Upon completion of washing, monitor the victim for radioactivity.

EYE CONTACT: Remove victim to a restricted area for decontamination. Thoroughly wash eyes with large amounts of water, occasionally lifting the upper and lower lids (approximately 15 minutes). Following the water treatment, provide an isotonic solution. Monitor the victim for radioactivity. If activity is present, rewash the eyes, and remonitor until little or no radioactivity is present. Medical problems take priority over radiological concerns. Get medical attention immediately

INGESTION: In the case of ingestion of radioactive substances, the mouth should be rinsed out immediately after the accident, care being taken not to swallow the water used for this purpose. Medical problems take priority over radiological concerns. Get medical attention immediately.

SECTION 5: FIRE FIGHTING MEASURES

FIRE AND EXPLOSION HAZARD: Negligible fire hazard when exposed to heat or flame.

Slight explosion hazard when exposed to heat or flame.

EXTINGUISHING MEDIA: Dry chemical or carbon dioxide. (*Emergency Response Guidebook* (ERG), developed jointly by Transport Canada (TC), the U. S. Department of Transportation (DOT) and the Secretariat of Transportation and Communications of Mexico (SCT).)

For larger fires, use water spray, fog or regular foam (*Emergency Response Guidebook*, ERG.)

FIREFIGHTING: Move container from fire area if you can do it without risk. Apply cooling water to sides of containers exposed to flames until well after fire is out. Stay away from ends of tanks. If this is impossible, withdraw from area and let fire (*Emergency Response Guidebook*, ERG).

Contact local, State or Department of Energy radiological response team. Do not allow water to get on spilled material. Use water in flooding quantities as a fog if combustible materials are involved. Knock down vapors with water spray. Cool fire exposed containers with flooding quantities of water applied from as far a distance as possible. Avoid breathing dust and fumes; keep upwind.

HAZARDOUS COMBUSTION PRODUCTS: Thermal decomposition products may include corrosive fumes of hydrogen fluoride and toxic and hazardous fumes of uranium.

SECTION 6: ACCIDENTAL RELEASE MEASURES

OCCUPATIONAL SPILL: Do not touch spilled material. Try to freeze leakage by cooling at point of opening with carbon dioxide (dry ice). Use water spray to reduce vapor; do not put water directly on lead or spill area. For small spills, flush area with flooding amounts of water on a small part of the spill at a time. Keep unnecessary people away; isolate hazard area and deny entry. Stay upwind; keep out of low areas. Delay clean up until arrival or instruction of qualified radiation authority.

SECTION 7: HANDLING AND STORAGE

Observe all Federal, State and local regulations when storing this substance.

SECTION 8: EXPOSURE CONTROLS/PERSONAL PROTECTION

EXPOSURE LIMITS:
Uranium, soluble compounds (As U):

0.05 mg/m^3 OSHA PEL TWA
0.2 mg/m^3 ACGIH TLV TWA; 0.6 mg/m^3 ACGIH STEL
0.05 mg/m^3 NIOSH Recommended TWA

Hydrogen Fluoride

6 ppm OSHA STEL (15 minutes), 3.0 ppm OSHA PEL
0.5 ppm ACGIH TLV TWA, 2 ppm ACGIH Ceiling
6 ppm NIOSH Ceiling, 3 ppm NIOSH REL TWA (10 hours)

Occupational exposure to radioactive substances must adhere to standards established by the Occupational Safety and Health Administration, 29 CFR 1910.96, and/or the Nuclear Regulatory Commission, 10 CFR Part 20.

VENTILATION: At a minimum, provide local exhaust or process enclosure ventilation. Depending upon the specific work place activity and the radioactivity of the isotope, a more stringent ventilation system may be necessary to comply with exposure limits set forth by law (10 CFR 20.103)

Radioactive exposure levels should be maintained As Low As Reasonably Achievable (ALARA).

SHIELDING:
ALPHA PARTICLES: For the energy range of alpha particles usually encountered, a fraction of a millimeter of any ordinary material or a few inches of air is sufficient for absorbency.

BETA PARTICLES: Beta particles are more penetrating than alpha, and require more shielding. Materials composed mostly of elements of low atomic number such as acrylic, and thick rubber are most appropriate for the absorption of beta particles. Uranium hexafluoride, in quantities used for Certified Reference Materials and SME materials, does not emit significant amounts of beta particles.

GAMMA RAYS: The most suitable materials shielding gamma radiation are lead and iron. Uranium, in quantities used for Certified Reference Materials and SME materials, does not emit significant amounts of gamma radiation. Consult a radiation protection specialist or health physicist for more information.

ALPHA-NEUTRON REACTION: Neutrons of approximately 2 MeV are generated by the interaction of alpha particles from uranium with the nuclei of fluoride and other low-Z atoms. The magnitude of the neutron flux will vary based on the total activity of uranium (which is a function of enrichment) and the chemical compound in question (mixing of U and F). In the case of a storage cylinder of UF_6, the typical neutron dose rate from natural to 5% enriched uranium would be expected to be 0.01 to 0.2 mrem/hr. Neutron dose rates from P-10 tubes would be even lower.

EYE PROTECTION: Employee must wear appropriate eye protection that will not allow the introduction of particles into the eyes. Contact lenses should not be worn.

CLOTHING: Laboratory uses only protective clothing is required.

In the event of an accident, large-scale release or a large-scale clean-up full protective clothing will be necessary.

GLOVES: Employee must wear appropriate protective gloves to prevent contact with this substance. Used gloves should be disposed of as radioactive waste.

RESPIRATOR: The following respirators and maximum use concentrations are recommendations by the U.S. Department of Health and Human Services, NIOSH pocket guide to chemical hazards; NIOSH criteria documents or by the U.S. Department of Labor, 29 CFR 1910 Subpart Z.

The specific respirator selected must be based on contamination levels found in the work place, must not exceed the working limits of the respirator and be jointly approved by the National Institute for Occupational Safety and Health and the Mine Safety and Health Administration (NIOSH-MSHA).

URANIUM, SOLUBLE COMPOUNDS (As U), HALIDES:

AT ANY DETECTABLE CONCENTRATION:
Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode.

Any supplied air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive-pressure mode.

Escape - any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted acid gas canister having a high-efficiency particulate filter.

Any appropriate escape-type, self-contained breathing apparatus.

FOR FIREFIGHTING AND OTHER IMMEDIATELY DANGEROUS TO LIFE OR HEALTH CONDITIONS: Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive pressure mode.

Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive-pressure mode.

SECTION 9: PHYSICAL AND CHEMICAL PROPERTIES

APPEARANCE: Volatile, colorless or white, deliquescent monoclinic crystal solid.
MOLECULAR WEIGHT: (Approximately 349-352 depending on isotopic distribution)
MOLECULAR FORMULA: UF_6
BOILING POINT: 133□F (56^{o}C) sublimes
MELTING POINT: 149□F (65^{o}C)
VAPOR PRESSURE: 109 mm Hg @ 20^{o}C
SPECIFIC GRAVITY: 4.7 @ 21^{o}C
WATER SOLUBILITY: reacts vigorously
SOLVENT SOLUBILITY: Fluorocarbons, liquid chlorine and bromine, nitrobenzene, carbon tetrachloride, chloroform, tetrachloroethane.
VAPOR DENSITY (air = 1): 12
FLAMMABILITY: No data available
FLASH POINT: No data available
AUTOIGNITION TEMPERATURE: No data available
ODOR: Pungent
ODOR THRESHOLD: .04ppm.

Half-Life - The half-lives of the various uranium isotopes are as follows:

^{234}U = 2.47 X 10^{5} y; ^{235}U = 7.04 X 10^{8} y; ^{236}U = 2.39 X 10^{7}; ^{238}U = 4.51 X 10^{9} y; ^{233}U = 1.59 X 10^{5} y.

Specific activity - The specific activities of the various uranium isotopes are as follows:

^{233}U = 3.6 X 10^{2} MBq/g (9.7 X 10^{-3} Ci/g)

^{234}U = 2.3 X 10^{2} MBq/g (6.2 X 10^{-3} Ci/g)

^{235}U = 7.8 X 10^{-2} MBq/g (2.1 X 10^{-6} Ci/g)

^{236}U = 2.3 MBq/g (6.3 X 10^{-5} Ci/g)

$^{238}U = 1.2 \times 10^{-2}$ MBq/g (3.3×10^{-7} Ci/g)

SECTION 10: STABILITY AND REACTIVITY

REACTIVITY:

URANIUM HEXAFLUORIDE: Vigorous, exothermic reaction with water releases corrosive hydrogen fluoride and toxic uranyl fluoride.

This compound will attack some plastics, rubbers, and coatings. These materials should not be used to contain uranium hexafluoride.

CONDITIONS TO AVOID: May ignite combustible materials such as paper, wood, and oil. Container may explode in heat or fire.

INCOMPATIBILITIES:
URANIUM HEXAFLUORIDE:
Aromatic Hydrocarbons and Hydroxy compounds: Interaction with benzene, toluene or xylene is very vigorous with separation of carbons.
Water: Vigorous, exothermic reaction releases corrosive hydrogen fluoride and toxic uranyl fluoride.
Metals: Reacts with most metals; should be handled in a copper apparatus.

HAZARDOUS DECOMPOSITION: Thermal decomposition products may include corrosive fumes of hydrogen fluoride and toxic and hazardous fumes of uranium.

POLYMERIZATION:
Hazardous polymerization has not been reported to occur under normal temperature and pressure.

SECTION 11: TOXICOLOGY INFORMATION

Uranium hexafluoride, upon exposure to moisture in air will release hydrogen fluoride which is a poisonous and corrosive gas as well as uranyl oxy-fluoride which is a nephrotoxin. The material usually has a low level of radioactivity with the chemical hazard greatly exceeding the radiation hazard for all but highly enriched materials. Hydrogen fluoride is highly corrosive to the skin, eyes and the respiratory tract. The primary hazard of inhalation of uranium hexafluoride (byproduct hydrogen fluoride) is its corrosivity. Uranium hexafluoride (byproduct hydrogen fluoride) is also highly toxic by inhalation. Poisoning affects the kidneys, liver, lungs and hematopoietic system and causes disorders in protein and carbohydrate metabolism. Uranium poisoning may be acute or

chronic, associated with both the chemical and radiological toxicity. Uranium is a weak alpha emitter. Cancer of the lung, osteosarcoma, and lymphoma has all been reported as a result of radiation exposure to uranium. Deaths reported from acute inhalation of uranium hexafluoride have been due to the corrosive effect of the compound on the lungs.

HEALTH EFFECTS
INHALATION:
URANIUM HEXAFLUORIDE:
RADIOACTIVE/NEPHROTOXIC/HIGHLY TOXIC.

ACUTE EXPOSURE: Serious cases of poisoning have been observed after workers were exposed to uranium hexafluoride. An exploding container of this compound poisoned 18 persons, two of whom died. The survivors suffered from irritation of the upper airways, and one of them from pulmonary edema. Gastrointestinal changes were also observed. Radiographs revealed a diffuse inflammatory process in the lungs and pronounced kidney lesions. The kidney is the organ most directly affected by soluble uranium compounds, such as uranium hexafluoride. Effects on the kidney are more severe and occur prior to effects on the liver. The deleterious effects of uranium on the liver are a result of changes in blood chemistry brought on by renal dysfunction.

CHRONIC EXPOSURE: Chronic symptoms may develop after prolonged contact with soluble uranium compounds. The degree of the symptoms depends on the level and time of exposure. Chronic exposure frequently results in changes in the blood. These changes may be due in part to the radioactive properties of uranium. The toxic effects of uranium compounds may also result in kidney failure, chronic hepatitis, gastritis and other conditions.

ALPHA RADIATION:
ACUTE EXPOSURE - Alpha radiation will kill cells immediately adjacent to the source of contact. Large insoluble particles may remain at or near the site of deposition, and cause local damage. Soluble compounds may rapidly enter the bloodstream. The damage depends on how quickly they are eliminated, and the susceptibility of the tissue in which they are stored.

CHRONIC EXPOSURE - The effects of chronic exposure by internally deposited alpha active material is dependent upon the amount, enrichment, and tissue. If large amounts become internally deposited, lung cancer, sterility, anemia, leukemia, or bone cancer may occur.

SKIN CONTACT:
URANIUM HEXAFLUORIDE:
RADIOACTIVE/NEPHROTOXIN.
ACUTE EXPOSURE - Contact with uranium hexafluoride can cause severe irritation to the skin. Uranium hexafluoride has been reported to be absorbed through intact human skin.

The effects of skin contact may then result in the kidney toxicity usually associated with inhalation or other routes.

CHRONIC EXPOSURE - Repeated or prolonged contact may result in irritation, dermatitis, and kidney failure. Kidney dysfunction can cause liver problems, and the symptoms of chronic hepatitis. Uranium tends to seek the kidney and bone. Over time, alpha emission may cause radiation damage to tissues in which uranium has been deposited.

EYE CONTACT:
URANIUM HEXAFLUORIDE:
RADIOACTIVE.
ACUTE EXPOSURE - Uranium hexafluoride was shown to cause moderately severe injury when dropped into the eyes of rabbits, guinea pigs, and mice. Contact lenses should not be worn when using this compound, or any soluble uranium compound.

CHRONIC EXPOSURE - Repeated or prolonged eye contact may result in irritation and conjunctivitis, or symptoms of radiation injury such as cataracts. See the following sections for information about alpha radiation and the eyes, as well as radiation sickness.

ALPHA RADIATION:
ACUTE EXPOSURE - Repeated or prolonged exposure to alpha radiation may result in cataract formation. Of the well-documented late effects of radiation on man, leukemia and cataracts have been observed at doses lower than those producing skin scarring and cancer or bone tumors. The lens of the eye is considered to be a critical organ for exposure to radiation. It is important to note that long-term eye contact with uranium hexafluoride would most likely result in serious damage to the cornea before cataracts would be formed. Normal usage of Certified Reference Materials or SME materials will not result in significant eye exposures except in cases of accidents or poor laboratory practice.

CHRONIC EXPOSURE - Repeated or prolonged exposure to alpha radiation may result in cataract formation. See acute exposure.

INGESTION:
URANIUM HEXAFLUORIDE:
RADIOACTIVE/NEPHROTOXIN.
ACUTE EXPOSURE - Oral toxicity of uranium compounds is lower than that by inhalation. Uranium compounds are toxic to the kidneys. Absorbed uranium is deposited in bone and the kidneys. Alpha emission from deposited uranium may damage either of these tissues. Poisoning may also occur from the fluoride component of this material. Fluoride poisoning may result in excessive salivation, nausea, vomiting, diarrhea, and abdominal cramps. Fluoride binding bivalent cations (calcium and magnesium) may result in weakness, tremor, shallow respiration, and convulsions and eventually lead to cardiac arrthymias.

CHRONIC EXPOSURE - Chronic poisoning may develop after prolonged exposure to soluble uranium compounds. There may be changes in the peripheral blood, such a leucopenia, lymphopenia, and neutropenia, and symptoms of vegetative dystonia. In addition to these chemical effects, long term irradiation of the kidney and bone marrow may damage these tissues.

ALPHA RADIATION:
ACUTE EXPOSURE - The fate of ingested alpha emitters depends on their solubility and valence.

CHRONIC EXPOSURE - Repeated ingestion of alpha emitters may increase cancer risks.

SECTION 12: ECOLOGICAL INFORMATION

Environmental Impact Rating (0-4): 2

Acute Aquatic Toxicity: Acute and chronic aquatic toxicity (Category 2)

Degradability: No data available

Log Bioconcentration Factor (BCF): No data available

Log Octanol/water partition coefficient: No data available

SECTION 13: DISPOSAL INFORMATION

Observe all Federal, State and local Regulations when disposing of this substance.

SECTION 14: TRANSPORTATION INFORMATION

The U.S. Department of Transportation (D.O.T.) Code of Federal Regulations (49 CFR Parts 100-185), the International Air Transportation Association (IATA), International Civil Aviation Organization (ICAO) and International Maritime Organization (IMDG) are all factored into the classification and transport of material.

Proper Shipping Name:
Hazard Class:
UN/ID Number:
Special Information:
Packing Group:

} To be determined on a case by case basis.

Classification of substances with multiple hazards must be determined in accordance with the criteria presented in the above mentioned regulations. Due to the various quantities/combinations of materials being shipped at one time, the information above must be determined based on the characteristics of the specific shipment.

SECTION 15: REGULATORY INFORMATION

TSCA STATUS:	N
CERCLA SECTION 103 (40 CFR 302.4):	N
SARA SECTION 302 (40 CFR 355.30):	N
SARA SECTION 304 (40 CFR 355.40):	N
SARA SECTION 313 (40 CFR 372.65):	N
OSHA PROCESS SAFETY (29 CFR 1910.119):	N
CALIFORNIA PROPOSITION 65:	N

SARA HAZARD CATEGORIES, SARA SECTIONS 311/312 (40 CFR 370.21)

ACUTE HAZARD:	Y
CHRONIC HAZARD:	Y
FIRE HAZARD:	N
REACTIVITY HAZARD:	Y
SUDDEN RELEASE HAZARD:	N

SECTION 16: OTHER INFORMATION

This material is prepared for use as a standard or in inter-laboratory comparison programs at analytical laboratories, which routinely handle uranium and/or plutonium. The New Brunswick Laboratory (NBL) assumes that recipients of this material have developed internal safety procedures, which guard against accidental exposure to radioactive and toxic materials, contamination of the laboratory environment, or criticality. NBL further expects that personnel who handle radioactive materials have been thoroughly trained in the safety procedures developed by and for their Laboratory.

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