SAFETY DATA SHEET

PLUTONIUM SULFATE TETRAHYDRATE

SECTION 1: CHEMICAL PRODUCTS & COMPANY IDENTIFICATION

New Brunswick Laboratory
U. S. Department of Energy
9800 South Cass Avenue
Argonne, IL 60439
1-630-252-2442

Emergency Phone Numbers: 1-630-252-6131 or 1-630-252-5731

Chemical Name: Plutonium Sulfate Tetrahydrate, 100%

Other Identifiers: PLUTONIUM SULFATE; CRM 136; CRM 137; CRM 138

Chemical Family: Metal sulfate. Radioactive.

SECTION 2: HAZARDS IDENTIFICATION

Chemical Hazard: None known

GHS Label Elements: Not applicable.

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

NFPA RATINGS (SCALE 0-4): HEALTH=U FIRE=0 REACTIVITY=0

EMERGENCY OVERVIEW: The toxicological properties have not been fully investigated. Handle with caution, normally in a glove box type enclosure.

POTENTIAL HEALTH EFFECTS:

INHALATION:
Short Term Exposure - May cause irritation. May cause kidney damage, yellowing of the skin and eyes, lack of appetite, nausea, vomiting, diarrhea, dehydration, blood in the urine, weakness, drowsiness, incoordination, twitching, sterility, blood disorders, convulsions and shock.

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

SKIN CONTACT:
Short Term Exposure - No information available on significant adverse effects.

Long Term Effects - May cause effects as reported in other exposures.

EYE CONTACT:
Short Term Exposure - May cause irritation, redness and swelling. Additional effects may include sores and eye damage.

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

INGESTION:
Short Term Exposure - No information available on significant adverse effects.

Long Term Effects - Same effects as short term exposure.

CARCINOGEN STATUS:

OSHA: N
NTP: N
IARC: N

Note: Plutonium materials may cause cancer when internally deposited.

SECTION 3: COMPOSITION/INFORMATION ON INGREDIENTS

Chemical Name: Plutonium Sulfate Tetrahydrate ($Pu(SO_4)2\ 4H_2O$)

CAS Number: 7440-97-5

Component: Plutonium Sulfate
Percentage: 100%
Other Contaminants: None

SECTION 4: FIRST AID MEASURES

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; alternatively, mouth-to-mouth resuscitation may be performed

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, paying particular attention to the head, finger nails and palms of the hands

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. Do not use eyebaths, rather provide a continuous and copious supply of fluid.

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.

Vomiting should be induced either mechanically, or with syrup of ipecac. Do not induce vomiting in an unconscious person.

SECTION 5: FIRE FIGHTING MEASURES

FIRE AND EXPLOSION HAZARD: Negligible fire or explosion hazard in bulk form; however, dusts, powders, or vapors are flammable or explosive when exposed to heat or flames. (Criticality safety is not a concern unless more than kilogram quantities of plutonium sulfate are involved).

EXTINGUISHING MEDIA: Dry chemical, carbon dioxide, water spray or regular foam (most recent *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 or fog (flooding amounts) (*Emergency Response Guidebook*, ERG).

FIREFIGHTING: Do not move damaged containers; move undamaged containers out of fire zone. For massive fire in cargo area, use unmanned hose holder or monitor nozzles (*Emergency Response Guidebook*, ERG).

Contact the local, State, or Department of Energy radiological response team. Use suitable agent for surrounding fire. Cool containers with flooding quantities of water applied from as far a distance as possible. Avoid breathing dusts or vapors, keep upwind. Keep unnecessary people out of area until declared safe by proper authorities.

SECTION 6: ACCIDENTAL RELEASE MEASURES

OCCUPATIONAL SPILL: Do not touch damaged containers or spilled material. Call radiation safety personnel for assistance. For small liquid spills, use absorbent pads or other non-dispersible absorbent materials. Isolate the area to prevent unnecessary access by non-essential personnel. Enter spill area only to save life; use all practical means to control the spread of possibly contaminated materials. Uninjured persons and possibly contaminated equipment and materials should be kept from leaving until monitored by qualified radiation authority. Cleanup should not be attempted except at the instruction of qualified radiation authority.

SECTION 7: HANDLING AND STORAGE

Precautions for Safe Handling: Avoid contact with skin, eyes and clothing. Avoid breathing. Observe all Federal, State, and local regulations when handling and storing this substance.

Conditions for Safe Storage: Store in accordance with 10 CFR 20. Store in radioactive materials area.

SECTION 8: EXPOSURE CONTROLS/PERSONAL PROTECTION

EXPOSURE LIMITS: 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. If purchased by DOE or a DOE governed facility 10 CFR 835. Foreign countries may have their own protection regulations.

Maintain all exposures as low as reasonably achievable.

VENTILATION: At a minimum, provide process enclosure ventilation. Depending upon work place activities, a more stringent ventilation system may be necessary to comply with exposure limits set forth by law (10 CFR 20.103). In particular, a High Efficiency Particulate Air (HEPA) filtration system may be required for handling and storing this material.

RADIATION EXPOSURE: Radiation exposure is typically lessened by reducing the time one spends in proximity to radioactive materials, increasing one's distance from the source of radiation, or shielding one's self from the source of radiation. While time and distance are self-explanatory, the proper material and thickness used for shielding is dependant on the type of radiation, its energy, and the dimensions of the source. Plutonium sulfate (as Pu-239), in gram quantities is considered an alpha emitter for most radiation protection purposes. Over a period of years however, any Pu-241 (a beta emitter) present will cause a build up of Americium (Am-241), which is both an alpha and gamma radiation emitter. See the *Certificate of Analysis* provided with each Certified Reference Material for details on isotopic composition.

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 absorbance.

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. Except in the case of Pu-241, plutonium does not emit significant amounts of Beta particles.

GAMMA RAYS: The most suitable materials for shielding gamma radiation are lead and iron. In gram quantities, plutonium is not a usually considered a gamma emitter. However, if Pu-241 is present, it will, over a period of years, decay via beta emissions to Americium 241 (Am-241). Am-241 is considered an alpha as well as a gamma emitter (approximately 60 KeV gamma). Consult a radiation protection specialist or health physicist for more information.

EYE PROTECTION: Employee must wear appropriate eye protection that will not allow the introduction of foreign material into the eyes. The use of contact lenses, even when worn under appropriate eye protection equipment, is prohibited by some laboratories. Their use should be evaluated on a case-by-case basis by an experienced Industrial Hygienist.

CLOTHING: Disposable overgarments, including foot covering (and head covering as necessary), should be worn by any employee engaged in handling plutonium-containing materials. These garments are recommended even if the employee is working with a glovebox containment system.

In the event of a large scale release or a large scale clean-up, full protective clothing and self-contained breathing apparatus should be used.

GLOVES: Employee must wear appropriate protective gloves to prevent contact with this substance. Generally, gloves are worn even when working in a glove box containment system. Used gloves should be disposed of as radioactive waste.

RESPIRATOR: Respirators should provide protection for the respiratory tract against inhalation of most of the radioactive particles encountered in the work place. Respirators offer no protection against external beta and gamma radiation, but will block alpha particles. (For additional information see: 10CFR20.103 Appendix A). Respiratory equipment must be certified by jointly certified by NIOSH/MSHA. The following respiratory protection is recommended. Lower levels of protection may be appropriate depending on containment systems. Consult a qualified health physicist for more information.

General conditions: Type 'C' supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure mode or with a full facepiece, helmet or hood operated in continuous-flow mode.

Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode.

For firefighting and other immediately dangerous to life or health conditions: Self-contained breathing apparatus with full facepiece operated in pressure-demand or other positive pressure mode.

Supplied-air respirator with full facepiece and operated in 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

DESCRIPTION:

Molecular weight: Approximately 407 (varies with isotopic abundance)
Molecular formula: $PuSO_4 \cdot 4H_20$
Boiling point: Unknown
Melting point: Unknown
Specific Gravity: Unknown
Water Solubility: Somewhat soluble
Solvent Solubility: Soluble in acids and NaOH solutions.

Specific Activity - The specific activities of the various plutonium isotopes (and ^{241}Am) are as follows:

$^{238}Pu = 6.3 \times 10^{5}$ MBq/g (17 Ci/g)

$^{239}Pu = 2.3 \times 10^{3}$ MBq/g (6.2×10^{-2} Ci/g)

$^{240}Pu = 8.5 \times 10^{3}$ MBq/g (2.3×10^{-1} Ci/g)

$^{241}Pu = 4.1 \times 10^{6}$ MBq/g (1.1×10^{2} Ci/g)

$^{242}Pu = 1.4 \times 10^{2}$ MBq/g (3.9×10^{-3} Ci/g)

$^{241}Am = 1.2 \times 10^{5}$ MBq/g (3.2 Ci/g)

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

$^{238}Pu = 87.74$ y; $^{239}Pu = 2.41 \times 10^{4}$ y; $^{240}Pu = 6.56 \times 10^{3}$ y; $^{241}Pu = 14.29$ y; $^{242}Pu = 3.73 \times 10^{5}$ y.

Critical Mass: >1.0 kg for $PuSO_4 \cdot 4H_2O$

SECTION 10: STABILITY AND REACTIVITY

REACTIVITY:

CONDITIONS TO AVOID - Radiation hazard, do not allow material to spread or contaminate water sources.

Care must be taken in the handling of large quantities of plutonium compounds to avoid unintentional formation of a critical mass (see SECTION 9, above). Plutonium in liquid solutions is more apt to become critical than plutonium contained in solid forms.

INCOMPATIBILITIES:
No incompatibilities could be found, however it is anticipated that violent reactions may occur with rare earth metals.

HAZARDOUS DECOMPOSITION:
When heated to decomposition it emits toxic fumes of SO_x.

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

SECTION 11: TOXICOLOGY INFORMATION

PLUTONIUM SULFATE TETRAHYDRATE:

CARCINOGEN STATUS – None chemically. However, exposure to ionizing radiation may cause cancer and plutonium may be carcinogenic when internally deposited.

ACUTE TOXICITY LEVEL - No data available.

TARGET EFFECTS - Plutonium in the body most often accumulates in the lungs, lymph nodes, liver and skeleton. Lesser, yet significant quantities may also be found in the gonads, spleen, and thyroid. The biological half-lives of plutonium have been reported to be 40 years in the liver and

100 years in the bone. Radioactive materials present the greatest hazard to those parts of the body in which it is most concentrated.

AT INCREASED RISK FOR EXPOSURE - Persons with chronic obstructive lung disease cannot clear inhaled materials resulting in above average doses to the tissues of the lung and bronchi. Persons with iron deficiency anemia may take up plutonium more readily than the general population as biologically plutonium acts in a similar fashion to iron.

ADDITIONAL DATA - Plutonium Sulfate Tetrahydrate is an emitter of alpha particles and some very soft gamma rays. Internal exposure to radioactive plutonium may result in significant whole-body irradiation.

HEALTH EFFECTS:
INHALATION
PLUTONIUM SULFATE TETRAHYDRATE:

ACUTE EXPOSURE - When inhaled, plutonium is retained in the lung with an effective half-life that varies from hundreds of days for plutonium oxides to tens of days for more soluble forms. Plutonium solubilized within the lungs is translocated to the liver and skeleton where it is retained.

Following an inhalation of an aerosol containing plutonium, the pattern of its deposition and clearance from the respiratory tract and the fraction eliminated from the body, as well as the fraction deposited in the target organ, depends on a variety of factors. These factors include the size, shape and density of the particles inhaled, as well as the chemical form. 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. Heavier inhaled particles will be brought up to the throat by ciliary action, and may then be swallowed. Lighter inhaled particles may become lodged in the alveolar air sacs and remain there for some time. Alpha radiation will kill cells immediately adjacent to the source of contact. Animals exposed to single high doses of plutonium sulfate tetrahydrate died from radiation pneumonitis characterized by edema, fibrosis and respiratory damage. Death occurred in 1-3 years. The livers of exposed animals were congested, pigmented and granular.

CHRONIC EXPOSURE - No clinical illness has been attributed to long-term internally deposited plutonium as a result of occupational exposure, and a mortality study of 224 plutonium workers has shown no excess deaths from any cause. One study with a small number of subjects showed a statistically significant increase in multiple myelomas. Long term exposure of dogs to plutonium oxide resulted in radiation pneumonititis, pulmonary fibrosis, and death due to primary neoplasia. 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:

ACUTE EXPOSURE - Alpha radiation is not usually an external hazard and penetration of plutonium sulfate tetrahydrate through healthy skin has never been reported. Contamination may occur through broken skin. The lens of the eye may also be affected if eye contact occurs, and local

damage may occur at the site of a wound. In extreme cases, absorption or penetration through damaged skin may result in radiation sickness.

CHRONIC EXPOSURE - No specific data is available. However, exposure to radiation may result in delayed effects. The delayed effects of radiation may be due either to a single large overexposure or continuing low-level overexposure. Delayed effects of exposure may include cancer, genetic effects, life span shortening and cataracts.

Cancer is observed most frequently in the hematopoietic (blood forming) system, as well as the thyroid, bone and skin. Leukemia is among the most likely forms of malignancy. Lung cancer may also occur due to insoluble radioactive materials residing in the lungs (see inhalation section above). Genetic effects may range from point mutations to severe chromosome damage such as strand breakage, translocations, and deletions (occurring in cases of extremely large doses). Theoretically, if the germ cells have been affected, the effects of the mutation may not become apparent until following generations. In humans there has never been a confirmed genetic effect caused by radiation exposure.

EYE CONTACT:
PLUTONIUM SULFATE TETRAHYDRATE:

ACUTE EXPOSURE - No specific data available. 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. Because alpha particles do not travel far in air, long term exposure of the eye to alpha radiation will only occur under conditions of extremely poor work practice.

CHRONIC EXPOSURE - No specific data available. Repeated or prolonged exposure to alpha radiation may result in cataract formation. See acute exposure.

INGESTION:
PLUTONIUM SULFATE TETRAHYDRATE:

ACUTE EXPOSURE - Intestinal absorption is virtually zero; 0.003% for soluble compounds such as plutonium sulfate.

CHRONIC EXPOSURE - No specific data available.

SECTION 12: ECOLOGICAL INFORMATION

Environmental Impact Rating (0-4): No data available

Acute Aquatic Toxicity: No data available

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. Disposal must be in accordance with 10 CFR 20 and 60.

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:
N/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:	N
CHRONIC HAZARD:	N
FIRE HAZARD:	N
REACTIVITY HAZARD:	N
SUDDEN RELEASE HAZARD:	N

SECTION 16: OTHER INFORMATION

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