SAFETY DATA SHEET

1 PRODUCT AND SUPPLIER IDENTIFICATION
Product Name: Hafnium Powder
Formula: Hf
Supplier: ESPI Metals
1050 Benson Way
Ashland, OR 97520
Telephone: 800-638-2581
Fax: 541-488-8313
Email: sales@espimetals.com
Emergency: Infotrac 800-535-5053 (US) or 352-323-3500 (24 hour)
Recommended Uses: Scientific Research

2 HAZARDS IDENTIFICATION
GHS Label Elements:

Signal Word: Danger
Hazard Statements: H228 Flammable solid.
Precautionary Statements: P210 Keep away from heat/sparks/open flames - No smoking, P280 Wear protective gloves/protective clothing/eye protection/face protection, P370+P378 In case of fire: Use Class D dry chemical extinguishing agent for extinction.

3 COMPOSITION/INFORMATION ON INGREDIENTS
Ingredient: CAS#: %: EC#
Hafnium: 7440-58-6 97-99.8 231-166-4
Zirconium: 7440-67-7 0.02-3 231-176-9

4 FIRST AID MEASURES
General Measures: Remove patient from area of exposure.
INHALATION: Remove to fresh air, keep warm and quiet, give oxygen if breathing is difficult. Seek medical attention.
INGESTION: Rinse mouth with water. Do not induce vomiting. Seek medical attention. Never induce vomiting or give anything by mouth to an unconscious person.
SKIN: Remove contaminated clothing, brush material off skin, wash affected area with soap and water. Seek medical attention if irritation develops or persists.
EYES: Flush eyes with lukewarm water, including under upper and lower eyelids, for at least 15 minutes. Seek medical attention if irritation develops or persists.
Most Important Symptoms/Effects, Acute and Delayed: May cause irritation. See section 11 for more information.
Indication of Immediate Medical Attention and Special Treatment: No other relevant information available.

5 FIREFIGHTING MEASURES
Extinguishing Media: Use Class D dry powder extinguishing agent or dry table salt.
Unsuitable Extinguishing Media: Do not use water, carbon dioxide or halocarbon extinguishing agents.
Specific Hazards Arising from the Material: Fine dust dispersed in air in sufficient concentrations, and in the presence of an ignition source, is a potential dust explosion hazard. May release hafnium oxide fume if involved in a fire.
Special Protective Equipment and Precautions for Firefighters: Wear full face, self-contained breathing apparatus and full protective clothing.
Additional Information: Control small fires by smothering with dry table salt or using a type D extinguisher. Separate burning material from larger mass, and allow it to burn out. Do not spray water on burning hafnium. Carbon dioxide is not effective in extinguishing burning hafnium either. If a fire starts in a mass of wet metal fines, an explosion may follow due to rapidly expanding gases. The explosive characteristic of such material is caused by the steam and hydrogen generated within the burning mass.

6 ACCIDENTAL RELEASE MEASURES
Personal Precautions, Protective Equipment, and Emergency Procedures: Wear appropriate respiratory and protective equipment specified in section 8. Isolate spill area and provide ventilation. Avoid breathing dust or fume. Avoid contact with skin and eyes. Eliminate all sources of ignition.
Methods and Materials for Containment and Cleaning Up: Avoid dust formation. Use only non-sparking tools and natural bristle brushes. Do not push powder for long distances across the floor. Keep in small piles away from each other. Place in non-sparking or anti-static containers.
Environmental Precautions: Do not allow to enter drains or to be released to the environment.
7 HANDLING AND STORAGE
Precautions for Safe Handling: Handle in an enclosed, controlled process. Use non-sparking tools. Protect from sources of ignition. Avoid creating dust. Avoid breathing dust or fumes. Provide adequate ventilation if dusts are created. Avoid contact with skin and eyes. Wash thoroughly before eating or smoking. See section 8 for information on personal protection equipment.

Conditions for Safe Storage: Store in a cool, dry area. Store material tightly sealed in properly labeled containers. Storage area should be free of combustibles and ignition sources. See section 10 for more information on incompatible materials.

8 EXPOSURE CONTROLS AND PERSONAL PROTECTION
Exposure Limits:

<table>
<thead>
<tr>
<th>Substance</th>
<th>OSHA/PEL</th>
<th>ACGIH/TLV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hafnium</td>
<td>0.5 mg/m³</td>
<td>0.5 mg/m³</td>
</tr>
<tr>
<td>Zirconium</td>
<td>5 mg/m³</td>
<td>5 mg/m³</td>
</tr>
</tbody>
</table>

Engineering Controls: When working with finely divided powders, handle in a controlled, enclosed environment. Ensure adequate ventilation to maintain exposures below occupational limits. Whenever possible the use of local exhaust ventilation or other engineering controls is the preferred method of controlling exposure to airborne dust and fume to meet established occupational exposure limits. Use good housekeeping and sanitation practices. Do not use tobacco or food in work area. Wash thoroughly before eating or smoking. Do not blow dust off clothing or skin with compressed air.

Individual Protection Measures, Such as Personal Protective Equipment:
- Respiratory Protection: Use suitable respirator when high concentrations are present.
- Eye Protection: Safety glasses
- Skin Protection: Impermeable gloves, protective work clothing as necessary.

9 PHYSICAL AND CHEMICAL PROPERTIES
Appearance:
- Form: Powder
- Color: Gray
- Odor: Odorless
- Odor Threshold: Not determined

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>N/A</td>
</tr>
<tr>
<td>Melting Point</td>
<td>2227±20 °C</td>
</tr>
<tr>
<td>Boiling Point</td>
<td>4602 °C</td>
</tr>
<tr>
<td>Flash Point</td>
<td>N/A</td>
</tr>
<tr>
<td>Evaporation Rate</td>
<td>N/A</td>
</tr>
<tr>
<td>Flammability</td>
<td>Flammable solid</td>
</tr>
<tr>
<td>Upper Flammable Limit</td>
<td>No data</td>
</tr>
<tr>
<td>Lower Flammable Limit</td>
<td>No data</td>
</tr>
<tr>
<td>Vapor Pressure</td>
<td>No data</td>
</tr>
<tr>
<td>Vapor Density</td>
<td>N/A</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relative Density (Specific Gravity)</td>
<td>13.31 g/cc @ 20 °C</td>
</tr>
<tr>
<td>Solubility in H₂O</td>
<td>Insoluble</td>
</tr>
<tr>
<td>Partition Coefficient (n-octanol/water):</td>
<td>Not determined</td>
</tr>
<tr>
<td>Autoignition Temperature</td>
<td>No data</td>
</tr>
<tr>
<td>Decomposition Temperature</td>
<td>No data</td>
</tr>
<tr>
<td>Viscosity</td>
<td>N/A</td>
</tr>
</tbody>
</table>

10 STABILITY AND REACTIVITY
Reactivity: No data
Chemical Stability: Stable under recommended storage conditions.
Possibility of Hazardous Reactions: Dust dispersed in air may be explosive. Keep fine turnings completely dry, or very wet. If wet, the water content should be more than 25% by weight for maximum safety in handling. Severe explosions can result from ignition of hafnium powder or machining fines containing moisture in the concentration range of 5 to 10%.

Conditions to Avoid: All sources of ignition. Dusting conditions.
Incompatible Materials: Hydrofluoric acid, hydrofluoric-nitric acid mixture, fluorine, chlorine, bromine, iodine, halocarbons, carbon tetrachloride, carbon tetrafluoride, freons, nitryl-fluoride.
Hazardous Decomposition Products: Hafnium oxide fume.
11 TOXICOLOGICAL INFORMATION

Likely Routes of Exposure: Inhalation, skin and eyes.
Symptoms of Exposure: May cause irritation if dusts or fumes are inhaled or swallowed. Fines/dusts may irritate skin and eyes.

Acute and Chronic Effects:
Hafnium: Hafnium metal is a mild irritant of the eyes, skin, and mucous membranes. No industrial poisonings involving hafnium have been reported.
Zirconium: Zirconium is generally considered to be physiologically inert.

Acute Toxicity: No data

Carcinogenicity: NTP: Not identified as carcinogenic IARC: Not identified as carcinogenic

To the best of our knowledge the chemical, physical and toxicological characteristics of the substance are not fully known.

12 ECOLOGICAL INFORMATION

Ecotoxicity: No data

Persistence and Degradability: No data
Bioaccumulative Potential: No data

Mobility in Soil: No data
Other Adverse Effects: Do not allow material to be released to the environment. No further relevant information available.

13 DISPOSAL CONSIDERATIONS

Waste Disposal Method:
Product: Reuse or recycle material whenever possible. Dispose of in accordance with Federal, State and Local regulations.
Packaging: Dispose of in accordance with Federal, State and Local regulations.

14 TRANSPORT INFORMATION

UN Number: UN2545
UN Proper Shipping Name: Hafnium powder, dry
Transport Hazard Class: 4.2
Packing Group: II
Marine Pollutant: No

15 REGULATORY INFORMATION

TSCA Listed: All components are listed.
WHMIS 2015 Classification: Flammable solids.

HMIS Ratings: Health: 1 Flammability: 3 Physical: 1
NFPA Ratings: Health: 1 Flammability: 3 Instability: 1

Chemical Safety Assessment: A chemical safety assessment has not been carried out.

16 OTHER INFORMATION

The information contained in this document is based on the state of our knowledge at the time of publication and is believed to be correct, but does not purport to be all inclusive and shall be used only as a guide. ESPI Metals makes no representation, warranty, or guarantee of any kind with respect to the information contained in this document or any use of the product based on this information. ESPI Metals shall not be held liable for any damages resulting from handling or from contact with the above product. Users should satisfy themselves that they have all current data relevant to their particular use.

Prepared by: ESPI Metals
Revised/Reviewed: July 2015
MATERIAL SAFETY DATA SHEET

I PRODUCT IDENTIFICATION

Trade Name: Copper Telluride
Chemical Family: Metal telluride
Molecular Weight: 186.53

Synonyms: Copper monotelluride
Formula: CuTe
CAS #: 12019-23-7

II HAZARDOUS INGREDIENTS

<table>
<thead>
<tr>
<th>Hazardous Components</th>
<th>OSHA/PEL</th>
<th>ACGIH/TLV</th>
<th>Other</th>
<th>Percent</th>
<th>SEC. 302 (EHS)</th>
<th>SEC. 313</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper Telluride</td>
<td>1 mg/m³</td>
<td>1 mg/m³</td>
<td>NE</td>
<td>0-100</td>
<td>Yes 1 lb.</td>
<td>Yes</td>
</tr>
<tr>
<td>Tellurium Compounds</td>
<td>0.1 mg/m³</td>
<td>0.1 mg/m³</td>
<td>NE</td>
<td>0.0-100</td>
<td>No</td>
<td>Yes 1 lb.</td>
</tr>
</tbody>
</table>

RQ SEC. 313
SEC. 304

HMIS Ratings (0-4): Health: 3, Flammability: 0, Reactivity: 0

III PHYSICAL DATA

<table>
<thead>
<tr>
<th>Physical Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boiling Point:</td>
<td>NE or NA</td>
</tr>
<tr>
<td>Physical State:</td>
<td>Solid</td>
</tr>
<tr>
<td>Specific Gravity (Water=1):</td>
<td>NE</td>
</tr>
<tr>
<td>Vapor Pressure (mm Hg):</td>
<td>NE</td>
</tr>
<tr>
<td>Appearance and Odor:</td>
<td>Greyish-black powder and pieces, no odor.</td>
</tr>
<tr>
<td>Melting Point:</td>
<td>NE or NA</td>
</tr>
<tr>
<td>Evaporation Rate:</td>
<td>NA</td>
</tr>
<tr>
<td>Vapor Density (Air=1):</td>
<td>NA</td>
</tr>
<tr>
<td>Solubility in Water:</td>
<td>NE</td>
</tr>
<tr>
<td>% Volatile:</td>
<td>NE or NA</td>
</tr>
</tbody>
</table>

IV FIRE AND EXPLOSION HAZARDS DATA

Flash Point: NE or NA
Flammable Limits: LEL: NA UEL: NA

Method Used: Non-flammable
Extinguishing Media: Not applicable. Use suitable extinguishing media for surrounding materials and type of fire.

Special Fire Fighting Procedures: Firefighters must wear full face, self-contained breathing apparatus with full protective clothing to prevent contact with skin and eyes. Fumes from fire are hazardous. Isolate runoff to prevent environmental pollution.

Unusual Fire & Explosion Hazards: When heated to decomposition, or on contact with acid or acid fumes, copper telluride may emit toxic fumes.

V HEALTH HAZARD INFORMATION

Health Hazards (Acute and Chronic):

To the best of our knowledge the chemical, physical and toxicological properties of copper telluride have not been thoroughly investigated and recorded. Copper compounds: In animals, inhalation of copper dust has caused hemolysis of the red blood cells, deposition of hemofuscin in the liver and pancreas, and injury to the lung cells. Injection of the dust has caused cirrhosis of the liver and pancreas, and a condition closely resembling hemochromatosis or bronzed diabetes (Sax, Dangerous Properties of Industrial Materials, eighth edition).

Elemental tellurium has relatively low toxicity. It is converted in the body to dimethyl telluride which imparts a garlic-like odor to breath and sweat. Heavy exposures may, in addition, result in headache, drowsiness, metallic taste, loss of appetite, nausea, tremors, convulsion, and respiratory arrest (Sax, Dangerous Properties of Industrial Materials, eighth edition).

Routes of Entry: Inhalation, Skin, Eyes, Ingestion

Acute Effects:

**Inhalation**: DANGER-POISON. May cause a metallic taste in the mouth, congestion of the nasal mucous membranes, dry mouth, irritation to the respiratory tract, nausea, vomiting, garlic odor to the breath, sweat and urine.

**Ingestion**: DANGER-POISON. May cause a dry mouth, suppression of sweat, garlic odor to breath and urine, and acute copper toxicity.

**Skin**: May cause irritation.

**Eye**: May cause irritation to the conjunctiva.

Chronic Effects:

**Inhalation**: May cause ulceration and perforation of the nasal septum, pharyngeal congestion, anorexia, nausea, depression to the central nervous system and somnolence.

**Ingestion**: May cause irritation to the gastrointestinal tract, anorexia, nausea, depression to the central nervous system, somnolence and chronic copper toxicity. May cause damage to the nervous system, kidneys and enlarge the liver.

**Skin**: May cause dermatitis.

**Eye**: No chronic health effects recorded.

**Target Organs**: May affect the respiratory system, skin, liver, central nervous system, and kidneys.

Carcinogenicity: NTP? No  IARC Monographs? No  OSHA Regulated? No

Signs and Symptoms of Exposure:

**Inhalation**: May cause a red, dry throat, metallic taste in mouth, garlic-like odor to breath, sweat and urine, loss of appetite, sleepiness, nausea, congestion of the nasal and pharyngeal, sneezing, headache, excitability, dizziness and
difficulty breathing.

**Ingestion**: May cause a dry mouth, garlic-like odor to breath and urine, loss of appetite, sleepiness, and nausea. Acute copper toxicity may cause: fever, tachycardia, hypotension, hemolytic anemia with intravascular hemolysis, oliguria, uremia, coma and cardiovascular collapse. Chronic copper toxicity may cause: nausea, vomiting, epigastric pain, yellow watery diarrhea, dizziness, general debility, jaundice, and green stools, saliva, and vomitus.

**Skin**: May cause redness, itching, and swelling.

**Eye**: May cause redness, itching, and swelling.

**Medical Conditions Generally Aggravated by Exposure**: Pre-existing respiratory, gastric disorders, and an increased risk for individuals with Wilson's disease.

**EMERGENCY AND FIRST AID PROCEDURES**:

**INHALATION**: Remove victim to fresh air; keep warm and quiet; give oxygen if breathing is difficult and seek medical attention immediately.

**INGESTION**: Give 1-2 glasses of milk or water and induce vomiting; seek medical attention immediately. Never induce vomiting or give anything by mouth to an unconscious person.

**SKIN**: Remove contaminated clothing; brush material off skin; wash affected area with mild soap and water; seek medical attention if symptoms persist.

**EYE**: Flush eyes with lukewarm water, lifting upper and lower eyelids, for at least 15 minutes. Seek medical attention if symptoms persist.

**VI REACTIVITY DATA**

**Stability**: Stable

**Conditions to Avoid (Instability)**: None

**Incompatibility - Materials to Avoid**: Acids and acid fumes

**Hazardous Decomposition or Byproducts**: None recorded

**Hazardous Polymerization**: Will not occur

**VII SPILL OR LEAK PROCEDURES**

**Steps to Be Taken in Case Material Is Released or Spilled**: Wear appropriate respiratory and protective equipment specified in Section VIII - Special Protection Information. Isolate spill area and provide ventilation. Vacuum up spill using a high efficiency particulate absolute (HEPA) air filter and place in a closed container for proper disposal. Take care not to raise dust.

**Waste Disposal Method**: Dispose of in accordance with Local, State and Federal regulations.

**VIII SPECIAL PROTECTION INFORMATION**

**Respiratory Protection (Specify Type)**: NIOSH approved dust, mist, vapor cartridge respirator.

**Ventilation**: **Local**: To maintain concentration at or below PEL, TLV

**Mechanical (General)**: Recommended

**Protective Gloves**: Rubber

**Eye Protection**: Safety glasses

**Other Protective Clothing or Equipment**: Protective gear suitable to prevent contamination.
IX  SPECIAL PRECAUTIONS

Precautions to Be Taken in Handling and Storage: Store in a cool, dry place in a tightly sealed container. Wash thoroughly after handling.

Work/Hygienic/Maintenance Practices: Implement engineering and work practice controls to reduce and maintain concentration of exposure at low levels. Use good housekeeping and sanitation practices. Do not use tobacco or food in work area. Wash thoroughly before eating and smoking. Do not blow dust off clothing or skin with compressed air.

Prepared by:  S Dierks
Dated:  June 1998