

MATERIAL SAFETY DATA SHEET

I. PRODUCT IDENTIFICATION

Manufacturer/Supplier:

ESPI Metals

1050 Benson Way, Ashland, OR 97520

Toll Free (800) 638-2581 * Fax (541) 488-8313

E-Mail: sales@espimetals.com

Trade Name: Barium**Formula:** Ba**CAS #:** 7440-39-3

II. HAZARDOUS INGREDIENTS

Hazardous Component: Barium**%:** 0-100**OSHA/PEL:** 0.5 mg/m³**ACGIH/TLV:** 0.5 mg/m³**HMIS Ratings:** Health: 2 Flammability: 3 Reactivity: 2

III. PHYSICAL DATA

Boiling Point: 1640 °C**Melting Point:** 725 °C**Vapor Density:** N/A**Solubility in H₂O:** Reacts violently**Vapor Pressure:** 13.3 hPa @ 1049 °C**Specific Gravity:** 3.51 @ 20 °C**Appearance and Odor:** Silver white metal, no odor.**% Volatiles:** N/A

NOTE: The physical data presented above are typical values and should not be construed as a specification.

IV. FIRE AND EXPLOSION HAZARDS DATA

Flash Point (Method used): N/A**Autoignition Temperature:** N/E**Explosive Limits:** Lower: N/E Upper: N/E**Extinguishing Media:** FLAMMABLE SOLID!! Use dry chemical/dolomite (powdered limestone). DO NOT USE WATER, CARBON DIOXIDE, OR HALOGENATED EXTINGUISHERS!**Special Firefighting Procedures:** Wear full face, self-contained breathing apparatus and full protective clothing to prevent contact with skin and eyes. Flammable solid.**Unusual Fire and Explosion Hazards:** Material readily reacts with water generating flammable and/or explosive hydrogen gas. Do not expose to air and fire. Emits toxic fumes under fire conditions. Isolate with dolomite and allow to burn. Large Fires: Contain and smother with dolomite.**Caution!** Fire may reignite after having been extinguished. Blend with large excess of dolomite.

V. HEALTH HAZARD INFORMATION

Effects of Exposure:

To the best of our knowledge the chemical, physical, and toxicological properties of barium have not been thoroughly investigated and recorded.

Barium poisoning is virtually unknown in industry, although the potential exists when the soluble forms are used. When ingested or given orally, the soluble ionized barium compounds exert a profound effect on all muscles and especially smooth muscles, markedly increasing their contractility. The heart rate is slowed and may stop in systole. Other effects are increased intestinal peristalsis, vascular constriction, bladder contraction, and increased voluntary muscle tension.

Acute Effects:

Inhalation: Can cause irritation to the nose, throat, and upper respiratory tract.

Ingestion: Causes severe irritation of the mouth, throat, and esophagus.

Skin: Contact with skin can cause mild to moderate irritation. Contact with skin can lead to the development of a hypersensitivity (ie. allergic) in susceptible individuals.

Eye: Can cause mild to moderate irritation to the ocular tissues.

Chronic Effects: Severe irritation or burns.

Primary Routes of Exposure: Eye, skin, and inhalation.

Target Organs: Depending on the route, frequency, and duration of exposure, toxicity may occur in the following organs and/or systems: Respiratory System, Eye, Skin, Immune System (Allergic Reactions), Central Nervous System, and Heart.

Medical Conditions Generally Aggravated by Exposure: Respiratory system, skin, immune system and/or specific chemical allergies, central nervous system, and the heart.

Carcinogenicity: NTP: No IARC: No OSHA: No

EMERGENCY AND FIRST AID PROCEDURES:

INHALATION: Remove to fresh air. If symptoms develop, seek immediate medical attention. If not breathing, give artificial respiration.

INGESTION: Seek immediate medical attention.

SKIN: Immediately remove and isolate contaminated clothing. Carefully brush material off skin and wash area with soap and water. Seek medical attention if irritation develops.

EYE: Contamination of the eyes should be treated by immediate and prolonged irrigation with copious amounts of water. Lift upper and lower eye lids frequently. Get prompt medical attention.

NOTE TO PHYSICIAN: Treatment should be directed at preventing absorption, administering to the symptoms as they occur, and providing supportive therapy.

VI. REACTIVITY DATA

Stability: Stable

Conditions to Avoid: Water/moisture. Avoid friction, heat, sparks, and flame.

Incompatibility (Materials to Avoid): Water or moisture, oxidizing agents, oxygen, acids, halocarbons, carbon dioxide, ammonia.

Hazardous Decomposition Products: Toxic fumes of hydrogen and barium oxide.

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. Isolate spill area and provide ventilation. Keep unprotected persons away. Shovel spilled product and place in a closed container for further handling and disposal. Do not flush to sewer, stream, or other bodies of water. Keep away from ignition sources.

Waste Disposal Method: Material in the elemental state should be recovered for reuse or recycling. Observe all federal, state & local regulations.

VIII. SPECIAL PROTECTION INFORMATION

Respiratory Protection: Avoid breathing dust. Wear a NIOSH/MSHA approved dust respirator.

Ventilation: Provide adequate ventilation. Handle only in protective argon or helium atmosphere or under oil.

Protective Gloves: Leather-palmed, heat resistant gloves.

Eye Protection: Chemical splash goggles and a full face shield. An eye wash facility should be readily available.

Other Protective Clothing or Equipment: The use of fire resistant outer clothing is advisable.

IX. SPECIAL PRECAUTIONS

Precautions to Be Taken in Handling and Storage: Barium metal should be stored in tightly-closed containers under argon or helium atmosphere or a paraffin oil blanket. When handling, wear non-sparking shoes and flame resistant clothing. Avoid friction, heat, sparks, and flame. Use only non-sparking tools and utensils. Ground all equipment, vessels, tables, and other metallic objects that may come into contact with the product. Do not store together with acids, halogens and oxidizing agents. Store away from water/moisture.

Other Precautions: Can autoignite in air. Extremely sensitive to shock, heat, friction and static electricity. Rubber gloves, rubber protective clothing and apron, goggles and gas filter mask should be worn when working in a barium storage area.

Empty Container Precautions: This container is hazardous when empty. Do not use heat, sparks, open flame, torches, or cigarettes on or near empty container. Empty containers can retain product residues. Do not reuse empty container for food, clothing, or other products for human or animal consumption or where skin contact may occur.

Work Practices: Implement engineering and work practice controls to reduce and maintain concentration of exposure at low levels. Do not use tobacco or food in work area. Wash thoroughly after handling, especially before eating, drinking, smoking, or using restroom facilities. Contaminated clothing and shoes should be thoroughly cleaned before reuse. Do not blow dust off clothing or skin with compressed air. Maintain eyewash capable of sustained flushing, safety drench shower and facilities for washing.

DOT Regulations:

Hazard Class: 4.3

Identification Number: UN1400

Packing Group: II

Proper Shipping Name: Barium

Label: Dangerous when wet

The above information is believed to be correct, but does not purport to be all inclusive and shall be used only as a guide. ESPI shall not be held liable for any damage resulting from handling or from contact with the above product.

Issued by: S. Dierks

Dated: March 2006

**ELECTRONIC SPACE PRODUCTS INTERNATIONAL**

1050 Benson Way, Ashland, OR 97520
Toll Free (800) 638-2581 * Fax (541) 488-8313
E-Mail: sales@espimetals.com

MATERIAL SAFETY DATA SHEET**I PRODUCT IDENTIFICATION**

Trade Name: Barium Titanate
Formula: BaTiO₃
CAS #: 12047-27-7

Chemical Family: Metal Titanate
Molecular Weight: 233.21

II HAZARDOUS INGREDIENTS

Hazardous Component	%	OSHA PEL	ACGIH/TLV
Barium Titanate	0-100	0.5 mg/m ³ (as Ba)	0.5 mg/m ³ (as Ba)

HMIS Rating: Health: 2 **Flammability:** 0 **Reactivity:** 0 **Personal Protection:** E

III PHYSICAL DATA

Boiling Point (°C):	No Data	Melting Point:	1654 °C
Specific Gravity:	5.85 g/cc	Vapor Pressure:	N/A
Vapor Density:	N/A	% Volatile:	N/A
Appearance and Odor:	White to gray powder or pieces, no odor.	Solubility in H₂O:	Insoluble

IV FIRE AND EXPLOSION HAZARDS DATA

Flash Point: N/A
Flammable Limits: Upper: N/E Lower: N/E

Autoignition Temperature: N/E

Extinguishing Media: Use suitable extinguishing media for surrounding material 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.

Unusual Fire and Explosion Hazards: May emit toxic fumes of barium oxide when heated to decomposition.

V HEALTH HAZARD INFORMATION

Effects of Exposure:

To the best of our knowledge, the chemical, physical and toxicological properties of barium titanate have not been thoroughly investigated and recorded.

Barium compounds may cause severe gastroenteritis, including abdominal pain, vomiting and diarrhea, tremors, faintness, paralysis of the arms and legs, and slow or irregular heartbeat. Severe cases may produce collapse and death due to respiratory failure. Soluble barium compounds are more likely to cause these effects than insoluble compounds. Inhalation of fumes may cause sore throat, coughing, labored breathing, and irritation of the respiratory tract as well as the above symptoms.

Titanium compounds are considered physiologically inert. There are no reported cases where titanium compounds have caused intoxication.

Acute Effects:

Inhalation: May cause irritation to the upper respiratory system, dizziness, nausea, vomiting, colic, diarrhea, rapid respiration, high blood pressure, irregular heart action, convulsions, paralysis and acute barium poisoning.

Ingestion: May cause irritation to the gastrointestinal tract, vomiting, colic, diarrhea, slow irregular pulse, transient hypertension, convulsions, tremors, muscular paralysis and acute barium poisoning.

Skin: May cause irritation.

Eye: May cause irritation.

Chronic Effects:

Inhalation: May cause pulmonary granulomas and chronic barium poisoning.

Ingestion: May cause chronic barium poisoning.

Skin: May cause skin granulomas and dermatitis.

Eye: May cause corneal opacity and blindness.

Medical Conditions Generally Aggravated By Exposure: Inhalation may aggravate pre-existing disorders.

Carcinogenicity: None **NTP?** No **IARC Monographs?** No **OSHA Regulated?** No

EMERGENCY AND FIRST AID PROCEDURES:

INHALATION: Remove to fresh air, keep warm and quiet, give oxygen if breathing is difficult. Seek immediate medical advice.

INGESTION: If conscious, give 1 to 2 glasses of water and induce vomiting. Seek immediate medical attention. Never induce vomiting or give anything by mouth to an unconscious person.

SKIN: Remove any contaminated clothing, brush off of skin, flush with running water, wash carefully with soap and water. Consult a doctor.

EYES: Flush eyes with plenty of lukewarm water, including under upper and lower eyelid for at least 15 minutes. Consult a doctor.

VI REACTIVITY DATA

Stability: Stable

Conditions to Avoid: None known

Incompatibility (Material to Avoid): Acids, oxidizing agents.

Hazardous Decomposition Products: Barium and barium oxide fumes.

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. Vacuum up spill using a high efficiency particle 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 respirator is required if TLV and PEL exposure limits are exceeded.

Ventilation: Use local exhaust to maintain concentrations at or below PEL, TLV. General exhaust is recommended.

Protective Gloves: Protective gloves required.

Eye Protection: Safety glasses required.

Other Protective Equipment: Protective gear suitable to prevent contamination.

IX SPECIAL PRECAUTIONS

Other Handling and Storage Conditions: Keep container closed. Store in a cool, dry place. Wash thoroughly after handling. Store away from acids and oxidizing agents.

Work 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. Maintain eye wash capable of sustained flushing, safety drench shower and facilities for washing.

DOT Regulations:

Hazard Class: 6.1

Identification Number: UN1564

Packing Group: III
Proper Shipping Name: Barium compounds, n.o.s., toxic

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Prepared by: S. Dierks
Dated: August 2005

MATERIAL SAFETY DATA SHEET

I. PRODUCT IDENTIFICATION

Manufacturer/Supplier:

ESPI Metals

1050 Benson Way, Ashland, OR 97520

Toll Free (800) 638-2581 * Fax (541) 488-8313

E-Mail: sales@espimetals.com

Trade Name: Bismuth
Formula: Bi
CAS: 7440-69-9
Chemical Family: Metal

II. HAZARDOUS INGREDIENTS

Hazardous Components: Bismuth
Percentage: 100
OSHA/PEL: N/E
ACGIH/TLV: N/E

HMIS Ratings: Health: 3 **Flammability:** 3 **Reactivity:** 0 **Protective Equip:** H: glasses, gloves, clothing, combo resp.

III. PHYSICAL DATA

Boiling Point: 1420 °C
Melting Point: 271.3 °C
Specific Gravity 9.80 g/cc
Vapor Density: N/A
Solubility in H₂O: Insoluble
Vapor Pressure: 1 mm at 1020 °C
% Volatile: N/E or N/A
Evaporation Rate: N/A
Appearance and Odor: Gray to black powder, bright metallic solid, no odor.

IV. FIRE AND EXPLOSION HAZARDS DATA

Flash Point: N/E or N/A**Autoignition Temperature:** N/E**Explosive Limits:** Lower: N/E **Upper:** N/E

Extinguishing Media: POWDER: Use class D extinguisher or special powder for metal fires. SOLID: Use suitable extinguishing media for surrounding material and type of fire.

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

Unusual Fire and Explosion Hazards: Flammable when exposed to flame. May react with acid or acid fumes to emit toxic

fumes. May react with $[\text{Bi}(\text{OH})_3 + \text{Al}(\text{OH})_3]$ coprecipitated, and hydrogen to produce a spontaneously flammable product. Superficially oxidized by air.

V. HEALTH HAZARD INFORMATION

Effects of Exposure:

Bismuth and its salts can cause kidney damage, although the degree of such damage is usually mild. Large doses can be fatal. Industrially it is considered one of the less toxic of the heavy metals. Serious and sometimes fatal poisoning may occur from the injection of large doses into closed cavities and from extensive application to burns. It is stated that the administration of bismuth should be stopped when gingivitis appears, for otherwise serious ulceration stomatitis is likely to result. Other toxic results may develop, such as a vague feeling of bodily discomfort, presence of albumin or other protein substance in the urine, diarrhea, skin reactions and sometimes serious exodermatitis. (Sax, Dangerous Properties of Industrial Materials, eighth edition)

Acute Effects:

Inhalation: POISON. May be a nuisance dust causing respiratory irritation. May cause foul breath, metallic taste and gingivitis.

Ingestion: POISON. May cause malaise, albuminuria, diarrhea, skin reactions, stomatitis, headache, fever, rheumatic pain and a black line may form on gums in the mouth.

Skin: May cause irritation

Eye: May cause irritation

Chronic Effects:

Inhalation: May affect the function of the liver and the kidneys.

Ingestion: May affect the function of the liver and kidneys. May cause anemia, black line may form on gums and ulcerative stomatitis.

Skin: May cause dermatitis.

Eye: No chronic health effects recorded.

Target Organs: May affect the kidneys and liver.

Medical Conditions Generally Aggravated by Exposure: Pre-existing skin and respiratory disorders.

Routes of Entry: Inhalation, Skin, and Ingestion

Carcinogenicity: None **NTP?:** No **IARC Monographs?:** No **OSHA Regulated?:** No

EMERGENCY AND FIRST AID PROCEDURES:

INHALATION: Remove to fresh air. If breathing is difficult, give oxygen. Seek medical attention.

INGESTION: Administer 1-2 glasses of milk or water and induce vomiting. Seek medical attention. Never give anything by mouth or induce vomiting in an unconscious person.

SKIN: Brush material off skin and wash area with soap and water. Seek medical attention if symptoms persist.

EYE: Flush eyes with lukewarm water for at least 15 minute. Seek medical attention if symptoms persist.

VI. REACTIVITY DATA

Stability: Stable

Conditions to avoid: Heat, flame, incompatible materials.

Incompatibilities: Aluminum, BrF_3 , acids, NOF , NH_4NO_3 , HClO_3 , Cl_2 , IF_5 , HNO_3 , HClO_4 , oxidants.

Hazardous Decomposition Products: Bismuth, oxides of bismuth and hydrogen.

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. Isolate spill, insure proper ventilation and extinguish sources of ignition. Vacuum up spill using a high efficiency particulate absolute (HEPA) air filter and place in a container for proper disposal. Take care not to raise dust. Use non-sparking tools.

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

VIII. SPECIAL PROTECTION INFORMATION

Respiratory Protection (Specify Type): Wear a NIOSH-approved dust-mist-fume cartridge respirator.

Ventilation: Use local exhaust to maintain concentration at low exposure levels. Handle powders in a controlled, enclosed environment. General exhaust is not recommended.

Protective Gloves: Rubber gloves

Eye Protection: Safety Glasses

Other Protective Equipment: Protective gear suitable to prevent contamination.

IX. SPECIAL PRECAUTIONS

Precautions to Be Taken in Handling and Storage: Store in tightly closed containers in a cool, dry place. Store away from incompatible materials. Wash hands and face thoroughly after handling and before meals.

Work 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 or smoking. Do not blow dust off clothing or skin with compressed air.

TSCA: Listed in the EPA TSCA Inventory

DOT Regulations:

Shot, Ingot, Pieces, Rod, Sheet:

Hazard Class: None

Powder:

Hazard Class: 4.1

Identification Number: UN3089

Packing Group: II

Proper Shipping Name: Metal powder, flammable, n.o.s. (bismuth)

The above information is believed to be correct, but does not purport to be all inclusive and shall be used only as a guide. ESPI shall not be held liable for any damage resulting from handling or from contact with the above product.

Issued by: S. Dierks
Date: April 2006



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MATERIAL SAFETY DATA SHEET

I PRODUCT IDENTIFICATION

Trade Name: Bismuth Titanate
CAS #: 112010-77-4

Chemical Family: Metal Oxide
Formula: $\text{Bi}_4\text{Ti}_3\text{O}_{12}$

II HAZARDOUS INGREDIENTS

Hazardous Components	%	OSHA/PEL	ACGIH/TLV	Sec 302	Sec 304	Sec 313
Bismuth Titanate	0-100	N/E	N/E	No	No	No

HMIS Ratings: Health: 3 Flammability: 0 Reactivity: 1 **Protective Equip:** H: goggles, gloves, apron, vapor respirator

III PHYSICAL DATA

Boiling Point:	870 °C	Melting Point:	870 °C
Specific Gravity (H₂O=1):	N/E	Vapor Pressure:	N/E
Vapor Density:	N/A	Evaporation Rate:	N/A
Solubility in H₂O:	Insoluble	% Volatile:	N/A
Appearance and Odor:	Light yellow powder and pieces, no odor.		

IV FIRE AND EXPLOSION HAZARD DATA

Flash Point: N/A

Method Used: Non-flammable

Explosive Limits: Lower: N/A Upper: N/A

Extinguishing Media: Use suitable extinguishing media for surrounding materials and type of fire.

Special Firefighting 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 and Explosion Hazards: None recorded

V HEALTH HAZARD INFORMATION

Effects of Exposure:

To the best of our knowledge the chemical, physical and toxicological properties of bismuth titanate have not been thoroughly investigated and recorded.

Bismuth and bismuth salts can cause kidney damage, althou the degree of such damage is usually mild. Large doses can be fatal. Industrially it is considered one of the less toxic of the heavy metals. Serious and sometimes fatal poisoning may occur from the injection of large doses into closed cavities and from extensive application to burns. It is stated that the administration of bismuth should be stopped when gingivitis appears, for otherwise serious ulceration stomatitis is likely to result. Other toxic results may develop, such as a vague feeling of bodily discomfort, presence of albumin or other protein substance in the urine, diarrhea, skin reactions and sometimes serious exodermatitis.

Titanium compounds are considered physiologically inert. There are no reported cases where titanium compounds have caused intoxication. The dusts of titanium or most titanium oxide may be placed in the nuisance category. (Sax, Dangerous Properties of Industrial Materials.)

Acute Effects:

Inhalation: POISON. May be a nuisance dust causing respiratory irritation. May cause foul breath, metallic taste and gingivitis.

Ingestion: POISON. May cause malaise, albuminuria, diarrhea, skin reactions, stomatitis, diarrhea, headache, fever, rheumatic pain and a black line may form on gums in the mouth.

Skin: May cause irritation.

Eye: May cause irritation.

Chronic Effects:

Inhalation: May affect the function of the liver and kidneys.

Ingestion: May affect the function of the liver and kidneys. May cause anemia, black line may form on gums and ulcerative stomatitis.

Skin: May cause dermatitis.

Eye: No chronic health effects recorded.

Target Organs: May affect the liver and kidneys.

Medical Conditions Generally Aggravated by Exposure: Pre-existing skin and respiratory disorders.

Carcinogenicity: NTP: No IARC: No OSHA: No

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.

INGESTION: If conscious, give 1-2 glasses of milk or water and induce vomiting; keep warm and quiet. Seek medical attention. Never give anything by mouth or induce vomiting in 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: None

Incompatibility (Materials to Avoid): None recorded

Hazardous Decomposition Products: 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. 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 all Federal, State and Local regulations.

VIII SPECIAL PROTECTION INFORMATION

Respiratory Protection: NIOSH approved dust-mist-fume respirator.

Ventilation: Use local exhaust to maintain concentration at or below the PEL, TLV. General exhaust is recommended.

Protective Gloves: Rubber gloves

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 tightly sealed container. Store in a cool, dry area. Wash thoroughly after handling. Ensure good ventilation at the workplace. Open and handle container with care.

Work 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 or smoking. Do not blow dust off clothing or skin with compressed air.

The above information is believed to be correct, but does not purport to be all inclusive and shall be used only as a guide. ESPI shall not be held liable for any damage resulting from handling or from contact with the above product.

Issued by: S. Dierks
Date: July 2005

Approved By: D. Mehls 2/4/97	MORGAN ELECTRO CERAMICS	Document N°: MS-1379
Approved By: W. Hocevar 2/4/97	Type: Material Specification	
Prepared By: B. Hocevar M. Collis	Title: MSDS for PZT Powder	Creation Date: 2-4-97

Revision Record

Rev.	Date	Change Description	Changed By
N/C	2-4-97	Initial Release	
A	11-15-99	DCN 9096	MC
B	10-22-04	DCN 10593	TJ
C	4-26-06	DCN 10926	MP

TITLE:	MSDS for PZT Powder	TYPE	Specification	
		DOC . NUM.	MS-1379	Rev. C



MATERIAL SAFETY DATA SHEET

UCT AND COMPANY IDENTIFICATION

Manufacturer's Name

Morgan Electro Ceramics
(440) 232-8600

Emergency Telephone Number

CHEMTREC: 1-800-424-9300

Address

232 Forbes Road
Bedford, Ohio 44146

Date Prepared

February 17, 2006
(Replaces October, 2004 version)

Product Name

Piezoelectric Ceramic Powder:
Lead Zirconate Titanate (PZT)
Lead Magnesium Niobate – Lead
Titanate (PMN-PT)

Trade Names and Synonyms

MEC Grades: PZT-402, PZT-404, PZT-4M, PZT4S, PZT-5A3, PZT-501, PZT-5H2, PZT-5J1, PZT-5K, PZT-5L, PZT-502, PZT-508, PZT-701, PZT-702, PZT-801, PZT-8D, PZT-8M, PMN-PT

SECTION 2—HAZARDS IDENTIFICATION

Potential Health Effects:

- Eyes:** Can cause mechanical irritation. Particles imbedded in the eyes can cause inflammation, degeneration of tissue and discoloration.
- Skin:** Repeated and prolonged exposure can cause irritation and dermatitis, mostly through mechanical abrasion. The toxic metal constituents are present as complex mixtures of oxides and are not generally released from the products or absorbed through skin.
- Ingestion:** Ingested lead-containing dust can accumulate in the body and cause long-term damage to the nervous system, the brain and kidneys. Exposure to Lead has been linked to reproductive disorders and birth defects.
- Inhalation:** Chronic (long term) exposure to inhalable Lead-containing dusts may cause health effects similar to that for ingestion. Exposure to dust can cause respiratory irritation, especially aggravating to pre-existing conditions and long-term inhalation of dust can result in lung damage.

TITLE:	MSDS for PZT Powder	TYPE	Specification	
		DOC . NUM.	MS-1379	Rev. C

SECTION 3—COMPOSITION INFORMATION

Lead Zirconate Titanate or Lead Magnesium Niobate-Lead Titanate.

These materials are complex oxide ceramics. The ceramics contain no discrete elemental metal or metal oxide components that may become chemically or biologically available during normal handling and use. The raw materials for these products include hazardous components. Lead and its compounds make up 70% by weight of the products, nickel and its compounds up to 5% by weight, and uranium and antimony and their compounds up to 1% by weight.

No specific hazard information is available on the dust that may be generated from these products during normal handling and use. Therefore, as a precautionary measure, these products should be treated as if their hazardous components were chemically or biologically available during normal handling and use. Lead may be leached from these products in neutral, acidic and alkaline aqueous solutions.

SECTION 4—FIRST AID PROCEDURES

Eyes:	Flush with water. Seek medical attention if irritation continues.
Skin:	If irritation develops, wash exposed area with soap and water. Remove contaminated clothing and launder before re-use.
Ingestion:	No adverse effects requiring first aid are anticipated by this route of exposure in normal handling and use. However, if symptoms develop or persist, seek medical attention. In case of an acute ingestion, induce vomiting in a conscious individual and seek medical attention.
Inhalation:	In the case of acute exposure, remove individual to fresh air and seek medical attention if symptoms develop or persist.

TITLE:	MSDS for PZT Powder	TYPE	Specification	
		DOC . NUM.	MS-1379	Rev. C

SECTION 5—FIRE FIGHTING MEASURES

This product is not very combustible, but may burn if exposed to high temperatures.

Flash Point: Not applicable.

Flammable Limits: Not applicable.

Extinguishing Media: Use CO₂, sand, dry chemical or water to extinguish.

Special Fire Fighting Procedures: Use protective clothing and self-contained breathing apparatus appropriate for the surrounding fire.

Unusual Fire and Explosion Hazards: Metal Oxide fumes, vapor and/or dust may occur and are considered toxic and respiratory irritants.

SECTION 6—ACCIDENTAL RELEASE MEASURES

Clean area of spill, returning all material possible to container. Wear gloves, goggles and an appropriate NIOSH-approved respirator, if airborne concentrations exceed established exposure limits. Avoid creating, breathing and ingesting airborne dust. Use a vacuum with a high efficiency filters (HEPA). Do not broom, sweep or use compressed air for cleaning.

SECTION 7—HANDLING AND STORAGE

Store in cool, dry, well-ventilated area away from strong acids and bases. Practice good housekeeping to avoid the accumulation of dust in the workplace and with the requirements set forth in the OSHA Lead Standard 29 CFR 1910.1025. Avoid creating and breathing airborne dust. Use a vacuum with a high efficiency filters (HEPA) if significant amounts of dust are created. Do not broom, sweep or use compressed air to blow off dust. Wash hands thoroughly after handling and do not eat or drink in areas where handled.

SECTION 8—EXPOSURE CONTROLS/PERSONAL PROTECTION

Before using these products, be familiar with the OSHA Lead Standard, 29 CFR 1910.1025. Controlling exposures to dust to meet the lead permissible exposure limit (PEL) will ensure that the PELs for nickel, uranium and antimony will not be exceeded.

MATERIAL	CAS NO.	OSHA PEL	ACGIH TLV
Lead	7439-92-1	0.05 mg/m ³	0.05 mg/m ³
Zirconium	7440-67-7	5 mg/m ³	5 mg/m ³ TWA, 10 mg/m ³ STEL
Titanium	7440-32-6	None Established	None Established
Niobium	7440-03-1	None Established	None Established
Strontium	7440-24-6	None Established	None Established
Nickel	7440-02-0	1 mg/m ³	1.5 mg/m ³
Barium	7440-39-3	None Established	None Established

TITLE:	MSDS for PZT Powder	TYPE	Specification	
		DOC . NUM.	MS-1379	Rev. C

MATERIAL	CAS NO.	OSHA PEL	ACGIH TLV
Lanthanum	7439-91-0	None Established	None Established
Iron	7439-89-6	0.5 mg/m ³	0.5 mg/m ³
Uranium	7440-61-1	0.25 mg/m ³	0.2 mg/m ³ TWA, 0.6 mg/m ³ STEL
Antimony	7440-36-0	0.5 mg/m ³	0.5 mg/m ³
Manganese	7439-96-5	1 mg/m ³	0.2 mg/m ³
Yttrium	7440-65-5	1 mg/m ³	1 mg/m ³
Tin	7440-31-5	2 mg/m ³	2 mg/m ³

Ventilation: Provide sufficient general and local exhaust ventilation to maintain airborne concentrations below established exposure limits.

Respiratory Protection: Use an appropriate NIOSH-approved respirator if airborne concentrations exceed established exposure limits. Utilization of respiratory equipment should be in accordance with 29 CFR 1910.1025 and 29 CFR 1910.134

Protective Clothing: Avoid direct skin contact, wear normal work clothing during product use and handling. Protective clothing is required if lead exposure exceeds PEL (see above). Work clothing should be left at work site and be properly laundered or disposed after use, with the wash water disposed of in accordance with local, state and federal regulations. Personal clothing, including shoes should be protected from contamination.

Eye Protection: Wear chemical/safety glasses with side shields.

SECTION 9—PHYSICAL AND CHEMICAL PROPERTIES

Appearance:	Yellow or tan powder	Odor:	No odor
Melting Point:	1,647 °F (Approximately)	Boiling Point:	2,691 °F (Approximately)
Vapor Pressure (mmHg):	10 @ 1,985 °F	Percent Volatile:	Not applicable
Vapor Density:	Not applicable	Evaporation Rate:	Not applicable
Solubility in Water:	Not applicable	Specific Gravity:	7.6

TITLE:	MSDS for PZT Powder	TYPE	Specification	
		DOC . NUM.	MS-1379	Rev. C

SECTION 10—STABILITY AND REACTIVITY

Stability:	Stable to 500 °C. Do not heat in the presence of strong oxidizers.
Hazardous Decomposition:	High temperatures or fire may produce metal oxide fumes, vapor and/or dust.
Hazardous Polymerization:	Not applicable.

SECTION 11—TOXICOLOGICAL INFORMATION

Carcinogenicity: The International Agency for Research on Cancer (IARC) classifies Lead Compounds (not metallic lead) as a Category 2A (probably carcinogenic to humans). The National Toxicology Program (NTP) classifies Lead/Lead Compounds as reasonably anticipated to be a human carcinogen based on limited human evidence and laboratory testing of animals.

SECTION 12—ECOLOGICAL INFORMATION

Lead has a high acute and chronic toxicity to aquatic life. Lead causes nerve and behavioral effects in animal life and can bio-accumulate.

SECTION 13—DISPOSAL CONSIDERATIONS

Dispose in accordance with federal, state, and local regulations.

SECTION 14—TRANSPORT INFORMATION

This product is regulated as a hazardous material/dangerous good for transportation purposes by US DOT and ICAO/IATA. This product is transported as:

Lead compounds, soluble, n.o.s., (Piezoelectric Ceramic Powder), 6.1, UN2291, PG III

TITLE:	MSDS for PZT Powder	TYPE	Specification	
		DOC . NUM.	MS-1379	Rev. C

SECTION 15—REGULATORY INFORMATION

CERCLA:	Lead/Lead Compounds and nickel are CERCLA Hazardous Substances, if in a dust form.
Toxic Substances Control Act (TSCA):	All ingredients are listed on the TSCA inventory.
SARA Title III, Section 313:	Lead/lead compounds, nickel and antimony are subject to the reporting requirements of Section 313 of the Emergency Planning and Community Right-to-Know Act.
OSHA:	The control of Lead in general industry is addressed in 29 CFR 1919.1025.
State Regulatory Information:	No additional information.

SECTION 16—SPECIAL INFORMATION

Reasonable care has been taken in the preparation of the information contained in this Material Safety Data Sheet and the information provided is given in good faith. However, Morgan Electro Ceramics assumes no responsibility as the accuracy of the information drawn from raw material supplier Material Safety Data Sheets and other sources. No warranty, expressed or implied, is made. The information contained in this Material Safety Data Sheet relates to the piezoelectric ceramic powder manufactured and sold by Morgan Electro Ceramics and to the dust that may be generated in shipping, handling and use.

<u>Distribution</u>	<u>Number of Copies</u>
Facilities Manager	1
Purchasing Manager	1
Company Website	1



ELECTRONIC SPACE PRODUCTS INTERNATIONAL

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MATERIAL SAFETY DATA SHEET

I PRODUCT IDENTIFICATION

Trade Name:	Lead Titanate	Chemical Family:	Metal titanate
Synonyms:	Lead metatitanate	Formula:	PbTiO ₃
CAS #:	12060-00-3		

II HAZARDOUS INGREDIENTS

<u>Hazardous Components</u>	<u>%</u>	<u>OSHA/PEL</u>	<u>ACGIH/TLV</u>	<u>Other Limits</u>	<u>Sec. 302</u>	<u>Sec. 304</u>	<u>Sec. 313</u>
Lead Titanate	0-100	.05 mg(Pb)/m ³	.15 mg(Pb)/m ³	AL 30 ug/m ³	No	Yes 10 lb	Yes

HMIS Ratings (0-4): **Health:** 3 (chronic health hazard) **Flammability:** 0 **Reactivity:** 0
HMIS Protective Equipment: G: glasses, gloves, combination respirator.

III PHYSICAL DATA

Boiling Point:	N/E or N/A	Melting Point:	N/E or N/A
Vapor Pressure:	N/E	Specific Gravity (H₂O = 1):	7.52 gm/cc
Vapor Density:	N/A	Solubility in	
Appearance and Odor:	Yellow powder, no odor.	% Volatile:	H₂O: N/E or N/A

IV FIRE AND EXPLOSION HAZARD DATA

Flash Point: N/E or N/A

Method Used: Non-flammable

Explosive Limits: Lower: N/A Upper: N/A

Extinguishing Media: Use suitable extinguishing media for surrounding materials and type of fire.

Special Firefighting 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 and Explosion Hazards: When heated to decomposition, lead titanate may emit toxic fumes of lead.

V HEALTH HAZARD INFORMATION

Routes of Entry: Inhalation, ingestion.

Effects of Exposure:

Some lead compounds are experimental neoplastigens and tumorigens. Lead poisoning is one of the commonest of occupational diseases. The lead must be in such form, and so distributed, as to gain entrance into the body or tissues of the worker in measurable quantity, otherwise no exposure can be said to exist. Some lead compounds are carcinogens of the lungs and kidneys. Lead is a cumulative poison. Increasing amounts build up in the body and eventually reach a point where symptoms and disability occur.

Titanium is generally considered to be physiologically inert. There are no reported cases in the literature where titanium as such has caused human intoxication. The dusts of titanium or most titanium compounds such as titanium oxide may be placed in the nuisance category.

Acute Effects:

Inhalation: DANGER-POISON. May cause irritation to the upper respiratory system, insomnia, dryness of the mouth and a metallic taste.

Ingestion: DANGER-POISON. May cause constipation and abdominal pain, colic tremors, nausea, vomiting, diarrhea, metallic taste, loss of appetite, irritability and muscle pain. May cause acute lead toxicity.

Skin: May cause irritation.

Eye: May cause irritation.

Chronic Effects:

Inhalation: May cause chronic lead toxicity. May be toxic to the central and peripheral nervous system affecting the cerebellum, spinal cord, motor and sensory nerves.

Ingestion: May cause anemia, gingival lead line, paralysis in the wrist and permanent neurological injury. May cause chronic lead toxicity. May cause nephritis, scarring and shrinking of the kidney tissue.

Skin: No chronic health effects recorded.

Eye: No chronic health effects recorded.

Target Organs: May affect the gastrointestinal tract, central nervous system, kidneys, blood, skin and the gingival tissue.

Medical Conditions Generally Aggravated by Exposure: Pre-existing lung and circulatory disorders.

Carcinogenicity: NTP: No IARC: No OSHA: Yes

EMERGENCY FIRST AID PROCEDURES:

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

INGESTION: Give 1-2 glasses water or milk and 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 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: None

Incompatibility (Material to Avoid): None

Hazardous Decomposition Products: Fumes of lead.

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. 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 Federal, State and Local regulations.

VIII SPECIAL PROTECTION INFORMATION

Respiratory Protection: Select according to OSHA 29 CFR 1910.1025(f)(2) Table II.

Ventilation: Use local exhaust to maintain concentration at or below the TLV, PEL. General exhaust is not recommended.

Protective Gloves: Rubber gloves.

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 tightly closed container in a cool, dry area. 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 or smoking. Do not blow dust off clothing or skin with compressed air.

Some of the chemicals listed herein are research or experimental substances which may be toxic, as defined by various governmental regulations. In accordance with Environmental Protection Agency regulations and the Toxic Substance Control Act (TSCA), these materials should only be handled by, or under the direct supervision of, a "technically qualified individual", as defined in 40 CFR 710.2(aa).

The above information is believed to be correct, but does not purport to be all inclusive and shall be used only as a guide. ESPI shall not be held liable for any damage resulting from handling or from contact with the above product.

Issued by: S. Dierks
Dated: January 1995



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MATERIAL SAFETY DATA SHEET

I PRODUCT IDENTIFICATION

Trade Name: Lead Zirconate
Formula: PbZrO₃

Chemical Family: Metal zirconate
CAS #: 12060-01-4

II HAZARDOUS INGREDIENTS

Hazardous Components	%	OSHA/PEL	ACGIH/TLV	Other Limits	Sec. 302	Sec. 304	Sec. 313
Lead Zirconate	0-100	.05 mg(Pb)/m ³	.15 mg(Pb)/m ³	AL 30 ug/m ³	No	Yes 1 lb	Yes

HMIS Ratings (0-4): **Health:** 3 (chronic health hazard) **Flammability:** 0 **Reactivity:** 0
HMIS Protective Equipment: G: glasses, gloves, combination respirator.

III PHYSICAL DATA

Boiling Point:	N/E or N/A	Melting Point:	N/E or N/A
Vapor Pressure:	N/E	Specific Gravity (H₂O = 1):	N/E
Vapor Density:	N/A	Solubility in H₂O:	N/E
Appearance and Odor:	Orange-yellow powder, no odor.	% Volatile:	N/E or N/A

IV FIRE AND EXPLOSION HAZARD DATA

Flash Point: N/E or N/A
Explosive Limits: Lower: N/A Upper: N/A

Method Used: Non-flammable

Extinguishing Media: Use suitable extinguishing media for surrounding materials and type of fire.

Special Firefighting 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 and Explosion Hazard: When heated to decomposition, lead zirconate may emit toxic lead oxide fumes.

V HEALTH HAZARD INFORMATION

Effects of Exposure:

To the best of our knowledge the chemical, physical and toxicological properties of lead zirconate have not been thoroughly investigated and recorded.

Some lead compounds are experimental neoplastigens and tumorigens. Lead poisoning is one of the commonest of occupational diseases. The lead must be in such form, and so distributed, as to gain entrance into the body or tissues of the worker in measurable quantity, otherwise no exposure can be said to exist. Some lead compounds are carcinogens of the lungs and kidneys. Lead is a cumulative poison. Increasing amounts build up in the body and eventually reach a point where symptoms and disability occur.

Zirconium compounds are not an important industrial poison. Most zirconium compounds in common use are insoluble and considered inert. Pulmonary granuloma in zirconium workers has been reported.

Acute Effects:

Inhalation: DANGER-POISON. May cause irritation to the upper respiratory system, mucous membranes of the nose and throat, insomnia, dryness of the mouth and a metallic taste.

Ingestion: DANGER-POISON. May cause constipation and abdominal pain, colic, tremors, nausea, vomiting, diarrhea, metallic taste, loss of appetite, irritability and muscle pain. May cause acute lead toxicity.

Skin: May cause irritation.

Eye: May cause irritation.

Chronic Effects:

Inhalation: May cause chronic lead toxicity. May be toxic to the central and peripheral nervous system affecting the cerebellum, spinal cord, motor and sensory nerves.

Ingestion: May cause anemia, gingival lead line, paralysis in the wrist and permanent neurological injury. May cause chronic lead toxicity. may cause nephritis, scarring and shrinking of the kidney tissue.

Skin: May cause skin granulomas.

Eye: No chronic health effects recorded.

Target Organs: May affect the gastrointestinal tract, respiratory and central nervous system, kidneys, blood, skin and the gingival tissue.

Routes of Entry: Inhalation, ingestion.

Medical Conditions Generally Aggravated by Exposure: Pre-existing lung and circulatory disorders.

Carcinogenicity: NTP: No IARC: No OSHA: Yes

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.

INGESTION: Give 1-2 glasses of milk or water and 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 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: None

Incompatibility (Material to Avoid): None recorded.

Hazardous Decomposition Products: Fumes of lead oxides.

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. 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.

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