MATERIAL SAFETY DATA SHEET

MSDS-CCA
Copper-Zinc-Manganese-Iron Alloys
Date: November 16, 2005
Revision: 1

ULTRA INFILTRANT
13111 Penneagle Drive
Carmel, IN 46033
PHONE 888-ULTRA-55

IMPORTANT - All users, including employees, customers, and users of the product should read and be familiar with this MSDS before handling and disposing of this product.

SECTION I- MATERIAL IDENTIFICATION

Description: Copper-Zinc-Manganese-Iron Alloys
Product Codes: UI332
Forms: wire, rod

HMIS Ratings
Health-2
Fire-1
Reactivity-1

SECTION II- COMPOSITION/INFORMATION ON INGREDIENTS

Component	CAS Number	OSHA PEL-TWA	OSHA-PEL-C	ACGIH TLV-TWA	ACGIH TLV-STEL
Copper	7440-50-8	1 mg/m^3, as dust 0.1 mg/m^3, as fume	none	1 mg/m^3, as dust 0.2 mg/m^3, as fume	none
Iron	7439-89-6	10 mg/m^3, as iron oxide	none	5 mg/m^3, as iron oxide	none
Manganese	7439-89-5	none	5 mg/m^3,	0.2 mg/m^3	none
Zinc	7440-66-6	5 mg/m^3, (as ZnO fume)	none	5 mg/m^3, (as ZnO fume)	10 mg/m^3, (as ZnO fume)

SECTION III- PHYSICAL DATA

Physical Form:	solid (metal residues may include oxides)		Specific Gravity	Approx. 8.9
Boiling Point:	n/a		Solubility (H_2O)	Insoluble
Vapor Pressure:	n/a		Color:	Varies with Composition
Evaporation Rate:	n/a		Odor:	none
Vapor Density:	n/a			

SECTION IV- FIRE AND EXPLOSION DATA

Flash Point (Method): n/a **Autoignition Temperature:** n/a **Flammable Limits(LEL/UEL):** n/a

Overview: Solid massive form is not combustible under normal conditions of temperature and pressure. Fire and explosion hazards are moderate for material in the form of dust and fine powder when exposed to heat, flames, sparks, or by reaction with incompatible materials (see Section V).

Conditions to Avoid: Do not allow dust and fine powder to accumulate. Avoid creating sources of ignition sources, sparks, and flame in areas of dust and powder accumulations, or where there is a high airborne concentration.

Extinguishing Media to Use: Class D dry powder, dry sand, or specialized dry powders.

Special Fire Fighting Instructions: Firefighters should wear NIOSH-approved self-contained breathing apparatus with full facepiece in a positive-pressure mode, and full protective clothing. Avoid spreading fires of powder and dust. Dust clouds may be explosive. Take all appropriate steps to prevent formation of dust clouds. If fire is isolated, it may be allowed to burn itself out. Do not disturb burning metal while extinguishing the fire. Use fire fighting methods and media as appropriate for surrounding materials.

Hazardous Combustion Products: Metals involved in a fire at very high temperatures or in a molten state produce metal or metal oxide fumes that may be toxic as well as irritating to the respiratory system.

SECTION V- REACTIVITY DATA

Stability: Stable under foreseeable conditions of transport and storage.

Hazardous Decomposition Byproducts: Metal fume and/or metal oxide fume.

Hazardous Polymerization: Will not occur.

Conditions to Avoid:

- During storage, avoid exposure to strong acids, bases, oxidizers and the materials indicated below in the *Incompatibility* section.
- Molten metal may react violently with water. Never put water or other liquids on it, as it may explode. Similarly, do not melt wet metal.
- This product can react with strong acids or oxidizing agents, which can liberate highly flammable hydrogen gas.
- During storage, avoid exposure to strong acids, bases, oxidizers and the materials indicated below in the *Incompatibility* section.
- Copper forms potentially explosive reactants with acetylene, ammonium nitrate, 3-bromopropyne, ethylene oxide and lead azide.
- In the presence of halogenated compounds, copper powder may explode through heat, percussion, or friction.
- Upon extended contact with wet acetylene and ammonia, copper may form an explosive peroxide.

SECTION V- REACTIVITY DATA (Continued)

Incompatibility (Materials to Avoid): Strong acids; strong bases; ammonium nitrate; inorganic and organic peroxides; bromates, chlorates, and iodates of alkali and alkali earth metals; halogens; hydrazine; hydrazoic acid; performic acid; selenium; dioxane; sulfur; titanium plus potassium perchlorate; nitric acid; nitrogen dioxide; sulfur dioxide; phosphorus; chlorine trifluoride; peroxides.

SECTION VI- HEALTH HAZARD DATA

Overview: These products have not been tested for toxicological properties by the manufacturer. Symptoms and health effects of the component elements from scientific studies and reports are described herein.

Route(s) of Entry: Ingestion; inhalation.

Eye Hazards: Eye contact with these products in finely divided forms may cause irritation, conjunctivitis, and/or ulceration of the cornea.

Skin Hazards: Skin contact with these products in finely divided forms may cause irritation, discoloration, and contact dermatitis.

Ingestion Hazards: Ingestion of finely divided forms of these products may cause nausea, vomiting, and gastrointestinal (GI) tract irritation. Potential health effects from chronic long-term ingestion are similar to those described under *Inhalation Hazards* below.

Inhalation Hazards: The symptoms and effects of the component elements described here have occurred from excessively high and/or prolonged exposures, and do not necessarily represent the potential health hazards existing under foreseeable conditions of product use.

Copper: Acute exposure may cause *metal fume fever*, which is characterized by respiratory tract irritation, a metallic taste, cough, dry throat, chills, fever, tightness of chest, headache nausea, shortness of breath, vomiting, and fatigue. Symptoms usually abate in 24-48 hours, leaving no known permanent effects. Long-term chronic exposure may damage the liver, kidney, spleen, pancreas, and brain.

Iron: Chronic inhalation exposure to iron oxide dust or fume may cause *Siderosis*, a benign pneumoconiosis that produces radiographic changes in the lungs, but no significant physiological impairment.

Manganese: Acute inhalation may irritate the nose, throat, and upper respiratory tract, and produce flu-like symptoms and/or pneumonia. Chronic exposure may cause *Manganism,* a disease of the central nervous system characterized by sleeplessness, muscle weakness, mental confusion, and spastic responses.

Zinc: Acute exposure to zinc oxide fume may cause *metal fume fever* (see Copper, above). Chronic effects from long-term exposure have not been established for either zinc oxide or metallic zinc.

Carcinogenicity: No components of this product are classified as potential or demonstrated carcinogens by IARC, NTP, or the Occupational Safety and Health Administration (OSHA).

Medical Conditions Aggravated by Overexposure: Pre-existing pulmonary diseases (e.g., bronchitis, asthma) may be aggravated by inhalation overexposure, particularly as fume. Chronic overexposure by inhalation and/or ingestion may aggravate pre-existing diseases of the liver, kidneys, gastrointestinal system, and nervous system.

Emergency First Aid Procedures:

Eyes: Flush affected areas with water for at least fifteen minutes. Seek medical assistance if necessary.

Skin: Remove contaminated clothing. Wash affected area with large quantities of water for at least five minutes.

Ingestion: If subject is conscious, induce vomiting. If unconscious or convulsive, get immediate medical assistance.

Inhalation: If signs and symptoms of toxicity are observed, remove subject from area, administer oxygen, and seek medical attention. Keep the subject warm and at rest. Perform artificial respiration if breathing has stopped.

Note to Physician: None of the components are acutely toxic by ingestion, nor are they absorbed through the skin. Extensive or prolonged skin contact may cause contact dermatitis.

Toxicology Data:

Component (CASRN)	LD_{50} (Route/species)	LC_{50} (Species)
Copper (7440-50-8)	no data available	no data available
Iron (7439-89-6)	30 gm/kg (oral/rat)	no data available
Manganese (7439-96-5)	9 gm/kg (oral/rat)	no data available
Zinc (7440-66-6)	no data available	no data available

SECTION VII - PRECAUTIONS FOR SAFE HANDLING AND USE

Potential for Exposure: Metal dust and fume exposure may occur when alloys are subject to grinding, cutting, extreme heat, and other forms of metalworking. If dust and fume are generated, avoid inhalation through the use of appropriate engineering controls (e.g., ventilation) and/or personal protective equipment, as described in Section VIII.

Handling and Storage: No special handling procedures are required. Do not store near strong acids, bases, oxidizing agents, or incompatible materials (see Section V). Prevent exposure to rainwater, which may cause storm drain pollution.

Accidental Release Measures: If a powdered form of product is spilled, clean up spillage so as to minimize dust generation. Wet sweeping or vacuuming using HEPA filtration are recommended. Prevent exposure to rainwater and possible storm water pollution.

Waste Disposal: Recycle unused product whenever possible. Dispose of all waste products in accordance with applicable Federal, State/Provincial, and local regulations.

SECTION VIII - CONTROL MEASURES

Engineering Controls: Use appropriate ventilation (e.g., dilution, local exhaust) adequate to maintain concentrations of all components and their decomposition byproducts to within their respective OSHA, PELs, or other applicable standards. Follow appropriate guidance documents, such as NFPA, ANSI, and industrial ventilation design principles and practices.

Eye/Face Protection: Wear eye protection adequate to prevent eye contact with powdered forms of product and/or injury from the type of operation in which the product is used. Appropriate protection may include safety glasses with side shields, goggles, face shields, helmets, or lenses of tinted glass. Safety eyewash stations should be nearby locations of work with these products.

Skin Protection: Wear protective gloves and clothing appropriate to the type of operation in which the product is used. Melting, pouring, grinding, cutting, or welding operations will require appropriate protective gloves and/or clothing. Depending upon the operation, additional protective gear, such as leggings, gauntlets, helmets, etc., may be required. If there is the potential for extensive or prolonged contact with powdered forms of product, wear protective gloves or barrier creams to prevent sensitization and/or dermatitis.

Respiratory Protection: If an exposure level exceeds an applicable exposure standard, use a NIOSH-approved respirator having a configuration (type of facepiece, filter media, assigned protection factor, etc.) appropriate to the concentration of the contaminant(s) generated. For guidance on selection and use of respiratory protection, consult American National Standard Z88.2 (ANSI, New York, NY 10036 USA).

Work/Hygiene Practices: Eating, drinking, and use of tobacco should be prohibited in work areas. Wash hands and face before eating, drinking, using tobacco products, or applying cosmetics. Do not wear contaminated clothing into break and lunch rooms. Contaminated clothing should not be worn home, but should be left at the workplace.

SECTION IX - REGULATORY INFORMATION

Transportation Regulatory Information: These products are not classified as *Hazardous Substances* or *Dangerous Goods* per U.S. Department of Transportation (DOT), International Air Transport Association (IATA), or International Maritime Organization (IMO) regulations.

U.S. Regulatory Information:

SARA Hazard Classes: Acute Health Hazard; Delayed Health Hazard

Section 313 Supply Notification: These products contain the following ingredients in concentration greater than 1% (for carcinogens 0.1%) that are subject to Toxic Release Inventory (TRI) reporting under Section 313 of the Emergency Planning and Community Right-to-Know Act (EPCRA) of 1986 and 40CFR Part 372:

Copper (CASRN 7440-50-8)
Manganese (CASRN 7439-96-5)

Occupational Safety and Health Administration: If these products are used in a manner that creates employee exposure exceeding their respective *Permissible Exposure Limits (PELs)*, some of the requirements of 29CFR Part 1910 may apply. Consult the standards for requirements specific to your operation. If uncertain, consult a qualified industrial hygienist or other health professional for guidance.

Canadian Regulatory Information:

***Workplace Hazardous Materials Information System* (WHMIS) Class(es) and Division(s):** None applicable

Components on Ingredients Disclosure List:

Copper, elemental (CASRN 7440-50-8)
Manganese, elemental (CASRN 7439-96-5)

DISCLAIMER OF LIABILITY

The information in this MSDS was obtained from sources that we believe are reliable. HOWEVER, THE INFORMATION IS PROVIDED WITHOUT ANY WARRANTY, EXPRESSED OR IMPLIED, REGARDING ITS CORRECTNESS.

The conditions or methods of handling, storage, use, and disposal of the product are beyond our control, and MAY be beyond our knowledge. FOR THIS AND OTHER REASONS, WE DO NOT ASSUME RESPONSIBILITY, AND EXPRESSLY DISCLAIM LIABILITY, FOR LOSS, DAMAGE OR EXPENSE ARISING OUT OF OR IN ANY WAY CONNECTED WITH THE HANDLING, STORAGE, USE, OR DISPOSAL OF THE PRODUCT.

PRODUCT HOMOGENEITY

The following SEM images demonstrate the difference in element distribution between a powdered infiltrant and Ultra Infiltrant. Figure 1 illustrates the powdered infiltrant (consisting of pure copper, a copper-zinc prealloy, pure iron and pure manganese) and the resulting lack of even distribution — as a whole and among specific elements. Figure 2 clearly shows Ultra Infiltrant's (a homogeneous alloy of Zn, Mn, and Fe in the base copper) uniform distribution of elements throughout the sample.

Figure 1: Powder Image XF5

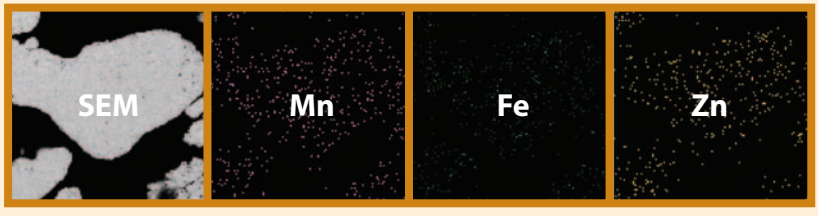
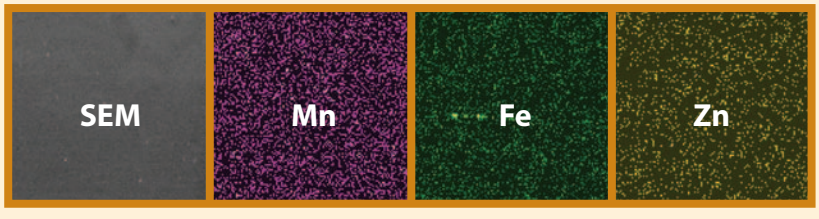


Figure 2: Ultra Infiltrant Drawn Wire



An x-ray spectra illustrates the elements found in a powdered infiltrant as compared to Ultra Infiltrant. The size of the peaks indicates the relative amount of each element. Note that the amount of Fe in the powdered infiltrant (Figure 3) is greater than Ultra Infiltrant (Figure 4). While the same elements were found in each material, Figure 3 shows several extraneous impurities such as Al and Ti.

Figure 3: Loose Powder

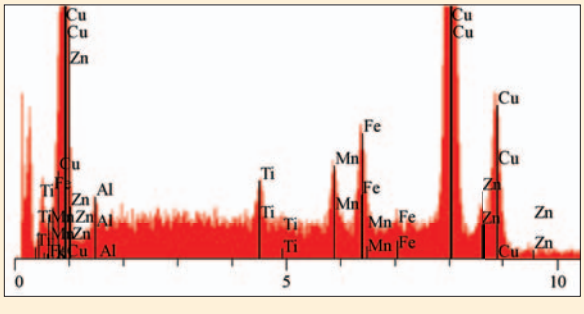
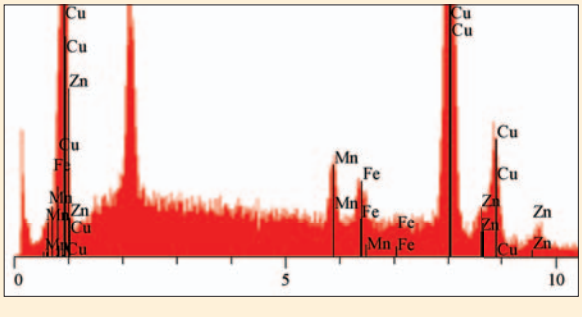


Figure 4: Ultra Infiltrant Drawn Wire



METALLURGICAL MICROSTRUCTURE TEST RESULTS

Ultra Infiltrant is laboratory-proven to provide even penetration into the green sample, providing consistent density. This increased consistency results in superior strength so, in addition to all the production problems that Ultra Infiltrant eliminates, it also creates a better end product.

Figure 1: Sample density 7.55 g/cc after infiltration (6.7 g/cc iron matrix density).

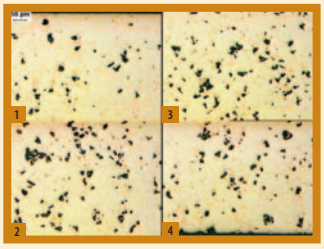


Figure 1 shows a cross section of an FX-1008 sample sintered with Ultra Infiltrant. Q1 represents the top surface of the sample with the black bar at the top showing the upper surface of the alloy, with Q2 showing one-third through the sample, Q3 showing two-thirds through the sample and Q4 illustrating the bottom of the sample. The pores in the image are shown in black. There is not enough infiltrant at this level to completely fill the pores. Average porosity in Q1 is 4%; Q2-3 is 8% and 7% in Q4. Though Q1 shows more infiltrant penetration, the remaining sections are fairly consistent in overall infiltration density.

Figure 2: Sample density 7.8 g/cc after infiltration (6.95 g/cc iron matrix density).

Figure 2 illustrates Ultra Infiltrant penetration for an FX-1008 sample with a higher iron matrix density than shown in Figure 1. Q1 shows 1% porosity, Q2-3 show 3% and Q4 is 2% porous. Again Q1 shows increased density, but the remaining three sections are very consistent.

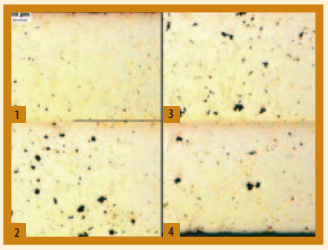


Figure 3: Sample density 7.8 g/cc after infiltration (6.95 g/cc iron matrix density).

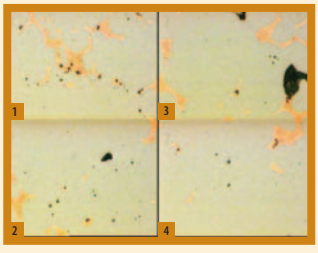
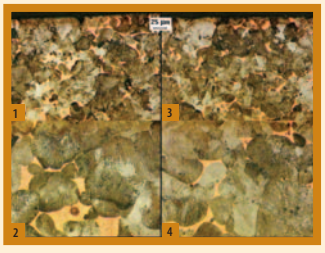


Figure 3 shows the sample from Figure 2 at a higher magnification. Small pores are 1-2 micron(s) in size and found mainly in the iron matrix, but also in the Ultra Infiltrant.

Figure 4: Etched microstructures of the samples from Figures 1 and 2.

Figure 4 shows a side-by-side comparison of samples from Figures 1 and 2 (above) at increased magnification. Q1 and Q2 show the sample from Figure 1 at 125X and 800X magnification, respectively. Q3 and Q4 show the sample from Figure 2 at 125X and 800X magnification, respectively. Both samples show 100% pearlite microstructure in the iron, as desired for this alloy, all the way to the outer surface, with no evidence of decarburization. The red-pink regions are the Ultra Infiltrant. The brown/gray areas are the etched steel matrix and the black regions are the remaining pores. In sample 2, very few pores remain in Q3 and Q4.



TECHNICAL DATA

The following data for the FX-1008 copper infiltrated steel alloy was developed using Ultra Infiltrant and Quebec Metal Powder Atomet 28 iron powder + 0.9% graphite + 0.75% Acrawax C lubricant for the iron skeleton. Sintering was performed at 2060°F for 20 minutes in a 90 nitrogen – 10 hydrogen atmosphere with a conventional cooling rate. Two different trials were conducted to demonstrate the effect of two different sintering cycles.

Trial 1-FX-1008

Green Density (g/cm^3)	Infiltrant (%)	Infiltrated Density (g/cm^3)	Tensile Strength (psi)	Yield Strength (psi)	Elongation (%)	TRS (psi)	Hardness (HRC)	Impact Energy (ft-lbf)
6.65	14.5	7.55	114,000	86,000	2.7	215,000	21	11
6.9	13.5	7.7	127,000	94,000	3.0	219,000	27	12
MPIF Std 35		7.3	87,000	60,000	3.0	166,000	89 HRB	10

Trial 2-FX-1008

Green Density (g/cm^3)	Infiltrant (%)	Infiltrated Density (g/cm^3)	Tensile Strength (psi)	Yield Strength (psi)	Elongation (%)	TRS (psi)	Hardness (HRC)	Impact Energy (ft-lbf)
6.7	14.0	7.6	120,000	91,000	1.3	195,000	28	11
6.95	10.8	7.65	123,000	96,000	1.3	207,000	28	13
6.95	14.3	7.8	123,000	98,000	1.2	216,000	32	11

The following data for the FX-1008 copper infiltrated steel alloy was developed using Ultra Infiltrant and Quebec Metal Powder Atomet 1001 steel powder + 0.8% graphite + 0.75% Acrawax C lubricant for the steel skeleton. Sintering was performed at 2060°F for 20 minutes in a 90 nitrogen–10 hydrogen atmosphere with a conventional cooling rate.

Trial 3-FX-1008

Green Density (g/cm^3)	Infiltrant (%)	Infiltrated Density (g/cm^3)	TRS (psi)	Hardness (HRB)
6.7	11.3	7.33	222,000	94
MPIF Std 35		7.3	166,000	89

TECHNICAL DATA

The dimensional size change data from Trials 1 and 2 illustrate the consistency of the Ultra Infiltrant as the amount of infiltrant and sintering conditions varied in commercial practice.

Dimensional change using Ultra Infiltrant

Green Density (g/cm^3)	Infiltrant (%)	Infiltrated Density (g/cm^3)	Dimensional Change from Die Size (%)
6.7	10.9	7.45	+0.32
6.65	14.5	7.55	+0.29
6.7	14.0	7.6	+0.36
6.95	10.8	7.65	+0.40
6.9	13.5	7.7	+0.42
6.95	14.3	7.8	+0.48

The following data for the FX-1008 copper infiltrated steel alloy was developed to compare the Ultra Infiltrant and a powdered infiltrant with Quebec Metal Powder Atomet 28 iron powder + 0.9% graphite + 0.75% Acrawax C lubricant for the iron skeleton. Sintering was performed at 2060°F for 20 minutes in a 90 nitrogen – 10 hydrogen atmosphere with a conventional cooling rate.

Trial 4-FX-1008

Infiltrant	Infiltrant (%)	Infiltrated Density (g/cm^3)	Tensile Strength (psi)	Yield Strength (psi)	Elongation (%)	TRS (psi)	Hardness	Impact Energy (ft-lbf)
Ultra	10.9	7.45	114,000	91,000	2	187,000	92 HRB	14
Powder	13.5	7.45	117,000	90,500	1	189,000	25 HRC	12

Iron skeleton density for both infiltrants 6.7-6.75 g/cc

A 19% reduction in the amount of infiltrant, using Ultra Infiltrant, yielded equivalent properties to the powdered infiltrant.