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Worldwide Research & Development

Environmental Health & Safety

September 4, 2014

Licensing Assistant Section
Nuclear Materials Safety Branch
U.S. Nuclear Regulatory Commission, Region I
2100 Renaissance Boulevard, Suite 100
King of Prussia, PA 19406-2713

RE: License No. 06-05869-03
Docket No. 030-38124
Control No. 583584

Dear Ms. Ullrich:

We are writing in response to your email request for additional information dated July 14, 2014. We forwarded your request to the organization that conducted the radiological decommissioning for Pfizer, Chase Environmental Group (Chase) of Oak Ridge, Tennessee. Chase performed an assessment of the metal remaining within the cyclotron vault and then provided a response to your specific questions. This response is enclosed with this letter.

If you have any additional questions or concerns, please contact us.

Sincerely,

Eric Watters
EHS Site Lead

David J. Durkee
Radiation Safety Officer

Enclosures:
1. Chase Response

August 25, 2014

Betsy Ullrich, Senior Health Physicist
Commercial, Industrial, R&D and Academic Branch
Division of Nuclear Materials Safety
US NRC Region I Office

RE: Response to Pfizer Cyclotron Final Status Report RAI Dated July 14, 2014

Dear Ms. Ullrich,

This letter is in response to your request for additional information in your e-mail dated July 14, 2014 regarding doses associated with potentially activated steel in the cyclotron room. Chase Environmental Group, Inc. (Chase) has the following response:

Background Information

Chase removed all steel components at the floor surface as well as the aluminum pan that forms the cyclotron pit. The only potentially impacted steel remaining at the site is rebar embedded in the concrete floor. One of the concrete cores taken directly under one of the targets contained a piece of rebar at a depth of 2-4". This is believed to be the shallowest layer of rebar, therefore expected to be the most highly activated. The steel rebar was separated from the concrete and analyzed by gamma spectroscopy analysis at Teledyne Brown Engineering. Due to the low activity, only two gamma emitting nuclides were detected, Co-60 and Mn-54. The analytical results are attached.

Typically steel samples are analyzed to quantify the activation products by gamma spectroscopy. Gamma spectroscopy can easily identify common activation products in steel such as cobalt-60 because it is a strong gamma emitter. However two activation products, Fe-55 and Ni-63, do not emit gammas suitable for detection by gamma spectroscopy. A very high percentage of iron and nickel (>95%) partition to the steel during recycling in an electric arc furnace and are therefore not readily available for inhalation or ingestion; due to their low energy emissions, they are not a significant component of external dose, resulting in very low dose conversion factors for recycling processes.

There are two considerations when assigning dose for these hard to detect nuclides. The first is how much Fe-55 and Ni-63 can be expected to be produced during cyclotron operations relative to nuclides which can be quantified through gamma spectroscopy. The second consideration is how much dose is assigned to the critical group.

Activation Calculations

The neutron activation of rebar can be estimated by analyzing the chemical makeup of carbon steel and identifying the target isotopes that produce radioactive isotopes. The equation used to calculate activity caused by neutron activation is presented below.

$$A = N \sigma \phi [1 - e^{(-\lambda t_{irr})}]$$

A = activity (dps)
N = number of atoms of the target isotope
= $m/W \times \theta \times 6.023 \times 10^{23}$
m = mass of the element in the irradiated sample (g)
θ = isotopic abundance
W= atomic weight of the element (g/mole)
λ = decay constant = $0.693/t^{1/2}$
$t^{1/2}$ = half-life (yr)
ϕ = neutron flux ($n.cm^{-2}.sec^{-1}$)
σ = activation cross-section ($10^{-24} cm^2$)
t_{irr} = irradiation time (yr)

Rebar is composed mostly of iron with several trace impurities. Iron content is approximately 99% of the chemical composition of rebar, but the abundance of Fe-54, the target for production of Fe-55, is only 5.85% of naturally-occurring iron. The percentage of cobalt in rebar is only 0.09% by weight, but Co-59 is the only stable isotope of cobalt. All cobalt that absorbs a neutron will become radioactive Co-60. Nickel content is held below 1% during rebar production and the isotopic abundance of Ni-62, the target for production of Ni-63, is 3.64%.

The activation cross section is a measure of the probability that a neutron will interact with a particular nuclide. The activation cross section is 2.25 barns for Fe-54 and 14.5 barns for Ni-62. Co-59 has a larger activation cross section of 37.18.

There is a buildup process involved as nuclide production by neutron activation approaches equilibrium with the decaying radioactive product. This buildup is related to the decay constant of the product. After about five half-lives this value reaches approximate equilibrium. However, initially this can have a significant influence on activation compared to isotopes with significantly different half-life values. When all other factors are equal, longer half-life isotopes are slower to build up than short half-life isotopes. Half-lives of the nuclides of concern are: Fe-55 (2.7 years), Ni-63 (96 years), and Co-60 (5.3 years). Therefore, Ni-63 buildup is significantly less than Co-60 and Fe-55 buildup for irradiation times less than 50 years.

Calculations reveal that for the same thermal neutron flux and irradiation time, Ni-63 activity is much less than Co-60 activity in rebar. However, the percentage of iron in rebar compared to cobalt is so dominant that Fe-55 activity is higher than Co-60 activity for the same operational conditions, but is still within an order of magnitude. The ratio of Fe-55 activity to Co-60 activity is around a value of 8 at an irradiation time of zero and gradually goes down to a value of 4 at an irradiation time of 53 years. The results of calculations for a thermal neutron flux of 1E11 neutrons/cm^2/sec and irradiation time of one year are shown in the table below.

Parameter	Parameter Value		
	Fe-55	Ni-63	Co-60
Half-Life (yr)	2.7	96	5.271
Target Nuclide	Fe-54	Ni-62	Co-59
Target Isotopic Abundance	5.85%	3.64%	100%
Target Cross Section (Barns)	2.25	14.5	37.18
Abundance in Rebar (weight % Fe, Ni, or Co)[1]	99%	1%	0.09%
Molecular Weight (g/mole Fe, Ni, or Co)	55.85	58.69	58.93
Activity Result (dps)	31,784,719	38,906	4,213,394
Fraction of Co-60 Activity	7.544	0.009	1.000

Dose Calculations

NUREG 1640 provides nuclide-specific dose conversion factors (DCFs) to relate surface and volumetric radioactivity concentrations to an annual dose to an average member of the critical group in mrem/yr. NUREG 1640 Table 2.1 lists the nuclide-specific critical groups and associated DCFs for all NUREG 1640 recycling and disposal scenarios (the most conservative nuclide-specific DCFs for each material). The DCFs for the nuclides of concern are presented in the table below. For the same activity concentration, Co-60 contributes over five orders of magnitude more dose than Ni-63 or Fe-55.

Nuclide	Mass-Based DCF [2] (mrem/yr per pCi/g)	Critical Group
Co-60	1.9E-1	Scrap Yard
Mn-54	5.9E-2	Scrap Yard
Fe-55	1.7E-6	Scrap Yard
Ni-63	1.7E-6	Scrap Yard

The dose resulting from recycling or disposal of steel was bound using the volumetric-based DCFs. NUREG 1640 mass-based dose calculations are presented in the table below. There is much less than 1 metric ton of potentially activated steel at the site, which is less than 0.02% of the 7,328 tons conservatively assumed. Therefore, a correction is applied to account for volume differences between the model assumptions and the amount of potentially impacted steel in the cyclotron room. Both corrected and uncorrected doses are presented to demonstrate that modeled doses are acceptable, even without applying the volume correction.

[1] Steel chemistry data obtained from the attached Nucor Steel Safety Data Sheet for carbon steel.

[2] The DCFs listed in NUREG 1640 Table 2.1 were converted to conventional units of mrem/yr per pCi/g using the conversion factor of 0.0037 specified in the Table 2.1 footnote.

Nuclide	Average Activity Concentration (pCi/g)	Mass-Based DCF (mrem/yr per pCi/g)	Dose Using NUREG 1640 Volume Assumptions (mrem/yr)	Volume Corrected Dose (mrem/yr)
Co-60	3.96	1.9E-01	7.6E-01	1.0E-04
Mn-54	0.19	5.9E-02	1.1E-02	1.5E-06
Fe-55	31.68	1.7E-06	5.4E-05	7.4E-09
Ni-63	3.96	1.7E-06	6.9E-06	9.4E-10
		Total	**7.7E-01**	**1.1E-04**

Conclusion

Based upon the gamma spectroscopy results, the activity concentrations are 3.96 pCi/g for Co-60 and 0.19 pCi/g for Mn-54. Even when conservatively assuming that the Fe-55 concentration is at eight times that level and Ni-63 activity is the same as Co-60, both Fe-55 and Ni-63 have an insignificant contribution to assigned dose compared to Co-60.

SAFETY DATA SHEET

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Trade Name: Merchant and rebar steel
CAS Number: Not applicable
Synonyms: Carbon Steels
Use/Description: Bar and structural steel products, billets (sheet steel for Castrip®)

Nucor Mill Locations **24 Hour Contact – CHEMTREC 1-800-424-9300**

Nucor Steel – South Carolina
300 Steel Mill Road
Darlington, S.C. 29540
(843) 393-5841

Nucor Steel – Auburn, Inc.
25 Quarry Road
Auburn, N.Y. 13021
(315) 253-4561

Nucor Steel – Texas
U.S. Highway 79 South
Jewett, Texas 75846
(903) 626-4461

Nucor Steel Connecticut, Inc.
35 Toelles Road
Wallingford, CT 06492
(203) 265-0615

Nucor Steel Kankakee, Inc.
One Nucor Way
Bourbonnais, IL 60914
(815) 939-5541

Nucor Steel – Utah
West Cemetery Road
Plymouth, Utah 84330
(435) 458-2300

Nucor Steel Marion, Inc.
912 Cheney Avenue
Marion, Ohio 43302
(740) 383-4011

Nucor Steel Kingman, LLC
3000 West Old Highway 66
Kingman, AZ 86413
(928) 718-7035

Nucor Steel Jackson, Inc.
3630 Fourth Street
Flowood, MS 39232
(601) 939-1623

Nucor Steel Birmingham, Inc.
2301 F.L. Shuttlesworth Drive
Birmingham, Alabama 35234
(205) 250-7400

Nucor Steel – Berkeley
1455 Hagan Avenue
Huger, SC 29450
(843) 336-6000

Nucor Steel – Nebraska
2911 East Nucor Road
Norfolk, Nebraska 68701
(402) 644-0200

Nucor Steel Seattle, Inc.
2424 SW Andover
Seattle, WA 98106
(206) 933-2222

Nucor Yamato Steel/ Nucor Castrip Arkansas, LLC
5929 E. State Hwy 18
Armorel, AR 72310
(870) 762-5500

2. HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW
STEEL PRODUCTS AS SOLD BY NUCOR ARE NOT HAZARDOUS PER OSHA GHS 29 CFR 1910, 1915, 1926. However, individual customer processes, (such as welding, sawing, brazing, grinding, abrasive blasting, and machining) may result in the formation of fumes, dust (combustible or otherwise), and/or particulate that may present the following hazards:

OSHA Hazards:
Carcinogen
Skin Sensitizer
Target Organ Effect – Lungs

GHS Classification:
Carcinogenicity (Category 2)
Skin Sensitization (Category 1)
Specific Target Organ Toxicity-Repeated Exposure (Category 1)

Pictogram(s):

Signal Word: Danger

Hazard Statement(s)
H317: Dust/fumes may cause an allergic skin reaction.
H351: Dust/fumes suspected of causing cancer via inhalation.
H372: Inhalation of dust/fumes causes damage to respiratory tract through prolonged or repeated exposure.

Precautionary Statement(s)
P202: Do not handle until all safety precautions have been read and understood.
P261: Avoid breathing dust/fumes.
P281: Use personal protective equipment as required.
P308+P313: If exposed or concerned: Get medical advice/attention.

Potential Health Effects

Eye Contact
Dusts or particulates may cause mechanical irritation including pain, tearing, and redness. Scratching of the cornea can occur if eye is rubbed. Fumes may be irritating. Contact with the heated material may cause thermal burns.

Skin Contact
Dusts or particulates may cause mechanical irritation due to abrasion. Coated steel may cause skin irritation in sensitive individuals (see Section 16 for additional information.) Some components in this product are capable of causing an allergic reaction, possibly resulting in burning, itching and skin eruptions. Contact with heated material may cause thermal burns.

Inhalation
Dusts may cause irritation of the nose, throat, and lungs. Excessive inhalation of metallic fumes and dusts may result in metal fume fever, an influenza-like illness. It is characterized by a sweet or metallic taste in the mouth, accompanied by dryness and irritation of the throat, cough, shortness of breath, pulmonary edema, general malaise, weakness, fatigue, muscle and joint pains, blurred vision, fever and chills. Typical symptoms last from 12 to 48 hours.

Ingestion
Not expected to be acutely toxic via ingestion based on the physical and chemical properties of the product. Swallowing of excessive amounts of the dust may cause irritation, nausea, and diarrhea.

Potential Fire and Explosion Hazards
Under normal conditions, steel products do not present fire or explosion hazards, and dust generated by handling steel products is oxidized and not combustible. Processing of steel product by some individual customers may produce potentially combustible dust that may represent a fire or explosion hazard.

Chronic or Special Toxic Effects
Repeated exposure to fine dusts may inflame the nasal mucosa and cause changes to the lung. In addition, a red-brown pigmentation of the eye and/or skin may occur. Welding fumes have been associated with adverse health effects. Contains components that may cause cancer or reproductive effects. The following components are listed by NTP, OSHA, or IARC as carcinogens: Nickel, chromium (hexavalent), cobalt, lead, cadmium, antimony (trioxide), arsenic, beryllium. See Section 11, for additional, specific information on effects noted above.

Target Organs
Overexposure to specific components of this product that are generated in dusts or fumes may cause adverse effects to the following organs or systems: eyes, skin, liver, kidney, central nervous system, cardiovascular system, respiratory system.

Medical Conditions Aggravated by Exposure
Diseases of the skin such as eczema may be aggravated by exposure. Also, disorders of the respiratory system including asthma, bronchitis, and emphysema. Long-term inhalation exposure to agents that cause pneumoconiosis (e.g. dust) may act synergistically with inhalation of oxide fumes or dusts of this product.

3. COMPOSITION/INFORMATION ON INGREDIENTS

Components		CAS No.	% Weight	Exposure Limits			
				ACGIH TLV (mg/m³)		OSHA PEL (mg/m³)	
Base Metal:							
Iron	(Fe)	7439-89-6	Balance	5	Oxide Dust/Fume	10	Oxide Dust/Fume
Alloying Elements							
Aluminum	(Al)	7429-90-5	<0.05	10 5	Dust Fume	15 5	Dust Respirable fraction
Antimony	(Sb)	7440-36-0	<0.9	0.5	As Antimony	0.5	As Antimony
Arsenic	(As)	7440-38-2	<0.09	0.01	As Arsenic (A1 Carcinogen)	0.01	As Arsenic
Beryllium	(Be)	7440-41-7	<0.09	0.00 2 0.01	As Beryllium (A1 Carcinogen) As Beryllium (STEL)	0.002 0.005	As Beryllium As Beryllium (Ceiling)
Boron	(B)	7440-42-8	<0.9	10	Oxide Dust	15	Oxide Dust
Cadmium	(Cd)	7440-43-9	<0.09	0.01 0.00 2	As Cadmium (A2 Carcinogen) Respirable fraction	0.005 0.0025	As Cadmium As Cadmium (Action Level)
Calcium	(Ca)	1305-78-8	<0.9	2	Oxide Dust	5	Oxide Dust
Carbon	(C)	7440-44-0	<1.0		Not Established		Not Established
Chromium	(Cr)	7440-47-3	0.01-1.0	0.5	Metal	1	Metal
Cobalt	(Co)	7440-48-4	<0.09	0.02	As Cobalt (A3 Carcinogen)	0.1	Metal/Dust/Fume
Copper	(Cu)	7440-50-8	<0.9	1 0.2	Dust Fume	1 0.1	Dust Fume
Lead	(Pb)	7439-92-1	<0.05	0.05	Dust / Fume (A3 Carcinogen)	0.05	Dust / Fume
Magnesium	(Mg)	7439-95-4	<0.9		Not Established		Not Established
Manganese	(Mn)	7439-96-5	0.2-2	0.2	Elemental Mn and Inorg Compounds	5	Fume (Ceiling)
Molybdenum	(Mo)	7439-98-7	<0.9	10	Insoluble Compounds	15	Insoluble Compounds
Niobium	(Nb)	7440-03-1	<0.9		Not Established		
Nickel	(Ni)	7440-02-0	<1.0	1.5	Metal	1	Metal and Insoluble Compounds
Nitrogen	(N)	7727-37-9	<0.9		Simple Asphyxiant		Simple Asphyxiant
Phosphorus	(P)	7723-14-0	<0.9	0.1	Phosphorus	0.1	Phosphorus
Selenium	(Se)	7782-49-2	<0.9	0.2	Selenium	0.2	Selenium
Silicon	(Si)	7440-21-3	<0.9	10	Dust	15	Dust
Sulfur	(S)	7446-09-05	<0.9	5.2 13	Sulfur Dioxide Sulfur Dioxide (STEL)	13	Sulfur Dioxide
Tin	(Sn)	7440-31-5	<0.9	2	Metal,Oxide and Inorganic Compounds	2	Inorganic Compounds
Titanium	(Ti)	7440-32-6	<0.9		Not Established		Not Established
Tungsten	(W)	7440-33-7	<0.9	5 10	Insoluble Compounds as W Insoluble Compounds as W (STEL)		Not Established
Vanadium	(V)	7440-62-2	<0.9	0.05	Oxide Dust/Fume	0.5 0.1	Oxide Dust (Ceiling) Oxide Fume (Ceiling)
Zinc	(Zn)	7440-66-6	0.0-0.10	10 5 10	Oxide Dust OxideFume Oxide Fume (STEL)	5 10	Oxide Fume Oxide Dust

NOTE: No permissible exposure limits (PEL) or threshold limit values (TLV) exist for steel over all. The above listing is a summary of elements used in alloying Nucor Steel Products. Various grades of steel will contain different combinations of these elements and/or trace materials. Exact specifications may be found by calling the division and asking for a specifications sheet.

4. FIRST AID MEASURES

Eye Contact - In case of overexposure to dusts or fumes, immediately flush eyes with plenty of water for at least 15 minutes occasionally lifting the eye lids. Get medical attention if irritation persists. Thermal burns should be treated as medical emergencies.
Skin Contact - In case of overexposure to dusts or particulates, wash with soap and plenty of water. Get medical attention if irritation develops or persists. If thermal burn occurs, flush area with cold water and get immediate medical attention.
Inhalation - In case of overexposure to dusts or fumes, remove to fresh air. Get immediate medical attention if symptoms described in this SDS develop.
Ingestion - Not considered an ingestion hazard. However, if excessive amounts of dust or particulates are swallowed, treat symptomatically and supportively. Get medical attention.
Notes to Physician - Inhalation of metal fume or metal oxides may produce an acute febrile state, with cough, chills, weakness, and general malaise, nausea, vomiting, muscle cramps, and remarkable leukocytosis. Treatment is symptomatic, and condition is self limited in 24-48 hours. Chronic exposure to dusts may result in pneumoconiosis of mixed type.

5. FIRE FIGHTING MEASURES

Flash Point (Method) - Not applicable
Flammable Limits (% volume in air) - Not applicable
Auto ignition Temperature - Not applicable
Extinguishing Media - For molten metal, use dry powder or sand. For steel dust use or dry sand, water, foam, argon or nitrogen.
Special Fire Fighting Procedures - Do not use water on molten metal. Do not use Carbon Dioxide (CO_2). Firefighters should not enter confined spaces without wearing NIOSH/MSHA approved positive pressure breathing apparatus (SCBA) with full face mask and full protective equipment.
Unusual Fire or Explosion Hazards - Steel products do not present fire or explosion hazards under normal conditions. Any non-oxidized fine metal particles/ dust generated by grinding, sawing, abrasive blasting, or individual customer processes may produce materials that the customer should test for combustibility and other hazards in accordance with applicable regulations. High concentrations of combustible metallic fines in the air may present an explosion hazard.

6. ACCIDENTAL RELEASE MEASURES

Precautions if Material is Spilled or Released - Emergency response is unlikely unless in the form of combustible dust. Avoid inhalation, eye, or skin contact of dusts by using appropriate precautions outlined in this SDS (see section 8). Fine turnings and small chips should be swept or vacuumed and placed into appropriate disposable containers. Keep fine dust or powder away from sources of ignition. Scrap should be reclaimed for recycling. Prevent materials from entering drains, sewers, or waterways. Specific standards and regulations may be applicable to materials generated by individual customer processes. As appropriate, these standards and regulations should be consulted for applicability.
Fire and Explosion Hazards - Some customer processes may generate combustible dust that may require specific precautions when cleaning spills or releases of dust.
Environmental Precautions - Some grades of steel may contain reportable quantities of alloying elements. See Section 15 for additional information.
Waste Disposal Methods - Dispose of used or unused product in accordance with applicable Federal, State, and Local regulations. Please recycle.

7. HANDLING AND STORAGE

Storage Temperatures - Stable under normal temperatures and pressures.
Precautions to be Taken in Handling and Storing - Store away from strong oxidizers. Dusts and/or powders, alone, or combined with process specific fluids, may form explosive mixtures with air. Applicable Federal, state and local laws and regulations may require testing dust generated from processing of steel

products to determine if it represents a fire or explosion hazard and to determine appropriate protection methods. Avoid breathing dusts or fumes.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Operations with potential for generating high concentrations of airborne particulates or fumes should be evaluated and controlled as necessary.
Eye Protection - Use safety glasses. Dust resistant safety goggles are recommended under circumstances where particles could cause mechanical injury such as grinding or cutting. Face shield should be used when welding or cutting.
Skin - Appropriate protective gloves should be worn as necessary. Good personal hygiene practices should be followed including cleansing exposed skin several times daily with soap and water, and laundering or dry cleaning soiled work clothing.
Respiratory Protection - NIOSH/MSHA approved dust/fume/mist respirator should be used to avoid excessive exposure. See Section 3 for component material information exposure limits. If such concentrations are sufficiently high that this respirator is inadequate, or high enough to cause oxygen deficiency, use a positive pressure self-contained breathing apparatus (SCBA). Follow all applicable respirator use, fitting, and training standards and regulations.
Ventilation - Provide general and/or local exhaust ventilation to control airborne levels of dust or fumes below exposure limits.
Exposure Guidelines - No permissible exposure limits (PEL) or threshold limit values (TLV) exist for steel. See Section 3 for component materials. Various grades of steel will contain different combinations of these elements. Trace elements may also be present in minute amounts

9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance and Odor – Silver grey to grey black with metallic luster.
Boiling Point - Not applicable
Melting Point - Approximately 2800 °F
pH - Not applicable
Specific Gravity (at 15.6°C) - Not applicable
Density (at 15.6 °C) - Not applicable
Vapor Pressure - Not applicable
Vapor Density (air = 1) - Not applicable
% Volatile, by Volume - Not applicable
Solubility in Water - Insoluble.
Evaporation Rate (Butyl Acetate = 1) - Not applicable
Other Physical and Chemical Data - None

10. STABILITY AND REACTIVITY

Stability - Stable
Conditions to Avoid - Steel at temperatures above the melting point may liberate fumes containing oxides of iron and alloying elements. Avoid generation of airborne fume.
Hazardous Polymerization - Will not occur.
Incompatibility (Materials to Avoid) - Reacts with strong acids to form hydrogen gas. Do not store near strong oxidizers.
Hazardous Decomposition Products - Metallic fumes may be produced during welding, burning, grinding, and possibly machining or any situation with the potential for thermal decomposition. Refer to ANSI Z49.1

11. TOXICOLOGICAL INFORMATION

The primary component of this product is iron. Long-term exposure to iron dusts or fumes can result in a condition called siderosis which is considered to be a benign pneumoconiosis. Symptoms may include chronic bronchitis, emphysema, and shortness of breath upon exertion. Penetration of iron particles in the skin or eye may cause an exogenous or ocular siderosis which may be characterized by a red-brown

pigmentation of the affected area. Ingestion overexposures to iron may affect the gastrointestinal, nervous, and hematopoietic system and the liver. Iron and steel founding, but not iron or iron oxide, has been listed as carcinogenic (Group 1) by IARC.

When this product is welded, fumes are generated. Welding fumes may be different in composition from the original welding product, with the chief component being ordinary oxides of the metal being welded. Chronic health effects (including cancer) have been associated with the fumes and dusts of individual component metals (see above), and welding fumes as a general category have been listed by IARC as a carcinogen (Group 2B). There is also limited evidence that welding fumes may cause adverse reproductive and fetal effects. Evidence is stronger where welding materials contain known reproductive toxins, e.g., lead, which may be present in the coating material of this product.

Breathing fumes or dusts of this product may result in metal fume fever, which is an illness produced by inhaling metal oxides. These oxides are produced by heating various metals including cadmium, zinc, magnesium, copper, antimony, nickel, cobalt, manganese, tin, lead, beryllium, silver, chromium, aluminum, selenium, iron, and arsenic. The most common agents involved are zinc and copper.

This product may contain small amounts of manganese. Prolonged exposure to manganese dusts or fumes is associated with "manganism", a Parkinson-like syndrome characterized by a variety of neurological symptoms including muscle spasms, gait disturbances, tremors, and psychoses.

This product may contain small amounts of cadmium. Primary target organs for cadmium overexposure are the lung and the kidney. Because of its cumulative nature, chronic cadmium poisoning can cause serious disease which takes many years to develop and may continue to progress despite cessation of exposure. Progression of the disease may not reflect current exposure conditions. It is also capable of causing a painful osteomalacia called "Itai-Itai" in postmenopausal women, and has caused developmental effects and/or reproductive effects in male and female animals. Cadmium is a listed carcinogen by NTP, OSHA, and IARC (Group 1).

This product may contain small amounts of chromium. Prolonged and repeated overexposure to chromium dusts or fumes may cause skin ulcers, nasal irritation and ulceration, kidney damage and cancer of the respiratory system. Chromium is skin sensitizer. Cancer is generally attributed to the hexavalent (+6) form of chromium which is listed as a carcinogen by NTP and IARC (Group 1).

This product may contain small amounts of nickel. Prolonged and repeated contact with nickel may cause sensitization dermatitis. Inhalation of nickel compounds has caused lung damage as well as sinus, nasal and lung cancer in laboratory animals. Nickel is a listed carcinogen by NTP and IARC (Group 1).

This product may contain small amounts of vanadium. Adverse effects from dermal, inhalation or parenteral exposure to various vanadium compounds have been reported. The major target for vanadium pentoxide toxicity is the respiratory tract. Fumes or dust can cause severe eye and respiratory irritation, and systemic effects. Chronic bronchitis, green tongue, conjunctivitis, pharyngitis, rhinitis, rales, chronic productive cough, and tightness of the chest have been reported following overexposure. Allergic reactions resulting from skin and inhalation exposures have also been reported. A statistical association between vanadium air levels and lung cancer has been suggested, but vanadium currently is not regarded as a human carcinogen.

This product may contain small amounts of lead. Lead can accumulate in the body. Consequently, exposure to fumes or dust may produce signs of polyneuritis, diminished vision and peripheral neuropathy, such as tingling and loss of feeling in fingers, arms and legs. Lead is a known reproductive and developmental toxin. It is also associated with central nervous system disorders, anemia, kidney dysfunction and neurobehavioral abnormalities. The brain is a major target organ for lead exposure. Elemental lead is listed as an IARC 2B carcinogen.

The product may contain small amounts of copper. Copper dust and fumes can irritate the eyes, nose and throat causing coughing, wheezing, nosebleeds, ulcers and metal fume fever. Other effects from repeated inhalation of copper fumes include a metallic or sweet taste, and discoloration of skin, teeth or hair. Copper also may cause an allergic skin reaction. Overexposure to copper can affect the liver.

12. ECOLOGICAL INFORMATION

Aquatic Ecotoxicological Data - No specific information available on this product.
Environmental Fate Data - No specific information available on this product.

13. DISPOSAL CONSIDERATIONS

Recovery and reuse, rather than disposal, should be the ultimate goal of handling efforts. Dispose in accordance with federal, state, and local health and environmental regulations. Prevent materials from entering drains, sewers, or waterways.

14. TRANSPORT INFORMATION

DOT Proper Shipping Name - Not regulated
DOT Hazard Classification - Not regulated
UN/NA Number - Not applicable
DOT Packing Group - Not applicable
Labeling Requirements - Not applicable
Placards - Not applicable
DOT Hazardous Substance - Not applicable
DOT Marine Pollutant - Not applicable

15. REGULATORY INFORMATION

This product is not hazardous under the criteria of the Federal OSHA Hazard Communication Standard 29 CFR 1910.1200. However, dusts and fumes from this product may be combustible or hazardous and require protection to comply with applicable Federal, state and local laws and regulations.

California Proposition 65: This product contains chemicals (antimony [oxide], arsenic, beryllium, chromium [hexavalent], cobalt, cadmium, lead, nickel) known to the State of California to cause cancer and chemicals (cadmium, lead) known to the State of California to cause birth defects or other reproductive harm.

Massachusetts Substance List: Aluminum, Antimony, Arsenic, Beryllium, Boron, Cadmium, Chromium, Cobalt, Copper, Lead, Magnesium, Manganese, Molybdenum, Nickel, Nitrogen, Phosphorus, Selenium, Silicon, Sulfur, Tin, Titanium, Tungsten, Vanadium, Zinc

Pennsylvania Hazardous Substance List: Aluminum, Antimony, Arsenic, Beryllium, Boron, Cadmium, Chromium, Cobalt, Copper, Lead, Magnesium, Manganese, Molybdenum, Nickel, Nitrogen, Phosphorus, Selenium, Silicon, Sulfur, Tin, Titanium, Tungsten, Vanadium, Zinc

New Jersey Hazardous Substance List: Aluminum, Antimony, Arsenic, Beryllium, Boron, Cadmium, Chromium, Cobalt, Copper, Lead, Magnesium, Manganese, Molybdenum, Nickel, Nitrogen, Phosphorus, Selenium, Silicon, Sulfur, Tin, Titanium, Tungsten, Vanadium, Zinc

Toxic Substances Control Act (TSCA)
Components of this product are listed on the TSCA Inventory.

Comprehensive Environmental Response, Compensation and Liability Act (CERCLA)
Steel is not reportable, however, it contains hazardous substances that may be reportable if released in pieces with diameters less than or equal to 0.004 inches (RQ marked with a "*").

Chemical Name	Reportable Quantity (in lb)
Antimony	5000*
Arsenic	1*
Beryllium	10*
Cadmium	10*
Chromium	5000*
Copper	5000*

Chemical Name	Reportable Quantity (in lb)
Lead	10*
Nickel	100*
Phosphorus	1
Selenium	100*
Zinc	1000*

Superfund Amendments and Reauthorization Act of 1986 (SARA), Title III
SECTION 311/312 HAZARD CATEGORIES: Immediate Health Effect, Delayed Health Effect

This product contains the following EPCRA Section 313 chemicals subject to the reporting requirements of Section 313 of the Emergency Planning and Community Right – To – Know Act of 1986 (40 CFR 372):

SECTION 313 REPORTABLE INGREDIENTS:

Chemical Name	CAS Number	Concentration (% by weight)	Reportable
Aluminum	7429-90-5	<0.05	No – Less than 1%
Antimony	7440-36-0	<0.9	No – Less than 1%
Arsenic	7440-38-2	<0.09	No – Less than 0.1%
Beryllium	7440-41-7	<0.09	No – Less than 0.1%
Cadmium	7440-43-9	<0.09	No – Less than 0.1%
Chromium	7440-47-3	0.01-1.0	Yes – Greater than 0.1%
Cobalt	7440-48-4	<0.09	No – Less than 0.1%
Copper	7440-50-8	<0.9	No – Less than 1%
Lead	7439-92-1	<0.05	Yes
Manganese	7439-96-5	0.2-2	Yes – Greater than 1%
Nickel	7440-02-0	<1.0	Yes – Greater than 0.1%
Phosphorus	7723-14-0	<0.9	No – Less than 1%
Selenium	7782-49-2	<0.9	No – Less than 1%
Vanadium	7440-62-2	<0.9	No – Less than 1%
Zinc	7440-66-6	0-0.10	No – Less than 1%

Concentrations based on analytical data and process knowledge of typical products distributed by the facility.

16. OTHER INFORMATION

This SDS covers Nucor product as delivered from the Nucor facility, but does not include chemicals that may be applied by subsequent handlers and/or distributors of this product. This could include a variety of materials including oils, paints, galvanization, etc. that are not included in this SDS. Additionally, specialty orders may require application of coating material not listed in this SDS. SDSs for any Nucor-applied specialty coating will be provided separately. During welding, precautions should be taken for airborne contaminants that may originate from components of the welding rod. Arc or spark generated when welding or burning could be a source of ignition for combustible and/or flammable materials. The information in this Safety Data Sheet (SDS) was obtained from sources which we believe are reliable; however, the information is provided without any representation or warranty, expressed or implied, regarding the accuracy or 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 this product.

TELEDYNE
BROWN ENGINEERING, INC.
A Teledyne Technologies Company
2508 Quality Lane
Knoxville, TN 37931-3133
865-690-6819

Dave Culp
Chase Environmental Group, Inc.
109 Flint Rd.

Oak Ridge, TN 37830

Report of Analysis/Certificate of Conformance

08/20/2014

LIMS #: L59867
Project ID#: CH085-3EPFIZERCYC-13
Received: 08/01/2014
Delivery Date: 08/31/2014
P.O.#: SIGNED QUOTE
Release #:
SDG#:

This is to certify that Teledyne Brown Engineering - Environmental Services located at 2508 Quality Lane, Knoxville, Tennessee, 37931, has analyzed, tested and documented samples, as received by the laboratory, as specified in the applicable purchase order.

This also certifies that requirements of applicable codes, standards and specifications have been fully met and that any quality assurance documentation which verified conformance to the purchase order is on file and may be examined upon request.

I hereby certify that the above statements are true and correct.

Keith Jeter
Operations Manager

Cross Reference Table

Client ID	Laboratory ID	Station ID (if applicable)
C1308014-008	L59867-1	

Method Reference Numbers

Matrix	Analysis	Method Reference
SD	GAMMA	EPA 901.1

Report of Analysis

08/20/14 13:15

TELEDYNE BROWN ENGINEERING, INC.
A Teledyne Technologies Company

L59867

Chase Environmental Group, Inc.

CH085-3EPFIZERCYC-13

Sample ID: **C1308014-008**
Station:
Description:
LIMS Number: L59867-1

Collect Start: 02/14/2014 13:48
Collect Stop:
Receive Date: 08/01/2014

Matrix: Solids (SD)
Volume:
% Moisture:

Radionuclide	SOP#	Activity Conc	Uncertainty 2 Sigma	MDC	Units	Run #	Aliquot Volume	Aliquot Units	Reference Date	Count Date	Count Time	Count Units	Flag Values		
K-40	2007	2.89E-01	4.17E-01	**4.15E-01**	pCi/g		151.5	g wet	02/14/14 13:48	08/19/14	14467	Sec	U		Yes
SC-46	2007	-2.32E-01	2.35E-01	**3.59E-01**	pCi/g		151.5	g wet	02/14/14 13:48	08/19/14	14467	Sec	U		No
MN-54	2007	**1.86E-01**	8.46E-02	1.13E-01	pCi/g		151.5	g wet	02/14/14 13:48	08/19/14	14467	Sec	+		Yes
CO-58	2007	-6.72E-02	2.59E-01	**4.17E-01**	pCi/g		151.5	g wet	02/14/14 13:48	08/19/14	14467	Sec	U		No
FE-59	2007	6.32E-01	1.79E+00	**3.04E+00**	pCi/g		151.5	g wet	02/14/14 13:48	08/19/14	14467	Sec	U		No
CO-60	2007	**3.96E+00**	1.41E-01	8.00E-02	pCi/g		151.5	g wet	02/14/14 13:48	08/19/14	14467	Sec	+		Yes
ZN-65	2007	8.89E-02	1.92E-01	**3.27E-01**	pCi/g		151.5	g wet	02/14/14 13:48	08/19/14	14467	Sec	U		No
CS-134	2007	-2.48E-02	5.13E-02	**7.18E-02**	pCi/g		151.5	g wet	02/14/14 13:48	08/19/14	14467	Sec	U		No
CS-137	2007	4.44E-02	4.14E-02	**7.29E-02**	pCi/g		151.5	g wet	02/14/14 13:48	08/19/14	14467	Sec	U		No
EU-152	2007	-3.98E-02	9.99E-02	**1.61E-01**	pCi/g		151.5	g wet	02/14/14 13:48	08/19/14	14467	Sec	U		No
EU-154	2007	-2.44E-02	1.08E-01	**1.73E-01**	pCi/g		151.5	g wet	02/14/14 13:48	08/19/14	14467	Sec	U		No
EU-155	2007	2.31E-02	9.50E-02	**1.57E-01**	pCi/g		151.5	g wet	02/14/14 13:48	08/19/14	14467	Sec	U		No

Flag Values
U = Compound/Analyte not detected (< MDC) or less than 3 sigma
\+ = Activity concentration exceeds MDC and 3 sigma; peak identified(gamma only)
U* = Compound/Analyte not detected. Peak not identified, but forced activity concentration exceeds MDC and 3 sigma
High = Activity concentration exceeds customer reporting value
Spec = MDC exceeds customer technical specification
L = Low recovery
H = High recovery

Bolded text indicates reportable value.

No = Peak not identified in gamma spectrum
Yes = Peak identified in gamma spectrum

**** Unless otherwise noted, the analytical results reported are related only to the samples tested in the condition they are received by the laboratory.

MDC - Minimum Detectable Concentration

L59867

Chain of Custody Record

No. C1308014-03

Chase Environmental Group, Inc.
109 Flint Road
Oak Ridge, TN 37830

Project Name: Pfizer Groton Cyclotron	Project Number: C1308014
Send Report To: Dave Culp, dculp@chaseenv.com	Sampler (Print Name): Dave Culp
Address: 109 Flint Road	Sampler (Print Name): N/A
Oak Ridge, TN 37830	Shipment Method: Hand Deliver
Phone: 865-207-3664	Laboratory Receiving: Teledyne Brown
Fax: 865-481-8818	

Purchase Order #: N/A

Field Sample ID	Sample Date	Sample Time	Sample Matrix	Number of Containers	Analysis Requested: Gamma Spec	Comments, Special Instructions, etc.	Lab Sample ID (to be completed by lab)
C1308014-008	2-14-14	1348	Steel	1	X	Pit, Target Area 2, Rebar, 2"-4" DEPTH	
Use the Chase Cyclotron Activation Product Library, Standard Turnaround Times							

Relinquished by: (Signature)	Received by: (Signature)	Date: 2-19-14	Time: 1400
Relinquished by: (Signature)	Received by: (Signature)	Date: 7-28-14	Time: 1700
Relinquished by: (Signature)	Received by: (Signature) Jonathan Simmons	Date: 8/1/14	Time: 10:30

Sample Custodian Remarks (Completed By laboratory):

QA/QC level		Turnaround	
Level I	☐	Routine	☐
Level II	☐	24 Hour	☐
Level III	☐	1 Week	☐
Other	☐	Other _____	