1219403

Waste Designation, Rev. 34

Prepared by:

Approved: 2/12/13

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0642808

Waste Stream Name: 300-296 Media
Generating Facility: 324 Facility, Waste Site 300-296
Profile Number: WD-300296MEDIA001 Rev. 0
Prepared By: M. Wendling

This waste designation has been performed in accordance with WAC 173-303 and 40 CFR 261 and 268 and is believed to be complete and accurate in accordance with all applicable rules and regulations in effect at the time it was prepared.

**Methodology:**

This designation is based on information provided by the generator: "324 Building Radiochemical Engineering Cells, High Level Vault, Low Level Vault, and Associated Area Closure Plan" DOE/RL-96-73 Rev. 3 (2005) (UCM # 626677), "Listed Waste History at Hanford Facility TSD Units" WHC-MR-0517 (1996) (UCM # 188017), '324 Building Basis for Interim Operation", WCH-140, Decisional Draft Rev. 7 (2012) (UCM # 2041675), "324 Building Basis for Interim Operation" HNF-012055 (2003), "Technical Summary Nuclear Waste Vitrification Project" PNL-3038 (1979), "Characterization Documents For the 324 Chemical Engineering Building" CCN125750 (2006), "Waste Designation Process for 324 Building Radiochemical Engineering Cells And 327 Building Hot Cells" HNF-3590, Rev. 1 (1999), "Safety Analysis Report Chemical and Materials Engineering Laboratory 324 Building" BNWL-CC-2028 (1969), "River Protection Project Solid Waste Hazardous Chemical Characterization Guide" HNF-SD-WM-PLN-119 Rev 2 (2002), "Data Quality Objectives Summary Report for the

300-296, Soil Contamination Under the 324 Building B-Cell Waste Site" WCH-467 (2011) (UCM # 1906666), "Sampling and Analysis Plan for Intrusive Characterization of the 300-296 Waste Site, Soil Contamination Under the 324 Building B-Cell" DOE/RL-2011-51(2011) (UCM # 1915161), "Radiological Profile Methodology for Remote-Handled Transuranic Mixed Waste from 324 Facility B-Cell" HNF-6572 Rev. 1 (2000). Laboratory results were obtained from "Transmittal of Analytical Data Reports in Support of 324 Soils Analyses" PNL-252 (2011). RTECS was used for WA State toxicity determination.

**Summary:**

Assigned Waste Codes: None
Land Disposal Restrictions: None
Radioactive Status: To be determined prior to packaging, shipment, or disposal.

**Applicability & Description:**

Waste disposed under this designation is limited to media and debris from Waste Site 300-296 and includes, but is not limited to, soil, concrete, rock, asphalt, and wood,
CERCLA authorization is documented in "Remedial Design Report / Remedial Action Work Plan for the 300 Area" DOE/RL-2001-47 Rev. 3.

**Characteristics:**

Ignitability:

This waste matrix is primarily radiologically contaminated soil. There's no process knowledge of spills of any ignitable substances to this waste media. Therefore, HWN D001 is not applied.

Corrosive:

As a solid the waste cannot be a D002 waste. Laboratory results, per Washington State Corrosivity criteria, yielded results well within acceptable (non-regulated) ranges. Dangerous Waste Number WSC2 is not applied.

Reactivity:

As this material is a soil matrix with no known cyanide or sulfide contamination, Hazardous Waste Number D003 is not applied. The waste is in a stable matrix, and exhibits no signs of any dangerous reactions (i.e., spontaneous changes).

Prepared by: _____

Approved: _____

Toxicity:

From the DQO Summary Report: "...barium, cadmium, lead, and total chromium were added based on a review of materials handled within B-Cell and the B-Cell mix established during the cleanup and removal of materials found on the floor of B-Cell. Laboratory analyses of materials previously sampled inside B-Cell did not result in mercury being listed as a contaminant of concern.. Similarly, there are no known sources for mercury in the contamination that has migrated out of B-Cell into the subsurface. Therefore, mercury will not be a contaminant of concern for the 300-296 waste site." Selected metals were analyzed for, but not detected above the regulatory limit. Therefore, no D004-D043 codes are applicable.

Toxic Dangerous Waste:

The toxic dangerous waste calculations were performed, and the waste doe not meet the definition of a toxic dangerous waste, WT02.

Persistent Dangerous Waste:

There's no process knowledge that would lead to a persistent dangerous waste designation. Additionally, asphaltic materials designated only for the presence of PAHs, are excepted from regulation as State persistent waste under WAC 173-303-071(3)(e). Therefore, this waste does not designate as a persistent dangerous waste.

**Listings:**

F Listing:

There is no analytical data, or process knowledge to support a F listing.

K Listing:

There is no analytical data, or process knowledge to support a K listing.

P/U Listing:

There is no analytical data, or process knowledge to support a P or U listing.

PCBs:

There is no analytical data, or process knowledge to support a PCB's as being present in this waste stream.

**Radiological:**

The waste is contaminated with radioactive materials. A radiological determination must be performed prior to packaging, shipping, or disposing of this waste stream.

**Land Disposal Restrictions:**

None.

## TOXIC DANGEROUS WASTE CALCULATION

**Species codes:**

| | |
|---|---|
| Fish (mg/L): | a |
| Oral Rat (mg/kg): | b |
| Inhalation Rat (mg/L): | c |
| Dermal Rabbit (mg/kg): | d |

| **Equivalent Concentration:** | **X:** | **B:** | **D:** | 0.00E+00 | 0.00E+00 | 3.30E-07 |
|---|---|---|---|---|---|---|
| | **A:** | **C:** | | 0.00E+00 | 0.00E+00 | |

***Total EC:*** ***3.3E-07***

**Is waste toxic?** **No** Waste Code: **None**

| CAS# | Constituent | $LD_{50}$ | Concentration (ppm) | Species | Toxic category |
|---|---|---|---|---|---|
| 7429-90-5 | Aluminum | *** | **13.60** | | none |
| 7440-36-0 | Antimony | not present | **0.000** | | none |
| 7440-38-2 | Arsenic | not present | **0.000** | | none |
| 7440-39-3 | Barium | *** | **0.13** | | none |
| 7440-41-7 | Beryllium | not present | **0.000** | | none |
| 7440-69-9 | Bismuth | 5000 | **0.02** | b | D |
| 7440-42-8 | Boron | 560 | **0.07** | b | D |
| 7440-43-9 | Cadmium | not present | **0.000** | | none |
| 7440-70-2 | Calcium | *** | **15.60** | | none |
| 7440-45-1 | Cerium | % | **0.04** | | none |
| 7440-47-3 | Chromium | *** | **0.03** | | none |
| 7440-48-4 | Cobalt | 6171 | **0.01** | b | non-toxic |
| 7440-50-8 | Copper | *** | **0.03** | | none |
| 7429-91-6 | Dysprosium | % | **0.002** | | none |
| 7440-53-1 | Europium | % | **0.003** | | none |
| 7439-89-6 | Iron | 750 | **31.80** | b | D |
| 7439-91-0 | Lanthanum | % | **0.04** | | none |
| 7439-92-1 | Lead | not present | **0.000** | | none |
| 7439-93-2 | Lithium | *** | **0.01** | | none |
| 7439-95-4 | Magnesium | *** | **6.42** | | none |
| 7439-96-5 | Manganese | 9000 | **0.47** | b | non-toxic |
| 7439-98-7 | Molybdenum | *** | **0.005** | | none |
| 7440-00-8 | Neodymium | *** | **0.02** | | none |
| 7440-02-0 | Nickel | *** | **0.06** | | none |
| 7440-05-3 | Palladium | not present | **0.000** | | none |
| 7723-14-0 | Phosphorus | (A) | **0.74** | | none |
| 7440-09-7 | Potassium | *** | **2.64** | | none |
| 7440-16-6 | Rhodium | not present | **0.000** | | none |
| 7440-18-8 | Ruthenium | % | **0.004** | | none |
| 7782-49-2 | Selenium | not present | **0.000** | | none |
| 7440-21-3 | Silicon | 3160 | **1.07** | b | D |
| 7440-22-4 | Silver | *** | **0.004** | | none |
| 7440-23-5 | Sodium | *** | **1.54** | | none |
| 7440-24-6 | Strontium | *** | **0.06** | | none |
| 7704-34-9 | Sulfur | *** | **0.06** | | none |
| 7440-25-7 | Tantalum | not present | **0.000** | | none |
| 13494-80-9 | Tellurium | not present | **0.000** | | none |
| 7440-28-0 | Thallium | not present | **0.000** | | none |
| 7440-29-1 | Thorium | *** | **0.005** | | none |

| CAS# | Constituent | $LD_{50}$ | Concentration (ppm) | Species | Toxic category |
|---|---|---|---|---|---|
| 7440-31-5 | Tin | *** | **0.01** | | none |
| 7440-32-6 | Titanium | *** | **2.00** | | none |
| 7440-33-7 | Tungsten | not present | **0.000** | | none |
| 7440-61-1 | Uranium | *** | **0.06** | | none |
| 7440-62-2 | Vanadium | *** | **0.06** | | none |
| 7440-65-5 | Yttrium | *** | **0.01** | | none |
| 7440-66-6 | Zinc | *** | **0.15** | | none |
| 7440-67-7 | Zirconium | *** | **0.02** | | none |

Notes:
not present: Laboratory results < detection limit of instrumentation
*** No usable acute toxicity data found in RTECS
% Not found in RTECS
(A) The LD50 data provided in RTECS is for unreacted phophorus and is therefore not applicable. Red and white phophorus are highly reactive (spontaneously ingite in air) and would not be present in building matrix characterization samples.

**Persistent Dangerous Waste Calculation**

| | |
|---|---|
| **Total HOC:** | **0** |
| **Total PAH:** | **0** |

**Is waste persistent?** **No** **Waste Code:** None

| **Halogenated Organic Compounds** | **PPM** | **Conc. (%)** | **PAH** | **PPM** | **Conc. (%)** |
|---|---|---|---|---|---|
| | | 0 | Acenaphthene | | 0 |
| | | 0 | Acenaphthylene | | 0 |
| | | 0 | Anthracene | | 0 |
| | | 0 | Benzo(a)anthracene | | 0 |
| | | 0 | Benzo(a)pyrene | | 0 |
| | | 0 | Benzo(b)fluoranthene | | 0 |
| | | 0 | Benzo(g,h,i)perylene | | 0 |
| | | 0 | Benzo(k)fluoranthene | | 0 |
| | | 0 | Chrysene | | 0 |
| | | 0 | Dibenz(a,h)anthracene | | 0 |
| | | 0 | Dibenzo(a,j)acridine | | 0 |
| | | 0 | Dibenzo(a,e)pyrene | | 0 |
| | | 0 | Dibenzo(a,h)pyrene | | 0 |
| | | 0 | Dibenzo(a,i)pyrene | | 0 |
| | | 0 | Dibenzo(a,l)pyrene | | 0 |
| | | 0 | Fluoranthene | | 0 |
| | | 0 | Fluorene | | 0 |
| | | 0 | Indeno(1,2,3-c,d)pyrene | | 0 |
| | | 0 | Phenanthrene | | 0 |
| | | 0 | Pyrene | | 0 |

**TCLP Calculation**
**Number of hits:** 0

| CAS# | Constituent | TCLP result (ppm) | Total Result (ppm) | Converted total to TCLP | Limit (mg/L) | Waste Code |
|---|---|---|---|---|---|---|
| | **Metals:** | | | | | |
| 7440-38-2 | Arsenic | | 0 | 0 | 5.00 | D004 |
| 7440-39-3 | Barium | | 0.13 | 0.0065 | 100.00 | D005 |
| 7440-43-9 | Cadmium | | 0 | 0 | 1.00 | D006 |
| 7440-47-3 | Chromium | | 0.03 | 0.001555 | 5.00 | D007 |
| 7439-92-1 | Lead | | 0 | 0 | 5.00 | D008 |
| 7439-97-6 | Mercury | | | 0 | 0.20 | D009 |
| 7782-49-2 | Selenium | | 0 | 0 | 1.00 | D010 |
| 7440-22-4 | Silver | | 0.00399 | 0.0001995 | 5.00 | D011 |
| | **Pest/Herb** | | | | | |
| 57-74-9 | Chlordane | | | 0 | 0.03 | D020 |
| 94-75-7 | 2,4-D | | | 0 | 10.00 | D016 |
| 72-20-8 | Endrin | | | 0 | 0.02 | D012 |
| 76-44-8 | Heptachlor & Epoxide | | | 0 | 0.008 | D031 |
| 58-89-9 | Lindane | | | 0 | 0.40 | D013 |
| 72-43-5 | Methoxychlor | | | 0 | 10.00 | D014 |
| 93-72-1 | 2,4,5,-TP (Silvex) | | | 0 | 1.00 | D017 |
| 8001-35-2 | Toxaphene | | | 0 | 0.50 | D015 |
| | **Organics** | | | | | |
| 71-43-2 | Benzene | | | 0 | 0.50 | D018 |
| 56-23-5 | Carbon Tetrachloride | | | 0 | 0.50 | D019 |
| 108-90-7 | Chlorobenzene | | | 0 | 100.00 | D021 |
| 67-66-3 | Chloroform | | | 0 | 6.00 | D022 |
| 95-48-7 | o-Cresol | | | 0 | 200.00 | D023 |
| 108-39-4 | m-Cresol | | | 0 | 200.00 | D024 |
| 106-44-5 | p-Cresol | | | 0 | 200.00 | D025 |
| 1319-77-3 | total-Cresol | | | 0 | 200.00 | D026 |
| 106-46-7 | 1,4-Dichlorobenzene | | | 0 | 7.50 | D027 |
| 107-06-2 | 1,2-Dichloroethane | | | 0 | 0.50 | D028 |
| 75-35-4 | 1,1-Dichloroethylene | | | 0 | 0.70 | D029 |
| 121-14-2 | 2,4-Dinitrotoluene | | | 0 | 0.13 | D030 |
| 118-74-1 | Hexachlorobenzene | | | 0 | 0.13 | D032 |
| 87-68-3 | Hexachlorobutadiene | | | 0 | 0.50 | D033 |
| 67-72-1 | Hexachloroethane | | | 0 | 3.00 | D034 |
| 78-93-3 | Methyl Ethyl Ketone | | | 0 | 200.00 | D035 |
| 98-95-3 | Nitrobenzene | | | 0 | 2.00 | D036 |
| 87-86-5 | Pentachlorophenol | | | 0 | 100.00 | D037 |
| 110-86-1 | Pyridine | | | 0 | 5.00 | D038 |
| 127-18-4 | Tetrachloroethylene | | | 0 | 0.70 | D039 |
| 79-01-6 | Trichloroethylene | | | 0 | 0.50 | D040 |
| 95-95-4 | 2,4,5 Trichlorophenol | | | 0 | 400.00 | D041 |
| 88-06-2 | 2,4,6 Trichlorophenol | | | 0 | 2.00 | D042 |
| 75-01-4 | Vinyl chloride | | | 0 | 0.20 | D043 |

Process Knowledge Review Paper Supporting Waste Designation WD-300296MEDIA001 Rev. 0

**Scope:**
This technical position paper summarizes the results of an independent, Process Knowledge (PK) based, review of historical documents detailing processes, missions, and operations performed within the 324 Building.

This review was conducted in support of the waste designation process. This PK review supports the conclusions of The Data Quality Objectives Summary Report for the 300-296, Soil Contamination under the 324 Building B-Cell Waste Site (UCM # 1906666).

This review, the DQO Summary Report, and the information provided by laboratory analysis of the samples collected to date, form the basis for this waste designation.

Site 300-296 is located beneath the Radiological Engineering Cells (REC) portion of the 324 building. The REC was comprised of four hot cells labeled A-Cell, B-Cell, C-Cell, and D-Cell. This waste site was contaminated with materials that leaked through the building floor, specifically from B-Cell operations.

The 324 Engineering Development Laboratories (EDL) was excluded from this PK research, as there is no evidence that suggests the soil becoming contaminated from EDL operations.

Likewise, it is doubtful that the soil contamination came from a Shielded Material Facility (SMF) operational process, but as SMF operations had closer ties to the REC missions, projects, and processes SMF operational processes were researched as well.

Due to the potential for the 324 facility performing project in support of the Hanford Tank Waste mission, this PK review put a special emphasis on Federally Listed (specific and non-specific source wastes). As discussed below, contact with Tank Waste may lead to the assignment of F001 through F005 (see Appendix A for definitions).

**Discussion:**
As defined (see Appendix A), specific F codes apply to waste in cases where it can be determined, by the use of process knowledge, the make up of solvent and solvent mixtures before use. The process knowledge must give information that the waste was generated in a manner consistent with the listing criteria. Without this process knowledge the waste is not a listed waste. Analytical results alone, cannot determine the applicability of listed waste codes.

Discovery that 324 Building operations conducted project missions in support of Hanford Tank Farms is of particular significance in making a listed waste determination if the process used actual Hanford tank waste materials.

From the *River Protection Project Solid Waste Hazardous Chemical Characterization Guide (2002): "Through process knowledge, it is believed that all the above identified codes (F001 thru F0005) apply to tank contacted secondary waste. Tank (waste)*

*contacted debris and soil are assigned the identified F-codes, due to the "derived-from" and "mixture" rules" and are managed as low level mixed waste.*

Historically, the 324 Building provided a diversified capability for high-activity radioactive chemical processing studies, metallurgical engineering studies, and non radioactive waste treatability pilot-scale studies. The work performed in the building changed as programs began and concluded. Typically, 30 to 50 projects were in progress at any one time. (See Appendix B for a summary of activities performed in the REC & SMF).

The 300-296 Data Quality Objectives Report calls out barium (D005), cadmium (D006), chromium (D007), and lead (D008), as being potential metals contaminants of concern and pH (as this waste stream is a solid, pH is a Washington State only potential concern (WSC2)).

**Conclusions:**
Federal Listed Waste Numbers (F codes) should not be assigned to the 300-296 waste. The results of this Process Knowledge review have yielded no direct evidence that the facilities' past missions and process involved use of Hanford Tank waste or use of "listed" solvents that might have been transported to the soil from leaks in the B-Cell liner. While the reviewed documents (see References) contain multiple references to "*mixed wastes*", "*chemicals*", and "*...waste from PUREX and from B-Plant*" this, in itself, is insufficient information to assign the F001 – F005 codes.

The remaining F-codes are not assigned to this waste, based on process knowledge of operations performed in the 324 building. Likewise, K-waste codes are not assigned by definition (does not meet the specific source definitions).

P and\or U waste codes are not assigned, as the materials that leaked from 324 were not "discarded chemical products".

Toxicity characteristic metals waste codes (D004, D005, D006, D007, D008, D010, and D011) are not assigned, based on the analytical results of samples J1D49 and J1JD50, reported in PNNL "Transmittal of Analytical Data Reports in Support of 324 Soils Analyses" (9/27/2011). D009 (mercury) was not assigned, as it was not analyzed for, and, based on this process knowledge review; mercury is not anticipated to be present in the waste stream at concentrations exceeding regulatory concentrations.

Due to the extremely high radioactivity of the samples collected from 300-296, these samples were not analyzed for remaining suite of hazardous substances regulated for their toxicity characteristics (D012 – D044), nor were these required analytes, per the DQO Summary Report. These waste codes are not assigned to this waste stream. Based on this PK review, there were no processes or missions conducted that would reasonably lead to the conclusion that these substances will be present in the waste materials at or above Federally Regulated concentrations. This rationale is further discussed in the Summary DQO report.

The Washington State solid acid testing was performed on these samples and the resulted pH reported would not require the assignment of the WSC2 code.

This Washington State Toxicity of this waste stream was "book" evaluated; using the information presented in the sample analytical results and no Washington State Dangerous Waste codes apply.

**References:**


- 324 Building Radiochemical Engineering Cells, High Level Vault, Low Level Vault, and Associated Area Closure Plan DOE/RL-96-73 Rev. 3 (2005) (UCM # 626677)
- Listed Waste History at Hanford Facility TSD Units WHC-MR-0517 (1996) (UCM # 188017)
- 324 Building Basis for Interim Operation, WCH-140, Decisional Draft Rev. 7 (2012) (UCM # 2041675)
- 324 Building Basis for Interim Operation HNF-012055 (2003)
- Technical Summary Nuclear Waste Vitrification Project PNL-3038 (1979)
- Characterization Documents For the 324 Chemical Engineering Building CCN125750 (2006)
- Waste Designation Process for 324 Building Radiochemical Engineering Cells And 327 Building Hot Cells HNF-3590, Rev. 1 (1999)
- Safety Analysis Report Chemical and Materials Engineering Laboratory 324 Building BNWL-CC-2028 (1969)
- River Protection Project Solid Waste Hazardous Chemical Characterization Guide HNF-SD-WM-PLN-119 Rev 2 (2002)
- Transmittal of Analytical Data Reports in Support of 324 Soils Analyses PNL-252 (2011) (UCM # 1946235)
- Data Quality Objectives Summary Report for the 300-296, Soil Contamination Under the 324 Building B-Cell Waste Site WCH-467 (2011) (UCM # 1906666)
- Sampling and Analysis Plan for Intrusive Characterization of the 300-296 Waste Site, Soil Contamination Under the 324 Building B-Cell DOE/RL-2011-51(2011) (UCM # 1915161)
- Radiological Profile Methodology for Remote-Handled Transuranic Mixed Waste from 324 Facility B-Cell HNF-6572 Rev. 1 (2000)

APPENDIX A

**Federally Listed Waste Codes F001 – F005 Definition:**

*Ref: 40 CFR § 261.31 Hazardous wastes from nonspecific sources.*

*(a) The following solid wastes are listed hazardous wastes from non-specific sources unless they are excluded under §§ 260.20 and 260.22 and listed in appendix IX.*

***F001***

*The following spent halogenated solvents used in degreasing: Tetrachloroethylene, trichloroethylene, methylene chloride, 1,1,1-trichloroethane, carbon tetrachloride, and chlorinated fluorocarbons; all spent solvent mixtures/blends used in degreasing containing, before use, a total of ten percent or more (by volume) of one or more of the above halogenated solvents or those solvents listed in F002, F004, and F005; and still bottoms from the recovery of these spent solvents and spent solvent mixtures. (T)*

***F002***

*The following spent halogenated solvents: Tetrachloroethylene, methylene chloride, trichloroethylene, 1,1,1-trichloroethane, chlorobenzene, 1,1,2-trichloro-1,2,2-trifluoroethane, ortho-dichlorobenzene, trichlorofluoromethane, and 1,1,2-trichloroethane; all spent solvent mixtures/blends containing, before use, a total of ten percent or more (by volume) of one or more of the above halogenated solvents or those listed in F001, F004, or F005; and still bottoms from the recovery of these spent solvents and spent solvent mixtures.(T)*

***F003***

*The following spent non-halogenated solvents: Xylene, acetone, ethyl acetate, ethylbenzene, ethyl ether, methyl isobutyl ketone, n-butyl alcohol, cyclohexanone, and methanol; all spent solvent mixtures/blends containing, before use, only the above spent non-halogenated solvents; and all spent solvent mixtures/blends containing, before use, one or more of the above non-halogenated solvents, and, a total of ten percent or more (by volume) of one or more of those solvents listed in F001, F002,F004, and F005; and still bottoms from the recovery of these spent solvents and spent solvent mixtures. (I)**

***F004***

*The following spent non-halogenated solvents: Cresols and cresylic acid, and nitrobenzene; all spent solvent mixtures/blends containing, before use, a total of ten percent or more (by volume) of one or more of the above non-halogenated solvents or those solvents listed in F001, F002, and F005; and still bottoms from the recovery of these spent solvents and spent solvent mixtures. (T)*

***F005***

*The following spent non-halogenated solvents: Toluene, methyl ethyl ketone, carbon disulfide, isobutanol, pyridine, benzene, 2-ethoxyethanol, and 2-nitropropane; all spent solvent mixtures/blends containing, before use, a total of ten percent or more (by volume) of one or more of the above non-halogenated solvents or those solvents listed in F001, F002, or F004; and still bottoms from the recovery of these spent solvents and spent solvent mixtures.*

APPENDIX B

Activities performed in the Radiological Engineering Cells (REC) include:

- Developed and demonstrated treatment technologies from laboratory-scale to pilot-scale systems for conditioning gaseous, liquid, and solid radioactive and hazardous waste, including Hanford defense waste
- Developed and characterized borosilicate glass waste forms for immobilization of Hanford defense waste
- Characterized the long-term storage behavior of spent nuclear fuel
- Measured heat-generating rates of radioactive materials
- Examined the stability of radioactive materials under controlled storage conditions in water or air
- Packaged (and currently package) waste from size reduction and cleanup activities
- Fabricated radioactive borosilicate glass canisters to aid in repository testing
- Developed and demonstrated mechanical systems for packaging and handling containerized borosilicate glass
- Prepared and analyzed, as required, isotope production targets, radioactive sources, and other special radioactive components
- Demonstrated in cell, electrolytic decontamination of cylinders containing processed power reactor waste
- Developed and evaluated borosilicate and other in-cell solidification processes
- Conducted nondestructive examination and destructive examination on irradiated spent light-water reactor fuel
- Sectioned isotope production targets; loaded sections in containers, welded containers closed; and leak-tested containers before shipment offsite
- Developed and demonstrated novel waste treatment technologies to support Hanford environmental restoration activities

A brief summary of projects performed in the 324 SMF cells include:

- Conducted in cell testing on various irradiated structural materials such as zirconium, stainless steel, and refractory metals
- Performed gamma scanning on cesium chloride capsules, Fast Flux Test Facility fuel pins, Experimental Breeder Reactor II fuel pins, and SP 100 fuel pins
- Performed in cell profilometry on cesium chloride capsules, Fast Flux Test Facility fuel pins, Experimental Breeder Reactor II fuel pins, SP 100 test pins, and other cylindrical irradiated specimens
- Performed macro- and microphotography on fuel pins, cesium chloride samples, and miscellaneous structural material specimens
- Conducted Fast Flux Test Facility and Experimental Breeder Reactor II fuel pin wire wrap and wire wrap removal
- Performed radiography of encapsulated radioactive materials (e.g., gamma radiation or heat sources)
- Received, leak-checked, certified, and shipped various onsite and offsite casks; performed leak checking and certification in the airlock cell
- Provided short- and long-term storage of radioactive reactor structural material specimens
- Cleaned Fast Flux Test Facility test canisters, sorted test assembly specimens, and processed materials open-test assembly experiments
- Checked irradiation-experiment capsule encapsulation welds for leaks
- Destructively examined cesium chloride capsules in preparation for the processing of salt for encapsulation, fabrication, and assembly of source capsules for irradiators
- Fabricated radioactive sources for irradiators
- Performed post-irradiation examinations on tritium-bearing components and experiments, including sectioning/partitioning, gas recovery, and sample analysis

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Canadian Centre for Occupational Health and Safety

CCOHS

# RTECS Registry of Toxic Effects of Chemical Substances®

Data source: Accelrys, Inc.

## CHEMICAL IDENTIFICATION

| | |
|---|---|
| **RTECS Number** | NO4565500 |
| **Chemical Name** | Iron |
| **CAS Registry Number** | 7439-89-6 |
| **Other CAS Registry Nos.** | 8011-79-8<br>8053-60-9<br>39344-71-3<br>70884-35-4<br>73135-38-3<br>129048-51-7<br>195161-83-2<br>199281-22-6 |
| **Last Updated** | 201204 |
| **Data Items Cited** | 53 |
| **Molecular Formula** | Fe |
| **Molecular Weight** | 55.85 |
| **Compound Descriptor** | Tumorigen<br>Human |

**Synonyms/Trade Names**

3ZhP
Ancor en 80/150
Armco iron
Carbonyl iron
Copy Powder CS 105-175
Diseases, iron overload
EFV 250/400
EO 5A
Elemental iron
Ferrovac E
GS 6
Iron fulleride (FeC2O)
LOHA
Micropowder R 2430
NC 100
PZh2M
PZhO
Remko
SUY-B 2

## HEALTH HAZARD DATA

**ACUTE TOXICITY DATA**

| Type of Test | Route of Exposure or Administration | Species/Test System | Dose Data | Toxic Effects | Reference |
|---|---|---|---|---|---|
| TDLo - Lowest published toxic dose | Oral | Human - child | 77 mg/kg | Behavioral - irritability Gastrointestinal - nausea or vomiting Blood - normocytic anemia | JTCTDW Journal of Toxicology, Clinical Toxicology. (Marcel Dekker, 270 Madison Ave., New York, NY 10016) V.19- 1982- Volume (issue)/page/year: 25,251,1987 |
| LD50 - Lethal dose, 50 percent kill | Oral | Rodent - rat | 30 gm/kg | Nutritional and Gross Metabolic - weight loss or decreased weight gain | IJPAAO Indian Journal of Pharmacy. (Bombay, India) V.1-40(1), 1939-78. For publisher information, see IJSIDW. Volume (issue)/page/year: 13,240,1951 |
| LDLo - Lowest published lethal dose | Intraperitoneal | Rodent - rabbit | 20 mg/kg | Details of toxic effects not reported other than lethal dose value | NTIS** National Technical Information Service. (Springfield, VA 22161) Formerly U.S. Clearinghouse for Scientific & Technical Information. Volume (issue)/page/year: PB158-508 |
| LD50 - Lethal dose, 50 percent kill | Oral | Rodent - guinea pig | 20 gm/kg | Nutritional and Gross Metabolic - weight loss or decreased weight gain | IJPAAO Indian Journal of Pharmacy. (Bombay, India) V.1-40(1), 1939-78. For publisher information, see IJSIDW. Volume (issue)/page/year: 13,240,1951 |
| LD50 - Lethal dose, 50 percent kill | Oral | Human | 200 mg/kg | Vascular - shock Liver - hepatitis (hepatocellular necrosis), diffuse Nutritional and Gross Metabolic - metabolic acidosis | VCVN5* "Vrednie chemichescie veshestva. Neorganicheskie soedinenia elementov V-VII groopp" (Hazardous substances. Inornanic substances containing V-VII group elements), Bandman A.L. et |

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|---|---|---|---|---|---|
| | | | | | al., Chimia, 1989. Volume (issue)/page/year: -,432,1989 |
| TDLo - Lowest published toxic dose | Administration into the eye | Rodent - rat | 37.5 mg/kg | Sense Organs and Special Senses (Eye) - retinal changes (pigmentary depositions, retinitis, other) Biochemical - Enzyme inhibition, induction, or change in blood or tissue levels - other oxidoreductases | HETOEA Human & Experimental Toxicology. (Macmillan Press Ltd., Brunel Road, Houndmills, Basingstoke, Hampshire, RG21 2XS, UK) V.9- 1990- Volume (issue)/page/year: 27,327,2008 |
| LD50 - Lethal dose, 50 percent kill | Oral | Rodent - rat | 750 mg/kg | Blood - changes in serum composition (e.g. TP, bilirubin, cholesterol) Biochemical - Enzyme inhibition, induction, or change in blood or tissue levels - transaminases | AJEMEN American Journal of Emergency Medicine. (WB Saunders, Philadelphia, PA) V.1- 1983- Volume (issue)/page/year: 27,761,2009 |
| LC50 - Lethal concentration, 50 percent kill | Chemical added to tank with water (dissolved in water) | Invertebrate - daphnia | 4400 ug/L/48H | Details of toxic effects not reported other than lethal dose value | TIVIEQ Toxicology In Vitro. (Pergamon Press Inc., Maxwell House, Fairview Park, Elmsford, NY 10523) V.1- 1987- Volume (issue)/page/year: 31,125,1995 |
| TDLo - Lowest published toxic dose | Intracerebral | Rodent - rat | 558.5 ng/kg | Brain and Coverings - other degenerative changes Biochemical - Metabolism (Intermediary) - lipids including transport Biochemical - Neurotransmitters or modulators (putative) - dopamine in striatum | JOETD7 Journal of Ethnopharmacology. (Elsevier Scientific Pub. Ireland Ltd., POB 85, Limerick, Ireland) V.1- 1979- Volume (issue)/page/year: 134,884,2011 |

**OTHER MULTIPLE DOSE TOXICITY DATA**

| Type of Test | Route of Exposure or Administration | Species/Test System | Dose Data | Toxic Effects | Reference |
|---|---|---|---|---|---|
| TDLo - Lowest published toxic dose | Oral | Rodent - rat | 63 gm/kg/6W (continuous) | Liver - other changes Blood - other changes Biochemical - Enzyme inhibition, induction, or change in blood or tissue levels - catalases | TXCYAC Toxicology. (Elsevier Scientific Pub. Ireland, Ltd., POB 85, Limerick, Ireland) V.1- 1973- Volume (issue)/page/year: 124,73,1997 |
| TCLo - Lowest published toxic concentration | Inhalation | Rodent - rat | 250 mg/m3/6H/4W (intermittent) | Lungs, Thorax, or Respiration - chronic pulmonary edema Lungs, Thorax, or Respiration - other changes | TXAPA9 Toxicology and Applied Pharmacology. (Academic Press, Inc., 1 E. First St., Duluth, MN 55802) V.1- 1959- Volume (issue)/page/year: 145,10,1997 |
| TCLo - Lowest published toxic concentration | Inhalation | Rodent - rat | 150 mg/m3/4H/78W (intermittent) | Lungs, Thorax, or Respiration - other changes Liver - other changes Nutritional and Gross Metabolic - weight loss or decreased weight gain | VCVN5* "Vrednie chemichescie veshestva. Neorganicheskie soedinenia elementov V-VII groopp" (Hazardous substances. Inornanic substances containing V-VII group elements), Bandman A.L. et al., Chimia, 1989. Volume (issue)/page/year: -,433,1989 |
| TDLo - Lowest published toxic dose | Oral | Rodent - rat | 105 mg/kg/5W (continuous) | Liver - tumors Tumorigenic - active as anti-cancer agent Tumorigenic - protects against induction of experimental tumors | CALEDQ Cancer Letters (Shannon, Ireland). (Elsevier Scientific Pub. Ireland Ltd., POB 85, Limerick, Ireland) V.1- 1975- Volume (issue)/page/year: 146,207,1999 |
| TDLo - Lowest published toxic dose | Oral | Rodent - rat | 16800 mg/kg/4W (continuous) | Lungs, Thorax, or Respiration - other changes Nutritional and Gross Metabolic - changes in metals, not otherwise specified | TXAPA9 Toxicology and Applied Pharmacology. (Academic Press, Inc., 1 E. First St., Duluth, MN 55802) V.1- 1959- Volume (issue)/page/year: 210,17,2006 |
| TDLo - | Subcutaneous | Rodent - | 41.4 mg/kg/2W | Reproductive - | HETOEA Human & |

| | | | | | |
|---|---|---|---|---|---|
| Lowest published toxic dose | | mouse | (intermittent) | Paternal Effects - spermatogenesis (incl. genetic material, sperm morphology, motility, and count) | Experimental Toxicology. (Macmillan Press Ltd., Brunel Road, Houndmills, Basingstoke, Hampshire, RG21 2XS, UK) V.9- 1990- Volume (issue)/page/year: 22,275,2003 |
| TDLo - Lowest published toxic dose | Oral | Rodent - rat | 219.6 gm/kg/183D (continuous) | Cardiac - cardiomyopathy including infarction Biochemical - Metabolism (Intermediary) - xanthine, purine or nucleotides including urate Biochemical - Metabolism (Intermediary) - other | HETOEA Human & Experimental Toxicology. (Macmillan Press Ltd., Brunel Road, Houndmills, Basingstoke, Hampshire, RG21 2XS, UK) V.9- 1990- Volume (issue)/page/year: 25,375,2006 |

**TUMORIGENIC DATA**

| Type of Test | Route of Exposure or Administration | Species/Test System | Dose Data | Toxic Effects | Reference |
|---|---|---|---|---|---|
| TDLo - Lowest published toxic dose | Intratracheal | Rodent - rat | 450 mg/kg/15W (intermittent) | Tumorigenic - equivocal tumorigenic agent by RTECS criteria Lungs, Thorax, or Respiration - tumors | SAIGBL Sangyo Igaku. Japanese Journal of Industrial Health. (Nippon Sangyo Eisei Igakkai, Kosu Eisei Bldg., 1-29-8, Shinjuku, Shinjuku-ku, Tokyo 160, Japan) V.1- 1959- Volume (issue)/page/year: 16,380,1974 |

**REVIEWS**

| | |
|---|---|
| TOXICOLOGY REVIEW | CREOH* Critical Reviews in Oncology/Hematology (Elsevier Science, P.O.Box 7247-7682,Philadelphia,PA 19170 -7682,USA OR Elsevier Science B.V.,P.O.Box 1270,1000 BG Amsterdam,The Netherlands) V. 1- 1983- Volume(issue)/page/year: 42,93,2002 |
| TOXICOLOGY REVIEW | NEJMAG New England Journal of Medicine. (Massachusetts Medical Soc., 10 Shattuck St., Boston, MA 02115) V.198- 1928- Volume(issue)/page/year: 342,186,2000 |
| TOXICOLOGY REVIEW | JTCTDW Journal of Toxicology, Clinical Toxicology. (Marcel Dekker, 270 Madison Ave., New York, NY 10016) V.19- 1982- Volume(issue)/page/year: 39,7,2001 |

| | |
|---|---|
| TOXICOLOGY REVIEW | CTOXAO Clinical Toxicology. (New York, NY) V.1-18, 1968-81. For publisher information, see JTCTDW. Volume(issue)/page/year: 39,721,2001 |
| TOXICOLOGY REVIEW | MUREAV Mutation Research. (Elsevier Science Pub. B.V., POB 211, 1000 AE Amsterdam, Netherlands) V.1- 1964- Volume(issue)/page/year: 613,103,2006 |
| TOXICOLOGY REVIEW | MUTAEX Mutagenesis. (Oxford Univ. Press, Pinkhill House, Southfield Road, Eynsham, Oxford OX8 1JJ, UK) V.1- 1986- Volume(issue)/page/year: 19,251,2004 |
| TOXICOLOGY REVIEW | TOPADD Toxicologic Pathology. (c/o Dr. F.A. de la Iglesia, Warner-Lambert Co., Pharmaceutical Research Div., POB 1047, Ann Arbor, MI 48106) V.6 (3/4)- 1978- Volume(issue)/page/year: 32(Suppl. 2),71,2004 |
| TOXICOLOGY REVIEW | MUREAV Mutation Research. (Elsevier Science Pub. B.V., POB 211, 1000 AE Amsterdam, Netherlands) V.1- 1964- Volume(issue)/page/year: 533,153,2003 |
| TOXICOLOGY REVIEW | REPTED Reproductive Toxicology. (Pergamon Press Inc., Maxwell House, Fairview Park, Elmsford, NY 10523) V.1- 1987- Volume(issue)/page/year: 23,260,2007 |
| TOXICOLOGY REVIEW | REPTED Reproductive Toxicology. (Pergamon Press Inc., Maxwell House, Fairview Park, Elmsford, NY 10523) V.1- 1987- Volume(issue)/page/year: 23,428,2007 |
| TOXICOLOGY REVIEW | HBTME* Handbook on the Toxicology of Metals (Third Edition) Edited by: Gunnar F. Nordberg, Bruce A. Fowler, Monica Nordberg and Lars T. Friberg, Elsevier Inc 2007 Volume(issue)/page/year: ,577,2007 |
| TOXICOLOGY REVIEW | HPCQA4 Human Pathology. (W.B. Saunders Co., W. Washington Sq., Philadelphia, PA 19105) V.1- 1970- Volume(issue)/page/year: 38,527,2007 |
| TOXICOLOGY REVIEW | HUTOX* Human Toxicology, Edited by: Jacques Descotes, Elsevier B.V., 1996 Volume(issue)/page/year: -,247,1996 |
| TOXICOLOGY REVIEW | HUTOX* Human Toxicology, Edited by: Jacques Descotes, Elsevier B.V., 1996 Volume(issue)/page/year: -,473,1996 |
| TOXICOLOGY REVIEW | HTOPA* Handbook of Toxicologic Pathology (Second Edition) Edited by: Wanda M. Haschek, Colin G. Rousseaux and Matthew A. Wallig, Elsevier Inc, 2002 Volume(issue)/page/year: 1,595,2002 |
| TOXICOLOGY REVIEW | MUREAV Mutation Research. (Elsevier Science Pub. B.V., POB 211, 1000 AE Amsterdam, Netherlands) V.1- 1964- Volume(issue)/page/year: 674,36,2009 |
| TOXICOLOGY REVIEW | MUREAV Mutation Research. (Elsevier Science Pub. B.V., POB 211, 1000 AE Amsterdam, Netherlands) V.1- 1964- Volume(issue)/page/year: 674,73,2009 |
| TOXICOLOGY REVIEW | PREEY* Progress in Retinal and Eye Research (Oxford Pergamon) V.13- 1994- Volume(issue)/page/year: 26,649,2007 |
| TOXICOLOGY REVIEW | MUREAV Mutation Research. (Elsevier Science Pub. B.V., POB 211, 1000 AE Amsterdam, Netherlands) V.1- 1964- Volume(issue)/page/year: 667,82,2009 |
| TOXICOLOGY REVIEW | NEUCL* Neurologic clinics (Philadelphia : Saunders) V.1- 1983- Volume (issue)/page/year: 23,485,2005 |
| TOXICOLOGY REVIEW | NTAPM* Neurotoxicology: Approaches And Methods. Louis W. Chang, William Slikker Jr. ed, Academic Press, 1995 Volume(issue)/page/year: -,753,1995 |
| TOXICOLOGY REVIEW | MUTAEX Mutagenesis. (Oxford Univ. Press, Pinkhill House, Southfield Road, Eynsham, Oxford OX8 1JJ, UK) V.1- 1986- Volume(issue)/page/year: 26,57,2011 |

**OCCUPATIONAL EXPOSURE LIMITS**

OEL-RUSSIA: TWA 10 mg/m3, JUN2003

**NIOSH STANDARDS DEVELOPMENT AND SURVEILLANCE DATA**

**NIOSH Occupational Exposure Survey Data**

NOHS - National Occupational Hazard Survey (1974)
Hazard code: 91095
No. of industries: 160
No. of facilities: 13096 (estimated)
No. of occupations: 115
No. of employees: 207672 (estimated)

NOES - National Occupational Exposure Survey (1983)
Hazard code: T0176
No. of industries: 130
No. of facilities: 13865 (estimated)
No. of occupations: 72
No. of employees: 204603 (estimated)
No. of female employees: 16574 (estimated)

NOES - National Occupational Exposure Survey (1983)
Hazard code: X3724
No. of industries: 1
No. of facilities: 122 (estimated)
No. of occupations: 2
No. of employees: 1670 (estimated)

NOES - National Occupational Exposure Survey (1983)
Hazard code: X5910
No. of industries: 1
No. of facilities: 3 (estimated)
No. of occupations: 1
No. of employees: 400 (estimated)
No. of female employees: 400 (estimated)

NOES - National Occupational Exposure Survey (1983)
Hazard code: X5996
No. of industries: 1
No. of facilities: 45 (estimated)
No. of occupations: 1
No. of employees: 179 (estimated)

NOES - National Occupational Exposure Survey (1983)
Hazard code: 91095
No. of industries: 364
No. of facilities: 103949 (estimated)
No. of occupations: 174
No. of employees: 1312446 (estimated)
No. of female employees: 116899 (estimated)

**STATUS IN U.S.**

EPA TSCA Section 8(b) CHEMICAL INVENTORY

EPA TSCA Section 8(d) unpublished health/safety studies

EPA TSCA TEST SUBMISSION (TSCATS) DATA BASE, JANUARY 2001

NIOSH Analytical Method, 1994: Metals in urine, 8310

NIOSH Analytical Method, 1994: Elements in blood or tissue, 8005

OSHA ANALYTICAL METHOD #ID121

OSHA ANALYTICAL METHOD #ID125G

**END OF RECORD**

RTECS® is provided quarterly by Accelrys, Inc., and was last updated: **October, 2012**.

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www.ccohs.ca E-mail: clientservices@ccohs.ca Fax: (905) 572-2206 Phone: (905) 572-2981
Mail: 135 Hunter Street East, Hamilton Ontario L8N 1M5

Canadian Centre for Occupational Health and Safety

RTECS Registry of Toxic Effects of Chemical Substances®

Data source: Accelrys, Inc.

## CHEMICAL IDENTIFICATION

| | |
|---|---|
| **RTECS Number** | OO9275000 |
| **Chemical Name** | Manganese |
| **CAS Registry Number** | 7439-96-5 |
| **Last Updated** | 201204 |
| **Data Items Cited** | 130 |
| **Molecular Formula** | Mn |
| **Molecular Weight** | 54.94 |
| **Wiswesser Line Notation** | MN |
| **Compound Descriptor** | Tumorigen<br>Mutagen<br>Human<br>Primary Irritant<br>Reproductive Effector |

**Synonyms/Trade Names**

Colloidal manganese
Magnacat
Mangan
Manganese
Mangan nitridovany
Tronamang

## HEALTH HAZARD DATA

### SKIN/EYE IRRITATION DATA

| Type of Test | Route of Exposure or Administration | Species/Test System | Dose Data | Reaction Severity | Reference |
|---|---|---|---|---|---|
| Standard Draize test | Administration onto the skin | Rodent - rabbit | 500 mg/24H | Mild | 28ZPAK "Sbornik Vysledku Toxixologickeho Vysetreni Latek A Pripravku," Marhold, J.V., Institut Pro Vychovu Vedoucicn Pracovniku Chemickeho Prumyclu Praha, Czechoslovakia, 1972 Volume(issue)/page/year: -,21,1972 |
| Standard Draize | Administration into the eye | Rodent - rabbit | 500 mg/24H | Mild | 28ZPAK "Sbornik Vysledku Toxixologickeho Vysetreni |

| | |
|---|---|
| test | Latek A Pripravku," Marhold, J.V., Institut Pro Vychovu Vedoucicn Pracovniku Chemickeho Prumyclu Praha, Czechoslovakia, 1972 Volume(issue)/page/year: -,21,1972 |

**ACUTE TOXICITY DATA**

| Type of Test | Route of Exposure or Administration | Species/Test System | Dose Data | Toxic Effects | Reference |
|---|---|---|---|---|---|
| TCLo - Lowest published toxic concentration | Inhalation | Human - man | 2300 ug/m3 | Brain and Coverings - other degenerative changes Behavioral - changes in motor activity (specific assay) Behavioral - muscle weakness | AIHAAP American Industrial Hygiene Association Journal. (AIHA, 475 Wolf Ledges Pkwy., Akron, OH 44311) V.19- 1958- Volume (issue)/page/year: 27,454,1966 |
| LD50 - Lethal dose, 50 percent kill | Oral | Rodent - rat | 9 gm/kg | Details of toxic effects not reported other than lethal dose value | 28ZPAK "Sbornik Vysledku Toxixologickeho Vysetreni Latek A Pripravku," Marhold, J.V., Institut Pro Vychovu Vedoucicn Pracovniku Chemickeho Prumyclu Praha, Czechoslovakia, 1972 Volume (issue)/page/year: -,21,1972 |
| LC50 - Lethal concentration, 50 percent kill | Chemical added to tank with water (dissolved in water) | Invertebrate - daphnia | 5700 ug/L/48H | Details of toxic effects not reported other than lethal dose value | TIVIEQ Toxicology In Vitro. (Pergamon Press Inc., Maxwell House, Fairview Park, Elmsford, NY 10523) V.1- 1987- Volume (issue)/page/year: 31,125,1995 |

**OTHER MULTIPLE DOSE TOXICITY DATA**

| Type of Test | Route of Exposure or Administration | Species/Test System | Dose Data | Toxic Effects | Reference |
|---|---|---|---|---|---|
| TCLo - | Inhalation | Rodent - rat | 3709 | Brain and | TOXID9 |

| | | | | | |
|---|---|---|---|---|---|
| Lowest published toxic concentration | | | mg/m3/6H/13W (intermittent) | Coverings - other degenerative changes Behavioral - changes in motor activity (specific assay) Lungs, Thorax, or Respiration - other changes | Toxicologist. (Soc. of Toxicology, Inc., 475 Wolf Ledge Parkway, Akron, OH 44311) V.1- 1981- Volume (issue)/page/year: 54,85,2000 |
| TDLo - Lowest published toxic dose | Intraperitoneal | Rodent - rat | 180 mg/kg/30D (intermittent) | Brain and Coverings - other degenerative changes Blood - changes in serum composition (e.g. TP, bilirubin, cholesterol) Nutritional and Gross Metabolic - changes in metals, not otherwise specified | TOLED5 Toxicology Letters. (Elsevier Science Pub. B.V., POB 211, 1000 AE Amsterdam, Netherlands) V.1- 1977- Volume (issue)/page/year: 7,217,1981 |
| TCLo - Lowest published toxic concentration | Inhalation | Human - man | 210 ug/m3/5Y (intermittent) | Endocrine - other changes | ACLSCP Annals of Clinical and Laboratory Science. (1833 Delancey Pl., Philadelphia, PA 19103) V.1- 1971- Volume (issue)/page/year: 26,10,1996 |
| TCLo - Lowest published toxic concentration | Inhalation | Rodent - rat | 0.3 mg/m3/5H/26W (intermittent) | Lungs, Thorax, or Respiration - fibrosis (interstitial) Immunological Including Allergic - decrease in cellular immune response | VCVN5* "Vrednie chemichescie veshestva. Neorganicheskie soedinenia elementov V-VII groopp" (Hazardous substances. Inornanic substances containing V-VII group elements), Bandman A.L. et al., Chimia, 1989. Volume (issue)/page/year: -,412,1989 |
| TCLo - Lowest published toxic concentration | Inhalation | Primate - monkey | 0.3 mg/m3/5H/26W (intermittent) | Lungs, Thorax, or Respiration - fibrosis (interstitial) Immunological Including Allergic - decrease in cellular immune response | VCVN5* "Vrednie chemichescie veshestva. Neorganicheskie soedinenia elementov V-VII groopp" (Hazardous substances. Inornanic substances containing V-VII group elements), Bandman A.L. et al., Chimia, 1989. |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | Volume (issue)/page/year: -,412,1989 |
| TCLo - Lowest published toxic concentration | Inhalation | Rodent - rat | 0.7 mg/m3/24H/22W (continuous) | Lungs, Thorax, or Respiration - fibrosis (interstitial) Immunological Including Allergic - decrease in cellular immune response | VCVN5* "Vrednie chemichescie veshestva. Neorganicheskie soedinenia elementov V-VII groopp" (Hazardous substances. Inornanic substances containing V-VII group elements), Bandman A.L. et al., Chimia, 1989. Volume (issue)/page/year: -,412,1989 |
| TCLo - Lowest published toxic concentration | Inhalation | Rodent - mouse | 0.7 mg/m3/24H/22W (continuous) | Lungs, Thorax, or Respiration - fibrosis (interstitial) Immunological Including Allergic - decrease in cellular immune response | VCVN5* "Vrednie chemichescie veshestva. Neorganicheskie soedinenia elementov V-VII groopp" (Hazardous substances. Inornanic substances containing V-VII group elements), Bandman A.L. et al., Chimia, 1989. Volume (issue)/page/year: -,412,1989 |
| TCLo - Lowest published toxic concentration | Inhalation | Human | 250 mg/m3/1Y (intermittent) | Peripheral Nerve and Sensation - sensory change involving peripheral nerve Behavioral - irritability Lungs, Thorax, or Respiration - other changes | VCVN5* "Vrednie chemichescie veshestva. Neorganicheskie soedinenia elementov V-VII groopp" (Hazardous substances. Inornanic substances containing V-VII group elements), Bandman A.L. et al., Chimia, 1989. Volume (issue)/page/year: -,413,1989 |
| TCLo - Lowest published toxic concentration | Inhalation | Human | 0.5 mg/m3/39W (intermittent) | Brain and Coverings - other degenerative changes Peripheral Nerve and Sensation - sensory change involving | VCVN5* "Vrednie chemichescie veshestva. Neorganicheskie soedinenia elementov V-VII groopp" (Hazardous substances. |

| | | | | | |
|---|---|---|---|---|---|
| | | | | peripheral nerve Behavioral - irritability | Inornanic substances containing V-VII group elements), Bandman A.L. et al., Chimia, 1989. Volume (issue)/page/year: -,413,1989 |
| TDLo - Lowest published toxic dose | Oral | Rodent - rat | 200 mg/kg/20D (intermittent) | Reproductive - Specific Developmental Abnormalities - Central Nervous System Reproductive - Effects on Newborn - biochemical and metabolic Reproductive - Effects on Newborn - behavioral | NRTXDN Neurotoxicology. (Intox Press, Inc., POB 34075, Little Rock, AR 72203) V.1- 1979- Volume (issue)/page/year: 23,645,2002 |
| TDLo - Lowest published toxic dose | Intraperitoneal | Rodent - rat | 216 mg/kg/15W (intermittent) | Biochemical - Neurotransmitters or modulators (putative) - dopamine at other sites | TOXID9 Toxicologist. (Soc. of Toxicology, Inc., 475 Wolf Ledge Parkway, Akron, OH 44311) V.1- 1981- Volume (issue)/page/year: 44,122,2005 |
| TDLo - Lowest published toxic dose | Intraperitoneal | Rodent - rat | 144 mg/kg/5W (intermittent) | Behavioral - alteration of classical conditioning Biochemical - Neurotransmitters or modulators (putative) - dopamine at other sites | TOXID9 Toxicologist. (Soc. of Toxicology, Inc., 475 Wolf Ledge Parkway, Akron, OH 44311) V.1- 1981- Volume (issue)/page/year: 44,122,2005 |
| TDLo - Lowest published toxic dose | Unreported | Rodent - rat | 24 mg/kg/5W (intermittent) | Brain and Coverings - other degenerative changes Behavioral - ataxia Biochemical - Metabolism (Intermediary) - amino acids (including renal excretion) | TOXID9 Toxicologist. (Soc. of Toxicology, Inc., 475 Wolf Ledge Parkway, Akron, OH 44311) V.1- 1981- Volume (issue)/page/year: 78,82,2004 |
| TDLo - Lowest published toxic dose | Unreported | Rodent - rat | 72 mg/kg/5W (intermittent) | Behavioral - changes in motor activity (specific assay) | TOXID9 Toxicologist. (Soc. of Toxicology, Inc., 475 Wolf Ledge Parkway, Akron, OH 44311) V.1- 1981- Volume (issue)/page/year: 78,82,2004 |
| TDLo - | Intraperitoneal | Rodent - rat | 57.6 mg/kg/4W | Brain and | TOXID9 |

| | | | | | |
|---|---|---|---|---|---|
| Lowest published toxic dose | | | (intermittent) | Coverings - other degenerative changes Behavioral - changes in psychophysiological tests | Toxicologist. (Soc. of Toxicology, Inc., 475 Wolf Ledge Parkway, Akron, OH 44311) V.1- 1981- Volume (issue)/page/year: 66,205,2002 |
| - | Inhalation | Rodent - rat | 0.71 mg/m3/2H/10D (intermittent) | Biochemical - Enzyme inhibition, induction, or change in blood or tissue levels - other oxidoreductases Biochemical - Metabolism (Intermediary) - other proteins | NRTXDN Neurotoxicology. (Intox Press, Inc., POB 34075, Little Rock, AR 72203) V.1- 1979- Volume (issue)/page/year: 27,395,2006 |
| - | Oral | Rodent - rat | 5.25 mg/kg/21D (intermittent) | Behavioral - changes in motor activity (specific assay) Nutritional and Gross Metabolic - weight loss or decreased weight gain Biochemical - Neurotransmitters or modulators (putative) - dopamine in striatum | NETEEC Neurotoxicology and Teratology. (Pergamon Press Inc., Maxwell House, Fairview Park, Elmsford, NY 10523) V.9- 1987- Volume (issue)/page/year: 28,323,2006 |
| TDLo - Lowest published toxic dose | Oral | Rodent - rat | 185 mg/kg/37D (continuous) | Nutritional and Gross Metabolic - changes in iron Biochemical - Metabolism (Intermediary) - Plasma proteins not involving coagulation | TOSCF2 Toxicological Sciences (Oxford University Press, 6277 Sea Harbor Drive, Orlando, FL 32887 ) V. 41, Jan. 1998- Volume (issue)/page/year: 92,516,2006 |
| TDLo - Lowest published toxic dose | Inhalation | Human | >0.1 mg/kg/1Y (intermittent) | Behavioral - changes in motor activity (specific assay) | TOXID9 Toxicologist. (Soc. of Toxicology, Inc., 475 Wolf Ledge Parkway, Akron, OH 44311) V.1- 1981- Volume (issue)/page/year: -,144,2008 |

**TUMORIGENIC DATA**

| Type of Test | Route of Exposure or Administration | Species/Test System | Dose Data | Toxic Effects | Reference |
|---|---|---|---|---|---|
| TDLo - Lowest published | Intramuscular | Rodent - rat | 400 mg/kg/1Y (intermittent) | Tumorigenic - equivocal tumorigenic | NCIUS* Progress Report for Contract No. PH-43-64-886, |

| | | | | | | |
|---|---|---|---|---|---|---|
| toxic dose | | | | | agent by RTECS criteria Tumorigenic - tumors at site of application | Submitted to the National Cancer Institute by The Institute of Chemical Biology, University of San Francisco. (San Francisco, CA 94117) Volume (issue)/page/year: PH43-64-886 |

**REPRODUCTIVE DATA**

| Type of Test | Route of Exposure or Administration | Species/Test System | Dose Data | Sex/Duration | Toxic Effects | Reference |
|---|---|---|---|---|---|---|
| TDLo - Lowest published toxic dose | Oral | Rodent - rat | 50 mg/kg | lactating female 20 day(s) post-birth | Reproductive - Specific Developmental Abnormalities - Central Nervous System Reproductive - Effects on Newborn - biochemical and metabolic Reproductive - Effects on Newborn - behavioral | NRTXDN Neurotoxicology. (Intox Press, Inc., POB 34075, Little Rock, AR 72203) V.1- 1979- Volume (issue)/page/year: 23,635,2002 |
| TDLo - Lowest published toxic dose | Oral | Rodent - mouse | 322.5 mg/kg | male 43 day(s) pre-mating | Reproductive - Paternal Effects - spermatogenesis (incl. genetic material, sperm morphology, motility, and count) | REPTED Reproductive Toxicology. (Pergamon Press Inc., Maxwell House, Fairview Park, Elmsford, NY 10523) V.1- 1987- Volume (issue)/page/year: 17,547,2003 |
| TDLo - Lowest published toxic dose | Oral | Rodent - mouse | 1290 mg/kg | male 43 day(s) pre-mating | Reproductive - Paternal Effects - testes, epididymis, sperm duct | REPTED Reproductive Toxicology. (Pergamon Press Inc., Maxwell House, Fairview Park, Elmsford, NY 10523) V.1- 1987- Volume (issue)/page/year: 17,547,2003 |
| TCLo - Lowest published toxic concentration | Inhalation | Rodent - rat | 0.71 mg/m3 | female 15-16 day(s) after conception | Reproductive - Effects on Newborn - biochemical and metabolic | NRTXDN Neurotoxicology. (Intox Press, Inc., POB 34075, Little Rock, AR 72203) V.1- 1979- Volume |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | (issue)/page/year: 27,395,2006 |
| TCLo - Lowest published toxic concentration | Inhalation | Rodent - rat | 0.71 mg/m3 | multigenerations | Reproductive - Effects on Newborn - biochemical and metabolic | NRTXDN Neurotoxicology. (Intox Press, Inc., POB 34075, Little Rock, AR 72203) V.1- 1979- Volume (issue)/page/year: 27,395,2006 |
| TDLo - Lowest published toxic dose | Oral | Rodent - rat | 90 mg/kg | lactating female 18 day(s) post-birth | Reproductive - Effects on Newborn - growth statistics (e.g.%, reduced weight gain) Reproductive - Effects on Newborn - biochemical and metabolic Reproductive - Effects on Newborn - other postnatal measures or effects | TOSCF2 Toxicological Sciences (Oxford University Press, 6277 Sea Harbor Drive, Orlando, FL 32887 ) V. 41, Jan. 1998- Volume (issue)/page/year: 92,516,2006 |

**MUTATION DATA**

| Type of Test | Route of Exposure or Administration | Species/Test System | Dose Data | Reference |
|---|---|---|---|---|
| Dominant lethal test | Intraperitoneal | Rodent - rat | 25 mg/kg | VCVN5* "Vrednie chemichescie veshestva. Neorganicheskie soedinenia elementov V-VII groopp" (Hazardous substances. Inornanic substances containing V-VII group elements), Bandman A.L. et al., Chimia, 1989. Volume (issue)/page/year: -,413,1989 |

**REVIEWS**

| | |
|---|---|
| ACGIH TLV-TWA 0.2 mg/m3 | DTLVS* The Threshold Limit Values (TLVs) and Biological Exposure Indices (BEIs) booklet issues by American Conference of Governmental Industrial Hygienists (ACGIH), Cincinnati, OH, 1996 Volume(issue)/page/year: TLV/BEI,2010 |
| TOXICOLOGY REVIEW | BCPCA6 Biochemical Pharmacology. (Pergamon Press Inc., Maxwell House, Fairview Park, Elmsford, NY 10523) V.1- 1958- Volume(issue)/page/year: 66,1,2003 |
| TOXICOLOGY REVIEW | ACLSCP Annals of Clinical and Laboratory Science. (1833 Delancey Pl., Philadelphia, PA 19103) V.1- 1971- Volume(issue)/page/year: 4,487,1974 |
| TOXICOLOGY REVIEW | ADTEAS Advances in Teratology. (New York, NY) V.1-5, 1966-72. Discontinued. Volume(issue)/page/year: 5,51,1972 |
| TOXICOLOGY REVIEW | FOREAE Food Research. (Champaign, IL) V.1-25, 1936-60. For publisher information, see JFDSAZ. Volume(issue)/page/year: 7,313,1942 |

| | |
|---|---|
| TOXICOLOGY REVIEW | KOTTAM Kogai to Taisaku. Journal of Environmental Pollution Control. (Kogai Taisaku Gijutsu Dokokai, Shuwa-Akasaka Bldg., 9-1-244, Akasaka, Minato-ku, Tokyo 107, Japan) V.1- 1965- Volume(issue)/page/year: 11,1300,1975 |
| TOXICOLOGY REVIEW | 85DHAX "Medical and Biologic Effects of Environmental Pollutants Series," Washington, DC, National Academy of Sciences, 1972-77 Volume (issue)/page/year: Mn,1,1973 |
| TOXICOLOGY REVIEW | PEXTAR Progress in Experimental Tumor Research. (S. Karger AG, Postfach CH-4009 Basel, Switzerland) V.1- 1960- Volume (issue)/page/year: 12,102,1969 |
| TOXICOLOGY REVIEW | IMSUAI Industrial Medicine and Surgery. (Northbrook, IL) V.18-42, 1949-73. For publisher information, see IOHSA5. Volume(issue)/page/year: 24,1,1955 |
| TOXICOLOGY REVIEW | CREOH* Critical Reviews in Oncology/Hematology (Elsevier Science, P.O.Box 7247-7682,Philadelphia,PA 19170 -7682,USA OR Elsevier Science B.V.,P.O.Box 1270,1000 BG Amsterdam,The Netherlands) V. 1- 1983- Volume(issue)/page/year: 42,25,2002 |
| TOXICOLOGY REVIEW | TOLED5 Toxicology Letters. (Elsevier Science Pub. B.V., POB 211, 1000 AE Amsterdam, Netherlands) V.1- 1977- Volume(issue)/page/year: 134,17,2002 |
| TOXICOLOGY REVIEW | MUREAV Mutation Research. (Elsevier Science Pub. B.V., POB 211, 1000 AE Amsterdam, Netherlands) V.1- 1964- Volume(issue)/page/year: 613,103,2006 |
| TOXICOLOGY REVIEW | NRTXDN Neurotoxicology. (Intox Press, Inc., POB 34075, Little Rock, AR 72203) V.1- 1979- Volume(issue)/page/year: 27,147,2006 |
| TOXICOLOGY REVIEW | NRTXDN Neurotoxicology. (Intox Press, Inc., POB 34075, Little Rock, AR 72203) V.1- 1979- Volume(issue)/page/year: 27,304,2006 |
| TOXICOLOGY REVIEW | NRTXDN Neurotoxicology. (Intox Press, Inc., POB 34075, Little Rock, AR 72203) V.1- 1979- Volume(issue)/page/year: 27,315,2006 |
| TOXICOLOGY REVIEW | NRTXDN Neurotoxicology. (Intox Press, Inc., POB 34075, Little Rock, AR 72203) V.1- 1979- Volume(issue)/page/year: 27,333,2006 |
| TOXICOLOGY REVIEW | NRTXDN Neurotoxicology. (Intox Press, Inc., POB 34075, Little Rock, AR 72203) V.1- 1979- Volume(issue)/page/year: 27,340,2006 |
| TOXICOLOGY REVIEW | NRTXDN Neurotoxicology. (Intox Press, Inc., POB 34075, Little Rock, AR 72203) V.1- 1979- Volume(issue)/page/year: 27,347,2006 |
| TOXICOLOGY REVIEW | NRTXDN Neurotoxicology. (Intox Press, Inc., POB 34075, Little Rock, AR 72203) V.1- 1979- Volume(issue)/page/year: 27,350,2006 |
| TOXICOLOGY REVIEW | NRTXDN Neurotoxicology. (Intox Press, Inc., POB 34075, Little Rock, AR 72203) V.1- 1979- Volume(issue)/page/year: 27,362,2006 |
| TOXICOLOGY REVIEW | NRTXDN Neurotoxicology. (Intox Press, Inc., POB 34075, Little Rock, AR 72203) V.1- 1979- Volume(issue)/page/year: 27,369,2006 |
| TOXICOLOGY REVIEW | NRTXDN Neurotoxicology. (Intox Press, Inc., POB 34075, Little Rock, AR 72203) V.1- 1979- Volume(issue)/page/year: 27,429,2006 |
| TOXICOLOGY REVIEW | MUREAV Mutation Research. (Elsevier Science Pub. B.V., POB 211, 1000 AE Amsterdam, Netherlands) V.1- 1964- Volume(issue)/page/year: 613,76,2006 |
| TOXICOLOGY REVIEW | REPTED Reproductive Toxicology. (Pergamon Press Inc., Maxwell House, Fairview Park, Elmsford, NY 10523) V.1- 1987- Volume(issue)/page/year: 23,260,2007 |
| TOXICOLOGY REVIEW | ITODC* Immunotoxicology of Drugs and Chemicals: an Experimental and Clinical Approach. Volume I: Principles and Methods of Immunotoxicology. Edited by: J. Descotes, Elsevier B.V., 2009 Volume(issue)/page/year: -,355,2004 |
| TOXICOLOGY REVIEW | HUTOX* Human Toxicology, Edited by: Jacques Descotes, Elsevier B.V., 1996 Volume(issue)/page/year: -,515,1996 |

| | |
|---|---|
| TOXICOLOGY REVIEW | HTOPA* Handbook of Toxicologic Pathology (Second Edition) Edited by: Wanda M. Haschek, Colin G. Rousseaux and Matthew A. Wallig, Elsevier Inc, 2002 Volume(issue)/page/year: 1,595,2002 |
| TOXICOLOGY REVIEW | MUREAV Mutation Research. (Elsevier Science Pub. B.V., POB 211, 1000 AE Amsterdam, Netherlands) V.1- 1964- Volume(issue)/page/year: 674,73,2009 |
| TOXICOLOGY REVIEW | MUREAV Mutation Research. (Elsevier Science Pub. B.V., POB 211, 1000 AE Amsterdam, Netherlands) V.1- 1964- Volume(issue)/page/year: 674,137,2009 |
| TOXICOLOGY REVIEW | PTPAD4 Pharmacology and Therapeutics, Part A: Chemotherapy, Toxicology and Metabolic Inhibitors. (Oxford, UK) V.1-2, 1976-78. For publisher information, see PHTHDT. Volume(issue)/page/year: 113,229,2007 |
| TOXICOLOGY REVIEW | MUREAV Mutation Research. (Elsevier Science Pub. B.V., POB 211, 1000 AE Amsterdam, Netherlands) V.1- 1964- Volume(issue)/page/year: 667,82,2009 |
| TOXICOLOGY REVIEW | NEUCL* Neurologic clinics (Philadelphia : Saunders) V.1- 1983- Volume (issue)/page/year: 23,485,2005 |
| TOXICOLOGY REVIEW | NETEEC Neurotoxicology and Teratology. (Pergamon Press Inc., Maxwell House, Fairview Park, Elmsford, NY 10523) V.9- 1987- Volume (issue)/page/year: 32,16,2010 |
| TOXICOLOGY REVIEW | NTAPM* Neurotoxicology: Approaches And Methods. Louis W. Chang, William Slikker Jr. ed, Academic Press, 1995 Volume(issue)/page/year: -,265,1995 |
| TOXICOLOGY REVIEW | NTAPM* Neurotoxicology: Approaches And Methods. Louis W. Chang, William Slikker Jr. ed, Academic Press, 1995 Volume(issue)/page/year: -,617,1995 |
| TOXICOLOGY REVIEW | NTAPM* Neurotoxicology: Approaches And Methods. Louis W. Chang, William Slikker Jr. ed, Academic Press, 1995 Volume(issue)/page/year: -,629,1995 |
| TOXICOLOGY REVIEW | NTAPM* Neurotoxicology: Approaches And Methods. Louis W. Chang, William Slikker Jr. ed, Academic Press, 1995 Volume(issue)/page/year: -,689,1995 |
| TOXICOLOGY REVIEW | NTAPM* Neurotoxicology: Approaches And Methods. Louis W. Chang, William Slikker Jr. ed, Academic Press, 1995 Volume(issue)/page/year: -,711,1995 |
| TOXICOLOGY REVIEW | NTAPM* Neurotoxicology: Approaches And Methods. Louis W. Chang, William Slikker Jr. ed, Academic Press, 1995 Volume(issue)/page/year: -,727,1995 |
| TOXICOLOGY REVIEW | NTAPM* Neurotoxicology: Approaches And Methods. Louis W. Chang, William Slikker Jr. ed, Academic Press, 1995 Volume(issue)/page/year: -,753,1995 |
| TOXICOLOGY REVIEW | NBREV* Neuroscience and biobehavioral reviews (New York Ny : Pergamon Press) V.2- 1978- Volume(issue)/page/year: 15,333,1991 |
| TOXICOLOGY REVIEW | NRTXDN Neurotoxicology. (Intox Press, Inc., POB 34075, Little Rock, AR 72203) V.1- 1979- Volume(issue)/page/year: 31,555,2010 |

**U.S. STANDARDS AND REGULATIONS**

MSHA STANDARD:air-CL 5 mg/m3
DTLVS* The Threshold Limit Values (TLVs) and Biological Exposure Indices (BEIs) booklet issues by American Conference of Governmental Industrial Hygienists (ACGIH), Cincinnati, OH, 1996 Volume(issue)/page/year: 3,149,1971

OSHA PEL (Gen Indu):CL 5 mg(Mn)/m3, fume
CFRGBR Code of Federal Regulations. (U.S. Government Printing Office, Supt. of

Documents, Washington, DC 20402) Volume(issue)/page/year: 29,1910.1000,1994

OSHA PEL (Construc):CL 5 mg(Mn)/m3, fume
CFRGBR Code of Federal Regulations. (U.S. Government Printing Office, Supt. of Documents, Washington, DC 20402) Volume(issue)/page/year: 29,1926.55,1994

OSHA PEL (Shipyard):CL 5 mg(Mn)/m3, fume
CFRGBR Code of Federal Regulations. (U.S. Government Printing Office, Supt. of Documents, Washington, DC 20402) Volume(issue)/page/year: 29,1915.1000,1993

OSHA PEL (Fed Cont):CL 5 mg(Mn)/m3, fume
CFRGBR Code of Federal Regulations. (U.S. Government Printing Office, Supt. of Documents, Washington, DC 20402) Volume(issue)/page/year: 41,50-204.50,1994

**OCCUPATIONAL EXPOSURE LIMITS**

OEL-ARAB Republic of Egypt: TWA 5 mg/m3, JAN1993

OEL-AUSTRALIA: TWA 1 mg/m3 (dust), JUL2008

OEL-AUSTRALIA: TWA 1 mg/m3, STEL 3 mg/m3 (fume), JUL2008

OEL-BELGIUM: TWA 0.2 mg/m3, MAR2002

OEL-DENMARK: TWA 0.2 mg(Mn)/m3 (fume), MAY2011

OEL-DENMARK: TWA 0.2 mg/m3 (dust), MAY2011

OEL-DENMARK: TWA 0.1 mg/m3 (respirable), MAY2011

OEL-DENMARK: TWA 0.1 mg/m3, MAY2011

OEL-FINLAND: TWA 0.2 mg/m3, inhal. dust, NOV2011

OEL-FINLAND: TWA 0.1 mg/m3, resp. dust, NOV2011

OEL-FRANCE: VME 1 mg/m3 (fume), FEB2006

OEL-GERMANY: MAK 0.5 mg(Mn)/m3 (inhalable), 2005

OEL-GERMANY: MAK 0.5 mg/m3 (inhalable), 2005

OEL-HUNGARY: TWA 5 mg/m3, STEL 20 mg/m3, SEP2000

OEL-ICELAND: TWA 1 mg/m3 (resp. dust), NOV2011

OEL-JAPAN: OEL 0.2 mg/m3, MAY2009

OEL-KOREA: TWA 1 mg/m3, STEL 3 mg/m3 (fume), 2006

OEL-KOREA: TWA 5 mg/m3 (dust), 2006

OEL-MEXICO: TWA 0.2 mg(Mn)/m3, 2004

OEL-MEXICO: TWA 0.2 mg(Mn)/m3;STEL 3 mg(Mn)/m3, 2004

OEL-MEXICO: TWA 0.2 mg/m3, 2004

OEL-MEXICO: TWA 1 mg(Mn)/m3 (fume), 2004

OEL-THE NETHERLANDS: MAC-TGG 1 mg/m3, 2003

OEL-NEW ZEALAND: TWA 1 mg/m3 (dust), JAN2002

OEL-NEW ZEALAND: TWA 1 mg/m3; STEL 3 mg/m3 (fume), JAN2002

OEL-NORWAY: TWA 1 mg/m3, JAN1999

OEL-PERU: TWA 0,2 mg/m3, JUL2005

OEL-THE PHILIPPINES: TWA 5 mg/m3, JAN1993

OEL-RUSSIA: TWA 0.1 mg/m3, STEL 0.6 mg/m3, JUN2003

OEL-SWEDEN: TWA 0.2 mg/m3, (total dust);TWA 0.1 mg/m3, (resp. dust), JUN2005

OEL-SWITZERLAND: MAK-W 0.5 mg/m3, DEC2006

OEL-THAILAND: TWA 5 mg/m3, JAN1993

OEL-TURKEY: TWA 5 mg/m3 (fume), JAN1993

OEL-UNITED KINGDOM: TWA 0.5 mg/m3, OCT2007

OEL IN ARGENTINA, BULGARIA, COLOMBIA, JORDAN check ACGIH TLV;

OEL IN SINGAPORE, VIETNAM check ACGIH TLV

## NIOSH STANDARDS DEVELOPMENT AND SURVEILLANCE DATA

### NIOSH Recommended Exposure Level (Rel)

NIOSH REL TO MANGANESE COMPDS (as Mn)-air:TWA 1 mg/m3;STEL 3 mg/m3
NIOSH* National Institute of Occupational Safety and Health, U.S. Dept. of Health, Education, and Welfare, Reports and Memoranda. Volume(issue)/page/year: DHHS #92-100,1992

### NIOSH Occupational Exposure Survey Data

NOHS - National Occupational Hazard Survey (1974)
Hazard code: 44000
No. of industries: 29
No. of facilities: 1963 (estimated)
No. of occupations: 53
No. of employees: 19787 (estimated)

NOES - National Occupational Exposure Survey (1983)
Hazard code: X5920

No. of industries: 2
No. of facilities: 26 (estimated)
No. of occupations: 4
No. of employees: 305 (estimated)
No. of female employees: 71 (estimated)

NOES - National Occupational Exposure Survey (1983)
Hazard code: X5992
No. of industries: 9
No. of facilities: 235 (estimated)
No. of occupations: 9
No. of employees: 4560 (estimated)
No. of female employees: 12 (estimated)

NOES - National Occupational Exposure Survey (1983)
Hazard code: 44000
No. of industries: 316
No. of facilities: 66404 (estimated)
No. of occupations: 125
No. of employees: 756403 (estimated)
No. of female employees: 15912 (estimated)

**STATUS IN U.S.**

ATSDR TOXICOLOGY PROFILE
NTIS** National Technical Information Service. (Springfield, VA 22161) Formerly U.S. Clearinghouse for Scientific & Technical Information. Volume(issue)/page/year: PB/2000/108025

EPA TSCA Section 8(b) CHEMICAL INVENTORY

EPA TSCA Section 8(d) unpublished health/safety studies

On EPA IRIS database

EPA TSCA TEST SUBMISSION (TSCATS) DATA BASE, JANUARY 2001

NIOSH Analytical Method, 1994: Elements by ICP, 7300

NIOSH Analytical Method, 1994: Elements in blood or tissue, 8005

NIOSH Analytical Method, 1994: Metals in urine, 8310

OSHA ANALYTICAL METHOD #ID-125G

OSHA ANALYTICAL METHOD #ID121

**END OF RECORD**

RTECS® is provided quarterly by Accelrys, Inc., and was last updated: **October, 2012.**

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Canadian Centre for Occupational Health and Safety

RTECS Registry of Toxic Effects of Chemical Substances®

Data source: Accelrys, Inc.

## CHEMICAL IDENTIFICATION

| | |
|---|---|
| **RTECS Number** | EB2600000 |
| **Chemical Name** | Bismuth |
| **CAS Registry Number** | 7440-69-9 |
| **Last Updated** | 201103 |
| **Data Items Cited** | 18 |
| **Molecular Formula** | Bi |
| **Molecular Weight** | 208.98 |
| **Compound Descriptor** | Human |

**Synonyms/Trade Names**

Bismuth-209

## HEALTH HAZARD DATA

## ACUTE TOXICITY DATA

| Type of Test | Route of Exposure or Administration | Species/Test System | Dose Data | Toxic Effects | Reference |
|---|---|---|---|---|---|
| LDLo - Lowest published lethal dose | Unreported | Human - man | 221 mg/kg | Details of toxic effects not reported other than lethal dose value | 85DCAI "Poisoning; Toxicology, Symptoms, Treatments," 2nd ed., Arena, J.M., Springfield, IL, C.C. Thomas, 1970 Volume (issue)/page/year: 2,73,1970 |
| LD50 - Lethal dose, 50 percent kill | Oral | Rodent - mouse | 10 gm/kg | Details of toxic effects not reported other than lethal dose value | GTPZAB Gigiena Truda i Professional'nye Zabolevaniya. Labor Hygiene and Occupational Diseases. (V/O Mezhdunarodnaya Kniga, 113095 Moscow, USSR) |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | V.1-36, 1957-1992. For publisher information, see MTPEEI Volume (issue)/page/year: 30(6),16,1986 |
| LDLo - Lowest published lethal dose | Unreported | Rodent - rabbit | 535 mg/kg | Behavioral - food intake (animal) Behavioral - coma Kidney/Ureter/Bladder - urine volume decreased | JPETAB Journal of Pharmacology and Experimental Therapeutics. (Williams & Wilkins Co., 428 E. Preston St., Baltimore, MD 21202) V.1-1909/10- Volume (issue)/page/year: 28,121,1926 |
| LDLo - Lowest published lethal dose | Intraperitoneal | Rodent - mouse | 4000 mg/kg | Brain and Coverings - other degenerative changes Sense Organs and Special Senses (Ear) - changes in vestibular functions Behavioral - muscle contraction or spasticity | VCVN5* "Vrednie chemichescie veshestva. Neorganicheskie soedinenia elementov V-VII groopp" (Hazardous substances. Inornanic substances containing V-VII group elements), Bandman A.L. et al., Chimia, 1989. Volume (issue)/page/year: -,113,1993 |
| LD50 - Lethal dose, 50 percent kill | Oral | Rodent - rat | 5 gm/kg | Details of toxic effects not reported other than lethal dose value | ENTOX* Encyclopedia of Toxicology: Reference Book, Elsevier, 2005 Volume (issue)/page/year: -,312,2005 |

**REVIEWS**

| | |
|---|---|
| TOXICOLOGY REVIEW | ADSYAF Archives of Dermatology and Syphilology. (Chicago, IL) V.1-62, 1920-50. For publisher information, see ARDEAC. Volume (issue)/page/year: 26,797,1932 |
| TOXICOLOGY REVIEW | PTPAD4 Pharmacology and Therapeutics, Part A: Chemotherapy, Toxicology and Metabolic Inhibitors. (Oxford, UK) V.1-2, 1976-78. For publisher information, see PHTHDT. Volume(issue)/page/year: 1,153,1976 |
| TOXICOLOGY REVIEW | ENTOX* Encyclopedia of Toxicology: Reference Book, Elsevier, 2005 Volume(issue)/page/year: -,312,2005 |
| TOXICOLOGY REVIEW | HBTME* Handbook on the Toxicology of Metals (Third Edition) Edited by: Gunnar F. Nordberg, Bruce A. Fowler, Monica Nordberg and Lars T. Friberg, Elsevier Inc 2007 Volume(issue)/page/year: ,433,2007 |
| TOXICOLOGY | HTOPA* Handbook of Toxicologic Pathology (Second Edition) Edited by: |

| | |
|---|---|
| REVIEW | Wanda M. Haschek, Colin G. Rousseaux and Matthew A. Wallig, Elsevier Inc, 2002 Volume(issue)/page/year: 1,701,2002 |
| TOXICOLOGY REVIEW | BPRCG* Best Practice & Research. Clinical gastroenterology (Amsterdam : Elsevier) V.15- 2001- Volume(issue)/page/year: 21,849,2007 |
| TOXICOLOGY REVIEW | NTAPM* Neurotoxicology: Approaches And Methods. Louis W. Chang, William Slikker Jr. ed, Academic Press, 1995 Volume(issue)/page/year: -,629,1995 |

**OCCUPATIONAL EXPOSURE LIMITS**

OEL-RUSSIA: STEL 0.5 mg/m3, JUN2003

**NIOSH STANDARDS DEVELOPMENT AND SURVEILLANCE DATA**

**NIOSH Occupational Exposure Survey Data**

NOHS - National Occupational Hazard Survey (1974)
Hazard code: 12783
No. of industries: 11
No. of facilities: 365 (estimated)
No. of occupations: 35
No. of employees: 20336 (estimated)

NOES - National Occupational Exposure Survey (1983)
Hazard code: 12783
No. of industries: 14
No. of facilities: 451 (estimated)
No. of occupations: 34
No. of employees: 14666 (estimated)
No. of female employees: 4387 (estimated)

**STATUS IN U.S.**

EPA TSCA Section 8(b) CHEMICAL INVENTORY

EPA TSCA TEST SUBMISSION (TSCATS) DATA BASE, JANUARY 2001

OSHA ANALYTICAL METHOD #ID121

**END OF RECORD**

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Canadian Centre for Occupational Health and Safety

RTECS Registry of Toxic Effects of Chemical Substances®

Data source: Accelrys, Inc.

## CHEMICAL IDENTIFICATION

| | |
|---|---|
| **RTECS Number** | GF8750000 |
| **Chemical Name** | Cobalt |
| **CAS Registry Number** | 7440-48-4 |
| **Last Updated** | 201204 |
| **Data Items Cited** | 108 |
| **Molecular Formula** | Co |
| **Molecular Weight** | 58.93 |
| **Wiswesser Line Notation** | CO |
| **Compound Descriptor** | Tumorigen<br>Mutagen<br>Human |

**Synonyms/Trade Names**

Aquacat
C.I. 77320
Cobalt
Cobalt metallic
Cobalt-59
Kobalt
NCI-C60311
Super cobalt

## HEALTH HAZARD DATA

### ACUTE TOXICITY DATA

| Type of Test | Route of Exposure or Administration | Species/Test System | Dose Data | Toxic Effects | Reference |
|---|---|---|---|---|---|
| LD50 - Lethal dose, 50 percent kill | Oral | Rodent - rat | 6171 mg/kg | Behavioral - somnolence (general depressed activity)<br>Behavioral - ataxia<br>Gastrointestinal - hypermotility, diarrhea | ATDAEI Acute Toxicity Data. Journal of the American College of Toxicology, Part B. (Mary Ann Liebert, Inc., 1651 Third Ave., New York, NY 10128) V.1- 1990- Volume (issue)/page/year: 1,686,1992 |

| | | | | |
|---|---|---|---|---|
| LD50 - Lethal Intraperitoneal dose, 50 percent kill | Rodent - rat | 100 mg/kg | Vascular - regional or general arteriolar or venous dilation Liver - other changes Blood - other changes | INMEAF Industrial Medicine. (Chicago, IL) V.1-18, 1932-49. For publisher information, see IOHSA5. Volume (issue)/page/year: 15,482,1946 |
| LDLo - Lowest Intravenous published lethal dose | Rodent - rat | 100 mg/kg | Details of toxic effects not reported other than lethal dose value | EQSSDX Environmental Quality and Safety, Supplement. (Stuttgart, Fed. Rep. Ger.) V.1-5, 1975-76. Discontinued. Volume (issue)/page/year: 1,1,1975 |
| LDLo - Lowest Intratracheal published lethal dose | Rodent - rat | 25 mg/kg | Details of toxic effects not reported other than lethal dose value | NTIS** National Technical Information Service. (Springfield, VA 22161) Formerly U.S. Clearinghouse for Scientific & Technical Information. Volume (issue)/page/year: AEC-TR-6710 |
| LDLo - Lowest Intraperitoneal published lethal dose | Rodent - mouse | 100 mg/kg | Details of toxic effects not reported other than lethal dose value | EQSSDX Environmental Quality and Safety, Supplement. (Stuttgart, Fed. Rep. Ger.) V.1-5, 1975-76. Discontinued. Volume (issue)/page/year: 1,1,1975 |
| LDLo - Lowest Oral published lethal dose | Rodent - rabbit | 750 mg/kg | Behavioral - somnolence (general depressed activity) | AIPTAK Archives Internationales de Pharmacodynamie et de Therapie. (Heymans Institute of Pharmacology, De Pintelaan 185, B-9000 Ghent, Belgium) V.4-1898- Volume (issue)/page/year: 62,347,1939 |
| LDLo - Lowest Intravenous published lethal dose | Rodent - rabbit | 100 mg/kg | Details of toxic effects not reported other than lethal dose value | EQSSDX Environmental Quality and Safety, Supplement. (Stuttgart, Fed. Rep. Ger.) V.1-5, |

| | | | | |
|---|---|---|---|---|
| | | | | 1975-76. Discontinued. Volume (issue)/page/year: 1,1,1975 |
| TDLo - Lowest Intratracheal published toxic dose | Rodent - rat | 250 mg/kg | Lungs, Thorax, or Respiration - other changes | VCVN5* "Vrednie chemichescie veshestva. Neorganicheskie soedinenia elementov V-VII groopp" (Hazardous substances. Inornanic substances containing V-VII group elements), Bandman A.L. et al., Chimia, 1989. Volume (issue)/page/year: -,452,1989 |
| TDLo - Lowest Intratracheal published toxic dose | Rodent - rat | 50 mg/kg | Lungs, Thorax, or Respiration - other changes Liver - hepatitis (hepatocellular necrosis), diffuse Kidney/Ureter/Bladder - changes in tubules (including acute renal failure, acute tubular necrosis) | VCVN5* "Vrednie chemichescie veshestva. Neorganicheskie soedinenia elementov V-VII groopp" (Hazardous substances. Inornanic substances containing V-VII group elements), Bandman A.L. et al., Chimia, 1989. Volume (issue)/page/year: -,452,1989 |
| LDLo - Lowest Intratracheal published lethal dose | Rodent - rat | 25 mg/kg | Lungs, Thorax, or Respiration - structural or functional change in trachea or bronchi Lungs, Thorax, or Respiration - fibrosis (interstitial) Liver - fatty liver degeneration | VCVN5* "Vrednie chemichescie veshestva. Neorganicheskie soedinenia elementov V-VII groopp" (Hazardous substances. Inornanic substances containing V-VII group elements), Bandman A.L. et al., Chimia, 1989. Volume (issue)/page/year: -,452,1989 |
| LDLo - Lowest Oral published lethal dose | Human | 0.28 mg/kg | Brain and Coverings - other degenerative changes Lungs, Thorax, or Respiration - emphysema | VCVN5* "Vrednie chemichescie veshestva. Neorganicheskie soedinenia elementov V-VII |

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|---|---|---|---|---|---|
| | | | | | groopp" (Hazardous substances. Inornanic substances containing V-VII group elements), Bandman A.L. et al., Chimia, 1989. Volume (issue)/page/year: -,457,1989 |
| TDLo - Lowest published toxic dose | Intratracheal | Rodent - rat | 2500 ug/kg | Lungs, Thorax, or Respiration - acute pulmonary edema | HBTME* Handbook on the Toxicology of Metals (Third Edition) Edited by: Gunnar F. Nordberg, Bruce A. Fowler, Monica Nordberg and Lars T. Friberg, Elsevier Inc 2007 Volume (issue)/page/year: -,511,2007 |
| TDLo - Lowest published toxic dose | Intratracheal | Rodent - rat | 25 mg/kg | Lungs, Thorax, or Respiration - fibrosis (interstitial) Lungs, Thorax, or Respiration - fibrosing alveolitis | HBTME* Handbook on the Toxicology of Metals (Third Edition) Edited by: Gunnar F. Nordberg, Bruce A. Fowler, Monica Nordberg and Lars T. Friberg, Elsevier Inc 2007 Volume (issue)/page/year: -,511,2007 |
| LC50 - Lethal concentration, 50 percent kill | Chemical added to tank with water (dissolved in water) | Invertebrate - daphnia | 21 ug/L/48H | Details of toxic effects not reported other than lethal dose value | TIVIEQ Toxicology In Vitro. (Pergamon Press Inc., Maxwell House, Fairview Park, Elmsford, NY 10523) V.1- 1987- Volume (issue)/page/year: 31,125,1995 |

**OTHER MULTIPLE DOSE TOXICITY DATA**

| Type of Test | Route of Exposure or Administration | Species/Test System | Dose Data | Toxic Effects | Reference |
|---|---|---|---|---|---|
| TCLo - Lowest published toxic concentration | Inhalation | Rodent - rat | 200 mg/m3/17W (intermittent) | Vascular - regional or general arteriolar or venous dilation Lungs, Thorax, or Respiration - other changes Kidney/Ureter/Bladder - changes in tubules (including acute renal failure, acute tubular necrosis) | GTPZAB Gigiena Truda i Professional'nye Zabolevaniya. Labor Hygiene and Occupational Diseases. (V/O Mezhdunarodnaya Kniga, 113095 Moscow, USSR) |

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|---|---|---|---|---|---|
| | | | | | V.1-36, 1957-1992. For publisher information, see MTPEEI Volume (issue)/page/year: 3(3),36,1959 |
| TCLo - Lowest published toxic concentration | Inhalation | Mammal - pig | 100 ug/m3/6H/13W (intermittent) | Lungs, Thorax, or Respiration - changes in pulmonary vascular resistance Lungs, Thorax, or Respiration - other changes | AIHAAP American Industrial Hygiene Association Journal. (AIHA, 475 Wolf Ledges Pkwy., Akron, OH 44311) V.19- 1958- Volume (issue)/page/year: 36,17,1975 |
| TCLo - Lowest published toxic concentration | Inhalation | Rodent - rabbit | 10 mg/m3/4H/1W (intermittent) | Related to Chronic Data - death | VCVN5* "Vrednie chemichescie veshestva. Neorganicheskie soedinenia elementov V-VII groopp" (Hazardous substances. Inornanic substances containing V-VII group elements), Bandman A.L. et al., Chimia, 1989. Volume (issue)/page/year: -,457,1989 |
| TCLo - Lowest published toxic concentration | Inhalation | Rodent - rabbit | 10 mg/m3/2H/56D (intermittent) | Behavioral - food intake (animal) Lungs, Thorax, or Respiration - emphysema Liver - fatty liver degeneration | VCVN5* "Vrednie chemichescie veshestva. Neorganicheskie soedinenia elementov V-VII groopp" (Hazardous substances. Inornanic substances containing V-VII group elements), Bandman A.L. et al., Chimia, 1989. Volume (issue)/page/year: -,457,1989 |
| TCLo - Lowest published toxic concentration | Inhalation | Rodent - rat | 0.5 mg/m3/24H/13W (continuous) | Brain and Coverings - other degenerative changes Peripheral Nerve and Sensation - recording from peripheral motor nerve Liver - other changes | VCVN5* "Vrednie chemichescie veshestva. Neorganicheskie soedinenia elementov V-VII groopp" (Hazardous substances. Inornanic substances containing V-VII group elements), |

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|---|---|---|---|---|---|
| | | | | | Bandman A.L. et al., Chimia, 1989. Volume (issue)/page/year: -,460,1989 |
| TCLo - Lowest published toxic concentration | Inhalation | Rodent - rat | 0.09 mg/m3/24H/4W (continuous) | Peripheral Nerve and Sensation - recording from afferent nerve | VCVN5* "Vrednie chemichescie veshestva. Neorganicheskie soedinenia elementov V-VII groopp" (Hazardous substances. Inornanic substances containing V-VII group elements), Bandman A.L. et al., Chimia, 1989. Volume (issue)/page/year: -,460,1989 |
| TCLo - Lowest published toxic concentration | Inhalation | Rodent - rat | 0.09 mg/m3/24H/8W (continuous) | Lungs, Thorax, or Respiration - other changes Kidney/Ureter/Bladder - urine volume decreased Biochemical - Enzyme inhibition, induction, or change in blood or tissue levels - dehydrogenases | VCVN5* "Vrednie chemichescie veshestva. Neorganicheskie soedinenia elementov V-VII groopp" (Hazardous substances. Inornanic substances containing V-VII group elements), Bandman A.L. et al., Chimia, 1989. Volume (issue)/page/year: -,460,1989 |
| TCLo - Lowest published toxic concentration | Inhalation | Rodent - rat | 0.09 mg/m3/24H/8W (continuous) | Lungs, Thorax, or Respiration - other changes Kidney/Ureter/Bladder - proteinuria Biochemical - Enzyme inhibition, induction, or change in blood or tissue levels - dehydrogenases | VCVN5* "Vrednie chemichescie veshestva. Neorganicheskie soedinenia elementov V-VII groopp" (Hazardous substances. Inornanic substances containing V-VII group elements), Bandman A.L. et al., Chimia, 1989. Volume (issue)/page/year: -,460,1989 |
| TCLo - Lowest published toxic concentration | Inhalation | Rodent - rat | 0.09 mg/m3/24H/17W (continuous) | Lungs, Thorax, or Respiration - other changes Biochemical - Enzyme inhibition, induction, or change in blood or tissue | VCVN5* "Vrednie chemichescie veshestva. Neorganicheskie soedinenia elementov V-VII |

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|---|---|---|---|---|---|
| | | | | levels - multiple enzyme effects Biochemical - Metabolism (Intermediary) - TCA cycle | groopp" (Hazardous substances. Inornanic substances containing V-VII group elements), Bandman A.L. et al., Chimia, 1989. Volume (issue)/page/year: -,461,1989 |
| TDLo - Lowest published toxic dose | Oral | Rodent - rabbit | 360 mg/kg/36D (continuous) | Liver - other changes Blood - changes in serum composition (e.g. TP, bilirubin, cholesterol) | VCVN5* "Vrednie chemichescie veshestva. Neorganicheskie soedinenia elementov V-VII groopp" (Hazardous substances. Inornanic substances containing V-VII group elements), Bandman A.L. et al., Chimia, 1989. Volume (issue)/page/year: -,458,1989 |
| TCLo - Lowest published toxic concentration | Inhalation | Human | 0.1 mg/m3/4W (intermittent) | Lungs, Thorax, or Respiration - fibrosis (interstitial) | VCVN5* "Vrednie chemichescie veshestva. Neorganicheskie soedinenia elementov V-VII groopp" (Hazardous substances. Inornanic substances containing V-VII group elements), Bandman A.L. et al., Chimia, 1989. Volume (issue)/page/year: -,463,1989 |
| TDLo - Lowest published toxic dose | Oral | Rodent - mouse | 390 mg/kg/15D (intermittent) | Endocrine - evidence of thyroid hypofunction | TOXID9 Toxicologist. (Soc. of Toxicology, Inc., 475 Wolf Ledge Parkway, Akron, OH 44311) V.1-1981- Volume (issue)/page/year: -,189,2008 |
| TCLo - Lowest published toxic concentration | Inhalation | Rodent - rat | 2 mg/m3/4D (intermittent) | Lungs, Thorax, or Respiration - fibrosing alveolitis | HBTME* Handbook on the Toxicology of Metals (Third Edition) Edited by: Gunnar F. Nordberg, Bruce A. Fowler, Monica Nordberg and Lars |

T. Friberg, Elsevier Inc 2007 Volume (issue)/page/year: -,511,2007

**TUMORIGENIC DATA**

| Type of Test | Route of Exposure or Administration | Species/Test System | Dose Data | Toxic Effects | Reference |
|---|---|---|---|---|---|
| TDLo - Lowest published toxic dose | Intramuscular | Rodent - rat | 126 mg/kg | Tumorigenic - neoplastic by RTECS criteria Gastrointestinal - tumors Tumorigenic - tumors at site of application | NATUAS Nature. (Nature Subscription Dept., POB 1018, Manasguan, NJ 08736) V.1- 1869- Volume (issue)/page/year: 173,822,1954 |
| TDLo - Lowest published toxic dose | Implant | Rodent - rabbit | 75 mg/kg | Tumorigenic - equivocal tumorigenic agent by RTECS criteria Musculoskeletal - tumors | ZEKBAI Zeitschrift fuer Krebsforschung. (Berlin, Fed. Rep. Ger.) V.1-75, 1903-71. For publisher information, see JCROD7. Volume (issue)/page/year: 52,425,1942 |
| TD - Toxic dose (other than lowest) | Intramuscular | Rodent - rat | 126 mg/kg | Tumorigenic - neoplastic by RTECS criteria Tumorigenic - tumors at site of application | BJCAAI British Journal of Cancer. (Macmillan Press Ltd., Houndmills, Basingstoke, Hants. RG21 2XS, UK) V.1- 1947- Volume (issue)/page/year: 10,668,1956 |

**MUTATION DATA**

| Type of Test | Route of Exposure or Administration | Species/Test System | Dose Data | Reference |
|---|---|---|---|---|
| Micronucleus test | | Human Leukocyte | 600 ug/L | MUREAV Mutation Research. (Elsevier Science Pub. B.V., POB 211, 1000 AE Amsterdam, Netherlands) V.1- 1964- Volume (issue)/page/year: 392,31,1997 |
| DNA damage | | Human Leukocyte | 3 mg/L | MUREAV Mutation Research. (Elsevier Science Pub. B.V., POB 211, 1000 AE Amsterdam, Netherlands) V.1- 1964- Volume (issue)/page/year: 392,31,1997 |
| Micronucleus test | | Human Leukocyte | 0.6 mg/L/15M | MOCAT* Molecular Cancer Therapeutics (Philadelphia, |

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|---|---|---|---|
| | | | PA : American Association for Cancer Research) V.1- 2001- Volume (issue)/page/year: 18,177,2003 |
| Mutation test systems - not otherwise specified | Human Leukocyte | 6 mg/L/24H | TXAPA9 Toxicology and Applied Pharmacology. (Academic Press, Inc., 1 E. First St., Duluth, MN 55802) V.1- 1959- Volume (issue)/page/year: 227,299,2008 |
| DNA damage | Human Lymphocyte | 25 umol/L/1H | TOXID9 Toxicologist. (Soc. of Toxicology, Inc., 475 Wolf Ledge Parkway, Akron, OH 44311) V.1- 1981- Volume (issue)/page/year: 12,430,2008 |

**REVIEWS**

| | |
|---|---|
| ACGIH TLV-TWA 0.02 mg/m3 | DTLVS* The Threshold Limit Values (TLVs) and Biological Exposure Indices (BEIs) booklet issues by American Conference of Governmental Industrial Hygienists (ACGIH), Cincinnati, OH, 1996 Volume(issue)/page/year: TLV/BEI,2010 |
| ACGIH TLV-Confirmed animal carcinogen | DTLVS* The Threshold Limit Values (TLVs) and Biological Exposure Indices (BEIs) booklet issues by American Conference of Governmental Industrial Hygienists (ACGIH), Cincinnati, OH, 1996 Volume(issue)/page/year: TLV/BEI,2010 |
| IARC Cancer Review:Animal Sufficient Evidence | IMEMDT IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Man. (WHO Publications Centre USA, 49 Sheridan Ave., Albany, NY 12210) V.1- 1972- Volume(issue)/page/year: 52,363,1991 |
| IARC Cancer Review:Human Inadequate Evidence | IMEMDT IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Man. (WHO Publications Centre USA, 49 Sheridan Ave., Albany, NY 12210) V.1- 1972- Volume(issue)/page/year: 52,363,1991 |
| IARC Cancer Review: Group 2B | IMEMDT IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Man. (WHO Publications Centre USA, 49 Sheridan Ave., Albany, NY 12210) V.1- 1972- Volume(issue)/page/year: 86,133,2006 |
| IARC Cancer Review:Group 2B | IMEMDT IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Man. (WHO Publications Centre USA, 49 Sheridan Ave., Albany, NY 12210) V.1- 1972- Volume(issue)/page/year: 52,363,1991 |
| TOXICOLOGY REVIEW | MUTAEX Mutagenesis. (Oxford Univ. Press, Pinkhill House, Southfield Road, Eynsham, Oxford OX8 1JJ, UK) V.1- 1986- Volume (issue)/page/year: 26,185,2011 |
| TOXICOLOGY REVIEW | AEMBAP Advances in Experimental Medicine and Biology. (Plenum Pub. Corp., 233 Spring St., New York, NY 10013) V.1- 1967- Volume(issue)/page/year: 40,239,1973 |
| TOXICOLOGY REVIEW | ADTEAS Advances in Teratology. (New York, NY) V.1-5, 1966-72. Discontinued. Volume(issue)/page/year: 5,51,1972 |
| TOXICOLOGY REVIEW | KOTTAM Kogai to Taisaku. Journal of Environmental Pollution Control. (Kogai Taisaku Gijutsu Dokokai, Shuwa-Akasaka Bldg., 9-1-244, Akasaka, Minato-ku, Tokyo 107, Japan) V.1- 1965- Volume (issue)/page/year: 11,1300,1975 |

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|---|---|
| TOXICOLOGY REVIEW | FOREAE Food Research. (Champaign, IL) V.1-25, 1936-60. For publisher information, see JFDSAZ. Volume(issue)/page/year: 7,313,1942 |
| TOXICOLOGY REVIEW | MIBUBI Mikrobiyoloji Bulteni. Bulletin of Microbiology. (c/o Dr. A. Tevfik Cenqiz, Ankara Universitesi Tip Fakultesi Mikrobiyoloji Ana Bilim Dah, Ankara, Turkey) V.1- 1967- Volume(issue)/page/year: 9,321,1975 |
| TOXICOLOGY REVIEW | FCTXAV Food and Cosmetics Toxicology. (London, UK) V.1-19, 1963-81. For publisher information, see FCTOD7. Volume (issue)/page/year: 9,105,1971 |
| TOXICOLOGY REVIEW | 85CVA2 "Oncology 1970, Proceedings of the Tenth International Cancer Congress," Chicago, Year Book Medical Pub., 1971 Volume (issue)/page/year: 5,63,1970 |
| TOXICOLOGY REVIEW | PEXTAR Progress in Experimental Tumor Research. (S. Karger AG, Postfach CH-4009 Basel, Switzerland) V.1- 1960- Volume (issue)/page/year: 12,102,1969 |
| TOXICOLOGY REVIEW | GSAMAQ Memoir--Geological Society of America. (POB 9140, Boulder, CO 80302) No.1- 1934- Volume(issue)/page/year: 123,109,1971 |
| TOXICOLOGY REVIEW | AMTODM Advances in Modern Toxicology. (John Wiley & Sons, Inc., 605 Third Ave., New York, NY 10016) V.1, 1976-79. Discontinued. Volume(issue)/page/year: 3,209,1977 |
| TOXICOLOGY REVIEW | TOLED5 Toxicology Letters. (Elsevier Science Pub. B.V., POB 211, 1000 AE Amsterdam, Netherlands) V.1- 1977- Volume (issue)/page/year: 127,55,2002 |
| TOXICOLOGY REVIEW | TOLED5 Toxicology Letters. (Elsevier Science Pub. B.V., POB 211, 1000 AE Amsterdam, Netherlands) V.1- 1977- Volume (issue)/page/year: 127,63,2002 |
| TOXICOLOGY REVIEW | MUTAEX Mutagenesis. (Oxford Univ. Press, Pinkhill House, Southfield Road, Eynsham, Oxford OX8 1JJ, UK) V.1- 1986- Volume (issue)/page/year: 15,431,2000 |
| TOXICOLOGY REVIEW | MUREAV Mutation Research. (Elsevier Science Pub. B.V., POB 211, 1000 AE Amsterdam, Netherlands) V.1- 1964- Volume (issue)/page/year: 613,103,2006 |
| TOXICOLOGY REVIEW | ENTOX* Encyclopedia of Toxicology: Reference Book, Elsevier, 2005 Volume(issue)/page/year: -,631,2005 |
| TOXICOLOGY REVIEW | JJATDK JAT, Journal of Applied Toxicology. (John Wiley & Sons Ltd., Baffins Lane, Chichester, W. Sussex PO19 1UD, UK) V.1- 1981- Volume(issue)/page/year: 26,191,2006 |
| TOXICOLOGY REVIEW | HBTME* Handbook on the Toxicology of Metals (Third Edition) Edited by: Gunnar F. Nordberg, Bruce A. Fowler, Monica Nordberg and Lars T. Friberg, Elsevier Inc 2007 Volume(issue)/page/year: ,511,2007 |
| TOXICOLOGY REVIEW | HUTOX* Human Toxicology, Edited by: Jacques Descotes, Elsevier B.V., 1996 Volume(issue)/page/year: -,515,1996 |
| TOXICOLOGY REVIEW | HTOPA* Handbook of Toxicologic Pathology (Second Edition) Edited by: Wanda M. Haschek, Colin G. Rousseaux and Matthew A. Wallig, Elsevier Inc, 2002 Volume(issue)/page/year: 1,595,2002 |
| TOXICOLOGY REVIEW | MUREAV Mutation Research. (Elsevier Science Pub. B.V., POB 211, 1000 AE Amsterdam, Netherlands) V.1- 1964- Volume (issue)/page/year: 681,93,2009 |
| TOXICOLOGY REVIEW | MUREAV Mutation Research. (Elsevier Science Pub. B.V., POB 211, 1000 AE Amsterdam, Netherlands) V.1- 1964- Volume (issue)/page/year: 674,3,2009 |
| TOXICOLOGY REVIEW | MUREAV Mutation Research. (Elsevier Science Pub. B.V., POB 211, 1000 AE Amsterdam, Netherlands) V.1- 1964- Volume |

| | |
|---|---|
| | (issue)/page/year: 674,31,2009 |
| TOXICOLOGY REVIEW | MUREAV Mutation Research. (Elsevier Science Pub. B.V., POB 211, 1000 AE Amsterdam, Netherlands) V.1- 1964- Volume (issue)/page/year: 674,73,2009 |
| TOXICOLOGY REVIEW | PTPAD4 Pharmacology and Therapeutics, Part A: Chemotherapy, Toxicology and Metabolic Inhibitors. (Oxford, UK) V.1-2, 1976-78. For publisher information, see PHTHDT. Volume(issue)/page/year: 113,229,2007 |
| TOXICOLOGY REVIEW | COCPH* Clinical Ocular Pharmacology (Fifth Edition), Bartlett, J.D. ed., Elsevier Inc, 2008 Volume(issue)/page/year: -,701,2008 |

**U.S. STANDARDS AND REGULATIONS**

MSHA STANDARD-air:TWA 0.1 mg/m3 (dust and fume)
DTLVS* The Threshold Limit Values (TLVs) and Biological Exposure Indices (BEIs) booklet issues by American Conference of Governmental Industrial Hygienists (ACGIH), Cincinnati, OH, 1996 Volume(issue)/page/year: 3,59,1971

OSHA PEL (Gen Indu):8H TWA 0.1 mg(Co)/m3
CFRGBR Code of Federal Regulations. (U.S. Government Printing Office, Supt. of Documents, Washington, DC 20402) Volume(issue)/page/year: 29,1910.1000,1994

OSHA PEL (Construc):8H TWA 0.1 mg(Co)/m3 (metal,fume,dust)
CFRGBR Code of Federal Regulations. (U.S. Government Printing Office, Supt. of Documents, Washington, DC 20402) Volume(issue)/page/year: 29,1926.55,1994

OSHA PEL (Shipyard):8H TWA 0.1 mg(Co)/m3
CFRGBR Code of Federal Regulations. (U.S. Government Printing Office, Supt. of Documents, Washington, DC 20402) Volume(issue)/page/year: 29,1915.1000,1993

OSHA PEL (Fed Cont):8H TWA 0.1 mg/m3, fume and dust
CFRGBR Code of Federal Regulations. (U.S. Government Printing Office, Supt. of Documents, Washington, DC 20402) Volume(issue)/page/year: 41,50-204.50,1994

**OCCUPATIONAL EXPOSURE LIMITS**

OEL-ARAB Republic of Egypt: TWA 0.1 mg/m3, JAN1993

OEL-AUSTRALIA: TWA 0.05 mg/m3, JUL2008

OEL-AUSTRIA: TRK-TMW 0.5 mg/m3;KZW 2 mg/m3, inhal, sen, 2007

OEL-AUSTRIA: TRK-TMW 0.1 mg/m3;KZW 0.4 mg/m3, inhal, sen, 2007

OEL-BELGIUM: TWA 0.02 mg/m3 (fume, dust), MAR2002

OEL-DENMARK: TWA 0.01 mg(Co)/m3 (fume, dust), carc, MAY2011

OEL-FINLAND: TWA 0.02 mg/m3, NOV2011

OEL-HUNGARY: TWA 0.1 mg/m3, STEL 0.4 mg/m3, SEP2000

OEL-ICELAND: TWA 0.02 mg(Co)/m3 (dust, fume), sen, NOV2011

OEL-JAPAN: OEL 0.05 mg/m3, 2B carcinogen, sen, MAY2009

OEL-MEXICO: TWA 0.1 mg(Co)/m3, 2004

OEL-THE NETHERLANDS: MAC-TGG 0.02 mg/m3, 2003

OEL-NEW ZEALAND: TWA 0.05 mg/m3 (dust and fume), JAN2002

OEL-NORWAY: TWA 0.05 mg/m3, JAN1999

OEL-PERU: TWA 0.02 mg/m3, JUL2005

OEL-THE PHILIPPINES: TWA 0.1 mg/m3, JAN1993

OEL-POLAND: MAC(TWA) 0.05 mg/m3, MAC(STEL) 0.2 mg/m3, JAN1999

OEL-RUSSIA: STEL 0.5 mg/m3, JUN2003

OEL-SWEDEN: TWA 0.05 mg/m3, Sen, JUN2005

OEL-SWITZERLAND: MAK-W 0.1 mg/m3, DEC2006

OEL-UNITED KINGDOM: TWA 0.1 mg/m3, sen, OCT2007

OEL IN ARGENTINA, BULGARIA, COLOMBIA, JORDAN check ACGIH TLV;

OEL IN SINGAPORE, VIETNAM check ACGIH TLV

## NIOSH STANDARDS DEVELOPMENT AND SURVEILLANCE DATA

### NIOSH Recommended Exposure Level (Rel)

NIOSH REL TO COBALT METAL, dust and fume-air:10H TWA 0.05 mg/m3
NIOSH* National Institute of Occupational Safety and Health, U.S. Dept. of Health, Education, and Welfare, Reports and Memoranda. Volume(issue)/page/year: DHHS #92-100,1992

### NIOSH Occupational Exposure Survey Data

NOHS - National Occupational Hazard Survey (1974)
Hazard code: 19770
No. of industries: 27
No. of facilities: 1331 (estimated)
No. of occupations: 27
No. of employees: 8513 (estimated)

NOES - National Occupational Exposure Survey (1983)
Hazard code: X5978
No. of industries: 8
No. of facilities: 151 (estimated)
No. of occupations: 7
No. of employees: 1326 (estimated)
No. of female employees: 128 (estimated)

NOES - National Occupational Exposure Survey (1983)
Hazard code: 19770

No. of industries: 57
No. of facilities: 3263 (estimated)
No. of occupations: 86
No. of employees: 78694 (estimated)
No. of female employees: 2650 (estimated)

**STATUS IN U.S.**

ATSDR TOXICOLOGY PROFILE
NTIS** National Technical Information Service. (Springfield, VA 22161) Formerly U.S. Clearinghouse for Scientific & Technical Information. Volume(issue)/page/year: PB/93/110724/AS

EPA TSCA Section 8(b) CHEMICAL INVENTORY

EPA TSCA Section 8(d) unpublished health/safety studies

On EPA IRIS database

EPA TSCA TEST SUBMISSION (TSCATS) DATA BASE, JANUARY 2001

NIOSH Analytical Method, 1994: Cobalt and compounds as Co, 7027

NIOSH Analytical Method, 1994: Elements by ICP, 7300

NIOSH Analytical Method, 1994: Elements in blood or tissue, 8005

OSHA ANALYTICAL METHOD #ID121

**END OF RECORD**

RTECS® is provided quarterly by Accelrys, Inc., and was last updated: **October, 2012**.

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Mail: 135 Hunter Street East, Hamilton Ontario L8N 1M5

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Canadian Centre for Occupational Health and Safety

RTECS Registry of Toxic Effects of Chemical Substances®

Data source: Accelrys, Inc.

## CHEMICAL IDENTIFICATION

| | |
|---|---|
| **RTECS Number** | ED7350000 |
| **Chemical Name** | Boron |
| **CAS Registry Number** | 7440-42-8 |
| **Last Updated** | 201110 |
| **Data Items Cited** | 25 |
| **Molecular Formula** | B |
| **Molecular Weight** | 10.81 |
| **Wiswesser Line Notation** | B |
| **Compound Descriptor** | Reproductive Effector |

## HEALTH HAZARD DATA

### ACUTE TOXICITY DATA

| Type of Test | Route of Exposure or Administration | Species/Test System | Dose Data | Toxic Effects | Reference |
|---|---|---|---|---|---|
| LD50 - Lethal dose, 50 percent kill | Oral | Rodent - rat | 650 mg/kg | Details of toxic effects not reported other than lethal dose value | GISAAA Gigiena i Sanitariya. For English translation, see HYSAAV. (V/O Mezhdunarodnaya Kniga, 113095 Moscow, USSR) V.1-1936- Volume (issue)/page/year: 35 (11),11,1970 |
| LD50 - Lethal dose, 50 percent kill | Intraperitoneal | Rodent - rat | 7 gm/kg | Details of toxic effects not reported other than lethal dose value | GTPZAB Gigiena Truda i Professional'nye Zabolevaniya. Labor Hygiene and Occupational Diseases. (V/O Mezhdunarodnaya Kniga, 113095 Moscow, USSR) V.1-36, 1957-1992. For publisher information, see MTPEEI Volume (issue)/page/year: 35 (2),42,1991 |
| LD50 - Lethal | Oral | Rodent - mouse | 560 mg/kg | Details of toxic | GISAAA Gigiena i Sanitariya. For English translation, see |

| | | | | | |
|---|---|---|---|---|---|
| dose, 50 percent kill | | | | effects not reported other than lethal dose value | HYSAAV. (V/O Mezhdunarodnaya Kniga, 113095 Moscow, USSR) V.1-1936- Volume (issue)/page/year: 35 (11),11,1970 |
| LD50 - Lethal dose, 50 percent kill | Intraperitoneal | Rodent - mouse | 11 gm/kg | Details of toxic effects not reported other than lethal dose value | GTPZAB Gigiena Truda i Professional'nye Zabolevaniya. Labor Hygiene and Occupational Diseases. (V/O Mezhdunarodnaya Kniga, 113095 Moscow, USSR) V.1-36, 1957-1992. For publisher information, see MTPEEI Volume (issue)/page/year: 35 (2),42,1991 |
| LD50 - Lethal dose, 50 percent kill | Oral | Mammal - dog | 310 mg/kg | Details of toxic effects not reported other than lethal dose value | GISAAA Gigiena i Sanitariya. For English translation, see HYSAAV. (V/O Mezhdunarodnaya Kniga, 113095 Moscow, USSR) V.1-1936- Volume (issue)/page/year: 35 (11),11,1970 |
| LD50 - Lethal dose, 50 percent kill | Oral | Mammal - cat | 250 mg/kg | Details of toxic effects not reported other than lethal dose value | GISAAA Gigiena i Sanitariya. For English translation, see HYSAAV. (V/O Mezhdunarodnaya Kniga, 113095 Moscow, USSR) V.1-1936- Volume (issue)/page/year: 35 (11),11,1970 |
| LD50 - Lethal dose, 50 percent kill | Oral | Rodent - rabbit | 310 mg/kg | Details of toxic effects not reported other than lethal dose value | GISAAA Gigiena i Sanitariya. For English translation, see HYSAAV. (V/O Mezhdunarodnaya Kniga, 113095 Moscow, USSR) V.1-1936- Volume (issue)/page/year: 35 (11),11,1970 |
| LD50 - Lethal dose, 50 percent kill | Oral | Rodent - guinea pig | 310 mg/kg | Details of toxic effects not reported other than lethal dose value | GISAAA Gigiena i Sanitariya. For English translation, see HYSAAV. (V/O Mezhdunarodnaya Kniga, 113095 Moscow, USSR) V.1-1936- Volume (issue)/page/year: 35 (11),11,1970 |
| LD50 - Lethal dose, 50 percent kill | Oral | Mammal - species unspecified | 300 mg/kg | Details of toxic effects not reported other than lethal dose value | GISAAA Gigiena i Sanitariya. For English translation, see HYSAAV. (V/O Mezhdunarodnaya Kniga, 113095 Moscow, USSR) V.1-1936- Volume (issue)/page/year: 40 (9),49,1975 |

**OTHER MULTIPLE DOSE TOXICITY DATA**

| Type of Test | Route of Exposure or Administration | Species/Test System | Dose Data | Toxic Effects | Reference |
|---|---|---|---|---|---|
| TDLo - Lowest published toxic dose | Oral | Rodent - rat | 32 gm/kg/30D (intermittent) | Brain and Coverings - other degenerative changes Cardiac - other changes Liver - liver function tests impaired | GTPZAB Gigiena Truda i Professional'nye Zabolevaniya. Labor Hygiene and Occupational Diseases. (V/O Mezhdunarodnaya Kniga, 113095 Moscow, USSR) V.1-36, 1957-1992. For publisher information, see MTPEEI Volume (issue)/page/year: 35(2),42,1991 |
| TCLo - Lowest published toxic concentration | Inhalation | Rodent - rat | 10560 ug/m3/4H/17W (intermittent) | Lungs, Thorax, or Respiration - other changes Nutritional and Gross Metabolic - weight loss or decreased weight gain | GTPZAB Gigiena Truda i Professional'nye Zabolevaniya. Labor Hygiene and Occupational Diseases. (V/O Mezhdunarodnaya Kniga, 113095 Moscow, USSR) V.1-36, 1957-1992. For publisher information, see MTPEEI Volume (issue)/page/year: 35(2),42,1991 |
| TDLo - Lowest published toxic dose | Oral | Rodent - rabbit | 2821 mg/kg/13W (intermittent) | Biochemical - Enzyme inhibition, induction, or change in blood or tissue levels - dehydrogenases Biochemical - Enzyme inhibition, induction, or change in blood or tissue levels - transaminases Biochemical - Enzyme inhibition, induction, or change in blood or tissue levels | GISAAA Gigiena i Sanitariya. For English translation, see HYSAAV. (V/O Mezhdunarodnaya Kniga, 113095 Moscow, USSR) V.1- 1936- Volume (issue)/page/year: 35(11),11,1970 |

- other transferases

**REPRODUCTIVE DATA**

| Type of Test | Route of Exposure or Administration | Species/Test System | Dose Data | Sex/Duration | Toxic Effects | Reference |
|---|---|---|---|---|---|---|
| TDLo - Lowest published toxic dose | Oral | Rodent - rat | 4.95 mg/kg | female 1-22 day(s) after conception | Reproductive - Effects on Embryo or Fetus - fetotoxicity (except death, e.g., stunted fetus) Reproductive - Effects on Embryo or Fetus - fetal death | VCVN1* "Vrednie chemichescie veshestva. Neorganicheskie soedinenia elementov I-IV groopp" (Hazardous substances. Inornanic substances containing I-IV group elements), Filov V.A., Chimia, 1988. Volume (issue)/page/year: -,195,1988 |

**REVIEWS**

| | |
|---|---|
| TOXICOLOGY REVIEW | KOTTAM Kogai to Taisaku. Journal of Environmental Pollution Control. (Kogai Taisaku Gijutsu Dokokai, Shuwa-Akasaka Bldg., 9-1-244, Akasaka, Minato-ku, Tokyo 107, Japan) V.1- 1965- Volume(issue)/page/year: 11,1300,1975 |
| TOXICOLOGY REVIEW | CLCHAU Clinical Chemistry (Winston-Salem, NC). (American Assoc. for Clinical Chemistry, 1725 K St., NW, Washington, DC 20006) V.1- 1955- Volume(issue)/page/year: 19,361,1973 |
| TOXICOLOGY REVIEW | ENTOX* Encyclopedia of Toxicology: Reference Book, Elsevier, 2005 Volume(issue)/page/year: -,331,2005 |
| TOXICOLOGY REVIEW | MUREAV Mutation Research. (Elsevier Science Pub. B.V., POB 211, 1000 AE Amsterdam, Netherlands) V.1- 1964- Volume(issue)/page/year: 705,11,2010 |

**NIOSH STANDARDS DEVELOPMENT AND SURVEILLANCE DATA**

**NIOSH Occupational Exposure Survey Data**

NOHS - National Occupational Hazard Survey (1974)
Hazard code: 80251
No. of industries: 35
No. of facilities: 995 (estimated)
No. of occupations: 31
No. of employees: 6536 (estimated)

NOES - National Occupational Exposure Survey (1983)
Hazard code: X4244
No. of industries: 1
No. of facilities: 3 (estimated)
No. of occupations: 1

No. of employees: 65 (estimated)

NOES - National Occupational Exposure Survey (1983)
Hazard code: 80251
No. of industries: 48
No. of facilities: 2277 (estimated)
No. of occupations: 74
No. of employees: 41637 (estimated)
No. of female employees: 4576 (estimated)

**STATUS IN U.S.**

ATSDR TOXICOLOGY PROFILE
NTIS** National Technical Information Service. (Springfield, VA 22161) Formerly U.S. Clearinghouse for Scientific & Technical Information. Volume(issue)/page/year: PB/93/110674/AS

EPA TSCA Section 8(b) CHEMICAL INVENTORY

EPA TSCA Section 8(d) unpublished health/safety studies

On EPA IRIS database

EPA TSCA TEST SUBMISSION (TSCATS) DATA BASE, JANUARY 2001

**END OF RECORD**

RTECS® is provided quarterly by Accelrys, Inc., and was last updated: **October, 2012**.

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Mark Record | Show Term(s) | Show Contents | Field Help | Back to Results

Canadian Centre for Occupational Health and Safety

CCOHS

# RTECS Registry of Toxic Effects of Chemical Substances®

Data source: Accelrys, Inc.

## CHEMICAL IDENTIFICATION

| | |
|---|---|
| **RTECS Number** | VW0400000 |
| **Chemical Name** | Silicon |
| **CAS Registry Number** | 7440-21-3 |
| **Last Updated** | 201204 |
| **Data Items Cited** | 35 |
| **Molecular Formula** | Si |
| **Molecular Weight** | 28.09 |
| **Compound Descriptor** | Primary Irritant |

**Synonyms/Trade Names**

Defoamer S-10
Polyeristalline silicon powder
Silicon

## HEALTH HAZARD DATA

### SKIN/EYE IRRITATION DATA

| Type of Test | Route of Exposure or Administration | Species/Test System | Dose Data | Reaction Severity | Reference |
|---|---|---|---|---|---|
| Standard Draize test | Administration into the eye | Rodent - rabbit | 3 mg | Mild | FAONAU FAO Nutrition Meetings Report Series. (Rome, Italy) No.?-57, 1948-77. Discontinued. Volume(issue)/page/year: 53A,21,1974 |

### ACUTE TOXICITY DATA

| Type of Test | Route of Exposure or Administration | Species/Test System | Dose Data | Toxic Effects | Reference |
|---|---|---|---|---|---|
| LD50 - Lethal dose, 50 percent kill | Oral | Rodent - rat | 3160 mg/kg | Details of toxic effects not reported other than lethal dose value | FAONAU FAO Nutrition Meetings Report Series. (Rome, Italy) No.?-57, 1948-77. Discontinued. Volume |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | (issue)/page/year: 53A,21,1974 |
| LDLo - Lowest published lethal dose | Intraperitoneal | Rodent - rat | 500 mg/kg | Sense Organs and Special Senses (Olfaction) - effect, not otherwise specified Sense Organs and Special Senses (Eye) - effect, not otherwise specified Lungs, Thorax, or Respiration - respiratory stimulation | NTIS** National Technical Information Service. (Springfield, VA 22161) Formerly U.S. Clearinghouse for Scientific & Technical Information. Volume (issue)/page/year: OTS0536164 |

**U.S. STANDARDS AND REGULATIONS**

MSHA STANDARD-air:TWA 10 mg/m3
DTLWS* "Documentation of the Threshold Limit Values for Substances in Workroom Air," Supplements. For publisher information, see 85INA8. Volume(issue)/page/year: 3,27,1973

OSHA PEL (Gen Indu):8H TWA 15 mg/m3, total dust
CFRGBR Code of Federal Regulations. (U.S. Government Printing Office, Supt. of Documents, Washington, DC 20402) Volume(issue)/page/year: 29,1910.1000,1994

OSHA PEL (Gen Indu):8H TWA 5 mg/m3, respirable fraction
CFRGBR Code of Federal Regulations. (U.S. Government Printing Office, Supt. of Documents, Washington, DC 20402) Volume(issue)/page/year: 29,1910.1000,1994

OSHA PEL (Construc):8H TWA 15 mg/m3, total dust
CFRGBR Code of Federal Regulations. (U.S. Government Printing Office, Supt. of Documents, Washington, DC 20402) Volume(issue)/page/year: 29,1926.55,1994

OSHA PEL (Construc):8H TWA 5 mg/m3, respirable fraction
CFRGBR Code of Federal Regulations. (U.S. Government Printing Office, Supt. of Documents, Washington, DC 20402) Volume(issue)/page/year: 29,1926.55,1994

OSHA PEL (Shipyard):8H TWA 15 mg/m3, total dust
CFRGBR Code of Federal Regulations. (U.S. Government Printing Office, Supt. of Documents, Washington, DC 20402) Volume(issue)/page/year: 29,1915.1000,1993

OSHA PEL (Shipyard):8H TWA 5 mg/m3, respirable fraction
CFRGBR Code of Federal Regulations. (U.S. Government Printing Office, Supt. of Documents, Washington, DC 20402) Volume(issue)/page/year: 29,1915.1000,1993

**OCCUPATIONAL EXPOSURE LIMITS**

OEL-BELGIUM: TWA 10 mg/m3, MAR2002

OEL-DENMARK: TWA 10 mg/m3, MAY2011

OEL-FRANCE: VME 10 mg/m3, FEB2006

OEL-ICELAND: TWA 0.5 ppm (0.7 mg/m3), NOV2011

OEL-KOREA: TWA 10 mg/m3, 2006

OEL-MEXICO: TWA 10 mg/m3;STEL 20 mg/m3 (inhalable), 2004

OEL-THE NETHERLANDS: MAC-TGG 10 mg/m3, 2003

OEL-NEW ZEALAND: TWA 10 mg/m3 (inspirable dust), JAN2002

OEL-NORWAY: TWA 10 mg/m3, JAN1999

OEL-PERU: TWA 10 mg/m3 (inhal), 4 mg/m3 (resp), JUL2005

OEL-SWITZERLAND: MAK-W 3 mg/m3, DEC2006

OEL-UNITED KINGDOM: TWA 10 mg/m3 (inhal. dust), OCT2007

OEL-UNITED KINGDOM: TWA 4 mg/m3 (resp. dust), OCT2007

OEL IN ARGENTINA, BULGARIA, COLOMBIA, JORDAN check ACGIH TLV;

OEL IN SINGAPORE, VIETNAM check ACGIH TLV

## NIOSH STANDARDS DEVELOPMENT AND SURVEILLANCE DATA

### NIOSH Recommended Exposure Level (Rel)

NIOSH REL TO SILICON, respirable fraction-air:10H TWA 5 mg/m3
NIOSH* National Institute of Occupational Safety and Health, U.S. Dept. of Health, Education, and Welfare, Reports and Memoranda. Volume(issue)/page/year: DHHS #92-100,1992

NIOSH REL TO SILICON, total dust-air:10H TWA 10 mg/m3
NIOSH* National Institute of Occupational Safety and Health, U.S. Dept. of Health, Education, and Welfare, Reports and Memoranda. Volume(issue)/page/year: DHHS #92-100,1992

### NIOSH Occupational Exposure Survey Data

NOHS - National Occupational Hazard Survey (1974)
Hazard code: 68695
No. of industries: 48
No. of facilities: 3856 (estimated)
No. of occupations: 66
No. of employees: 99138 (estimated)

NOES - National Occupational Exposure Survey (1983)
Hazard code: X4229
No. of industries: 1
No. of facilities: 12 (estimated)

No. of occupations: 5
No. of employees: 1740 (estimated)
No. of female employees: 503 (estimated)

NOES - National Occupational Exposure Survey (1983)
Hazard code: X4230
No. of industries: 6
No. of facilities: 118 (estimated)
No. of occupations: 6
No. of employees: 1962 (estimated)
No. of female employees: 112 (estimated)

NOES - National Occupational Exposure Survey (1983)
Hazard code: X6495
No. of industries: 1
No. of facilities: 19 (estimated)
No. of occupations: 2
No. of employees: 2379 (estimated)

NOES - National Occupational Exposure Survey (1983)
Hazard code: 68695
No. of industries: 296
No. of facilities: 59062 (estimated)
No. of occupations: 129
No. of employees: 693583 (estimated)
No. of female employees: 28164 (estimated)

**STATUS IN U.S.**

EPA TSCA Section 8(b) CHEMICAL INVENTORY

EPA TSCA Section 8(d) unpublished health/safety studies

EPA TSCA TEST SUBMISSION (TSCATS) DATA BASE, JANUARY 2001

**END OF RECORD**

RTECS® is provided quarterly by Accelrys, Inc., and was last updated: **October, 2012**.

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www.ccohs.ca E-mail: clientservices@ccohs.ca Fax: (905) 572-2206 Phone: (905) 572-2981
Mail: 135 Hunter Street East, Hamilton Ontario L8N 1M5

161417

Pacific Northwest
NATIONAL LABORATORY

Tel: (509) 375-5426
Fax: (509) 375-5322
MSIN: P7-25
karl.pool@pnnl.gov

September 27, 2011

60965-2011-L1

Rich Weiss
Senior Scientist
Washington Closure Hanford
2620 Fermi Avenue
Richland, WA 99354

Dear Rich:

**Transmittal of Analytical Data Reports in Support of 324 Soils Analyses**

The Analytical data reports listed below have been transmitted to Washington Closure Hanford (WCH). The data reports are associated with WCH samples J1JD49 and J1JD50. The Analytical Services Request (ASR) associated with Sample J1JD49 is ASR 8888 and the ASR associated with Sample J1JD50 is ASR 8902.

Data Reports for ASR 8888

ICP/OES Analyses Report
pH Analyses Report (Both J1JD49 and J1JD50)
Americium 241 Analysis
Plutionium 238, 239+240 Analysis
Uranium 233+234, 235+236 and 238 Analyses
Sr-90 by Liquid Scintillation Spectrometry
Gamma Energy Analyses

Data Reports for ASR 8902

ICP/OES Analyses Report
pH Analyses Report (Both J1JD49 and J1JD50)
Americium 241 Analysis
Plutionium 238, 239+240 Analysis
Uranium 233+234, 235+236 and 238 Analyses

Sr-90 by Liquid Scintillation Spectrometry
Gamma Energy Analyses

Sincerely,

Karl N Pool
Analytical Support Operations Project Manager
Radiochemical Sciences & Engineering Group

bcc: 60965 project file

**Pacific Northwest National Laboratory**
**PO Box 999, Richland, WA**
**Radiochemical Sciences and Engineering Group**

filename 11-1355 Pool
7/11/2011

Client: K. Pool
ASR: 8888

Project: 60965
WP: H54512

Prepared by: C. Soderquist 9-8-2011
Concur: T Trang-Le 9-8-2011

Procedures: PNL-ALO-129, Rev. 0 $HNO_3$-HCl Acid Extraction of Solids Using a Dry-Block Heater
RPG-CMC-450, Rev. 1 Gamma Energy Analysis (GEA) and Low-Energy Photon Spectrometry (LEPS)
Count date: 7-Jul-11
M&TE: Detectors D, E, G

| Sample | Lab ID | Measured Activity, **µCi per gram** ± 1s | | | | | |
|---|---|---|---|---|---|---|---|
| | | **Co-60** | **Cs-134** | **Cs-137** | **Eu-152** | **Eu-154** | **Am-241** |
| **J1JD49** | 11-1355 | **8.21E-3 ± 5%** | < 2.E-3 | **4.93E+0 ± 4%** | < 3.E-3 | < 2.E-3 | < 3.E-2 |
| | 11-1355 Dup | **5.12E-3 ± 7%** | < 1.E-3 | **3.93E+0 ± 4%** | < 3.E-3 | < 2.E-3 | < 7.E-2 |
| | RPD | 46% | - | 23% | - | - | - |
| | Hot cell blank | < 9.E-6 | < 1.E-5 | 4.69E-5 ± 11% | < 4.E-5 | < 2.E-5 | < 8.E-5 |

This soil sample was analyzed as received, without drying to constant weight. Duplicate sub-samples of about one gram apiece were weighed into Teflon centrifuge tubes and digested with a mixture of dilute nitric and hydrochloric acids for several hours to dissolve the analytes. The digested solids were centrifuged out of solution, and then the solution was diluted to known volume. Gamma emitters were measured in the digestion solution.

**Pacific Northwest National Laboratory**
**PO Box 999, Richland, WA**
**Radiochemical Sciences and Engineering Group**

filename 11-1355 Pool
8/22/2011

Client: K. Pool
ASR: 8888

Project: 60965
WP: H54512

Procedures: PNL-ALO-129, Rev. 0 $HNO_3$-HCl Acid Extraction of Solids Using a Dry-Block Heater
RPG-CMC-4001, Rev 1, Source Preparation for Gross Alpha and Gross Beta Analysis
RPG-CMC-408, Rev 2, Total Alpha and Beta Analysis
RPG-CMC-4015, Rev 0, Analysis of Soil and Sediment Samples for Actinides and Strontium-90
RPG-CMC-496, Rev 0, Coprecipitation Mounting of Actinides for Alpha Spectrometry
RPG-CMC-422, Rev 2, Solutions Analysis: Alpha Spectrometry

M&TE: Ludlum alpha counters (gross alpha), Alpha spectrometry counting system (all other analytes on this page)

Reference date August 10, 2011

| Sample | Lab ID | Measured Activity, **µCi per gram** ± 1s | | | | | |
|---|---|---|---|---|---|---|---|
| | | **Gross Alpha** | **Pu-238** | **Pu-239+240** | **Am-241** | **Cm-242** | **Cm-243+244** |
| **J1JD49** | 11-1355 | **7.89E-3 ± 4%** | **2.31E-3 ± 2%** | **9.03E-4 ± 3%** | **1.72E-3 ± 2%** | **9.54E-6 ± 17%** | **2.99E-3 ± 2%** |
| | 11-1355 Dup | **4.80E-3 ± 5%** | **1.26E-3 ± 2%** | **6.17E-4 ± 3%** | **1.05E-3 ± 2%** | **3.53E-6 ± 32%** | **1.73E-3 ± 2%** |
| | RPD | 49% | 58% | 38% | 48% | 92% | 53% |
| | Hot cell blank | < 2.E-4 | < 4.E-6 | < 5.E-6 | 2.97E-6 ± 31% | < 2.E-6 | 1.93E-6 ± 36% |
| | Lab blank | < 3.E-6 | < 6.E-8 | < 7.E-8 | < 8.E-8 | < 3.E-8 | < 3.E-8 |
| | Reagent spike | 98% | -- | 104% | 97% | -- | -- |
| | Matrix spike | 88% | -- | 99% | 97% | -- | -- |

**Pacific Northwest National Laboratory**
**PO Box 999, Richland, WA**
**Radiochemical Sciences and Engineering Group**

filename 11-1355 Pool
9/8/2011

Client: K. Pool
ASR: 8888

Project: 60965
WP: H54512

Procedures: PNL-ALO-129, Rev 0 $HNO_3$-HCl Acid Extraction of Solids Using a Dry-Block Heater
RPG-CMC-4001, Rev 1, Source Preparation for Gross Alpha and Gross Beta Analysis
RPG-CMC-408, Rev 2, Total Alpha and Beta Analysis
RPG-CMC-4015, Rev 0, Analysis of Soil and Sediment Samples for Actinides and Strontium-90 (uranium only)
RPG-CMC-476, Rev 0, Strontium Separation using Eichrom Strontium Resin
RPG-CMC-474, Rev 1, Measurement of Alpha and Beta Activity by Liquid Scintillation Spectrometry (Sr-90)
RPG-CMC-496, Rev 0, Coprecipitation Mounting of Actinides for Alpha Spectrometry (uranium)
RPG-CMC-422, Rev 2, Solutions Analysis: Alpha Spectrometry

M&TE: LB4100 proportional counters (gross beta), Perkin Elmer TriCarb model 3100 TR liquid scintillation spectrometer (Sr-90) alpha spectrometry counting system (uranium)

Reference date July 19, 2011 (Sr-90)

| Sample | Lab ID | Measured Activity, **µCi per gram ± 1s** | | | | |
|---|---|---|---|---|---|---|
| | | **Gross Beta** | **Sr-90** | **U-233+234** | **U-235+236** | **U-238** |
| **J1JD49** | 11-1355 | **5.91E+2 ± 4%** | **2.88E+2 ± 2%** | **3.32E-6 ± 13%** | < 3.E-7 | **2.10E-6 ± 17%** |
| | 11-1355 Dup | **6.36E+2 ± 4%** | **2.95E+2 ± 2%** | **2.56E-6 ± 12%** | < 4.E-7 | **2.57E-6 ± 11%** |
| | RPD | 7% | 2% | 26% (1.5s ) | -- | 20% |
| | Hot cell blank | < 4.E-4 | < 1.E-4 | < 6.E-7 | < 4.E-7 | < 4.E-7 |
| | Lab blank | < 5.E-6 | < 2.E-5 | < 5.E-9 | < 3.E-9 | < 3.E-9 |
| | Reagent spike | 90% | 98% | -- | -- | 98% |
| | Matrix spike | 77% | 98% | -- | -- | [Matrix spike was lost in process] |

# Radiochemistry M&TE List

| ID | Number of Detectors | Property # | Model or Serial # | Location, in Bldg. 325 | Procedures using the M&TE | PM Contract? |
|---|---|---|---|---|---|---|
| **Dual Alpha Beta Gas Proportional Counters** | | | | | | |
| Oxford LB4100 | 16 | WD13066 | L8285-O | 425 | Total alpha, total beta, Sr/Y90, Tc99 | Y |
| **Alpha Counters** | | | | | | |
| Ludlum | 10 | multiple | multiple | 425 | Total Alpha | N |
| AEA (Ortec)* | 32 | multiple | multiple | 425 | AEA (total alpha, Pu, Am/Cm,Np) | N |
| **Liquid Scintillation** | | | | | | |
| Perkin Elmer 3100TR | 1 | WD48466 | DG08061340 | 425 | H-3, C-14, Ni-63, Se-79, Pu-241, Sr-90 | Y |
| Packard 2550 | 1 | WD06783 | 401664 | 425 | H-3, C-14, Ni-63, Se-79, Pu-241, Sr-90 | Y |
| **Gamma** | | | | | | |
| HpGe* | 7 | see list | see list | 425 | GEA with 2 Ortec Nomad portables | N |
| LEPS (x-rays)* | 2 | see list | see list | 425 | X-ray (Fe-55, Ni-59, Nb-93m) | N |
| **Uranium** | | | | | | |
| Chemcheck | 1 | WC47898 | KPA11R | 525 | Uranium KPA | N |
| ***Spectral Analysis System** | | | | | | |
| Canberra - VAX 3000 | 1 | WD12890 | PE42AJB | 425 | AEA, GEA | N |
| Canberra - VAX 3100 | 1 | WC38624 | KA235W0225 | 425 | AEA, GEA (Backup VAX) | N |

**List of Gamma Detectors**

| Name | Property Tag | Vendor | Model | Serial # | Type | Eff. % | CMC? |
|---|---|---|---|---|---|---|---|
| C | WD25157 | EG&G Ortec | GEM70200P | 33TP40378A | Ge | 70 | Y |
| D | WD06582 | Princeton | IGC7022SD | 2542 | Ge | 70 | Y |
| E | WD12833 | EG&G Ortec | GEM100210 | 34P40535A | Ge | 100 | Y |
| G | WD35719 | Canberra | GC4020 | 9923007 | Ge | 40 | Y |
| H | PT00941 | Tennelec | CPVS3040195 | 6028 | Ge | 40 | Y |
| I | WD12076 | EG&G Ortec | GLP3638510P | 33TE187 | LEPS | X-RAY | Y |
| J | WD12075 | EG&G Ortec | GLP3638510P | 33TE190 | LEPS | X-RAY | Y |
| K | WD06581 | Princeton | NIGC6022SD | 3612 | P-Ge | 60 | Y |
| L | WD36413 | EG&G Ortec | GEM20P-Plus | 44TP21884A | Ge | 20 | Y |
| M | WD73130 | Canberra | GC10021 | 9722 | Ge | 100 | Y |
| N | WD73129 | Canberra | GC10021 | 9716 | Ge | 100 | Y |
| P | WD59508 | EG&G Ortec | GEM30210 | 24P80V | Ge | 30 | Y |
| T | WD25687 | EG&G Ortec | GEM15180P | 35TP11079A | Ge | 15 | Y |

Printed 5/04/2011

*Battelle PNNL/RPL/ASO Radiochemistry Analysis Report*
*P.O. Box 999, 902 Battelle Blvd., Richland, Washington 99352*

# Gamma Energy Analysis (GEA)

**Project / WP#:** 60965/ H54512
**ASR#:** 8888.00
**Client:** KN Pool
**Total Samples:** 1

| RPL ID | Client Sample ID |
|---|---|
| 11-1355 | J1JD49 |

| | |
|---|---|
| **Analysis Type:** | GEA- for all positively measured or non-detected isotopes |
| **Sample Processing Prior to Radiochemical Processing/Analysis** | ☐ None<br>☒ Digested as per PNL-ALO-129, Rev. 0 *$HNO_3$-HCl Acid Extraction of Solids Using a Dry Block Heater, (6/29/11 to 7/1/11 N. Green)*<br>☐ Fusion as per PNL-ALO-115, *Solubilization of Metals from Solids Using a KOH-$KNO_3$ Fusion*<br>☐ Other:<br>Preparation may also involve attaining a GEA geometry that is compatible with the calibration geometry. |
| | |
| **Analysis Procedure:** | RPG-CMC-450, Rev. 1 *Gamma Energy Analysis (GEA) and Low-Energy Photon Spectrometry (LEPS)* |
| **Reference Date:** | No Reference required for this ASR |
| **Analysis Date or Date Range:** | July 7, 2011 |
| **Technician/Analyst:** | MG Cantaloub |
| | |
| **Rad Chem Electronic Data File:** | *11-1355 Pool.xls* |
| **ASO Project 98620 File:** | *File Plan 5871, T4.4 Technical (Radiochemistry), Gamma Calibration, daily checks, and maintenance records; and T3 standard certificates and preparation. Also, balance calibration and Performance check records.* |
| **M&TE Number(s):** | *Detectors D,E,G ( M & TE unique identifiers in attached supporting documents)* |

Prepare / Date: 9/20/11

T Trang-Le / Reviewer / Date: 9/20/11

## SAMPLE RESULTS

Activities for all gamma emitters detected in these samples are presented in an attached Excel spreadsheet for ASR 8888.00. All data are reported in units of µCi/g with estimates of the total propagated uncertainty reported at the 1-sigma level.

ASO Project File, ASR-8888 has been created for this report including all appropriate supporting records which may include the Pipette Performance Verification form, Standard Certificates, Laboratory Bench Record, Shielded Analytical Laboratory Bench Sheet, and Gamma Energy Analysis printouts. Detector calibration records, control charts and balance calibration records can be found in the ASO Records.

### Sample Preparation, Separation, Mounting and Counting Methods

Quality control (QC) samples prepared include duplicates of all samples as well as reagent blank for each preparative method. The quality control (QC) sample results for each of the isotopes measured above background have been evaluated and are discussed below. A summary of the GEA analysis results, including QC sample performance, is given in the attached Data Report.

ASO received the sampling device and loaded the entire sampling device into the SAL hot cells. The sampling device was retrieved from the plastic sleeving and the soil sample was removed from the inside of the sampling tube. One gram aliquots of the soil sample were then placed in Teflon oak ridge tubes and digested with a mixture of 8M $HNO_3$ and 8M HCl using PNNL procedure PNL-ALO-129. At the completion of the digestion, the insoluble residue was rinsed three consecutive times with the same $HNO_3$/HCl acid mixture to remove any interstitial liquid. Each rinse was collected and added to the original digestate solution. The digestate solution was brought to a final volume of 100 mL in a volumetric flask. The leachate solution was used for radioanalytical analyses and ICP metals analysis; only GEA data are included in this report.

## QUALITY CONTROL RESULTS

Tracer:

Tracers are not used for ASO GEA methods.

Process Blank (PB):

A reagent blank was prepared with this ASR.

The ASO-QAP-001 requires the activities of the gamma emitting isotopes of interest measured in the PB to be within the acceptance criteria of less than 5% of the sample isotope concentration or less than sample minimum detectable activity (MDA) – (See comments). For isotopes of interest that were not detected in the PB and samples, the PB minimum detectable concentration (MDC) was less than the MDC measured in the samples. The isotopes of interest that were detected in the samples above the MDC are all greater than 5% of the activity level present in the PB

Required Detection Limits

Required detection limits were not specified for this ASR.

Blank Spike (BS)/Laboratory Control Sample (LCS)/ Matrix Spike (MS):

There are no BS, LCS or MS samples analyzed for ASO GEA analyses. Instrument performance is assessed by the analyses of daily control counts and weekly background counts, as discussed below.

Duplicate Relative Percent Difference (RPD):

Duplicate results are required to agree within ≤20% relative percent difference, taking into consideration the statistical uncertainties in the data. Duplicate results for these samples ranged from 23% to 46% .

For samples:

| RPL Number | Client Sample ID | Isotopes | RPD Differences |
|---|---|---|---|
| 11-1355 | J1JD49 | Co-60 | 46% |
| 11-1355 DUP | J1JD49 DUP | Cs-137 | 23% |

The duplicate RPD Requirement of ±20% was exceeded for Co-60, and Cs-137.

Replicate Relative Standard Deviation (RSD):

Replicate samples were not required to be run for this ASR.

**Instrument Calibration and Quality Control**

Gamma detectors are calibrated using multi-isotope standards that are NIST-traceable and prepared in the identical counting geometry used for the samples for all detectors. Counter control sources containing Am-241, Cs-137 and Co-60 are then analyzed daily before the use of each detector. There is a K Basin DQO that is referenced to ASO procedure RPG-CMC-450, that requires that a counter control source is checked daily and must be within ±3 sigma or ±3% of the control value, whichever is greater. Gamma counting was not performed unless the control counts were within the required limits. Background counts are performed on all gamma detectors at least weekly for either an overnight or weekend count. The most recent background is subtracted from all sample counts.

**Assumption and Limitations of the Data**

The digestion was performed following procedure PNL-ALO-129. For this digestion, the concentrations of nitric and hydrochloric acid were increased to 8M for each acid. Additionally, the volumes of each reagent acid were increased to ensure sufficient excess acid was present to solubilize the acid soluble analytes.

**Interferences/Resolution**

None.

**Uncertainty**

For gamma counting, the uncertainty in the efficiency, counting data, photon abundance and the nuclear half-life are included in the calculation of the total uncertainty along with a systematic uncertainty for sample prep. The Canberra Genie software includes both random and systematic uncertainties in the calculation of the total uncertainties which are listed on the report. We conservatively estimate that 2% is the lowest uncertainty possible for our GEA measurements taking into account systematic uncertainties in gamma calibration standards.

**Comments**

1. The results have been corrected for all dilution factors resulting from sample processing.

2. Minimum Detectable Activity (MDA) and Minimum Detectable Concentration (MDC). Sample results are compared to the process blank results to evaluate if the blank contains 5% or more of the analyte of interest. When samples undergo digestion and/or dilution (process factors), the MDA must be adjusted for the process factors to accurately compare activity levels in the blank to activity levels in the samples. Process blank results have been adjusted for digestion and/or process factors for evaluation of the 5% criteria.

Attachment: Data Report Sample Results for ASR 8888.

*Battelle PNNL/RPL/ASO Radiochemistry Analysis Report*
*P.O. Box 999, 902 Battelle Blvd., Richland, Washington 99352*

# Sr-90 by Liquid Scintillation Spectrometry

| | |
|---|---|
| **Project / WP#:** | 60965/ H54512 |
| **ASR#:** | 8888.00 |
| **Client:** | KN Pool |
| **Total # of Samples:** | 1 |

| RPL ID | Client Sample ID |
|---|---|
| 11-1355 | J1JD49 |

| | |
|---|---|
| **Analysis Type:** | Sr-90 |
| **Sample Processing Prior to Radiochemical Processing/Analysis** | ☐ None<br>☒ Digested as per PNL-ALO-129, Rev. 0, *$HNO_3$-HCl Acid Extraction of Solids Using a Dry Block Heater, (7/19/11 to 7/20/11 N. Green)*<br>☐ Fusion as per PNL-ALO-115, *Solubilization of Metals from Solids Using a $KOH$-$KNO_3$ Fusion*<br>☐ Other: |
| **Pre-dilution Prior to Radiochemical Processing?** | ☒ No<br>☐ Yes |
| **Total Alpha and Beta Preparation Procedure:** | RPG-CMC-4001, Rev. 1, *Source Preparation For Gross Alpha and Gross Beta Analyses.* |
| **Technician/Analyst:** | K. Carson, 7-12-11 |
| **Spike Standard ID's** | R-569-a-4 (Sr-90), R-485-a-10 (Pu 239) |
| **Analysis Procedure** | RPG-CMC-408, Rev. 2, *Total Alpha and Beta Analysis* |
| **Technician/Analyst:** | T. Trung-Le, 7-19-11 |
| **Separation Procedure:** | RPG-CMC-476, Rev. 0, *Strontium Separation Using Eichrom Strontium Resin* |
| **Spike Standard ID:** | R-569-a-3 (Sr-90) |
| **Separation Date:** | 7/19/11 12:40 p.m. |
| **Technician/Analyst:** | K. Carson |
| **Analysis Procedure:** | RPG-CMC-474, Rev. 1, *Measurement of Alpha and Beta Activity by Liquid Scintillation Spectrometry* |
| **Reference Date:** | N/A |
| **Analysis Date or Date Range:** | 7/21/11 (first count), 7/27/11 (second count) |
| **Technician/Analyst:** | T. Trang-Le |
| **Rad Chem Electronic Data File:** | 11-1355 Pool.xls |
| **ASO Project 98620 File:** | File Plan 5871: T 60695 8888: Sample preparation and analysis records; T-4.4 LSC 3100 calibration, daily checks, and maintenance records; and T3 standard certificates and preparation. Also, balance calibration and performance check records. |
| **M&TE Number(s):** | Perkin Elmer Tri-Carb 3100, Serial # DG08061340, RPL 425, Tri-Carb 2700TR software version 1.04 dated 9/99. |

Kirk N. Pool / 9/20/11 — **Preparer** / **Date**

T Trang-Le / 9/20/11 — **Reviewer** / **Date**

## SAMPLE RESULTS

See attached data report, Sample Results for ASR 8888. All sample data are reported in μCi/g with a 1-σ uncertainty (see Comments).

### Sample preparation, separation, mounting, and counting

ASO received the sampling device and loaded the entire sampling device into the SAL hot cells. The sampling device was retrieved from the plastic sleeving and the soil sample was removed from the inside of the sampling tube. One gram aliquots of the soil sample were then placed in Teflon oak ridge tubes and digested with a mixture of 8M $HNO_3$ and 8M HCl using PNNL procedure PNL-ALO-129. At the completion of the digestion, the insoluble residue was rinsed three consecutive times with the same $HNO_3$/HCl acid mixture to remove any interstitial liquid. Each rinse was collected and added to the original digestate solution. The digestate solution was brought to a final volume of 100 mL in a volumetric flask. The leachate solution was used for radioanalytical analyses and ICP metals analysis; only Sr-90 data are included in this report.

Although not formally requested by the ASR, gross alpha and gross beta analyses were performed on each sample to obtain information to estimate aliquot sizes for other analyses and for checking the internal consistency of the Sr-90 data. The gross alpha and gross beta results are included in the data tables as supplemental information only. Gross alpha and gross beta activity were measured by evaporating small aliquots of leachate onto counting planchets per procedure RPG-CMC-4001 and counting per procedure RPG-CMC-408. The sum of the major beta emitters, in this case Sr/Y-90 and Cs-137, agree very well with the gross beta results.

## QUALITY CONTROL RESULTS

Radioanalytical quality control (QC) samples prepared in the SAL hot cells include a hot cell process blank (PB), and sample duplicate. No Sr-90 MS was prepared at time of digestion. Additional laboratory QC samples were prepared prior to separations; these include a laboratory separation blank, a reagent blank spike (BS), and a matrix spike (i.e., addition of Sr-90 standard to an aliquot of one of the samples).

### Instrument Calibration Control

Hot Cell Process Blank (PB) and Laboratory separations blank (LB):

The Sr-90 activity measured in the PB is required to be within the acceptance criteria of less than sample minimum detectable activity (MDA) or less than 5% of the sample isotope concentration. The Sr-90 PB is <5% of all sample results; thus meeting the acceptance criteria. There are no acceptance criteria for LB (see Comments).

Blank Spike (BS) – reagent spike:

The BS recovery of 98% meets the procedure acceptance criteria of 80% to 120% recovery.

Matrix Spike (MS):

The MS recovery of 98% meets the acceptance criterion of 75% to 125% recovery. Note: the MS sample was prepared "after" digestion (see comments), by adding a known Sr-90 standard quantity to an aliquot of J1JD49 (11-1355).

Duplicate – Relative Percent Difference (RPD):

Duplicate results are required to agree within ≤20% RPD. The ASO QAP further specifies that the two results need to be >5 times the MDA or have individual uncertainties <20%. Duplicate result was 2% RPD; thus meeting the ≤20% requirement.

**Instrument Quality Control**

The liquid scintillation counter is calibrated for tritium and C-14 using quenched standard sets that are purchased from the vendor. Daily control counts are then performed using a tritium, C-14, and a background count sample. The instrument software assesses the performance of the control counts and provides control charts to ensure the continuing calibration of the instrument. If the daily performance check fails, then the instrument is not used. Preventative maintenance and repairs are performed by the vendor under our service contract. The counting efficiency for Sr-90 is assumed to be 100%; therefore no specific Sr-90 calibration is performed. The LSC system calibration and performance is verified by assessing the recovery of a reagent spike and a matrix spike that are included in every batch of samples. A preparation blank (i.e., digestion blank) and a laboratory separations blank are also included with every batch of samples; the instrument background is subtracted from all results and the preparation and separation blanks are used to assess sample contamination during sample processing steps.

**Assumption and Limitations of the Data**

The 1-σ uncertainty reported for each Sr-90 result has been set at 2%. Although the calculated uncertainty values are less than 2% for all samples, the radiochemistry convention is to not report calculated uncertainties less than 2%, but to provide a more realistic estimate of the uncertainty in view of systematic uncertainties that are not fully accounted for in the uncertainty calculations.

**Comments**

1. The results have been corrected for all dilution factors resulting from sample processing.
2. Post-Digestion Spike (PS) - A spike made after the initial sample preparation (e.g., fusion, digestion, or leach) is considered a PS. When extremely radioactive samples are analyzed, most of the radio-analytical spikes are made after the sample preparation (to avoid excessive consumption of spike and avoid creating unnecessary waste) and are post-digestion spikes. The MS prepared with this batch of sample is considered a PS, since the Sr-90 spike was not added prior to the digestion process.
3. Radiochemistry Electronic Systems File "11-1355 Pool" has been created for this report. Supporting records such as Pipette Performance Verification forms, Laboratory Bench Record, Shielded Analytical Laboratory (SAL) Bench Sheet, Standards Certifications and preparation records, and balance calibration and performance check records are maintained per RS&E Group ASO File Plan 5871.
4. Sample results are compared to the process blank results to evaluate if the blank contains 5% or more of the measured isotope; the process blank results have been adjusted for all processing factors for the evaluation of the 5% criterion.
5. The stated 1-σ uncertainty represents the total propagated error associated with processing and counting operations and includes weighing errors, volume uncertainties, and counting error.

Attachment: Data Report -- Sample Results for ASR 8888

*Battelle PNNL/RPL/ASO Radiochemistry Analysis Report*
*P.O. Box 999, 902 Battelle Blvd., Richland, Washington 99352*

# Uranium 233+234, 235+236, 238 Analyses

| | |
|---|---|
| **Project / WP#:** | 60965/ H54512 |
| **ASR#:** | 8888.00 |
| **Client:** | KN Pool |
| **Total # of Samples:** | 1 |

| RPL ID | Client Sample ID |
|---|---|
| 11-1355 | J1JD49 |

| | |
|---|---|
| **Analysis Type:** | AEA – U-233+234, 235+236, 238 |
| **Sample Processing Prior to Radiochemical Processing/Analysis** | ☐ None<br>☒ Digested as per PNL-ALO-129, Rev. 0, *$HNO_3$-HCl Acid Extraction of Solids Using a Dry Block Heater, (7/19/11 to 7/20/11 J. Chenault))*<br>☐ Fusion as per PNL-ALO-115, *Solubilization of Metals from Solids Using a $KOH$-$KNO_3$ Fusion*<br>☐ Other: |
| **Pre-dilution Prior to Radiochemical Processing?** | ☒ No<br>☐ Yes -- *example 2 mL to 100 mL; 50x dilution* |
| **Total Alpha and Beta Preparation Procedure:** | RPG-CMC-4001, Rev. 1, *Source Preparation For Gross Alpha and Gross Beta Analyses.* |
| **Technician/Analyst:** | K. Carson, 7-26-11 |
| **Spike Standard ID's** | R-569-a-2 (Sr-90), R-485-b-7 (Pu 239) |
| **Analysis Procedure** | RPG-CMC-408, Rev. 2, *Total Alpha and Beta Analysis* |
| **Technician/Analyst:** | T. Trang-Le, 7-26-11 (Gross Alpha), 7-27-11 (Gross Beta) |
| **Uranium Separation Procedure:** | RPG-CMC-4015, Rev. 0, *Analysis of Soil and Sediment Samples for Actinides and SR-90* |
| **Technician/Analyst:** | K. Carson, 8-23-11 |
| **Spike and Tracer Standard ID's:** | R608b (U) |
| **Co-Precipitation Procedure:** | RPG-CMC-496, Rev. 0, *Coprecipitation Mounting of Actinides for Alpha Spectroscopy* |
| **Technician/Analyst:** | K. Carson, 8-29-11 |
| **Analysis Procedure:** | RPG-CMC-422, Rev. 2, *Solutions Analysis: Alpha Spectrometry* |
| **Reference Date:** | 9/1/11 |
| **Analysis Date or Date Range:** | 8/31/11 and 9/1/11 |
| **Technician/Analyst:** | T. Trang-Le |
| **Analysis Data (File):** | 11-1355 Pool.xls |
| **CMC Project 98620 File:** | File Plan 5871: T 60965 8902: Sample preparation and analysis records; T-4.4 Alpha Detector calibration, calibration verification checks, and maintenance records; and T3 Standard certificates and preparation. Also balance calibration and instrument performance checks. |
| **M&TE Number(s):** | Ortec AEA counters – 32 counters – See attached M&TE list |

| | | | |
|---|---|---|---|
| [signature] | 9/20/11 | T Trang-Le | 9/20/11 |
| **Preparer** | **Date** | **Reviewer** | **Date** |

**Sample Results**

See attached data report, U-233+234, U-235+236 and U-238 Sample Results for ASR 8888. All data are reported in units of μCi/g with estimates of the total propagated uncertainty reported at the 1-sigma level.

**Sample Preparation, Separation, Mounting and Counting Methods**

ASO received the sampling device and loaded the entire sampling device into the SAL hot cells. The sampling device was retrieved from the plastic sleeving and the soil sample was removed from the inside of the sampling tube. One gram aliquots of the soil sample were then placed in Teflon oak ridge tubes and digested with a mixture of 8M $HNO_3$ and 8M HCl using PNNL procedure PNL-ALO-129. At the completion of the digestion, the insoluble residue was rinsed three consecutive times with the same $HNO_3$/HCl acid mixture to remove any interstitial liquid. Each rinse was collected and added to the original digestate solution. The digestate solution was brought to a final volume of 100 mL in a volumetric flask. The leachate solution was used for radioanalytical analyses and ICP metals analysis; only U-AEA is reported in this report.

Following the digestion process, the Pu was separated from the sludge leachate by anion exchange using procedure RPG-CMC-4015. The separated Pu fraction was then mounted for alpha spectrometry by co-precipitation using procedure RPG-CMC-496, and then counted using alpha spectrometry using procedure RPC-CMC-422. The samples were counted on August 31st and September 1st, 2011; no decay corrections were made.

Although not formally requested by the ASR, gross alpha and gross beta analyses were performed on each sample to obtain information to estimate aliquot sizes for other analyses and for checking the internal consistency of the Pu alpha isotopic data. The gross alpha and gross beta results are included in the data tables as supplemental information only. Gross alpha and gross beta activity were measured by evaporating small aliquots of leachate onto counting planchets per procedure RPG-CMC-4001 and counting per procedure RPG-CMC-408. These procedures are not required to be pre-approved by K-Basin project staff as they are used to generate opportunistic data only. The sum of the major alpha emitters, in this case Pu-238, Pu-239+240, Am-241 and Cm-243+244, agrees very well with the gross alpha results.

## QUALITY CONTROL RESULTS

Quality control (QC) samples prepared in the SAL hot cells include a hot cell process blank (PB), sample duplicates for each sample, and a matrix spike (MS – for ICP/OES only). Additional QC samples were prepared prior to separations; these include a laboratory separation blank, a reagent blank spike (BS, spiked with natural U), and a matrix spike (MS) made by adding natural U standard to a diluted sample.

Tracer:

Tracer is not used for analyses of U.

Hot Cell Process Blank (PB) and Laboratory separations blank (LB):

The U-233+234, U-235+236 and U-238 activities measured in the PB are required to be within the acceptance criteria of less than 5% of the sample isotope concentration or less than sample minimum detectable activity (MDA) – see comments. The PB U-233+234, U-235+236 and U-238 activities are less than 5% of any sample activity. There are no acceptance criteria for LB

Blank Spike (BS) – reagent spike:

The BS (natural uranium, U-238) recovery of 98% meets the acceptance criteria of 80% to 120% recovery.

Matrix Spike (MS):

The MS sample was lost in the sample preparation process and recovery of the MS could not be accurately calculated.

Duplicate -- Relative Percent Difference (RPD):

Duplicate results are required to agree within ≤20% RPD. The duplicate result for U-233+234 was 26% RPD exceeding the acceptance criteria of ≤20% (Note: when the Mean Difference (MD) calculation is applied the MD = 0.717 which is less than 1.96, indicating the results are not statistically different at the 95% confidence level) . The U-238 was 20%, within the acceptance criteria of ≤20% RPD.

**Instrument Quality Control**

Alpha counters undergo calibration annually to determine the counter's efficiency over the normal calibration range of 3 to 6 MeV. The vendor software determines a constant detector efficiency for this energy range. U samples are counted and results calculated using the established detector efficiency.

Detector backgrounds are determined every 4 weeks or after the last analytical run, whichever is longer. Detector background counts are subtracted from all subsequent sample counts. A process blank is analyzed with each analytical batch to evaluate for contamination in the sample preparation process.

**Assumption and Limitations of the Data**

The matrix spike sample was partially spilled in the process of analyzing the sample batch. Although not reported due to the unknown quantity of sample and spike lost in the sample preparation process, the recovery of the matrix spike was calculated to be 67%. This indicates the added spike was recoverable in the sample preparation matrix. Additionally, the good recovery (98%) of the BS indicates that the column chemistry was working as expected.

**Comments**

1. The results have been corrected for all dilution factors resulting from sample processing.

2. Post-Digestion Spike (PS) - A spike made after the initial sample preparation (e.g., fusion, digestion, or leach) is considered a PS. When extremely radioactive samples are analyzed, most of the radio analytical spikes are made after the sample preparation and aliquot dilution (to avoid excessive consumption of spike and avoid creating unnecessary waste). The MS prepared with this sample batch is considered a PS, since the natural uranium spike was not added prior to the digestion process.

3. The 1-sigma uncertainty represents the total propagated error associated with processing and counting operations and includes weighing errors, volume uncertainties, and counting error.

4. The sample results are compared to the process blank to evaluate if the blank contains 5% or more of the measured isotope; the process blank result has been adjusted for all processing factors for evaluation of the 5% criterion.

5. The Laboratory Blank (LB) is prepared using laboratory reagents and provides data only on the cleanliness of the radiochemistry preparation process. LB results are not normalized to processing or dilution factors associated with the samples.

Attachment: Data Report -- Sample Results for ASR 8888

*Battelle PNNL/RPL/ASO Radiochemistry Analysis Report*
*P.O. Box 999, 902 Battelle Blvd., Richland, Washington 99352*

# Plutonium 238, 239+240 Analysis

| | |
|---|---|
| **Project / WP#:** | 60965/ H54512 |
| **ASR#:** | 8888.00 |
| **Client:** | KN Pool |
| **Total # of Samples:** | 1 |

| RPL ID | Client Sample ID |
|---|---|
| 11-1355 | J1JD49 |

| | |
|---|---|
| **Analysis Type:** | AEA – Pu-238, Pu-239+240 |
| **Sample Processing Prior to Radiochemical Processing/Analysis** | ☐ None<br>☒ Digested as per PNL-ALO-129, Rev. 0, *$HNO_3$-HCl Acid Extraction of Solids Using a Dry Block Heater, (6/29/11 to 7/1/11 N. Green)*<br>☐ Fusion as per PNL-ALO-115, *Solubilization of Metals from Solids Using a $KOH$-$KNO_3$ Fusion*<br>☐ Other: |
| **Pre-dilution Prior to Radiochemical Processing?** | ☒ No |
| | ☐ Yes -- *example 2 mL to 100 mL; 50x dilution* |
| **Total Alpha and Beta Preparation Procedure:** | RPG-CMC-4001, Rev. 1, *Source Preparation For Gross Alpha and Gross Beta analyses.* |
| **Technician/Analyst:** | L. Darnell, 7-6-11 (Gross Alpha), K. Carson, 7-12-11 (Gross Beta) |
| **Spike Standard ID's** | R-569-a-4 (Sr-90), R-485-a-10 (Pu 239) |
| **Analysis Procedure** | RPG-CMC-408, Rev. 2, *Total Alpha and Beta Analysis* |
| **Technician/Analyst:** | T. Trang-Le, 7-19-11 |
| **Plutonium Separation Procedure:** | RPG-CMC-4015, Rev. 0, *Analysis of Soil and Sediment Samples for Actinides and SR-90* |
| **Technician/Analyst:** | K. Carson, 8-3-11 |
| **Spike and Tracer Standard ID's:** | R-485-b-7 (Pu-239), R-570-a-1 (Pu-242 tracer) |
| **Co-Precipitation Procedure:** | RPG-CMC-496, Rev. 0, *Coprecipitation Mounting of Actinides for Alpha Spectroscopy* |
| **Technician/Analyst:** | K. Carson, 8-3-11 |
| **Analysis Procedure:** | RPG-CMC-422, Rev. 2, *Solutions Analysis: Alpha Spectrometry* |
| **Reference Date:** | Same as counting dates (8/3/11 and 8/9/11) |
| **Analysis Date or Date Range:** | 8/3/11 and 8/9/11 |
| **Technician/Analyst:** | T. Trang-Le |
| **Analysis Data (File):** | 11-1355 Pool.xls |
| **CMC Project 98620 File:** | File Plan 5871: T 60965 8888: Sample preparation and analysis records; T-4.4 Alpha Detector calibration, calibration verification checks, and maintenance records; and T3 Standard certificates and preparation. Also balance calibration and instrument performance checks. |
| **M&TE Number(s):** | Ortec AEA counters – 32 counters – See attached M&TE list |

Kul N. Pool / 9/20/11 — Preparer / Date

T Trang-le / 9/20/11 — Reviewer / Date

**Sample Results**

See attached data report, Pu-238 and Pu-239+240 Sample Results for ASR 8888. All data are reported in units of µCi/g with estimates of the total propagated uncertainty reported at the 1-sigma level.

**Sample Preparation, Separation, Mounting and Counting Methods**

ASO received the sampling device and loaded the entire sampling device into the SAL hot cells. The sampling device was retrieved from the plastic sleeving and the soil sample was removed from the inside of the sampling tube. One gram aliquots of the soil sample were then placed in Teflon oak ridge tubes and digested with a mixture of 8M $HNO_3$ and 8M HCl using PNNL procedure PNL-ALO-129. At the completion of the digestion, the insoluble residue was rinsed three consecutive times with the same $HNO_3$/HCl acid mixture to remove any interstitial liquid. Each rinse was collected and added to the original digestate solution. The digestate solution was brought to a final volume of 100 mL in a volumetric flask. The leachate solution was used for radioanalytical analyses and ICP metals analysis; only Pu-AEA is reported in this report.

Following the digestion process, the Pu was separated from the sludge leachate by anion exchange using procedure RPG-CMC-4015. The separated Pu fraction was then mounted for alpha spectrometry by co-precipitation using procedure RPG-CMC-496, and then counted using alpha spectrometry using procedure RPC-CMC-422. The samples were counted on August 3rd and 9th, 2011; no decay corrections were made.

Although not formally requested by the ASR, gross alpha and gross beta analyses were performed on each sample to obtain information to estimate aliquot sizes for other analyses and for checking the internal consistency of the Pu alpha isotopic data. The gross alpha and gross beta results are included in the data tables as supplemental information only. Gross alpha and gross beta activity were measured by evaporating small aliquots of leachate onto counting planchets per procedure RPG-CMC-4001 and counting per procedure RPG-CMC-408. The sum of the major alpha emitters, in this case Pu-238, Pu-239+240, Am-241 and Cm-243+244, agrees very well with the gross alpha results.

## QUALITY CONTROL RESULTS

Quality control (QC) samples prepared in the SAL hot cells include a hot cell process blank (PB), sample duplicates for each sample, and a matrix spike (MS – for ICP/OES only). Additional QC samples were prepared prior to separations; these include a laboratory separation blank, a reagent blank spike (BS, spiked with Pu-239), and a matrix spike (MS) made by adding Pu-239 standard to a diluted sample.

Tracer:

The Pu-242 tracer is added to every sample after appropriate dilution and prior to plutonium separations. The use Pu-242 tracer corrects for radiochemical yield and mathematically removes the detector counting efficiency from the results calculations. Tracer recover is required to be high enough to provide acceptable counting statistics. The Pu-242 tracer counting statistics were acceptable for all samples. The tracer recoveries ranged from 70% to 97%.

Hot Cell Process Blank (PB) and Laboratory separations blank (LB):

The Pu-238 and Pu-239+240 activities measured in the PB are required to be within the acceptance criteria of less than 5% of the sample isotope concentration or less than sample minimum detectable activity (MDA) – see comments. The PB Pu-238 and Pu-239+240 activities are significantly less than 5% of any sample activity. There are no acceptance criteria for LB

Blank Spike (BS) – reagent spike:

The BS (Pu-239) recovery of 104% meets the acceptance criteria of 80% to 120% recovery.

Matrix Spike (MS):

The MS recovery of 99% meets the acceptance criterion of 75% to 125% recovery. Note: the MS sample was prepared after digestion, by adding a known Pu-239 standard quantity to an aliquot of the leachate. Sample number 11-1355 (J1JD49) was selected as the matrix spike sample.

Duplicate – Relative Percent Difference (RPD):

Duplicate results are required to agree within ≤20% RPD. The duplicate result of 58% RPD for Pu-238 and 38% for Pu-239+240 exceeds the ≤20% requirement. See Assumptions and Limitations of the Data.

**Instrument Quality Control**

Counter control source counting is not required when samples are spiked with tracers. When tracers are used, the absolute counting efficiencies are not used.

Detector backgrounds are determined every 4 weeks or after the last analytical run, whichever is longer. Detector background counts are subtracted from all subsequent sample counts. A process blank is analyzed with each analytical batch to evaluate for contamination in the sample preparation process.

**Assumption and Limitations of the Data**

The duplicate precision for all alpha emitters exceeded 20%, Pu-238 and Pu-239+240 included. However, the ratio of alpha activity between sample and duplicate was consistent. This is likely due to sample homogeneity during the initial sub-sampling in the hot cell.

**Comments**

1. The results have been corrected for all dilution factors resulting from sample processing.

2. Post-Digestion Spike (PS) - A spike made after the initial sample preparation (e.g., fusion, digestion, or leach) is considered a PS. When extremely radioactive samples are analyzed, most of the radio analytical spikes are made after the sample preparation and aliquot dilution (to avoid excessive consumption of spike and avoid creating unnecessary waste). The MS prepared with this sample batch is considered a PS, since the Pu-239 spike was not added prior to the digestion process.

3. Each alpha spectrum was examined for potential interferences from other alpha emitting isotopes. Pu-242 and Am-243 tracers are added at the start of the chemical separation process. The presence of Am-243 in the Pu-AEA would indicate interference from Am-241 on the Pu-238 peak. The alpha spectra were evaluated to verify the removal of Am from the Pu. There was no evidence of interfering isotopes, including Am.

4. The 1-sigma uncertainty represents the total propagated error associated with processing and counting operations and includes weighing errors, volume uncertainties, and counting error.

5. The sample results are compared to the process blank to evaluate if the blank contains 5% or more of the measured isotope; the process blank result has been adjusted for all processing factors for evaluation of the 5% criterion.

6. The Laboratory Blank (LB) is prepared using laboratory reagents and provides data only on the cleanliness of the radiochemistry preparation process. LB results are not normalized to processing or dilution factors associated with the samples.

Attachment: Data Report -- Sample Results for ASR 8888

*Battelle PNNL/RPL/ASO Radiochemistry Analysis Report*
*P.O. Box 999, 902 Battelle Blvd., Richland, Washington 99352*

# Americium 241 Analysis

| | |
|---|---|
| **Project / WP#:** | 60965/ H54512 |
| **ASR#:** | 8888.00 |
| **Client:** | KN Pool |
| **Total # of Samples:** | 1 |

| RPL ID | Client Sample ID |
|---|---|
| 11-1355 | J1JD49 |

| | |
|---|---|
| **Analysis Type:** | AEA – Am-241 |
| **Sample Processing Prior to Radiochemical Processing/Analysis** | ☐ None<br>☒ Digested as per PNL-ALO-129, Rev. 0, *$HNO_3$-HCl Acid Extraction of Solids Using a Dry Block Heater, (6/29/11 to 7/1/11 N. Green)*<br>☐ Fusion as per PNL-ALO-115, *Solubilization of Metals from Solids Using a KOH-$KNO_3$ Fusion*<br>☐ Other: |
| **Pre-dilution Prior to Radiochemical Processing?** | ☒ No<br>☐ Yes – *example 2 mL to 100 mL; 50x dilution* |
| **Total Alpha and Beta Preparation Procedure:** | RPG-CMC-4001, Rev. 1, *Source Preparation For Gross Alpha and Gross Beta analyses.* |
| **Technician/Analyst:** | L. Darnell, 7-6-11 (Gross Alpha), K. Carson, 7-12-11 (Gross Beta) |
| **Spike Standard ID's** | R-569-a-4 (Sr-90), R-485-a-10 (Pu 239) |
| **Analysis Procedure** | RPG-CMC-408, Rev. 2, *Total Alpha and Beta Analysis* |
| **Technician/Analyst:** | T. Trang-Le, 7-19-11 |
| **Americium Separation Procedure:** | RPG-CMC-4015, Rev. 0, *Analysis of Soil and Sediment Samples for Actinides and SR-90* |
| **Technician/Analyst:** | K. Carson, 8-5-11 |
| **Spike and Tracer Standard ID's:** | R-542-a-3 (Am-241), R-571-a-2 (Am-243 tracer) |
| **Co-Precipitation Procedure:** | RPG-CMC-496, Rev. 0, *Co-precipitation Mounting of Actinides for Alpha Spectroscopy* |
| **Technician/Analyst:** | K. Carson, 8-5-11 |
| **Analysis Procedure:** | RPG-CMC-422, Rev. 2, *Solutions Analysis: Alpha Spectrometry* |
| **Reference Date:** | Same as counting dates (8/10/11 and 8/11/11) |
| **Analysis Date or Date Range:** | 8/10/11 and 8/11/11 |
| **Technician/Analyst:** | T. Trang-Le |
| **Analysis Data (File):** | 11-1355 Pool.xls |
| **CMC Project 98620 File:** | File Plan 5871: T 50965 8888: Sample preparation and analysis records; T-4.4 Alpha Detector calibration, calibration verification checks, and maintenance records; and T3 Standard certificates and preparation. Also balance calibration and instrument performance checks. |
| **M&TE Number(s):** | Ortec AEA counters – 32 counters – See attached M&TE list |

Kurt N. Pool / 9/20/11 — Preparer / Date

T Trang-Le / 9/20/11 — Reviewer / Date

**Sample Results**

See attached data report, Am-241 Sample Results for ASR 8888. All data are reported in units of µCi/g with estimates of the total propagated uncertainty reported at the 1-sigma level.

**Sample Preparation, Separation, Mounting and Counting Methods**

ASO received the sampling device and loaded the entire sampling device into the SAL hot cells. The sampling device was retrieved from the plastic sleeving and the soil sample was removed from the inside of the sampling tube. One gram aliquots of the soil sample were then placed in Teflon oak ridge tubes and digested with a mixture of 8M $HNO_3$ and 8M HCl using PNNL procedure PNL-ALO-129. At the completion of the digestion, the insoluble residue was rinsed three consecutive times with the same $HNO_3$/HCl acid mixture to remove any interstitial liquid. Each rinse was collected and added to the original digestate solution. The digestate solution was brought to a final volume of 100 mL in a volumetric flask. The leachate solution was used for radioanalytical analyses and ICP metals analysis; only Am-AEA data are included in this report. Cm isotopes follow the separation chemistry of Am and have been included in the final data summary tables.

Following the digestion process, the Pu and U were first removed from the leachate by anion exchange chromatography using procedure RPG-CMC-4015. The Am and Cm were separated from the load and wash solution using Eichrom TRU resin per procedure RPG-CMC-4015. The separated Am/Cm fraction was then mounted for alpha spectrometry by co-precipitation using procedure RPG-CMC-496, then counted by alpha spectroscopy using procedure RPC-CMC-422. The samples were counted on August 11$^{th}$ and 12$^{th}$, 2011; no decay corrections were made.

Although not formally requested by the ASR, gross alpha and gross beta analyses were performed on each sample to obtain information to estimate aliquot sizes for other analyses and for checking the internal consistency of the Am alpha isotopic data. The gross alpha and gross beta results are included in the data tables as supplemental information only. Gross alpha and gross beta activity were measured by evaporating small aliquots of leachate onto counting planchets per procedure RPG-CMC-4001 and counting per procedure RPG-CMC-408. The sum of the major alpha emitters, in this case Pu-238, Pu-239+240, Am-241 and Cm-243+244, agrees very well with the gross alpha results.

## QUALITY CONTROL RESULTS

Quality control (QC) samples prepared in the SAL hot cells include a hot cell process blank (PB), sample duplicates for each sample, and a matrix spike (MS – for ICP/OES only). Additional QC samples were prepared prior to separations; these include a laboratory separation blank, a reagent blank spike (BS), and a matrix spike (MS) made by adding Am-241 standard to a diluted sample.

Tracer:

The Am-243 tracer is added to every sample after appropriate dilution and prior to americium separations. The Am-243 tracer corrects for radiochemical yield and mathematically removes the detector counting efficiency from the results calculations. Tracer recover is required to be high enough to provide acceptable counting statistics. The Am-243 tracer counting statistics were acceptable for all samples. The tracer recoveries ranged from 95% to 111%.

Hot Cell Process Blank (PB) and Laboratory separations blank (LB):

The Am-241 activity measured in the PB are required to be within the acceptance criteria of less than 5% of the sample isotope concentration or less than sample minimum detectable activity (MDA) – see comments. The PB Am-241 activity is significantly less than 5% of any sample activity. There are no acceptance criteria for LB (see comment section below).

Blank Spike (BS) – reagent spike:

The BS recovery of 97% meets the acceptance criteria of 80% to 120% recovery.

Matrix Spike (MS):

The MS recovery of 97% meets the acceptance criterion of 75% to 125% recovery. Note: the MS sample was prepared after digestion, by adding a known Am-241 standard quantity to an aliquot of the leachate. Sample number 11-1355 (J1JD49) was selected as the matrix spike sample.

Duplicate -- Relative Percent Difference (RPD):

Duplicate results are required to agree within ≤20% RPD. The duplicate result of 48% RPD exceeds the ≤20% requirement. See Assumptions and Limitations of the Data.

**Instrument Quality Control**

Counter control source counting is not required when samples are spiked with tracers. When tracers are used, the absolute counting efficiencies are not used.

Detector backgrounds are determined every 4 weeks or after the last analytical run, whichever is longer. Detector background counts are subtracted from all subsequent sample counts. A process blank is analyzed with each analytical batch to evaluate for contamination in the sample preparation process.

**Assumption and Limitations of the Data**

The duplicate precision for all alpha emitters, Am-241 included, between sample and duplicate exceeded 20%. However, the ratio of alpha activity between sample and duplicate was consistent. This is likely due to sample homogeneity during the initial sub-sampling in the hot cell.

**Comments**

1. The results have been corrected for all dilution factors resulting from sample processing.

2. Post-Digestion Spike (PS) - A spike made after the initial sample preparation (e.g., fusion, digestion, or leach) is considered a PS. When extremely radioactive samples are analyzed, most of the radioanalytical spikes are made after the sample preparation and dilution (to avoid excessive consumption of spike and avoid creating unnecessary waste). The MS prepared with this batch of samples is considered a PS, since the Am-241 spike was not added prior to the digestion process.

3. The 1-sigma uncertainty represents the total propagated error associated with processing and counting operations and include; weighing errors, volume uncertainties, and counting error.

4. The sample results are compared to the process blank to evaluate if the blank contains 5% or more of the measured isotope; the process blank result has been adjusted for all processing factors for evaluation of the 5% criterion.

5. The Laboratory Blank (LB) is prepared using laboratory reagents and provides data on the cleanliness of the radiochemistry preparation/separation processes. LB results are not normalized to processing or dilution factors associated with the samples.

Attachment: Data Report – Sample Results for ASR 8888

**Pacific Northwest National Laboratory**
**PO Box 999, Richland, WA**
**Radiochemical Sciences and Engineering Group**

filename 11-1397 Pool
8/22/2011

Client: K. Pool
ASR: 8902

Project: 52578
WP: H54512

Prepared by: C. Soderquist 9-8-2011

Concur: T Trang-Le 9/8/2011

Procedures: PNL-ALO-129, Rev. 0, $HNO_3$-HCl Acid Extraction of Solids Using a Dry-Block Heater
RPG-CMC-450, Rev. 1 Gamma Energy Analysis (GEA) and Low-Energy Photon Spectrometry (LEPS)
RPG-CMC-4001, Rev. 1, Source Preparation for Gross Alpha and Gross Beta Analysis
RPG-CMC-408, Rev. 2, Total Alpha and Beta Analysis
RPG-CMC-476, Rev. 0, Strontium Separation using Eichrom Strontium Resin
RPG-CMC-474, Rev. 1, Measurement of Alpha and Beta Activity by Liquid Scintillation Spectrometry

Count date: July 27, 2011

M & TE: Gamma Detector T, LB4100 proportional counter (gross beta), Perkin Elmer liquid scintillation spectrometer model 3100TR (Sr-90)

| | | Measured Activities, µCi/g with 1-sigma uncertainty | | | | | |
|---|---|---|---|---|---|---|---|
| **Sample ID** | **RPL ID** | **Co-60** | **Cs-137** | **Eu-154** | **Am-241** | **Gross Beta** | **Sr-90** |
| **J1JD50** | 11-1397 | <6.E-2 | **8.19E+3 ± 7%** | <4.E-1 | <3.E+1 | **9.26E+3 ± 4%** | **3.87E+2 ± 2%** |
| | 11-1397 Dup | <1.E-1 | **7.78E+3 ± 7%** | <3.E-1 | <3.E+1 | **8.79E+3 ± 4%** | **3.68E+2 ± 2%** |
| | RPD | -- | 5% | -- | -- | 5% | 5% |
| | Hot cell blank | <8.E-4 | 4.46E-3 ± 16% | <2.E-3 | <1.E-2 | 6.96E-3 ± 6% | 1.25E-3 ± 3% |
| | Lab blank | -- | -- | -- | -- | <4.E-6 | <2.E-5 |
| | Reagent spike | -- | -- | -- | -- | 88% | 102% |
| | Matrix spike | -- | -- | -- | -- | * | 104% |

This soil sample was digested in a nitric-hydrochloric acid mixture, in duplicate, in a hot cell. The acid digestion solution was centrifuged to remove the undissolved soil, then removed from cell and delivered to the analytical lab for radiochemistry.

No gamma emitters were detected other than Cs-137. The gross beta matrix spike was too small for the sample activity, and no spike recovery could be calculated.

**Pacific Northwest National Laboratory**
**PO Box 999, Richland, WA**
**Radiochemical Sciences and Engineering Group**

filename 11-1397 Pool
8/22/2011

Client: K Pool
ASR 8902

Project: 52578
WP: H54512

Procedures: PNL-ALO-129, Rev. 0, $HNO_3$-HCl Acid Extraction of Solids Using a Dry-Block Heater
RPG-CMC-4001, Rev. 1, Source Preparation for Gross Alpha and Gross Beta Analysis
RPG-CMC-408, Rev. 2, Total Alpha and Beta Analysis
RPG-CMC-4015, Rev. 0, Analysis of Soil and Sediment Samples for Actinides and Strontium-90
RPG-CMC-496, Rev. 0, Coprecipitation Mounting of Actinides for Alpha Spectrometry
RPG-CMC-422, Rev. 2, Solutions Analysis: Alpha Spectrometry
Reference Date August 15, 2011
M & TE: Ludlum alpha counters (gross alpha), Alpha spectrometry counting system

| | | Measured Activities, µCi per gram ± 1s uncertainty | | | | | |
|---|---|---|---|---|---|---|---|
| **Sample ID** | Lab ID | **Gross Alpha** | **Pu-238** | **Pu-239+240** | **Am-241** | **Cm-242** | **Cm-243+244** |
| **J1JD50** | 11-1397 | **4.97E-1 ± 2%** | **1.59E-1 ± 2%** | **2.72E-2 ± 4%** | **9.62E-2 ± 3%** | **4.65E-4 ± 26%** | **1.87E-1 ± 2%** |
| | 11-1397 Dup | **4.02E-1 ± 2%** | **1.36E-1 ± 2%** | **2.13E-2 ± 3%** | **8.18E-2 ± 3%** | **5.07E-4 ± 34%** | **1.69E-1 ± 3%** |
| | RPD | 21% | 16% | 24% | 16% | 9% | 10% |
| | Hot Cell Blank | 2.45E-4 ± 22% | 7.57E-5 ± 7% | 3.15E-5 ± 11% | 5.58E-5 ± 6% | <2.E-6 | 8.47E-5 ± 5% |
| | Lab blank | <2.E-6 | <4.E-8 | <3.E-8 | <3.E-8 | <2.E-8 | <3.E-8 |
| | Reagent spike | 96% | -- | 102% | 95% | -- | -- |
| | Matrix spike | 89% | -- | 104% | 91% | -- | -- |

This soil sample was digested in a nitric-hydrochloric acid mixture, in duplicate, in a hot cell. The acid digestion solution was centrifuged to remove the undissolved soil, then removed from cell and delivered to the analytical lab for radiochemistry.

**Pacific Northwest National Laboratory**
**PO Box 999, Richland, WA**
**Radiochemical Sciences and Engineering Group**

filename 11-1397 Pool
9/8/2011

Client: K Pool Project: 52578
ASR 8902 WP: H54512

Procedures: PNL-ALO-129, Rev. 0, $HNO_3$-HCl Acid Extraction of Solids Using a Dry-Block Heater
RPG-CMC-4015, Rev. 0, Analysis of Soil and Sediment Samples for Actinides and Strontium-90
RPG-CMC-496, Rev. 0, Coprecipitation Mounting of Actinides for Alpha Spectrometry
RPG-CMC-422, Rev. 2, Solutions Analysis: Alpha Spectrometry
Reference Date September 1, 2011
M & TE: Alpha spectrometry counting system

| | | Measured Activities, µCi per gram ± 1s uncertainty | | |
|---|---|---|---|---|
| **Sample ID** | Lab ID | **U-233+234** | **U-235+236** | **U-238** |
| **J1JD50** | 11-1397 | **1.34E-5 ± 6%** | **1.91E-6 ± 16%** | **1.10E-5 ± 7%** |
| | 11-1397 Dup | **1.23E-5 ± 7%** | **2.35E-6 ± 17%** | **1.09E-5 ± 7%** |
| | RPD | 9% | 20% | 1% |
| | Hot Cell Blank | <4.E-7 | <3.E-7 | <2.E-7 |
| | Lab blank | <5.E-9 | <3.E-9 | <3.E-9 |
| | Reagent spike | -- | -- | 98% |
| | Matrix spike | -- | -- | [Matrix spike was lost in process] |

This soil sample was digested in a nitric-hydrochloric acid mixture, in duplicate, in a hot cell. The acid digestion solution was centrifuged to remove the undissolved soil, then removed from cell and delivered to the analytical lab for radiochemistry.

## Radiochemistry M&TE List

| ID | Number of Detectors | Property # | Model or Serial # | Location, in Bldg. 325 | Procedures using the M&TE | | | PM Contract? |
|---|---|---|---|---|---|---|---|---|
| **Dual Alpha Beta Gas Proportional Counters** | | | | | | | | |
| Oxford LB4100 | 16 | WD13066 | L8285-O | 425 | Total alpha, total beta, Sr/Y90, Tc99 | | | Y |
| **Alpha Counters** | | | | | | | | |
| Ludlum | 10 | multiple | multiple | 425 | Total Alpha | | | N |
| AEA (Ortec)* | 32 | multiple | multiple | 425 | AEA (total alpha, Pu, Am/Cm,Np) | | | N |
| **Liquid Scintillation** | | | | | | | | |
| Perkin Elmer 3100TR | 1 | WD48466 | DG08061340 | 425 | H-3, C-14, Ni-63, Se-79, Pu-241, Sr-90 | | | Y |
| Packard 2550 | 1 | WD06783 | 401664 | 425 | H-3, C-14, Ni-63, Se-79, Pu-241, Sr-90 | | | Y |
| **Gamma** | | | | | | | | |
| HpGe* | 7 | see list | see list | 425 | GEA with 2 Ortec Nomad portables | | | N |
| LEPS (x-rays)* | 2 | see list | see list | 425 | X-ray (Fe-55, Ni-59, Nb-93m) | | | N |
| **Uranium** | | | | | | | | |
| Chemcheck | 1 | WC47898 | KPA11R | 525 | Uranium KPA | | | N |
| ***Spectral Analysis System** | | | | | | | | |
| Canberra - VAX 3000 | 1 | WD12890 | PE42AJB | 425 | AEA, GEA | | | N |
| Canberra - VAX 3100 | 1 | WC38624 | KA235W0225 | 425 | AEA, GEA (Backup VAX) | | | N |

**List of Gamma Detectors**

| Name | Property Tag | Vendor | Model | Serial # | Type | Eff. % | CMC? |
|---|---|---|---|---|---|---|---|
| C | WD25157 | EG&G Ortec | GEM70200P | 33TP40378A | Ge | 70 | Y |
| D | WD06582 | Princeton | IGC7022SD | 2542 | Ge | 70 | Y |
| E | WD12833 | EG&G Ortec | GEM100210 | 34P40535A | Ge | 100 | Y |
| G | WD35719 | Canberra | GC4020 | 9923007 | Ge | 40 | Y |
| H | PT00941 | Tennelec | CPVS3040195 | 6028 | Ge | 40 | Y |
| I | WD12076 | EG&G Ortec | GLP3638510P | 33TE187 | LEPS | X-RAY | Y |
| J | WD12075 | EG&G Ortec | GLP3638510P | 33TE190 | LEPS | X-RAY | Y |
| K | WD06581 | Princeton | NIGC6022SD | 3612 | P-Ge | 60 | Y |
| L | WD36413 | EG&G Ortec | GEM20P-Plus | 44TP21884A | Ge | 20 | Y |
| M | WD73130 | Canberra | GC10021 | 9722 | Ge | 100 | Y |
| N | WD73129 | Canberra | GC10021 | 9716 | Ge | 100 | Y |
| P | WD59508 | EG&G Ortec | GEM30210 | 24P80V | Ge | 30 | Y |
| T | WD25687 | EG&G Ortec | GEM15180P | 35TP11079A | Ge | 15 | Y |

Printed 5/04/2011

*Battelle PNNL/RPL/ASO Radiochemistry Analysis Report*
*P.O. Box 999, 902 Battelle Blvd., Richland, Washington 99352*

# Gamma Energy Analysis (GEA)

**Project / WP#:** 60965/ H54512
**ASR#:** 8902.00
**Client:** KN Pool
**Total Samples:** 1

| RPL ID | Client Sample ID |
|---|---|
| 11-1397 | J1JD50 |

| | |
|---|---|
| **Analysis Type:** | GEA- for all positively measured or non-detected isotopes |
| **Sample Processing Prior to Radiochemical Processing/Analysis** | ☐ None<br>☒ Digested as per PNL-ALO-129, Rev. 0 *$HNO_3$-HCl Acid Extraction of Solids Using a Dry Block Heater, (7/19/11 to 7/20/11 J. Chenault)*<br>☐ Fusion as per PNL-ALO-115, *Solubilization of Metals from Solids Using a KOH-$KNO_3$ Fusion*<br>☐ Other:<br>Preparation may also involve attaining a GEA geometry that is compatible with the calibration geometry. |
| | |
| **Analysis Procedure:** | RPG-CMC-450, Rev. 1 *Gamma Energy Analysis (GEA) and Low-Energy Photon Spectrometry (LEPS)* |
| **Reference Date:** | No Reference required for this ASR |
| **Analysis Date or Date Range:** | July 27, 2011 |
| **Technician/Analyst:** | MG Cantaloub |
| | |
| **Rad Chem Electronic Data File:** | *11-1397 Pool.xls* |
| **ASO Project 98620 File:** | *File Plan 5871, T4.4 Technical (Radiochemistry), Gamma Calibration, daily checks, and maintenance records; and T3 standard certificates and preparation. Also, balance calibration and Performance check records.* |
| **M&TE Number(s):** | *Detector T ( M & TE unique identifiers in attached supporting documents)* |

Prepare / Date: 9/20/11

Reviewer / Date: T Trang-le / 9/20/11

**SAMPLE RESULTS**

Activities for all gamma emitters detected in these samples are presented in an attached Excel spreadsheet for ASR 8902.00. All data are reported in units of µCi/g with estimates of the total propagated uncertainty reported at the 1-sigma level.

ASO Project File, ASR-8902 has been created for this report including all appropriate supporting records which may include the Pipette Performance Verification form, Standard Certificates, Laboratory Bench Record, Shielded Analytical Laboratory Bench Sheet, and Gamma Energy Analysis printouts. Detector calibration records, control charts and balance calibration records can be found in the ASO Records.

**Sample Preparation, Separation, Mounting and Counting Methods**

Quality control (QC) samples prepared include duplicates of all samples as well as reagent blank for each preparative method. The quality control (QC) sample results for each of the isotopes measured above background have been evaluated and are discussed below. A summary of the GEA analysis results, including QC sample performance, is given in the attached Data Report.

ASO received the sampling device and loaded the entire sampling device into the SAL hot cells. The sampling device was retrieved from the plastic sleeving and the soil sample was removed from the inside of the sampling tube. One gram aliquots of the soil sample were then placed in Teflon oak ridge tubes and digested with a mixture of 8M $HNO_3$ and 8M HCl using PNNL procedure PNL-ALO-129. At the completion of the digestion, the insoluble residue was rinsed three consecutive times with the same $HNO_3$/HCl acid mixture to remove any interstitial liquid. Each rinse was collected and added to the original digestate solution. The digestate solution was brought to a final volume of 100 mL in a volumetric flask. The leachate solution was used for radioanalytical analyses and ICP metals analysis; only GEA data are included in this report.

## QUALITY CONTROL RESULTS

Tracer:

Tracers are not used for ASO GEA methods.

Process Blank (PB):

A reagent blank was prepared with this ASR.

The ASO-QAP-001 requires the activities of the gamma emitting isotopes of interest measured in the PB to be within the acceptance criteria of less than 5% of the sample isotope concentration or less than sample minimum detectable activity (MDA) – (See comments). For isotopes of interest that were not detected in the PB and samples, the PB minimum detectable concentration (MDC) was less than the MDC measured in the samples. The isotopes of interest that were detected in the samples above the MDC are all greater than 5% of the activity level present in the PB

Required Detection Limits

Required detection limits were not specified for this ASR.

Blank Spike (BS)/Laboratory Control Sample (LCS)/ Matrix Spike (MS):

There are no BS, LCS or MS samples analyzed for ASO GEA analyses. Instrument performance is assessed by the analyses of daily control counts and weekly background counts, as discussed below.

Duplicate Relative Percent Difference (RPD):

Duplicate results are required to agree within ≤20% relative percent difference, taking into consideration the statistical uncertainties in the data. The duplicate result for Cs-137 (the only gamma isotope detected) was 5%.

Replicate Relative Standard Deviation (RSD):

Replicate samples were not required to be run for this ASR.

**Instrument Calibration and Quality Control**

Gamma detectors are calibrated using multi-isotope standards that are NIST-traceable and prepared in the identical counting geometry used for the samples for all detectors. Counter control sources containing Am-241, Cs-137 and Co-60 are then analyzed daily before the use of each detector. There is a K Basin DQO that is referenced to ASO procedure RPG-CMC-450, that requires that a counter control source is checked daily and must be within ±3 sigma or ±3% of the control value, whichever is greater. Gamma counting was not performed unless the control counts were within the required limits. Background counts are performed on all gamma detectors at least weekly for either an overnight or weekend count. The most recent background is subtracted from all sample counts.

**Assumption and Limitations of the Data**

The digestion was performed following procedure PNL-ALO-129. For this digestion, the concentrations of nitric and hydrochloric acid were increased to 8M for each acid. Additionally, the volumes of each reagent acid were increased to ensure sufficient excess acid was present to solubilize the acid soluble analytes.

**Interferences/Resolution**

None.

**Uncertainty**

For gamma counting, the uncertainty in the efficiency, counting data, photon abundance and the nuclear half-life are included in the calculation of the total uncertainty along with a systematic uncertainty for sample prep. The Canberra Genie software includes both random and systematic uncertainties in the calculation of the total uncertainties which are listed on the report. We conservatively estimate that 2% is the lowest uncertainty possible for our GEA measurements taking into account systematic uncertainties in gamma calibration standards.

**Comments**

1. The results have been corrected for all dilution factors resulting from sample processing.

2. Minimum Detectable Activity (MDA) and Minimum Detectable Concentration (MDC). Sample results are compared to the process blank results to evaluate if the blank contains 5% or more of the analyte of interest. When samples undergo digestion and/or dilution (process factors), the MDA must be adjusted for the process factors to accurately compare activity levels in the blank to activity levels in the samples. Process blank results have been adjusted for digestion and/or process factors for evaluation of the 5% criteria.

Attachment: Data Report Sample Results for ASR 8902.

*Battelle PNNL/RPL/ASO Radiochemistry Analysis Report*
*P.O. Box 999, 902 Battelle Blvd., Richland, Washington 99352*

# Sr-90 by Liquid Scintillation Spectrometry

| | |
|---|---|
| **Project / WP#:** | 60965/ H54512 |
| **ASR#:** | 8902.00 |
| **Client:** | KN Pool |
| **Total # of Samples:** | 1 |

| RPL ID | Client Sample ID |
|---|---|
| 11-1397 | J1JD50 |

| | |
|---|---|
| **Analysis Type:** | Sr-90 |
| **Sample Processing Prior to Radiochemical Processing/Analysis** | ☐ None<br>☒ Digested as per PNL-ALO-129, Rev. 0, *$HNO_3$-HCl Acid Extraction of Solids Using a Dry Block Heater, (7/19/11 to 7/20/11 J. Chenault)*<br>☐ Fusion as per PNL-ALO-115, *Solubilization of Metals from Solids Using a $KOH$-$KNO_3$ Fusion*<br>☐ Other: |
| **Pre-dilution Prior to Radiochemical Processing?** | ☒ No<br>☐ Yes |
| **Total Alpha and Beta Preparation Procedure:** | RPG-CMC-4001, Rev. 1, *Source Preparation For Gross Alpha and Gross Beta Analyses.* |
| **Technician/Analyst:** | K. Carson, 7-26-11 |
| **Spike Standard ID's** | R-569-a-2 (Sr-90), R-485-b-7 (Pu 239) |
| **Analysis Procedure** | RPG-CMC-408, Rev. 2, *Total Alpha and Beta Analysis* |
| **Technician/Analyst:** | T. Trang-Le, 7-26-11 (Gross Alpha), 7-27-11 (Gross Beta) |
| **Separation Procedure:** | RPG-CMC-476, Rev. 0, *Strontium Separation Using Eichrom Strontium Resin* |
| **Spike Standard ID:** | R-569-a-2 (Sr-90) |
| **Separation Date:** | 8/8/11 13:45 p.m. |
| **Technician/Analyst:** | K. Carson |
| **Analysis Procedure:** | RPG-CMC-474, Rev. 1, *Measurement of Alpha and Beta Activity by Liquid Scintillation Spectrometry* |
| **Reference Date:** | N/A |
| **Analysis Date or Date Range:** | 8/10/11 (first count), 8/12/11 (second count) |
| **Technician/Analyst:** | T. Trang-Le |
| **Rad Chem Electronic Data File:** | 11-1397 Pool.xls |
| **ASO Project 98620 File:** | File Plan 5871: T 60695 8902: Sample preparation and analysis records; T-4.4 LSC 3100 calibration, daily checks, and maintenance records; and T3 standard certificates and preparation. Also, balance calibration and performance check records. |
| **M&TE Number(s):** | Perkin Elmer Tri-Carb 3100, Serial # DG08061340, RPL 425, Tri-Carb 2700TR software version 1.04 dated 9/99. |

| Preparer | Date | Reviewer | Date |
|---|---|---|---|
| [signature] | 9/20/11 | T Trang-Le | 9/20/11 |

## SAMPLE RESULTS

See attached data report, Sample Results for ASR 8902. All sample data are reported in µCi/g with a 1-σ uncertainty (see Comments).

### Sample preparation, separation, mounting, and counting

ASO received the sampling device and loaded the entire sampling device into the SAL hot cells. The sampling device was retrieved from the plastic sleeving and the soil sample was removed from the inside of the sampling tube. One gram aliquots of the soil sample were then placed in Teflon oak ridge tubes and digested with a mixture of 8M $HNO_3$ and 8M HCl using PNNL procedure PNL-ALO-129. At the completion of the digestion, the insoluble residue was rinsed three consecutive times with the same $HNO_3$/HCl acid mixture to remove any interstitial liquid. Each rinse was collected and added to the original digestate solution. The digestate solution was brought to a final volume of 100 mL in a volumetric flask. The leachate solution was used for radioanalytical analyses and ICP metals analysis; only Sr-90 data are included in this report.

Although not formally requested by the ASR, gross alpha and gross beta analyses were performed on each sample to obtain information to estimate aliquot sizes for other analyses and for checking the internal consistency of the Sr-90 data. The gross alpha and gross beta results are included in the data tables as supplemental information only. Gross alpha and gross beta activity were measured by evaporating small aliquots of leachate onto counting planchets per procedure RPG-CMC-4001 and counting per procedure RPG-CMC-408. The sum of the major beta emitters, in this case Sr/Y-90 and Cs-137, agree very well with the gross beta results.

## QUALITY CONTROL RESULTS

Radioanalytical quality control (QC) samples prepared in the SAL hot cells include a hot cell process blank (PB), and sample duplicate. No Sr-90 MS was prepared at time of digestion. Additional laboratory QC samples were prepared prior to separations; these include a laboratory separation blank, a reagent blank spike (BS), and a matrix spike (i.e., addition of Sr-90 standard to an aliquot of one of the samples).

### Instrument Calibration Control

Hot Cell Process Blank (PB) and Laboratory separations blank (LB):

The Sr-90 activity measured in the PB is required to be within the acceptance criteria of less than sample minimum detectable activity (MDA) or less than 5% of the sample isotope concentration. The Sr-90 PB is <5% of all sample results; thus meeting the acceptance criteria. There are no acceptance criteria for LB (see Comments).

Blank Spike (BS) – reagent spike:

The BS recovery of 102% meets the procedure acceptance criteria of 80% to 120% recovery.

Matrix Spike (MS):

The MS recovery of 104% meets the acceptance criterion of 75% to 125% recovery. Note: the MS sample was prepared "after" digestion (see comments), by adding a known Sr-90 standard quantity to an aliquot of J1JD50 Dup (11-1397 Dup).

Duplicate -- Relative Percent Difference (RPD):

Duplicate results are required to agree within ≤20% RPD. The ASO QAP further specifies that the two results need to be >5 times the MDA or have individual uncertainties <20%. Duplicate result was 5% RPD; thus meeting the ≤20% requirement.

**Instrument Quality Control**

The liquid scintillation counter is calibrated for tritium and C-14 using quenched standard sets that are purchased from the vendor. Daily control counts are then performed using a tritium, C-14, and a background count sample. The instrument software assesses the performance of the control counts and provides control charts to ensure the continuing calibration of the instrument. If the daily performance check fails, then the instrument is not used. Preventative maintenance and repairs are performed by the vendor under our service contract. The counting efficiency for Sr-90 is assumed to be 100%; therefore no specific Sr-90 calibration is performed. The LSC system calibration and performance is verified by assessing the recovery of a reagent spike and a matrix spike that are included in every batch of samples. A preparation blank (i.e., digestion blank) and a laboratory separations blank are also included with every batch of samples; the instrument background is subtracted from all results and the preparation and separation blanks are used to assess sample contamination during sample processing steps.

**Assumption and Limitations of the Data**

The 1-σ uncertainty reported for each Sr-90 result has been set at 2%. Although the calculated uncertainty values are less than 2% for all samples, the radiochemistry convention is to not report calculated uncertainties less than 2%, but to provide a more realistic estimate of the uncertainty in view of systematic uncertainties that are not fully accounted for in the uncertainty calculations.

**Comments**

1. The results have been corrected for all dilution factors resulting from sample processing.
2. Post-Digestion Spike (PS) - A spike made after the initial sample preparation (e.g., fusion, digestion, or leach) is considered a PS. When extremely radioactive samples are analyzed, most of the radio-analytical spikes are made after the sample preparation (to avoid excessive consumption of spike and avoid creating unnecessary waste) and are post-digestion spikes. The MS prepared with this batch of sample is considered a PS, since the Sr-90 spike was not added prior to the digestion process.
3. Radiochemistry Electronic Systems File "11-1397 Pool" has been created for this report. Supporting records such as Pipette Performance Verification forms, Laboratory Bench Record, Shielded Analytical Laboratory (SAL) Bench Sheet, Standards Certifications and preparation records, and balance calibration and performance check records are maintained per RS&E Group ASO File Plan 5871.
4. Sample results are compared to the process blank results to evaluate if the blank contains 5% or more of the measured isotope; the process blank results have been adjusted for all processing factors for the evaluation of the 5% criterion.
5. The stated 1-σ uncertainty represents the total propagated error associated with processing and counting operations and includes weighing errors, volume uncertainties, and counting error.

Attachment: Data Report -- Sample Results for ASR 8902

*Battelle PNNL/RPL/ASO Radiochemistry Analysis Report*
*P.O. Box 999, 902 Battelle Blvd., Richland, Washington 99352*

# Uranium 233+234, 235+236, 238 Analyses

| | |
|---|---|
| **Project / WP#:** | 60965/ H54512 |
| **ASR#:** | 8902.00 |
| **Client:** | KN Pool |
| **Total # of Samples:** | 1 |

| RPL ID | Client Sample ID |
|---|---|
| 11-1397 | J1JD50 |

| | |
|---|---|
| **Analysis Type:** | AEA – U-233+234, 235+236, 238 |
| **Sample Processing Prior to Radiochemical Processing/Analysis** | ☐ None<br>☒ Digested as per PNL-ALO-129, Rev. 0, *$HNO_3$-HCl Acid Extraction of Solids Using a Dry Block Heater, (7/19/11 to 7/20/11 J. Chenault))*<br>☐ Fusion as per PNL-ALO-115, *Solubilization of Metals from Solids Using a $KOH$-$KNO_3$ Fusion*<br>☐ Other: |
| **Pre-dilution Prior to Radiochemical Processing?** | ☒ No<br>☐ Yes -- *example 2 mL to 100 mL; 50x dilution* |
| **Total Alpha and Beta Preparation Procedure:** | RPG-CMC-4001, Rev. 1, *Source Preparation For Gross Alpha and Gross Beta Analyses.* |
| **Technician/Analyst:** | K. Carson, 7-26-11 |
| **Spike Standard ID's** | R-569-a-2 (Sr-90), R-485-b-7 (Pu 239) |
| **Analysis Procedure** | RPG-CMC-408, Rev. 2, *Total Alpha and Beta Analysis* |
| **Technician/Analyst:** | T. Trang-Le, 7-26-11 (Gross Alpha), 7-27-11 (Gross Beta) |
| **Uranium Separation Procedure:** | RPG-CMC-4015, Rev. 0, *Analysis of Soil and Sediment Samples for Actinides and SR-90* |
| **Technician/Analyst:** | K. Carson, 8-23-11 |
| **Spike and Tracer Standard ID's:** | R608b (U) |
| **Co-Precipitation Procedure:** | RPG-CMC-496, Rev. 0, *Coprecipitation Mounting of Actinides for Alpha Spectroscopy* |
| **Technician/Analyst:** | K. Carson, 8-29-11 |
| **Analysis Procedure:** | RPG-CMC-422, Rev. 2, *Solutions Analysis: Alpha Spectrometry* |
| **Reference Date:** | 9/1/11 |
| **Analysis Date or Date Range:** | 8/31/11 and 9/1/11 |
| **Technician/Analyst:** | T. Trang-Le |
| **Analysis Data (File):** | 11-1397 Pool.xls |
| **CMC Project 98620 File:** | File Plan 5871: T 60965 8902: Sample preparation and analysis records; T-4.4 Alpha Detector calibration, calibration verification checks, and maintenance records; and T3 Standard certificates and preparation. Also balance calibration and instrument performance checks. |
| **M&TE Number(s):** | Ortec AEA counters – 32 counters – See attached M&TE list |

| | | | |
|---|---|---|---|
| [signature] | 9/20/11 | T Trang-le | 9/20/11 |
| **Preparer** | **Date** | **Reviewer** | **Date** |

**Sample Results**

See attached data report, U-233+234, U-235+236 and U-238 Sample Results for ASR 8902. All data are reported in units of μCi/g with estimates of the total propagated uncertainty reported at the 1-sigma level.

**Sample Preparation, Separation, Mounting and Counting Methods**

ASO received the sampling device and loaded the entire sampling device into the SAL hot cells. The sampling device was retrieved from the plastic sleeving and the soil sample was removed from the inside of the sampling tube. One gram aliquots of the soil sample were then placed in Teflon oak ridge tubes and digested with a mixture of 8M $HNO_3$ and 8M HCl using PNNL procedure PNL-ALO-129. At the completion of the digestion, the insoluble residue was rinsed three consecutive times with the same $HNO_3$/HCl acid mixture to remove any interstitial liquid. Each rinse was collected and added to the original digestate solution. The digestate solution was brought to a final volume of 100 mL in a volumetric flask. The leachate solution was used for radioanalytical analyses and ICP metals analysis; only U-AEA is reported in this report.

Following the digestion process, the Pu was separated from the sludge leachate by anion exchange using procedure RPG-CMC-4015. The separated Pu fraction was then mounted for alpha spectrometry by co-precipitation using procedure RPG-CMC-496, and then counted using alpha spectrometry using procedure RPC-CMC-422. The samples were counted on August 31st and September 1st, 2011; no decay corrections were made.

Although not formally requested by the ASR, gross alpha and gross beta analyses were performed on each sample to obtain information to estimate aliquot sizes for other analyses and for checking the internal consistency of the Pu alpha isotopic data. The gross alpha and gross beta results are included in the data tables as supplemental information only. Gross alpha and gross beta activity were measured by evaporating small aliquots of leachate onto counting planchets per procedure RPG-CMC-4001 and counting per procedure RPG-CMC-408. These procedures are not required to be pre-approved by K-Basin project staff as they are used to generate opportunistic data only. The sum of the major alpha emitters, in this case Pu-238, Pu-239+240, Am-241 and Cm-243+244, agrees very well with the gross alpha results.

## QUALITY CONTROL RESULTS

Quality control (QC) samples prepared in the SAL hot cells include a hot cell process blank (PB), sample duplicates for each sample, and a matrix spike (MS – for ICP/OES only). Additional QC samples were prepared prior to separations; these include a laboratory separation blank, a reagent blank spike (BS, spiked with natural U), and a matrix spike (MS) made by adding natural U standard to a diluted sample.

Tracer:

Tracer is not used for analyses of U.

Hot Cell Process Blank (PB) and Laboratory separations blank (LB):

The U-233+234, U-235+236 and U-238 activities measured in the PB are required to be within the acceptance criteria of less than 5% of the sample isotope concentration or less than sample minimum detectable activity (MDA) – see comments. The PB U-233+234, U-235+236 and U-238 activities are less than 5% of any sample activity. There are no acceptance criteria for LB

Blank Spike (BS) – reagent spike:

The BS (natural uranium, U-238) recovery of 98% meets the acceptance criteria of 80% to 120% recovery.

Matrix Spike (MS):

The MS sample was lost in the sample preparation process and recovery of the MS could not be accurately calculated.

Duplicate -- Relative Percent Difference (RPD):

Duplicate results are required to agree within ≤20% RPD. The duplicate result for U-233+234 was 9% RPD, U-235+23 was 20% and U-238 was 1%, within the acceptance criteria of ≤20% RPD.

**Instrument Quality Control**

Alpha counters undergo calibration annually to determine the counter's efficiency over the normal calibration range of 3 to 6 MeV. The vendor software determines a constant detector efficiency for this energy range. U samples are counted and results calculated using the established detector efficiency.

Detector backgrounds are determined every 4 weeks or after the last analytical run, whichever is longer. Detector background counts are subtracted from all subsequent sample counts. A process blank is analyzed with each analytical batch to evaluate for contamination in the sample preparation process.

**Assumption and Limitations of the Data**

The matrix spike sample was partially spilled in the process of analyzing the sample batch. Although not reported due to the unknown quantity of sample and spike lost in the sample preparation process, the recovery of the matrix spike was calculated to be 67%. This indicates the added spike was recoverable in the sample preparation matrix. Additionally, the good recovery (98%) of the BS indicates that the column chemistry was working as expected.

**Comments**

1. The results have been corrected for all dilution factors resulting from sample processing.

2. Post-Digestion Spike (PS) - A spike made after the initial sample preparation (e.g., fusion, digestion, or leach) is considered a PS. When extremely radioactive samples are analyzed, most of the radio analytical spikes are made after the sample preparation and aliquot dilution (to avoid excessive consumption of spike and avoid creating unnecessary waste). The MS prepared with this sample batch is considered a PS, since the natural uranium spike was not added prior to the digestion process.

3. The 1-sigma uncertainty represents the total propagated error associated with processing and counting operations and includes weighing errors, volume uncertainties, and counting error.

4. The sample results are compared to the process blank to evaluate if the blank contains 5% or more of the measured isotope; the process blank result has been adjusted for all processing factors for evaluation of the 5% criterion.

5. The Laboratory Blank (LB) is prepared using laboratory reagents and provides data only on the cleanliness of the radiochemistry preparation process. LB results are not normalized to processing or dilution factors associated with the samples.

Attachment: Data Report -- Sample Results for ASR 8902

*Battelle PNNL/RPL/ASO Radiochemistry Analysis Report*
*P.O. Box 999, 902 Battelle Blvd., Richland, Washington 99352*

# Plutonium 238, 239+240 Analysis

| | |
|---|---|
| **Project / WP#:** | 60965/ H54512 |
| **ASR#:** | 8902.00 |
| **Client:** | KN Pool |
| **Total # of Samples:** | 1 |

| RPL ID | Client Sample ID |
|---|---|
| 11-1397 | J1JD50 |

| | |
|---|---|
| **Analysis Type:** | AEA – Pu-238, Pu-239+240 |
| **Sample Processing Prior to Radiochemical Processing/Analysis** | ☐ None<br>☒ Digested as per PNL-ALO-129, Rev. 0, *$HNO_3$-HCl Acid Extraction of Solids Using a Dry Block Heater. (7/19/11 to 7/20/11 J. Chenault))*<br>☐ Fusion as per PNL-ALO-115, *Solubilization of Metals from Solids Using a $KOH$-$KNO_3$ Fusion*<br>☐ Other: |
| **Pre-dilution Prior to Radiochemical Processing?** | ☒ No |
| | ☐ Yes -- *example 2 mL to 100 mL; 50x dilution* |
| **Total Alpha and Beta Preparation Procedure:** | RPG-CMC-4001, Rev. 1, *Source Preparation For Gross Alpha and Gross Beta Analyses.* |
| **Technician/Analyst:** | K. Carson, 7-26-11 |
| **Spike Standard ID's** | R-569-a-2 (Sr-90), R-485-b-7 (Pu 239) |
| **Analysis Procedure** | RPG-CMC-408, Rev. 2, *Total Alpha and Beta Analysis* |
| **Technician/Analyst:** | T. Trang-Le, 7-26-11 (Gross Alpha), 7-27-11 (Gross Beta) |
| **Plutonium Separation Procedure:** | RPG-CMC-4015, Rev. 0, *Analysis of Soil and Sediment Samples for Actinides and SR-90* |
| **Technician/Analyst:** | K. Carson, 8-10-11 |
| **Spike and Tracer Standard ID's:** | R-485-b-7 (Pu-239), R-570-a-1 (Pu-242 tracer) |
| **Co-Precipitation Procedure:** | RPG-CMC-496, Rev. 0, *Coprecipitation Mounting of Actinides for Alpha Spectroscopy* |
| **Technician/Analyst:** | K. Carson, 8-10-11 |
| **Analysis Procedure:** | RPG-CMC-422, Rev. 2, *Solutions Analysis: Alpha Spectrometry* |
| **Reference Date:** | Same as counting dates (8/11/11 and 8/15/11) |
| **Analysis Date or Date Range:** | 8/11/11 and 8/15/11 |
| **Technician/Analyst:** | T. Trang-Le |
| **Analysis Data (File):** | 11-1397 Pool.xls |
| **CMC Project 98620 File:** | File Plan 5871: T 60965 8902: Sample preparation and analysis records; T-4.4 Alpha Detector calibration, calibration verification checks, and maintenance records; and T3 Standard certificates and preparation. Also balance calibration and instrument performance checks. |
| **M&TE Number(s):** | Ortec AEA counters – 32 counters – See attached M&TE list |

[signature] / 9/20/11 — Preparer / Date

T Trang-Le / 9/20/11 — Reviewer / Date

**Sample Results**

See attached data report, Pu-238 and Pu-239+240 Sample Results for ASR 8902. All data are reported in units of μCi/g with estimates of the total propagated uncertainty reported at the 1-sigma level.

**Sample Preparation, Separation, Mounting and Counting Methods**

ASO received the sampling device and loaded the entire sampling device into the SAL hot cells. The sampling device was retrieved from the plastic sleeving and the soil sample was removed from the inside of the sampling tube. One gram aliquots of the soil sample were then placed in Teflon oak ridge tubes and digested with a mixture of 8M $HNO_3$ and 8M HCl using PNNL procedure PNL-ALO-129. At the completion of the digestion, the insoluble residue was rinsed three consecutive times with the same $HNO_3$/HCl acid mixture to remove any interstitial liquid. Each rinse was collected and added to the original digestate solution. The digestate solution was brought to a final volume of 100 mL in a volumetric flask. The leachate solution was used for radioanalytical analyses and ICP metals analysis; only Pu-AEA is reported in this report.

Following the digestion process, the Pu was separated from the sludge leachate by anion exchange using procedure RPG-CMC-4015. The separated Pu fraction was then mounted for alpha spectrometry by co-precipitation using procedure RPG-CMC-496, and then counted using alpha spectrometry using procedure RPC-CMC-422. The samples were counted on August 11$^{th}$ and 15$^{th}$, 2011; no decay corrections were made.

Although not formally requested by the ASR, gross alpha and gross beta analyses were performed on each sample to obtain information to estimate aliquot sizes for other analyses and for checking the internal consistency of the Pu alpha isotopic data. The gross alpha and gross beta results are included in the data tables as supplemental information only. Gross alpha and gross beta activity were measured by evaporating small aliquots of leachate onto counting planchets per procedure RPG-CMC-4001 and counting per procedure RPG-CMC-408. These procedures are not required to be pre-approved by K-Basin project staff as they are used to generate opportunistic data only. The sum of the major alpha emitters, in this case Pu-238, Pu-239+240, Am-241 and Cm-243+244, agrees very well with the gross alpha results.

## QUALITY CONTROL RESULTS

Quality control (QC) samples prepared in the SAL hot cells include a hot cell process blank (PB), sample duplicates for each sample, and a matrix spike (MS – for ICP/OES only). Additional QC samples were prepared prior to separations; these include a laboratory separation blank, a reagent blank spike (BS, spiked with Pu-239), and a matrix spike (MS) made by adding Pu-239 standard to a diluted sample.

Tracer:

The Pu-242 tracer is added to every sample after appropriate dilution and prior to plutonium separations. The use Pu-242 tracer corrects for radiochemical yield and mathematically removes the detector counting efficiency from the results calculations. Tracer recover is required to be high enough to provide acceptable counting statistics. The Pu-242 tracer counting statistics were acceptable for all samples. The tracer recoveries ranged from 93% to 98%.

Hot Cell Process Blank (PB) and Laboratory separations blank (LB):

The Pu-238 and Pu-239+240 activities measured in the PB are required to be within the acceptance criteria of less than 5% of the sample isotope concentration or less than sample minimum detectable activity (MDA) – see comments. The PB Pu-238 and Pu-239+240 activities are significantly less than 5% of any sample activity. There are no acceptance criteria for LB

Blank Spike (BS) – reagent spike:

The BS (Pu-239) recovery of 102% meets the acceptance criteria of 80% to 120% recovery.

Matrix Spike (MS):

The MS recovery of 104% meets the acceptance criterion of 75% to 125% recovery. Note: the MS sample was prepared after digestion, by adding a known Pu-239 standard quantity to an aliquot of the leachate. Sample number 11-1397 Dup (J1JD50 Dup) was selected as the matrix spike sample.

Duplicate -- Relative Percent Difference (RPD):

Duplicate results are required to agree within ≤20% RPD. The duplicate result for Pu-238 was 16% RPD, within the acceptance criteria of ≤20%. The Pu-239+240 duplicate result of 24% RPD exceeds the ≤20% requirement.

**Instrument Quality Control**

Counter control source counting is not required when samples are spiked with tracers. When tracers are used, the absolute counting efficiencies are not used.

Detector backgrounds are determined every 4 weeks or after the last analytical run, whichever is longer. Detector background counts are subtracted from all subsequent sample counts. A process blank is analyzed with each analytical batch to evaluate for contamination in the sample preparation process.

**Assumption and Limitations of the Data**

**None**

**Comments**

1. The results have been corrected for all dilution factors resulting from sample processing.

2. Post-Digestion Spike (PS) - A spike made after the initial sample preparation (e.g., fusion, digestion, or leach) is considered a PS. When extremely radioactive samples are analyzed, most of the radio analytical spikes are made after the sample preparation and aliquot dilution (to avoid excessive consumption of spike and avoid creating unnecessary waste). The MS prepared with this sample batch is considered a PS, since the Pu-239 spike was not added prior to the digestion process.

3. Each alpha spectrum was examined for potential interferences from other alpha emitting isotopes. Pu-242 and Am-243 tracers are added at the start of the chemical separation process. The presence of Am-243 in the Pu-AEA would indicate interference from Am-241 on the Pu-238 peak. The alpha spectra were evaluated to verify the removal of Am from the Pu. There was no evidence of interfering isotopes, including Am.

4. The 1-sigma uncertainty represents the total propagated error associated with processing and counting operations and includes weighing errors, volume uncertainties, and counting error.

5. The sample results are compared to the process blank to evaluate if the blank contains 5% or more of the measured isotope; the process blank result has been adjusted for all processing factors for evaluation of the 5% criterion.

6. The Laboratory Blank (LB) is prepared using laboratory reagents and provides data only on the cleanliness of the radiochemistry preparation process. LB results are not normalized to processing or dilution factors associated with the samples.

Attachment: Data Report -- Sample Results for ASR 8902

*Battelle PNNL/RPL/ASO Radiochemistry Analysis Report*
*P.O. Box 999, 902 Battelle Blvd., Richland, Washington 99352*

# Americium 241 Analysis

| | |
|---|---|
| **Project / WP#:** | 60965/ H54512 |
| **ASR#:** | 8902.00 |
| **Client:** | KN Pool |
| **Total # of Samples:** | 1 |

| RPL ID | Client Sample ID |
|---|---|
| 11-1397 | J1JD50 |

| | |
|---|---|
| **Analysis Type:** | AEA – Am-241 |
| **Sample Processing Prior to Radiochemical Processing/Analysis** | ☐ None<br>☒ Digested as per PNL-ALO-129, Rev. 0, *$HNO_3$-HCl Acid Extraction of Solids Using a Dry Block Heater, (7/19/11 to 7/20/11 J. Chenault)*<br>☐ Fusion as per PNL-ALO-115, *Solubilization of Metals from Solids Using a $KOH$-$KNO_3$ Fusion*<br>☐ Other: |
| **Pre-dilution Prior to Radiochemical Processing?** | ☒ No<br>☐ Yes – *example 2 mL to 100 mL; 50x dilution* |
| **Total Alpha and Beta Preparation Procedure:** | RPG-CMC-4001, Rev. 1, *Source Preparation For Gross Alpha and Gross Beta Analyses.* |
| **Technician/Analyst:** | K. Carson, 7-26-11 |
| **Spike Standard ID's** | R-569-a-2 (Sr-90), R-485-b-7 (Pu 239) |
| **Analysis Procedure** | RPG-CMC-408, Rev. 2, *Total Alpha and Beta Analysis* |
| **Technician/Analyst:** | T. Trang-Le, 7-26-11 (Gross Alpha), 7-27-11 (Gross Beta) |
| **Americium Separation Procedure:** | RPG-CMC-4015, Rev. 0, *Analysis of Soil and Sediment Samples for Actinides and SR-90* |
| **Technician/Analyst:** | L. Darnell, 8-15-11 |
| **Spike and Tracer Standard ID's:** | R-542-a-3 (Am-241), R-571-a-2 (Am-243 tracer) |
| **Co-Precipitation Procedure:** | RPG-CMC-496, Rev. 0, *Co-precipitation Mounting of Actinides for Alpha Spectroscopy* |
| **Technician/Analyst:** | L. Darnell, 8-15-11 |
| **Analysis Procedure:** | RPG-CMC-422, Rev. 2, *Solutions Analysis: Alpha Spectrometry* |
| **Reference Date:** | Same as counting date (8/16/11) |
| **Analysis Date or Date Range:** | 8/16/11 |
| **Technician/Analyst:** | T. Trang-Le |
| **Analysis Data (File):** | 11-1397 Pool.xls |
| **CMC Project 98620 File:** | File Plan 5871: T 60965 8902: Sample preparation and analysis records; T-4.4 Alpha Detector calibration, calibration verification checks, and maintenance records; and T3 Standard certificates and preparation. Also balance calibration and instrument performance checks. |
| **M&TE Number(s):** | Ortec AEA counters – 32 counters – See attached M&TE list |

[signature] / 9/20/11 — **Preparer** / **Date**

T Trang-Le / 9/20/11 — **Reviewer** / **Date**

**Sample Results**

See attached data report, Am-241 Sample Results for ASR 8902. All data are reported in units of µCi/g with estimates of the total propagated uncertainty reported at the 1-sigma level.

**Sample Preparation, Separation, Mounting and Counting Methods**

ASO received the sampling device and loaded the entire sampling device into the SAL hot cells. The sampling device was retrieved from the plastic sleeving and the soil sample was removed from the inside of the sampling tube. One gram aliquots of the soil sample were then placed in Teflon oak ridge tubes and digested with a mixture of 8M $HNO_3$ and 8M HCl using PNNL procedure PNL-ALO-129. At the completion of the digestion, the insoluble residue was rinsed three consecutive times with the same $HNO_3$/HCl acid mixture to remove any interstitial liquid. Each rinse was collected and added to the original digestate solution. The digestate solution was brought to a final volume of 100 mL in a volumetric flask. The leachate solution was used for radioanalytical analyses and ICP metals analysis; only Am-AEA data are included in this report. Cm isotopes follow the separation chemistry of Am and have been included in the final data summary tables.

Following the digestion process, the Pu and U were first removed from the leachate by anion exchange chromatography using procedure RPG-CMC-4015. The Am and Cm were separated from the load and wash solution using Eichrom TRU resin per procedure RPG-CMC-4015. The separated Am/Cm fraction was then mounted for alpha spectrometry by co-precipitation using procedure RPG-CMC-496, then counted by alpha spectroscopy using procedure RPC-CMC-422. The samples were counted on August 16$^{th}$, 2011; no decay corrections were made.

Although not formally requested by the ASR, gross alpha and gross beta analyses were performed on each sample to obtain information to estimate aliquot sizes for other analyses and for checking the internal consistency of the Am alpha isotopic data. The gross alpha and gross beta results are included in the data tables as supplemental information only. Gross alpha and gross beta activity were measured by evaporating small aliquots of leachate onto counting planchets per procedure RPG-CMC-4001 and counting per procedure RPG-CMC-408. The sum of the major alpha emitters, in this case Pu-238, Pu-239+240, Am-241 and Cm-243+244, agrees very well with the gross alpha results.

## QUALITY CONTROL RESULTS

Quality control (QC) samples prepared in the SAL hot cells include a hot cell process blank (PB), sample duplicates for each sample, and a matrix spike (MS – for ICP/OES only). Additional QC samples were prepared prior to separations; these include a laboratory separation blank, a reagent blank spike (BS), and a matrix spike (MS) made by adding Am-241 standard to a diluted sample.

Tracer:

The Am-243 tracer is added to every sample after appropriate dilution and prior to americium separations. The Am-243 tracer corrects for radiochemical yield and mathematically removes the detector counting efficiency from the results calculations. Tracer recover is required to be high enough to provide acceptable counting statistics. The Am-243 tracer counting statistics were acceptable for all samples. The tracer recoveries ranged from 97% to 106%.

Hot Cell Process Blank (PB) and Laboratory separations blank (LB):

The Am-241 activity measured in the PB are required to be within the acceptance criteria of less than 5% of the sample isotope concentration or less than sample minimum detectable activity (MDA) – see comments. The PB Am-241 activity is significantly less than 5% of any sample activity. There are no acceptance criteria for LB (see comment section below).

Blank Spike (BS) – reagent spike:

The BS recovery of 95% meets the acceptance criteria of 80% to 120% recovery.

Matrix Spike (MS):

The MS recovery of 91% meets the acceptance criterion of 75% to 125% recovery. Note: the MS sample was prepared after digestion, by adding a known Am-241 standard quantity to an aliquot of the leachate. Sample number 11-1397 Dup (J1JD50 Dup) was selected as the matrix spike sample.

Duplicate -- Relative Percent Difference (RPD):

Duplicate results are required to agree within ≤20% RPD. The duplicate result of 16% RPD is within the ≤20% requirement.

**Instrument Quality Control**

Counter control source counting is not required when samples are spiked with tracers. When tracers are used, the absolute counting efficiencies are not used.

Detector backgrounds are determined every 4 weeks or after the last analytical run, whichever is longer. Detector background counts are subtracted from all subsequent sample counts. A process blank is analyzed with each analytical batch to evaluate for contamination in the sample preparation process.

**Assumption and Limitations of the Data**

None

**Comments**

1. The results have been corrected for all dilution factors resulting from sample processing.

2. Post-Digestion Spike (PS) - A spike made after the initial sample preparation (e.g., fusion, digestion, or leach) is considered a PS. When extremely radioactive samples are analyzed, most of the radioanalytical spikes are made after the sample preparation and dilution (to avoid excessive consumption of spike and avoid creating unnecessary waste). The MS prepared with this batch of samples is considered a PS, since the Am-241 spike was not added prior to the digestion process.

3. The 1-sigma uncertainty represents the total propagated error associated with processing and counting operations and include; weighing errors, volume uncertainties, and counting error.

4. The sample results are compared to the process blank to evaluate if the blank contains 5% or more of the measured isotope; the process blank result has been adjusted for all processing factors for evaluation of the 5% criterion.

5. The Laboratory Blank (LB) is prepared using laboratory reagents and provides data on the cleanliness of the radiochemistry preparation/separation processes. LB results are not normalized to processing or dilution factors associated with the samples.

Attachment: Data Report – Sample Results for ASR 8902

**Project / WP#:** 60965 / H54512
**ASR#:** 8888
**Client:** K. Pool
**Total Samples:** 1 (solid)

| | First | Last |
|---|---|---|
| **RPL#:** | 11-1355 | -- |
| **Client ID:** | J1JD49 | -- |
| **Sample Preparation**: PNL-ALO-129, "$HNO_3$-HCl Extraction of Solids for Metals Analysis Using a Dry-Block Heater", 7/1/11 (SAL/ng). | | |

**Procedure:** RPG-CMC-211, "Determination of Elemental Composition by Inductively Coupled Argon Plasma Optical Emission Spectrometry (ICP-OES)", Rev. 3.

**Analyst:** J. Carter

**Analysis Date (File):** 7-13-2011 (C0393)

**See Chemical Measurement Center 98620 file:** ICP-325-405-3
(Calibration and Maintenance Records)

**M&TE Number:** N827583 (PerkinElmer 5300DV ICP-OES, S/N 077N5122002)
WD66158 (Sartorius ME414S Balance, S/N 224066373)

BMCln 7/20/11
Preparer

C Q Velony 7/22/11
Review and Concur

One sample was provided for ICP-OES analysis under Analytical Service Request (ASR) 8888. The sample was processed in the Shielded Analytical Laboratory (SAL) following RPL procedure PNL-ALO-129 using ~1 gram of sample with dilution to a final volume of 100 mL.

Analytes of interest (AOIs) were specified in the ASR, and are listed in the upper section of the attached ICP-OES Data Report. The quality control (QC) results for these AOIs have been evaluated and are presented below. Analytes other than AOIs are reported in the bottom section of the report, but have not been fully evaluated for QC performance. The results are given as µg/g for each detected analyte, and have been adjusted for all laboratory processing factors and instrument dilutions.

Calibration of the ICP-OES was done following the manufacturer's recommended calibration procedure and using multi-analyte custom standard solutions traceable to the National Institute of Standards and Technology (NIST). Midrange calibration verification standards (MCVA and MCVB) were used to verify acceptance of the two-point calibration curves obtained for each analyte, and also used for continuing calibration verification.

The controlling document was ASO-QAP-001. Instrument calibrations, QC checks and blanks (e.g., ICV/ICB, CCV/CCB, LLS, ICS), blank spike, matrix spike, post spike, duplicate, and serial dilution were conducted during the analysis run. The blank spike and matrix spike were prepared using a custom solution, BPNL-QC-1A.

Preparation Blank (PB):

A preparation blank (reagents only) was prepared for the extraction process. The concentrations of all AOIs were within the acceptance criteria of ≤EQL (estimated quantitation level) or less than ≤5% of the concentration in the sample.

Blank Spike (BS)/Laboratory Control Sample (LCS):

A blank spike was prepared for the extraction process. Recovery values are listed for all analytes included in the spike that were measured at or above the EQL. The recovery values were within the acceptance criterion of 80% to 120% for all AOIs meeting the above requirement.

Matrix-Spiked Sample:

A matrix spike was prepared for the extraction process. Recovery values are listed for all analytes included in the spike that were measured at or above the EQL. The recovery values were within the acceptance criterion of 75% to 125% for all AOIs meeting the above requirement.

Duplicate Relative Percent Difference (RPD):

A duplicate was prepared for the sample. RPDs are listed for all analytes that were measured at or above the EQL. The RPDs were within the acceptance criterion of ≤20% for all AOIs meeting the above requirement.

Post-Spike/Analytical Spike Sample (A Component):

A post spike (A Component) was conducted the sample. Recovery values are listed for all analytes in the spike that were measured at or above the EQL, and that had a spike concentration ≥25% of that in the sample. The recovery values were within the acceptance criterion of 75% to 125% for all AOIs meeting the above requirements.

Post Spike/Analytical Spike Sample (B Component):

A post spike (B Component) was conducted on the sample. Recovery values are listed for all analytes in the spike that were measured at or above the EQL, and that had a spike concentration ≥25% of that in the sample. No AOIs were included in the spike B Component.

Serial dilution:

Five-fold serial dilution was conducted on the sample. Percent differences (%Ds) are listed for all analytes that had a concentration at or above the EQL in the diluted sample. The %Ds were within the acceptance criterion of ≤10% for all AOIs meeting the above requirement.

Other QC:

Barium was slightly negative (~0.006 μg/mL) for the ICB and CCBs, and for the ICSs. The negative shift was the result of small Ba signal in the initial calibration blank that reduced over time. This negative shift, however, had no statistical effect on the reported data as the levels of Ba in the ICB/CCBs and ICSs was negligible compared to the level of Ba in the sample itself. All other instrument-related QC tests for the AOIs passed within the appropriate acceptance criteria.

Comments:

1) The "Final Results" have been corrected for all laboratory dilutions performed on the samples during processing and analysis, unless specifically noted.
2) Instrument detection limits (IDL) and estimated quantitation limits (EQL) shown are for acidified water and/or fusion flux matrices as applicable. Detection limits for other matrices may be determined if requested. Method detection limits (MDL) can be estimated by multiplying the IDL by the "Multiplier". The estimated quantitation limit (EQL) for each concentration value can be obtained by multiplying the EQL by the "Multiplier".
3) Routine precision and bias is typically ±15% or better for samples in dilute, acidified water (e.g. 2% v/v $HNO_3$ or less) at analyte concentrations > EQL up to the upper calibration level. This also presumes that the total dissolved solids concentration in the sample is less than 5000 μg/mL (0.5 per cent by weight). Note that bracketed values listed in the data report are within the MDL and the EQL, and have potential uncertainties greater than 15%. Concentration values < MDL are listed as "- -". Note, that calibration and QC standards are validated to a precision of ±10%.
4) Absolute precision, bias and detection limits may be determined on each sample if required by the client. The maximum number of significant figures for all ICP measurements is two.
5) Analytes included in the spike A component (for the AS/PS) are; Ag, Al, As, B, Ba, Be, Bi, Ca, Cd, Co, Cr, Cu, Fe, K, Li, Mg, Mn, Mo, Na, Ni, P, Pb, Sb, Se, Si, Sn, Sr, Ta, Ti, Tl, V, W, Y, Zn, and Zr. Analytes included in the spike B component are; Ce, Dy, Eu, La, Nd, Pd, Rh, Ru, S, Te, Th, and U.

# Battelle PNNL/RPG/Inorganic Analysis ... ICPOES Data Report



| | | Run Date > | 7/13/2011 | 7/13/2011 | 7/13/2011 | 7/13/2011 |
|---|---|---|---|---|---|---|
| | | Multiplier > | 85.7 | 85.8 | 85.6 | 429.1 |
| | | RPL/LAB > | 11-1355-129-PB | 11-1355-129-S | 11-1355-129-D | 11-1355-129-S @ 5x |
| Instr. Det. Limit (IDL) | Est. Quant. Limit (EQL) | Client ID > | Prep Blank | J1JD49 | | J1JD49-S |
| (µg/mL) | (µg/mL) | (Analyte) | (µg/g) | (µg/g) | (µg/g) | (µg/g) |
| 0.0001 | 0.001 | Ba | -- | 123 | 130 | |
| 0.0009 | 0.009 | Cd | -- | -- | -- | |
| 0.0015 | 0.015 | Cr | -- | 30.1 | 31.1 | |
| 0.0100 | 0.100 | Pb | -- | [8.0] | [7.3] | |
| Other Analytes | | | | | | |
| 0.0009 | 0.009 | Ag | [0.12] | 3.99 | 3.81 | |
| 0.0021 | 0.021 | Al | [0.41] | 13,200 | 13,600 | |
| 0.0190 | 0.190 | As | -- | [5.3] | [3.5] | |
| 0.0038 | 0.038 | B | [1.5] | 10.2 | 10.2 | |
| 0.0000 | 0.001 | Be | [0.0026] | 0.438 | 0.452 | |
| 0.0092 | 0.092 | Bi | 12.2 | 23.0 | 14.3 | |
| 0.0036 | 0.036 | Ca | -- | 15,600 | 15,600 | |
| 0.0043 | 0.043 | Ce | -- | 29.3 | 30.8 | |
| 0.0008 | 0.008 | Co | [0.093] | 8.72 | 9.25 | |
| 0.0008 | 0.008 | Cu | [0.10] | 28.9 | 24.4 | |
| 0.0006 | 0.006 | Dy | -- | 1.51 | 1.60 | |
| 0.0002 | 0.002 | Eu | -- | 3.28 | 3.32 | |
| 0.0003 | 0.003 | Fe | 1.11 | over-range | over-range | 31,800 |
| 0.0190 | 0.190 | K | 38.2 | 2,520 | 2,640 | |
| 0.0007 | 0.007 | La | -- | 23.3 | 24.6 | |
| 0.0005 | 0.005 | Li | [0.35] | 14.3 | 14.9 | |
| 0.0012 | 0.012 | Mg | -- | 6,250 | 6,420 | |
| 0.0001 | 0.001 | Mn | [0.021] | 454 | 452 | |
| 0.0020 | 0.020 | Mo | -- | 4.49 | 4.58 | |
| 0.0063 | 0.063 | Na | 6.26 | 759 | 783 | |
| 0.0016 | 0.016 | Nd | -- | 14.2 | 15.1 | |
| 0.0016 | 0.016 | Ni | -- | 19.0 | 19.5 | |
| 0.0250 | 0.250 | P | -- | 743 | 740 | |
| 0.0039 | 0.039 | Pd | -- | -- | -- | |
| 0.0048 | 0.048 | Rh | -- | -- | -- | |
| 0.0023 | 0.023 | Ru | -- | 2.73 | 3.92 | |
| 0.0160 | 0.160 | S | [2.6] | 56.2 | 51.7 | |
| 0.0240 | 0.240 | Sb | -- | -- | -- | |
| 0.0380 | 0.380 | Se | -- | [30] | [32] | |
| 0.0027 | 0.027 | Si | [0.74] | 1,070 | 587 | |
| 0.0068 | 0.068 | Sn | [2.2] | 11.7 | 10.9 | |
| 0.0000 | 0.000 | Sr | -- | 63.4 | 64.7 | |
| 0.0080 | 0.080 | Ta | -- | [4.0] | [3.6] | |
| 0.0080 | 0.080 | Te | -- | -- | -- | |
| 0.0032 | 0.032 | Th | -- | 4.71 | 4.95 | |
| 0.0002 | 0.002 | Ti | -- | 1,950 | 2,000 | |
| 0.0200 | 0.200 | Tl | [2.7] | -- | -- | |
| 0.0140 | 0.140 | U | -- | 56.9 | 59.8 | |
| 0.0005 | 0.005 | V | [0.15] | 60.0 | 60.8 | |
| 0.0074 | 0.074 | W | -- | [1.7] | [1.1] | |
| 0.0001 | 0.001 | Y | -- | 9.59 | 9.92 | |
| 0.0016 | 0.016 | Zn | 1.97 | 76.1 | 71.4 | |
| 0.0006 | 0.006 | Zr | -- | 24.0 | 24.8 | |

*1) "--" indicates the value is < MDL. The method detection limit (MDL) = IDL times the "multiplier" near the top of each column. The estimated sample quantitation limit = EQL (in Column 2) times the "multiplier". Overall error for values ≥ EQL is estimated to be within ±15%.*

*2) Values in brackets [ ] are ≥ MDL but < EQL, with errors likely to exceed 15%.*

# Battelle PNNL/RPG/Inorganic Analysis ... ICPOES Data Report

QC Performance 7/13/2011

| Criteria > | ≤ 20% | 80%-120% | 75%-125% | 75%-125% | 75%-125% | ≤ 10% |
|---|---|---|---|---|---|---|
| QC ID > | 11-1355 Dup | LCS/BS | 11-1355 MS | 11-1355 + PS-A | 11-1355 + PS-B | 11-1355 5-fold Serial Dil |
| Analytes | RPD (%) | %Rec | %Rec | %Rec | %Rec | %Diff |
| Ba | 5.4 | 101 | 103 | 93 | | 0.7 |
| Cd | | 104 | 93 | 95 | | |
| Cr | 3.3 | 106 | 93 | 99 | | 7.6 |
| Pb | | 104 | 93 | 97 | | |
| Other Analytes | | | | | | |
| Ag | 4.6 | | | 94 | | 37.3 |
| Al | 3.0 | 104 | nr | nr | | 5.5 |
| As | | | | 96 | | |
| B | 0.6 | | | 100 | | |
| Be | 3.1 | 107 | 103 | 101 | | 3.1 |
| Bi | 46.7 | 96 | 54 | 93 | | |
| Ca | 0.2 | 104 | nr | nr | | 6.5 |
| Ce | 5.1 | 95 | 91 | | 92 | 9.8 |
| Co | 5.9 | | | 97 | | 12.2 |
| Cu | 17.1 | 107 | 95 | 102 | | 3.3 |
| Dy | 5.8 | | | | 100 | |
| Eu | 1.0 | | | | 100 | 16.8 |
| Fe | | 105 | nr | nr | | |
| K | 4.6 | 103 | 106 | 102 | | 2.0 |
| La | 5.4 | 105 | 99 | | 103 | 39.9 |
| Li | 3.9 | 107 | 111 | 105 | | 3.8 |
| Mg | 2.7 | 104 | nr | 97 | | 8.5 |
| Mn | 0.6 | 105 | nr | nr | | 7.0 |
| Mo | 2.1 | | | 97 | | |
| Na | 3.2 | 105 | 106 | 99 | | 0.2 |
| Nd | 5.9 | 104 | 104 | | 100 | 27.0 |
| Ni | 2.8 | 104 | 92 | 97 | | 12.0 |
| P | 0.4 | | | 96 | | 8.0 |
| Pd | | | | | 89 | |
| Rh | | | | | 95 | |
| Ru | 35.6 | | | | 93 | |
| S | 8.2 | | | | 95 | |
| Sb | | | | 95 | | |
| Se | | | | 99 | | |
| Si | 58.1 | | | 100 | | 15.3 |
| Sn | 7.1 | | | 94 | | |
| Sr | 2.0 | 102 | nr | 96 | | 6.8 |
| Ta | | | | 98 | | |
| Te | | | | | 94 | |
| Th | 4.9 | 103 | 94 | | 97 | |
| Ti | 2.6 | | | nr | | 7.6 |
| Tl | | | | 88 | | |
| U | 5.1 | 103 | 101 | | 96 | |
| V | 1.3 | 93 | 93 | 92 | | 7.1 |
| W | | | | 102 | | |
| Y | 3.4 | | | 94 | | 5.4 |
| Zn | 6.3 | 105 | 80 | 94 | | 65.2 |
| Zr | 3.2 | | | 100 | | 4.1 |

*Shaded results are outside the acceptance criteria.*

*nr = spike concentration less than 25% of sample concentration. Matrix effects can be assessed from the serial dilution.*

**Project / WP#:** 60965 / H54512
**ASR#:** 8902
**Client:** K. Pool
**Total Samples:** 1 (solid)

| | First | Last |
|---|---|---|
| **RPL#:** | 11-1397 | -- |
| **Client ID:** | J1JD50 | -- |

**Sample Preparation:** PNL-ALO-129, "$HNO_3$-HCl Extraction of Solids for Metals Analysis Using a Dry-Block Heater", 7/25/11 (SAL/jc).

**Procedure:** RPG-CMC-211, "Determination of Elemental Composition by Inductively Coupled Argon Plasma Optical Emission Spectrometry (ICP-OES)", Rev. 3.

**Analyst:** J. Carter

**Analysis Date (File):** 7-25-2011 (C0397)

**See Chemical Measurement Center 98620 file:** ICP-325-405-3
(Calibration and Maintenance Records)

**M&TE Number:** N827583 (PerkinElmer 5300DV ICP-OES, S/N 077N5122002)
WD66158 (Sartorius ME414S Balance, S/N 224066373)

7/26/11
Preparer

8/3/11
Review and Concur

One sample was provided for ICP-OES analysis under Analytical Service Request (ASR) 8902. The sample was processed in the Shielded Analytical Laboratory (SAL) following RPL procedure PNL-ALO-129 using ~1 gram of sample with dilution to a final volume of 100 mL.

Analytes of interest (AOIs) were specified in the ASR, and are listed in the upper section of the attached ICP-OES Data Report. The quality control (QC) results for these AOIs have been evaluated and are presented below. Analytes other than AOIs are reported in the bottom section of the report, but have not been fully evaluated for QC performance. The results are given as µg/g for each detected analyte, and have been adjusted for all laboratory processing factors and instrument dilutions.

Calibration of the ICP-OES was done following the manufacturer's recommended calibration procedure and using multi-analyte custom standard solutions traceable to the National Institute of Standards and Technology (NIST). Midrange calibration verification standards (MCVA and MCVB) were used to verify acceptance of the two-point calibration curves obtained for each analyte, and also used for continuing calibration verification.

The controlling document was ASO-QAP-001. Instrument calibrations, QC checks and blanks (e.g., ICV/ICB, CCV/CCB, LLS, ICS), blank spike, matrix spike, post spike, duplicate, and serial dilution were conducted during the analysis run. The blank spike and matrix spike were prepared using a custom solution, BPNL-QC-1A.

Preparation Blank (PB):

A preparation blank (reagents only) was prepared for the extraction process. The concentrations of all AOIs were within the acceptance criteria of ≤EQL (estimated quantitation level) or less than ≤5% of the concentration in the sample.

Blank Spike (BS)/Laboratory Control Sample (LCS):

A blank spike was prepared for the extraction process. Recovery values are listed for all analytes included in the spike that were measured at or above the EQL. The recovery values were within the acceptance criterion of 80% to 120% for all AOIs meeting the above requirement.

Matrix-Spiked Sample:

A matrix spike was prepared for the extraction process. Recovery values are listed for all analytes included in the spike that were measured at or above the EQL. The recovery values were within the acceptance criterion of 75% to 125% for all AOIs meeting the above requirement.

Duplicate Relative Percent Difference (RPD):

A duplicate was prepared for the sample. RPDs are listed for all analytes that were measured at or above the EQL. The RPDs were within the acceptance criterion of ≤20% for all AOIs meeting the above requirement.

Post-Spike/Analytical Spike Sample (A Component):

A post spike (A Component) was conducted the sample. Recovery values are listed for all analytes in the spike that were measured at or above the EQL, and that had a spike concentration ≥25% of that in the sample. The recovery values were within the acceptance criterion of 75% to 125% for all AOIs meeting the above requirements.

Post Spike/Analytical Spike Sample (B Component):

A post spike (B Component) was conducted on the sample. Recovery values are listed for all analytes in the spike that were measured at or above the EQL, and that had a spike concentration ≥25% of that in the sample. No AOIs were included in the spike B Component.

Serial dilution:

Five-fold serial dilution was conducted on the sample. Percent differences (%Ds) are listed for all analytes that had a concentration at or above the EQL in the diluted sample. The %Ds were within the acceptance criterion of ≤10% for all AOIs meeting the above requirement.

Other QC:

All other instrument-related QC tests for the AOIs passed within the appropriate acceptance criteria.

Comments:

1) The "Final Results" have been corrected for all laboratory dilutions performed on the samples during processing and analysis, unless specifically noted.
2) Instrument detection limits (IDL) and estimated quantitation limits (EQL) shown are for acidified water and/or fusion flux matrices as applicable. Detection limits for other matrices may be determined if requested. Method detection limits (MDL) can be estimated by multiplying the IDL by the "Multiplier". The estimated quantitation limit (EQL) for each concentration value can be obtained by multiplying the EQL by the "Multiplier".
3) Routine precision and bias is typically ±15% or better for samples in dilute, acidified water (e.g. 2% v/v $HNO_3$ or less) at analyte concentrations > EQL up to the upper calibration level. This also presumes that the total dissolved solids concentration in the sample is less than 5000 μg/mL (0.5 per cent by weight). Note that bracketed values listed in the data report are within the MDL and the EQL, and have potential uncertainties greater than 15%. Concentration values < MDL are listed as "- -". Note, that calibration and QC standards are validated to a precision of ±10%.
4) Absolute precision, bias and detection limits may be determined on each sample if required by the client. The maximum number of significant figures for all ICP measurements is two.
5) Analytes included in the spike A component (for the AS/PS) are; Ag, Al, As, B, Ba, Be, Bi, Ca, Cd, Co, Cr, Cu, Fe, K, Li, Mg, Mn, Mo, Na, Ni, P, Pb, Sb, Se, Si, Sn, Sr, Ta, Ti, Tl, V, W, Y, Zn, and Zr. Analytes included in the spike B component are; Ce, Dy, Eu, La, Nd, Pd, Rh, Ru, S, Te, Th, and U.

# Battelle PNNL/RPG/Inorganic Analysis ... ICPOES Data Report



| | | Run Date > | 7/25/2011 | 7/25/2011 | 7/25/2011 | 7/25/2011 |
|---|---|---|---|---|---|---|
| | | Multiplier > | 1.0 | 93.8 | 894.3 | 987.2 |
| | | RPL/LAB > | 405 diluent | 11-1397-129 PB | 11-1397-129 S @ 10x | 11-1397-129 D @ 10x |
| Instr. Det. Limit (IDL) | Est. Quant. Limit (EQL) | Client ID > | Lab diluent | Prep Blank | J1JD50 | |
| (µg/mL) | (µg/mL) | (Analyte) | (µg/mL) | (µg/g) | (µg/g) | (µg/g) |
| 0.0001 | 0.001 | Ba | -- | 2.08 | 113 | 108 |
| 0.0009 | 0.009 | Cd | -- | [0.45] | 11.0 | 11.5 |
| 0.0015 | 0.015 | Cr | -- | [0.17] | 19.7 | 19.6 |
| 0.0100 | 0.100 | Pb | -- | [2.4] | [13] | [16] |
| Other Analytes | | | | | | |
| 0.0009 | 0.009 | Ag | -- | [0.73] | [7.0] | [8.1] |
| 0.0021 | 0.021 | Al | -- | [1.5] | 8,350 | 8,690 |
| 0.0190 | 0.190 | As | -- | -- | -- | -- |
| 0.0038 | 0.038 | B | [0.015] | [1.6] | 69.6 | 73.6 |
| 0.0000 | 0.001 | Be | -- | -- | [0.24] | [0.25] |
| 0.0092 | 0.092 | Bi | [0.017] | 31.5 | [32] | [48] |
| 0.0036 | 0.036 | Ca | -- | [2.2] | 11,600 | 12,600 |
| 0.0043 | 0.043 | Ce | -- | -- | 40.0 | [40] |
| 0.0008 | 0.008 | Co | -- | -- | [6.8] | 8.09 |
| 0.0008 | 0.008 | Cu | -- | 1.32 | 22.1 | 20.4 |
| 0.0006 | 0.006 | Dy | -- | -- | [0.98] | [1.4] |
| 0.0002 | 0.002 | Eu | -- | -- | 2.39 | 2.58 |
| 0.0003 | 0.003 | Fe | -- | 1.55 | 22,400 | 22,400 |
| 0.0190 | 0.190 | K | -- | 76.4 | 1,600 | 1,650 |
| 0.0007 | 0.007 | La | -- | -- | 44.2 | 34.0 |
| 0.0005 | 0.005 | Li | -- | 1.81 | 5.47 | 7.47 |
| 0.0012 | 0.012 | Mg | -- | -- | 4,660 | 4,950 |
| 0.0001 | 0.001 | Mn | -- | -- | 466 | 429 |
| 0.0020 | 0.020 | Mo | -- | -- | [4.6] | -- |
| 0.0063 | 0.063 | Na | -- | 50.9 | 1,520 | 1,540 |
| 0.0016 | 0.016 | Nd | -- | -- | 19.8 | 19.6 |
| 0.0016 | 0.016 | Ni | -- | -- | 59.9 | 53.8 |
| 0.0250 | 0.250 | P | -- | [2.7] | 633 | 631 |
| 0.0039 | 0.039 | Pd | -- | -- | -- | -- |
| 0.0048 | 0.048 | Rh | -- | -- | -- | -- |
| 0.0023 | 0.023 | Ru | -- | -- | -- | -- |
| 0.0160 | 0.160 | S | [0.029] | [5.9] | [110] | [45] |
| 0.0240 | 0.240 | Sb | [0.024] | [3.4] | [30] | -- |
| 0.0380 | 0.380 | Se | -- | -- | [71] | -- |
| 0.0027 | 0.027 | Si | -- | -- | -- | -- |
| 0.0068 | 0.068 | Sn | -- | -- | -- | -- |
| 0.0000 | 0.000 | Sr | -- | -- | 55.1 | 58.7 |
| 0.0080 | 0.080 | Ta | -- | -- | [9.4] | [14] |
| 0.0080 | 0.080 | Te | -- | -- | [7.7] | -- |
| 0.0032 | 0.032 | Th | -- | -- | -- | -- |
| 0.0002 | 0.002 | Ti | -- | [0.025] | 1,810 | 1,960 |
| 0.0200 | 0.200 | Tl | -- | [2.5] | -- | -- |
| 0.0140 | 0.140 | U | -- | -- | [87] | [100] |
| 0.0005 | 0.005 | V | -- | -- | 56.0 | 53.8 |
| 0.0074 | 0.074 | W | -- | -- | [14] | -- |
| 0.0001 | 0.001 | Y | -- | -- | 8.34 | 8.90 |
| 0.0016 | 0.016 | Zn | -- | 16.4 | 145 | 138 |
| 0.0006 | 0.006 | Zr | -- | -- | 18.6 | 19.1 |

*1) "--" indicates the value is < MDL. The method detection limit (MDL) = IDL times the "multiplier" near the top of each column. The estimated sample quantitation limit = EQL (in Column 2) times the "multiplier". Overall error for values ≥ EQL is estimated to be within ±15%.*

*2) Values in brackets [ ] are ≥ MDL but < EQL, with errors likely to exceed 15%.*

# Battelle PNNL/RPG/Inorganic Analysis ... ICPOES Data Report

7/25/2011

| Criteria > | ≤ 20% | 80%-120% | 75%-125% | 75%-125% | 75%-125% | ≤ 10% |
|---|---|---|---|---|---|---|
| QC ID > | 11-1397 Dup | LCS/BS | 11-1397 MS | 11-1397 + PS-A | 11-1397 + PS-B | 11-1397 5-fold Serial Dil |
| Analytes | RPD (%) | %Rec | %Rec | %Rec | %Rec | %Diff |
| Ba | 5.3 | 102 | 124 | 103 | | 4.5 |
| Cd | 4.9 | 103 | 106 | 104 | | |
| Cr | 0.7 | 105 | 117 | 103 | | |
| Pb | | 100 | 98 | 99 | | |
| Other Analytes | | | | | | |
| Ag | | | | 94 | | |
| Al | 4.0 | 102 | 132 | 102 | | 0.7 |
| As | | | | 101 | | |
| B | 5.6 | | | 106 | | |
| Be | | 103 | 103 | 99 | | |
| Bi | | 63 | 118 | 92 | | |
| Ca | 8.1 | 105 | nr | 103 | | 1.1 |
| Ce | | 99 | 99 | | 102 | |
| Co | | | | 99 | | |
| Cu | 7.9 | 104 | 111 | 112 | | |
| Dy | | | | | 97 | |
| Eu | 7.6 | | | | 96 | |
| Fe | 0.2 | 106 | nr | 100 | | 2.1 |
| K | 3.0 | 108 | 113 | 107 | | 11.3 |
| La | 25.9 | 93 | 97 | | 97 | 20.5 |
| Li | 31.0 | 111 | 115 | 107 | | |
| Mg | 6.0 | 104 | nr | 103 | | 0.9 |
| Mn | 8.2 | 103 | nr | 102 | | 6.4 |
| Mo | | | | 98 | | |
| Na | 1.3 | 101 | 135 | 102 | | 9.0 |
| Nd | 1.1 | 91 | 93 | | 94 | |
| Ni | 10.7 | 101 | 107 | 101 | | |
| P | 0.3 | | | 100 | | |
| Pd | | | | | 97 | |
| Rh | | | | | 95 | |
| Ru | | | | | 94 | |
| S | | | | | 96 | |
| Sb | | | | 100 | | |
| Se | | | | 98 | | |
| Si | | | | | | |
| Sn | | | | 92 | | |
| Sr | 6.3 | 104 | nr | 104 | | 7.8 |
| Ta | | | | 100 | | |
| Te | | | | | 101 | |
| Th | | 94 | 95 | | 96 | |
| Ti | 7.9 | | | 102 | | 0.5 |
| Tl | | | | 92 | | |
| U | | 102 | 103 | | 104 | |
| V | 4.2 | 94 | 114 | 99 | | 0.1 |
| W | | | | 99 | | |
| Y | 6.4 | | | 103 | | 9.9 |
| Zn | 4.9 | 85 | 124 | 97 | | 1.6 |
| Zr | 2.6 | | | 105 | | |

*Shaded results are outside the acceptance criteria.*

*nr = spike concentration less than 25% of sample concentration. Matrix effects can be assessed from the serial dilution.*

*Pacific Northwest National Laboratory*
*Radiochemical Science and Engineering Group*
*pH Report – pH for Soil Samples*
*PO Box 999, Richland, Washington 99352*

**Project Number:** 60965
**Charge Code:** H54512
**ASR Numbers:** 8888 & 8902
**Client:** K. Pool
**Total Samples:** 2

| RPL Sample ID | Client sample ID |
|---|---|
| 11-1355 | J1JD49 |
| 11-1397 | J1JD50 |

| | |
|---|---|
| **Analysis Procedure** | PNL-ALO-290, Rev. 0, *Determination of pH in Soil Samples* |
| **Sample Preparation Procedure** | None |
| **Analyst** | J. Chenault |
| **Analysis Date** | 8/9/11 |
| **Cal/Verify Standards** | Orion Lot# OZ2; exp 1/2012 (pH 4)<br>Ricca Lot# 1002527; exp 2/2012 (pH 7)<br>Ricca Lot# 1002419; exp 8/2011 (pH10)<br>Orion Lot# OZ2; exp 1/2012 (pH 7; ICV/CCV) |
| **Excel Data File** | NA |
| **M&TE Numbers** | Beckman 360, #4884 |
| **All Analysis Records** | ASR File 8888 & 8902 |

Kurt N. Pool — 9/13/11
**Prepared By** — **Date**

T Trang-Le — 9/13/11
**Reviewed By** — **Date**

**Sample Analysis/Results Discussion**

The soil samples submitted under these ASR's came from 2 separate sampling events. The first sample was received at PNNL on 6/21/11 and the second sample received at PNNL on 6/30/11. The soil samples were removed from the sampling devices, transferred to pre-tarred vials and the final mass of collected sample recorded. Approximately 8.5 grams of soil was collected for the first sample and 7.2 grams collected for the second. Along with the pH analyses request, ICP/OES and radiochemistry analyses were requested. Priority was placed on obtaining digested sample aliquots for the ICP/OES and radiochemistry analyses. The acid digestion preparation, performed in the PNNL hot cells, consumed approximately 3 grams of each sample, leaving the remainder for pH.

The soil pH procedure was implemented in the PNNL hot cells. Two, one gram aliquots of each sample was prepared for pH analyses by addition of 10 mL of water and then stirred for 30 minutes. The stirring was then stopped and the samples let to settle for one hour prior to pH measurement. The pH of each sample was measured at least twice, with the probe removed and rinsed between measurements. The final reported pH value is the average of the pH values measured for each sample. The final results are presented in Table 1.

**Background**

N/A

**Sample Preparation**

The soil samples were prepared for pH analyses by contacting ~ 1gram of soil with 10 mL of water, stirred for 30 minutes, let to settle for one hour, then the water pH measured.

**Quality Control Discussion**

Calibration Check Standards: The calibration of the pH measurement system is checked by analyzing an initial calibration verification check standard (ICV) and continuing calibration verification check sample (CCV). For this analyses batch, the result for the ICV was 6.91 and the result for the CCV was 6.93, meeting the procedure DQO criterion of agreement within $\pm 0.1$ pH unit of the certified value for the pH buffer solution.

Duplicates: Precision of the pH measurements is demonstrated by analyzing at least one sample/ sample duplicate sample pair in every 10 samples; the procedure DQO criterion is agreement between duplicates within 0.1 pH unit of the sample result. In this case both samples were analyzed in duplicate. The average pH values for sample J1JD49 were 8.4 and 8.4 and for sample J1JD50 were 7.8 and 7.8.

**Deviation from Procedure**

The pH procedure calls for a 1:1 addition of water to soil, that is, for every gram of soil add one mL of water. Due to the limited amount of sample available, and the need to generate enough liquid volume for the pH probe to obtain an accurate measurement, the volume of water added to one gram of sample was increased to 10 mL. The WCH client provided approval for this approach in e-mail correspondence with the PNNL project manager.

The method blank (de-ionized water) was not analyzed as part of the analysis batch. The de-ionized water used in the pH analyses procedure was obtained fresh from the Millipore water polishing unit and

loaded into the hot cell for use that same day. The method blank was accidently omitted for this analyses batch.

**General Comments**

None

| Table 1 - Measured pH – ASR 8888 and 8902 | | | | |
|---|---|---|---|---|
| **Client Sample ID** | RPL ID | 1st Reading | 2nd Reading | Average |
| J1JD49 | 11-1355 | 8.44 | 8.45 | **8.4** |
| J1JD49-dup | 11-1355-dup | 8.40 | 8.42 | **8.4** |
| J1JD50 | 11-1397 | 7.80 | 7.83 | **7.8** |
| J1JD50-dup | 11-1397-dup | 7.88 | 7.80 | **7.8** |

# PNL-ALO-290 - Determination of pH in Soil Samples

**BENCHSHEET**

Client Name: Pool

[a]M&TE Manufacturer/Model/Ser#: Beckman 360 - SN 4882

Special Instructions: Use one gram of sample to 10 mL of water

ASR# (Work Authorization): 8888 & 8902

Analysis Date: 8/9/11

Location (Room): SAL

QA plan: X ASO-QAP-001

☐ Other (_____)

| | RPL Sample Number | RPL / Client Sample ID / Sample Mass | Buffer pH Cert. Value[b] | 1st Reading (pH units) | 2nd Reading (pH units) | 3rd Reading (pH Units)[c] | 4th Reading (pH units)[c] | Difference (pH units)[d] | Average (pH Units)[e] |
|---|---|---|---|---|---|---|---|---|---|
| * | n/a | ICV - Initial Cal Verification (after Cal) | 7.00 | 6.91 | n/a | n/a | n/a | | n/a |
| 1 | 11-1355 | J1JD49 1.0395g | N/A | 8.44 | 8.45 | | | | |
| 2 | 11-1355-Dup | J1JD49-Dup 1.0637g | N/A | 8.52* | 8.40 | 8.42 | | | |
| 3 | 11-1397 | J1JD50 1.0592g | N/A | 7.68* | 7.80 | 7.83 | | | |
| 4 | 11-1397-Dup | J1JD50-Dup 1.0111g | N/A | 7.88 | 7.80 | | | | |
| 5 | | | | | | | | | |
| 6 | | | | | | | | | |
| 7 | | | | | | | | | |
| 8 | | | | | | | | | |
| 9 | | | | | | | | | |
| 10 | | | | | | | | | |
| * | n/a | CCV - Continuing Cal Verification | | | n/a | n/a | n/a | | n/a |

| pH Standards (List All Calibration & Verification Buffers) | | | | pH Std Used For (check as appropriate) | | |
|---|---|---|---|---|---|---|
| Lot # | Exp. Date. | CMS # | pH Cert. Value | Cal | ICV | CCV |
| Orion - OZ2 | 12-Jan | 327668 | 4.01 | X | ☐ | ☐ |
| Ricca - 1002527 | 12-Feb | 320145 | 7.00 | X | ☐ | ☐ |
| Ricca - 1002419 | 11-Aug | 320144 | 10.00 | X | ☐ | ☐ |
| Orion - 910104 | 12-Jan | 320129 | 7.00 | ☐ | X | X |
| | | | | ☐ | ☐ | ☐ |

| Calibration Slope (if available) | |
|---|---|
| Calibration Slope: | 95.3 |

| Ambient Temperature | |
|---|---|
| Temperature after Calibration: | 28 °C |
| Temperature after Analysis: | 28 °C |

Notes/Observations:

* pH values not used to calculate average

[a] Use of ATC is assumed. If ATC is not used, it is the responsibility of the Cognizant Scientist to adjust pH results for differences between cal buffer and sample solution temperatures.
Check box if ATC was NOT used. X

[b] Enter pH cert. value for ICV, CCV, or any other pH standard measured; leave blank for sample measurements.

[c] If needed. Once acceptance criterion is met, no additional measurments are necessary.

[d] Difference in pH units between last two recorded sample pH readings or between ICV/CCV buffer value and measured pH value.

[e] Typically the average of only the last two sample pH readings is used.

[f] Other measurement benchsheets/worksheets may be substituted at the discretion of the Cognizant Scientist.

Page 1 of 1

Analyst/Date: JW 8/9/11

Reviewer/Date: [illegible] 8/9/11