Emerging Contaminant – Tungsten

April 2008

FACT SHEET

At a Glance

- Hard, steel-gray to tin-white solid.
- Highest melting point among metals.
- Highly flammable and may cause fire or explosion when exposed to oxidants.
- Low solubility in water and high sorption (soil/water distribution) coefficients at low to neutral pH levels.
- Typically used in welding, oil-drilling, electrical, and aerospace industries.
- Currently used in "Green Bullets" as an environmentally friendly alternative to conventional lead-based ammunition.
- Exposure may cause eye and skin irritation, cough, nausea, diffuse Interstitial pulmonary fibrosis, and changes in blood.
- Has not been classified for carcinogenic effects.
- Exposure limits set by the National Institute for Occupational Safety and Health (NIOSH) and the American Conference of Governmental Industrial Hygienists (ACGIH).
- No federal drinking water standard has been established.
- Treatment methods for tungsten in environmental media are currently under development. Methods under investigation involve ice-electrodes, chemical recovery/soil washing, and phytoremediation.

Introduction

An "emerging contaminant" is a chemical or material that is characterized by a perceived, potential, or real threat to human health or the environment or a lack of published health standards. A contaminant may also be "emerging" because a new source or a new pathway to humans has been discovered or a new detection method or treatment technology has been developed (DoD 2007). This fact sheet, developed by the U.S. Environmental Protection Agency (EPA) Federal Facilities Restoration and Reuse Office (FFRRO), provides a brief summary for tungsten, including: physical and chemical properties; environmental and health impacts; existing federal and state guidelines; detection and treatment methods; and additional sources of information.

Tungsten was originally considered a metal that remains stable in soil and does not dissolve easily in water. However, it is now a growing concern to the EPA and Department of Defense (DoD) because recent research indicates that tungsten may not be as stable as was indicated in earlier studies. Furthermore, varying soil properties such as pH may cause tungsten to dissolve and leach into the underlying aquifer (ATSDR 2005). Currently, little information is available about the fate of tungsten in the environment and its effects on human health. Research about tungsten is ongoing and includes health effects and risks, degradation processes, and an inventory of its use in the defense industry as a substitute for lead-based munitions. This fact sheet provides basic information on tungsten to site managers and other field personnel who may be faced with tungsten contamination at a cleanup site.

What is tungsten?

- Tungsten (also known as Wolfram and represented by the letter W in the periodic table) is a naturally occurring element that exists in the form of minerals or other compounds but typically not as a pure metal (NIOSH 2005; ATSDR 2005).
- Wolframite ($[FeMn]WO_4$), and Scheelite ($CaWO_4$) are two common minerals that contain tungsten (Werner and others 1998).
- Based on its purity, the color of tungsten may range from white for the pure metal to steel-gray for the metal with impurities. It is commercially available in powdered or solid form (ATSDR 2005; NIOSH 2005; NIOSH 2007).
- The melting point of tungsten is the highest among metals and it resists corrosion. It is a good conductor of electricity and acts as a catalyst in chemical reactions (ATSDR 2005; Massachusetts DEP 2006; Werner and others 1998).

United States Environmental Protection Agency
Solid Waste and Emergency Response (5106P)
EPA 505-F-07-005
April 2008

What is tungsten (continued)?

- Tungsten ore is used primarily to produce tungsten carbide and tungsten alloys, which are used in many general welding and metal-cutting applications, in making drilling equipment for oil wells, and in operations within the aerospace industry. Tungsten metal is also used to produce lamp filaments, X-ray tubes, dyes, and paints for fabrics (ATSDR 2005; Werner and others 1998).
- The DoD has used tungsten as a replacement for lead in bullets and other ammunition since 1999 (Massachusetts National Guard 2006).

What are the environmental impacts of tungsten?

- Tungsten is a common contaminant at industrial sites that use tungsten and at DoD sites involved in the manufacture, storage, and use of tungsten-based ammunition (DoD 2007).
- Tungsten particles may be present in air as a result of mining, weathering of rocks, or industrial applications that involve tungsten. These particles may settle on soil, water, or other surfaces and can be deposited through rain or other forms of precipitation (ATSDR 2005; Massachusetts DEP 2006).
- Tungsten powder is highly flammable and may ignite instantly on contact with air (ATSDR 2005; NJDEP 2000). Tungsten also may cause fire or explosion on contact with oxidants (NIOSH 2007).
- Tungsten has been detected at six National Priorities List (NPL) sites (ATSDR 2005).
- Earlier research on tungsten indicated that it is stable in soil because of its soil binding capacity and its insolubility in water. At lower pH values, sorption coefficients increase, indicating lower mobility of tungsten. Recent studies indicate that an elevated pH level in soil at a site may increase the solubility of tungsten by decreasing its sorption coefficient, which may cause it to leach more readily into the groundwater table. (ATSDR 2005; NIEHS 2003; TOXNET 2007; Warminsky and Larson 2004).
- In 1997, EPA Region 1 issued administrative orders to suspend the use of lead bullets at the Massachusetts Military Reservation (MMR). Small arms training at MMR continued uninterrupted using tungsten nylon bullets. However, the stability of tungsten in the environment became questionable when tungsten was detected in the groundwater and above baseline levels in soil at a small arms range at MMR in 2006, resulting in the suspension of the use of the tungsten nylon bullets at MMR (EPA 2007; ATSDR 2005; Massachusetts National Guard 2006).
- Under the U.S. Army's Green Bullet program, nearly 88 million bullets were produced, of which 33 million remain unfired and available for use at training ranges across the country. Currently, the Army Environmental Center is looking at training ranges to evaluate the presence of various chemicals and other potential contaminants, including tungsten (Defense Environmental Alert 2007).

Exhibit 1: Physical and Chemical Properties of Tungsten
(NIOSH 2005; NIEHS 2003; TOXNET 2007)

Property	Value
CAS Number	7440-33-7
Physical Description (Physical state at room temperature)	Hard, steel-gray to tin-white solid
Molecular weight (g/mol)	183.9
Water solubility (g/L at 25^{o}C)	Insoluble at pH less than 6.5
Boiling point (^{o}C)	5,927
Melting point (^{o}C)	3,410
Vapor pressure at 25^{o}C (mm Hg)	0
Specific gravity	19.3

Notes: g/mol – gram per mole; g/L – grams per liter; ^{o}C – degrees Celsius; mm Hg – millimeters of mercury.

What are the health effects of tungsten?

- Occupational exposure is considered the most common scenario for human exposure to tungsten and its compounds. Inhalation, ingestion, and dermal and eye contact are the possible exposure pathways (ATSDR 2005; NIOSH 2007).
- Occupational inhalation exposure to tungsten is known to affect the eyes, skin, respiratory system, and blood (ATSDR 2005). Tungsten may cause irritation to eyes, skin and throat; diffuse interstitial pulmonary fibrosis; loss of appetite; nausea; cough; and changes in the blood (NIOSH 2005).
- Tungsten has not been classified for carcinogenic effects by the Department of Health and Human Services (DHHS), the International Agency for Research on Cancer (IARC), or EPA (ATSDR 2005).
- Studies on rats have shown that oral exposure to tungsten caused post-implantation deaths and developmental abnormalities in the musculoskeletal system. Exposure of pregnant rats to sodium tungstate resulted in fetal death (NIEHS 2003).

Are there any existing federal and state guidelines and health standards for tungsten?

- A federal drinking water standard has not been established for tungsten.
- The National Institute for Occupational Safety and Health (NIOSH) and the American Conference of Industrial Hygienists (ACGIH) have established a recommended exposure limit (REL) of 5 milligrams per cubic meter (mg/m^3) as the time-weighted average (TWA) over a 10-hour work exposure and 10 mg/m^3 as the 15-minute, short-term exposure limit (STEL) for airborne exposure to tungsten (ATSDR 2005; NIOSH 2007; NJDEP 2000).
- The Occupational Safety and Health Administration (OSHA) recommends an exposure limit of 5 mg/m^3 to insoluble compounds of tungsten and a 1 mg/m^3 limit of exposure to soluble compounds in construction and shipyard industries (ATSDR 2005).

What detection and site characterization methods are available for tungsten?

- NIOSH Method 7074 – flame atomic absorption spectroscopy with a detection limit of 0.1 mg/m^3 for insoluble forms of tungsten and 0.05 mg/m^3 for soluble forms of tungsten in air (NIOSH 2005; TOXNET 2007).
- Other NIOSH methods known to be used for tungsten are Methods 7300 and 7301. Information about detection limits for these methods is not available in the references cited (NIOSH 2005; TOXNET 2007).
- OSHA ID213 – inductively coupled plasma atomic emission spectroscopy (ICP-AES) with a detection limit of 0.34 mg/m^3 for tungsten in air (NIOSH 2005; OSHA 2007).
- Tungsten in soil and water can be measured using the ICP-AES, ICP-mass spectrometry (ICP-MS), and ultraviolet/visible spectroscopy (UV/VIS) methods (ATSDR 2005).

What technologies are being used to treat tungsten?

- Treatment technologies to address tungsten contamination in environmental media are currently under development. According to preliminary studies conducted by various research groups, potential treatment methods involve chemical recovery/soil washing and phytoremediation (Lehr 2004; Warminsky and Larson 2004).
- "Ice electrode" is an innovative technology being evaluated for liquid media. This technology is based on the conventional electroplating technique and uses an electrode coated with a thin layer of ice. Tungsten ions adhere to the ice-coated electrode and can be removed by melting the ice (Lehr 2004).

Where can I find more information about tungsten?

- Agency for Toxic Substances and Disease Registry (ATSDR). 2005. Toxicological Profile for Tungsten. http://www.atsdr.cdc.gov/toxprofiles/tp186.pdf
- Hazardous Substances Data Bank: Tungsten Compounds. http://toxnet.nlm.nih.gov/cgi-bin/sis/search/r?dbs+hsdb:@term+@na+tungsten+compounds.
- Inside EPA. 2007. Defense Environment Alert – Emerging Contaminants: Army risk study on tungsten could be first step toward regulation. January 23, 2007.
- Lehr, Jay H. 2004. Wiley's Remediation Technologies Handbook: Major Contaminant Chemicals and Chemical Groups (ISBN 0-471-45599-7), pp. 282, 567, & 568.
- Massachusetts Department of Environmental Protection (DEP). 2006. Fact Sheet: Tungsten and Tungsten Compounds.
- Massachusetts National Guard. 2006. Massachusetts National Guard Temporarily Suspends Use of Tungsten-Nylon Ammunition at Camp Edwards, Massachusetts – News Release. .
- National Institute for Occupational Safety and Health (NIOSH). 2005. NIOSH Pocket Guide to Chemical Hazards: Tungsten.
- National Institute of Environmental Health Sciences (NIEHS). 2003. Tungsten and Selected Tungsten Compounds – review of Toxicological Literature.
- National Institute for Occupational Safety and Health (NIOSH). 2007. www.cdc.gov/niosh/ipcsneng/neng1404.html.
- New Jersey Department of Health and Senior Services. 2000. Hazardous Substance Fact Sheet: Tungsten. http://nj.gov/health/eoh/rtkweb/documents/fs/1959.pdf
- Occupational Safety and Health Administration (OSHA). 2007. Tungsten and Cobalt in Workplace Atmospheres (ICP Analysis).
- U.S. Department of Defense. 2007. Emerging Contaminants. www.denix.osd.mil/denix/Public/Library/MERIT/merit.html.
- U.S. Environmental Protection Agency Region 1. 2007. Massachusetts Military Reservation. www.epa.gov/region01/mmr/.
- Warminsky, Michael F. (AMEC Earth and Environmental, Inc., Somerset, NJ) and Dr. Steven Larson (U.S. Army Engineer Research and Development Center, Vicksburg, MS). Recovery and Recycling of Tungsten and Lead from Small Arms Firing Range Soils. 2004. Presented at the Annual Conference on Soil, Sediment, and Water – University of Massachusetts Fall Conference (October 19-21). www.umasssoils.com/abstracts2004/Tuesday/trainingranges.htm.
- Werner, Antony B.T., W. David Sinclair, and Earle B. Amey (USGS). 1998. International Strategic Mineral Issues Summary Report—Tungsten; USGS Circular 930-O. http://pubs.usgs.gov/pdf/circular/c930-o.pdf

Contact Information

If you have any questions or comments on this fact sheet, please contact: Mary Cooke, FFRRO, by phone at (703) 603-8712 or by e-mail at cooke.maryt@epa.gov.