Managing Chemical & Material Risks

November 2013

Paul Yaroschak, P.E.
Deputy for Chemical & Material Risk Management
Office of the Deputy Under Secretary of Defense
(Installations & Environment)
Chemical Related Programs in Our Portfolio

- Emerging Contaminants Program
- DoD-wide chemical management policy
  - Enterprise chemical data management
  - REACH\(^1\) Strategic Plan
- Review & comment of IRIS risk assessments
- DoD Strategic Sustainability Performance Plan
  - Required by E.O. 13514…requires reduction in toxic substances
- Sustainable Chemicals & Materials for Defense Forum
- ESOH policy & procedures for DoD acquisition process
  - Chemical safety & hazard communication are important elements
  - Sustainability Analysis Initiative using Life Cycle Assessment

\(^1\) Registration, Evaluation, Authorisation and Restriction of Chemicals
Part 1 – Context, Trends, & Emerging Contaminants (ECs) Program Refresher
Trends

• **Use of Precautionary Principle**
  – Must understand health & environmental effects before using chemicals

• **Bio-monitoring – What’s showing up in humans?**
  – Centers for Disease Control’s national bio-monitoring & California voluntary program

• **Evolving Risk Assessment Science & Process**

• **Green Chemistry**

• **International, Federal, & State Chemical Management Laws & Regulations**
  – Restrictions or banning of chemicals/materials (e.g., BPA)
  – EPA Chemical Management Plans
  – California Green Chemistry Law
  – EU’s REACH
  – Pending TSCA\(^1\) reform

\(^1\) Toxic Substances Control Act
Emerging Contaminants Program History

• ~2004 – Perchlorate detections in groundwater & drinking water
  – Disputes between DoD and regulators over response actions

• 2005 – DoD forms EC Work group with EPA & ECOS
  – EC Definition agreed

• 2006 – Three white papers developed
  – Tiered toxicity values - What if no IRIS value?
  – Action Triggers – When to take action when no IRIS value
  – Risk Communication – What to tell the public

• 2008/9 – DoD creates EC funding line & policy instruction

• 2009 – Harvard University “Innovations in American Government” Award
What is an Emerging Contaminant?

- Chemicals & materials that have pathways to enter the environment and present real or potential unacceptable human health or environmental risks…

  and either

  - do not have peer-reviewed human health standards

  or

  - Standards/regulations are evolving due to new science, detection capabilities, or pathways.
**EC “Scan-Watch-Action” Process**

- **Scan**
  - Over-the-horizon
  - Review literature, periodicals, regulatory communications, etc.

- **Watch**
  - Possible DoD impacts
  - Monitor events; Conduct Phase I qualitative impact assessment

- **Action**
  - Probable high DoD impacts
  - Conduct Phase II quantitative impact assessment; develop & rank RMOs*

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RMOs to ECGC

- Risk Management Options (RMOs) to ECGC

- Approved RMOs become Risk Management Actions (RMAs)
• Potential ECs screened --- over 600
• Phase I Impact Assessments completed --- 32
• Phase II Impact Assessments completed --- 11
  – All current/former action list chemicals completed.

• 60 Risk Management Options (RMOs) developed & turned into Risk Management Actions (RMAs)
  – 32 completed, 20 in-progress, 5 pending, 3 deferred
EC Watch List – November 2013

- Tungsten/alloys
- 1,4-dioxane*
- Metal Nanomaterials
- Carbon Nanomaterials
- Perfluorooctyl sulfonate (PFOS)
- Perfluorooctanoic acid (PFOA)
- Di-nitrotoluenes (DNT)
- Nickel
- Cadmium
- Manganese

- Cobalt
- Antimony
- Diisocyanates
- Dioxins
- TCE ...moved from action list
- Perchlorate ...moved from action list
- decaBDE
- Vanadium & compounds
- NDMA
- DNAN
- NTO [Energetic Compounds]

- Phase I Impact Assessment completed

* To be re-assessed
EC Action List – November 2013

- Royal Demolition eXplosive (RDX)
  - Cyclotrimethylenetrinitramine
- Hexavalent Chromium (Cr6+)
- Naphthalene …pending downgrade to watch list
- Beryllium (Be)
- Sulfur Hexafluoride (SF6)
- Lead
- Phthalates
  - 1-Bromopropane …pending ECGC approval

- Phase II Impact Assessment completed.
Part 2 – Risks & Risk Management Actions
Perchlorate Risk Management Strategy

- **DoD Policies & Sampling/Characterization** – Find the releases
  - DoD Sampling began ~15 years ago
  - DoD 2006 sampling policy memo required sampling in all media (ranges covered by DoDI)
  - California site prioritization protocol completed
  - DoD 2009 policy uses new EPA recommended Preliminary Remediation Goal (PRG); supersedes previous policy memos and says use EPA RfD

- **Response via DERP\(^1\)** – Address the releases
  - Lack of MCL *does not stop* response actions
  - RfD used for site-specific risk assessments

- **Invest in R&D** – Determine sources & substitutes
  - Over $114M invested in perchlorate substitutes
  - Sampling & analytical methods, and
  - Treatment technologies

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\(^1\) Defense Environmental Restoration Program
Sulfur Hexafluoride (SF6) Background

• A non-flammable, non-toxic gas – no human health concerns
• Extremely stable, with excellent dielectric properties (electrical insulation and arc-quenching)
• A high global warming potential – 22,800 times more potent than carbon dioxide ($\text{CO}_2$) – long lasting in the atmosphere
• Average global SF6 concentration has increased by about 7 percent per year during the 1980s and 1990s
SF6 Commercial Uses

- High-voltage electrical switchgear & transformers
- High-energy imaging equipment
- Research - atomic particle tandem accelerators
SF6 Military Uses

- Pressurization/dielectric for aircraft targeting pods/avionics -- Airborne Warning and Control System (AWACS) radar (e.g., E-3 Aircraft)
- Waveguide pressurization for shipboard targeting radar (e.g., MK 92 Fire Control System)
- Comprehensive Nuclear Test Ban Treaty monitoring and nuclear event detection
Sulfur Hexafluoride (SF6) is used in radar systems (e.g., AWACS aircraft); helicopter rotor-blade leak tests; discharge testing in fire suppression systems; electrical switch gear; and propulsion systems for specific weapons (e.g., MK-50 torpedo) in service and under design.

Likelihood of Toxicity Value/Regulatory Change

1. Probability that Greenhouse Gas emission initiatives will restrict use/availability of SF6

![Likelihood of Toxicity Value/Regulatory Change Chart]
SF6 Risk Management Actions

- DoD Policy issued on SF6 capture & recycling
- RDT&E on substitutes for mission critical applications
- Coordination with Electric Power Research Institute on substitutes for electrical infrastructure
DoD Hexavalent Chromium Minimization

Cr^{6+}

Non-Chrome Primer

DANGER
HEXAVALENT CHROMIUM
CHROMIUM (VI) OR Cr(VI)
CANCER HAZARD
CAN DAMAGE SKIN, EYES, NASAL PASSAGES, AND LUNGS.
AUTHORIZED PERSONNEL ONLY.
RESPIRATORS MAY BE REQUIRED IN THIS AREA.

Cr(III) and Cr(VI) by ICP-MS

Intensity (cps)

Time (seconds)
Desired DoD Paradigm Shift for Cr6+

- Default use of Cr6+
- “Promotion” of substitutes
- Can result in business as usual

- Default use of substitutes
- Use of Cr6+ if no substitute can meet performance requirements
- Bias for change

Note: The required performance shouldn’t be based on Cr6+ but on a level of acceptable performance for the application
Three Part Cr6+ Strategy

Cr6+ Minimization Policy
USD(AT&L) memo of 8 April 2009
Sets the Desired Course

Legacy Project
Minimize Cr6+ in Existing Specs

Defense Federal Acquisition Rule
Minimizes Cr6+ in New Acquisitions
Lead – Why on the Action List?

• Evolving science & regulations pose a risk to range operations…most munitions contain lead

• Lead-free electronics pose a risk to DoD supply chain…short-circuiting in components
Lead Risk Management Actions

• RDT&E on lead free munitions

• DoD-Industry Consortium on lead-free electronics
  – Develop technologies to detect lead-free circuit boards
  – Develop viable lead-free solders

• National Academy of Sciences Study
  – Concern: Lead exposures to personnel such as small-arms range instructors given new human health science
  – Conclusion: “A review of the epidemiologic and toxicologic data allowed the committee to conclude that there is overwhelming evidence that the OSHA standard provides inadequate protection for DOD firing-range personnel and for any other worker populations covered by the general industry standard.”

• Underway: Development of DoD BLL standards
  – Surveillance & action levels
Department of Defense Emerging Contaminants Program

Harvard University – Ash Institute for Democratic Governance & Innovation
Integrating Sustainability into DoD Acquisition Programs

October 2013

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Objectives

Better Informed Acquisition Decisions leading to:

- Increased sustainability of systems, platforms and supporting infrastructure
- Lower Total Ownership Cost

How? **Sustainability Analysis Using Life Cycle Assessment (LCA) Methods**
Sustainability Analysis = SLCA + LCCs

Relative Impacts

Life Cycle Costs
SLCA Model for DoD

Inputs
- Energy
- Chemicals & Materials
- Water Use
- Land Use

System Boundary
- Research & Development
- Production & Deployment
- Operation & Support
- Disposal

Impacts
- Mission Impacts
- Human Health Impacts
- Environmental Impacts
- Life Cycle Costs

Acquisition, Technology and Logistics

Outputs
Note: Alternatives with a smaller footprint should be preferred over those with a larger footprint.
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Questions & Discussion

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Backup Slides
How Can ECs Affect DoD?

• Cause adverse health effects on operating forces, DoD employees, and/or public
  – Human health protection paramount

• Reduce training/readiness
  – Restrictions on use of ranges

• Restrict availability and/or cost of materials or chemicals
  – Adverse impact on mission-critical applications & industrial base community

• Increase O&M and/or cleanup costs
  – Resource drain from mission needs
Phase I Impact Assessment Process

1. Likelihood of Toxicity Value/Regulatory Change
2. Scoping and Data Collection
3. Impact on DoD Functional Areas

<table>
<thead>
<tr>
<th>ES&amp;H</th>
<th>Training &amp; Readiness</th>
<th>Acquisition/ RDT&amp;E</th>
<th>POMD of DoD Assets</th>
<th>Cleanup</th>
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Results:
- Recommendation – Move to Action List?
- Initial Risk Management Options
Perchlorate - Background

• A salt…1 chlorine + 4 oxygen atoms …Highly soluble in water…can inhibit normal thyroid function at certain levels…pregnant women/fetuses especially sensitive

• Potassium or ammonium perchlorate is used as an oxidizer in some missiles, rockets, munitions due to its powerful and insensitive nature (DoD/NASA)

• Also used in fireworks, explosives, road flares, matches, dyes, paint, air bags, recyclable batteries

• Found in some fertilizers, degradation of household bleach products, water disinfection products, herbicides and other products with chlorine or perchloric acid

• Found naturally – in arid parts of the world
Evolving Perchlorate Science

• **2005 NAS\(^1\)** Peer Review of science
  – Recommended RfD of 0.0007 mg/kg/day

• **2006 CDC\(^2\)** studies (more ongoing)

• **2007 FDA\(^3\)** “Market Basket” Total Diet Study
  – Various foods (e.g., lettuce, tomatoes, milk) tested for perchlorate
  – Perchlorate intake from food is below the current RfD for even sensitive subpopulations

• **State/Federal/Academic Studies**
  – Numerous sources, including natural, likely contributors to exposure
  – Isotopic analysis now allows distinguishing between natural and man-made sources…more details later in brief

• **EPA IG Report – Dec 2008**

• **EPA Request for More Information for Regulatory Determination Analysis – Aug 2009**

• **Research continued to date**
  – Much focused on impacts of perchlorate relative to other goitrogens

\(^1\) NAS = National Academy of Sciences  \(^2\) CDC = Center for Disease Control  \(^3\) FDA = Food & Drug Administration
DoD-Wide Perchlorate Sampling Results

- **Over 300 installations/FUDS sampled to date**
  - Represents all potential sources of releases in all media
  - Over 52,000 samples …vast majority below 4 ppb
    - Installation summaries on line for public access; Annually updated
- **All sites with possible perchlorate releases have appropriate actions* underway or completed in consultation with regulators**

* Actions underway include any or all of: initial sampling, continuous monitoring, risk assessments, consultation with regulators, & remedial actions
California Prioritization Protocol Results  
- A Success Story -

- DoD & CAL agreed on protocol to screen DoD sites for risk to ground/surface drinking water
- Total of 924 possible sites jointly screened  
  – Details on next slide
- DoD & CAL met in March 2008 to review results  
  – CAL-DTSC and WQCB agree that no sites currently pose a threat to drinking water  
  – Appropriate actions being taken regarding releases - Mostly confined to DoD properties
- DoD and CAL authored article in *Environmental Management* journal describing success of program
What Are the Potential Sources of Perchlorate?

- **Road Flares**
  - 20-40 million flares sold annually; 5-6% potassium perchlorate in unburned flares
  - Max concentration leaving highway 314,000 ppb (measured)

- **Fireworks**
  - Over 200 M lbs. consumed in U.S. per year…90% imported
  - fireworks contain up to 70% potassium perchlorate
  - Field sampling…Pre-fireworks at non-detect…Post fireworks up to 5000 ppb

- **Fertilizers**
  - >100 million lbs. Chilean fertilizer applied in the U.S.; High in perchlorate…100,000 ppb
  - > 400,000 lbs. per year still being applied (e.g., organic farming)

- **Defoilants/Weed Killers**
  - By product - 17,000-22,000 ppb

- **Household Bleach & Drinking Water Treatments**
  - Increases with age and with exposure to sunlight

- **Natural Sources**
  - Arid southwest US & Antarctica*

- **Ozone**
  - Uptake by plants theorized as a mechanism by which perchlorate is found in plants; initial studies $O_3$ nonattainment areas have plants with higher perchlorate

* Environmental Science & Technology, February 15, 2010
Techniques now Available to Distinguish Natural from Manmade Sources: Isotopic Analysis

- Elements in a compound can have widely different isotopic ratios or atomic mass based on mode of formation
- Stable isotope ratios provide a unique “fingerprint” of a chemical compound
- Future research shows promise for distinguishing among different manufactured sources
DoD Perchlorate Substitution RDT&E

- Replacement of Perchlorate in Training Simulators
  - Ground Burst Simulators & Hand Grenade Simulators
    • Account for majority of expended perchlorate on Army Training ranges
    • Production contract for replacement composition (black powder) was awarded in February 08; Limited production began in 09, Full manufacturing production in 11
  - Booby Trap Simulators: Production of 3 types of perchlorate-free versions - phase in FY11-13
  - Training Rocket Warhead (2.75” Rocket): perhaps as early as FY13 - production pending final qualification and Program Manager approval

- Perchlorate-Free - Pyrotechnic Signal Smokes and Flares
  - M126 A1 Red Signal Flare: Production expected in FY12
  - Mk124 Day/Night Signal: Requires qualification and final PM approval prior to implementation

- Perchlorate-Free Fuzes
  - Development underway of a perchlorate-free delay for handheld signals
  - Applications in dozens of systems’ fuzes used throughout DOD with production quantities in the millions.
Take-Away Messages

- DoD has acted responsibly regarding potential perchlorate releases
- Sampling continuing & response actions underway or completed, where warranted
- DoD does not appear to be the major source of perchlorate contamination nationwide
  - Natural and a wide variety of non-DoD sources are likely responsible for low level, wide-spread contamination
  - New technologies can allow DoD/Regulators to identify sources
- DoD investment in risk management measures such as treatment & substitution RDT&E continues
Phase I Impact Assessment Completed

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Date</th>
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<tr>
<td>Perchlorate</td>
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<tr>
<td>Hexavalent Chromium</td>
<td>Sept 2006</td>
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<tr>
<td>Naphthalene</td>
<td>Sept 2006</td>
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<tr>
<td>Trichloroethylene (TCE)</td>
<td>Oct 2006</td>
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<tr>
<td>1,2,3-Trichloropropane (TCP)</td>
<td>Nov 2006</td>
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n-Nitrosodimethyamine (NDMA)    | Nov 2006|
|1,4-Dioxane                     | Dec 2006|
|Dinitrotoluenes (DNT)           | Dec 2006|
|Perfluorooctanoic Acid (PFOA)   | Jan 2007|
|Perfluorooctyl Sulphonate (PFOS)| Jan 2007|
|Polybrominated Diphenyl Ethers (PBDEs)| Jan 2007|
|Dioxins                         | Feb 2007|
|Tetrachloroethylene (PCE)       | Feb 2007|
|Beryllium                       | Mar 2007|
|Lead                            | Mar 2007|
|RDX (Royal Demolition eXplosive)| Mar 2007|
|Tungsten                        | Mar 2007|
|Nickel                          | May 2007|
|Hexavalent Chromium             | Jul 2007|
|Tungsten Alloy                  | Dec 2007|
|Sulfur Hexafluoride (SF6)       | Jan 2008|
|Naphthalene                     | Apr 2008|
|Cadmium                         | May 2008|
|Lead                            | July 2008|
|Cerium                          | May 2009|
|Cadmium                         | Sept 2010|
|Dinitrotoluenes (DNT)           | Jan 2011|
|Nanomaterials (Metal-Based)     | Feb 2011|
|Manganese                       | May 2011|
|Diisocyanates                   | Jun 2011|
|Phthalate Esters                | Jun 2011|
|Nanomaterials (Carbon-Based)    | Nov 2011|
|Decabromodiphenyl Ether         | Apr 2012|
|Vanadium and Compounds          | Oct 2012|
|1-Bromopropane (1-BP)           | Jan 2013|

This summary is for chemicals on which all three parts of a Phase I Impact Assessment were completed.
Phase I Impact Assessment Results Summary

Recommended for Watch List

- Cadmium and Compounds
- Cerium ***
- Cobalt and Compounds
- Decabromodiphenyl Ether (deca-BDE)
- Diisocyanates
- Dinitrotoluenes (DNT)
- 1,4-Dioxane
- Dioxins
- Manganese and Compounds
- Nanomaterials (Metal- and Carbon-Based)
- Nickel
- Perfluorooctyl Sulfonate (PFOS)
- Tetrachloroethylene (PCE) ***
- Tungsten
- Tungsten Alloy
- Vanadium and Compounds

Dropped After Phase I

- Dichlorobenzenes
- Polybrominated diphenyl ethers (PBDEs)
- 1,2,3-Trichloropropane (TCP)

Recommended for Phase II / Action List

- Beryllium
- Hexavalent Chromium
- Lead
- Naphthalene
- Perchlorate *
- Perfluorooctanoic Acid (PFOA) **
- Phthalate Esters
- RDX
- Sulfur Hexafluoride (SF6)
- Trichloroethylene (TCE) **
- 1-Bromopropane (1-BP) (proposed)

Future Assessments (anticipated date)

- 1,4-Dioxane (Inhalation only) (TBD)
- n-Nitrosodimethylamine (NDMA) (TBD)
- 2,4-Dinitroanisole (DNAN) and 5-Nitro-1,2,4-triazol-3-one (NTO) (components in insensitive explosive formulations) (TBD)
- Cobalt (pending IRIS review) (TBD)

Determining Need for Phase I Assessment

- Antimony

* Demoted to Watch List in September 2010
** Subsequent Phase II Impact Assessment recommended delisting from the Action List and adding to the Watch List
*** Regulatory developments supported delisting from the Watch List
Phthalates Background

• Organic compounds derived from petroleum…phthalates are esters of phthalic acid
• Main uses:
  – Plasticizers to increase flexibility, durability and transparency of plastic products and to soften polyvinyl chloride (PVC) products
  – Solvents for oil-based dyes and nitrocellulose-based lacquers and coatings
• Due to their universally beneficial qualities, phthalates have found their way into a wide variety of consumer products
• Widespread human exposure…a number of phthalates appear in human biomonitoring surveys
Phthalates Risk Drivers

- CPSC\(^1\) assessments and/or EPA Chemical Action Plan (CAP) for phthalates may result in requirements to label, restrict, or ban specific phthalates
- Three phthalates\(^2\) included on the *REACH Authorisation List* (Annex XIV) cannot be placed on the market or used after 21 July 2015 without authorization
- Bottom line: Production of certain phthalates discontinued in U.S. additional suppliers may stop producing specialty phthalates critical to DoD applications
  - Time/cost intensive RDT&E needed for phthalate substitutes
  - Items made with new materials may require re-qualification

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\(^1\) Consumer Product Safety Commission

\(^2\) BBP—Butyl benzyl phthalate; DEHP—Di(2-ethylhexyl) phthalate; DBP—Dibutyl phthalate
The specific phthalates in a product depends on the properties the phthalates impart and their cost.

Phthalate-containing products include:
- **Medical supplies and devices** (i.e., intravenous (IV) tubing and blood bags)
- Dental materials
- Paints, wood varnishes and lacquers
- Anti-corrosion and anti-fouling paints
- Wire and cable applications
- Sealing compounds
- Vinyl tile
- Textiles and textile inks
- Cosmetics
- **Food packaging**
Phthalates Military Uses

- Solid rocket fuel binder
- Rocket motors & cartridges
- Plastics, rubber and vinyl components
- Wire insulation

- CBRN equipment (protective masks, gloves, boots, hoods)
Phthalates are used as a plasticizer to create preferable physical properties in plastic products. Critical DoD phthalate-containing items include CBR equipment (protective masks, gloves, boots, hoods), propellant mixtures used in numerous munitions products, and a variety of sealers, paints, and resins.

**Likelihood of Toxicity Value/Regulatory Change**

1. Probability that USEPA TSCA chemical management regulations will restrict use/availability of phthalates

2. Probability that EU REACH chemical management regulations will restrict use/availability of phthalates.
Phthalates Risk Management Actions

• Issued early Risk Alert

• Completed Phase II Impact Assessment

• Worked with Joint Program Executive Office for Chemical & Biological Defense (JPEO-CBD) to minimize risk to protective equipment

• Issued Risk Memo to DoD Acquisition Executives
  – Locate critical applications requiring phthalates
  – Take risk management actions (e.g., testing substitutes)