Paducah Gaseous Diffusion Plant Nickel: Historical and Economic Analysis

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Nickel

- Metallic Alloys
  - Austenitic stainless steels
  - Rechargeable batteries
- Coinage

- Production currently at near-capacity levels

DOE Uranium Enrichment Nickel

- Volumetrically contaminated metal (^{99}Tc and ^{235}U)
  - 9,700 t of ingots at Paducah
  - 6,000 t scrap at Oak Ridge
  - 20,000 t scrap expected from decommissioning at Paducah, Oak Ridge, and Portsmouth
- Classified as non-RCRA waste

Contamination Breakdown

Nuclide	Sample Result (pCi/g)			Standard Deviation
	Minimum	Maximum	Average	
Alpha	4.60	4.60	4.60	N/A
Beta	3.970	11,400	6.980	2,650
^{237}Np	0.163	0.470	0.268	0.126
^{239}Pu	6.06	7.53	6.73	0.743
^{99}Tc	8.77	23,500	13,800	5,990
^{230}Th	1.13	1.13	1.13	N/A
^{232}Th	0.0000264	0.0118	0.000500	0.00196
^{235}U	0.000210	0.0184	0.00560	0.00770
^{238}U	0.00213	0.912	0.120	0.197
Np= Neptunium Th=Thorium Pu=Plutonium U=Uranium Tc=Technetium N/A=Not applicable; minimum, maximum, and average based on 1 sample result				

Disposition of Nickel– Expressions of Interest, DOE, March 9, 2007

Paducah Ingots

- 1977-1982 17 Million lbs “clean” nickel smelted and sold
- 1983-1986 20 million lbs “dirty” nickel smelted and formed into ingots
  - In open storage on PGDP site

Project Goals

- Summarize the history of the issues with regard to the release of the nickel
- Report on the possible economic paths forward for the nickel at Paducah
- Analyze the technical, regulatory, and political issues associated with a nickel release
- Propose strategies for overcoming barriers to nickel release

Regulatory & Technical Background

- 1993 Westinghouse study of electrorefining
  - Did not consider ^{99}Tc
- 1993 DOE/ANL risk analysis of recycling or disposing of contaminated metals
  - Worker exposure to ^{99}Tc during melt process constraining
- 1993 ORNL Technology Evaluation
  - Evaluated available nickel purification methods
    - Smelt purification, electrorefining, leach/electr-winning, Mond process
  - Cited need for further research on the Mond process
- 1993 Martin Marietta report
  - Recovery of nickel considered a priority
  - Cited electrorefining as most promising technology

- 1993 DOE Program Summary
  - Obstacles for release: lack of
    - Standards
    - Public understanding
    - Public confidence in DOE
  - Manufacturing Sciences Corporation (MSC) & Chemical Vapor Metal Refining (CVMR) were to decontaminate and make steel to store nuclear waste
    - Concerns about feasibility due to non-standard sizes in DOE and NRC-licensed facilities
- 1994 Review by Compere
  - Examined industrial methods for nickel purification
    - Electrolysis methods considered most attractive

- 1995 ANL study for DOE
  - Feasibility study of radioactive scrap recycling
    - Human health risk
    - Environmental impact
    - Sociopolitical concerns
  - Utilized International Commission on Radioactive Protection (ICRP) standards
  - Scope considered only recycling and disposal
  - Tiered release system maintained acceptable dose levels
    - Public is growing accustomed to “safe” radiation exposure
    - Public expects government protection from all risks

- 1995 MSC/Colorado School of Mines study
  - Performed basic economic feasibility study
  - Nickel recovery for internal use appeared favored over disposal
- 1997 MSC, American Technologies Inc. and Science Applications International Corporations (SAIC)
  - Contracted to remediate metals in exchange for rights to metals
  - Demonstrated reduction of ^{99}Tc levels to between 1 and 10 Bq/g

- 1995 SAIC Report, 1996 ORNL Report
  - Preparation for sale of Paducah ingots to Scientific Ecology Group (SEG)
  - Environmental Assessment evaluating impact of resale on international market
    - Would not affect he quality of the human environment as defined by the National Environmental Policy Act of 1969
    - No environmental impact statement would be required
  - Paducah nickel would be processed at ORNL by SEG and shipped to Spain for industrial use
  - Concluded that continued storage in Paducah failed to meet “As low as reasonably achievable” (ALARA) standards while providing benefit to DOE
    - Runoff
    - Loss of economic value
  - Rejected internal recycle, unrestricted release, improved storage, direct disposal
    - Appropriate technologies
    - Regulatory constraints
    - Economic considerations

- 2000 ELR Consultants report
  - Recommended CVD Manufacturing vapor deposition process
- 2002 DOE CFP
  - Purify nickel for reuse in nuclear industry
  - MSD investigated restricted release scenarios
- 2002 National Council on Radiation Protection and Measurements
  - 4-year study on potentially radioactive scrap metal (PRSM) disposition
    - Existing guidelines on pollution prevention basis for PRSM management
    - Current regulatory systems lacks a range of viable options
    - Need for consistent national and international standards
    - Both the metal industry and the public must be involved in the development of standards and approaches
  - Recommendations
    - Set of uniform clearance standards
    - Use of a licensed mill/brokerage as a clearinghouse for recycling

- 2004 KRCEE report
  - Baseline measurements of background radiation in commercially available nickel
- 2004 CVMR-USA Proposal
  - Proprietary process for cleansing nickel (not independently validated)
  - Contingent on lifting of DOE moratorium
    - Unrestricted release
    - Industrial use on a lease basis

- 2002 El-Azzami and Grulke
  - Thermodynamic investigation of distillation as feasible recovery process
- 2004 DOE RFO for PGDP remediation
  - Included nickel relocation in the scope with CERCLA documentation
  - Any other use would require DOE approval and return of net revenues to the government
  - Subsequent amendment required the firm "develop and evaluate alternate uses of the Nickel ingots and require competitive bids for its reuse"
- March 2007 DOE request for Expressions of Interest
  - Covers 15,300 tons of nickel scrap
  - Does not obligate DOE to issue solicitation
  - General clearance and release not a consideration

Obstacles to Release

- Technical Obstacles
  - Electrorefining documented to reduce activities to 1 to 10 Bq/g
  - CVMR claims removal of 99.99% of ^{99}Tc, but resulting activity level uncertain
- Demonstration of effectiveness required before clearance can be considered

Regulatory Obstacles

- DOE Order 5400.5
  - Upon transfer, receivers agree to the following:
    - Doses to the public from all sources must not exceed 100 mrem/yr
    - Exposure limits to be a approved in a manner consistent with the ALARA process
    - Affected states and the NRC must be involved
  - Does not address volumetric contamination in the approval process
- International Atomic Energy Agency
  - Risks low enough to not warrant regulation
  - Optimized radiation protection
  - Risk-based standards should be possible for unrestricted release
- 1999 Report by Chen
  - Trivial risk defined as 10^{-6} to 10^{-7} for an individual, or 1mSv/yr

Lack of NRC Guidelines

- EU limit for ^{99}Tc 1,000 Bq/g
- IAEA criteria for ^{99}Tc 300 Bq/g
- Health Physics Society ANSI proposed standards
  - 1 mrem/y dose per person
  - Criteria for ^{99}Tc 50 Bq/g
- NRC reported to have been supportive of 1999 ORNL release plan
  - Would have limited exposure to less than 10 mrem/y/person
- NRC commissioned 1999 study considered
  - Continued case-by-case review
  - Recycling of slightly contaminated but safe solids
  - Release of material for restricted use
  - No release, requiring permanent disposal
- Draft proposal recommended a dose criterion limit of 1 mrem/yr (50 Bq/g)
- Concluded case-by case review sufficient in light of higher priority issues

DOE Moratorium

- Triggered 1/12/2000 by imminent ORNL release
  - No contaminated metal releases
  - Modification to policy overdue
  - Assessment performed by DOE in 90's indicated no significant risk to consumers
  - "I am making this decision" to assure American consumers "that scrap metal released from Energy department facilities for recycling contains no detectable contamination from departmental activities."– Bill Richardson
- Expanded to include all radioactively contaminated materials July 2000

2002 DOE Draft Guide

- Property to be characterized and decontaminated, if possible, before release
- Residual levels to be as near background levels as practical, following ALARA requirements and DOE limits
- All releases to be fully documented and reported, with public involvement and notification, and complete records maintenance

- Surface standards may be adapted
- ANSI standards a potential option
- Case-by-case approval still required

Political Obstacles

- Kentucky's Congressional delegation supports lifting of the moratorium pending a completed DOE study
- Ted Strickland (Ohio) proposed an amendment requiring all contaminated solids to be disposed as LLW

- Scrap metal industry
- Labor Unions
- Public

Scrap Metal Industry

- Metals Industry Recycling Coalition
- Nickel Development Institute
- Nickel Producers Environmental Research Association

- All strongly oppose any release
  - DOE history of unintended releases
  - Cost of detection failure ($10-$24 million)

Industry proposal

- Recycling at a licensed, dedicated facility and reuse within DOE
- Use at NRC facilities with appropriate standards to prevent eventual release
- Disposal into an appropriate landfill

- No change to the moratorium

Labor Unions

- Concerns about exposure during recovery process
- May support if worker safety is adequately addressed
  - Will likely require environmental assessment

Public Opposition

- "We are intrigued by some of the innovative uses British Nuclear Fuels Ltd have found for 100,000 tons of scrap metal from decommissioned nuclear plants in America. Despite claims in the Washington Post that traces of radioactive material can accumulate over decades in nickel plated pipes and other machinery, the US department of energy have given the go-ahead to a controversial recycling programme. Up to date this has led to little more than industrial machinery being produced from the low-level radioactive scrap. More recently, however, a contract between the Oak Ridge National Laboratory in Tennessee and our own BNFL looks set to transform 100,000 tons of radioactive metal - nickel, aluminum, copper and steel - into belt buckles, zippers, frying pans, forks, knives, prams, intrauterine devices, dental fillings and braces. What an enterprising bunch they are at BNFL." (Guardian Editor 1999).

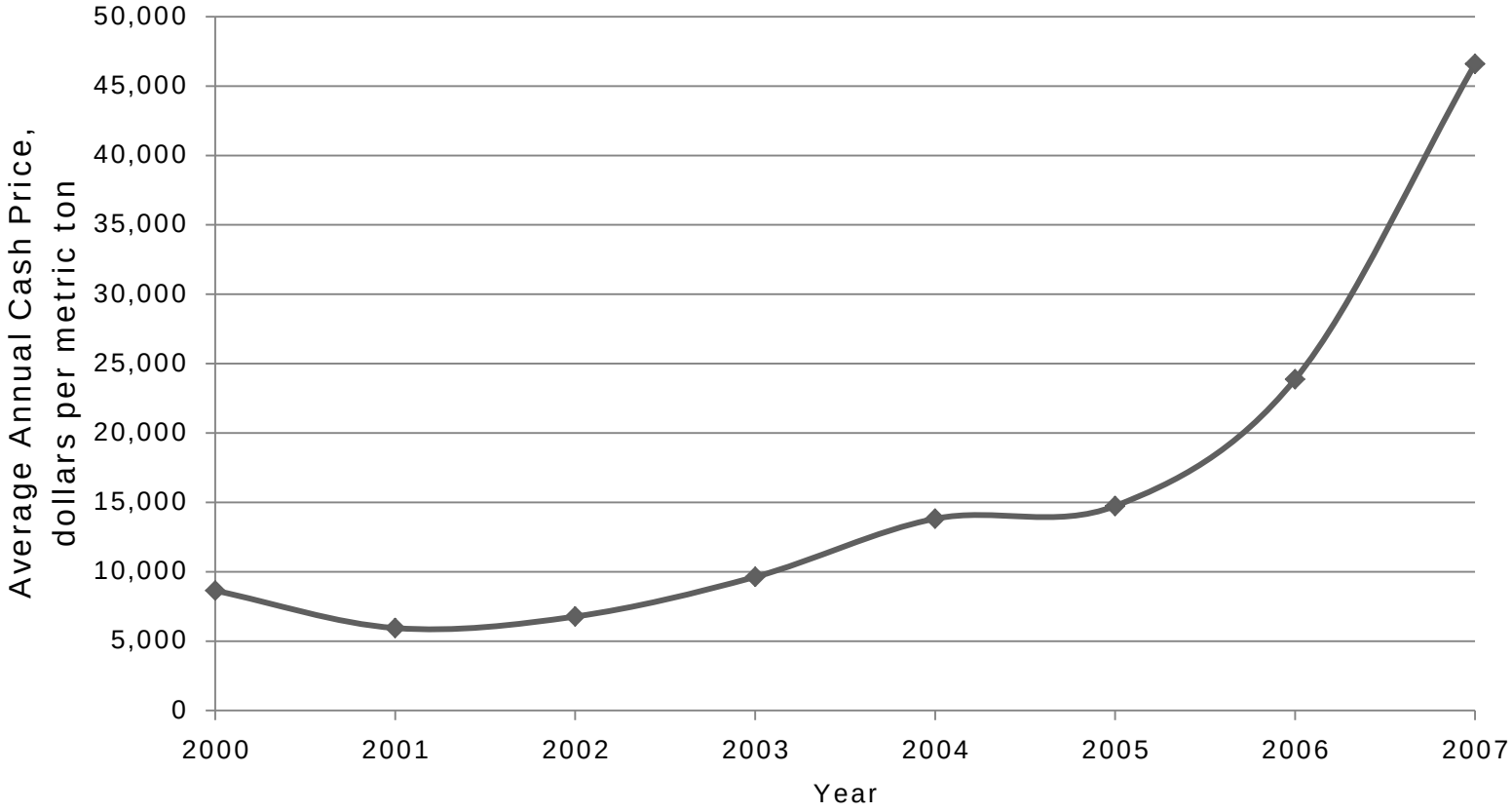
Impact of Nickel Release

- Hall Amendment allows property transfer to mitigate adverse economic consequences to a community
- Property must be excess to the needs of the DOE, and the cost of replacement less than 110% of transport costs
- Most likely community benefit would come from construction and operation of plants associated with nickel recovery and reuse within DOE

Potential Impact of Clearance and Release

- 9500 tons of nickel from ingots
  - Assumes CVMR projection of 98% recovery
  - Opening price 10/29/2007 $37,332/ton
- Current Market Value:
  - $335 million at most
    - Scrap usually valued at about 50% of virgin material
    - History of material would further devalue

Nickel Price Trends



Previous Estimates of Recovery Cost

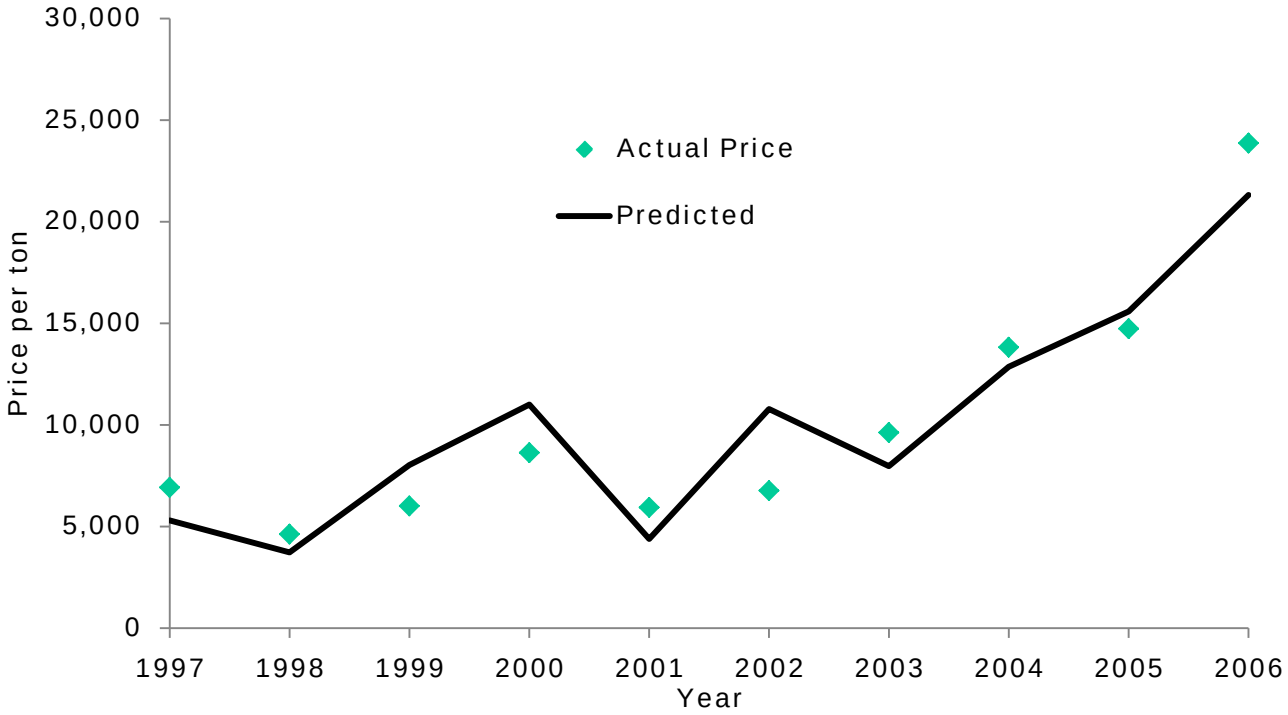
- Electrorefining for sale to Spain
  - $43 million
  - Refiner to retain net profit
  - Nickel price <$5000/ton
- 2002 PACRO estimate of $8 to $12 million net recovery

Potential Impact of Schedule on Price

- Assume inverse dependence of price on inventory and direct dependence on consumption
- Domestic consumption exceeds 80,000 ton/y
- Regression of data for past 10 years results in $R^2=0.864$

$$\text{Price} = 3.60292 \times 10^8/(\text{Total Inventory}) + 0.26817(\text{Total Consumption}) - 64485$$

- A 1000 ton addition to the market may reduce prices by 8%



Other Key Economic Factors

- Increased demand from emerging economies
- Move from NiMH to Li-Ion batteries

- Note U.S. no longer maintains a strategic reserve of nickel
  - U.S. consumes 40% of world supply but produces 10%

Recommendations to Overcome Barriers

- Development or verification of appropriate technology
  - Note electrorefining is reported to meet international standards for ^{99}Tc
- If background levels cannot be achieved, process for re-use within nuclear complex
  - DOE
  - NRC
  - Navy

Additional Recommendations

- Proceed with continuous involvement of
  - Scrap metal industry
  - Labor unions
  - Public

Most Likely Path Forward

- Possibilities:
  - Continued open storage on DOE grounds
  - Disposal into appropriate landfill
  - Recycling at licensed, dedicated facility and reuse within nuclear complex
  - Cleansing to background levels for general clearance for release

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Questions?

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