UK/KRCEE Doc #: P9.6 2007

Metal Separation Technologies Expression of Interest

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Prepared for
United States Department of Energy Portsmouth/Paducah Project Office
Acknowledgment: This material is based upon work supported by the Department of Energy under Award Number DE-FG05-03OR23032.

April 2007

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April 2007

Response to Expression of Interest Request
DE-EI30-07CC40008

Metal Separation Technologies, Inc.
Coldstream Research Campus
1501 Bull Lea Road
Lexington, Kentucky 40511

A. Responsible Interested Party

General company background

Metal Separation Technologies, Inc., Coldstream Research Campus, 1501 Bull Lea Road, Lexington, Kentucky 40511. The Board of Directors consists of: Dr. Eric A. Grulke, University of Kentucky, 359 RG Anderson Building, Lexington, KY 40506, Mr. Dean Harvey, Von Allmen Center for Entrepreneurship, University of Kentucky, 330 E. Main St., #210, Lexington, KY 40507, and Dr. Leonard Heller, A256 ASTeCC Building, University of Kentucky, Lexington, KY 40506.

Dun and Bradstreet number

Metal Separation Technologies, Inc. is currently acquiring a Dun and Bradstreet number.

General company background statements

Metal Separation Technologies, Inc., a small business registered in the Commonwealth of Kentucky, is focused on manufacturing purified products from recycled contaminated scrap metals through innovative process technology. Metal Separation Technologies, Inc. is committed to local and regional economic development by locating the processing facilities near the DOE sites, by creating local jobs over a 10-year period, by providing local investment opportunities, and by working closely with the University of Kentucky faculty and students to build regional scientific expertise to enable new technology and business opportunities.

General company treatment facility background and operation statements

Metal Separation Technologies, Inc. is newly incorporated, does not have treatment facilities at this time, and does not have operation statements at this time. The President, Dr. Eric Grulke, has prior experience in industrial research, industrial operation of manufacturing plants, and design of various chemical processes. The Secretary and Treasurer, Dr. Len Heller, has extensive experience in start-up companies, and also serves as the Vice President for Economic Development for the University of Kentucky. A member of the Board of Directors, Mr. Dean Harvey, has extensive experience in entrepreneurship and business start-ups in Kentucky.

Mr. Patrick Powell is Director of the Western Region Innovation and Commercialization Center. He serves as an advisor to Metal Separation Technologies in working with the local community on facility planning, transportation, job creation, local permits and other issues.

Corporate liability insurance

Metal Separation Technologies, Inc. is currently seeking corporate liability insurance.

Current permits and licenses for handling nuclear waste and radioactive material

Metal Separation Technologies, Inc. is currently seeking the following permits and licenses for handling nuclear waste and radioactive material:

- Radioactive Material License Radiation Operator Certificate- Kentucky Cabinet for Health and Family Services, Radiation Health Branch
- Air permit- Kentucky Division for Air Quality
- Water permit- Kentucky Division of Water Quality

After discussion with the appropriate Kentucky regulatory agencies, other applicable permits will be obtained to ensure compliance with all federal, state, and local regulations and statutory mandates.

Current DOE possession facility authorizations and employees with DOE security clearance

Metal Separation Technologies, Inc. does not currently have either DOE possession facility authorizations or employees with DOE security clearance, but intends to hire employees and/or consultants who do have such authorities and clearances, or could obtain them.

Experience and performance record (past five years)

DOE & other government experience

None.

Other commercial experience relevant to this EOI

None.

B. Technical

Metal Separation Technologies, Inc. proposes an environmentally friendly, green chemistry, solution to the nickel purification problem. The separation of the key radioactive contaminant, ^{99}Tc, from nickel is based on the difference in their vapor pressures over a liquid phase of the contaminated material in a high temperature furnace. In this case, the vapor phase has a much lower concentration of ^{99}Tc than the liquid phase, and condensation of the vapor phase leads to a purified nickel product. While continuous distillation systems would be more efficient on a purely cost basis, Metal Separation Technologies proposes a batch process with a furnace capacity linked to the “lots” of nickel. In the case of the Paducah site, the furnace capacity and size would be based on nickel ingots 24” in diameter and 18” high, ~ 1 metric ton. A typical batch distillation might generate 900 kg of overhead product deficient in ^{99}Tc, and 100 kg of bottoms product with a ^{99}Tc content ten times that of the ingot treated. The overhead product would be sold to metal suppliers to the nuclear industry, while the bottoms product would be placed in long term storage.

Based on the radiological properties of nickel at the Paducah site, batch distillation processing conditions can be found that would produce an overhead vapor product meeting IAEA clearance limits for ^{99}Tc. However, these conditions depend on the levels and types of radioactive contaminants, which obviously vary from ingot to ingot. And, buyers of this purified nickel will want to know its purity. Therefore, Metal Separation Technologies proposes radiological characterization of each entering ingot and its overhead product (the level in the bottoms product is given by the difference), and an electronic database for tracking each lot from receipt at the DOE site to sales and storage. Tracking each lot through the process will provide documented evidence of the purity of the recycled nickel. The batch distillation process also provides processing flexibility based on the actual radiological composition of each ingot, so that meeting the IAEA clearance limit is assured with every batch while obtaining the largest amount of purified product.

A processing facility would be constructed near each of the DOE sites, and would be sized to purify the nickel at the specific site over a 10 year period. This would provide important, high tech jobs to the local communities, while minimizing the effect of this “new” recycled nickel scrap stream on the U.S. scrap nickel market.

This Expression of Interest plan is based on the radiological properties of nickel from the Paducah site, as similar properties have not been reported for the Oak Ridge material. Differences in chemical composition of the DOE scrap nickel, either in the concentration of the radioactive materials or the types of radioactive materials, will change process conditions and process economics.

Selection of the Metal Separation Technologies process for nickel purification would need to be linked with specific action by the Department of Energy. These include:

- DOE would provide insurance and/or indemnification to the reprocessing contractor to cover accidents, product liability suits, and similar issues.
- DOE would assure a market for the reprocessed nickel product with metal suppliers to the nuclear industry. This could include a specified volume of reprocessed nickel scrap over a specified time period.
- DOE would establish ways to support the price of the reprocessed nickel products.
- DOE would facilitate the long-term storage of the main byproduct, nickel enriched in the radioactive contaminants.
- DOE will provide prior records on the ingot production history, including smelting date, ingot number, and other pertinent information.
- Should the actual radiological and chemical composition of the ingots and shredded metal differ from those reported in the 1995 and 1999/2000 studies, DOE would work with Metal Separation Technologies to revise the purification plan.

There are a number of strategies by which DOE and Metal Separation Technologies, Inc. could address the liability, market and price issues, and these would need to be resolved prior to the awarding of a contract.

B1. Plan to transport, process and disposition nickel scrap

Metal Separation Technologies, Inc. proposes a batch distillation process to separate the technetium from the nickel scrap. The advantages of the physical vapor separation of Ni-Tc are:

- Nickel can be produced to meet IEAE clearance limits.
- The major contaminant (^{99}Tc) will be concentrated in the bottoms product.
- The bottoms liquid can be cast into ingots with elevated levels of ^{99}Tc for long-term storage.
- Other waste byproducts will include material recovered from degreasing and descaling operations, and particulates filtered from gas streams.
- The process is fundamentally simple to operate.
- Each scrap ingot or shredded scrap lot will be analyzed for radioactive contamination (^{99}Tc and ^{239}Pu primarily, but also Neptunium, Thorium and Uranium isotopes), inventoried and tracked throughout the receipt, transport, storage, processing, and sales steps.
- Each ingot will be converted to a product lot that can be isolated and will have its own MSDS analysis.
- Batch distillation is environmentally friendly, green chemistry, with no hazardous intermediates. The process utilities include cooling water, inert gas (nitrogen), and electricity.
- The process equipment can be fabricated by several suppliers of metal processing equipment, and is similar to equipment being used today.
- Processing strategies for ingots with multiple radioactive contaminants can be developed. Typically, distillation operations can be optimized to separate two key components. Should samples contain more than one key contaminant that would exceed the IEAE clearance limits, sequential separation steps may be required.
- The process technology is suitable for a small high tech business to operate over an extended period, providing local jobs for scrap metal reprocessing as well as a stable and small impact on the overall nickel scrap recycling market.
- The small product lots, ~ 900 kg each in the current plant design, will provide flexibility in product use for the nuclear industry and will have their own radiochemical analysis.

Transport, processing and disposition steps

The Metal Separation Technologies, Inc. solution has the following steps:

1) A complete inventory with barcode tags of all ingots and shredded scrap lots, including an electronic database that will contain lot numbers, current location, transportation dates, radiochemical analyses, links with historical data on smelting and/or shredding date, prior radiochemical analysis results (to be provided by DOE), processing dates, and sales date, shipping information, buyer ID, and other relevant information.

2) Degreasing and descaling of the ingots, followed by plastic wraps for sheltered storage. It is not clear whether these operations would best be done at the DOE site, or after transport to the Metal Separation Technologies, Inc. facility. Degreasing is needed to prevent organic material from entering the high temperature melting furnace/batch still. Descaling removes unwanted metal oxides that could foul the bottoms byproduct and create unwanted chemical reactions in the still. The ceramic plugs need to be removed prior to melting. Plastic wrap reduces further contamination of the ingots, and provides some protection in the case of spillage during transport.
3) Transport by truck or rail to Metal Separation Technologies, Inc. facilities. One facility is planned for each DOE site, and is expected to be local, i.e., within 30 miles of the DOE facility. These facilities will be fenced and have appropriate security systems.
4) Storage in a heated facility to prevent addition contamination (grease, dust, corrosion).
5) Radiochemical analysis of all lots. Metal Separation Technologies, Inc. assumes that all ingots are accompanied by buttons that can be used for analysis. Approximately 10-20 g of sample will be needed for these tests, which would be easiest to obtain from the buttons rather than the stored lots. Approximately 2,200 samples need to be assayed each year, with as many as 5 different radiochemical analyses for each one. These could be sent to laboratories, or an automated laboratory could be established on each site by Metal Separation Technologies, Inc. There are a number of automation techniques for radiochemical assays developed by research teams at PNNL.

   The incoming potentially contaminated ingots will be tested for radionuclides that may have entered the DOE process tream from recycled uranium. Purified nickel will be tested and labeled with the identified contaminating radionuclides and their concentrations, if demonstrated to be present. The total number of samples analyzed is expected to be approximately twenty thousand over ten years, each requiring 10 grams of sample material.

   A radiochemical analysis lab created at each facility would require four different instruments at a total cost of approximately one million dollars, several permits at a estimated cost of $140,000 a year, and at least two certified radiochemists ($200,000 per year). Cost for chemicals is estimated at $100,000 dollars per year. Tests contracted to outside labs might cost $300- $1,000 per test, depending on the level of testing and data validation required. The most efficient and cost-effective approach may be to contract with the Kentucky Radiation Health Branch Laboratory in Frankfort. This is the lab that tested virgin nickel samples for radionuclides for PACRO. The estimated cost of doing this for 10 years is 2 million dollars. Extra benefits to this method of testing include the offer of internships to university students to help train radiochemists, who would be necessary to ensure quality data at DOE facilities.

6) Batch distillation of lots. The separation of nickel and the radioactive contaminants is based on differences in vapor pressure at different temperatures. The practical operating temperature range for a batch distillation process is between the melting and boiling points of nickel. Figure 1 shows the vapor pressures of nickel and two key radioactive contaminants, ^{99}Tc, and ^{239}Pu. The table shows the melting and boiling points of each key component. Pure plutonium melts at a relatively low temperature, but boils about 300 K above the boiling point of nickel. Pure technetium melts at a relatively

Component	T_m, K	T_b, K
Plutonium	912	3503
Nickel	1728	3186
Technetium	2473	4538

high temperature and boils above 4500 K. The large differences in vapor pressure between nickel and technetium make batch distillation feasible. The vapor phase over a Ni/^{99}Tc liquid is significantly depleted in technetium and its continual removal from the still, followed by condensation, allows a separation to be made.

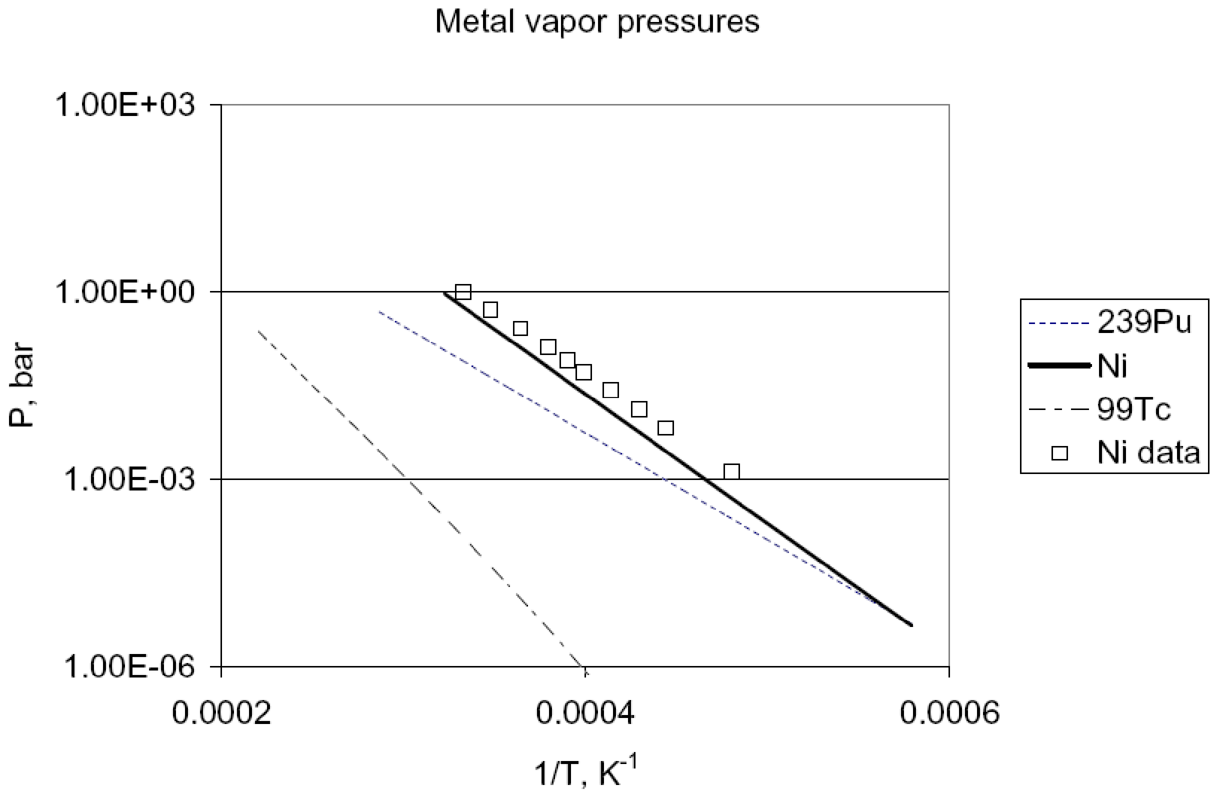

Figure 1. Metal vapor pressures.

The relative volatility of the key components is an important factor for the design of separation processes. Batch distillation is well-understood and separations are modeled using the pure component vapor pressures and the activity coefficients of the components. Regular solution theory normally applies to liquid metal solutions. The relative volatility of the two radioactive contaminants is shown in Figure 2.

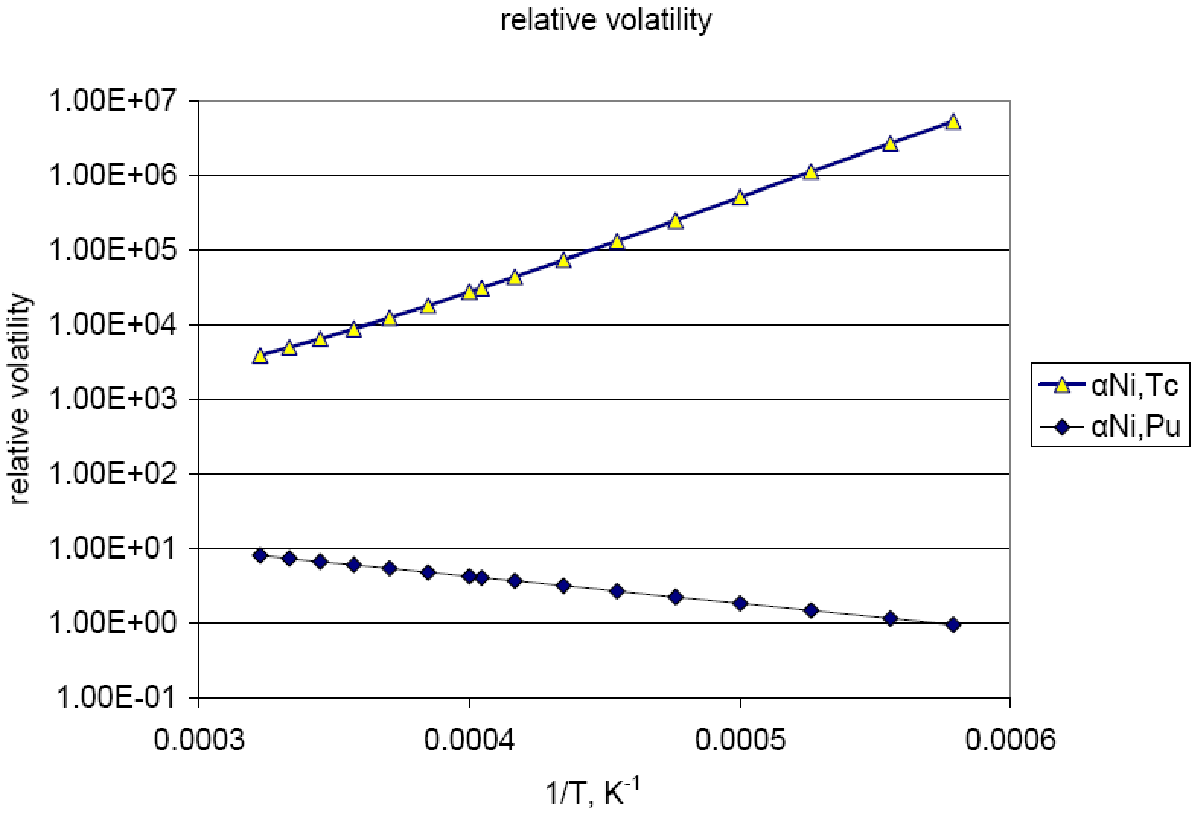

Figure 2. Relative volatility

As the temperature of liquid goes up (1/T goes down), the difference in vapor pressure between nickel and technetium decreases, and the purity of the overhead nickel would be reduced. The relative volatility of the nickel/plutonium pair has a different temperature dependence. As pure plutonium melts at a much lower temperature than nickel, its vapor pressure at the melting point nickel is actually greater. Since plutonium boils at a much higher temperature than nickel, the overhead nickel product increases in purity as temperature increases. Lots for which both levels of technetium and plutonium require processing to meet the IAEA clearance limits might potentially require two distillation operations.

Process equipment. Conventional metal furnaces that could be adapted to this service, and discussions with equipment manufacturers are underway. The metal vapor stream would be removed by vacuum, inert gas sweeps, or both. The technetium-rich bottoms byproduct would be cast into ingots for easy transport and storage in a long-term facility. The purified nickel liquid could be cast into ingots or sprayed into a powder form for improved blending in alloy operations. The preferred state of the purified product would be developed during the small-scale demonstration phase of the project.

Design basis. Plant capacity and economics are based on a ten year plant life for processing the ~9700 ingots at Paducah for which the radiological composition has been reported. Furnace/still capacity is based on one ingot at ~ 1000 kg. The design point assumes that 90% of the material will be distilled overhead, leaving ~ 100 kg of technetium-enriched nickel to be cast into ingots and stored. Of course, depending on the actual contamination of each ingot, more or less overhead product may be made. It is likely that ingots with similar contamination levels will be “campaigned” together to take advantage of requiring similar processing conditions.

7) Storage and sale of nickel to metal suppliers to the nuclear industry
8) Disposition of waste material
9) Decontamination and decommissioning of the equipment and facility at the end of its useful life.

Small-scale demonstration

Metal Separation Technologies, Inc. proposes a small scale demonstration of this technology. The key objective is to verify the design and operating conditions of the full scale equipment. The tasks will include: 1) establishing the evaporation rate for pure nickel, 2) performing the separation of nickel with 1 ppm ^{99}Tc at several operating conditions, 3) evaluating sweep gas and vacuum performance, and 4) evaluating production of nickel powder. The work will be done at the University of Kentucky under its radiation license, and the pilot scale equipment will be decontaminated after its use. Partial funding for the demonstration may be available.

Comparison of our product to IAEA clearance limits

^{99}Tc clearance limit. Samples of ingot materials were tested for radioactive contamination in separate studies, 1995 and 1999-2000. In the early study, all samples contained ^{99}Tc, with an average value of 14,460 pCi/g solid (0.86 ppm ^{99}Tc) and a maximum value of 71,600 pCi/g solid (4.2 ppm ^{99}Tc). The later study found 27 of 48 samples with ^{99}Tc, with an average value of 13,800 pCi/g solid (0.82 ppm ^{99}Tc) and a standard deviation of 600 pCi/g solid (0.036 ppm ^{99}Tc). Assuming a Gaussian distribution about the mean and a population of 10,000, there should be only one ingot with ^{99}Tc contamination of four standard deviations above the mean (16,200 pCi ^{99}Tc/g solid; ~1 ppm ^{99}Tc). **Therefore, 1 ppm ^{99}Tc was used as a representative feed concentration for process design.** The IEAE clearance limit for ^{99}Tc is 27 pCi/g solid (1.6 x 10^{-3} ppm ^{99}Tc or 1.6 x 10^{-9} weight fraction ^{99}Tc).

Figure 3. Batch distillation. ^{99}Tc

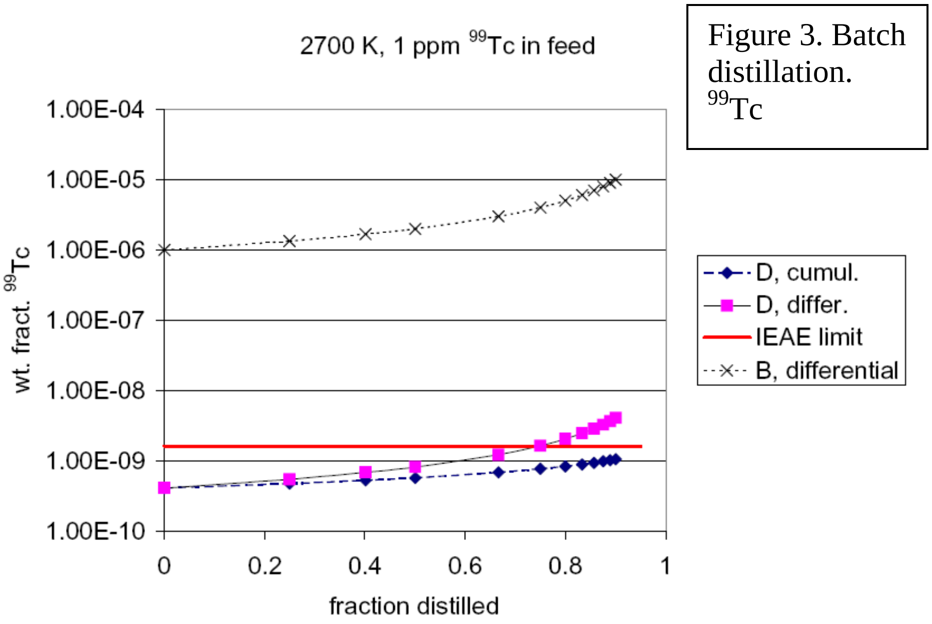

Figure 3 shows the expected batch distillation results for a feed of 1 ppm ^{99}Tc in nickel and an operating temperature of 2700 K. The data curves show the cumulative ^{99}Tc concentration in the entire distillate volume (D-diamonds), the differential ^{99}Tc concentration in the distillate stream (D-squares), and the ^{99}Tc concentration remaining in the furnace (B-x) as a function of the fraction of the nickel that is distilled. The batch process is stopped when 90% of the nickel is purified. The ^{99}Tc concentration in the furnace bottoms increases as vapor is removed, since nickel is preferentially removed overhead. The ^{99}Tc level in the overhead vapor increases as nickel is distilled, tracking the increasing concentration of this component in the liquid phase. The cumulative concentration of ^{99}Tc in the entire distillate stream also increases as nickel is distilled. The temperature was chosen so that the cumulative ^{99}Tc level was less than the IEAE clearance limit.

<u>^{239}Pu clearance limit</u>. While the 1995 sampling had only one ^{239}Pu analysis greater than the detection limit, the 1999/2000 sampling had 3 values of 36 greater than the detection limit. The average ^{239}Pu level of 6.7 pCi ^{239}Pu/g solid (1.15 x 10^{-10} g ^{239}Pu/g solid). This value was used as the feed concentration for finding process conditions to achieve the IEAE clearance limit for ^{239}Pu, 2.7 pCi ^{239}Pu/g solid (4.42 x 10^{-11} g ^{239}Pu/g solid). As shown in Fig. 2, the relative volatility of nickel in the nickel/plutonium pair increases as temperature increases. Figure 4 shows that batch distillation at 3000 K would lead to a nickel product meeting the IEAE clearance limits.

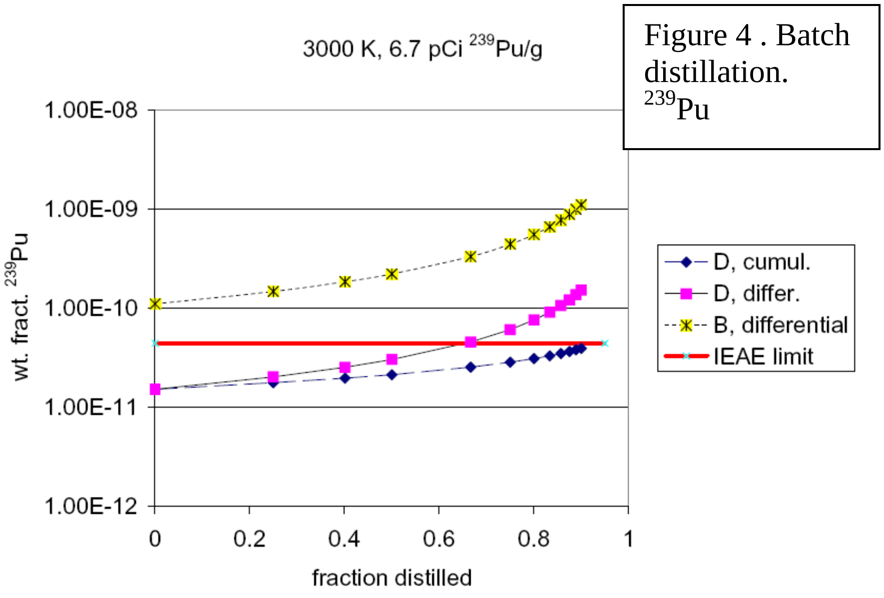

Figure 4 . Batch distillation. ^{239}Pu

As discussed previously, each separation between key components in distillation systems requires a processing step. If there are significant numbers of lots for which both technetium and plutonium must be removed to meet the IEAE clearance limits, it is likely that two processing steps will be required. If the percentage of lots for the entire sample population needing extra separations is the same as in the 1999/2000 sample, this would mean that ~800 of the 10,000 lots at Paducah would require additional processing steps. Should ingots be found with levels of radiological materials elevated above the IAEA clearance limits, treatment strategies would have to be revised. The sparse composition data for the ingots and shredded nickel inventories increase the uncertainty of processing requirements and process economics.

Proposed end use and recycling process

Our preferred product is separated lots of nickel powder for each ingot processed. Nickel ingots would be easier to produce, but might be more difficult to integrate into metal alloying processes. This material would be sold to metal recyclers approved by DOE for producing metal products to be used in the nuclear industry.

The Paducah plant would provide MSDS sheets for powder produced from each ingot. Therefore, it would be possible to provide products with a range of residual radioactivity levels, which could presumably each have different price points. The powder products would have the following advantages: 1) different lots could be blended to uniform grades, 2) MSDS sheets would be produced for each lot, preventing inadvertent commingling of materials, and 3) powder material could be readily added to alloying processes for precise control of composition.

The shredded Oak Ridge material has a lower bulk density, different storage lot sizes, and possibly, different radiological compositions. Therefore, Metal Separation Technologies is not able to propose a process design for the shredded Oak Ridge material at this time.

Location of treatment facilities

Treatment facilities would be constructed and operated near each of the two sources of radioactive contaminated scrap metal. The facility near Paducah would be designed to prepare, store and treat cylindrical ingots, while the facility near Oak Ridge would be designed to prepare, store and treat shredded material having a lower bulk density. The Oak Ridge facility might have additional pretreatment steps depending on whether surface contamination is present and/or could economically be removed from the shredded material. Process economics could vary between the two sites based on difference in feedstock. The Paducah plant has been sized to process ~ 1,000 ingots per year and is expected to operate for 10 years. The Oak Ridge plant could be designed for a similar time span. The ten year operating period would help provide price stability for the nickel product by lessening its impact on the overall recycled scrap nickel market. At these processing levels, the amount of processed RSM would be less than 1% of the U.S. scrap metal market. The process equipment would be decontaminated at the end of its useful life and the materials could be dispositioned appropriately.

The batch processing concept for processing radioactively contaminated scrap metal provides good flexibility in addressing changing feed characteristics. A mobile, skid-mounted system could be developed to treat small quantities of RSM at different sites.

System of controls at each facility

The batch process for each treatment facility will be designed for the composition and physical characteristics of the incoming nickel feed material. Metal Separation Technologies, Inc. plans an inventory tracking system that would be initiated with the receipt of the material at the DOE sites and concludes with the issuing of MSDS sheets for shipping the processed nickel to DOE-approved metal recyclers.

In the case of the Paducah plant, all ingots will be catalogued and bar coded prior to transport from the DOE facility. The bar code will be retained during storage and up to processing. After processing, each lot will be stored separately until it is shipped to a DOE-approved metal recycling facility. Should the market demand a powder nickel product, this could be accommodated by modifying the handling of the condensed vapor stream.

NEPA and other regulatory issues

Metal Separation Technologies, Inc. is currently seeking the following permits and licenses for handling nuclear waste and radioactive material:

- Radiation Material License Radiation Operator Certificate – Kentucky Cabinet for Health and Family Services, Radiation Health Branch
- Air permit- Kentucky Division for Air Quality
- Water permit- Kentucky Division of Water Quality

After discussion with the appropriate Kentucky regulatory agencies, other applicable permits will be obtained to ensure compliance with all federal, state and local regulations and statutory mandates.

The only commercial company that is specifically licensed to handle low level radioactive waste (Class A) and mixed waste is Envirocare of Utah. For more details on this company go to http://www.epa.gov/radiation/mixed-waste/mw_pg11a.htm .

Facility Decommissioning Plan. At the end of its useful life, the processing facility will need to be decontaminated and decommissioned. Decontamination, decommissioning and license termination will be addressed in compliance with all applicable NRC and Agreement State regulatory requirements.

Radiation Safety Plan. The radiation safety plan will meet NRC or Agreement State regulations for radioactive materials. In addition, shipment of radioactive materials will meet U.S. Department of Transportation, NRC, and Agreement State regulatory requirements.

Testing and controlling of employee radiation exposure. Overall employee exposure throughout this process is expected to be less than 82 mrem/year. Resrad-Recycle software will be used to estimate the potential radiation exposure to employees. Resrad-Recycle was developed by the Environmental Science Division at the Argonne National Laboratory to facilitate review of radiation safety issues in metals processing and fabrication facilities.

All employees will be required to undergo radiation training. Bioassays and radiation dosimeters will be utilized to ensure compliance with all licensed and regulator requirements.

Post-processing contamination levels

Grease and scale will be removed prior to melt processing. Both the distillate primary product and the bottoms byproduct should be clean of particulate impurities. The only additional waste might be mold flashings, which could be gathered for recycling to the process.

Byproduct and waste stream disposition

The extraneous nickel samples at Paducah, specifically, the three pallets of nickel scrap, the 52 asbestos-contaminated cylinders./,m the square ingots, and the ingots stuck in molds, cannot be accommodated in the current furnace design. The 25 elongated cylinders may not fit in the furnace melting zone. Table 1 shows the disposition of all entering material (1000 kg total mass; 0.5 kg grease, 1.5 kg scale, 1 ppm ^{99}Tc).

Table 1. Disposition of entering material. [a] – mold flashing suitable for recycling, [b] – particulates recovered from air filtration, may be partially recycled, [c] – material not recyclable to the process.

	Stream		
Item	Product, kg	Solid recovery , kg	Solid captured on filter, kg
Enriched nickel product	894.4	1.79[a]	0.89
Tc-rich ingot	99.8	.20[a]	
	994.2	1.99[a]	0.89[b]
Grease	0.5[c]		
scale		1.35[c]	0.15[c]
Plastic wrap		1[c]	

The processing of a 1000 kg ingot will result in 894 kg of nickel suitable for use in the nuclear industry, 99.8 kg of Tc-enriched material with a known composition (long-term storage), and 2-3 kg of material with potential contamination for long term storage. Should improved purification be developed in the future, the stored ^{99}Tc-enriched nickel ingots could be recovered and reprocessed.

B2. Plan to disposition 53 tons of scrap aluminum

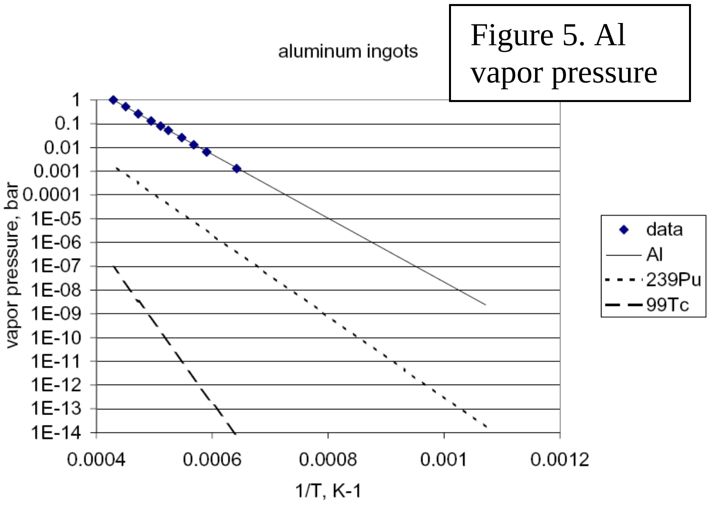

Figure 5. Al vapor pressure

The information provided by DOE on the scrap aluminum does not specify the source of radioactivity. Assuming that the source could be ^{99}Tc, ^{239}Pu, or both, we have prepared a plot of the pure component vapor pressures over the liquid range of aluminum (Figure 5). Batch separation of this mixture would be based on aluminum as the light key and plutonium as the heavy key. For all practical purposes, technetium would remain in the bottom product. The batch distillation might be operated at the normal boiling point of aluminum where the relative volatility for the aluminum/plutonium pair is greater than 500. Assuming that ^{239}Pu can represent the heavy key, two batch distillations would lower the radioactivity of the aluminum to 1.2 pCi ^{239}Pu/g solid, which is less than the IAEA clearance limit.

Metal Separation Technologies, Inc. can prepare a disposition plan when chemical composition information is available.

C. Cost and Benefit

Metal Separation Technologies, Inc. has prepared a cost estimate focused on the ingot feedstock at Paducah, since this has been better characterized by DOE. We assume that sites with the following characteristics can be identified: 1) located within 30 miles of the PGDP, 2) appropriate access by truck and/or rail, 3) covered, heat-controlled warehouse space ~ 50,000 ft^2, 4) access to city water for cooling, 5) electricity hook-up, 6) appropriate space for a nitrogen storage tank, 6) suitable for security fence construction and security system installation, and 7) processing (5-10 k ft^2), chemical analysis (2 k ft^2), and administration/records/sales (2-4 k ft^2) areas.

This cost estimate does not include transportation costs from PGDP to the site, transportation costs from the site to long-term storage for byproducts, degreasing/descaling/plastic wrapping/bar coding operations (which preferably would be accomplished at the PGDP storage location prior to ingot loading on truck/rail), decontamination costs for the process equipment and facility at the end of its useful life (10 years), and charges for the long-term storage of the process byproducts.

A similar cost estimate for treatment of the material at Oak Ridge could be prepared.

Order of magnitude cost estimate

The cost estimate is based on the composition data available for the ingots at the Paducah site. This estimate is based on the two radiological property reports, which tested only a small number of the total sample population. Processing costs to achieve the IAEA clearance limit would increase as the radioactive content increases.

The batch distillation process has been designed not to minimize processing costs, but to provide high technology jobs in the local community over a reasonable period of time with a yearly production capacity that should have minimal negative effects on the price of scrap nickel in the U.S. The cost estimates are summarized in the following table.

Table 2. Cost estimates by process task.

Task	Cost estimate, $/kg	Comments
Inventory system	$0.12 - $0.20/kg	A secure, electronic database on each lot with location, composition, and sample history.
Transport to processing facility	-	Not estimated as facility sites are not selected.
Degrease/descale and wrap	-	Process requirements to be determined during pilot scale study
Batch distillation	~$10.60/kg	Based on one processing step, 1 ppm ^{99}Tc as the contaminant, one metric ton furnace capacity. This estimate would be improved after the pilot scale study based on actual material and energy balances along with equipment quotations.
Radiochemical analysis	~$1.60/kg	Based on a complete lab installed at the manufacturing site. These costs might be reduced by using commercial testing facilities, or reduced testing needs based on operating experience.
Transport of purified product	-	Sales would be FOB the manufacturing site.
Transport of byproduct to long-term storage	-	Not estimated
Long-term storage of byproduct	-	Not estimated. The ^{99}Tc-enriched ingots need to be stored so that they could potentially be recovered for future reprocessing.
Long-term storage of waste	-	Not estimated.
Decontamination & plant decommission	-	Not estimated

Estimated discounted value of the nickel

The value of the nickel will be established by the marketplace. Metal Separation Technologies, Inc. believes that its process will be able to produce nickel meeting the IAEA clearance limits for ^{99}Tc and ^{239}Pu. The international market price for nickel is high now (~$40/kg), but has had price plateaus of ~$7/kg and ~$14/kg since 2000. The demand for nickel in developing countries, particularly China, has been driving the price increases. The U.S. market for nickel scrap has averaged about ~110,000 metric tons per year (P. H. Kuck, Mineral Commodities Summary: Nickel, USGS, 2007) while the total U.S. consumption has been above 200,000 metric tons per year.

In general, the price for scrap nickel is about 50% of the cost for virgin material. Between 50-60% of the total U.S. consumption is imported, so an additional source of scrap material might be beneficial. For a ten year manufacturing period, the amount of scrap nickel recovered from

DOE sources would be 1-2% of the U. S. market. Because this material would be a new product and its applicable market would be restricted, Metal Separation Technologies, Inc. believes that DOE will have to provide assurances that the costs of processing will be recovered.

Since purified nickel that had been radioactively contaminated would be a new product, and since its use would be restricted to nuclear industry applications (for which use volumes are difficult to find), it is not clear what its "market" price would be. Furthermore, this process has not been sized to optimize profits and minimize processing costs, but rather to provide a viable product manufactured locally over an extended period of time.

Benefits to the local communities

The processing technology and facility has been sized so that: 1) it can be locally operated to process the nickel scrap near its current site, 2) purification of all the material would occur over a ten year period, providing high technology jobs, 3) each lot of purified material will be characterized with respect to residual radioactivity, creating a product with the highest possible value, and 4) the ten year period would allow the community to identify other metal scrap purification problems for which batch distillation could be a viable solution.

D. Schedule

There are five key tasks: pilot plant operation to document the process performance and finalize the design, completion of the permitting processes (expected to take one year), completion of project funding (dependent on the final process design and associated costs; plant site selection; award of a construction contract), facilities construction (including installation of utilities, furnaces, and analytical equipment), and a 3 month plant start-up period. Full scale production would begin at the end of year 2.

Task	year 1				year 2			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
pilot plant operation	🟦	🟦	🟦					
permitting processes	🟩	🟩	🟩	🟩				
project funding	final process design/costs	🟨	🟨					
			construction contract	🟧				
facilities construction					🟩	🟩	🟩	
start-up								🟥

E. Additional information

None.

F. Additional information on aluminum ingots at Paducah

None.