Contaminated Scrap Metal Management on the Oak Ridge Reservation

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Large quantities of scrap metal are accumulating at the various Department of Energy (DOE) installations across the country as a result of ongoing DOE programs and missions in concert with present day waste management practices. DOE Oak Ridge alone is presently storing around 500,000 tons of scrap metal. The local generation rate, currently estimated at 1,400 tons/yr, is expected to increase sharply over the next couple of years as numerous environmental restoration and decommissioning programs gain momentum. Projections show that 775,000 tons of scrap metal could be generated at the K-25 Site over the next ten years. The Y-12 Plant and Oak Ridge National Laboratory (ORNL) have similar potentials. The history of scrap metal management at Oak Ridge and future challenges and opportunities are discussed.

Introduction

Scrap metal recycle technology is well developed on an industrial scale and, in fact, scrap metal recycle represents a major element of the metals production industry. Clearly, the potential value of DOE scrap metal in the secondary metals market warrants special management attention; however, the bulk of the DOE metal is contaminated with nuclear process radionuclides. In addition, regulatory and liability issues associated with the free release of radioactive material from a government facility have become particularly complex over the past 10 years. To further complicate the present situation, concern has been expressed about whether the cost of recycle will be higher than the cost of disposal. As a direct result of the peculiarities and uncertainties generally associated with DOE scrap metal disposition, DOE does not currently have a formal scrap metal recycle policy and program. In this context, however, DOE is aggressively pursuing a number of metal recycle options and is participating in several commercial technology demonstrations designed to form the nucleus of effective commercial-based scrap metal recycle processes. While waiting for the necessary regulatory and management decisions to be made, scrap metal procedures are being implemented at Oak Ridge to keep all viable process options open, as well as

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maximize future scrap metal worth, by segregating and sorting certain strategic metal streams where practical and cost effective.

Commercial Metals Recycling

Recycling represents a major proportion of the total domestic commercial metal production. Within the primary industries, significant quantities of scrap are generated through trimming operations in the production of semi-finished products such as sheet, plate, rod, bar, extrusions, and forgings. Such scrap forms are routinely remelted for reprocessing. The amount of trim scrap may range from about 10% to 50% of the weight of the original material to be processed. Additional scrap is generated when the semi-fabricated products are processed for the manufacture of parts and components. In many instances component manufacturers easily segregate scrap materials on an alloy-by-alloy basis to permit easier recycle by either the original materials supplier or within the commercial secondary metals industry. "Obsolete" or "old" scrap is generated when manufactured equipment is overhauled, dismantled, or scrapped.

The disposal of scrapped automobiles provides an excellent case study of the methods by which complex systems composed of numerous materials are dismantled and processed in manners to optimize the value and recycle opportunities for each of the constituent materials. Automotive recycling operations permit separate recovery of magnetic ferrous materials, non-magnetic copper alloys, zinc alloys, and stainless, high-grade aluminum alloys, and low-grade aluminum alloys. About 90% of all cars taken out of service are shredded through an established infrastructure for recycling, and about 75-80% of the average car (3100 lb) is metal scrap that is recycled. For the specific case of using scrap iron and steel in steelmaking rather than virgin iron ore and coal, the Institute of Scrap Recycling Industries[1] quotes EPA studies which indicate the following savings: reduced energy usage, 74%; reduced virgin material use, 90%; reduced air pollution, 86%; reduced water use, 40%; reduced water pollution, 76%; reduced mining wastes, 97%; and reduced consumer waste generation, 105%. In the case of aluminum beverage cans, recycling requires only 5% of the energy required to produce a can from virgin raw materials. This provides an economic driver such that over 63% of the aluminum beverage cans produced in the U.S. are now being recycled. Scrap recycle is a routine, economically significant feature of the commercial metal industry. From the standpoints of resource utilization, energy conservation, pollution abatement, and cost minimization, metals recycle makes very good sense. The same argument can be applied to the management of DOE scrap metal although the economics and regulatory considerations are not as straightforward.

Oak Ridge Scrap Metal Characterization

Historically, the typical makeup of the Oak Ridge Reservation (ORR) scrap metal is 80-85% ferrous metal/mild steel and 10-15% aluminum, with a balance of stainless steel, copper, brass, and nickel. Significant amounts of exotic metals such as tantalum, Inconel™, and titanium are also encountered from time to time. As a logical consequence of the nature and type of the major DOE Oak Ridge operations, the bulk of the ORR scrap metal is radioactively contaminated. As generated, most of the ORR scrap metal is only surface contaminated, with relatively little volumetric contaminated metal present. Uranium and associated daughter products, mainly thorium-234 and protactinium-234, are the predominant radionuclides that are characteristic of the local scrap.

The presence of enriched uranium greatly complicates the off-site handling and processing of metal taken from certain Y-12 Plant production facilities and the K-25 Site diffusion cascade because of strategic nuclear material (SNM) handling restrictions imposed on the private sector by the Nuclear Regulatory Commission (NRC). Specifically, uranium enriched in fissile content (uranium-235 above 0.711 weight %) is categorically classified as SNM by the Atomic Energy Act. In this case, there is no "de minimis" or "below regulatory concern" concentration of uranium that is exempt from NRC regulations. NRC licensed businesses can have up to 350 grams of SNM on-site at any given time. Metal taken from the decommissioned gaseous diffusion process also has significant potential for technetium-99 contamination as a result of recycling uranium from spent reactor fuels, primarily from the Hanford and Savannah River Plants. Trace quantities of transuranic elements such as plutonium-239 and neptunium-237 can also be found.

Nuclear fission by-products such as cesium-137 and strontium-90 and activation products such as cobalt-60 are the primary contaminants found on process scrap generated at ORNL. Uranium and transuranics are also likely to be found at ORNL.

Historical Scrap Metal Management Perspective

There have been numerous investigations, studies, and assessments over the years on the prospects of recycling contaminated scrap metal. One of the earliest references is a 1951 AEC report[2] which investigated the hazards from commercial release of uranium contaminated scrap metal. This was followed in 1952 by an article[3] in the trade journal *Iron Age* which was titled, "Sale of Uranium Contaminated Scrap Metal Recommended." A very recent assessment[4] in 1991 was made for recycling contaminated metal waste into stainless steel canisters for placing high-level waste into repositories. In the interim period, many laboratory-scale studies and engineering-scale demonstrations were completed and a fair amount of scrap metal has actually been processed and sold or put to use[5]. The results of these studies is that uranium and plutonium contamination (as well as many of their daughter products) can be removed quite easily from most metals by melting under a slag with the resulting processed metal having greatly reduced contaminant levels in the range of a few parts per million or less. In contrast, activation products such as cobalt-60 cannot generally be removed by conventional pyrometallurgical processing. Further, numerous physical methods and chemical processes can also be used to effectively decontaminate scrap metal.

In times past, scrap metal was collected at the sites and managed in open piles. Some storage yards were dedicated to contaminated metal, while others were used for clean metal. Each of the three Oak Ridge installations maintain their own scrap metal yards. Some equipment was sold for metal content on occasion or released to other government agencies. In the 1960's, large quantities of contaminated scrap metal had accumulated and was released to two local commercial scrap metal processors for smelting and commercial reuse. In total, commercial vendors processed over 1 million tons of contaminated metal, returning the contaminated slag to the local AEC installation for disposal and releasing the processed metal to the secondary metals market. Beginning in the 1960's, the sites were also given AEC approval to sell surplus surface uranium-contaminated "clean" metal using the free release criteria specified in the applicable AEC guidance document of the day (Manual Chapter 0520), based on average and maximum alpha surface concentration limits (5,000 and 25,000 d/m/100 sq cm). The accompanying beta-gamma radiation was limited to 1 mrad/h at the surface. Also, all "practical" steps had to be taken to recover enriched uranium from the scrap. Uranium-contaminated aluminum ingots with volumetric contamination resulting from local smelting operations were released under a different criteria (<300 ppm uranium content and 1,000 d/m/100 sq cm surface alpha).

Today, DOE surface contamination guidelines allow the general release of process contaminated metal scrap with less than 1,000 dpm/100 sq cm removable alpha or 5,000 dpm/100 sq cm fixed alpha from natural uranium, U-235, U-238, and associated daughter products and radionuclides with decay modes other than alpha emission (beta-gamma). Corresponding transuranic surface contamination guidelines have not been established. Currently, there is no DOE guidance with respect to the release of metal with volumetric or bulk contamination.

Smelting of contaminated metal was performed exclusively by commercial vendors licensed specifically to handle uranium contaminated materials. This practice was discontinued in the early 1970's after contaminated inventories were worked down; however, the general sale of "clean" metal continued through the 1980's and into the early 1990's, with the Oak Ridge installations selling an average of 2 million pounds of metal per year. The bulk of the ferrous metal was sold at a rate of $0.01 per pound and less. The non-ferrous metals averaged over $0.16 per pound. All off-site shipments, including "clean" scrap metal, were discontinued in April 1991 under a general DOE moratorium on the off-site disposal of hazardous waste. "Clean" metal has been accumulating on-site since the 1991 moratorium. Contaminated metal, on the other hand, has been accumulating since the early 1970's. In the mid-1980's, a local activity was initiated to study physical and chemical methods for decontaminating radioactively contaminated surfaces. There was also a significant commercial activity involving size reduction of 80,000 tons of contaminated metal equipment pieces generated during an earlier gaseous diffusion process upgrading project. The size reduction demonstration was followed by commercial attempts at decontamination of the same lot of scrap metal. DOE is currently releasing some metals on a case-by-case basis following well prescribed release criteria. Recently, DOE shipped over 700,000 pounds of contaminated metal to a commercial smelter for fabrication into shielding blocks for use at other DOE sites for high energy physics programs. DOE ORO has a goal of releasing 3,000,000 pounds of metal this fiscal year via this route.

Release mechanisms for potentially contaminated scrap metal at Oak Ridge have always followed the prescribed methods in effect at the time, based primarily on radiation survey coupled with some process knowledge regarding whether the metal could have absorbed or gained volumetric contamination. Records are kept based on source of metal, quantities, health physics readings, and disposition of the metal.

Discussion of Options

Three primary metal management routes are available for the ultimate disposition of contaminated DOE scrap metal: (1) disposal in an engineered low level waste storage facility, (2) restricted reuse as contaminated metal, and (3) decontamination and recycle as unrestricted or free release metal. The selection of the preferred option rests on consideration of technological, economic, and social issues. Based on the present level of knowledge and with limited cost information, there does not appear to be a single management approach suitable to all ORR scrap metal streams.

Radioactive material disposal costs based on limited experience will likely run in the range of $50 to $100/cubic foot. Assuming disposal in a B-25 type container (with 6,000 pound load limit), scrap metal disposal costs will be on the order of $2,000 to $4,000/ton. Super compaction could significantly reduce the disposal volume and hence directly reduce the disposal cost, which is based on total volume. Commercial super compaction, however, costs near $2,000/ton ($1.15/lb). Total weight is not particularly important as long as a suitable shipping/disposal container can be found that minimizes external container volume for a given scrap metal mass and special rigging is not required. The only scrap metal management requirement necessary to support off-site shipment and disposal is segregation of enriched uranium contaminated metal from depleted metal to facilitate better accountability of SNM.

In comparison to disposal, the cost of an existing commercial service to process DOE scrap metal to shielding blocks will be around $2,000 to $3,000/ton ($1.00 to 1.50/lb). Commercial interest has also been expressed in the manufacture of other contaminated metal products. For example, a B-25 container has been fabricated by a local firm from scrap metal similar to that found at the local DOE installations.

At the other end of the options spectrum, decontamination services would cost in the range of $700 to $4,000/ton depending on the type and nature of the contamination and type of decontamination process. Grit blasting, liquid abrasive washing, and high pressure water spraying are examples of the more common physical processes. Chemical processes involve the use of acid/alkali solutions and various proprietary chemical agents in a washing or dissolution configuration. Melt-refining and electro-refining processes are required to purify volumetrically contaminated metals. These types of processes are technically complicated and relatively expensive compared to the physical methods. For the most part, the major metal decontamination technologies are well developed on an industrial scale and generally have firm design bases. The primary detractor is unit cost.

An interesting number for comparison to decontamination cost is the health physics cost required to verify that suspect scrap metal is sufficiently clean for unrestricted release. For example, it takes a health physics technician 30 minutes to survey a 4' by 8' metal plate with a typical field survey instrument. Assuming two independent surveys (as required by local procedure), the verification cost will run near $100 to $200/ton for plate steel and over $400/ton for plate aluminum (low metal mass per unit volume compared to steel). On the other hand, considerably more technician time would be required to survey high specific surface area scrap (items with unusually high surface area per unit mass compared to plate or massive metal shapes) common in Oak Ridge scrap yards. Miscellaneous scrap metal monitoring could cost well over $1000/ton.

Decontaminated ferrous scrap metal, on the other hand, would bring around $100/ton on the secondary metal market. A comparable price for aluminum is $600/ton and copper is $1500/ton. Clearly, the economics of unrestricted ferrous metal recycle from DOE scrap does not appear to be a good argument based on the value of scrap steel relative to decontamination and verification costs unless the avoided costs associated with disposal ($2,000 to $4,000/ton) or contaminated metal fabrication ($2,000 to 3,000/ton) are taken into account. Economically, surface-contaminated scrap with a relatively small specific surface area such as plate and structural components is more attractive for decontamination and unrestricted release than scrap with relatively high specific surface area, scrap requiring considerable labor to disassemble, and scrap with inaccessible interior surfaces.

Oak Ridge Scrap Metal Management Practice

With due consideration of the technological and social issues, the primary driver of the Oak Ridge scrap metal management program is overall economics. In this context, recycle/disposal of contaminated metal is a significantly more expensive proposition than dealing with clean scrap and major efforts are being taken by the generator to keep clean metal streams segregated from contaminated metal. At the same management level, volumetric contaminated metal scrap is being positively identified and appropriately segregated from surface contaminated metal to reduce the risk of unrestricted release of this prohibited category of scrap. Further, enriched uranium and other fissile material-contaminated metal is being segregated from other contaminated scrap for SNM accountability.

Suspect scrap metal can be difficult and expensive to characterize (verify as releasable or not according to surface contamination), particularly if the subject items have high specific surface area, internal surface contamination requiring significant disassembly, or inaccessible surfaces. In this context, a graded management approach is being taken during the sorting process, commensurate with the strategic value of the metal. In particular, suspect non-ferrous metal such as aluminum, stainless, copper, brass, and nickel is being given top consideration in the recovery and free release management protocol. On the other hand, a lot of surface monitoring is not being done on suspect ferrous scrap except for larger pieces of structural plate, I-beams, and similar items with relatively small surface area per unit mass.

Larger structural steel items with limited surface contamination are being managed to preserve unrestricted recycle at some future point. In support of the unrestricted scrap recycle option, non-ferrous scrap is being sorted from ferrous. It is economical, in the general case, to allow deviation from this requirement if the non-ferrous content of the scrap is less than 1 to 2 % of the total (based on the relative value of the metals and cost to sort). Additional sorting of the non-ferrous stream is not being required except in special circumstance.

As an overall summary of current Oak Ridge scrap metal management practice, the following scrap metal segregation and sorting requirements are being implemented by the Energy Systems Waste Management Organization (ESWMO) for scrap metal generators at all ORR installations to preserve intrinsic metal value and keep future disposal/recycle options open while final metal disposition decisions are being made to recycle DOE metal: 1) Scrap metal generated in historically uncontaminated or otherwise certified radiologically clean plant areas is being segregated from contaminated scrap and stored as clean metal. This particular DOE metal stream is being managed by the installation landlord, not DOE Waste Management; 2) Enriched uranium and other fissile material contaminated scrap metal is being segregated from other contaminated scrap; 3) Volumetric contaminated scrap is being segregated from surface contaminated scrap; 4) Suspect surface contaminated scrap is being surveyed for free release status in those cases where the intrinsic metal value is obviously high and the overall cost associated with verification is economically feasible. Otherwise, suspect metal will be assumed contaminated and stored without supporting analytical proof; 5) Ferrous metal will be sorted from non-ferrous provided the fraction of non-ferrous is greater than 1 to 2 % of the total. This decision is being made on a case-by-case basis; 6) Non-ferrous scrap metal removed from plant waste streams is not being further sorted by metal type although any large quantity of a particular non-ferrous metal will not be deliberately mixed with miscellaneous metal if generated as a separate stream and convenient to keep segregated.

Concluding Comments

In the absence of a formal contaminated scrap metal program, DOE-OR is currently managing contaminated scrap metal to keep viable process options open and maximize future scrap metal worth. In the interim, DOE is aggressively pursuing a number of commercial technology demonstrations to establish performance baselines for future scrap metal management decisions. In this context, with due consideration of the technological and social issues, the primary issue in the selection of the optimum metal disposition pathway is economics. Based on the present level of knowledge, with limited cost data, there does not appear to be a single management scenario optimized to all ORR scrap metal streams. The formal program, therefore, will likely incorporate a broad selection of available disposal, decontamination, and recycle industrial capabilities.

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References

1. Facts and information published by the Institute of Scrap Recycling Industries, Inc., Washington, D. C., 1993

2. H. Blatz, J. H, Harley, M. Eisenbud, *Investigation of the Potential Hazard in Releasing Scrap Metal Contaminated with Uranium to Commercial Channels*, USAEC NY)-1558 (June 1951)

3. H. Blatz, "Sale of Uranium to Contaminated Scrap Recommended"' *Iron Age*, 170, 125-7.

4. G. A. Reiman, *Technical Assessment of Process to Enable Recycling of Low-Level Contaminated Metal Waste*, INEL Informal Report, EGG-MS-9879 (October 1991)

5. Letter, R. P. Whitfield to Distribution, *Radioactive Scrap Metal Recycling*, October 23, 1992