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Feasibility of Re-Melting NORM-Contaminated Scrap Metal

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ABSTRACT

Naturally occurring radioactive materials (NORM) sometimes accumulate inside pieces of equipment associated with oil and gas production and processing activities. Typically, the NORM accumulates when radium that is present in solution in produced water precipitates out in scale and sludge deposits. Scrap equipment containing residual quantities of these NORM-bearing scales and sludges can present a waste management problem if the radium concentrations exceed regulatory limits or activate the alarms on radiation screening devices installed at most scrap metal recycling facilities. Although NORM-contaminated scrap metal currently is not disposed of by re-melting, this form of recycling could present a viable disposition option for this waste stream. Studies indicate that re-melting NORM-contaminated scrap metal is a viable recycling option from a risk-based perspective. However, a myriad of economic, regulatory, and policy issues have caused the recyclers to turn away virtually all radioactive scrap metal. Until these issues can be resolved, re-melting of the petroleum industry's NORM-impacted scrap metal is unlikely to be a widespread practice. This paper summarizes the issues associated with re-melting radioactive scrap so that the petroleum industry and its regulators will understand the obstacles. This paper was prepared as part of a report being prepared by the Interstate Oil and Gas Compact Commission's NORM Subcommittee.

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INTRODUCTION

The Interstate Oil and Gas Compact Commission (IOGCC) recognizes that the regulation of petroleum industry wastes containing naturally occurring radioactive material (NORM) has created additional expenses for oil and gas production and processing operations. The IOGCC's Environmental and Safety Committee created a NORM Subcommittee to evaluate issues facing the petroleum industry and its regulators with respect to NORM. One objective shared by the industry and regulators is the development of NORM regulations that adequately protect human health and the environment while minimizing the associated economic burden.

To assist the state agencies that regulate oil and gas operations, the IOGCC's NORM Subcommittee has drafted a set of discussion papers that address many aspects of NORM regulations from defining appropriate exemption levels to identifying safe disposal or recycle options.(1) One of these discussion papers focuses on the potential for re-melting scrap equipment that has been impacted by NORM. This paper is presented here in its entirety.

BACKGROUND

Although NORM-impacted scrap metal generated by the petroleum industry currently is not disposed of by re-melting, this form of recycling could represent a viable disposition option for this waste stream. However, the scrap metal recycling industry faces a myriad of issues making it difficult to accept NORM-impacted materials at its facilities. Until these issues can be resolved, re-melting of the petroleum industry's NORM-impacted scrap metal is unlikely to become a widespread practice.

Scrap metal recycling is an important industry in the United States, providing a significant portion of supply of all types of metal.(2) While domestic steel consumption has declined over the last two decades, the scrap metal share of the iron and steel market has increased.(3) In 1997, scrap metal processors handled about 66 million to 70 million metric tons of scrap iron and steel,(4,5) of which approximately 46% was comprised of obsolete scrap (i.e., worn out, broken and discarded objects).(5) Recycled ferrous scrap made up approximately 72% of the country's raw steel production in 1997,(5) up from around 33% in 1980.(3) The international market for scrap metal recycling also is significant, with industrialized nations exporting scrap metal to developing nations as demand and business conditions dictate. In 1997, the U.S. exported approximately 8.9 million metric tons of ferrous scrap, having an estimated value of about $1.3 billion.(5)

These statistics reflect the fact that iron and steel scrap are vital raw materials for the production of new steel and cast iron products.(5) Recycling of scrap metal has become increasingly significant for several reasons. From an environmental perspective, recycling of scrap metal has become important because re-melting scrap a) requires much less energy than the production of iron or steel products from iron ore; b) reduces the

burden on landfill disposal facilities; c) prevents the accumulation of abandoned steel products in the environment; and d) avoids environmental damage resulting from replacement of the scrap metal through raw material production.(2,5) Because recycling scrap reduces the need to mine and process raw iron ore, health risks associated with mining and refining the metal (i.e., occupational injuries) also would be reduced.(2) From a technological perspective, recycling of scrap metal has become more significant with the proliferation of electric arc furnaces (EAFs), particularly through growth of the "mini-mills" that target specific markets.(6) EAFs use nearly 100% scrap iron and steel for the furnace charge, as opposed to basic oxygen furnaces, which use approximately 30% scrap, and open-hearth furnaces, which use around 50% scrap.(2) In the first half of 1998, EAFs consumed almost 70% of all recycled ferrous scrap,(7) up from only 37% in 1990.(2)

The scrap metal recycling industry generally will not accept any scrap metal that is radioactive. A specialized metal recycling segment of the radioactive waste handling industry does recycle radioactive scrap metal, generated by the U.S. Department of Energy and the nuclear power industry. While thousands of tons of this metal have been recycled within these sectors, very little has been smelted and recycled for public use.(2) These facilities have the capacity to handle a portion of the potential inventory of NORM-impacted scrap generated by a variety of industries, including the petroleum industry.

The reasoning behind the scrap metal recycling industry's reluctance to process radioactive scrap is understandable. In the past, there have been instances in which facilities have been contaminated by inadvertent re-melting of radioactive sources.(5,8,9) Most of these incidents appear to have involved sealed radioactive sources, such as Cs-137 level gauges, Co-60 therapy devices, and radium devices. Losses resulting from decontamination, waste disposal and lower profits reportedly have ranged from $7 million to $23 million per incident. To protect themselves from such losses, most metal recyclers have installed radiation detection systems to screen radioactive scrap. Usually, shipments found to contain radioactive material at any level are rejected and returned to the supplier. If possible, when a sealed source is involved, it is confiscated.

None of these documented incidents of facility contamination has involved scrap metal containing NORM; nonetheless, NORM-impacted scrap frequently is rejected by radiation detection systems and returned to the supplier.(8,9) According to estimates by the American Petroleum Industry (API), approximately 600,000 tons of NORM-impacted scrap are generated annually by the oil and gas industry, 75% of which would be rejected by the scrap recycling industry based on the use of radiation detection systems.(10,11) Prior to the installation of these systems in the late 1980s, NORM-impacted scrap was routinely processed by the metal recycling industry.

RADIOLOGICAL RISK

Several studies have indicated that re-melting of equipment containing radium-bearing materials presents minimal risk to the public, and that risk to workers can be controlled.(12,13) Bench-scale tests funded by the Petroleum Environmental Research

Forum (PERF) indicated that during the re-melting process, approximately 98% of the Ra-226, Ra-228 and Th-228 was recovered in the slag generated during re-melting.(12) The partitioning of Ra-226 to the offgas was calculated to be 0.0004%. Partitioning of Pb-210 and Po-210 were inconclusive.

On the basis of these measurements, estimated potential radiological doses to the public from airborne emissions, exposure to recycled metal or exposure to recycled slag are negligible.(13) Potential radiological doses to workers involved in the transportation, loading and unloading, re-melting and fabrication of the NORM-impacted scrap and resultant metal also are negligible if the NORM level of the feed is controlled.(13)

RECYCLING INDUSTRY CONCERNS

While re-melting of NORM-impacted scrap is technically feasible and presents little risk to human health and safety, there are several issues that must be addressed before metal recyclers will accept NORM-impacted scrap on a widespread basis. These issues are tied to either regulatory or economic constraints, or both. For the most part, economic constraints have not been quantified; however, the recycling industry can predict some degree of cost impact.

There are five primary areas of concern. One relates to segregation of the inbound feed material. Using the fixed load detectors currently installed at most facilities, it is not possible to identify specific types of radioactive contamination (i.e., a Cs-137 sealed source versus Ra-226 in pipe scale). Portable multi-channel analyzers could be used to identify specific radionuclides; however, recyclers would not be able to distinguish between discrete NORM (e.g., Ra-226 sealed source) and diffuse NORM (e.g., Ra-226 in pipe scale) without taking numerous individual measurements from each shipment that trip the detector's alarm. These limitations might make it difficult for the industry to cost-effectively segregate out larger sources of radiation from scrap containing NORM.

A second concern is that in order to process radioactive materials, a recycling facility might be required to obtain a license under Nuclear Regulatory Commission (NRC) and state regulations, unless specific exemptions were granted. These licenses would require extensive radiation safety programs to ensure that feed streams and discharge effluents are within established regulatory limits. The expenses associated with obtaining a license and implementing the required radiation safety programs might be prohibitive for the scrap recycling industry. For the most part, regulators have made no exceptions to these requirements for facilities that would process NORM-impacted scrap, even though the generators of the NORM-impacted scrap are not subject to such regulation. In Texas, a few mills have received regulatory approval to melt small quantities of NORM-impacted pipe.(6)

A third concern is the need to comply with existing, proposed or evolving volumetric standards for radioactivity in metal intended for "free release." These standards are being established to address nuclear industry materials, not petroleum industry NORM; however, the recycling industry has no regulatory guidance or other

basis for making this distinction. Three countries currently have volumetric standards for total radioactivity in metal: in Germany, the standard is 1 Bq/g (27 pCi/g); in Sweden, the standard is 0.1 Bq/g (2.7 pCi/g); and in Great Britain, the standard is 0.4 Bq/g (10.8 pCi/g). In addition, the International Atomic Energy Agency has recommended an international standard of 0.3 Bq/g (8.1 pCi/g).(14) National standards for volumetric contamination of metals are being considered by a number of agencies, including the NRC, U.S. Environmental Protection Agency, Conference of Radiation Control Program Directors, and American National Standards Institute. However, proposed regulations probably are several years away. Exceeding standards of this nature could limit the potential market for re-melted steel by preventing its "free release" for unrestricted use. To ensure these standards are met, recyclers would need to accurately measure the total activity level of each batch entering the smelter and would need to know with certainty how much of the radioactivity would remain after re-melting. Given the technological constraints on characterizing inbound feed material discussed above, it is hard to predict how difficult and costly it would be to consistently meet these standards or verify compliance.

A fourth concern is the potential radioactive contamination of baghouse dust and slag, byproducts of the re-melting process that have commercial value. Scrap metal recyclers are concerned they will have fewer disposition options for the baghouse dust and slag if they have a radioactive component.

A fifth concern is that steel recyclers sell their product to consumers who have a strong phobia of and bias against radiation and radioactivity. If recyclers see a risk that they might lose market share by being labeled as a "radiation" site, they might refuse to process any material suspected of being contaminated. Given the current stigma of radiation, this scenario is quite possible.(15)

ALTERNATIVE DISPOSAL OPTIONS

The inventory of NORM-impacted scrap metal generated by the petroleum industry each year must be handled in some fashion. Decontamination of the equipment is one option. While decontamination presents negligible risk to workers and the public,(13) it might not be a suitable alternative for a significant portion of the scrap metal inventory. Pipe, tubing and storage vessels can be decontaminated with some effort; however, a large portion of the scrap inventory consists of small items that cannot be easily cleaned (e.g., filters, and valves). Much of the rest of the inventory includes obsolete, worn out items that have no future use; cleaning these items before final disposition could be economically prohibitive.

Disposal of NORM scrap metal as low-level radioactive waste at a licensed facility is expensive. Given that the nation's current disposal capacity for low-level radioactive wastes is limited, from a policy perspective, it may make sense to reserve this capacity for that category of wastes, particularly if alternative disposal options for NORM materials are adequately protective of human health and the environment.

If the NORM scrap inventory is not recycled, production of additional raw steel will be required. Health risks and environmental impacts associated with replacement of the metal (i.e., those associated with mining, refining and smelting iron ore)(2) are greater than those associated with re-melting NORM-impacted scrap.(13)

CONCLUSIONS

From a health risk-based perspective, re-melting of NORM-impacted equipment appears to be a viable recycling option. As a result, within their NORM regulatory programs, states should consider the re-melting of petroleum industry equipment containing NORM at a level greater than the exemption level defining regulated NORM.

However, oil and gas regulators and the petroleum industry must recognize that a myriad of issues prevents re-melting of NORM-impacted scrap metal on a widespread basis. Before this recycling option can become widely available to the petroleum industry, numerous complex regulatory and economic issues must be addressed. The debate over this topic is occurring on both a national and international level and is not likely to be resolved quickly.

REFERENCES

1. Interstate Oil and Gas Compact Commission, Naturally Occurring Radioactive Materials (NORM), draft report of the NORM Subcommittee of the Environment and Safety Committee, Tulsa, Okla. (1999).

2. Nieves, L.A. et al., Evaluation of Radioactive Scrap Metal Recycling, ANL/EAD/TM-50, Argonne, Ill., Argonne National Laboratory (1995).

3. Zagone, E., "Recycling Over Time," *Scrap Processing and Recycling*, **52(6)**, 47-52 (1995).

4. Institute of Scrap Recycling Industries, Inc., "Association & Industry Profile — What is the Scrap Recycling Industry?," from the Institute of Scrap Recycling Industries, Inc. Internet site (www.isri.org/viewpage.cfm?pgid=1), Nov. 3 (1998).

5. Fenton, M., "Iron and Steel Scrap," in Mineral Commodities Summary, Reston, Va., U.S. Geological Survey, Jan. (1998).

6. Yusko, J.G., personal communication between Yusko (Pennsylvania Department of Environmental Protection, Radiation Protection, Pittsburgh, Pa.) and K.P. Smith (Argonne National Laboratory, Lakewood, Colo.), Jan. 13 (1999).

7. Fenton, M. and Johnson, D. "Iron and Steel Scrap in July 1998," in Mineral Industry Surveys, Reston, Va., U.S. Geological Survey, Oct. (1998).

8. Lubenau, J.O. and Yusko, J.G., "Radioactive Materials in Recycled Metals," *Health Physics*, **68(4)**, 440-451 (1995).

9. Lubenau, J.O. and Yusko, J.G., "Radioactive Materials in Recycled Metals — An Update," *Health Physics*, **74(3)**, 293-299 (1998).

10. American Petroleum Institute, A Naturally Occurring Radioactive Materials (NORM) Disposal Cost Study, API Publication 7100, Washington, D.C. (1996).

11. Grice, K., personal communication between Grice (API NORM Issues Group) and K.P. Smith (Argonne National Laboratory, Lakewood, Colo.), Sept. 16 (1998).

12. Dehmel, J.C., McNulty, T. and Johnson, D. Scrap Metal Recycling of NORM Contaminated Petroleum Equipment, Ponca City, Okla., Petroleum Environmental Research Forum (1992).

13. Smith, K.P., Blunt, D.L., Williams, G.P. and Tebes, C.L., Radiological Dose Assessment Related to Management of Naturally Occurring Radioactive Materials Generated by the Petroleum Industry, ANL/EAD-2, Argonne, Ill., Argonne National Laboratory (1996).

14. International Atomic Energy Agency, Clearance Levels for Radionuclides in Solid Materials: Application of Exemption Principles, IAEA Safety Series No. 111.G-1-5, Draft, Vienna, Austria (1994).

15. Rittenberg, R., personal communication between Rittenberg (Chase Environmental Group, Louisville, Ky.) and S. Winters (Industrial Safety Consulting Services, Clarksville, Tenn.), Jan. 7 (1999).