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NCRP Report No. 139, Risk-Based Classification of Radioactive and Hazardous Chemical Wastes, 2002, 433 pp. (soft cover), $55, National Council on Radiation Protection and Measurements, 7910 Woodmont Avenue, Suite 400, Bethesda, MD 20814; ISBN: 0-929600-72-X, http//www.ncrp.com.

HAZARDOUS waste is big business and billions of dollars have been spent over the last 50 years to resolve the issue of radioactive material (RAM) waste disposal. Many federal and state laws have addressed the problem, but a final solution has been elusive. Complicating the disposal issue in recent years is mixed waste—a mixture of hazardous chemicals and RAM. Lack of progress in RAM disposal has stunted the nuclear power industry, industrial RAM use has plateaued, and only short-lived nuclide usage in medicine has continued to expand.

The National Council on Radiation Protection (NCRP) has addressed the issue in Report No. 139 *Risk-Based Classification of Radioactive and Hazardous Chemical Wastes.* The Report claims that current RAM and hazardous waste classification schemes are either qualitative or source-based and, in many cases, are unrelated to risk. In contrast, NCRP proposes a broadly applicable quantitative risk-based classification scheme based on a dimensionless unit, Risk Index (RI), as follows:

$$\mathrm{RI} = \frac{(\mathrm{F})(\text{disposal risk})}{(\text{allowable risk})},$$

where F = a modifying factor;

Disposal risk is public health risk based on an intrusion scenario into a waste disposal site; and

Allowable risk is based on the acceptable public health risk (effective dose and EPA's chemical reference doses are acceptable as surrogates for risk).

The classification scheme leads to the following disposal options:

Waste class	Risk Index (RI)	Disposal method
Exempt	RI $\ll 1$	Municipal landfill
Low hazard	RI $\sim <1$	Regulated near-surface burial site
High hazard	RI $\gg 1$	Geological repository

Section 6, "Principles and Framework for a Comprehensive and Risk-Based Hazardous Waste Classification System" is the heart of the matter; and it is difficult reading. The concepts are not difficult to follow but, to cover all eventualities, the equations become abstract. Fortunately, there is Section 7, "Implications of the Recommended Risk-Based Classification System," where examples are given that are relatively easy to follow. Thus, one can get a good grasp of the schema.

One interesting example, subject to the schema, is mill tailings from processing 65% uranium ores (former Belgian Congo ores). The RI comes out to be between 50 and 100, considerably higher than the claim that the tailings were exempt. This risk analysis places them in the high hazard category indicated above.

Analysis of ^{137}Cs contaminated electric arc furnace dust (a mixed waste case) leads to a RI equal to 0.045 and, therefore, is clearly acceptable for disposal in a near-surface regulated burial site. In this example, one comes to grips with evaluating RIs for hazardous chemicals using the EPA methodology. One encounters the subtleties of hazardous chemicals interacting with organs and tissues in the intrusion scenario. These chemical bio-effects can be both deterministic (seldom encountered with RAM) and stochastic. There is also a difference in how risk for stochastic effects is handled. For RAM stochastic bio-effects the end point is cancer death; for hazardous chemicals stochastic bio-effects, the end point is cancer incidence (the latter mandated by law). This is where the "F" factor helps to place both RIs on a level field. This example also shows the challenge that the RI schema presents. Changing the intrusion scenario gives an RI equal to 2.4 and will possibly require a higher degree of control in disposal.

Waste disposal is part science and part politics, and the historical survey in Section 4, "Existing Classification Systems for Hazardous Waste," is especially rewarding in showing the interplay. There may have been a little scientific hubris on part of the old AEC in its approach to nuclear waste but, as the tortuous path from Lyons, Kansas (not mentioned in Report) to Yucca Mountain shows; it takes more than science to bury nuclear waste.

The pivotal laws are Atomic Energy Act of 1954 (AEA), Nuclear Waste Policy Act of 1982 and 1987 (NWPA), Resource Conservation and Recovery Act of 1976 (RCRA) and Toxic Substance Control Act of 1976 (TSCA). The historical summary shows how the AEA was initially interpreted as preempting other laws with respect to nuclear fuel cycle waste, but legal battles and the Federal Facility Compliance Act of 1992 reversed this and declared that AEA applied strictly to RAM. Other Acts (RCRA and TSCA) addressed hazardous chemicals in the waste. Thus was born mixed waste and dual regulation. For the DOE this has been no small matter as the Report states that DOE, with 525,000 cubic meters of mixed waste, struggles to comply with this complicated regulatory structure. Report No. 139 provides a rational basis to put mixed waste into the above classification schema.

Under RCRA, hazardous waste may be defined by some characteristic of the waste, e.g., ignitability, corrosivity, reactivity, toxicity, or a specified listed waste. Hazardous waste with treatable characteristics must be treated and rendered non-hazardous before disposal. Thus, bio-hazard waste is dismissed in the Report because it is treatable before disposal. Certain waste streams are born hazardous or exempt, unrelated to risk. For example, waste from combustion of coal and other fossil fuels, drilling fluids used in exploration, development or production of crude oil, are exempt from RCRA and TSCA. The latter have caused concerns in many States due to the naturally occurring radionuclides (mainly Radium) built up on pipes and has lead to another RAM waste stream—technically enhanced naturally occurring radioactive material (TENORM). Since the AEA did not cover naturally occurring (except as part of nuclear fuel cycle) and accelerator produced radioactive

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material (NARM) waste, this is a State responsibility that is addressed unevenly throughout the U.S. Section 4 also provides information on the IAEA waste classification scheme, which includes an intermediate hazard class.

Those who like to read the first and last sections in a report will be rewarded. Section 1, "Technical Summary," provides an excellent introduction on where we are in hazardous waste disposal and where the Committee hopes to go with the risk-based classification schema. The last, Section 8, "Conclusions and Recommendations," provides an insight on what the Committee would like to see happen, i.e., a risk-based scheme for classifying all types of hazardous waste. These two sections were also written as stand-alone sections.

Overall, the Report is divided into eight sections (there are no chapters, paragraphs or sub-paragraphs, all references are to Section 1 or Section 6.2.2.2.2). There is a Synopsis, Table of Contents, Glossary, Acronyms (important), References and Index (even more important). The Report was prepared by Scientific Committee 87-2 on Waste Classification Based on Risk. Committee members are Allen G. Croff, Chairman, Michael J. Bell, Yoram Cohen, Leonard C. Keifer, David C. Kocher, Dennis J. Paustenbach, Vern C. Rogers, and Andrew Wallo III.

The NCRP is to be commended for addressing the important topic of hazardous waste that has become a drag on the whole nuclear industry. Report No. 139 puts health physicists in contact with hazardous chemical waste and shows how RAM and hazardous chemicals may be melded together. The Report keeps its feet on the ground and takes no flying leap into space or the deep seabed.

The Atomic Energy Act (AEA) came at a pivotal time of nuclear development from war to peace. The time may be auspicious for new legislation to address the disposal of hazardous waste as the Committee indicates. We do not want to see thousands of 55-gallon drums of hazardous waste stacked in lower Manhattan awaiting a decision on their disposal. Now may be the time for comprehensive legislation to address the problem. Everyone involved with radiation protection and handling hazardous chemicals should be familiar with NCRP Report No. 139. Will this report answer everyone's waste problem and lead us out of the present quagmire? Maybe.

F. J. BRADLEY

605 *East* 82*nd Street, Apt* 2*H*
New York, NY 10028
bjfentr@aol.com