EVALUATION OF SECONDARY STREAMS IN MIXED WASTE TREATMENT

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INTRODUCTION

The United States Department of Energy (DOE) and its predecessors have generated wastes containing radioactive and hazardous chemical components (mixed wastes) for over 50 years. Facilities and processes generating these wastes as well as the regulations governing their management have changed. Now, DOE has 49 sites where mixed waste streams exist. The Federal Facility Compliance Act of 1992 (1) required DOE to prepare and obtain regulatory approval of plans for treating these mixed waste streams. Each of the involved DOE sites submitted its respective plan to regulators in April 1995 (2). Most of the individual plans were approved by the respective regulatory agencies in October 1995. In many cases, mixed waste treatment that was already being carried out and survived the alternative selection process is being used now to treat selected mixed waste streams. For other waste streams at sites throughout the DOE complex, treatment methods and schedules are subject to negotiation as the realities of ever decreasing budgets begin to drive the available options.

Secondary wastes generated by individual waste treatment systems are also mixed wastes that require treatment in the appropriate treatment system. At large DOE sites, secondary waste streams will be a major influence in optimizing design for primary treatment. Understanding these impacts is important not only for system design, but also for assurances that radiation releases and subsequent radiation exposures will be carefully controlled. Secondary wastes can greatly affect treatment system capacity needs, the types of treatment required, and the health physics program requirements.

MIXED WASTE TREATMENT

Mixed wastes subject to treatment are those wastes that meet one of the following criteria:

- Low-level mixed waste - contains hazardous constituents and radioactivity and is not classified as high-level waste, transuranic waste, spent nuclear fuel, or tailings or waste produced by the extraction or concentration of uranium or thorium from any ore processed for source material.
- Mixed transuranic waste - contains hazardous constituents and radioactive materials contaminated with greater than 100 nanocuries per gram of alpha-emitting radionuclides with atomic number greater than 92 and half-lives greater than 20 years.
- Mixed high-level waste - contains hazardous constituents as well as highly radioactive material with fission products, traces of uranium and plutonium, and other transuranic elements that result from the initial stage of chemical processing of spent nuclear fuel.

A review of some individual site treatment plans indicated that the compounding effects of secondary wastes from these primary treatment processes were not fully understood. The generation of secondary waste was one of several treatment evaluation criteria under the general category, *treatment effectiveness*, and was required to be considered in alternative assessments (3). The importance of this step is realized once the treatment of numerous waste streams begins and secondary waste from one or more treatment modules becomes competitive with primary waste streams requiring the same treatment. We will restrict our discussion to treatment of low-level mixed wastes. Selection of waste treatment technology depends on the physical form and the hazardous constituent or characteristic. With the exception of volatile species such as ^{137}Cs, radiological constituents are generally not considered important for selection of treatment technology. There is a U.S. EPA regulatory requirement to select the best available demonstrated technology for treatment based on the hazardous constituents in the waste.

The design of treatment modules identified during development of the treatment plans requires a thorough characterization of each waste stream. That is, each waste stream must be evaluated completely for physical, chemical, and radiological parameters regardless of its volume (mixed waste volumes range from a few liters to thousands of cubic meters). One obvious benefit from this evaluation is the determination of just how much of the current and projected waste is simply hazardous or low-level radioactive, and how much is truly mixed. Potentially hazardous wastes that do not exceed the hazardous waste treatment standard concentrations listed for wastes prohibited from land disposal may be shipped to and disposed of in existing permitted facilities. Likewise, low-level radioactive waste that is free of hazardous constituents or characteristics may be eligible for disposal in existing facilities licensed by the U.S. Nuclear Regulatory Commission or a host state.

TREATMENT CAPACITIES

Throughout the DOE complex, a number of permitted systems currently exist for the treatment of hazardous and toxic waste and mixed waste as well. Some of these systems represent the preferred treatment technology for mixed wastes currently stored or being generated at sites other than the host site. Consequently, where the waste streams from these other sites meet the waste acceptance criteria for existing facilities, agreements have been completed or are under negotiation for the acceptance of waste from these other sites. DOE encouraged this practice to the extent it was feasible (3), given the potential constraints of economics and acceptance by the cognizant regulatory authority. Working off the backlog of waste materials at the host site and from off-site locations then becomes a matter of coordination and scheduling.

Mixed waste to be treated on-site (whether generated on-site or from other sites) is subject to milestones included in the site specific compliance order issued by the regulatory authority with jurisdiction for that site. In establishing and then meeting these milestones, consideration must be given to the total capacity needs for any specific treatment technology (primary and secondary streams. During the review of individual site treatment plans, it was apparent that commercially available mobile or transportable treatment modules (4) would be used where possible. For a site with multiple mixed waste streams over a wide volumetric range, rigor must be applied to calculations of the total capacity of a given treatment module. This is especially true if waste stream treatment is to be carried out in parallel.

As an example, one DOE site has a total of 14 individual waste streams in the aqueous liquids/slurries waste category, but the total volume of this category is about 100 m^3, or 86,000 kg. Waste streams ranged from nickel stripping solution, blue print solution, firing range wash water, waste acid and bases, and decontamination wastewater. The preferred treatment technology for this category was physical/chemical treatment followed by recycling of treated water or discharge through a permitted National Pollutant Discharge Elimination System (NPDES) discharge point, and in either case, solidification of residuals. Due to the variety of streams in this waste category, the aqueous treatment module would require, at a minimum, the following capabilities: demusification, oil/water separation, chromium reduction, precipitation (as hydroxide or sulfide), chemical oxidation, alkaline chlorination, sedimentation, filtration, ion exchange, and carbon adsorption. Development of the detailed design or preparation of performance specifications for the aqueous treatment module requires consideration of secondary wastes generated by other treatment modules that will require subsequent treatment in the aqueous treatment module. At the example site above, secondary wastes from the combined treatment of: recoverable metals, inorganic media without arsenic, soils contaminated with chromium, cleanup and spill response residue, mercury-contaminated debris, combustible debris, inorganic metal debris, and batteries, requires 15 times the treatment capacity of waste streams in the aqueous liquids/ slurries alone.

TYPES OF SECONDARY WASTE

Secondary wastes from the primary treatment of mixed waste is a function of the total volume of waste in any given stream. A description of the variety of secondary wastes generated and the respective treatment for each is presented in Table 1. Although these example waste streams are from a single DOE site, a similar situation would be expected at any other site where the same preferred treatment technology is utilized. An example of the impact may be seen here where the required capacity for treatment of existing aqueous wastes is small compared to secondary streams from soil washing, from soft and hard debris washing, from the crusher/shredder, and from deactivation.

RADIOLOGICAL CONSIDERATIONS

From a radiological protection standpoint, special consideration must be given to the handling and processing of secondary wastes. In many instances, for example, where washing/leaching is used as the primary treatment of hazardous constituents, radioactive species may actually be concentrated in the process and thus introduce potential exposure situations that were not encountered in the ordinary health physics program prior to initiation of mixed waste treatment. Expected situations could require the use of shielding material around ion exchange columns where gamma-ray emitters (i.e., ^{137}Cs) have been stripped from aqueous solutions, and around sludge settling basins where gamma-ray emitters were precipitated during primary treatment. Concentrations of ^{3}H, ^{14}C, ^{99}Tc, ^{90}Sr, etc. in secondary streams are very likely to be significantly higher than in the original stream prior to treatment. Thus, special requirements will exist for the sampling and analysis of these secondary streams. Radionuclides mentioned above are beta emitters and are virtually impossible to characterize using in-situ techniques. The laboratory analysis of secondary stream samples will require significant resources and will require close coordination to ensure that treatment milestones are met.

Managing these secondary waste stream products will present at least some potentially new radiation exposure situations with resulting challenges for the radiation protection staff. Some considerations that will need to be made include the adequacy of training programs for members of the waste management teams and for the radiological control staff, the adequacy of protocols for sampling secondary wastes, the adequacy of and need for additional types of personnel protective equipment (gloves, shoe covers, clothing, respirators, etc.), and the adequacy of portable and installed instruments for monitoring radiation fields in work areas and the environment.

Table 1 Secondary Wastes from the Treatment of Mixed Waste

WASTE STREAM	PREFERRED TECHNOLOGY	SECONDARY WASTES	TREATMENT MODULE FOR SECONDARY WASTE
Aqueous Liquids/Slurries	physical/chemical	sludges oil/grease	stabilize/solidify incineration
Organic Liquids	incineration	ash and bags scrubber sludge	stabilize/solidify stabilize/solidify
Spent Organic Carbon	regeneration	condensed water/organics returned ashes/bags	incineration stabilize/solidify
Recoverable metals	washing/solidification	washwater washwater sludge waste metal oil/grease	aqueous treatment stabilize/solidify stabilize/solidify incineration
(1) Inorganic media w/o arsenic (2) Debris with mercury (3) Batteries	(1) stabilization (2) Acid leach/chemical precipitation (3) recycle	washwater washwater sludge	aqueous treatment stabilize/solidify
Organic Sludge/solids	incineration	ash/bags	stabilize/solidify
Soils with VOCs	incineration/stabilization	scrubber water ash/bags scrubber water sludge	aqueous treatment stabilize/solidify stabilize/solidify
(1)Soils with chromium (2)Spill response residue	(1)wash/chromium reduction/ stabilize (2) characterize/segregate/ treat	(1&2)processed waste (1&2)washwater (1&2)washwater sludge (2)oil/grease	stabilize/solidify aqueous treatment stabilize/solidify incineration
Combustible debris	physical/chemical extraction/stabilization	washwater washwater sludge	aqueous treatment stabilize/solidify
Inorganic metal debris	stabilization	separated water separated oil and grease	aqueous treatment incineration
Lab Packs	incineration/stabilization	washwater from crusher crushed waste streams washwater sludge ash/bags	aqueous treatment stabilize/solidify stabilize/solidify stabilize/solidify

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