CLASSIFICATION OF TMI WASTES

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The March 28, 1979 accident at Three Mile Island, Unit 2 (TMI-2) resulted in substantial fuel damage and subsequent contamination to the facility. One of the prime factors which needs to be considered in the cleanup of the facility is the disposal of the accident wastes and those wastes which will be generated during the cleanup operations.

In the past waste management concerns have been given only superficial consideration in reaching decisions regarding waste processing. However, the TMI-2 accident has brought waste management concerns to the forefront where they have in some cases become extremely important factors in selecting processing systems and equipment.

The proposed Low-Level Waste Management Regulation, 10 CFR 61, was published in the Federal Register on July 24, 1981. One of the most important issues addressed in the regulation is a waste classification system based on pathway evaluations. This system provides guidelines to classify wastes based on the nuclide concentrations in the wastes. Prior to that time the management of wastes had to be considered on a case-by-case basis, now these guidelines provide a basis for considering and balancing waste management and waste processing alternatives.

The 10 CFR 61 waste classification system establishes three waste categories. Class A wastes are those which have low specific activities and do not require stabilization. These wastes have radionuclide contents such that if the trench cap and the wastes deteriorate, public health and safety will not be jeopardized. The proposed regulation requires that Class A wastes be segregated from the higher activity Class B and C wastes.

Class B wastes have higher specific activities than do the Class A wastes and require stabilization. Wastes which require

Table I

10 CFR 61 Waste Classification System

Isotope	Column 1 Maximum concentration for Class A segregated waste. Above this, it is Class B stable waste $\mu Ci/cm^3$	Column 2 Concentrations above which some wastes become Class C intruder waste $\mu Ci/cm^3$	Column 3 Maximum concentration for any waste class $\mu Ci/cm^3$
Any with half-live less than 5 years	700	70,000	Theoretical maximum specific activity
H-3	40	10^8	Theoretical maximum specific activity[a]
C-14	0.8	0.8	0.8[a]
Ni-59	2.2	2.2	2.2
Co-60	700	70,000	Theoretical maximum specific activity
Ni-63	3.5	70	70
Nb-94	0.002	0.002	0.002
Sr-90	0.04	150	700
Tc-99	0.3	0.3	0.3[a]
I-129	0.008	0.008	0.008[a]
Cs-135	84	84	84
Cs-137	1.0	44	4600
Enriched Uranium	0.04	0.04	0.04
Natural or Depleted uranium	0.05	0.05	0.05
Alpha-emitting transuranic isotopes			10 nCi/g
Pu-241			350 nCi/g

[a] Near-surface disposal facilities will be limited to a specific quantity for the disposal site. This quantity will be determined at the time the license is issued and will be governed largely by the characteristics of the site. Therefore, the total activity of these isotopes in each package of waste must be shown on the shipping manifest (see §20.311 of this chapter).

Table I cont'd

For isotopes contained in metals, metal alloys, or permanently fixed on metal as contamination, the values above may be increased by a factor of ten, except natural or depleted uranium which can be the natural specific activity.

For isotopes not listed above, use the values for Sr-90 for beta emitting isotopes with little or no gamma radiation; the values for Cs-137 for beta emitting isotopes with significant gamma radiation; and the values for U-235 for alpha emitting isotopes other than radium.

Wastes containing chelating agents in concentrations greater than 0.1% are not permitted except as specifically approved by the Commission.

For mixtures of the above isotopes, the sum of ratios of an isotope concentration in waste to the concentration in the above table shall not exceed one for any waste class.

Concentrations may be averaged over volume of the package. For a 55 gallon drum, multiply the concentration limits by 200,000 to determine allowable total activity.

Until establishment and adoption of other values or criteria, the values in this table (or greater concentrations as may be approved by the Commission in particular cases) shall be used in categorizing waste for near-surface disposal.

Table II Trash, Contaminated Equipment, and Irradiated Hardware

Waste Type	Container Type	Typical Concentration Cs 137, uc/cc	Typical Concentration Sr 90, uc/cc	10 CFR 61 Class	Estimated Volume, ft^3 (b)
Trash	80 ft^3 LSA Box	0.02 (a)	0.001 (a)	A	82000-140000
Trash	55 Gal Drum	0.05 (c)	0.0025 (c)	A	48000-98000
Incinerated Trash	55 Gal Drum	0.5 (d)	0.025 (d)	A	3600-13000
Contaminated Equipment	80 ft^3 LSA Box 70 ft^3 Liner	0.05-0.3 (a)	0.002-0.02 (a)	A	18000-51000
Irradiated Hardware	80 ft^3 LSA Box	0.02 (e,g)	0.002 (e,g)	A	2700
Irradiated Hardware	70 ft^3 Liner	0.1 (f,g)	0.01 (f,g)	A	510-3300

Notes:
(a) Isotopic distribution based on GPU trash projections, packaged with VR factor of 2
(b) Reference TMI PEIS, NUREG-0683, Tables 8.49, 8.50, and 8.52
(c) Isotopic distribution based on GPU trash projections, packaged with VR factor of 5
(d) Isotopic distribution based on GPU trash projections, packaged with VR factor of 50
(e) Assumed radiation level of 200 mr/hr and 0.25 Ci/box
(f) Assumed radiation level of 1000 mr/hr and 1.25 Ci/liner
(g) Assumed 20 percent of activity to be Cs137 and 2 percent of activity to be Sr90, other isotopes assumed due to activation products

Table III Wastes from AFHB Liquids Processed by EPICOR-II System

Waste Type	Container Type	Typical Bulk Concentration Cs137, uc/cc (a)	Typical Bulk Concentration Sr90, uc/cc (a)	10 CFR 61 Class	Waste Contents per Liner, ft^3	Total Waste Volume, ft^3
EPICOR-II First Stage	50 ft^3 liner	1200	6.2 - 88 (b)	C (d)	30	2500
EPICOR-II Second Stage	50 ft^3 liner	0.097 - 18	0.35 - 11.5	B (c)	30	750
EPICOR-II Third Stage	170 ft^3 liner	0.01 - 1.5	0.093 - 6.6	B (c)	120	1200

Notes:
(a) Based on GPU calculations of estimated Sr90 and Cs137 depositions
(b) Reference GPU letter from G. Hovey (GPU) to B. Snyder (NRC), dated May 4, 1981
(c) These wastes were disposed of at an arid site at the bottom of normal trenches in a slit trench
(d) DOE has agreed to accept these wastes for research and development and disposal purposes

Table IV Wastes from SDS Processing of RB Sump and RCS

Waste Type	Container	Max Projected Bulk Conc. Cs137, uc/cc,(c)	Max Projected Bulk Conc. Sr90, uc/cc,(c)	10 CFR 61 Class	Waste Contents per Liner, ft^3	Estimated Total Waste Volume, ft^3 (c)
High Activity SDS Zeolite Liners	10 ft^3 vessel	270,000 220,000(f)	9000 (a) 7900 (f)	Above C Limits	8	180 (b)
Lower Activity Zeolite SDS Liners	10 ft^3 vessel	4500	720	C (g)	8	120 (d)
EPICOR-II First Stage	170 ft^3 liner	6 1 (f)	6 1 (f)	B	120	2400-3600
EPICOR-II Second Stage	170 ft^3 liner	6 1 (f)	6 1 (f)	B	120	600
EPICOR-II Third Stage	50 ft^3 liner	25 1 (f)	25 1 (f)	B	30	600
SDS Prefilters, 125 u and 10 u	10 ft^3 vessel	70	70	C (e)	10	250 (d)
SDS Post Filters, 0.45 u	55 Gal. Drum	5	5	B	NA	7.5 (e)
Leakage Containment Exchangers	10 ft^3 Vessel	5	5	B	8	50 (d)

Notes:
(a) Based on 2000 Ci loading from RCS processing
(b) Based on 10 liners generated from RB sump processing and 8 liners generated from RCS processing
(c) Reference Table 12, SDS SER, NUREG-0796
(d) Based on 10 liners generated from RB sump processing and 2 liners generated from RCS processing
(e) Assumes TRU activity is less than 10 nCi/gm
(f) Highest concentration as of January 25, 1982
(g) Some low activity liners may have low loadings such that these can be classified as Class B wastes

Table V Decontamination Solutions and Sludge Wastes

Waste Type	Container Type	Typical Concentration Cs137, uc/cc,(a)	Typical Concentration Sr90, uc/cc,(a)	10 CFR 61 Class	Estimated Waste Volume ft^3 (a)
AFHB Decontamination (e)	55 Gal. Drum	0.2	0.002	A	1800 - 2700
RB Decontamination (e)	55 Gal. Drum	0.2	0.002	A	1000 - 15000
RCS Decontamination Evaporator Bottoms (e)	55 Gal. Drum	30 - 90	30 - 90	B - C	4000 - 13000
RCS Decontamination Candecon Process (e)	10 ft^3 vessel	2000 - 20000	2000 - 20000	Above C Limits	10-20
AFHB Accident Sludge	55 Gal. Drum	1000 (b)	250 (b)	C	270
RB Accident Sludge (d)	55 Gal. Drum	20 (c)	20 (c)	B	180

Notes: (a) Reference TMI PEIS, NUREG-0683, Tables 8.5, 8.6, 8.10, 8.34 and 8.35
(b) Assumed isotopic distribution of 80 percent Cs 137 and 20 percent Sr 90 with 250 Ci per drum
(c) Assumed isotopic distribution of 50 percent Cs 137 and 50 percent Sr 90 with 7 Ci per drum
(d) Assumes the TRU activity is less than 10 nCi/gm
(e) If chelating agents are present additional disposal restrictions may apply

stabilization could be solidified into a monolithic mass or be placed in a high integrity container which would provide measures to assure trench cap stability and a degree of immobilization of the radionuclides.

Class C wastes have higher activities than do the Class B wastes. These wastes require both stabilization and burial with an intruder barrier. An intruder barrier provides isolation of the wastes from potential surface activities of inadvertent intruders following loss of institutional control of the site. Examples of potential surface activities would include farming or housing construction over a burial trench.

For wastes having isotopic concentrations which exceed the Class C limits, a case-by-case evaluation would be required in order to assess the limiting conditions for disposal. This evaluation would consider the proposed disposal site characteristics and operational procedures to be used. If the evaluation results show that the wastes are unacceptable for near surface disposal other disposal alternatives including disposal in a high-level waste repository would need to be considered.

Table I provides the Class A, B, and C waste classification system limits for radioisotopes of principal concern. These limits have been used to classify wastes from TMI-2 in Tables II through V. Waste streams evaluated include wastes currently existing, wastes planned to be generated, and wastes from selected processing alternatives. The characteristics of the TMI-2 wastes have been estimated based on data provided by the licensee to the NRC, in the TMI-2 Programmatic Environmental Impact Statement (PEIS) (NUREG-0683) and in the Safety Evaluation Report (SER) for the Submerged Demineralizer System (SDS) (NUREG-0796.)

Since Cs-137 and Sr-90 are the long-lived nuclides of concern, the TMI-2 waste classification is primarily based on concentration data for these nuclides. Tritium has been neglected since the activities in the TMI-2 raw wastes are less than 1 uc/cc and it is not anticipated that processing techniques which concentrate tritium will be used. Activation products like Co-60 have been detected in low concentrations because TMI-2 had only been operating for approximately 3 full power months prior to the accident. The activities of Co-60 in the wastes are expected to be much less than that Class A limit of 700 uc/cc (20 Ci/ft^3). It is expected that the Reactor Coolant System (RCS), Reactor Building (RB) sump liquids, the RB sludge and the SDS prefilters may contain fuel debris and, therefore, have TRU contents exceeding 10 nc/gm. Uranium concentrations in wastes processed from the RCS, RB sump liquids and RB sludge may also exceed Class C limits.

Table II presents the classification of trash, contaminated equipment, and irradiated components. These wastes are all expected to be Class A. Note, however, that if combustible trash is incinerated, the typical Sr-90 concentrations of the ash are lower than the Class A limit by less than a factor of 2. The nuclide data is based primarily on the AFHB trash data. It is recognized that the concentrations of the wastes may be variable and might exceed projected levels as well as Class A limits. Most of the trash, however, is expected to be at or below the typical concentrations presented.

The EPICOR-II wastes from AFHB cleanup are classified in Table III. The first stage wastes contain most of the radioactivity and are above the Class B limits for the Cs-137 concentration and in the range of the Class C limits for the Sr-90 concentration. These wastes, therefore, would be considered to be Class C requiring stabilization and an intruder barrier for commercial land disposal. However, due to the high specific activity loading on organic resins, non-routine waste conditions could be present. The Department of Energy (DOE) is investigating the condition of an EPICOR-II first stage liner and plans a similar program on a second liner and has agreed to accept these wastes for research and development and disposal purposes.

The second and third stage EPICOR-II liners contain levels of Cs-137 and Sr-90 greater than the Class B limit and less than the Class C maxima. Once 10 CFR 61 becomes effective such wastes would require stabilization. However, these wastes are somewhat similar to resin wastes from other nuclear power plants and, to compensate for not requiring stabilization at this time, these wastes, in a dewatered form, were buried at an arid site (Hanford) in a manner which provides both stability and an intruder barrier. Specifically, the wastes were placed in a slit trench at the bottom of a normal trench, and were backfilled with soil, on top of which are drums of solidified wastes. The disposal procedure, therefore, is judged to be essentially consistent with the proposed 10 CFR 61.

As shown in Table IV the SDS has produced high activity zeolite wastes which exceed the Class B limits for both Cs-137 and Sr-90. These wastes will be used by DOE in waste management research and development programs. In addition some lower activity zeolite wastes are projected which should be suitable for handling as Class B wastes. A modified EPICOR-II System has been used as a polisher following treatment in the zeolite beds. The wastes generated by the modified EPICOR-II are estimated to be Class B and are being disposed of at the bottom of the waste trench at an arid site.

The SDS prefilters will collect particulates from the liquids prior to entering the zeolite beds. These prefilters are estimated to be Class C wastes although it is expected that fuel debris might be present and the TRU content might exceed 10 nc/gm. The Licensee's sampling program will determine the TRU content in the waste streams being processed. It is expected that DOE will accept these wastes for research and development purposes. Post filters and leakage containment ion exchange vessels are expected to be Class B wastes.

Decontamination wastes and sludges are characterized and classified in Table V. Decontamination operations in the AFHB have provided liquids which were solidified using vinyl ester styrene. These wastes had low activities and were disposed of with the trash wastes. These wastes and others expected to be generated in the AFHB decontamination are Class A. Decontamination of the RB is also expected to generate solutions which would produce Class A wastes. If chelating agents are used, however, as part of any chemical solutions, some additional disposal restrictions may be required depending on the chelating agent concentrations and total quantities. The proposed 10 CFR 61 specifies that wastes containing greater than 0.1 percent chelating agents require NRC approval for disposal.

Processes for treating solutions from decontamination of the Reactor Coolant System (RCS) have not been selected. If a solution similar to DOW NS-1 is used and is evaporated the wastes could be either Class B or C depending on the effectiveness of the treatment and the total activity present. If the Can-Decon process is used with zeolite ion exchange beds, wastes could be produced which exceed the Class C limits.

Sludge in the AFHB sumps has a high activity and would be classified as a Class C waste. Sludge removed from the RB sump is, however, expected to have much longer activities and is expected to be a Class B waste based on the Cs-137 and Sr-90 concentrations. However, it is expected that fuel debris or particles are present in the RB sludge and will result in the wastes exceeding the 10 nc/gm TRU limit.

Conclusion

The cleanup of TMI-2 will produce a wide variety of waste types. Based on the proposed 10 CFR 61 waste classification system these wastes will primarily fall in Classes A, B, and C. However, a limited quantity of the wastes will exceed the Class C limits. DOE has agreed to accept the high activity and unusual wastes for research and development studies and disposal.