WMA-TR-1
Revision 0

VALUE/IMPACT ASSESSMENT
OF
TMI-2 RESIN SOLIDIFICATION

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1. INTRODUCTION

1.1 Task Statement

This report has been prepared to serve as a basis for a decision as to whether demineralizer resins used in cleanup of radioactive fission product contaminated water resulting from the TMI-2 accident of March 28, 1979, should be solidified prior to shipment, as an alternative to disposal in normal dewatered form. As such, this report is presented as a value/impact assessment, wherein all factors pertinent to the decision are assembled and evaluated. Both quantitative and qualitative factors are taken into account, and are designated as "values" (those considered to be beneficial) or "impacts" (detrimental aspects) relative to a decision to solidify resins.

1.2 Definition of Solidification

The term "solidification", as applied herein, refers to the use of state-of-the-art processes to encapsulate TMI-2 spent resins in a free standing monolithic solid form. Units of solidified resins thus produced would be stored, transported and ultimately buried within the steel containers, or "liners", in which they are initially formed. By definition, the solidified liners must contain no free liquid.

Although the solidification media used in a specific application may have some inherent shielding and leach resistance characteristics,these vary depending upon the specific media employed, the physical and chemical characteristics of the material solidified, mixing ratios, and other factors. Therefore, shielding and leach resistance characteristics are not established as criteria for the solidification process. It is assumed that, whether TMI-2 resin is disposed of in solidified or dewatered form, adequate external shielding will be applied during storage, handling and transportation and that the material will be packaged in a manner consistent with existing burial facility requirements and applicable regulations.

In this report, where necessary for estimating or assessment purposes, it has been assumed arbitrarily that concrete solidification methods would be used. Appendix A.2 describes the details of these assumptions. Optimization of solidification methods has not been addressed and would be done only if solidification were to become a requirement.

1.3 Approach

This assessment considers a number of issues associated with resin solidification. Evaluation of these issues are presented in Section 3, wherein they are individually addressed in terms of their influences on:

(a) TMI plant workers and general public near the plant.

(b) Transportation crews and general public along transport routes.

(c) Burial ground workers and general public near the burial ground.

(d) Met-Ed/GPU customers and stockholders.

As part of the assessment, an estimate of the quantity of waste resins resulting from TMI-2 cleanup has been developed using the best information available at the time of writing. The actual quantities will not be known until processing is commenced for each source of contaminated water. However, this is not a serious limitation of the assessment since the results should be viewed on a relative basis, that is, solidified versus dewatered resin.

In order to establish a range of values and impacts which would result from a requirement to solidify resins a case study has been conducted. The approach has been to define a family of cases which will bound the number of shipments of solidified resin compared with an expected number of dewatered resin shipments, since the number of shipments is a reasonable quantitative index for evaluating handling as well as transporting.

Thus, three cases have been defined which are a reference (best current estimate, but not necessarily optimum) case, a case which results in an upper bound on the number of solidified shipments, and a case that results in a lower bound on shipments. These are described in Section 4.

The results of this assessment are summarized in Section 2. The remainder of the report provides the basis for the results of Section 2.

2. EXECUTIVE SUMMARY

Solidification of TMI-2 spent resins would involve installation of separate and additional processing subsystems to both the Epicor and Submerged Demineralizer Systems. By nature, such solidification processes are complex, involving remote handling equipment and instrumentation, precise measuring requirements, mixing equipment and the like. For the TMI-2 application, the solidification equipment would have to be designed for operation and maintenance in a high radioactivity environment. Also, solidification of TMI-2 spent resins would substantially increase the number of resin vessels to be handled, shipped and buried.

A decision as to whether solidification of TMI-2 spent resins is warranted (in lieu of shipment and disposal in the dewatered form as currently accepted for radioactive spent resins) requires consideration of a variety of factors. A requirement to solidify TMI-2 resins would have assorted consequences, both "values" (beneficial effects) and "impacts" (detrimental effects), on various population groups. In this report those aspects of a solidification requirement, or "issues" as they are called herein, which have potential consequence have been identified and evaluated individually (see Section 3) and then assessed comparatively. The comparative assessment of the values and impacts associated with resin solidification is presented, in summary form, on Table 2-1.

Table 2-1 lists ten issues, and in each case displays its consequences (values or impacts) in terms of radiological and non-radiological health and safety, public relations, and financial effects. The bases for the values and impacts assigned in each case are presented in the individual Value/Impact Assessment Sheets in Section 3, and in subsequent backup material in this report.

From Table 2-1, three major points are evident:

(1) Of the ten issues addressed only one would appear to be of potentially significant value. That is the public relations value associated the radiological consequences of a transportation accident (Value/Impact Assessment Sheet 6). This item is particularly difficult to assess, relative to the other factors, because it is largely an emotional issue rooted in perceived rather than actual risk. Transportation of dewatered resins in NRC certified shipping containers is considered to be completely adequate from a radiological health and safety standpoint. However, the shipment of this material in solidified form may seem to the general public to be a major safety improvement and, therefore, may have significant public relations value.

(2) Regarding the overall radiological health and safety implications of solidification, the very slight (if any) decrease in risk of exposure as a result of transportation accidents is much overshadowed by the expected occupational exposures associated with the onsite solidification process. Since an actual solidification system has not been designed, this is a judgement factor, but the very nature of the solidification process along with the large quantities and high radioactivity of the TMI-2 resins to be treated strongly indicate that significant occupational exposures will be unavoidable.

(3) The additional financial cost and delay (which itself represents both financial cost and some radiological risk) which would be associated with a requirement to solidify TMI resins, are significant impacts.

In summary, the values and impacts addressed herein include a mixture of health and safety, financial, and sociological implications. These questions have been identified, quantified where possible, evaluated individually, and displayed for comparative assessment.

TABLE 1
TMI-2 VALUE/IMPACT ASSESSMENT
SOLIDIFICATION OF WASTE RESINS
(RELATIVE TO HANDLING, SHIPMENT & DISPOSAL
IN DEWATERED FORM)

No.	Issue	Radiological Health & Safety	Non-Radiological Health & Safety	Public Relations	$ Cost	Comments
1	Occupational Exposure During Solidification	Impact	-	-	-	Significant factor in decision
2	Solidification Accident Radiological Hazard	Slight Impact	-	-	-	Insignificant
3	Processing Delay	Slight Impact	-	-	Impact	Items 3 and 4 together represent potentially major cost
4	On-Site Solidification Costs	-	-	-	Impact	
5	Accident-Free Transportation Exposures	-	-	-	-	No value or impact
6	Transportation accident radiological hazard	Very slight value	-	Value	-	Radiological consequences judged extremely low based on use of approved cask
7	Transportation accident non-radiological hazards	-	Slight Impact	-	-	Insignificant
8	Off-Site Costs	-	-	-	Impact	Should not control decision
9	Occupational exposures at burial ground	Indeterminant	-	-	-	Insignificant
10	Fission product migration in ground	Possible value, undefined	-	Value	-	Generic disposal issue, affecting all radwaste; leach resistance not a solidification criterion
Summary of Values and Impacts		Radiological impacts (occupational exposure) far exceed radiological values	Insignificant	PR values may be significant. Primarily, they lie in uninformed public perception of risk rather than actual risk.	Cumulative costs of 3, 4 and 8 estimated at $5-10 million, potentially greater.	

3. VALUE/IMPACT ASSESSMENTS

The value/impact issues addressed herein are tabulated in Table 3-1, of this section. The potential value or impact associated with each, is based on assessments presented in this Section. Each assessment, on the following pages, relates to a specific phase of the operation; at the TMI site, during transportation to the burial facility, and at the burial site. The population groups potentially affected by a decision to solidify TMI wastes are considered to be those in the TMI site area, along the transportation route, at the burial ground and, the Met-Ed/GPU customers and stockholders.

Evaluations are provided with backup, where appropriate, by material in Appendices or by reference to published documents. The value/impact assessment sheets are summarized on Table 2-1 of Section 2.

TABLE 3-1

INDEX OF VALUE ASSESSMENT SHEETS

No.	Issue
1	Potential for increased occupational exposure during onsite solidification process.
2	Potential of increased radiological hazard resulting from accident or upset conditions during onsite solidification process.
3	Delay in processing existing radioactive water in TMI-2 Containment Building.
4	Increased expenditures associated with installation and operation of solidification system.
5	Potential for improved (decreased) radiological hazards associated with accident-free transportation of solidified resins.
6	Potential for improved (reduced) radiological consequences of transportation accidents.
7	Increased risk of non-radiological consequences of transportation accidents, associated with shipment of solidified resins.
8	Increased costs of shipment and disposal of solidified resins.

TABLE 3-1

INDEX OF VALUE ASSESSMENT SHEETS
(Continued)

No.	Issue
9	Potential for increases or decreases to occupational exposures of burial ground workers in handling solidified resin packages.
10	Potential for decreased migration of fission products, to the environs, from solidified wastes packages.

VALUE/IMPACT ASSESSMENT SHEET

Phase of Operation

At TMI Site

Statement of Issue

Increased handling and treatment of resins during the solidification process may increase the occupational exposure to onsite operators and maintenance personnel.

Affected Population

TMI plant workers and general public near the plant.

Evaluation

By the nature of the material to be solidified (i.e., highly radioactive spent resin), it is clear that the additional handling and processing required to solidify the material will result in some exposure to operators. Initial analyses show a dose increase to personnel of three to five if solidification is required. The total increase in exposure is in the range of 35 to 130 Person-REM.

Reference

Appendix A.6, this report.

Summary Assessment

The above personnel exposure is considered to be a significant impact associated with resin solidification.

VALUE/IMPACT ASSESSMENT SHEET

Phase of Operation

At TMI Site

Statement of Issue

The additional handling and solidification system operation may increase the probability of local radioactivity release and/or contamination, as a result of accident or upset conditions.

Affected Population

TMI plant workers and general public near the plant.

Evaluation

It is difficult to postulate any accident conditions associated with the resin solidification system, which could transport substantial amounts of radioactivity beyond the site boundaries. During the process virtually all of the radioactivity would be entrained on the resin beads. Reasonably conceivable accidents include, breech of system integrity (ruptures, spills, improper lineups, etc.) which have essentially no potential for energetic release of radioactive materials.

Reference

Proposed handling techniques for Epicor and SDS systems.

Summary Assessment

With proper procedures and operation, this should not be a significant impact. It is observed that costs and complexity will increase as more precautionary measures are built into the solidification system to minimize the chances of a spill.

VALUE/IMPACT ASSESSMENT SHEET

Phase of Operation

At TMI Site

Statement of Issue

A development program will be required to demonstrate resin solidification compatible with the submerged demineralizer system. Completion of this program may delay processing of Containment Building water.

Affected Population

TMI plant workers and general public near the plant.

Evaluation

Because of the unique nature of the submerged demineralizer system, combined with the very high radiation levels involved (contact dose rates estimated at several tens of thousand R/hr.), development and demonstration of a special solidification system represents a complex engineering and design problem. This is likely to delay processing of Containment Building water by three to six months or longer.

Summary Assessment

Delay in processing Containment Building water is considered to be a significant impact for two reasosn:

A. Retaining the large volume (600,000 gals) of radioactive water in an unprocessed liquid form is undesirable because the fission products are more suseptible to dispersion than it is in a reconcentrated form.

VALUE/IMPACT ASSESSMENT SHEET
(Continued)

B. Processing of Containment Building water is on the Critical Path Schedule for TMI-2 recovery. Delay in processing of the water therefore represents potential delay in recovery of the unit with attendant severe cost impact.

VALUE/IMPACT ASSESSMENT SHEET

Phase of Operation

At TMI Site

Statement of Issue

A requiremennt to solidify resins will result in increased capital and operating expenditures.

Affected Population

Met-Ed/GPU customers and stockholders.

Evaluation

The cost of a resin solidification system for this application, while not known with precision, is expected to be high, in the range of two to four million dollars. This estimated expense, represents a cost of 200 to 300% over current projections and includes installation, testing and operating costs over a period of several years.

> NOTE - This estimated expenditure is not based on detailed evaluation of any existing system, but rather as the author's judgement, taking into account the difficulties of handling highly radioactive materials.

Reference

Appendix A.2, this report

Summary Assessment

The above expenditure, while not large by comparison with overall TMI-2 recovery costs, is nonetheless significant. This issue also represents some additional financial risk, in the sense that its costs cannot be well-defined, and could exceed the above estimated range by a significant amount.

VALUE/IMPACT ASSESSMENT SHEET

Phase of Operation

During transport from TMI to Burial Facility.

Statement of Issue

Solidification of resins prior to shipment may alter radiological exposures received during accident-free transport to the burial site.

Affected Population

Transportation crews and general public along transport routes.

Evaluation

Solidification of resins at TMI will result in an increase in the overall number of shipments. The external dose rate of each package (shielded cask enclosing resin liner) will be maintained at the very low levels required by transportation regulations.

Studies by Sandia Laboratories, as referenced below, have concluded that the radiological effects of transport of radioactive material are minimal. The additional shipments from TMI-2 which would result from a requirement to solidify spent resins, represents an approximate doubling of risk, however this would not materially affect the Sandia Study conclusions because the absolute risk is very low.

Reference

Sandia 77-1927 "Transportation of Radioactive Materials near High Population Areas" (Draft Report)

NUREG-0170, "Final Environmental Statement on the Transportation of Radioactive Material by Air and Other Modes", December, 1977.

VALUE/IMPACT ASSESSMENT SHEET
continued

Summary Assessment

No significant value or impact associated with this issue.

VALUE/IMPACT ASSESSMENT SHEET

Phase of Operation

During transport from TMI to Burial Facility.

Statement of Issue

Radiological consequences of transportation accidents may be decreased if material is shipped in a solidified form.

Affected Population

Transportation crews and general public along transport routes.

Evaluation

Highly radioactive expended resins from TMI-2, whether in solidified or dewatered form, will be shipped in sealed steel liners enclosed in NRC approved type B casks*, qualified and demonstrated to retain their integrity under the most severe accident conditions. These casks have been considered to be adequate by NRC and DOT for protection of all shippable forms and activity levels of radioactive materials including spent fuel. If employed for TMI-2 shipments, this packaging will ensure that the probability of release of radioactive material as a result of a transportation accident, is extremely low. This conclusion is supported by NUREG-0112 (see reference, below).

Based on use of the above shipment system, the radiological consequences of a transportation accident have been accepted generically to be extremely

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*This report is not intended to address shipments of LSA or other low level radioactive waste which may be shipped in transportation casks other than Type B in accordance with applicable regulations.

VALUE/IMPACT ASSESSMENT SHEET
(Continued)

low, and can be considered to be so for TMI-2 spent resins, irrespective of whether the resins are in dewatered or solidified form. Relative to the overall transportation risk, the incremental risk associated with changes to the number of shipments or the form of the shipped material is considered to be minor.

Reference

NUREG-0112 "Final Supplement to the Final Environmental Statement, TMI-2" December, 1979, Page 5-12, Table 5.8.

Summary Assessment

Solidification of TMI-2 resins represents very slight (or perhaps no) value, in terms of radiological consequence of transportation accidents. It may represent some public relations value in terms of uninformed perception of reduced risk.

VALUE/IMPACT ASSESSMENT SHEET

Phase of Operation

During transport from TMI to Burial Facility.

Statement of Issue

The non-radioactive consequences of transportation accidents may be increased if material is shipped in a solidified form.

Affected Population

Transportation crews and general public along transport routes.

Evaluation

Requirement to solidify TMI-2 resins would result in an increase to the total number of shipments required from the site. Presuming that the risk of transportation accident consequences (physical injury or death to truck crew or bystanders) is proportional to the number of shipments, such a requirement would increase overall risk.

The increment, however, is slight. The Final Environmental Statement on Transportation of Radioactive Materials (NUREG-0170) evaluates the non-radiological risk to the driver of an exclusive-use vehicle transporting radioactive material. The major contribution to the evaluation was the transport of cold, spent fuel to and from nuclear plants, but other shipments, such as radiopharmaceutical, were included. The non-radiological risk was less than one fatality in every five years. The increased number of shipments resulting from the requirement to solidify TMI-2 resins is small compared with the total number of shipments considered in the evaluation.

Reference

NUREG-0170 (See Value/Impact Assessment Sheet 5)

VALUE/IMPACT ASSESSMENT SHEET
(Continued)

Summary Assessment

There is a slight impact associated with the issue, which should have little bearing on a decision.

VALUE/IMPACT ASSESSMENT SHEET

Phase of Operation

During transport from TMI to Burial Facility and at Burial Facility.

Statement of Issue

There will be increased financial costs associated with transportation and burial of spent resins, if a requirement to solidify spent resins is imposed.

Affected Population

Met-Ed/GPU customers and stockholders.

Evaluation

A requirement to solidify resins would result in an increase in the total number of shipments required from TMI site to the burial facility. This increased number of shipments will increase both transportation and burial costs, and will lengthen overall shipment schedule. The cost effect is estimated to be an increase of 1.5 to 2.0 times the base transportation/burial costs.* Depending on cask availability the cost increase could be several million dollars, and the schedule extension could be two years or more.

Reference

Tables A-3 and A-4, Appendix A.4, this report.

Summary Assessment

The cost impact, while not large relative to overall TMI-2 recovery cost, is significant.

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*It should be noted that burial costs used in this assessment have been estimated since actual fees have not been contractually established.

VALUE/IMPACT ASSESSMENT SHEET

Phase of Operation

At Burial Ground.

Statement of Issue

The occupational dose to burial ground workers may change as a result of solidifying TMI-2 resins.

Affected Population

Burial ground workers and general public near the burial ground.

Evaluation

The increased number of shipments asociated with a requirement to solidify TMI-2 spent resins would directly increase the amount of handling of packages for burial at the burial facility. On the other hand, in Appendix A.7 it is concluded that solidification can result in as much as a factor of ten reduction in liner surface dose rates for the higher activity level (SDS) resins. Surface dose rates, however, would still be on the order thousands of R/hr and, therefore, handling, appropriate for elevated radiation levels, would be required at the burial ground in either case.

While it is difficult to quantify the net effect of these two factors (increased number of handling steps vs. decreased dose rate, per unit) they are, to some extent at least, compensating effects. It is further assumed that controls and regulations at the burial grounds would effectively limit operator exposures to acceptable levels.

VALUE/IMPACT ASSESSMENT SHEET
(Continued)

Reference

Appendix A.7, this report.

Summary Assessment

This issue is not considered to be value or an impact, pertinent to a decision regarding solidification.

VALUE/IMPACT ASSESSMENT SHEET

Phase of Operation

At Burial Ground.

Statement of Issue

Solidification of resins may reduce migration rate of fission products at the burial grounds.

Affected Population

Burial ground workers and general public near the burial ground.

Evaluation

Leach resistance is not a criterion for resin solidification (Section 1.2). Furthermore, it is not clear that solidification would reduce leach rate compared with dewatered resin. Existing studies have shown that unsolidified dewatered resins have good retention characteristics comparable to other non-resin encapsulation (e.g., fission products in concrete). In any event, since there are considerable amounts of dewatered non-solidified resin already at the burial grounds, the contribution of TMI wastes constitutes a small part of the total, and the issue becomes a generic one. Therefore, the question of value from solidification of resins, should be answered on a generic basis and not with respect to the single case of TMI-2.

Reference

"Radioactive Waste Disposal, Low and High Level", Edited by W. R. Gilmore, Noyes Data Corportation, 1977, pp. 83, 84 (references BNL-21571)

VALUE/IMPACT ASSESSMENT SHEET
continued

Summary Assessment

With respect to TMI resins, there is no value associated with solidification as a means to reduce migration of fission products at the burial site.

4. CASE DEFINITION

Table 4-1 tabulates major case parameters of the three cases (and Table 4-2 is a summary of the resultant resin shipments in each case.) The bases for quantities contained in this table are in the Appendices. A brief definition of each case is given below followed by a discussion of the tabulated parameters in Section 4.4.

4.1 Case 1, Reference Case, Dewatered Resin

The first case represents current planning and complies with existing regulations. Resins will be dewatered and shipped in liners which are placed in casks for shipment.

4.2 Case 2, Study Case, Solidified Resin, Upper Bound on Shipments

The second case, solidification, assumes that the curie loading per unit volume of the resin is the same as the reference case. This case represents a upper value for the number of shipments and results in less resin and fewer curies per shipment. It is assumed that the Epicor and in-plant resins will require a new system for solidification and that equal parts resin and concrete will be mixed. The submerged demineralizer system (SDS), which has not yet been constructed, would require additional design features to allow solidification. For SDS resins, it is assumed that mixing will occur in the vessel in which the resin is operated. Additional margin will be required to ensure thorough mixing and one part resin to two parts concrete has been assumed. These solidification system assumptions are discussed in more detail in Appendix A.2.

4.3 Case 3, Study Case, Solidified Resin, Lower Bound on Shipments

The third case, also solidification, assumes that the curie loading per unit volume of the Epicor 2 and SDS can be doubled, thus minimizing the quantity of resin that would be used and likewise the number of shipments.

Such doubling is not feasible for the Epicor 1 and in-plant resins since they have already been used. Assumptions with regard to resin/concrete ratios are the same as for Case 2.

TABLE 4-1

MAJOR CASE PARAMETERS

Case & Resin Source	1. Total Vol. (ft^3)	2. Cask Contents (ft^3)	3. Cask (see text Section 4.3)	4. Activity Per Cask ($Ci\ Cs^{137}$ + noted)	5. No. Casks	6. No. Shipment/ Overweight
CASE 1						
In-Plant	1600	50	Y	150*	34	34/yes
Epicor 1	1500	145	X	5 plus 4 $CiCo^{60}$	11	11/no
Epicor 2	950	50	Y	200	19	19/yes
	1100	180	X	-	6	6/yes
SDS	600	10	Z	40,000	60	30/no
CASE 2						
In-Plant	3200	50	Y	75	68	68/yes
Epicor 1	3000	180	X	2.5 plus 2 $CiCo^{60}$	17	17/yes
Epicor 2	1900	50	Y	100	38	38/yes
	2200	180	X	-	12	12/yes
SDS	1800	10	Z	13,300	180	90/no
CASE 3						
In-Plant	3200	50	Y	same as Case 2	68	68/yes
Epicor 1	3000	180	X	same as Case 2	17	17/yes
Epicor 2	950	50	Y	200	19	19/yes
	1100	180	X	-	6	6/yes
SDS	900	10	Z	26,700	90	45/no

[illegible] and post-accident activities, estimated Cs^{137} equivalent

TABLE 4-2

SUMMARY OF

SCOPING ESTIMATES OF

RESIN SHIPMENTS

Source	Reference Case Dewatered Resin	Upper Bound Case Solidified Resin	Lower Bound Case Solidified Resin
In-Plant	34	68	68
Epicor 1	11	17	17
Epicor 2	25	50	25
SDS	30	90	45
TOTAL	100	225	155
Increase Factor	-	2.3	1.6

4.4 Table 4-1 Parameters

This section provides discussion of the information contained in Table 4-1 in the order of the columns in the table.

Total Volume (Table 4-1, Column 1)

The basis for the reference case volumes is presented in Appendix A.1 and represents either actual or design basis for the various sources. In Case 2, In-plant, Epicor 1 and Epicor 2 volumes are doubled; SDS volumes are increased threefold, consistent with previously stated assumptions. Case 3 volumes for In-plant and Epicor 1 resins are the same as Case 2 because the resins have already been loaded with basically all the activity they will acquire. Epicor 2 and SDS volumes are reduced by one-half from Case 2 because the curie loading per cubic foot is assumed to be twice the Case 2 value. The activity loading and the resin-to-concrete ratio are the two controlling factors for the volume of material generated.

Cask Contents (Table 4-1, Column 2)

Cask "liners" for TMI have been standardized as 50, 180 and 10 cubic feet and, as such, are the basis for this anaylsis. The bases for selecting liner size are beyond the scope of this report. The choices of which liner to use for a specific application is controlled by anticipated radiation levels and the available shipping casks. The volume of 145 cubic feet shown for Epicor 1 utilizes a 180 cubic foot liner which is assumed to be only partially filled to avoid the 80,000 lb. overweight load limit. Epicor 1 solidification cases were switched to 180 cubic feet payloads, resulting in overweight shipments because this will considerably reduce the total number of shipments relative to underweight shipments.

Cask Selection (Table 4-1, Column 3)

Cask identification and selection is discussed in Appendix A.3. Cask assignment does not change from Case 1 because it is not expected that the liner surface dose rates will be reduced by more than one order of magnitude (see Appendix A.6) and thus, liner volumes and cask selection are unaffected.

Activity Per Cask (Table 4-1, Column 4)

The activity per cask has been stated primarily for Cs-137, the principal isotope of concern because of its abundance, long half life, and gamma energy. For purposes here, this can be taken as also including Cs-134. With Epicor 1, analysis has shown that Co-58 and Co-60 are present in magnitude comparable to the cesium. The additional sources of activity are included in this case.

The activity contents for Cases 2 and 3 follow from the definitions of the cases themselves.

Number of Casks (Table 4-1, Column 5)

The number of casks required was determined by dividing the total volume by the cask contents volume. Rounding the result upwards was followed when the residual was 0.3 or greater.

Number of Shipments/Overweight (Table 4-1, Column 6)

The SDS system basis is two casks per shipment. All others utilize one cask per shipment. Overweight shipments are also indicated in this column and only Epicor 1 resin solidification has resulted in a change to an overweight condition. The overweight condition cannot be avoided if significant payload is to be shipped when the higher density solidified material is used.

APPENDIX A.1

Sources, Activities and Volumes of Resin

Estimated quantities of resin are shown in Table A-1. A twenty percent contingency has been added. The basis for volumes, shipping quantities and activities are discussed below.

In-Plant Resins - The volumes shown are for the actual volumes of various in-plant resin beds. Detailed knowledge of activity of these beds is not available at this writing because the degree of post-accident operation of their systems is not well known. It has been estimated that the activity is about 3 Curies per cubic foot. What is important is that activity as low as one-half Curie per cubic foot would require shipping in 50 cubic foot liners, which is the assumption shown in Table 3. This results from cask limitations; discussed later. These assumptions result in a conservatively large number of shipments.

Epicor 1 - The volumes shown are existing spent resin beds. The curie content as shown in Table 3 represents the worst case analysis of the seven beds. This resin is of sufficiently low activity to be shipped in large volumes. The choice of 145 or 180 cubic feet shown in Table 3 is a decision on whether to ship overweight, the lower number representing a non-overweight shipment.

The Epicor 1 system also has two charcoal beds which have been omitted from this analysis. It is assumed that these will be retained on site for sufficient decay of I-131 to allow their shipment as LSA material and thus solidification would not be required. Another reason for not considering the charcoal is that the scope of the study has been stated as applicable to resins.

Epicor 2 - The estimate of Epicor 2 resin volume is from the system design basis. The smaller liners are for the higher activity front end demineralizers and will contain activity sufficiently high to require 50 cubic foot packaging. The 180 cubic foot liners are for the polishing beds which will have lower activity levels. It has been assumed that for the larger liners, overweight shipments would be used to minimize the number. Charcoal beds have not been considered for the same reasons discussed above.

Submerged Demineralizer System (SDS) - The Table 3 values of the number, volume and curie loading of the resin beds is the design basis for the systems. (Reference Chem-Nuclear Proposal).

TABLE A-1

SOURCE OF RESINS

Location	Number of Beds	Volume ft^3	Total	Total w/20% Contingency
In-Plant				
Spent Resin Tank B	1	350	350	420
Spent Resin Tank A	1	150	150	180
Make Up Demin	2	50	100	120
Cond. Demin	4	160	640	770
Spent Fuel Demin	1	20	20	30
Reactor Coolant Demin	2	20	40	50
Clean Up Demin	1	20	20	30
				1600
Epicor 1	7	180	1260	1500
Epicor 2	16	50	800	950
	5	180	900	1100
SDS	50	10	500	600

APPENDIX A.2

Solidification System Assumptions

In order to assess the value/impact of solidifying resins at TMI-2, the following was assumed:

Solidification Agent:

Cement was selected as the solidification agent for this analysis. This selection was based upon the positive experience of solidifying resins with cement at other utilities' reactor facilities. While a specific system was not developed for this analysis, it is believed that one can be selected and utilized within the bounds of this analysis.

Solidification Systems:

The system designs assumed for this analysis are split into two categories: that needed for the In-Plant, Epicor 1 and Epicor 2 resins and that needed for SDS resins. Both systems are generally assumed to be temporary, perhaps portable, and operated in an environmentally acceptable enclosure.

In-Plant:

The resins, currently being held in existing TMI-2 demineralizers and storage tanks, will be transferred via existing plant systems, to a point where they can be removed to a temporary system. For solidifying the In-Plant resins, the temporary system will utilize 50 ft^3 liners with in-liner mixing. The resins will be sluiced into the liner and dewatered to 10% free water by volume, the cement will be added in a 1:1 ratio to the resin, the contents will be thoroughly mixed, and, after curing, the liner will be placed in storage or shipped off site for burial. The radiation exposure associated with this operation is presented in Appendix A.6. The costs associated with this operation are estimated at $2 million over two years in a service contract which would be in addition to existing contracts.

Epicor 1 and Epicor 2

The resins used in Epicor 1 and Epicor 2 operations will have been placed in storage in either the temporary or interim facility at TMI. Liner by liner, the spent resin will be retrieved from storage and brought to the temporary resin solidification system. The resin will be sluiced from its liner into a liner of equal size with in-liner mixing, and dewatered to 10% free water by volume. The cement will be added in a 1:1 ratio to the resin, the contents will be thoroughly mixed, and, after curing, the liner will be placed in storage or shipped off site for burial. The radiation exposure associated with this operation is presented in Appendix A.6. The system used for Epicor 1 and Epicor 2 resins is the same system used for the In-Plant resins and is covered by that cost estimate.

SDS

If it is decided that the TMI-2 resins will be solidified, the SDS resin liners will be provided with in-liner mixing and connections for adding cement. The resin liners will be dewatered, removed from service, placed in a shielded cask. Cement, in a 2:1 ratio to the resin will be added with sufficient water and the entire contents will be thoroughly mixed. After curing, the liner will be placed in storage or shipped off site for burial. The radiation exposure associated with this operation is presented in Appendix A.6. The costs associated with this system are estimated at $1 million as a service contract as part of SDS operation.

TABLE A-2

CASK DATA SUMMARY (NUREG-0383, Revision 1, Nov. '78)

DESIGNATION	CASK X	CASK Y		CASK Z
Owner	Chem-Nuclear	TVA	Chem-Nuclear	Chem-Nuclear
Model No.	CNSI-14-195H	LL-60-150	LL-50-100	CNS-1-13C
Certificate No./ Expiration Date	9094/Feb. 28, 1983	6568/Oct. 21, 1981	6601/Aug. 31, 1979	9081/July 31, 1982
Cavity Dimensions (in.)	Diameter - 77 Height - 80 1/8	Diameter - 72 (approx.) Height - 75 (approx.)	Diameter - 62 Height - 75	Diameter - 26 1/2 Height - 54
Shielding (in. Pb)	2 3/16	3 1/2	4 1/2 (equivalent)	5
Empty Wt. (lb.)	56,500	63,000	54,000	26,000
Max. Payload (lb.)	17,700	10,000	20,000	5,000
Number Existing	7	1	1	2/6 in construction
Rental Fee ($)	11,300	No Charge	20,000 (approx.)	9,700
Remarks	Payload value includes shoring and liner weight	Use by TVA every 30 to 60 days	Payload value includes shoring and liner weight	

APPENDIX A.3

Shipping Casks

Three casks have been assumed as a basis for shipping resins, dewatered or solidified. Their selection has been based on current plans and/or availability. Their capability for various levels of radioactivity is also a primary factor in their selection. In reference to Table 3, they are:

X Chem-Nuclear 14-195H

Y TVA LL-60-150 or Chem-Nuclear LL-50-100

Z Chem-Nuclear 1-13C

Some parameters of interest are shown in Table A-2. The primary decisions in their selection for this evaluation are:

Cask X - Used for large quantities of relatively low level material (25 R/hr). About 145 cubic foot of resin can be loaded without creating an overweight shipment. Standard 6′ diameter by 6′ high liners, containing about 180 cubic feet can also be utilized.

Cask Y - A type B cask used for up to 50 cubic feet (standard 4′ diameter by 4′ high) liners of higher level material. This cask results in an overweight shipment irrespective of the contents.

Cask Z - A type B cask which is the design basis cask for the submerged demineralizer system. Ten cubic foot liners of 40,000 Curies Cs-137 is the reference contents. Two casks can constitute a single shipment without being overweight.

Although these cask assumptions may not be the actual casks used, the effect on the value/analysis of other combinations is not significant as long as Type B casks will be used for dewatered resin that is higher activity than LSA specifications. This results in the assumption that road accidents will not result in release of the contents and possible dispersal of the resin.

APPENDIX A.4

Transportation and Disposal Costs

The Richland, Washington, burial site of NECO was used to calculate transportation and disposal costs as this appears to be a de facto "non-optimal" constraint imposed by outside decision makers. Chem-Nuclear cask rentals and a NECO schedule of burial charges were applied to the appropriate cask and resin shipments.

As shown in the breakdown of Burial Costs/Trip, (A-8), the principal costs are transportation, cask rental and liner surcharge at the burial site. Less significant costs are weight surcharge, cask handling and disposal volume fees. A fixed tractor-trailer charge applies to all casks, based on one cask per trip except for SDS shipments when two casks can be transported per trip. Cask rental is the largest single cost item.

Total estimated costs for the three cases are given in Table A-3 considering two options. If Cask Y is the TVA LL-60-150, there is no rental charge. Cask Y is utilized for more shipments than the others and cask rental if Chem-Nuclear LL-50-150 is used will almost double the total cost for transportation and disposal (Cask rental approximately \$20,000/trip).

Liner surcharge is a charge levied at the burial ground. NECO tabulated charges range from \$65/liner at 1 R/hr to \$800/liner at 100 R/hr. No liner surcharges were available for the Epicor 2 50 ft^3 and the SDS 10 ft^3 liners, so estimated charges of \$1000 and \$3000 respectively were assumed.

TABLE A-3

COST ESTIMATES, TRANSPORTATION AND DISPOSAL

Case 1	Cask	No. Shipments	Total Cost/ Shipment	Total Cost	Comments
In-Plant	Y	34	$ 7,800	$265,000	Liner Surcharge Estimated
Epicor 1	X	11	$11,300	$124,000	
Epicor 2	Y	19	$ 7,800	$148,000	
	X	6	$11,300	$ 68,000	
SDS	Z	30	$32,000	$960,000	Liner Surcharge Estimated

Grand Total, Case 1	Cask Y (TVA)	$1,295,000
	Cask Y (Chem-Nuclear)	$2,355,000

Case 2	Cask	No. Shipments	Total Cost/ Shipment	Total Cost	Comments
In-Plant	Y	68	$ 7,800	$530,000	Liner Surcharge Estimated
Epicor 1	X	17	$11,300	$192,000	
Epicor 2	Y	38	$ 7,800	$264,000	
	X	12	$11,300	$136,000	
SDS	Z	90	$32,000	$2,070,000	Liner Surcharge Estimated

Grand Total, Case 2	Cask Y (TVA)	$3,192,000
	Cask Y (Chem-Nuclear)	$5,312,000

Case 3	Cask	No. Shipments	Total Cost/ Shipment	Total Cost	Comments
In-Plant	Y	68	$ 7,800	$530,000	Liner Surcharge Estimated
Epicor 1	X	17	$11,300	$192,000	
Epicor 2	Y	19	$ 7,800	$148,000	
	X	6	$11,300	$ 68,000	
SDS	Z	45	$32,000	$1,035,000	Liner Surcharge Estimated

Grand Total, Case 3	Cask Y (TVA)	$1,973,000
	Cask Y (Chem-Nuclear)	$3,713,000

Note: Cask Y shipments using Chem-Nuclear cask are increased by $20,000/shipment (Rental Cost)

TABLE A-4

CASK AVAILABILITY ESTIMATE[a]

Cask	Number Available	Number Used	Case 1 # Trips	Case 1 Yrs.	Case 2 # Trips	Case 2 Yrs.	Case 3 # Trips	Case 3 Yrs.
X Chem-Nuclear 14-195H	7	2[b]	17	0.3	29	0.7	23	0.5
Y TVA LL-60-150 or Chem-Nuclear LL-50-100	1	1[c]	53	3.1	106	6.2	87	5.1
Y TVA LL-60-150 and Chem-Nuclear LL-50-100	2	2[c]	53	1.6	106	3.1	87	2.6
Z Chem-Nuclear 1-13C	2	2[d]	30	1	90	2.5	45	1.2

NOTES: a Assumes nominal two week turnaround; additional turnaround will increase time proportionately
b Assumes 100% availability of 2 casks
c Assumes 70% availability of each cask
d Assumes 150% availability (two casks used per shipment)

APPENDIX A.5

Cask Availability

Cask availability must be considered in a value/impact assessment which considers solidification. Only one cask may be available for shipping the 50 ft^3 liners (Cask Y) and for the 10 ft^3 liners (Cask Z). For the availability assumed in Table A-4, a decision to solidify resins will double the duration of the disposal phase and, if only one Cask Y is available, require shipments over a 6.2 year interval for the 50 ft^3 liners.

Dose Increase for On-Site Solidification

Table A-5 presents estimates for the exposure increase caused by on-site solidification. The per liner estimates are based on an evaluation for the Epicor 2 fifty cubic feet liner which is described in Appendix A.3. To obtain the Table A-5 results, the per liner estimates have been applied to all the shipments exclusive of the submerged demineralizer system (SDS). Thus, while the estimates may be high for the systems other than SDS, the margin will allow for the inability to estimate the SDS system solidification dose rates. In any event, the important observation is that the total exposure is estimated to be 3 to 5 times greater if solidification is required and that the magnitude is significant.

TABLE A-5

ESTIMATE OF ADDITIONAL OCCUPATIONAL EXPOSURE FOR SOLIDIFICATION

	Case 1	Case 2	Case 3
Number of Shipments Exclusive of SDS (Table 3)	70	135	110
Estimate Exposure[1] per Shipment, REM	.3 to .5	.65 to 1.1	.65 to 1.1
Estimated Total Exposure, REM	20 to 35	90 to 150	70 to 120

[1] Reference exposure per dewatered liner (mrem) 300 to 500
Increase in exposure for handling for solidification (mrem) 300 to 500
Increase in exposure for solidification operation (mrem) 50 to 100

APPENDIX A.7

Dose Reduction Effect of Solidification

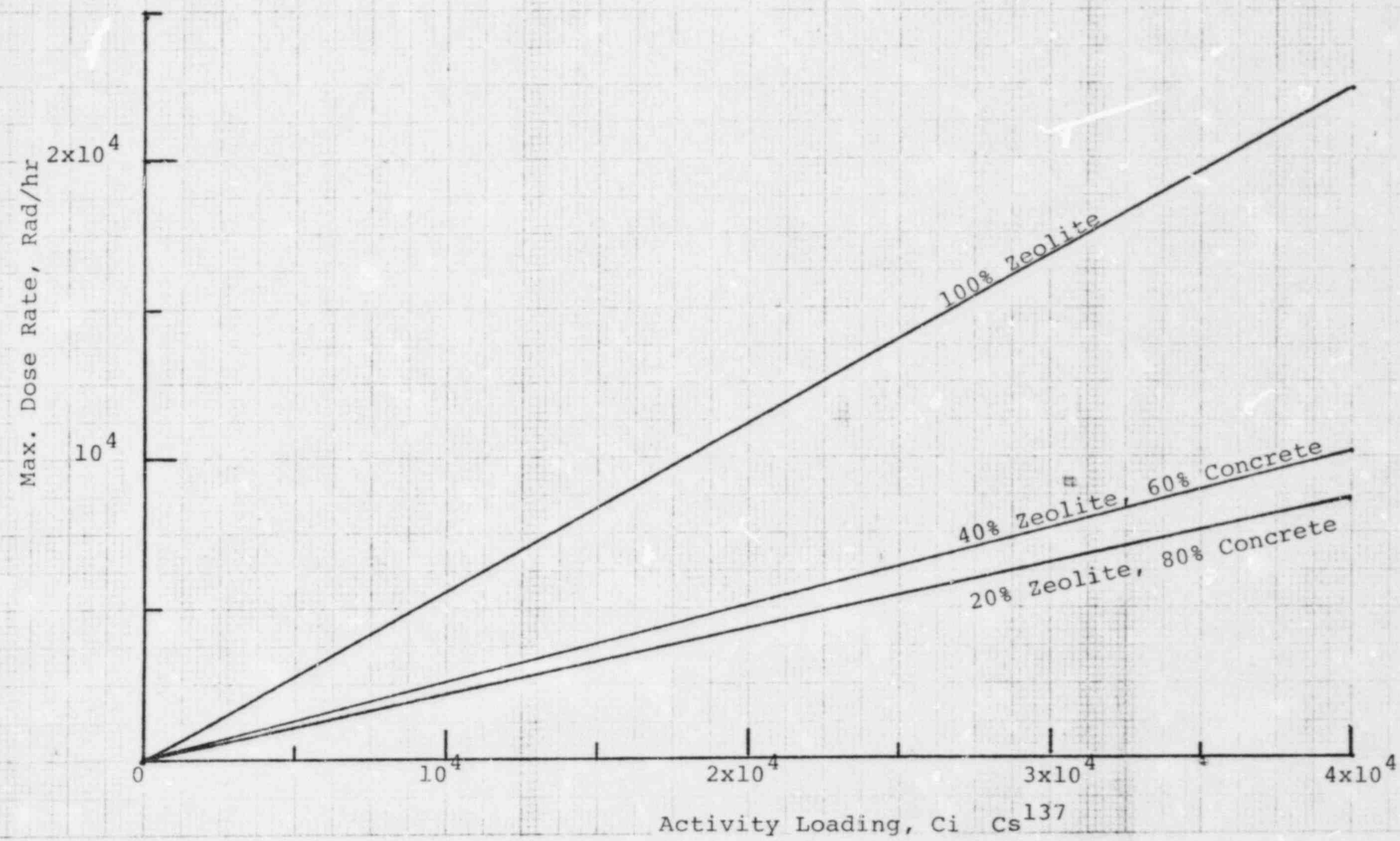
An analysis has been performed of the effect of solidification on surface dose of the material in a liner and is shown in Figure A-1. The model is the SDS liner which is a dewatered state has been postulated to contain as much as 40,000 curies of Cs-137. The purpose of the analysis was to aid in assessing the value of solidification for possibly reducing the handling doses or conversely, allowing handling with less concern. For a given inventory, the dose rate is only reduced to about one-third that without concrete. Even if one were to maintain the same 4000 Curies per cubic foot of resin and then take credit for a 1:2 resin to concrete solidification ratio, the total dose reduction would only be one order of magnitude, a factor of one-tenth. At the levels of radiation expected from the SDS processing, a factor of ten is of no consequence in the handling, either at the site or at the burial ground.

While an analysis is not shown for the larger liners, 50 and 180 cubic feet, which are loaded with less activity, the conclusions are qualitatively the same even though solidifying the larger liners would show proportionately more reduction in dose rate. The value of solidifying the lower activity resins (tens and hundreds of R/hr on contact) is lost in the noise when considered with respect to the higher activity resins (tens of thousands R/hr on contact). Since there is no significant dose reduction value for the higher activity resins, the conclusion is that solidification buys very little in terms of dose reduction volume.

FIGURE A-1

DOSE RATE vs. CURIE LOADING, Cs^{137}

10 cubic ft right-circular cylinder
1/4" stainless steel coating



APPENDIX A.8

Burial Costs (per trip): 4 ft (dia.) x 4 ft Liner (In-Plant, Epicor 2)

Item:	Cost:	Reference:
Transportation	$5,645	NECO Table
Disposal (50 ft^3 @ $4.75)	237.50	NECO Table
Liner Surcharge	1,000	Estimate-Exceeds NECO Table
Cask Handling	250	NECO Table
Weight Surcharge (63,000 lb)	630	NECO Table
Demurrage Charge	Not Included	NECO Table
Total Burial	$7,762.50	
Cask Rental (TVA LL-60-150)	No Charge	IO Memo - Edwards to Williams (Cask Availability - Epicor II 6/12/79)

Total, Cask + Burial $7,762.50 (approximately $7,800)

Burial Costs (per trip): 6 ft (dia.) x 6 ft Liner (In-Plant, Epicor 2)

Item:	Cost:	Reference:
Transportation	$5,645	NECO Table
Disposal (180 ft^3 @ $4.75)	855	NECO Table
Liner Surcharge (25 R/hr)*	515	NECO Table
Cask Handling	250	NECO Table
Weight Surcharge (46,500 lb)	465	NECO Table
Demurrage Charge	Not Included	
Total Burial	$7,730.00	
Cask Rental (CNS-14-195H) "Cask X"	$11,300	Chem-Nuclear Rental Data
Total, Cask + Burial	$19,030 (approximately $19,000)	

* Cask Limit

APPENDIX A.8 (Cont.)

Burial Costs (per trip): 10 ft^3 Liner (SDS)

Item:	Cost:	Reference:
Transportation	$5,645	NECO Table
Disposal (80 ft^3 @ $4.75)	95	NECO Table
Liner Surcharge (2 liners)	6,000	Estimate - Exceeds NECO Table
Cask Handling (2)	500	NECO Table
Weight Surcharge (15,000 lb)	150	NECO Table
Demurrage Charge	Not Included	NECO Table
Total Burial	$12,390.00	
Cask Rental (CNS 1-13C) Cask Z - Two Casks	$19,400	Chem-Nuclear Rental Data
Total, Cask + Burial	$31,790.00 (approximately $32,000)	

Jmi Rdg

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

August 14, 1979

Docket No. 50-320

MEMORANDUM FOR: R. C. Arnold, Vice President
Generation, GPU

FROM: John T. Collins, Deputy Director
TMI-2 Support

SUBJECT: TMI UNIT 2 RESIN SOLIDIFICATION VALUE IMPACT ASSESSMENT TECHNICAL REPORT WMA-TR-1

We have initiated our review of the subject report which was transmitted to me in your memo of August 1, 1979 and find that we need additional information and clarification of the data presented before we can complete our evaluation. The required information is contained in Enclosure 1. Your early response to this request would be appreciated.

John T. Collins

John T. Collins, Deputy Director
TMI-2 Support

Enclosure:
As Stated

cc: w/enclosure
R. Vollmer
R. Weller

7909140134

REQUEST FOR ADDITIONAL INFORMATION AND CLARIFICATION OF

INFORMATION CONTAINED IN WMA-TR-1

Page 11, Evaluation

You state that if solidification is required, the increase in exposure is in the range of 35 to 130 Person-Rem. What percentage of this increase is due to solidification of Epicor-II resins? of SDS resins?

Page 27, Section 4.2

The assumption of one part resin to two parts concrete for solidification of SDS resins is in substantial error. If solidification of SDS resins is required, Chem-Nuclear will use approximately 7 ft^3 of resin per container vice 10 ft^3 for no solidification requirement. This error impacts on estimated volumes in later portions of the analysis.

Page 36, Solidification Systems

The assumption that the solidification systems utilized are "temporary" and perhaps "portable" is inconsistent with the Evaluation on page 15 which estimates the cost for a system, including installation, at 2 to 4 million dollars.