ELECTRIC POWER RESEARCH INSTITUTE

Concentration Averaging and Encapsulation for Waste Classification

Presenters:

Phung Tran, EPRI Project Manager

David James, EPRI Technical Consultant

Key Contributors:

Sean Bushart, EPRI Sr. Program Manager

Ralph Andersen, NEI Director

Jene Vance, EPRI Technical Consultant

NEI/NRC Meeting

June 17, 2008

EPRI
R&D Strategy to Address Loss of Barnwell Disposal

Optimize Management of LLW

Operational Strategies
- Class B/C Minimization Strategies

Waste Characterization
- Sampling Techniques
- Scaling Factors

Ensure Safe, Secure, and Cost Effective LLW Storage

Facility Design Issues
- Outside storage
- Security Req
- 50.59 dose evaluations

Operational Issues
- Operational Guideline

Support New Options for LLW Disposal

BTP Revision

10 CFR 61.58

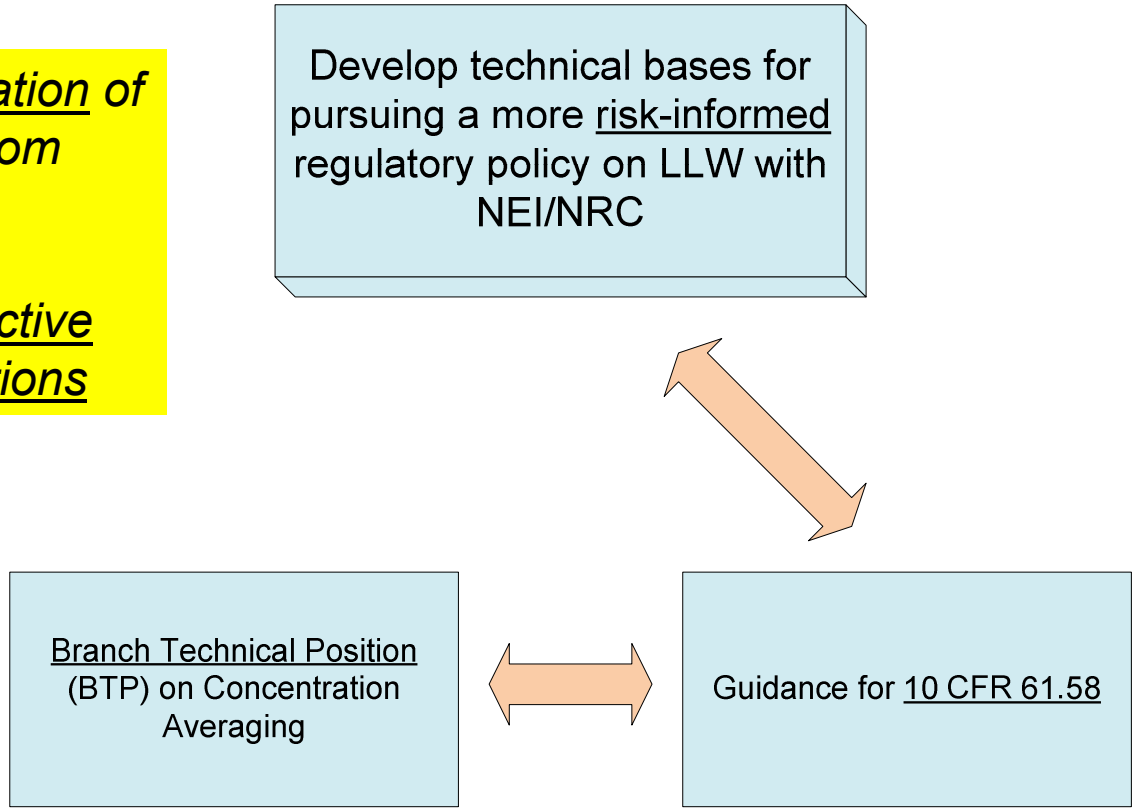
Revise 10 CFR 61

© 2007 Electric Power Research Institute, Inc. All rights reserved.

Project Goals

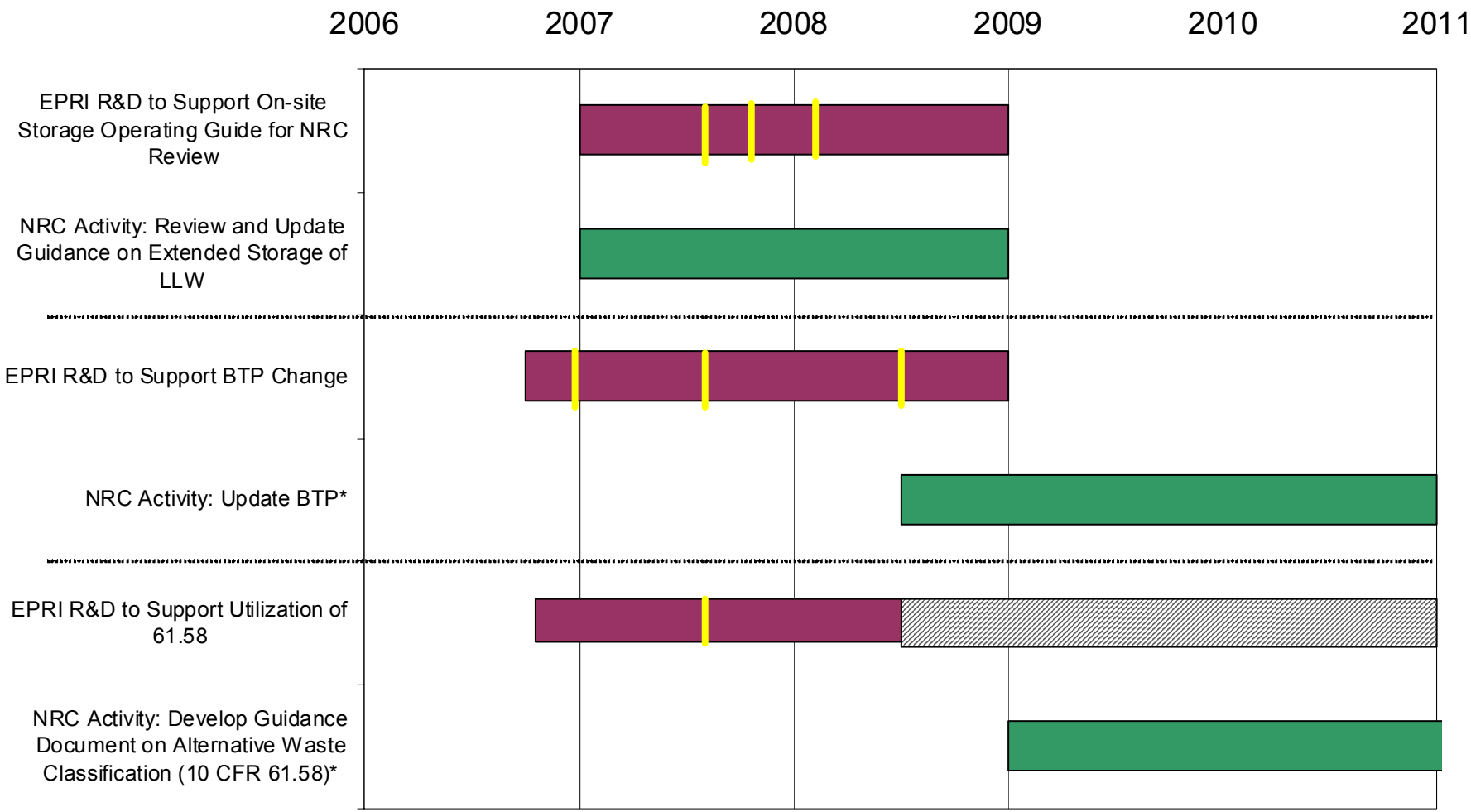
❖*Minimize the accumulation of Class B and C wastes from plant sites*

❖*Pursue more cost effective and reliable disposal options*



© 2007 Electric Power Research Institute, Inc. All rights reserved.

EPRI Research Strategy to Support Regulatory Changes to Resolve Waste Disposal Problem



= interactions with the NRC

* = completion date not indicated in SECY 07-0180

© 2007 Electric Power Research Institute, Inc. All rights reserved.

EPRI ELECTRIC POWER RESEARCH INSTITUTE

Key Objectives for this meeting

1. Obtain an improved understanding of NRC's goals and plans for key relevant topics addressed in Strategic Assessment (e.g. BTP revision, 10 CFR 61.58)
2. Discuss EPRI technical findings regarding BTP, identify:
   - Areas of agreement
   - Technical constraints
   - Supplemental analyses requirements
3. Determine path forward for future technical and policy oriented exchanges

© 2007 Electric Power Research Institute, Inc. All rights reserved.

Data Set used as a Basis for Analysis- Data Collection Effort in 2007

Objective:

To characterize process waste stream and to determine the quantities of waste generated on an industry level.

Results:

- Data Sources – shipping records
  - Gives indication of number of shipments and disposal volumes
  - Break down by radionuclide
- 41 PWR units and 24 BWR units responded, representing ~65% of the industry
- Total of 10,000 records compiled covering period from January ’03 to February ’07

© 2007 Electric Power Research Institute, Inc. All rights reserved.

Purpose of BTP on Concentration Averaging and Encapsulation

- Defines “acceptable practices” for determining concentrations of 10CFR61.55 nuclides in waste packages
- Address concern over the control of discrete items (i.e. sources)
- Assure compliance with 10CFR61 disposal concentration limits by extending applicability to other waste types
- Provide additional intruder protection that was not specifically addressed in EIS (introduces an Intruder “handling” scenario)

© 2007 Electric Power Research Institute, Inc. All rights reserved.

Inconsistencies Between BTP and 10 CFR 61

BTP		10 CFR 61
1. Averaging volume defined on basis of waste package	≠	1. Averaging volume based on that encountered by intruder (253 m^3 in EIS)
2. Limits averaging to a factor of 10	≠	2. No constraints on averaging
3. Mixing across different waste streams not allowed	≠	3. Only DAW was segregated for Classification
4. Attempts to exclude GTCC wastes from being mixed with other LLW	≠	4. No GTCC waste category; all source terms were included in averaging

© 2007 Electric Power Research Institute, Inc. All rights reserved.

Areas Requiring Clarification

- Volume Basis for Classification as it relates to intruder scenarios
- Averaging basis for homogeneous wastes
- Treatment of Cartridge Filters
- Reference volume for activated metal averaging
  - Relation to “handling” scenario
  - Factor of 1.5 on Nb-94 in activated metals

© 2007 Electric Power Research Institute, Inc. All rights reserved.

New Averaging Basis Proposal

1. Add clarification to BTP that classification limits in 10CFR61 are based on the average concentrations included in the disposal trench
2. Allow averaging for classification over a controlled volume of material where it can be demonstrated that performance objectives are met
3. Clarify that averaging restrictions pertain to “discrete” items only; no restrictions should be placed on homogeneous items

© 2007 Electric Power Research Institute, Inc. All rights reserved.

Averaging Beyond the package

VOLUME BASIS FOR AVERAGING

© 2007 Electric Power Research Institute, Inc. All rights reserved.

ELECTRIC POWER RESEARCH INSTITUTE

Impact of Increased Averaging Volume

- Analysis Performed Assuming:
  - All Waste Streams including Resins, Filters, DAW, and Activated Metal
  - Complete source term for current fleet of plants based on survey of operating period from 2002-2006
  - Disposal in open facility with 2 meters of cover, no stabilization assumed
  - Assumes waste is randomly distributed in package size volumes, no deliberate mixing
- Analysis performed using RESRAD, Microshield, IMPACTS
- Selected as extreme example

© 2007 Electric Power Research Institute, Inc. All rights reserved.

Dose Impacts from Current Inventory of Operational Wastes

- RESRAD simulation of Resident Intruder Scenario
- Includes all operational wastes
- Cs-137 accounts for 96% of risk for 100 Year Intruder

Nuclide	% of Dose Rate
Cs-137	96.20%
Sr-90	2.44%
Ni-63	0.77%
Pu-239	0.20%
Co-60	0.12%
Pu-241	0.09%
Am-241	0.07%
Nb-94	0.04%
Pu-238	0.03%
C-14	0.00%
Cm-242	0.00%

© 2007 Electric Power Research Institute, Inc. All rights reserved.

Cs-137 Average Concentrations Based on Different Averaging Scenarios

Case #	Description	Total Curies	Total Volume (ft^3)	Average Conc. (Ci/m^3)	Incremental Volume[1] (ft^3)
1	DAW Only (Base Case)	12	921465	4.6E-04	921465
2	Case 1 + Process Waste (Cs-137 concentration< 1 Ci/m3)	209	1010740	7.3E-03	89275
3	Case 2 + Process Waste (Cs-137 concentration > 1 Ci/m^3 and < 10 Ci/m3)	844	1017333	2.9E-02	6593
4	Case 3 + Process Waste (Cs-137 concentration >10 Ci/m^3)	1750	1018459	6.1E-02	1126

[1] Volume added from Base Case

© 2007 Electric Power Research Institute, Inc. All rights reserved.

Cs-137 Dose Rates Based on Different Averaging Scenarios

Case #	Description	Annual Volume (m^3)	Activity of Increment (Ci)	Conc. of Increment (Ci/m3)	Probability of Encountering Last Increment[1]	Performance (mrem/yr)[2]
1	DAW Only	26103.8	12	4.58E-04	1	**2**
2	Case 1 + Process Waste (Cs-137 concentration < 1 Ci/m3)	2529.0	197	7.77E-02	0.088327	**34**
3	Case 2 + Process Waste (Cs-137 concentration > 1 Ci/m^3 and < 10 Ci/m3)	186.8	647	3.47E+00	0.006481	**138**
4	Case 3 + Process Waste (Cs-137 concentration >10 Ci/m^3)	31.9	1103	3.46E+01	0.001105	**316**

[1] Probability of unearthing last material increment; based on waste as-packaged
[2] Annual Intruder Exposure (Intruder-Agriculture Scenario)

© 2007 Electric Power Research Institute, Inc. All rights reserved.

Why should the volume basis be increased

- By definition power plant process streams are LLRW and suitable for near surface disposal.
- The overall risk and related source term have been evaluated and shown acceptable for this disposition
- Improvements in disposal practices have largely eliminated the need for the classification distinction in 10CFR61
- Advances in computerized tracking enable improved inventory controls both for the generator and the disposal site

© 2007 Electric Power Research Institute, Inc. All rights reserved.

Why Allow Mixing?

- Mixing across all waste streams is the basic model followed in the EIS- Only DAW was segregated to allow its disposal as unstable waste
- If all waste meets conforms to stability requirements of the disposal venue there is no need for distinction of classification

© 2007 Electric Power Research Institute, Inc. All rights reserved.

Averaging Inside of the package

HOMOGENEOUS WASTES

© 2007 Electric Power Research Institute, Inc. All rights reserved.

Current BTP Treatment of Homogeneous Wastes

- Homogenous waste includes resins, filter media, DAW (most wastes proceeding from plant operation)
- BTP incorrectly implied that variability of activity (e.g. “hot spots”) was not accounted for in the EIS studies; hence guidance for each waste type. However, EIS does take this into account (see NUREG excerpt below).

> “Finally, there is the potential for localized areas of higher activity ("hot spots") within waste containers. However,, this would tend to be mitigated through averaging areas of higher concentration over areas of lower concentration. When concentration limits are calculated using the waste classification methodology, what is really being established is the average concentration across the volume of waste contacted. This could be several hundred cubic meters of soil and waste material.” NUREG/CR-0945 p. 5-33

© 2007 Electric Power Research Institute, Inc. All rights reserved.

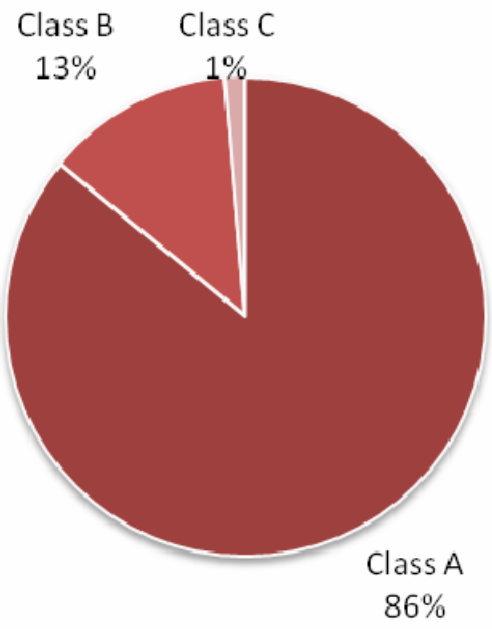
New Proposed Treatment/Clarification for Homogeneous Wastes

- Arguments made in relation to increasing the averaging basis apply as well to averaging homogeneous materials for classification inside or out of the container
- Averaging Constraints are not required for Homogeneous waste forms – Section can simply state that determining the concentrations following the original BTP on classification is acceptable

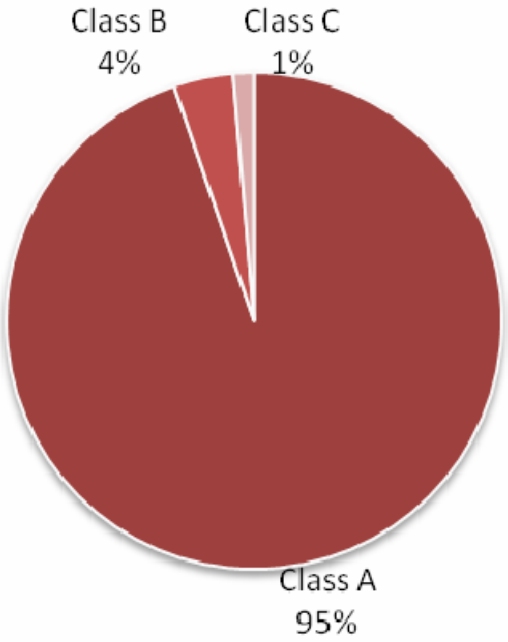
© 2007 Electric Power Research Institute, Inc. All rights reserved.

Resultant Disposal and Storage Impacts from Broader Averaging- Resins Only View

Generator Level Averaging Under BTP (Current Practice)



Industry Wide Averaging with BTP



65% Reduction in Storage Requirements

© 2007 Electric Power Research Institute, Inc. All rights reserved.

Summary of Technical Justification for New Averaging Approach

- Review indicates that intruder protection is adequately addressed in EIS; no additional constraints required
- 10CFR61 disposal model was developed to make accommodation for disposal practices of 1980
  - BTP constraints perpetuate model
  - Presents misconception of current disposal activity
- Averaging without a factor of 10 constraint
  - ☑ Meets Performance Objective < 500 mrem/yr to the Intruder without BTP restrictions
  - ☑ If current disposal practices were taken into account, additional protection margins could be demonstrated

© 2007 Electric Power Research Institute, Inc. All rights reserved.

CARTRIDGE FILTERS

© 2007 Electric Power Research Institute, Inc. All rights reserved.

Description of Cartridge Filters

- Consist of plastic or metal frame with a cellulosic or polymeric filter media
- Activity profile comparable to other streams – generally lower in Cs-137
- Activity is present as corrosion product contamination incorporated in media
- Support frame does not by itself retain or hold activity
- Physically and chemically more comparable to DAW than other streams

© 2007 Electric Power Research Institute, Inc. All rights reserved.

Cartridge Filters Do Not Meet Criteria for being "Discrete" Waste

- Classification is not expected to be driven by primary gamma activity since Cs-137 is not strongly retained by filters
- Filters, while concentrating waste, provide little in terms of volume and weight for averaging, as a consequence total activity content is small
- BTP restricts averaging to the envelop volume of the filter- this precludes averaging over a larger volume without taking exception to the BTP

© 2007 Electric Power Research Institute, Inc. All rights reserved.

Cartridge Filters Should Be Treated As Homogenous Waste

- Assuming an intruder accesses a filter package the activity contained in the package would be distributed over the entire volume encountered
- If the filters are not decomposed the intruder would recognize the configuration. The frames, if in tact, could be removed without retention of a major part of the activity
- Filters should be treated no differently than DAW or filter media

© 2007 Electric Power Research Institute, Inc. All rights reserved.

Proposed Change 3

- Eliminate special constraints on cartridge filter averaging
- Treat cartridge filters in a manner similar to DAW
  - Homogeneous when packaged
  - Average over volume of the package

© 2007 Electric Power Research Institute, Inc. All rights reserved.

ACTIVATED METALS

© 2007 Electric Power Research Institute, Inc. All rights reserved.

Activated Metals

- Constitute about 85% of the LLRW activity source term
- Dominant radionuclides include Co-60, Ni-63, short lived gamma Radionuclides (e.g. Cr-51, Mn-54, Fe-55, Fe-59, etc.)
- More than 99% of the gamma activity associated with activate metals is decayed out within the time frame of the institutional control period
- Classification dominated by Ni-63 and Nb-94
- Generally regarded as a stable waste form

© 2007 Electric Power Research Institute, Inc. All rights reserved.

What the BTP does with Activated Metals

- Introduces factor of 1.5 constraint on averaging “primary gammas” in activated metals
  - Primary gammas include Co-60,Cs-137, and Nb-94
  - Concern is that primary gammas represent an acute dose potential for a future intruder and require tighter control
- Equates activated metal risks to those associated with sealed sources based on postulated discrete items

© 2007 Electric Power Research Institute, Inc. All rights reserved.

Why Activated Metals Should Not Be Treated As Sealed Sources

- Activated metal components are generally much larger and are not amenable to the handling scenario
- Activated metals do not meet the concentration levels of sealed sources, dominant radionuclide in activated metals is Co-60 which will decay out before handling scenario kicks in
- Nb-94 in activated metals doesn't meet the activity condition in discrete size pieces

© 2007 Electric Power Research Institute, Inc. All rights reserved.

Activated Metals – Primary Gammas

- Co-60 the most dominant radionuclide in Activated Metals and the most constraining is not limited in B,C wastes because of the short half life.
- Cs-137 is not a factor in activated metals (only in sealed sources)
- Nb-94 is a trace contaminant in most metals, is usually not well known, and can be overlooked if not listed in a material test report– limits are already defined by a chronic exposure scenario

© 2007 Electric Power Research Institute, Inc. All rights reserved.

Activated Metals – Niobium 94

- Rarely exceeds 1 mCi (activity above which piecemeal consideration is required) in discrete size pieces of activated metal components (possible in some types of Inconel used in fuel assembly hardware)
- As packaged there is substantial excess volume in activated metal packages that contribute to local dilution in the disposal site which further limits the potential for acute exposure
- Factor of 1.5 is neither necessary nor appropriate – activity limits for Nb-94 are already based on chronic exposure

© 2007 Electric Power Research Institute, Inc. All rights reserved.

Proposed Changes

- Averaging Constraint of a factor of 1.5 for Primary Gammas should be expressly applied to discrete size items or dropped completely in reference to Activated metals
- Averaging of activated metals with exception of discrete items can be based on the volume of the container or the envelop volume of a large component as disposed.

© 2007 Electric Power Research Institute, Inc. All rights reserved.

Activated Metals Conclusions

- Factor of 1.5 for primary gammas should be limited to discrete item handling scenario.
- Activated metal containers are usually only filled to 15 - 20% of capacity- material is inherently stable
  - If the package is in tact, the intruder scenarios would be limited to the discovery scenario
  - If not, the local concentration of Nb-94 would be determined by the container volume
  - Co-60 is generally not a factor in the intruder time frames

© 2007 Electric Power Research Institute, Inc. All rights reserved.

SUMMARY/CONCLUSIONS

© 2007 Electric Power Research Institute, Inc. All rights reserved.

Summary of proposed changes

Topic	Requested Change	Principal Arguments
Averaging Basis	Broaden basis to equivalent to volume excavated by intruder	In line with bases for 10CFR61 concentration limits, BTP only addresses averaging inside of the package
Homogeneous Materials	Release Factor of 10 constraint on averaging	Variability in activity was considered in EIS, by definition non discrete
Cartridge Filters	Treat as homogeneous in manner similar to DAW – Allow Averaging Over Package Volume	Cartridge filters have nominal activity content, do not meet definition of discrete
Activated Metals	Eliminate primary gamma constraint, average over package volume	Gamma constraint only significant for Nb-94, limits set for chronic exposure

© 2007 Electric Power Research Institute, Inc. All rights reserved.

Benefits of adopting proposed changes

- Decreases the potential to orphan waste since classification would not depend on local off-setting of higher activity components
- Provides and more consistent and reliable basis for disposal planning
- Recognizes that certain streams will be accepted for near surface disposal
- Acknowledges inter-dependence of generators
  - Relaxed disposal criteria does not reduce the importance of characterization
  - Plants with high source terms need to be striving for reductions

© 2007 Electric Power Research Institute, Inc. All rights reserved.

Concluding Remarks

- Cs-137 figures prominently in overall classification and intruder risk
- Industry source term accounts for 1 million ft^3 (28300 m^3) per year
- At 1 Ci/m3, this results in 28300 Ci/year of Cs-137 which could potentially be disposed of within a Class A facility
- Entire industry source term is 1750 Ci/year or about 6% of the allowable limit under current regulations
- For stable Class A, averaging range should extend to the Class B limit for Cs-137 and Sr-90,

© 2007 Electric Power Research Institute, Inc. All rights reserved.

General Issues with 10 CFR 61

- 10 CFR 61 rulemaking was biased by disposal practices of 1980
- Does not include guidance for demonstrating the acceptability of engineered barriers
- A,B and C Waste Classes may not be necessary if the disposal site itself provides the structural stability and some intruder protection
- Even without credit improved disposal practice our analysis shows that the intruder exposure is kept below 500 mrem/yr
- GTCC is an artificial category not generally envisioned in the EIS reports for the waste types covered by regulation

© 2007 Electric Power Research Institute, Inc. All rights reserved.