Advisory Committee on Reactor Safeguards

Review of Draft Branch Technical Position on Concentration Averaging and Encapsulation

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October 4, 2011

Outline

- Introduction
- Technical Bases for Homogeneity Guidance
- Technical Bases for Alternative Approaches, Encapsulation, and Classifying Mixture of Items
- Summary

Topics Addressed

1. Demonstrating homogeneity and classifying homogeneous waste
2. Classifying mixture of individual items:
   a. activated metals, or
   b. contaminated materials, or
   c. cartridge filters
3. Encapsulation of sealed sources & other LLRW
4. Alternative Approaches

Introduction

Maurice Heath
Project Manager
October 4, 2011

What is the BTP

- **Guidance document for waste generators and processors**
  - **classifying waste for disposal under 10 CFR Part 61**
  - **provides a method for averaging and classifying radionuclide concentrations in waste over a volume or mass of waste package**
  - **widely used by generators, processors and agreement state regulators**

10 CFR 61 Subpart C - Performance Objectives

- **Protection of the general population from releases of radioactivity.**
- **Protection of individuals from inadvertent intrusion**
- **Protection of individuals during operations**
- **Stability of the disposal site after closure**

10 CFR Part 61 Requirements Applicable to BTP

- § 61.42, "Protection of individuals from inadvertent intrusion"

- § 61.55, "Waste classification"
  - Tables 1 and 2 – define Class A, B, and C waste
  - § 61.55(a)(8)
    - ✓ Allows for concentration averaging in determining waste class

- 10 CFR Part 20, Appendix G

Waste Classification Table 2
10 CFR 61.55

Radionuclide	Concentration, Ci/m^3		
	Col. 1 (Class A limit)	Col. 2 (Class B limit)	Col. 3 (Class C limit)
Total of all radionuclides with < 5 yr half-life	700	n/a	n/a
H-3	40	n/a	n/a
Co-60	700	n/a	n/a
Ni-63	3.5	70	700
Ni-63 in activated metal	35	700	7000
Sr-90	0.04	150	7000
Cs-137	1	44	4600

If concentration does not exceed column 1, waste is Class A. If concentration is > col. 1 and < col. 2, waste is Class B. If concentration is > col. 2 and < col. 3, waste is Class C. If > col. 3, waste is not acceptable for near-surface disposal

Background

- **Low-Level Waste Strategic Assessment, October 2007**
  - **Revisions to CA BTP – high priority**
  - **Risk-informed, performance-based**
- **Blending of LLW and SECY paper— CA BTP on hold**
- **SRM-SECY-10-0043**
  - **Risk-inform blending position in BTP**

Risk-Informed, Performance-Based

- Risk-Informed:
  - Decision making approach that uses risk insights, engineering judgment, safety limits, and other factors.
  - For establishing requirements that focus on issues commensurate with their importance to public health and safety
- Performance-based:
  - Performance and results as the primary bases for decisionmaking
  - Performance-based regulations have these attributes, among others:
    1. measurable, calculable or objectively observable parameters exist or can be developed to monitor performance;
    2. objective, criteria exist or can be developed to assess performance;
    3. licensees have flexibility to determine how to meet the established performance criteria in ways that will encourage and reward improved outcomes

Risk-Informed, Performance-Based

- **Risk-informed**
  - Guidance linked to limiting doses to inadvertent intruder
  - Protection of inadvertent intruder 1 of 4 objectives of Part 61
  - Reasonably foreseeable scenarios
  - Evaluated consequences to intruder (500 mrem dose limit)
- **Performance-based**
  - Measurable parameters (concentrations of radionuclides)
  - Additional flexibility provided in revised version for alternative approaches, as long as intruder protection is maintained

Major Changes to 1995 BTP

Revised BTP	1995 BTP	Reason for change
Removed factor of 10 constraint for blending of wastes	Blended wastes subject to factor of 10 constraint	Consistent with Commission blending SRM
Removed exceptions for blending of homogeneous wastes (resins, e.g.)	No constraints on blending if operational efficiency or worker dose reductions in play	Consistent with Commission blending SRM
Changed the Cs-137 sealed source limit from 30 Ci to 130 Ci, and Class B Co-60 limit from 700 Ci to no limit, based on new scenario.	30 Ci limit on Cs-137 sources, 700 Ci limit on Class B Co-60 sources.	1995 scenario unnecessarily conservative, creates orphan waste, esp. for DOE/NNSA
Consolidated sections addressing activated metals, contaminated materials, and cartridge filters into one	Three sections for each of these wastes, with virtually same technical positions	Improved readability and organization
Factor of 2 in place of 1.5 and factor applies to class limit, not average of mixture	Factor of 1.5 applied to variation around *average* concentration of mixture.	Uniformity (factor of 1.5) has no direct relationship to risk, especially when a mixture is uniform but well below the class limit. Tying factor to class limit gives risk connection. Two is a reasonable limit, staff believes
Factor of 10 tied to class limit, not average of mixture	Factor of 10 for non-primary gamma emitters tied to average of mixture	Same as above, first part
Added test for homogeneity for mixing similar homogeneous waste types	No test required	Need to ensure intruder protection, well drilling scenario
Added “Alternatives approaches” section and gives examples.	61.58 had to be invoked for alternative approaches, a high threshold	61.58 is for alternative to regulations, not guidance. Effect was to discourage use (only 1X in 16 years)
Revised and clarified technical bases in Appendix	Has technical basis for sealed source scenarios, but difficult to understand	Greater transparency, more realistic scenarios

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Site-Specific Analysis Rulemaking and BTP

Activity	Intruder Protection ?	Primary user	Purpose
Site-specific analysis rulemaking	Yes	Disposal facility	Regulation
Concentration Averaging BTP	Yes	Generators and processors	Guidance

Technical Basis for Homogeneity Guidance in the Branch Technical Position on Concentration Averaging and Encapsulation

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Sr. Systems Performance Analyst
October 4, 2011

Waste Types

- Homogeneous materials
- Activated metals
- Cartridge filters
- Contaminated materials
- Sealed sources

Topics Addressed

1. Demonstrating homogeneity and classifying homogeneous waste
2. Classifying mixture of individual items:
   a. activated metals, or
   b. contaminated materials, or
   c. cartridge filters
3. Encapsulation of sealed sources & other LLRW
4. Alternative Approaches

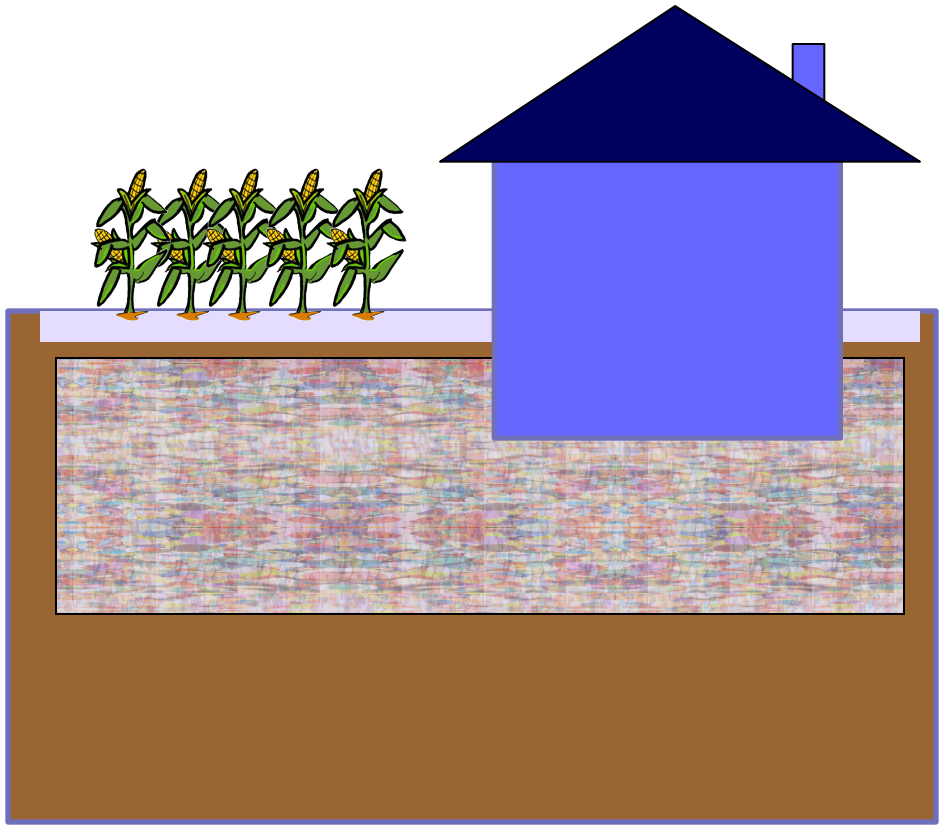
Homogeneity Guidance Topics

- **Homogeneous Waste Types**
- **Intentional Blending During Waste Processing (i.e., “large-scale” blending)**
- **Classification of Homogeneous Waste**

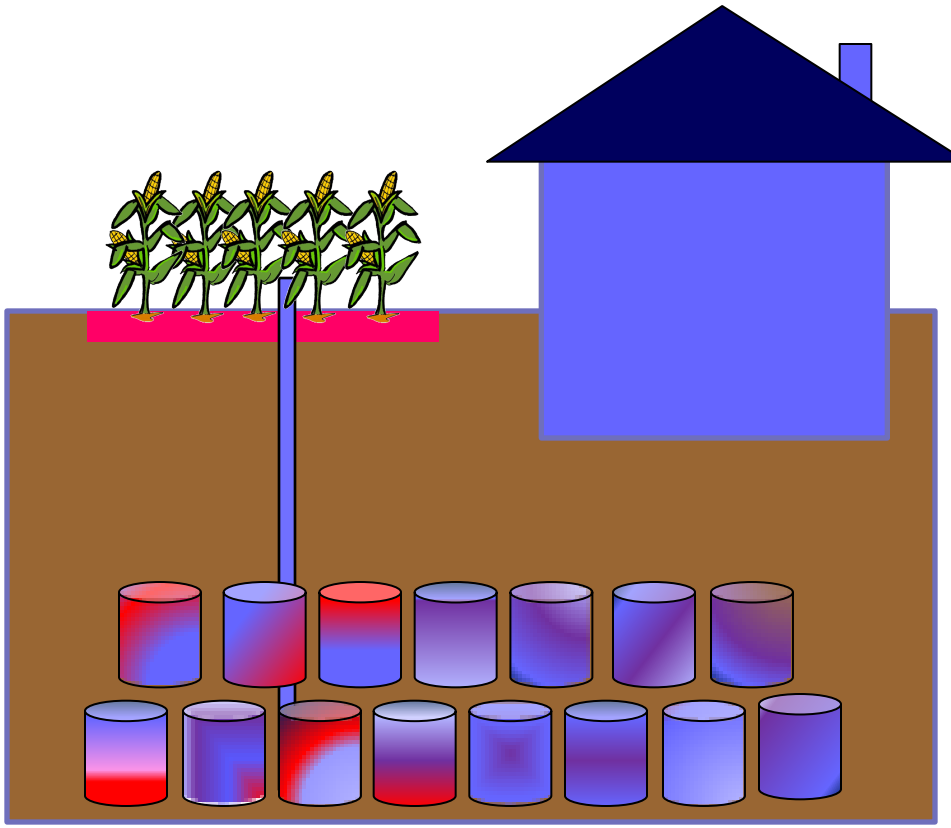
Reasons for Homogeneity Guidance

- Elimination of “factor of 10” constraint on inputs to a waste mixture
- Stakeholder concern
- Increased consideration of site-specific scenarios
- Commission direction (SRM-SECY-10-0043)

Alternate Conceptual Models



Part 61 Intrusion Analysis



Hypothetical Intrusion Scenario

Homogeneous Waste Types

- **Specific waste streams assumed to be homogeneous in the context of intrusion**
  - **Solidified or absorbed liquid, spent ion-exchange resins, filter media, evaporator bottom concentrates, ash, contaminated soil, and containerized dry active waste**

- **No homogeneity test proposed for designated homogeneous waste types**
  - **These wastes are homogeneous or easily mixed, or waste is expected to become easily mixed after 100 years**
  - **Waste classifiers advised to consider existing information**

Intentional Blending During Waste Processing

- Guidance based on dose to resident after a well is drilled on site
- Processors either demonstrate that process creates homogeneous waste or apply test to individual containers
- Homogeneous waste should not contain any pocket of waste larger than 1 cubic foot with a sum of fractions greater than 10

Classification of Homogeneous Waste

- More rigorous consideration of uncertainties recommended for waste with a sum of fractions close to 1
  - Consistent with 1983 Branch Technical Position
- Main sources of uncertainty expected to be
  - Spatial variability in radionuclide concentrations
  - Uncertainty in scaling factors
- Proposed Guidance: Sum of fractions should be less than 1 minus its standard error

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Technical Basis for Alternative Approaches, Encapsulation and Classifying Mixture of Individual Items in the Branch Technical Position on Concentration Averaging and Encapsulation

John R. Cochran
Sandia National Laboratories
October 4, 2011

Topics Addressed

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Roadmap

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Alternative Approaches and Alternative Provisions

- **Alternative Provisions**
  - 1995 BTP - deviation from BTP guidance via deviation from Part 61 regulation (61.58), high bar for deviating from guidance
  - Revised draft BTP – Alternative Provisions restricted to deviations from Part 61 regulation
- **Alternative Approaches**
  - new section in BTP
  - deviations from BTP

Alternative Approaches

- **New philosophy:**
  - **BTP provides broadly applicable "look up" guidance & sets uniform level safety for implementing Agreement States**
  - **Alternative Approaches provides Licensees / Agreement States with *specific NRC guidance* on factors to consider in submitting / approving alternative guidance**
- **Example Alternative Approaches – BTP sets maximum curie limits gamma-emitters that can be encapsulated, and AA states that larger curie sources might be safe, if buried > 10 m deep in long-lived source device**
- **Provides intruder protection, with flexibility**

Roadmap

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Encapsulation of Sealed Sources and Other LLRW

- **What is encapsulation:** Surround radioactive item (sealed source) in a binding matrix, in a container, where radioactivity remains in original dimensions
- **Why it is good:** waste form stability, worker protection, for classification average curies over entire volume or mass
- **BTP sets limits on encapsulation to prevent use of extreme measures**

1995 Guidance: Encapsulation of Sealed Sources and Other LLRW

- Max. encapsulating volume or mass 0.2 m^3 or 500 kg
- Max. curie non-gammas: Class C limit when averaged across encapsulating media
- Max. curie gamma-emitters: based on exposure scenario in BTP

1995 Gamma Curie Limits for Encapsulated Items

- 1995 curie limits for gamma emitters based on intruder exposure scenario in 1995 BTP
- Limits based on scenario where intruder is exposed for 2,360 hours to encapsulated source 1 m from intruder

Nuclide	For Waste Classified as Class A or B	For Waste Classified as Class C
Co-60	700 Ci	no limit
Nb-94	1 mCi	1 mCi
Cs-137/Ba-137m	3 mCi	30 Ci

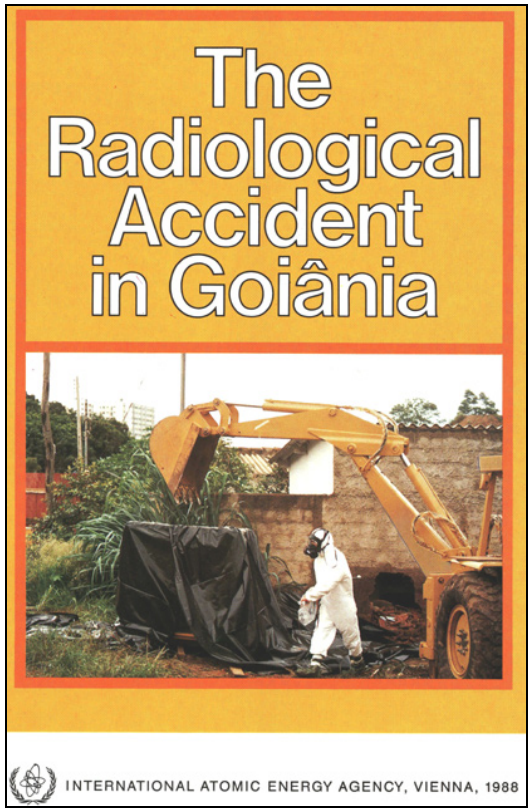
Revised Draft Guidance: Encapsulation of Sealed Sources and Other LLRW

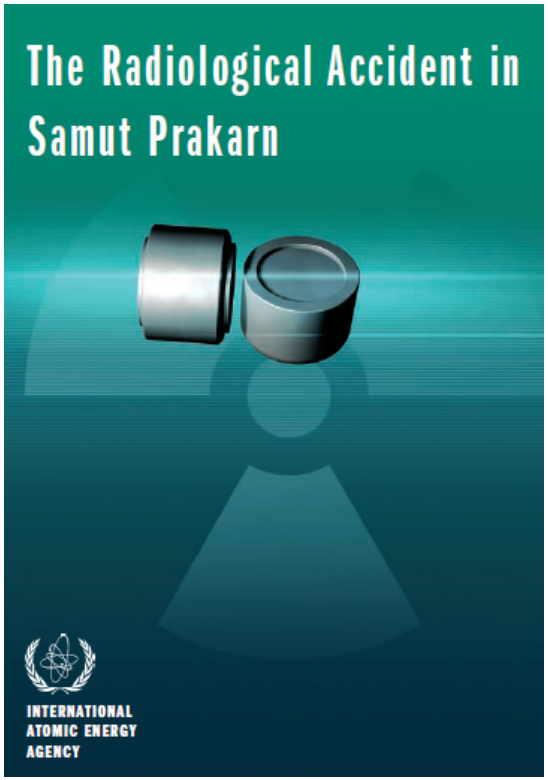
- Maximum encapsulating volume or mass 0.2 m^3 or 500 kg - No Change
- Maximum non-gammas: Class C limit when averaged across of 0.2 m^3 encapsulating package - No Change
- Maximum gamma-emitter curie limits: new exposure scenario, with higher curie limits
- Alternative Approaches also available

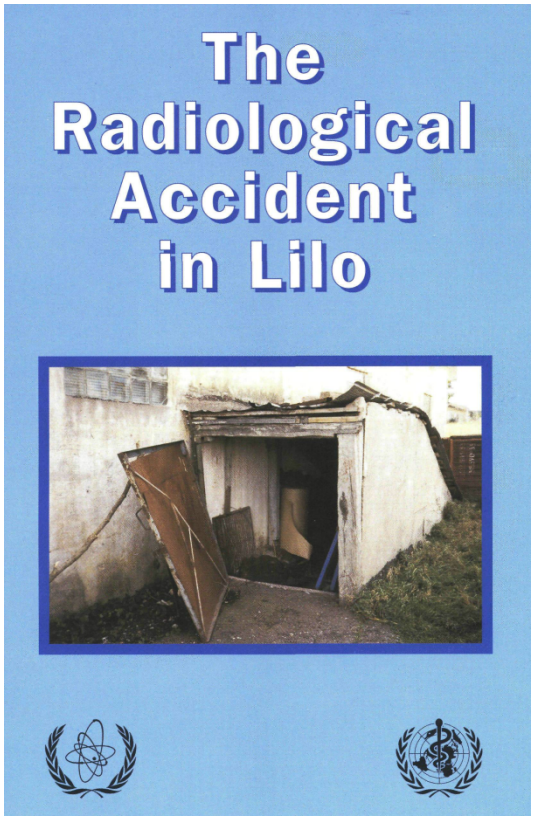
Development of Gamma-Emitting Sealed Source Carry-Away Scenario

- Accidents were a factor in developing new intruder sealed source scenario
- Considered sealed radioactive source accidents for inadvertent intruder discover of sealed radioactive source
- Developed “reasonably foreseeable, yet conservative” scenario

Reviewed Sealed Source Accidents







Reviewed Sealed Source Accidents

- **Common elements**
  - **Loss of regulatory control**
  - **Victims engaged in normal activities**
  - **Radiological hazard not recognizable**
  - **Many accidents resulted in fatalities (adults and children)**
  - **Unlikely, but severe consequences**

- **Many factors were considered in developing sealed source exposure scenario**

Gamma-Emitting Sealed Source Carry-Away Scenario

- **Not real, but stylized scenario used to ensure the intruder does not receive an inordinately high dose, should intrusion occur**

- **Scenario basics:**
  - **500 years after LLRW landfill closure, loss of control, recognition, knowledge**
  - **Containers / wastes / encapsulating media decayed**
  - **Stainless steel Cs-137 sealed radioactive source survived**

- Public works project, regional pipeline, trench through landfill
- Crew notices soil different, foreman urges crew keep working
- Individual finds sealed source: small, old, interesting
- No indication of a hazard

- **Individual takes home, 4 hours in coat pocket**
- **Curios shelf, 2 meters couch, 5 hours per week**

Results of Gamma-Emitting Sealed Source Carry-Away Scenario

- Analysis demonstrates need to protect intruder from small, highly-radioactive items
- Cs-137 sealed source ≤ 130 Ci at disposal, dose intruder ≤ 500 mrem at 500 years

Nuclide	Waste Classified as Class A	Waste Classified as Class B	Waste Classified as Class C
Co-60	140 Ci	No Limit.	No limit.
Nb-94	1 mCi	1 mCi	1 mCi
Cs-137/Ba- 137m	7.2 mCi	0.72 Ci	130 Ci

Summary: Revised Draft Encapsulation Guidance

- New scenario basis
- Reasonably foreseeable, yet conservative
- Higher curie limits – more stranded sources can be disposed
- Transparent basis for using Alternative Approaches

Roadmap

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1995 Guidance: Classifying Mixture Items

- **Mixture items: activated metals, *or* contaminated materials *or* cartridge filters *in single container***
- **Separate, but very similar guidance, for each waste type**
- **BTP defines "primary gamma emitters:" Co-60, Nb-94, and Cs-137/Ba-137m**
- **BTP also defines non-gammas emitters: H-3, C-14, Ni-59, Ni-63, and alpha-emitting TRU half-life > 5 years (except Pu-241 and Cm-242)**

1995 Guidance: Classifying Mixture Items

A. Classify mixture using class. piece w/ highest class,

or

B. Classify based on average of mixture, if hot spots are removed:

Gamma hot spots:

1. **Pieces < 0.01 ft^3 and > Table A gamma emitters**
2. **Factor 1.5 rule for pieces gamma emitters**

Non-gamma hot spots:

1. **Pieces > Table B for non-gamma pieces, any size**
2. **Factor 10 rule for non-gamma pieces**

Revised Draft Guidance: Classifying Mixture Items

A. No change - Classify mixture using class. piece w/ highest class, or

B. No change - Classify based on average of mixture, if:

1. **Change - Pieces < 0.01 ft^3 and > *Table A gamma emitters***
2. **Change - *Factor 2 rule* for pieces gamma emitters**
3. **Pieces > Table B for non-gamma pieces, any size**
4. **Change - Factor 10 rule for non-gamma pieces**

Revised Draft Guidance: Table A Updated

1. Pieces < 0.01 ft^3 and > Table A gamma emitters

- Updated Table A, which matches encapsulation values

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Revised Draft Guidance: Factor 2 Rule

2. Factor 2 Rule for pieces gamma emitters

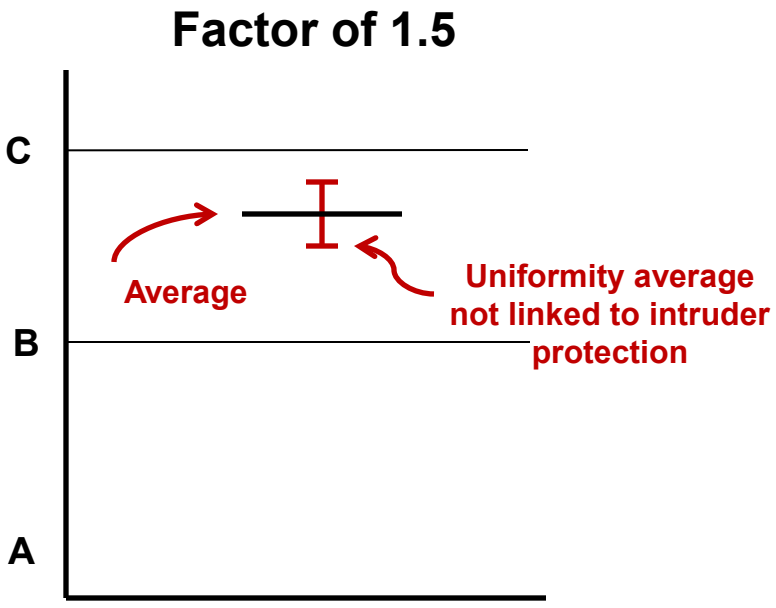
- **New Rule is based on new exposure scenario, that is similar to Gamma-Emitting Sealed Source Carry-Away Scenario used to set the encapsulation limits for gamma emitters and the Table A limits**

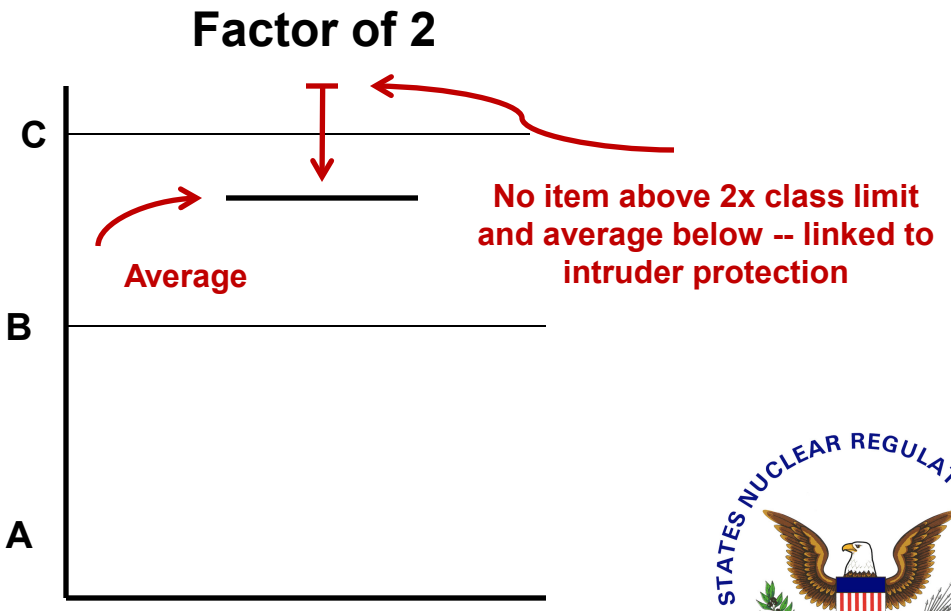
Results of Gamma-Emitting Larger Items Carry-Away Scenario

- Analysis demonstrates need to protect intruder from larger pieces of activated metal
- Nb-94 (Co-60 & Cs-137) activity ≤ 2 x Class limit, dose intruder ≤500 mrem at 500 years (Factor 2 Rule)

Revised Draft Guidance: Factor of 2 vs Factor of 1.5

- **Current, concentrations of individual nuclides, in individual items < 1.5 X *of respective average of each nuclide in mixture***
- **Proposed, concentration in individual items < 2 X *of the class limit for that nuclide***





Revised Draft Guidance: Factor 10 Rule

4. Factor 10 rule for non-gamma pieces

- **Proposed Factor 10 Rule similar to proposed Factor 2**
- **Current Factor 10 relative to *average of each non-gamma nuclide in mixture***
- **Proposed, Factor 10 Rule relative to c*lass limit for that nuclide***

Summary: Revised Draft Guidance Classifying Mixture Items

- New Table A – higher limits gamma
- Factor 2 Rule gammas
  - New intruder scenario
  - No lower limit
  - Linked to class limit, not average of mixture
- Factor 10 Rule non-gammas
  - No lower limit
  - Linked to class limit, not average of mixture

Summary: Alternative Approaches and Encapsulation

- **Alternative Approaches**
  - New philosophy
  - BTP provides “look up” guidance, uniform level safety
  - AA provides specific guidance for deviations
- **Encapsulation:**
  - New scenario basis for gamma-emitter curie limits
  - Higher curie limits – more stranded sources disposed
  - Transparent basis for using Alternative Approaches

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