DISUSED SEALED SOURCES AND HETEROGENEOUS WASTE – ASAM

From: presentations of the WG leader (L. Gagner) on both of the ASAM CDs + document on the test case inventory (P. Salzer)

CONTENT

- 1st Research Coordination Meeting (11-15 November 2002)
- 1st Joint Working Groups Meeting (2-6 June 2003)
- Determination of the test case inventory

SCOPE of HWWG

- **WASTE : THE BROAD VARIETY OF HETEROGENEOUS WASTE WITH A FOCUS ON SEALED SOURCES**
- **DISPOSAL OPTION : VARIOUS EXISTING OR PROPOSED NEAR SURFACE OPTION SUCH AS VAULT, BOREHOLE, TRENCH**
- **PHASE : OPERATIONAL AND POST-CLOSURE PHASE**
- **REFERENCE CASE : INFORMATION FROM A REAL SITE WITH EXISTING REFERENCE SAFETY CASE FOR LILW WASTE (CONSIDERING HOMOGENIETY)**

OBJECTIVE of HWWG

- **TO STUDY THE APPLICABILITY OF THE ISAM METHODOLOGY IN ORDER TO EVALUATE THE SAFETY IMPLICATIONS AND ACCEPTABILITY OF DISPOSING HETEROGENEOUS WASTE IN NEAR SURFACE DISPOSAL FACILITIES**

- **TO PROCEED FIRSTLY WITH THE ASSESSMENT OF DISPOSAL OF DISUSED SEALED SOURCES, AND SECONDLY WITH OTHER HETEROGENEOUS WASTE, SINCE THE NEED IS ESPECIALLY ACUTE FOR THE SEALED SOURCES**

OBJECTIVE of HWWG

- **SPECIFIC OBJECTIVES FOR SEALED SOURCES :**
  - **to advise on the evaluation of safety of existing disposal facilities containing disused sealed sources**
  - **to advise on the evaluation of different possible concepts (vaults, trenches, borehole) for the disposal of disused sealed sources**
  - **to evaluate and categorize the large variety of sealed sources, in terms of radiological characteristics, mechanical characteristics, and total inventory**
  - **to illustrate the application of safety assessment methodology to the derivation of waste acceptance criteria for different concepts**

OBJECTIVE of HWWG

- **SPECIFIC OBJECTIVES FOR <u>OTHER HETEROGENEOUS WASTE</u> :**

- **to advise on the evaluation of safety of disposal of different types of heterogeneous waste and specifically on the evaluation of the consistency of the safety assessment with regard to the heterogeneity of waste**
- **to evaluate the extension of existing safety analysis in order to demonstrate the disposability of new heterogeneous waste in existing near surface disposal facilities**
- **to identify the specific risks associated with different levels of heterogeneity**
- **to derive waste acceptance criteria**

PROPOSED ACTIVITIES

- APPLICATION OF THE ISAM METHODOLOGY
  - PRESENT A VOLUNTEER REFERENCE SITE
  - PRESENTATION OF NATIONAL EXPERIENCE
  - IDENTIFICATION OF IMPORTANT ISSUES AND THEIR PRIORITISATION
  - IDENTIFICATION OF GROUP TEST CASE FOR DISUSED SEALED SOURCES
    - Assessment context
    - Compilation of a detailed system description
    - Development of justification of exposure scenarios
    - Model development
    - Consequence analysis
    - Interpretation of results and conclusions
  - IDENTIFICATION OF GROUP TEST CASE FOR OTHER HETEROGENEOUS WASTE

EXPECTED OUTCOMES

- **TO DEMONSTRATE THE APPLICABILITY OF THE ISAM METHODOLOGY TO THE ASSESSMENT OF NEAR SURFACE DISPOSAL OF HETEROGENEOUS WASTE AND SEALED SOURCES**
- **SPECIFIC OUTCOMES:**
  - **classification of identified heterogeneous waste with regard to their radiological hazard level**
  - **identification of the additional radiological risks associated with such heterogeneous waste by comparison to standard waste**
  - **generation of relevant scenarios and models specifically associated with heterogeneous waste**
  - **derivation of illustrative activity limits**

EXPECTED PARTICIPANT INPUTS

- TO PROVIDE INFORMATION ON THE DISUSED SEALED SOURCES INVENTORY AND INVENTORY OF OTHERS HETEOGENEOUS WASTE, GENERATED IN THEIR COUNTRIES
- TO PRESENT AND DISCUSS APPROACHES FOR EVALUATION OF DISPOSABILITY OF DISUSED SEALED SOURCES
- PROVIDE INFORMATION ON THE NATIONAL EXPERIENCE CONCERNING THE WASTE FORM, THE EXISTING DISPOSAL CONCEPTS, THE APPROACHES TO SETTING LIMITS, THE REGULATORY FRAMEWORK
- TO ACTIVELY CONTRIBUTE IN THE WORKING GROUP DISCUSSION AND THE DEVELOPMENT , REVIEW AND DOCUMENTATION OF THE TEST CASE

PROGRAMME AND OUTCOMES OF 1ST RCM

- GROUP TEST CASE STRUCTURE
- WORK PLAN
  - WORKING GROUP ACTIVITIES AND MEETINGS - 2003
  - DETAILED PLAN UP TO 2005

SHORT TERM WORK PLAN DECIDED AT THE RCM

Sub-Group* : *Inventories Activities

- **Develop a form for sealed sources**
- **Complete the data on sealed sources**
- **Develop Inventory for the Test Case**
- **Selection of criteria for categorizing heterogeneity**
- **Develop a form for heterogeneous waste**
- **Complete data on waste heterogeneity**
- **Develop heterogeneous sources term for the Test Case**

SHORT TERM WORK PLAN DECIDED AT THE RCM

- *Sub-Group : Source Term Heterogeneity Analysis*
- *Sub-Group : Intruders Analysis*
- *Sub-Group: Site Specific Activities*

- **Identify available information from the Reference Safety Assessment and ISAM studies (Safety Assessment, WAC)**
- **Identify key issues for the Test Case**
- **Propose a work plan**

Progress Between the RCM and JWGM

⌦ ***Sub-Group*** **: *Inventories Activities* : Elaboration of a paper**

- **Very precise questionnaire sent to WG participants (based on radiological, mechanical and chemical characteristics of DSS)**
- **Information from national inventories : Argentina, Belgium, Cuba, France, Lithuania, Slovakia, South Africa, Spain**
- **Difficulties to provide mechanical and chemical information**
- **Consideration of IAEA categorization of DSS based on Activity/Danger**
- **Need for volunteer site DSS inventory + need to validate new criteria + need to develop Test Case DSS inventory**
- **Need to define criteria + inventory for other heterogeneous waste (Volunteer site + National information)**

Progress Between the RCM and JWGM

⌦ ***Sub-Group*** **: *Intruders Activities* : Production of a paper**

- **Identification of available information :**

→ **questionnaire to WG participants**

→ **homogeneous waste : common approach for intrusion scenario (Argentina, Belgium, France, Korea, Slovakia, South Africa, Spain)**

→ **DSS : FEP's + risk analysis from Spanish experience, Risk + Combination of state components from French experience**

- **Key issues :**

→ **generation of relevant set of scenarios**

→ **definition of an inventory**

→ **precision of calculation issues**

Progress Between the RCM and JWGM

- ***Sub-Group*** **: *Intruders Activities* : Production of a paper**
  - **Proposal of work plan :**
  - **Task 1 : Define an inventory (Top priority)**
  - **Task 2 : Define the system to be considered (Medium priority)**
  - **Task 3 : Select the relevant method to derive scenarios (Top Priority)**
  - **Task 4 : Generate relevant set of scenarios (Low priority)**
  - **Task 5 : Precise calculation issues of the assessment context (Low Priority)**
  - **Task 6 : Derive WAC (Low Priority)**

Progress Between the RCM and JWGM

- ***Sub-Group*** **: *Source Term Heterogeneity Analysis* : Production of a paper**
  - **Identification of available information :**
    - **No identified national experience on water modeling of heterogeneity**
  - **Key issues and proposal of work plan :**
    - **Task 1 : Define nature and extend of heterogeneities to consider**
    - **Task 2 : Define technical analysis approaches**
    - **Task 3 : Develop Test Cases**
    - **Task 4 : Solve Test Cases using different approach and codes**
    - **Task 5 : Compare and contrast different analysis approach**
    - **Task 6 : Examine methods to interpret the impacts of heterogeneities**
    - **Task 7 : Document of results and conclusions**

Progress Between the RCM and JWGM

⌦ *Sub-Group* : *Site Specific Analysis* : Production of a paper

➢ **Key issues and proposal of work plan :**

→ **Task 1 : Description review of the system (inventory, disposal, site)**

→ **Task 2 : Develop Test Case**

→ **Task 3 : Develop site specific scenarios (helped by outcomes of source term modeling and human intrusion scenarios)**

→ **Task 4 : Define technical analysis approaches and models (helped by outcomes of source term modeling and human intrusion scenarios)**

→ **Task 4 : Test Case calculation**

→ **Task 5 : Compare and contrast results**

→ **Task 7 : Document of results and conclusions**

OBJECTIVE OF THE JWGM

- Validation of criteria + Definition of Inventories to be considered
- Agreement on the Test Case
- Agreement on interaction between subgroups
- Review/Update of proposed work plan for each subgroup
- Selection of adapted methods for intruders and water analysis

OUTCOMES OF THE JWGM

- Criteria + Inventory for DSS and other heterogeneous waste (Intermediate Report)
- Precise description of the Test Case with site-specific available information and with validated work plan (Site-Specific Report)
- Updated work plan + Selection of adapted methods for intruders and water analysis (Intruder and water analysis Report)

OUTCOMES OF THE 1st JWGM

- ***Inventory Sub-Group***
  - **Disused sealed sources :**
    - → **Generation of DSS inventory based on Saratov + 8 participant contributions + IAEA TECDOC 1344 + exclusion of very short lived + exclusion of impurities**
    - → **Second iteration may be needed according to the needs for source term modeling and intruders calculations (relevant information for safety)**
  - **Other heterogeneous waste :**
    - → **Inventory produced, based on real practices and activity (hot containers), size (large items), degradation, and matrix (bituminous) criteria + Radium cont. ground**
    - → **Needs for source term modeling and intruders calculations will have to be expressed**
- ***Intruders Sub-Group***
  - **Scenario generation :**
    - → **Inventory of existing intruders scenarios for homogeneous waste**
    - → **Decision to explore and to combine FEP's method, risk approach, and combination of states methods**

OUTCOMES OF THE 1st JWGM

- ***Intruders Sub-Group***
  - **Assessment context, inventory and system description :**
    - **First definition provided, to be detailed**
- ***Source Term Modeling + Site Specific Sub-Group***
  - **Decision to regroup the two sub-groups until the next RCM**
  - **Inventory provided by inventory sub-group**
  - **System description: 5 concepts:**
    - **Shallow Borehole, Deep Borehole, Vault, Trench, Site composite**
  - **Model parameters:**
    - **First stage no credit for the waste form**
    - **Release controlled by solubility and sorption**
    - **Water flow and transport parameters from ISAM Radon Test Case**
  - **Four series of test problems defined**
    - **Different location of heterogeneities**

DOCUMENT FOR THE FEBRUARY 2004 RCM

- ***Inventory*** **: DOCUMENT**
  - **DSS + HW final inventory with criteria and justification**
- ***Intruders*** **: REPORT**
  - **Assessment context, inventory of DSS, generic system description including Saratov**
  - **Detailed description of the three methods to be used to generate scenarios**
  - **FEP's list adapted to intrusion in heterogeneity**
  - **First application of one or different methods**
- ***Source Term Modeling and Site Specific*****: REPORT**
  - **Assessment context, inventory of DSS, generic system description including Saratov**
  - **Test problem conceptual model description including all data for modeling**
  - **Series of technical reports describing model evaluations of the impact of heterogeneity in the water pathway**

Test case inventory proposal

Standard forms to summarize the national inventories. Responds obtained from:

- **Argentina**
- **Belgium**
- **Cuba,**
- **France,**
- **Lithuania,**
- **Slovakia,**
- **South Africa,**
- **Spain**

+ real inventory of the Saratov site presented on the JWGM

Very brief and non-comparable information ⇨need to use the approach of IAEA-TECDOC-1344

Test case inventory proposal

Estimation of the "generic inventory" has been performed in the following steps:

- **Determination of ranges of activity and category for typical application of sealed sources, for each safety important radionuclide. The very short-lived radionuclides (T1/2 ў 1 -3 x10^2 days) have not been considered, because the decay storage followed by the clearance seems to be the best final option of management of these disused sources.**
- **Assignment of some characteristics to the particular source applications based on brief obtained information, where possible.**
- **Estimation of typical activity for particular nuclides and particular source application, using also the national inventories.**
- **Comparison of national inventories with the Saratov site inventory and establishing the "final disused sealed source inventory in the Saratov disposal facility" for the ASAM Heterogeneity group exercise.**

Test case inventory proposal

Discussion on the JWGM:

- Definition of “sealed source”
- Very low-activity sources (e.g. ^{241}Am in smoke detectors)
- Disposal of low-activity long-lived sources (e.g. ^{226}Ra)
- Disposal of very high activity sources of ^{137}Cs
- Problem of the impurities.
- Not broadly used isotopes (etalons)

Conclusion:

Do not a priori exclude any activities, source types and nuclides from the test case considerations, with two exemptions:

- very short-lived radionuclides (T1/2 Ў 1-3 x 10^2 days, i.e.: ^{32}P, ^{35}S, ^{51}Cr, ^{54}Mn, ^{57}Co, ^{58}Co, ^{65}Zn, ^{85}Sr, ^{99}Mo, ^{106}Ru-Rh, ^{126}Sb, ^{125}I, ^{131}I, ^{144}Ce, ^{170}Tm, ^{192}Ir, ^{198}Au, ^{203}Hg, …) will not be considered,
- impurities will not be considered (lack of information)

Test case inventory proposal

Part of the proposed sealed source inventory table

Nuclide	Range of activity [Bq]	Pieces
^{241}Am (or Am/Be)	5E07 – 7E11	120
^{241}Am	1E04	20000
^{60}Co	1E10 – 1E17	200
^{60}Co	<1E10	1000
^{137}Cs	4E08 – 1E12	900
^{137}Cs	1E12 – 1E17	50
^{90}Sr	1E09 – 8E10	50
^{244}Cm	1E05 – 2E10	15
^{109}Cd	1E09	10
^{238,239}Pu (Pu/Be)	1E10 – 1E11	13 – 18
^{239}Pu	2E05 – 2E07	600

Good information about the source characteristics: www.hsrd.ornl.gov/nrc/sources/index.cfm

Estimation of the total test case inventory

Heterogeneities:

- **sealed sources disposed:**
  - **in the waste package container standardized for given disposal; emplaced in vaults,**
  - **in transportation/manipulation container; emplaced in vaults**
  - **inserted directly (without container) into the borehole,**
- **large metallic pieces from NPP decommissioning or others, disposed directly in disposal facility units,**

Estimation of the total test case inventory

Next mixture of heterogeneities:

- **pieces of solid waste inserted to the standardized container; container filled by cement mortar (metal pieces, briquettes pressed out from the waste incinerator ashes**
- **bituminized waste; wastes can be bituminized to drums, drums directly disposed or inserted into the overpack containers (filled by cement mortar),**
- **cemented waste,**
- **waste conditioned by other conditioning practices (higher activity wastes conditioned, for instance, by vitrification, with very small leaching rate) and finally inserted to standardized containers.**

Estimation of the total test case inventory

Slovak proposal:

Applying only the Saratov RADON-type facility with established disused sealed sources inventory + other waste disposed in the facility ⇨not principal methodological difference with the Safety re-assessment WG (Püspökszilagy facility test case) ⇨need to be more complex and include the whole spectrum of heterogeneities ⇨ proposal for two options of inventory/source term approach

Estimation of the total test case inventory

Option 1

"Replace" the Saratov vaults by the Mochovce disposal facility (two double-vaults), i.e. apply the Slovak disposal structure characteristics and arrangement of disposal and the Slovak other heterogeneities inventory + inventory of disused sealed sources (see above),

+ existing real Saratov borehole and trench.

Apply the Saratov site specific data for the test case

Estimation of the total test case inventory

Option 2

Apply the Saratov site disposal structures (vaults, borehole, trench) as they are and site characteristics, and "dispose" there:

- **the same disused sealed sources inventory as in the first option (some directly disposed in the vaults, some disposed in the transport/manipulation Pb-container, some emplaced in the borehole),**
- **+ other heterogeneous waste with relatively smaller volume:**
  - **bituminized NPP waste in drums**
  - **cemented NPP waste (same waste stream as in the first option, but smaller volume),**
  - **heterogeneous waste (solid pieces inside the standard container) packages (same as in the first option, but smaller amount),**
  - **large metallic pieces: bubbler really disposed of in the Saratov site plus one piece of large metal piece from the option 1,**
  - **Ra-contaminated soils in trench**

Mochovce site disposal structures

- 80 disposal units (concrete vaults) arranged into two double-rows (i.e. arrangement of vaults is 2x2x20 vaults)
- Individual double-row (2x20 vaults) is surrounded by the clay bath-tub 1 m thick on the bottom, 3 m by the sides.
- Each particular vault is 17.4 m wide, 5.4 m long; average height of individual vault is 5.5 m.
- All wastes are disposed of in standardized container (concrete cubic container reinforced by thin metal tapes/fibres) with inner volume 3.1 m^3.
- Total volume capacity of existing disposal structures is 7200 containers, i.e. 22320 m^3 of conditioned waste. In the individual vault, the containers are stacked on three levels (10 x 3 x 3 = 90 containers).

Option 1 ("Slovak part" of inventory)

Bituminized waste:

Nuclide	C-14	Ni-63	Se-79	Sr-90	Zr-93	Nb-94	Tc-99
[Bq/m^3]	1.4E+07	2.2E+07	<4.5E+05	1.0E+05	4.7E+04	<1.3E+06	4.3E+06
Nuclide	Sn-126	I-129	Cs-135	Cs-137	Sm-151	Pu-239,240	Am-241
[Bq/m^3]	<8.6E+06	3.4E+07	9.6E+04	6.0E+09	<3.0E+05	4.1E+02	1.8E+04

For the ASAM exercise purposes, it can be supposed that the total volume of disposed bituminized waste is 7000 m^3. The emplacement of waste packages containing bituminized waste is not pre-defined.

Cemented waste:

Nuclide	H-3	C-14	Sr-90	Tc-99	I-129
[Bq/m^3]	8.0E+07	4.9E+07	1.4E+06	<3.6E+04	1.9E+05
Nuclide	Cs-135	Cs-137	Pu-238	Pu-239,240	Am-241
[Bq/m^3]	3.0E+04	1.9E+08	3.8E+02	9.7E+02	1.3E+04

Volume of the cemented waste is determined as a total volume of waste disposed (22 320 m^3) minus bituminized waste volume and volume of wastes mentioned below.

Option 1(DSS in the "Slovak Containers")

It can be supposed that the DSSs inventory will be emplaced into 10 containers and displaced in the bottom of vaults (bottom layer of containers). Each container will be disposed of away from others (maximum one in any four adjacent vaults). There is only qualitative requirement for spreading the sources: effort to achieve uniform division of activity of particular nuclides as even as possible.

Option 1("Slovak part" of inventory)

- Metal pieces (main primary valves) from decommissioning of the NPP should be considered as directly disposed for the ASAM exercise

⇨Direct disposal of 24 contaminated assemblies containing two valves and approximately 5 m adjacent pipes could be taken into account. The mass of one assembly is approximately 6.5 tons, material: carbon steel. Inner contaminated surface of the assembly has been estimated as 11 m^2; the average surface activity as 6.7E+09 Bq/m^2. Abundance ratio of radionuclides:

Nuclide	Am-241	C-14	Cl-36	Co-60	Cs-135	Cs-137	Eu-152
	4.6E-03		1.8E-10	3.8E-01		3.2E-01	1.1E-02
Nuclide	H-3	I-129	Mo-93	Nb-94	Ni-59	Ni-63	Pd-107
	9.1E-04	1.3E-04	3.5E-06	8.5E-05	4.8E-04	5.5E-02	
Nuclide	Pu-238	Pu-239	Sm-151	Sn-126	Sr-90	Tc-99	Zr-93
	6.9E-04	2.1E-03	1.6E-03	3.0E-06	2.2E-01	6.0E-05	8.7E-06

⇨emplaced directly into two adjacent vaults.

Option 1("Slovak part" of inventory)

900 containers from the total amount will be filled with briquettes from high pressure compaction (compactable solid wastes – 50 %) or with non-compactable solid wastes (50%). The average concentration of radionuclides in these waste packages:

Nuclide	C-14	Sr-90	Tc-99	I-129	Cs-137	Pu-238,239
WP volume activity – compacted waste [Bq/m^3]	5.7E+07	2.9E+06	2.9E+05	8.6E+04	7.2E+09	2.9E+04
WP volume activity – non-compacted waste [Bq/m^3]	1.0E+07	5.0E+05	5.0E+04	1.5E+04	1.3E+09	5.0E+03

100 packages from this group could be characterized as "hot containers". These contain the solid waste after newly established technologies resulted in low-leaching solid waste (glass, Si-Al matrices, ceramics). Activity of ^{137}Cs in these containers is 100-times higher than values in the table. Spatial distribution of these containers is achieved by means of waste acceptance criteria. It can be considered that only one, occasionally two "hot containers" will be disposed in one vault in the bottom layer of the containers.

Option 1 (Saratov part)

- 5 trenches with the total volume of 150 m^3 filled with ^{226}Ra-contaminated ground (37 kBq/kg average specific activity),
- part of the sealed sources inventory is disposed of in the borehole
- cylindrical carbon steel tank, length: approximately 4 m, diameter approximately 3 m) contaminated with ^{226}Ra and disposed of in high-volume vault in the Saratov repository will be also considered (no information on the level of contamination)

Nuclide	Amount [Pcs]	Total activity [MBq] (01.01.2003)
Co-60	*10*	*0,106*
Co-60	*2*	*0,8*
Co-60	1	1,8
Co-60	46	2006
Co-60	5	143
Co-60	7	0,028
Co-60	850	19100
Co-60	9	3,74E+06
Cs-137	98	2,38E+06
Cs-137	4	6750
Cs-137	10	2,21E+06
Cs-137	15	4,62E+06
Cs-137	1	4870
Cs-137	61	3,02E+06
Cs-137	1	63,3
Cs-137	62	2,82E+06
Cs-137	16	5,29E+05
Cs-137	2	4305
Cs-137	15	4,81E+04
Cs-137	1	0,0017
Cs-137	14	2,55E+05

Option 2

Saratov site disposal structures:

- **three concrete vaults (i.e.: 3 x 200 m^3 volume capacity): A, B, D,**
- **concrete vault with 940 m^3 volume capacity: C,**
- **bore-hole containing the disused sealed sources**
- **5 trenches with the total volume of 150 m^3 filled with ^{226}Ra contaminated ground (37 kBq/kg average specific activity).**

200 l drums will be considered as the standardized waste package container for waste other than disused sealed sources (with exemption of larger metal pieces).

Option 2

- Vault A is filled with bituminized waste drums. Inventory same as in option 1.
- Vault B is filled with cemented waste drums. Inventory same as in option 1.
- The bubbler contaminated with ^{226}Ra is inserted into the vault C.
- All disused sealed sources are disposed of in the vaults C and D, as well as in the borehole. Sealed sources in the vault are disposed of in the following way:
  - 30 % of ^{60}Co and ^{137}Cs sources are disposed of inside the Pb-transport container,
  - neutron sources are disposed in the neutron sources containers (hydrocarbons or polyhydrocarbons),
  - 50 % of all sources are cemented in drums,
  - remaining sources (smaller activity gamma and all beta sources are directly inserted into vaults.
- 100 drums containing the cemented solid wastes are inserted to the vault C. “Hot package” from the option 1 has not been considered.
- Two large metal pieces from the option 1 are inserted into the vault C

The last development

- Document with the inventory proposal was sent to WG leader (end of July 2003) for the final choice
- Decision – final determination of inventory should be influenced backwards according with approaches to safety assessment methodologies
- No information about the final decision and about next development up to now