French - Slovak Summer School
`Decommissioning of NPP`
Kocovce, September 2009

AUTOMATIZED MATERIAL AND RADIOACTIVITY FLOW CONTROL TOOL IN DECOMMISSIONING PROCESS

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Contents

1. Introduction

The computer code "Omega" (Oracle Multicriterial General Assessment of Decommissioning) is used in decommissioning planning phase for following tasks:

- **Assembling the model calculation option of decommissioning**
- **Calculation of parameters of decommissioning for individual options**
- **Time and parametric optimisation of individual calculation options of decommissioning**
- **Comparison of options of decommissioning and choice of the most suitable option based on multicriterial analysis**

Computer simulation of the decommissioning process is one of the important attributes of above mentioned computer code. In the following chapters methods and tools for computer optimization of decommissioning waste processing will be discussed.

2. Types of Decommissioning Procedures

Calculation procedures used in the computer code Omega represent mathematical description of real decommissioning activities. These procedures can be sorted into following groups:

- **Material procedures – describe decommissioning activities with material of technological equipment and civil construction (i.e. predismantling decontamination and dismantling, radwaste processing, radwaste disposal/material release into environment)**

- **Time dependent procedures - describe non-material decommissioning activities, such as planning and preparation of documents, quality assurance, technical support, check processes, security activities etc.**

- **Financial procedures – realize some financial operations independent on above mentioned activities**

Relations between material procedures and the destiny of material during decommissioning process is performed by a set of tools, which create integral material and radioactivity flow discussed in the next chapters.

3. Integral Material and Radioactivity Flow

Integral material and radioactivity flow is created by following tools of material flow and radioactivity flow:

Tools of Material Flow

- **Tool of material decomposition**
- **Tool of material procedure input/output**
- **Tool of sequence of material procedures**

Tools of Radioactivity Flow

- **Nuclide vectors**
- **Distribution coefficients**
- **Time dependent nuclide decay**
- **Activity limits**
- **Activity sorters**

Because radioactivity is carried by material, there are close relations between the tools of material flow and the tools of radioactivity flow.

4. Tools of Material Flow

4.1 Tool of Material Decomposition

Tool provides decomposition of technological equipment or civil construction into elementary material items according to category of equipment/construction during dismantling or demolition.

Technological equipment/civil construction is described by following parameters:

- **physical parameters - weight, inner/outer surface, inner/outer surface contamination, induced activity and nuclide vectors (isotopic content of the contamination/induced activity)**
- **category**

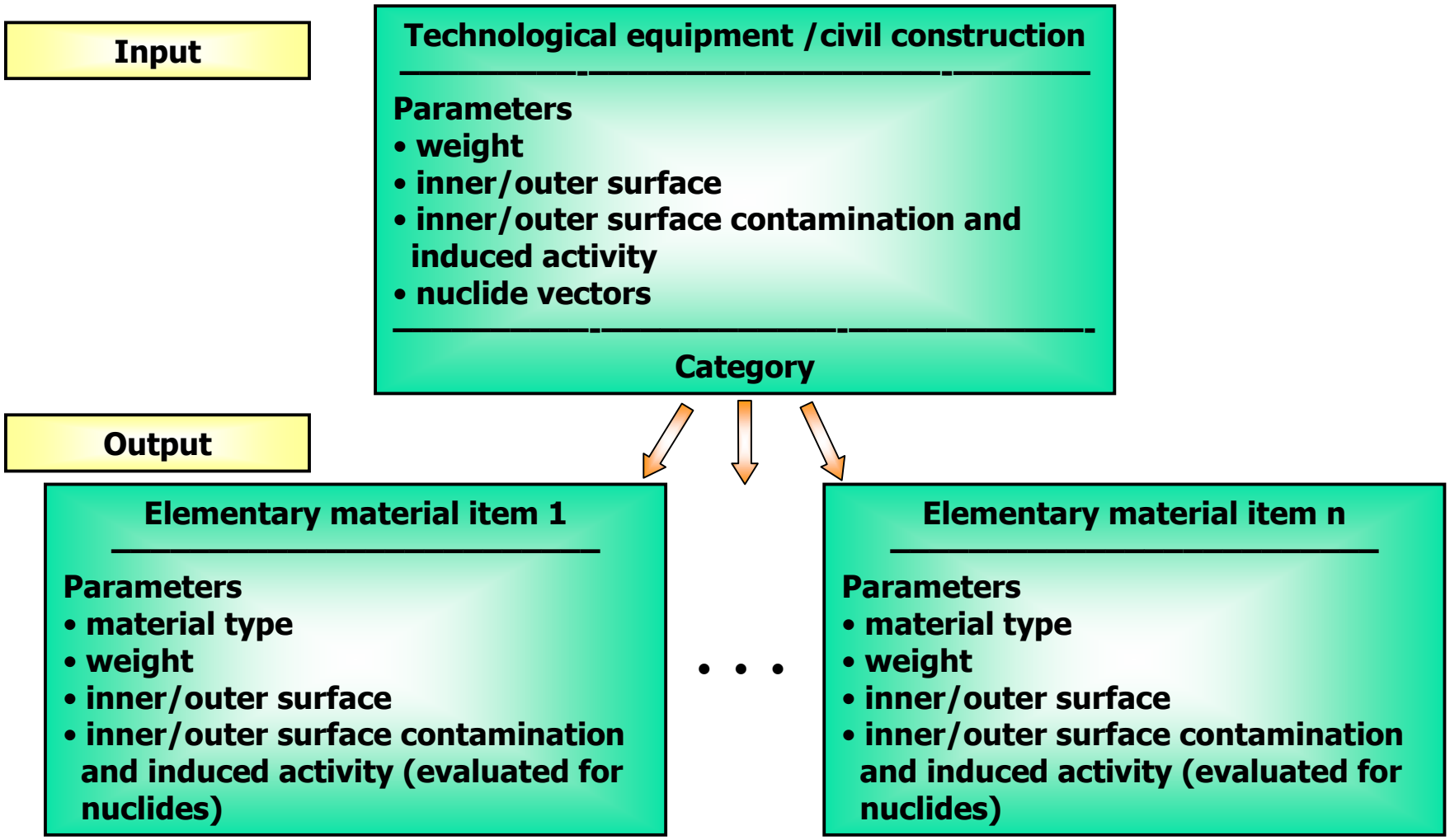
Category of equipment/construction defines:

- **set of elementary material items and material types of these items**
- **ratio of elementary material item physical parameter to equipment/ construction physical parameter for each item**

Tool transforms physical parameters of equipment/construction to parameters of set of elementary material items.

4. Tools of Material Flow

View of Tool of Material Decomposition



4. Tools of Material Flow

4.2 Tool of Material Procedure Input/Output

Each material procedure (i.e. procedure representing radwaste processing, radwaste disposal/material release into environment) has a following set of material input/output:

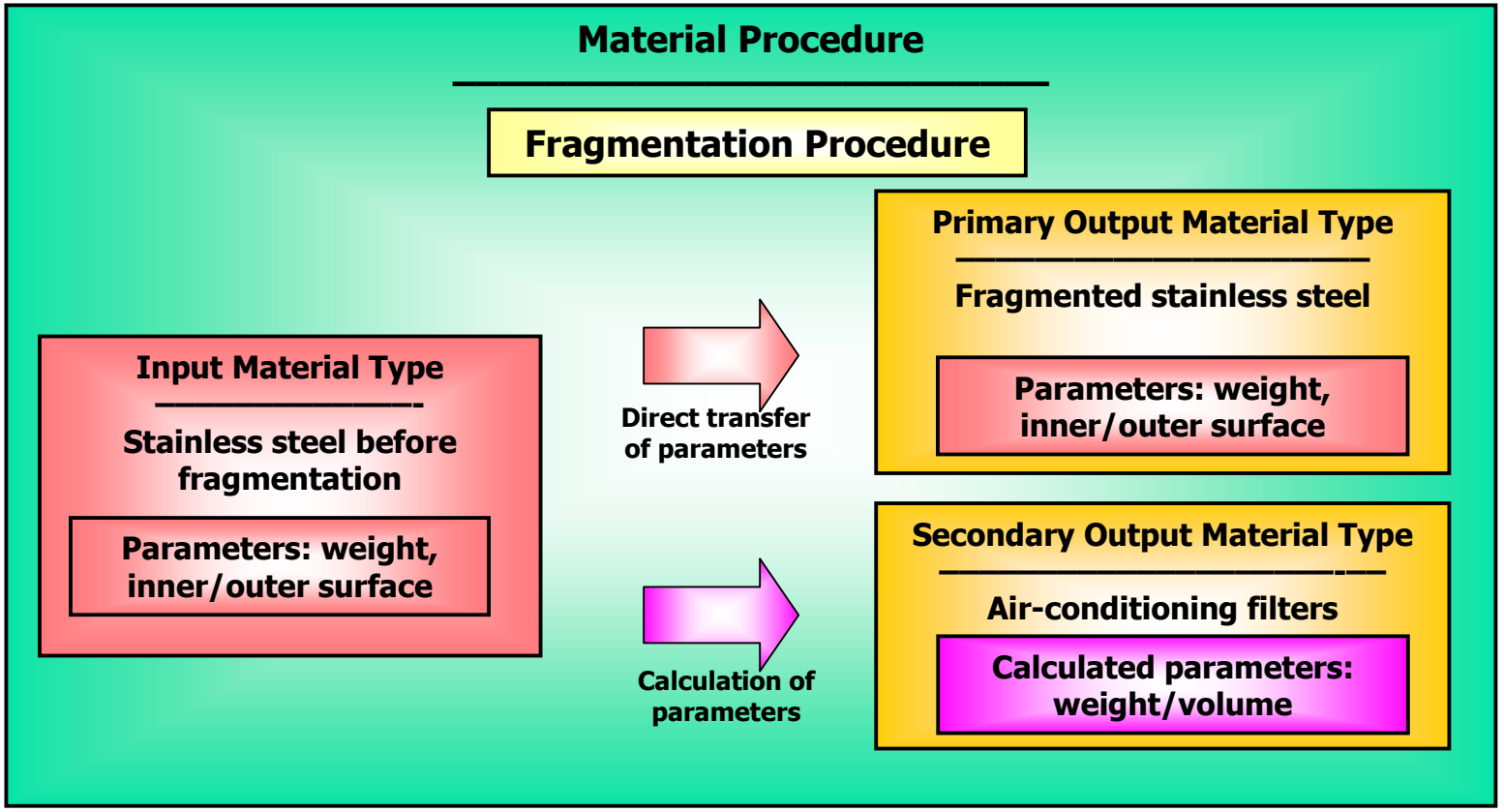
- **Input material type(s)** of elementary material items acceptable to the material procedure. It represents input primary radwaste, which is processed by the procedure. It is described by material parameters of weight and inner/outer surface.

- **Primary output material type(s)** of elementary material items. It represents output primary radwaste (product of processing). Values of primary output material parameters of weight and inner/outer surface are the same as those of input material parameters.

- **Secondary output material type(s)** of elementary material items. It represents output secondary radwaste (product of processing). Values of secondary output material parameters (weight/volume) are calculated by the procedure.

4. Tools of Material Flow

View of Example of Material Procedure Input/Output



4. Tools of Material Flow

4.3 Tool of Sequence of Material Procedures

Tool of sequence of material procedures is based on the following principles:

1. **Each primary/secondary output material type of material procedure is an input material type of another material procedure.**

2. **Each input material type is input material type of one material procedure exactly.**

3. **Material procedure accepts the elementary material items of certain input material type. It can accepts either all those material items or those material items, which were created in the certain date interval, defined by user. Material procedure can work in the two optional modes: date sensitive/ date non-sensitive.**

1st and 2nd principle allow to create a scenario, i.e. the distinct sequence of material procedures from predismantling decontamination up to release of material/ disposal of radwaste.

3rd principle allow to use one material procedure two or more times

5. Tools of Radioactivity Flow

5.1 Nuclide Vectors

- Nuclide vector describes isotopic content of radioactivity or dose rate, it is evaluated by ratio of radioactivity (or dose rate) of nuclide to overall radioactivity (or dose rate).

- Isotopic content knowledge is necessary, because the nuclides are distinguished in radioactivity flow for the purpose of :
  - calculation check of limits defined for nuclides
  - calculation of radioactivity decrease and dose rate decrease in time

Basic categories of nuclide vectors:

- Nuclide vectors of inner/outer surface contamination
- Nuclide vectors of induced activity/mass activity generally
- Nuclide vectors of dose rate

5. Tools of Radioactivity Flow

5.2 Distribution Coefficients

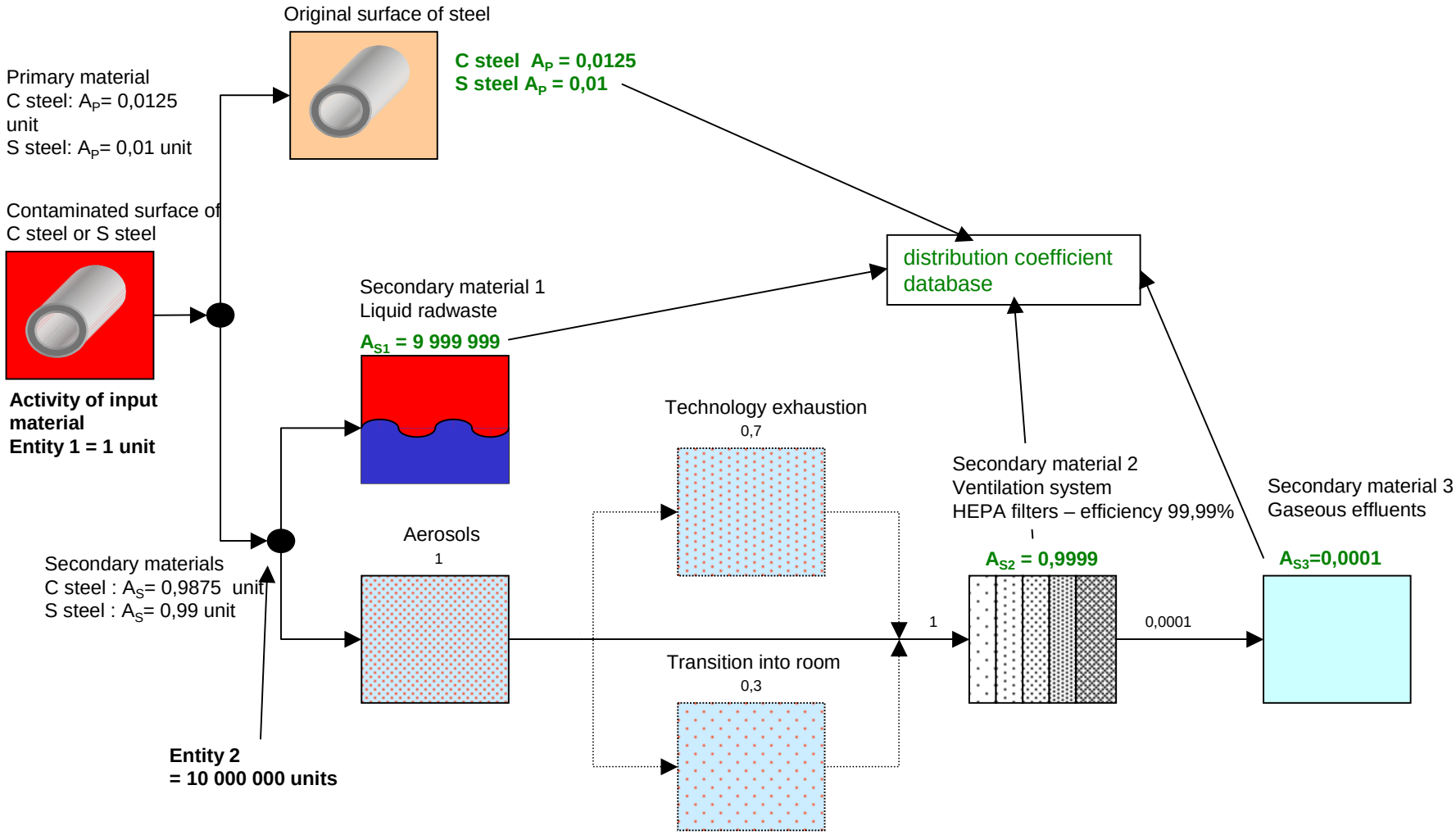
- This tool realises distribution of radioactivity in the material procedure, i.e. distribution of radioactivity of the input material type into radioactivity of the primary/secondary output material type(s)

- distribution coefficients take into consideration:
  - type and properties of the material procedure
  - properties of the primary/secondary output material type
  - type and properties of radionuclides – gaseous, volatile, insoluble etc.

- sources of evaluation of distribution coefficients:
  - known decontamination factors
  - measurements of surface contamination/mass activity/volume activity
  - operative experiences and literature

5. Tools of Radioactivity Flow

Example of schematic pattern of radioactivity flow with distribution coefficients within predismantling decontamination



5. Tools of Radioactivity Flow

5.3 Time Dependent Nuclide Decay

Time dependent nuclide decay is taken into account during calculation, because decrease of radioactivity causes:

- **change of radwaste quantity and assortment,**
- **increase of amount of materials for release into environment**
- **decrease of dose rates and exposure of personnel**
- **decrease of remote manipulators need (in the case of large time intervals)**

5. Tools of Radioactivity Flow

5.4 Activity Limits

Group of limits for material release/radwaste disposal:

- Limit of surface activity of the released solid materials
- Limit of mass activity of the released solid materials
- Limit of volume activity of the released liquids
- Limit of volume activity of the inner volume content of containers for disposal in repository

Group of technological limits:

- Limit of surface activity of the materials, which can be fragmented in fragmentation equipment
- Limit of volume activity of the materials, which can be compacted in super compactor

5. Tools of Radioactivity Flow

5.4 Activity Limits

Activity limits are defined for nuclides.

Surface/mass/volume activity of the material is in compliance with limit, when the following equation is valid:

$$\frac{A1}{AL1} + \frac{A2}{AL2} + \ldots + \frac{An}{ALn} < 1$$

where A1, A2, ... , An are surface/mass/volume activity of material for 1st, 2nd, ... , n-th nuclide

AL1, AL2, ... , ALn are surface/mass/volume limit activity for 1st, 2nd, ... , n-th nuclide

5. Tools of Radioactivity Flow

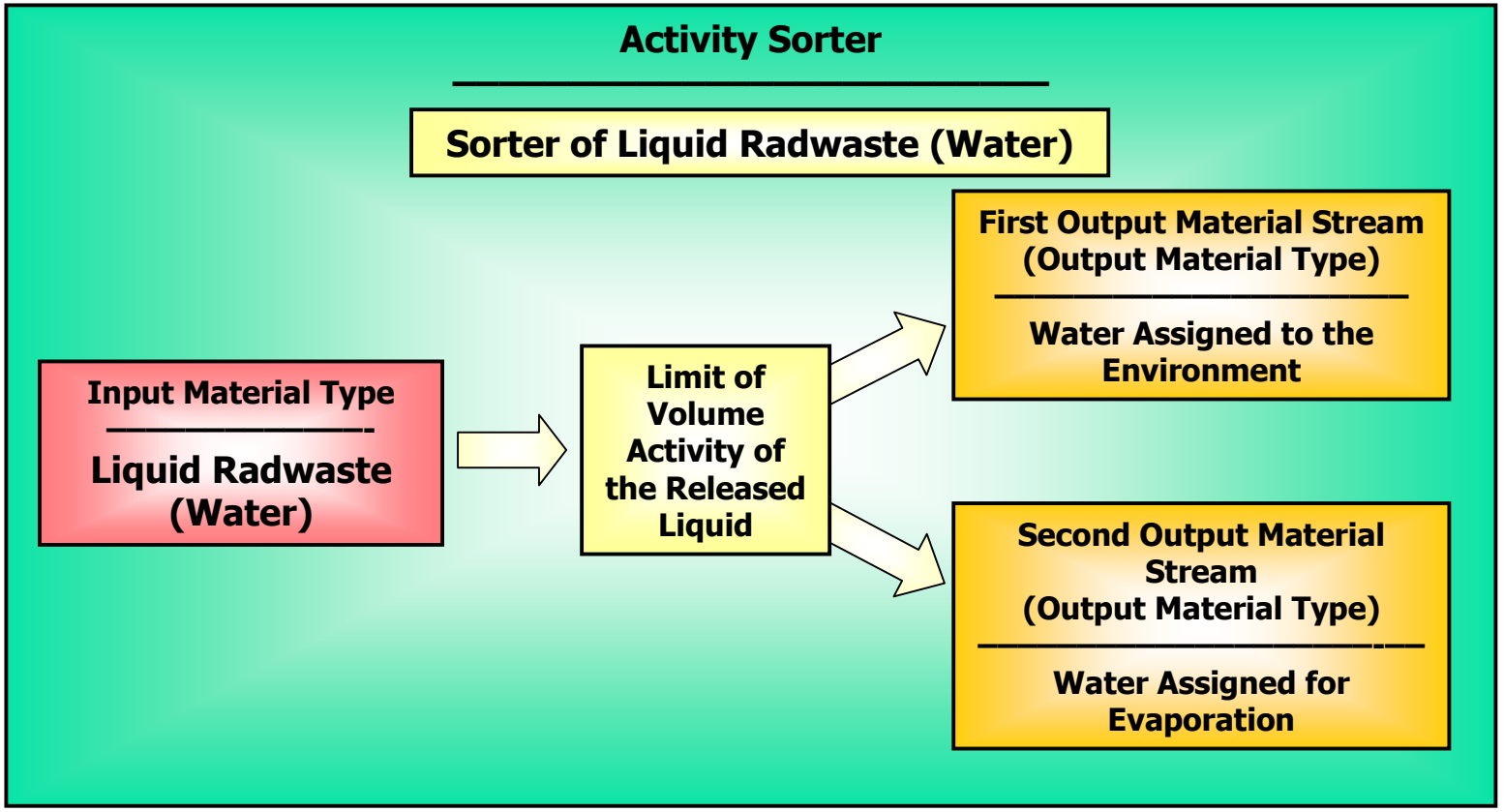
5.5 Activity Sorters

Activity sorters sorts materials on the basis of the compliance with activity limits in the following steps:

- **update of activity of material to the time of sorting/time of check (i.e. update because of time dependent decay)**
- **comparison of activity of material with limit (see equation in chapter 5.4)**
  - **if the activity of material is in compliance with activity limit, material is transferred into first output material stream,**
  - **otherwise material is transferred into second output material stream**

5. Tools of Radioactivity Flow

View of Example of Activity Sorter



6. Scenarios

Scenario organizes a part the material and radioactivity flow according to defined flow conditions.

There are three optional types of scenario, which can be chosen by user:

1st scenario flow conditions:

Condition A: Postdismanling decontamination is applied on that material, which can be released after application of this procedure.

Condition B: Postdismanling decontamination and melting is applied on that material, which can be released after application of these procedures.

Condition C: Super compaction is applied on that material, which doesn't comply with previous conditions.

6. Scenarios

2nd scenario flow conditions:

Condition A: Postdismanling decontamination is applied on that material, which can be released after application of this procedure.

Condition B: Super compaction is applied on that material, which doesn't comply with previous condition.

3rd scenario flow conditions:

Condition A: Melting is applied on that material, which can be released after application of this procedure.

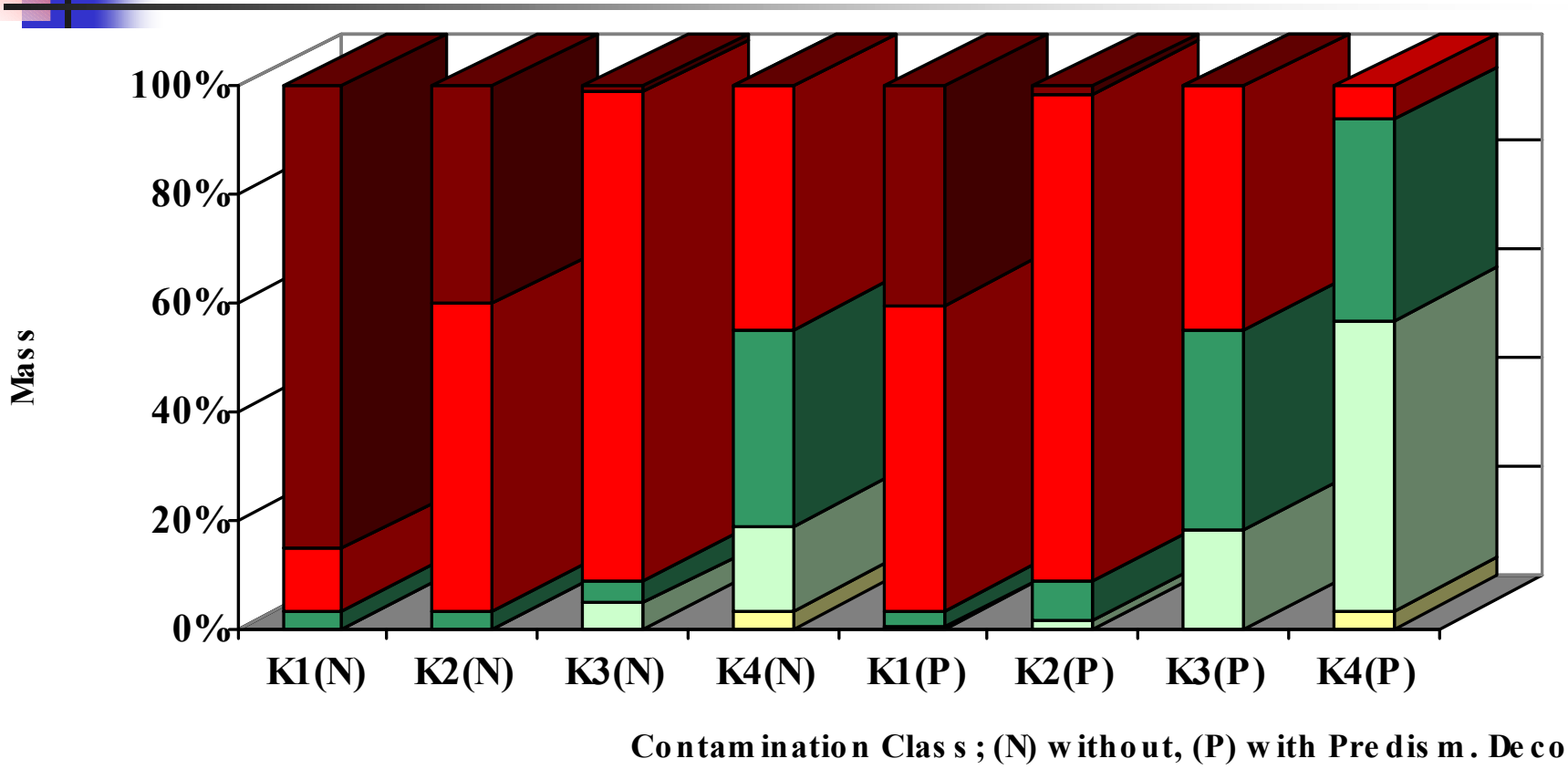
Condition B: Super compaction is applied on that material, which doesn't comply with previous condition.

7. Example

Model calculation for A-1 NPP Bohunice Primary Circuit:

- **Various levels of technological equipment contamination**
- **Various nuclide vectors**
- **Various scenarios**
- **Application / No application of pre-dismantling decontamination**
- **Various start time of decommissioning process**

7. Example



- Deep Geol. Rep.: Near. Surface. Rep.:
- Discharged to the Enviro after melting:
  after decontamination: after dismantling:

8. Conclusions

- Computer simulation of the decommissioning process is one of the important attributes of computer code Omega
- One of the basic tools of computer optimisation of decommissioning waste processing are the tools of integral material and radioactivity flow
- All the calculated parameters of materials are stored in each point of calculation process and they can be viewed
- Computer code Omega represents opened modular system, which can be improved
- Improvement of the module of optimisation of decommissioning waste processing will be performed in the frame of improvement of material procedures and scenarios