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Preliminary Evaluation of Gas Generation from the Korean LILW Repository using the SMOGG Code

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1. Introduction

For the permanent disposal of 100,000 drums of LILW (Low- and Intermediate-Level radioactive Waste) for the first stage of operation (800,000 drums in the long run) in Korea, the rock-cavern repository is being constructed at Gyeongju city. During the lifetime and post-closure period of the repository, it is expected that bulk gases (e.g. hydrogen, carbon dioxide, methane, etc.) are mainly produced by various mechanisms such as the metal corrosion, microbial degradation of organic materials, and radiolysis. Since gases generated have the potential threat to over-pressurize the repository, which can promote the transport of radionuclide contained in groundwater and gas, it is necessary to simulate the features of gas generation from the repository using the appropriate computer code prior to the start of operation. This paper describes the preliminary evaluation of gas generation from the repository using the SMOGG code.

2. Methods and Results

2.1 Computer Code System

Gas generation from the repository is evaluated using the SMOGG (Simplified Model Of Gas Generation) code, which is a modeling tool developed for assessing potential gas generation during the long-term management of the UK's radioactive wastes. SMOGG is intended, generally, to replace the previously used program, GAMMON, for gas generation calculations included in future repository or package assessments carried out by Nirex. This program provides a consistent and standardized approach to the gas generation assessment from radioactive waste packages during various phases (i.e. transport, repository operations, and post-closure).

2.2 Scenario evaluated

It would be expected that total of six silos are operated in the repository. However, the specific operational processes (and/or procedures) are not yet definitely settled. Hence, the following scenario, which is considered as one of the probable alternatives, is applied to this evaluation.

- 1st phase: Waste emplacement (It is assumed that 4 types - i.e. dry active waste, spent resin, concentrate, cartridge filter - of LILW packages, which are mainly generated from a number of origins, are disposed of in the repository.)
- 2nd phase: Repository closure (aerobic condition)
- 3rd phase: Groundwater infiltration (It is assumed that a water inflow rate is 0.007 $m^3yr^{-1}m^3$.)
- 4th phase: Re-saturation (anaerobic condition)

2.3 Input data

All the data applicable to the calculation can be easily inputted and handled using a customized MS-Excel spreadsheet which consists of a number of worksheets and provides the user interface. (For details such as format and meaning of the input data, refer to the user guide.[1])

The values presented in and taken from SAR of the repository were used, where possible.[2] Based on appropriate references and/or experience, otherwise, either typical values or reasonable assumptions were applied. Main input data used is as follows.

- Time scales
  - Calculation time: 0~1000 years
  - Emplacement of waste: 15 packages of each type each year from 20.5 to 59.5 years (i.e. 600 packages of each waste type in total)
  - Repository closure at 100 years
  - Groundwater re-saturation time is determined from an assumed water inflow rate.)

- Generic data for all package types
  - Drum: Carbon steel 1.5mm-thick (25kg of mass)
  - No grout and backfill material after closure
  - Wastes in vented packages
  - Temperature: 20℃(Constant)
  - External void volume associated with each package: 0.2 m^3
  - Void volume in drum: assumed to be porosity plus 10% of drum volume to separately account for an ullage space, etc. (except for cartridge filter packages)
  - Oxygen available to package at closure: This is calculated assuming the void volume in drum is filled with air containing 20.5% oxygen and is converted to a value in moles using the ideal gas law.

- Corrosion rates for carbon steel (taking account of the particular conditions): based on experience
- Initial radionuclide inventory: taken from SAR
- Fraction of ɣ -energy absorbed by waste: 0.9
- G-value (β /ɣ decay) for water: 0.5

• Data for dry active waste packages

- Total mass of package contents: 147.02kg (including 45.6kg of cellulose, 41.8kg of carbon steel, 42.6kg of plastic/rubber, 16.0kg of others, and 1.02kg of water)
- Organic degradation rate (taking account of the particular conditions): based on experience
- Cellulose degradation model used: Option 1
- ^{3}H and ^{14}C inventory: assumed to be uniformly distributed in metal component of waste
- G-value for cellulose and polymer: assumed to be the same and calculated so the average G-value for the waste is 0.4

• Spent resin packages (solidified using cement)

- Total mass of package contents: 338.0kg (including 31.8kg of resin and 74.4kg of water)
- G-value for polymer: calculated so the average G-value for the waste is 0.24

• Concentrate packages (solidified using cement)

- Total mass of package contents: 328.2kg
- Mass of water: calculated conservatively assuming all of porosity is water filled

• Cartridge filter packages (with concrete lining)

- Volume of drum: 0.136m^3
- Mass of filter: 20kg
- Mass of concrete lining: calculated as 176.8kg by assuming a density of concrete is 2000kg/ m^3
- Mass of water: calculated as 47.0kg assuming same water to cement ratio in lining as in spent resin packages and adding 0.5% of a drum
- Total mass of package contents: calculated as sum of component masses, i.e. 20+176.8+47=243.8kg
- Void volume in drum: 0.136m^3 minus volume of filter (assuming a density of 1000kg/ m^3)

2.4 Results and discussion

Figures 1 and 2 show the variation with time of gas generation rate and cumulative volume for all non-radioactive gases, respectively.

From these figures, it is found that carbon dioxide is mainly generated under aerobic conditions before the repository closure due to the microbial degradation of organic materials in dry active waste packages. In addition, it can be seen that under anaerobic conditions after the closure, hydrogen production rate due to corrosion is sharply increased, and methane and carbon dioxide is generated to the same extent.(Note: In Figure 1, generation rates of carbon dioxide after 100 years are overlapped with ones of methane.)

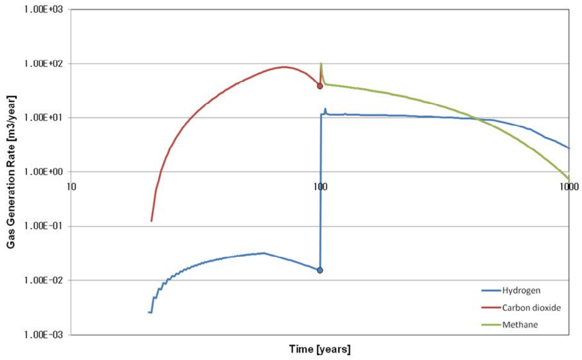

Fig. 1. Gas generation rate with time for all non-radioactive gases

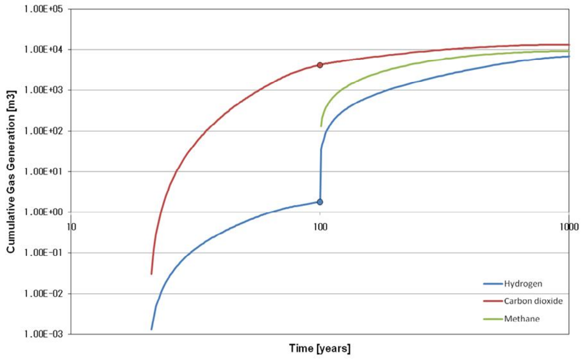

Fig. 2. Cumulative volume of gas generation with time for all non-radioactive gases

3. Conclusions

Since, as noted above, the specific operational procedures of the repository are not yet definitely settled, this evaluation should be supplemented by the appropriate data where possible. These results will be updated by the additional information and could be applied to such as the development of gas vent system in the repository, etc.

ACKNOWLEDGMENT

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