Thermal Management Methods for High-efficiency Geological Disposal of High-level Radioactive Wastes

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Introduction

- **Deep geological disposal (DGD) system** : *widely accepted disposal method for long-term isolation*
  - *designed and constructed with multiple barriers ➡ completely isolated in a stable deep geological environment*
- **Important consideration :** *the heat generated from the high-level waste loaded in the disposal container*
- **Conceptual analyses :** *on the effect of heat in a HLW repository system and on the thermal management methods*

Criteria related to decay heat of HLW

❑ **Public Notice on General Standards for Deep Geological Disposal Facilities for High-Level Radioactive Waste**

- **Standards related to decay heat from high-level waste**

➢ **Article 13 Paragraph 2 :** ***Engineered barriers shall be able to withstand decay heat and pressure caused by radioactive waste during operation and after closure of disposal facility in connection with other design features and characteristics of natural barriers.***

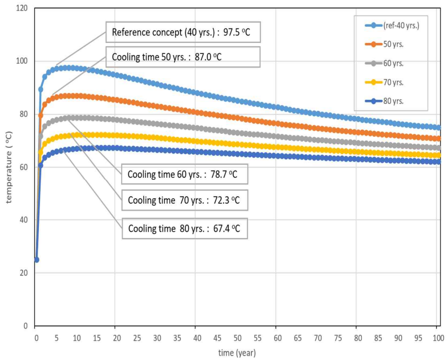
➢ **Article 18 :** ***Radioactive waste form characteristics shall maintain a physically and chemically stable solid form and function for a long time, in the disposal environment in conjunction with engineered barriers against decay heat and pressure.***

❑ **Methods were described to satisfy the criteria related to decay heat stipulated in this public notice on geological disposal facilities.**

Thermal Management Methods – Cooling Time

❑ **Extension of the spent nuclear fuel cooling time**

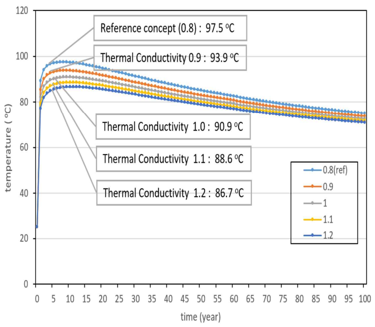
Time required to reduce 100 W per disposal container			Amount of thermal load reduced during 10 years' cooling per disposal container		
Decay heat (W)	Cooling time (yr.)	Required year for 100 W reduction (yr.)	Cooling time (yr.)	Decay heat (W)	Reduced decay heat (10 years, W)
1915	40		40	1915	
1900	40.5		50	1623	292
1800	43.7	3.2	60	1391	232
1700	47.15	3.5	70	1208	183
1600	50.9	3.8	80	1063	145
1500	55	4.1	90	948	115
1400	59.6	4.6	100	857	91
1300	64.7	5.1	110	774	83
1200	70.5	5.8	120	709	65
1100	77.2	6.7	130	656	53
1000	85.2	8.0	140	611	45
900	95	9.8	150	574	37
800	106.5	11.5	160	542	32
700	121.7	15.2	170	515	27
600	142.9	21.2	180	491	24
500	176	33.1	190	470	21
400	237	61.0	200	452	18
300	365	128.0			
200	640	275.0			
100	1360	720.0			



- **To meet the temperature limit (for example 100°C) according to the cooling period ➡ Increase the thermal load by adding spent nuclear fuel per disposal container**
- **To maximize the disposal efficiency in terms of the disposal area**
  ➡ **Reducing the disposition tunnel/disposal space.**

Thermal Management Methods – EBS Properties

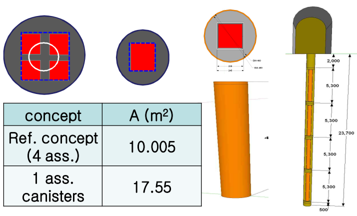
❑ **Buffer Thermal Conductivity**



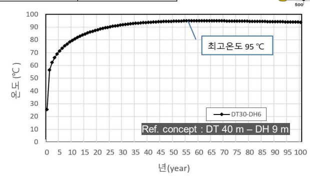
- Bentonite (buffer) thermal conductivity
  ➡ 0.8 (Ref. concept) ~ 1.2

❑ **Canister Improvement**

• Fourier's law of heat conduction : $Q_n = -kA\frac{\partial T}{\partial n}$



concept	A (m²)
Ref. concept (4 ass.)	10.005
1 ass. canisters	17.55



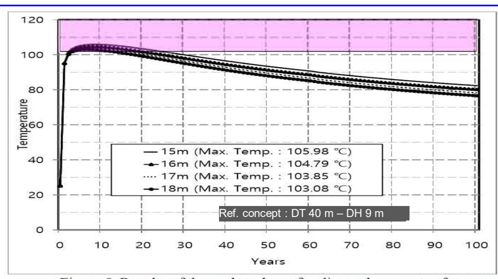
To maximize the disposal efficiency in terms of the area

- **by adding spent nuclear fuel per disposal container to meet the 100 ℃ limit requirement of the repository**
- **by reducing the disposition tunnel/disposal space**

Thermal Management Methods – Design Limit

❑ **Increase the thermal limit of Bentonite : 100°C ➡ 130°C**

2 CANI./D.H



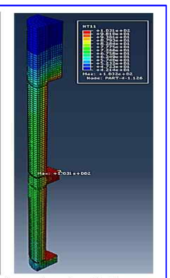
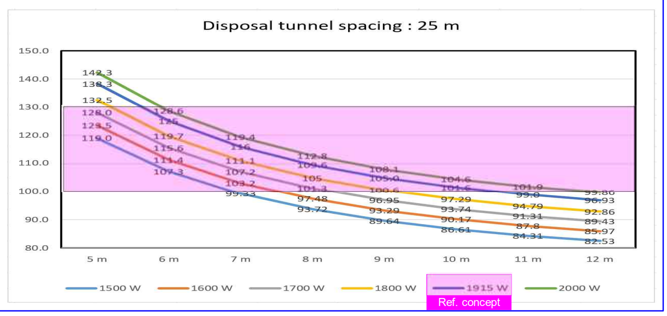


Figure 8. Results of thermal analyses for disposal concepts of two canisters in a borehole.

HEAT/CANI.



Concluding Remarks

- **In this paper, thermal management technology in the deep geological repository for spent nuclear fuels to improve disposal efficiency in terms of disposal area is presented and analyzed.**
- **This result will be used to establish the high-efficiency geological disposal system with efficient thermal management method applicable in Korea.**