Experience on the Commercial Operation of Ulchin Vitrification Facility

ISOE Asian ALARA Symposium

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Won-Gyo JUNG

Korea Hydro & Nuclear Power Co., Ltd

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Overview of UVF(1/12)

- **Title : Construction of Ulchin Vitrification Facility(UVF)**
- **Location : Ulchin NPP(unit 5&6)**
- **Project Period : Sept. '02 ~Oct. '09**
  - Completion of Design : Apr., 2005
  - Completion of Cold/Hot Tests : March, 2009
  - Start of Commercial Operation : Oct., 2009
- **Major activity**
  - Design/Construction/Tests/License
- **Waste to be treated**
  - Combustible dry active waste (DAW)
  - Low activity ion exchange resin (IER)
- **Throughput**
  - DAW : 20kg/h
  - Mixed waste (W1 : DAW + IER) : 18kg/h

Overview of UVF(2/12)

❖ Major Milestones of the Project

- End of design: April 2005
- Application for an operational license: June 2005
- Start of construction: June 2006
- Completion of construction: December 2007
- Completion of commissioning tests: May 2008
- Acquirement of an operational license: October 2008
- Completion of the hot test: March 2009
- Completion of the real waste test: September 2009
- Acquirement of the operational permit October 2009

Overview of UVF(3/12)

Commercialization
- Basic & Detailed Design
- Manufacturing
- Cold/Hot Tests
- Real Waste Test
- License

Sept. '02 ~ Oct. '09

Ulchin Vitrification Facility

CCIM Room

Control Room

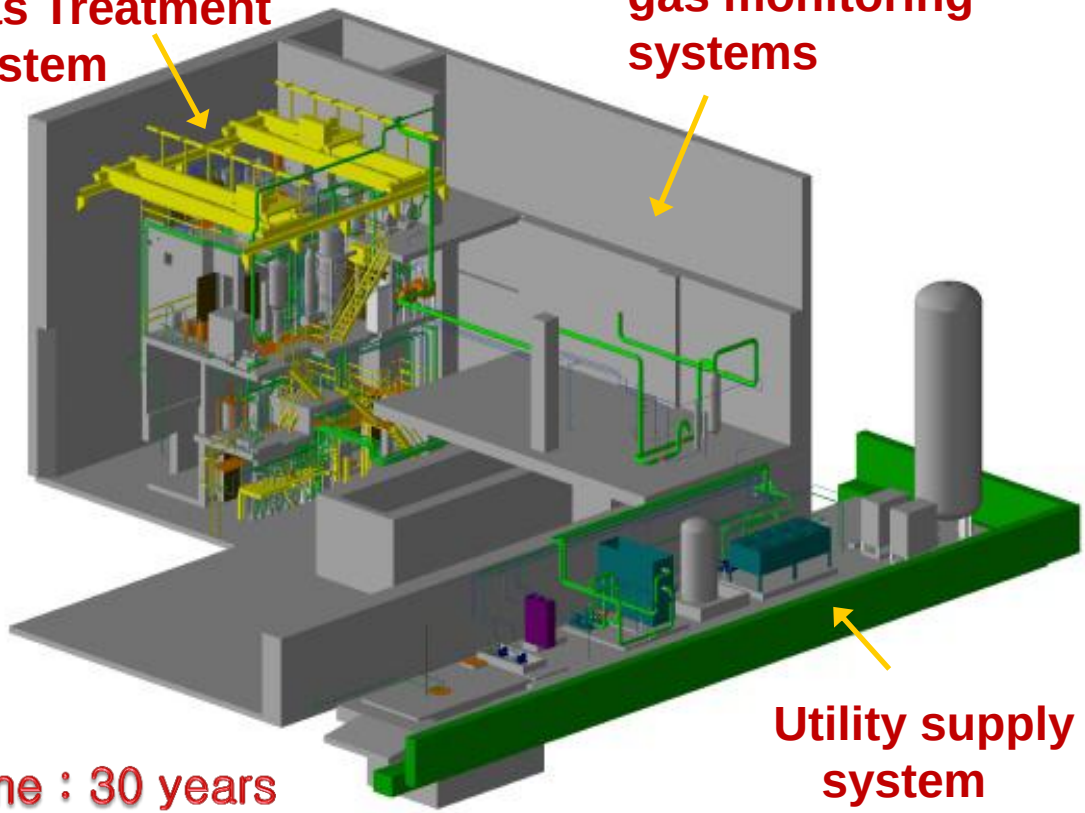
Overview of UVF(4/12)

❖ Components of UVF : CCIM, OGTS, Utility supply system

Main System : CCIM and Off-Gas Treatment System

De-NO_x and Off-gas monitoring systems

Volume of Main System
W 12m
x L 11m
x H 13.5m



Utility supply system

※Design Life Time : 30 years

Overview of UVF(5/12)

Feeding System

High Temp. Filter

Post Combustion Chamber

HEPA/ Activated Charcoal

DeNOx System

High Temp. HEPA Filter

Dust Recycling System

Off-Gas Cooler

Scrubber

Extraction Fan

Cold Crucible Induction Melter

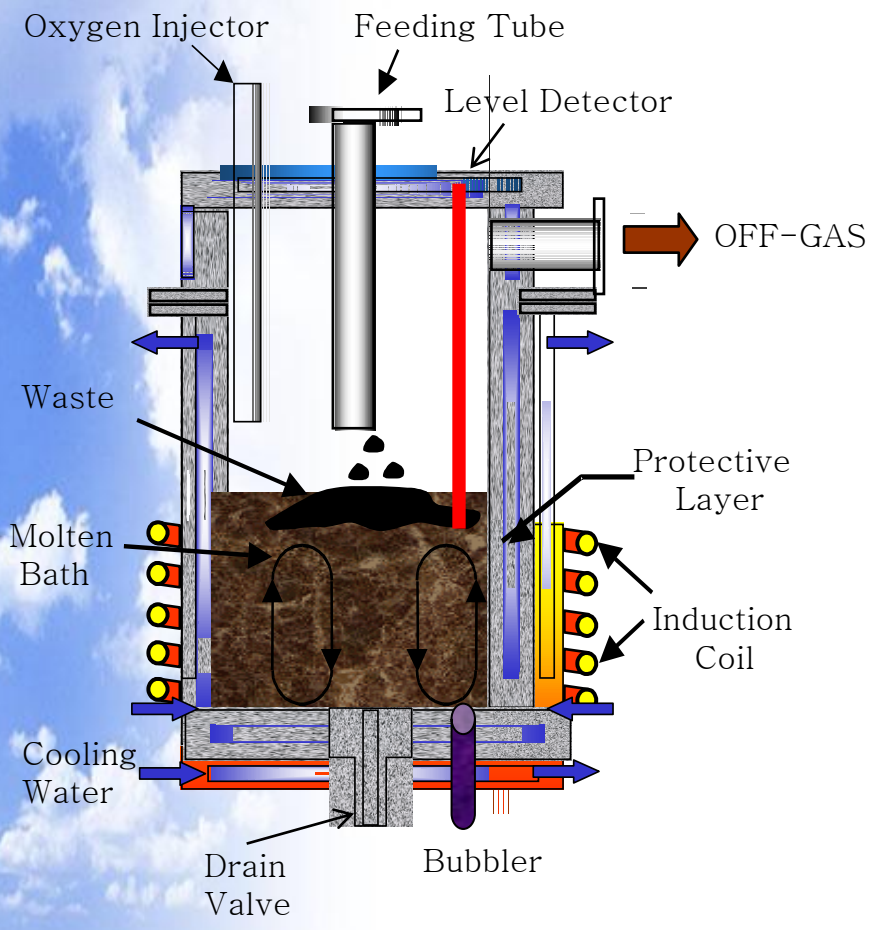
[Process Diagram of UVF]

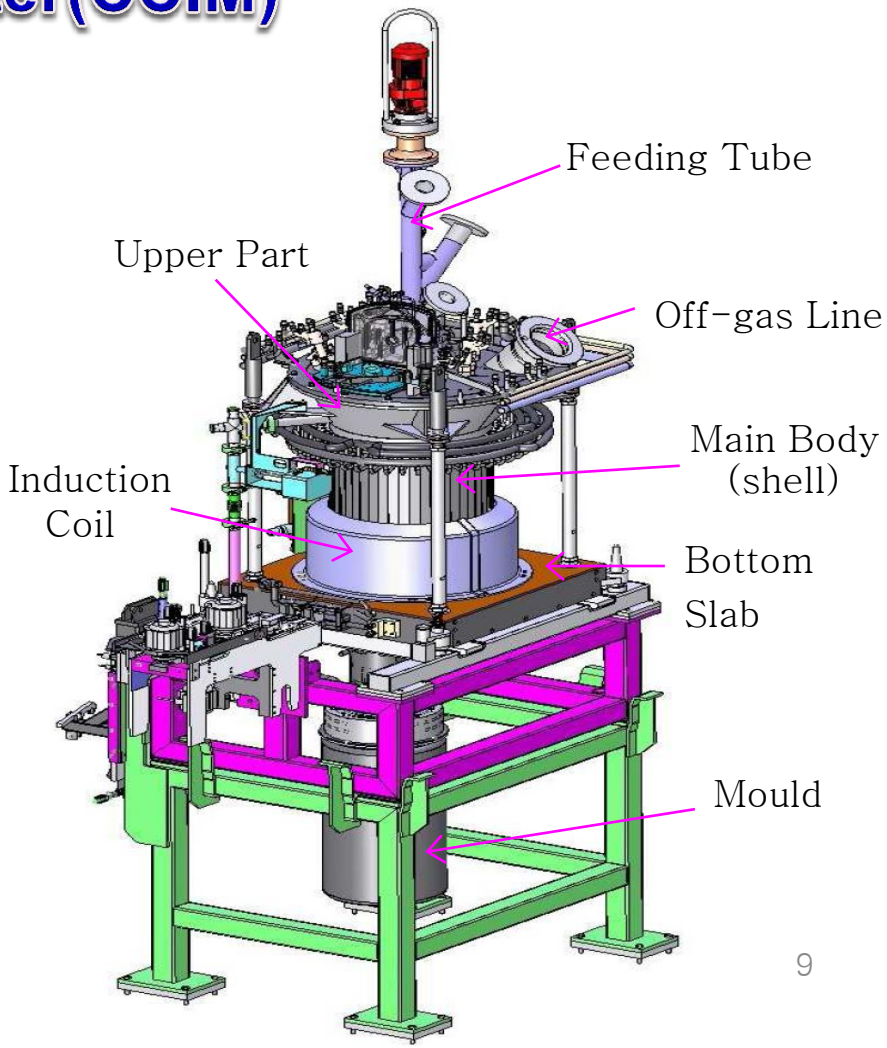
Overview of UVF(6/12)

System	Components
Pretreatment System	Metal detector, DAW shredder, Resin transfer pump, Crane, etc.
Waste Feeding System	DAW/Resin/Other waste/Glass storage and metering hopper, Feeding line, etc.
Melting System	Cold crucible induction melter, High frequency generator, Cooling lines, etc.
Off-gas Treatment System	High temp. filters, High temp. HEPA filters, Post combustion chamber, Scrubber, etc.
Dust Recycling System	Making/Storage hoppers, Feeding pumps, etc.
Others	Mould Treatment System, Secondary Waste Treatment System, Utility Supply System, etc.

Overview of UVF(7/12)

❖ Cold Crucible Induction Melter(CCIM)





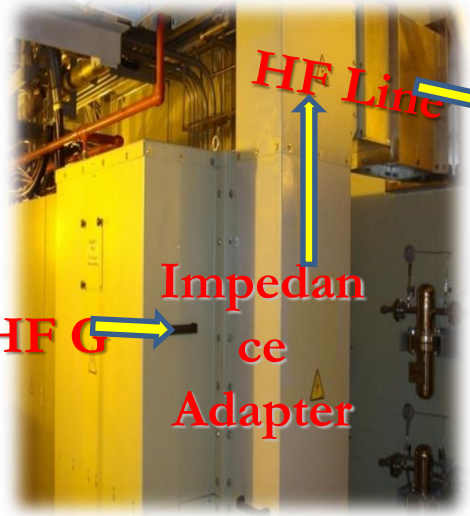
Overview of UVF(8/12)

❖ Cold Crucible Induction Melter(CCIM) System

- ➢ Body : water cooled segments
- ➢ Inner Diameter : 55cm
- ➢ Apply frequency : 250-300kHz
- ➢ Main components

(Upper & Lower Chamber,

Bottom slab, Induction coil, Glass Mould)

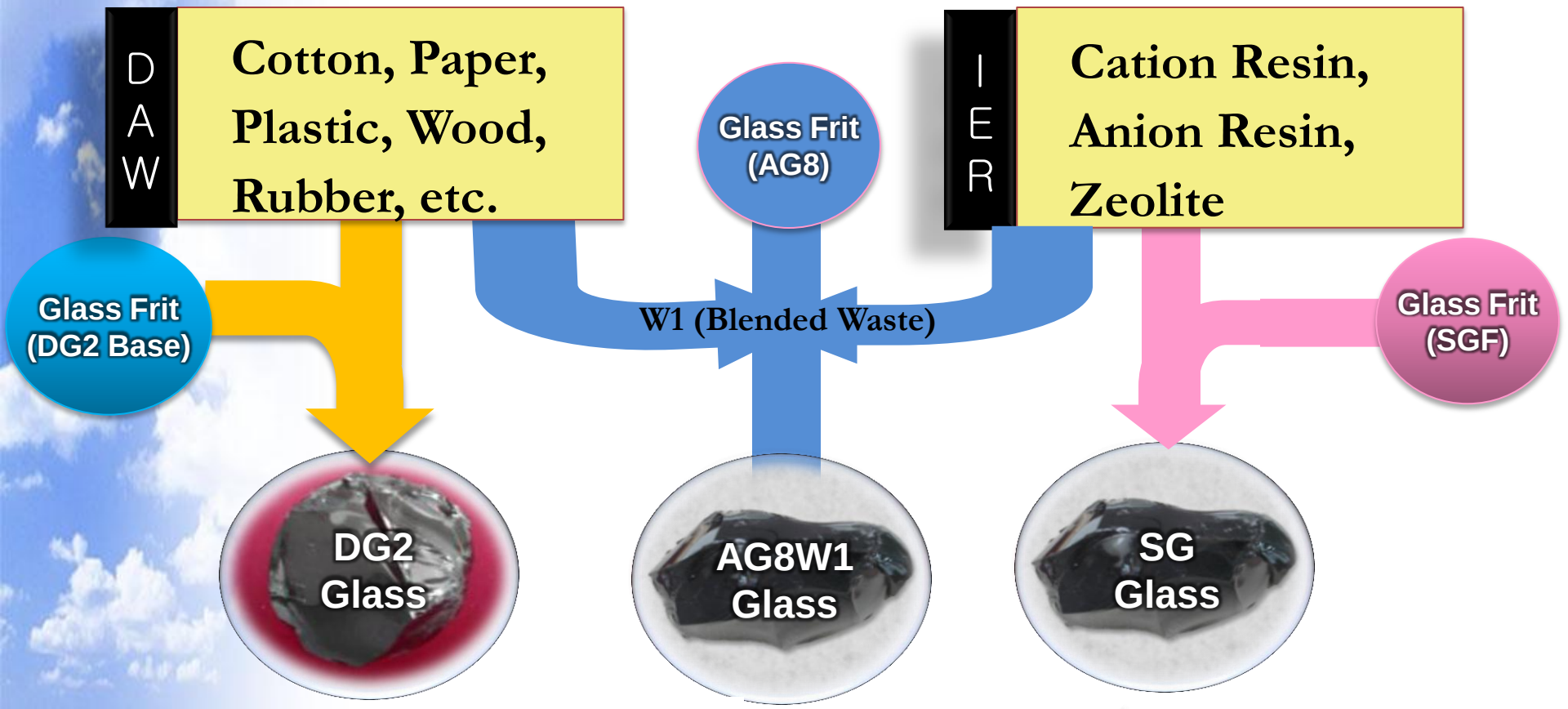


❖ Auxiliary system of CCIM : HFG, Impedance Adapter, HF Line & Mold

➢ Completion of Installation : October, 2007

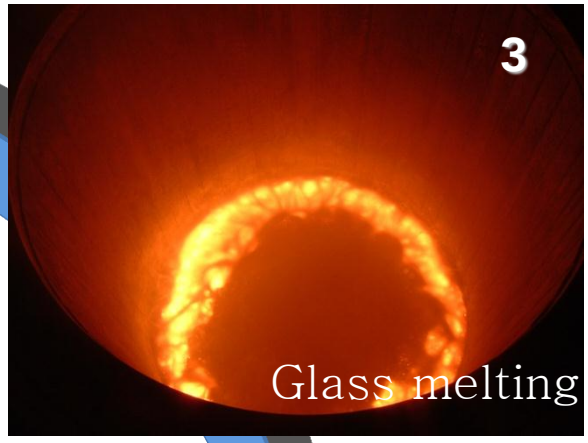
Overview of UVF(9/12)

❖ Three glass compositions(DG2 & AG8W1&SG) are used for vitrifying DAW & W1(blended waste) & IER, respectively.



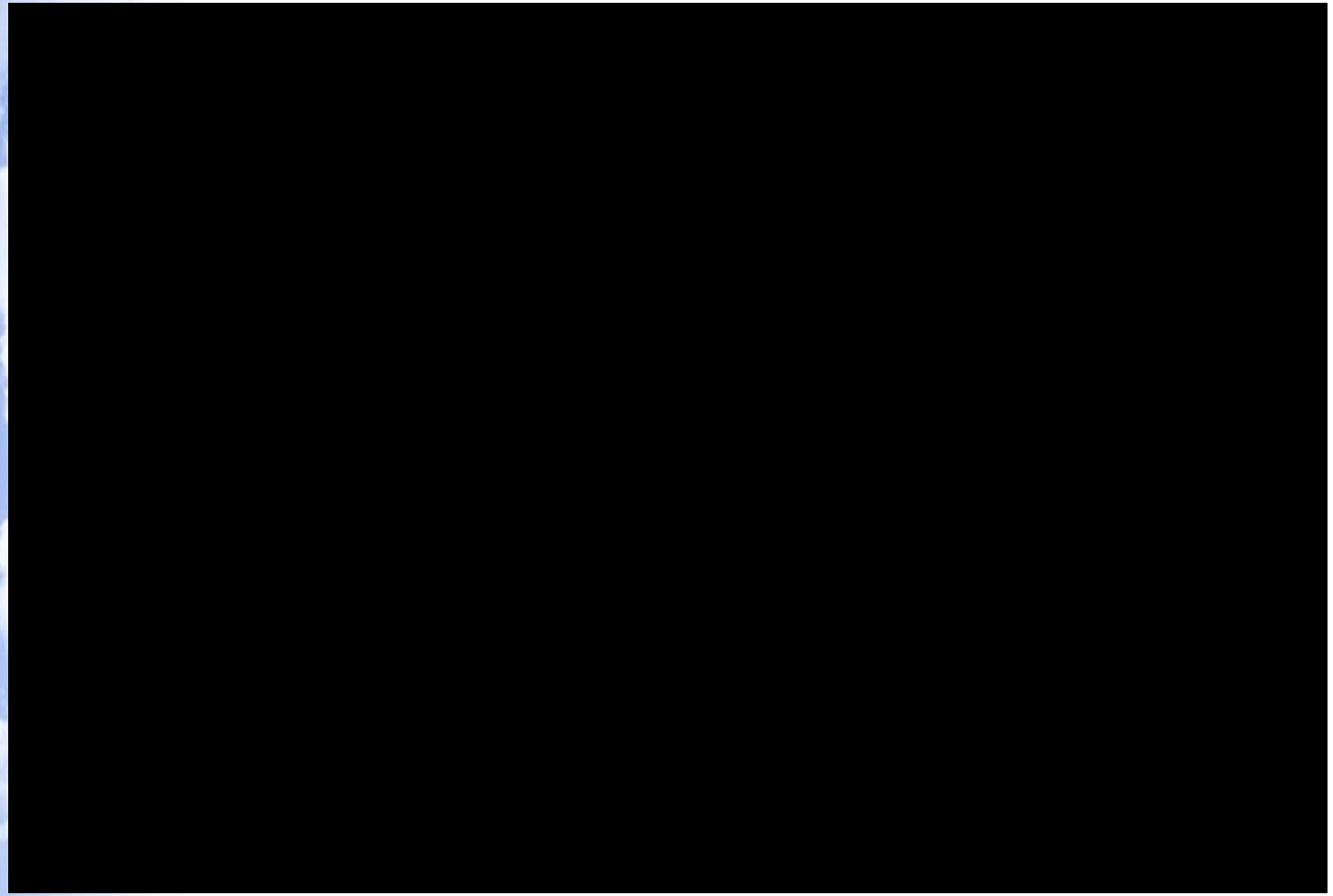
Overview of UVF(10/12)

Overview of UVF(11/12)



Overview of UVF(12/12)

❖ Simulation of Vitrification Process



Commissioning Tests(1/9)

- **Phase I**
  - Equipment Performance Test
  - System Functional Test
  - Preoperational Test
- **Phase II : Cold Test**
  - Verifying design performance
  - Using non-radioactive surrogate waste
- **Phase III : Hot Test**
  - Demonstrating radioactive decontamination factor
  - Radioactive surrogate waste loaded with Co-57 & Cs-137
- **Phase IV : Real Waste Test**
  - Verifying the operational stability of the UVF
  - Using DAW and W1 generated from Ulchin Nuclear units 5&6

Commissioning Tests(2/9)

I. Preoperational Test

- ❖ Blank Test
  - without glass melting
  - HFG and cooling system operation
- ❖ Glass melting and pouring test
- ❖ Waste vitrification test
  - Vitrifying DAW solely and blended waste(DAW+Resin)
- ❖ Checked items
  - Operability of the whole facility
  - Ranges of operational parameters
  - Off-gas flowrate and leakage, etc.

Commissioning Tests(3/9)

II. Cold Test

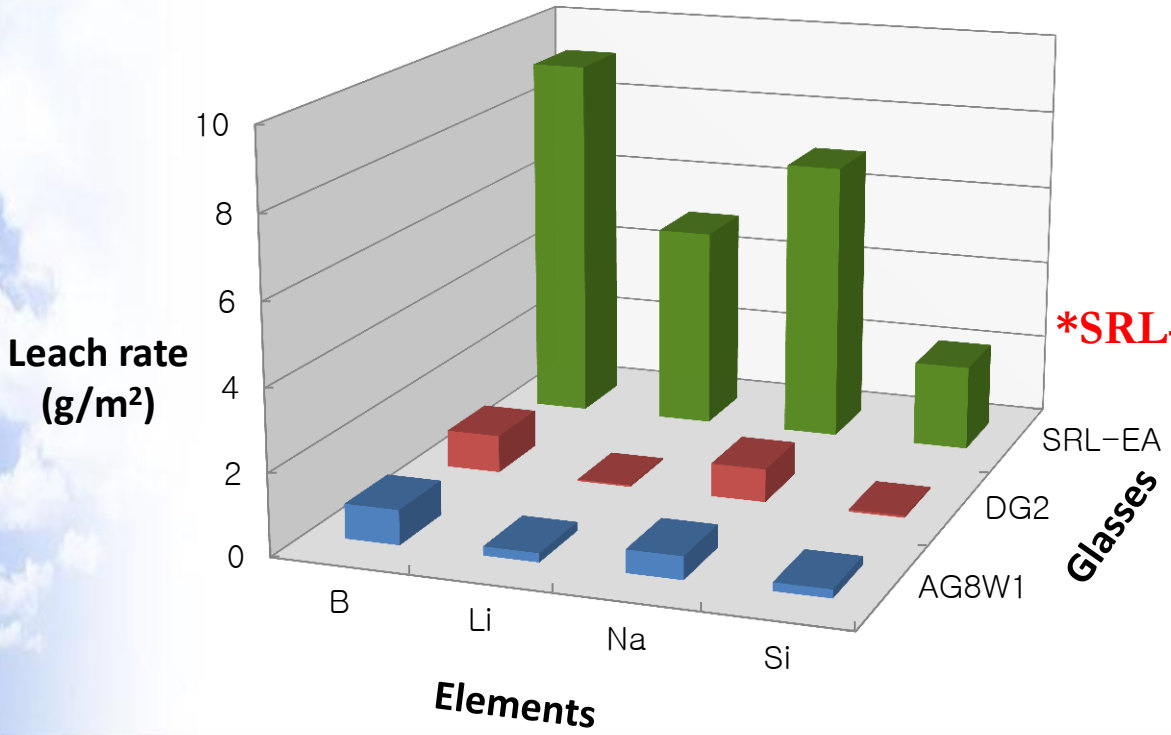
- **Objective**
  - To confirm the design performance and stability of the system
  - To evaluate the environmental safety
- **Waste :** Non-radioactive surrogate W1 loaded with Co & Fe
- **Feed rate :** 18 kg/h
- **Operation time :** about 200 hrs

Commissioning Tests(4/9)

II. Cold Test(cont'd)

❖ Chemical durability using the US DOE leaching method(7-day Product Consistency Test @90℃)

➢ AG8W1 & DG2 : lower leach rates compared to benchmark glass



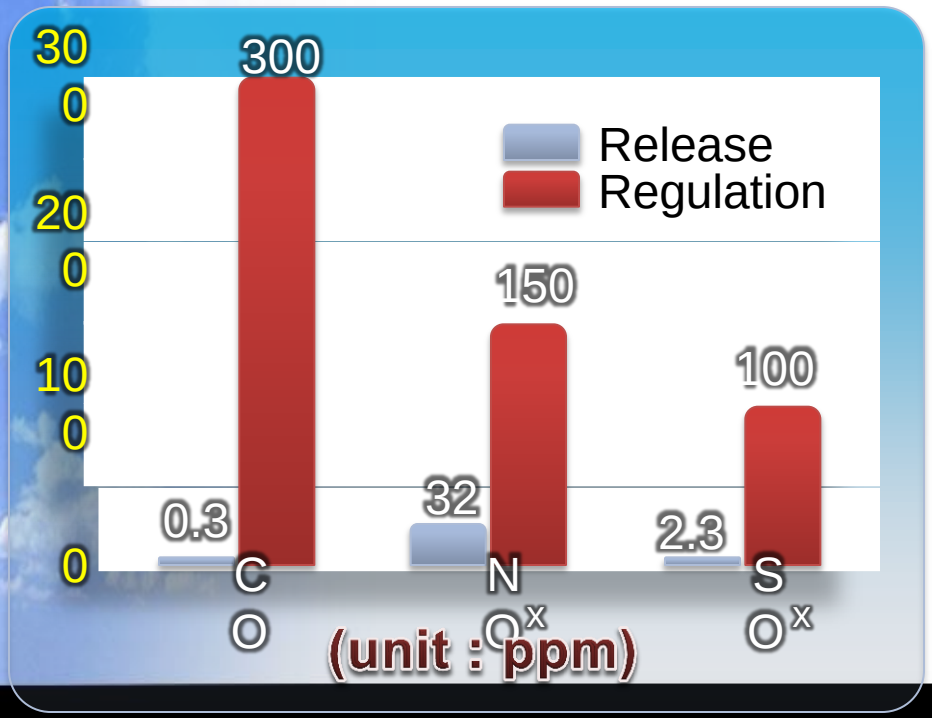
*SRL-EA : Benchmark glass

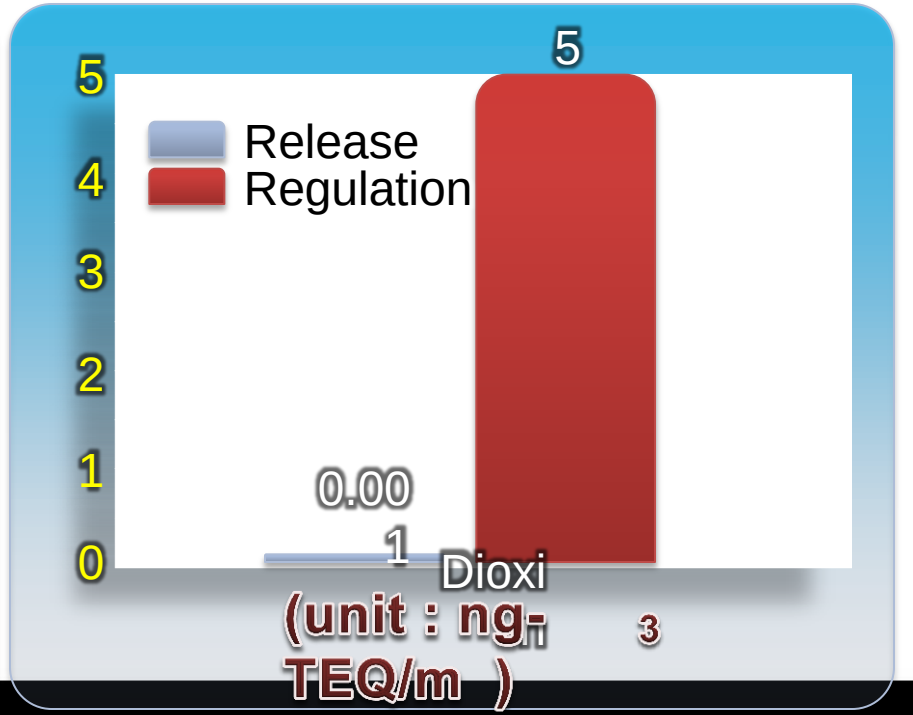
Commissioning Tests(5/9)

II. Cold Test(cont'd)

❖ Analyzed 25 toxicity gases and dust based on "Clean Air Conservation Act"

- ➢ 9 materials (Dioxin, etc) : well below regulatory limits
- ➢ Other 16 materials : not detected





Commissioning Tests(6/9)

II. Cold Test(cont'd)

- Dust removal efficiency
  - Across the first HTF(Design target : 99.9%)
    - Co : 99.986 %
    - Fe : 99.947 %
- Mechanical durability of vitrified form
  - Compressive strength : > 50,000 psi(Requirement : ≥500 psi)

Toxic gas analysis

Glass pouring

Commissioning Tests(7/9)

III. Hot Test

- Objective
  - To demonstrate the target Decontamination Factor(DF) of the process using radioactive isotopes
- Waste/Feed rate : W1, 18kg/h
- Loaded Radioisotopes : Co-60 & Cs-137
- Sampling areas : 4 areas in OGTS
- Major results
  - Total DF met all the design targets

    (Target DF : > 1.0×10^6)

    - DF for Co-60 : > 2.5×10^8
    - DF for Cs-137 : > 4.6×10^7

Loading RI on ion exchange resin

Commissioning Tests(8/9)

IV. Real Waste Test

- **Objective**
  - To verify long-term operational stability through a series of stepwise test operations
- **Waste Type**
  - DAW & W1 generated from Ulchin Nuclear units 5&6
- **Waste vitrified :** about 4,870 kg
- **Results**
  - showed excellent workability and long-term reliability

Commissioning Tests(9/9)

IV. Real Waste Test(cont'd)

❖ Test performance and vitrified waste amount

		1st	2nd	3rd	4th	5th	6th
Waste Type		DAW			Blended waste(W1)		DAW
Vitrified Waste (Feed rate)		505 kg (10 kg/h)	752kg (15 kg/h)	1,013 kg (20 kg/h)	902 kg (18 kg/h)	902 kg (18 kg/h)	795 kg (15 kg/h)
Glass type	Loading	DG2			AG8W1		DG2
	Feeding	DG2B			AG8		DG2B
Feeding time(hrs)		50	50	50	66	59	52
Poured Glass(kg)		68	121	82	118	136	66

Commercial Operation(1/3)

- **Stable Operation Conditions**
  - Accumulated Experience of Operation staffs
  - Stable system with some trouble shootings
- **Target Wastes and feeding rates**
  - DAW, LAIER, and W1(DAW and LAIER)
  - 18 ~ 20 kg/hrs (Max. 25 kg/hr)
- **Off-gas Characteristics**
  - Environmentally toxic material and radioactive nuclides into the off-gas are below the regulatory limit.
- **Chemical durability of glass**
  - Very low leaching rates using 7-day PCT (B, Na, Si, Li)

Commercial Operation(2/3)

❖ Amount of vitrified waste in the UVF

(As of Aug. 2012)

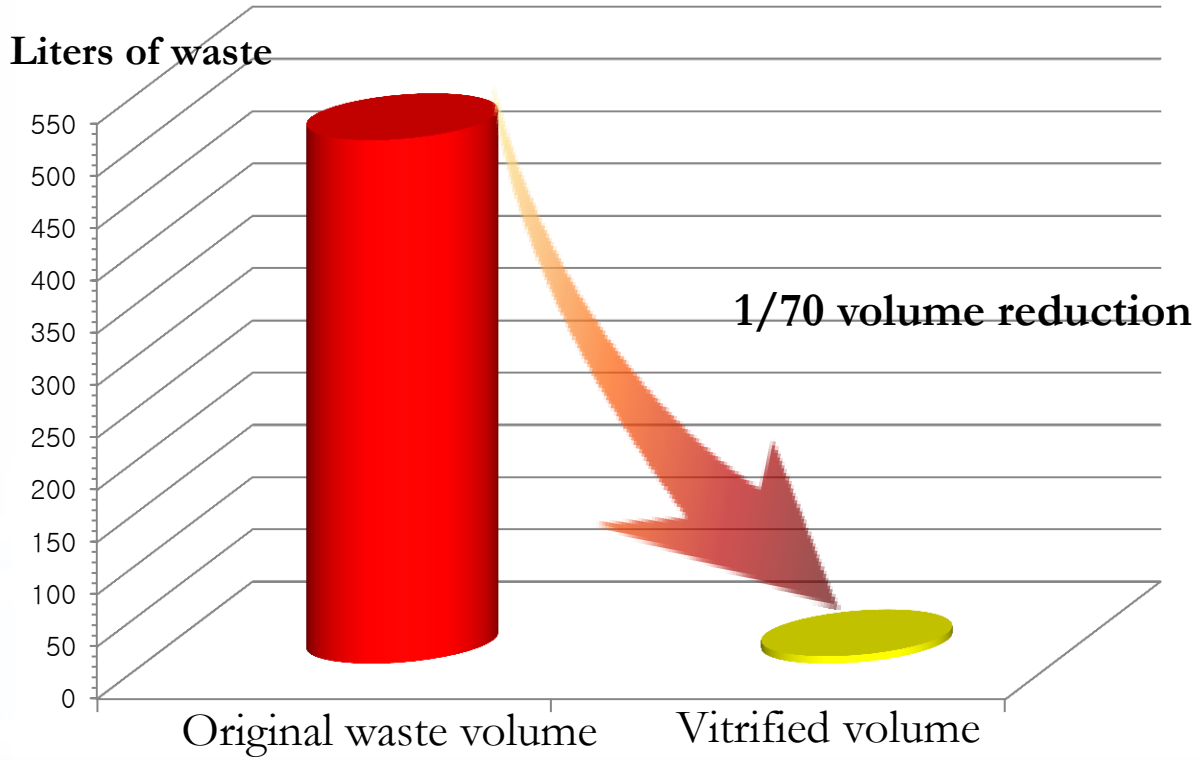
Period	Waste Amount(kg)		SUM
	DAW	Ion Exchange Resin	
Commissioning test	4,569	300	4,869
Commercial operation (since Oct. 26, '09)	14,815	4,648	19,463
Total	19,384	4,948	24,332

Commercial Operation(3/4)

❖ Volume reduction effect of real waste by UVF operation since April 2009

➢ Volume Reduction Factor for blended DAW & IER : about 70

(Volume Comparison : Original waste volume vs. Vitrified volume)



Commercial Operation(4/4)

❖ Effort for Public Acceptance

A briefing session held for local public

A briefing session held in the control room

Ulchin Young men's association visiting the UVF

Local residents visiting the exhibition hall

Summary(1/2)

- The first commercial LILW vitrification facility (UVF) was installed inside the Ulchin Nuclear Power Units 5&6.
  - Target waste : Combustible DAW and spent resin of Units 5&6
  - Capacity : Max. 25kg/h (waste feed rate)
  - Major systems : CCIM, off-gas treatment, & utility supply system

- Commissioning tests were performed successfully.
  - Cold tests with surrogate waste
  - Hot test with Co-57 and Cs-137 loaded surrogate waste
  - Using real wastes generated from Ulchin NPP

- The commercial operation of the UVF was commenced starting October, 2009. The volume reduction effect is remarkable.
  - About 1/70 volume reduction of combustible DAW & IER

Summary(2/2)

- The KHNP's vitrification technology will not only enhance the safety of the waste disposal repository, but will also greatly contribute to the further promotion of the Korean nuclear power generation program.

- Future Work
  - Vitrifying other wastes such as wastes generated from Ulchin Nuclear Power Units 1, 2, 3 & 4