

DEVELOPMENT OF ENGINEERING SCALE PYROPROCESSING FACILITY – PRIDE

HOTLAB 2015

Sep. 30, 2015

Ilje, Cho



**Korea Atomic Energy
Research Institute**

Outline

- I** Background
- II** Development of PRIDE
- III** Operation
- IV** Summary

Background

Background

- The Korea Atomic Energy Research Institute (KAERI) has been developing pyroprocessing technology since 1997, which is considered one of the promising fuel cycle options in Korea.
- Pyroprocessing is an electrochemical recycling technology to recover valuable resources (U, TRU, etc.) from spent fuels in molten salt media at 500~650°C.
- To demonstrate engineering scale pyroprocessing and to evaluate the technical feasibility of pyroprocessing, KAERI constructed a mock-up facility, named PRIDE (PyRoprocess Integrated inactive DEMonstration facility)
- **Purposes**
 - To demonstrate the engineering-scale integrated pyroprocessing experiments of all the processes using depleted uranium or simulated fuels
 - To find scale-up issues of pyroprocessing equipment, system engineering studies, remote operation and maintenance, advanced safeguards, waste transfer, etc.

PRIDE (PyRoprocess Integrated inactive DEMonstration Facility)

■ Overview

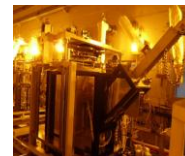
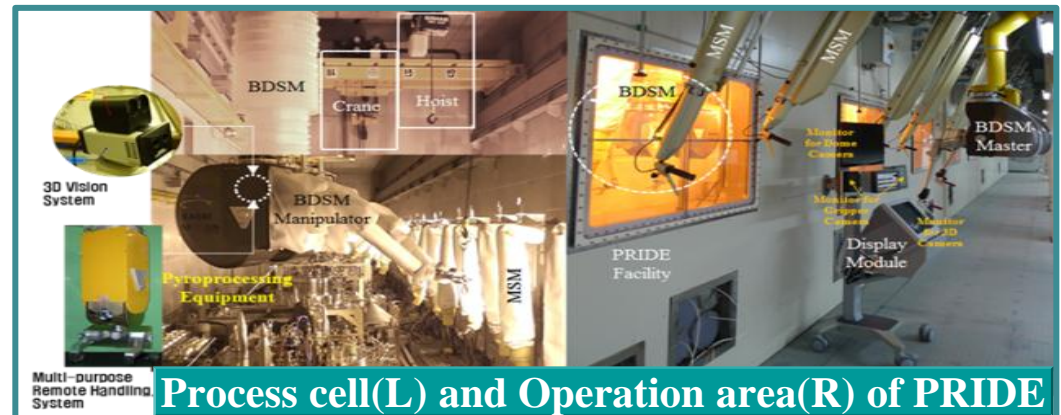
- Reuse of discarded U-conversion facility after decontamination and remodeling
- Milestone : Design('07~'08), Installation('09~'12.6), Test-run & Operation('12.7~)

■ Main feature

- Environment : Air (glove-box, 1st floor), Ar (air-tight cell, 2nd floor)
- Ar-cell : Dimension L40.3 x W4.8 x H6.4 m, Impurity(moisture & oxygen) < 50ppm
- Integrated pyroprocessing equipments (17 windows each equipped with 2 MSM)



Exterior of PRIDE



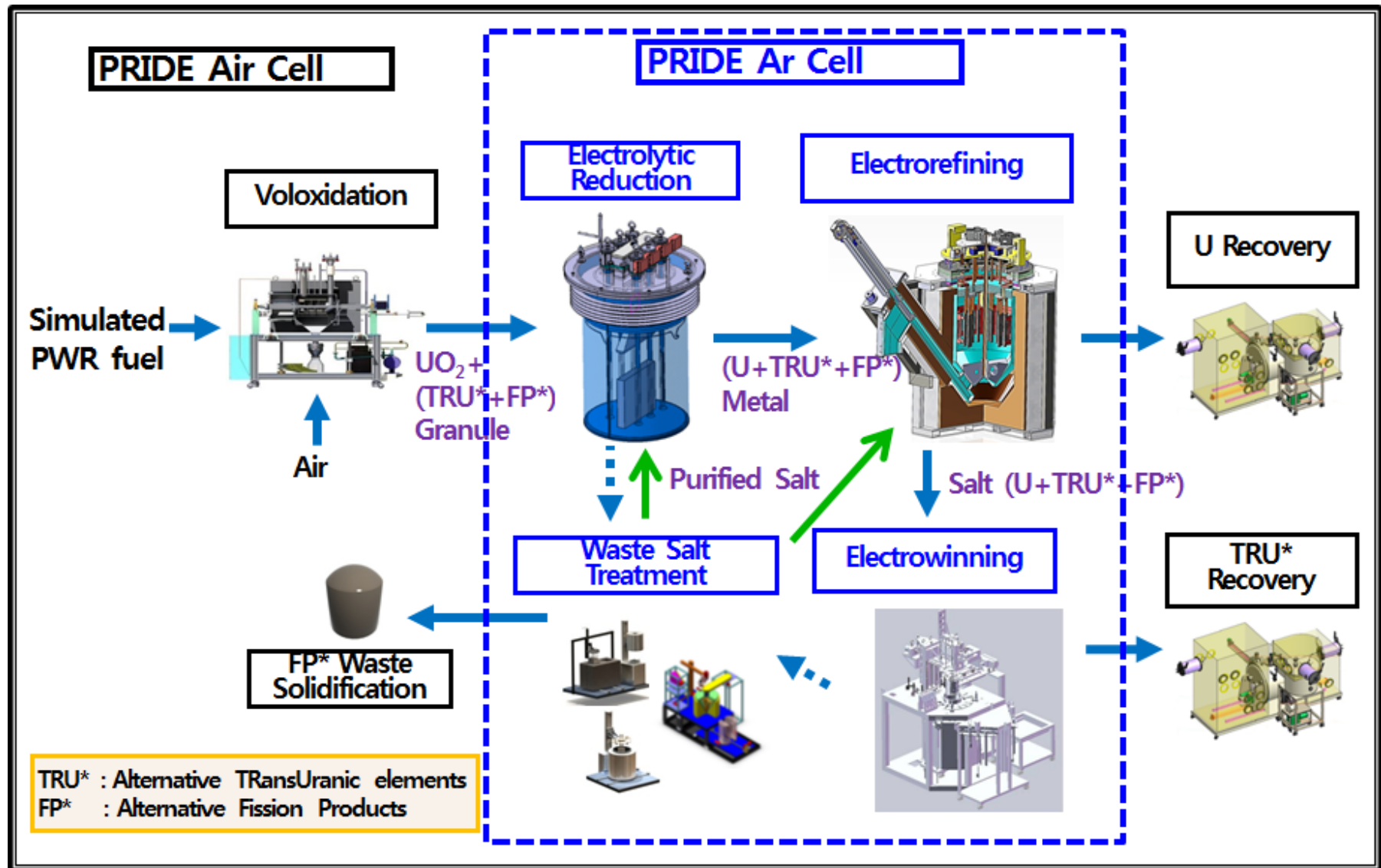
Development of PRIDE

Decontamination of Old Facility

- The existing uranium conversion plant (UCP) at KAERI site have been selected for PRIDE (Pyroprocess Mock-up Facility)
- UCP had been decontaminated for several years to decrease the radioactivity level
 - Decontamination of concrete walls ($< 0.4 \text{ Bq/cm}^2$)
 - Decontamination of stainless steel by ultrasonic
 - Decontamination of carbon steel by arc melting

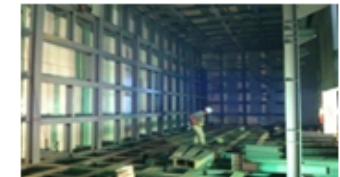


Process Flow Diagrams of PRIDE



Design and Construction of PRIDE

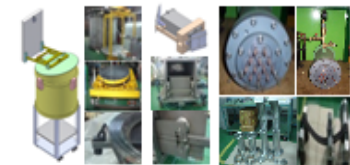
Argon Cell	<ul style="list-style-type: none"> ■ Design and Evaluation of Large Argon Cell Structure <ul style="list-style-type: none"> ▪ Design of leak-tight large argon cell structure ▪ Manufacturing lining and installation ▪ Install cell structure and welding inspection
Argon systems	<ul style="list-style-type: none"> ■ Argon System(Inert atmospheric system) Design and Evaluation <ul style="list-style-type: none"> ▪ Establish the operation and design requirements ▪ Make technical specifications of argon supply, circulation, cooling, and exhaust systems ▪ Install argon systems into PRIDE
Cell operation equipments	<ul style="list-style-type: none"> ■ Development of Cell Operation Equipments <ul style="list-style-type: none"> ▪ Large transport lock system ▪ Small transport lock system ▪ Crane and hoist ▪ Feed-through and maintenance system ▪ Auxiliary operation equipments (window, light, gravity tube, etc) ▪ Install operation equipments into PRIDE
Utilities	<ul style="list-style-type: none"> ■ Utilities Design and Evaluation <ul style="list-style-type: none"> ▪ Develop the operation and design requirements ▪ Make technical specifications of HVAC, cooling water system, RMS, E & C, etc. ▪ Install utilities into PRIDE



(Cell Structure)

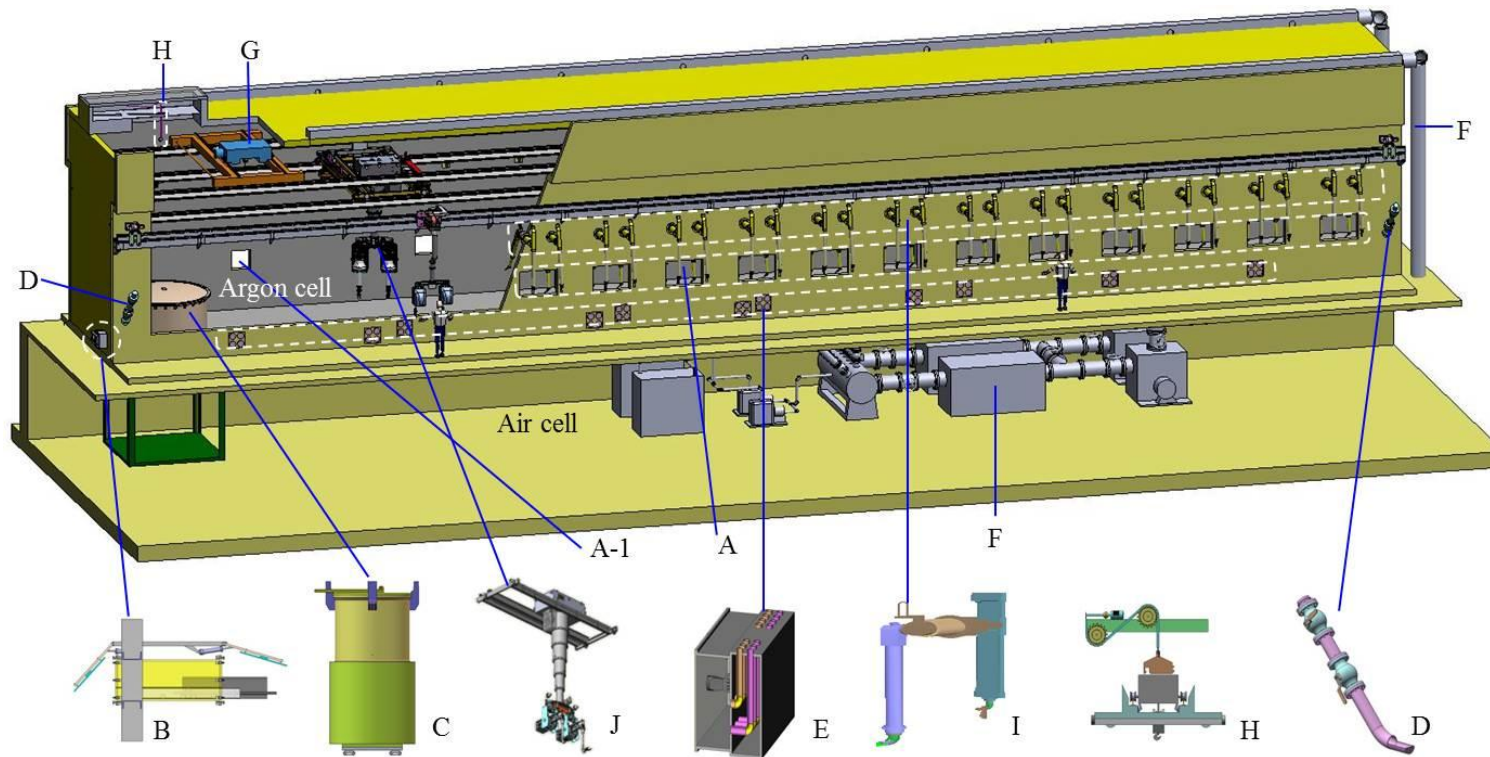


(Argon Systems)



(Utilities)

System Components of PRIDE



[Isometric section view of PRIDE]

- ◆ Cell equipment: 'A' through 'F'
- ◆ Remote handling systems: 'G' through 'J'
- ◆ In-cell monitoring systems: Not shown

System Components of PRIDE

◆ Cell equipment provide useful means necessary for functioning the argon cell.

▪ Viewing Windows

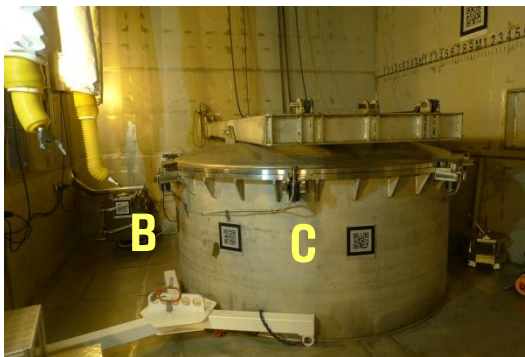
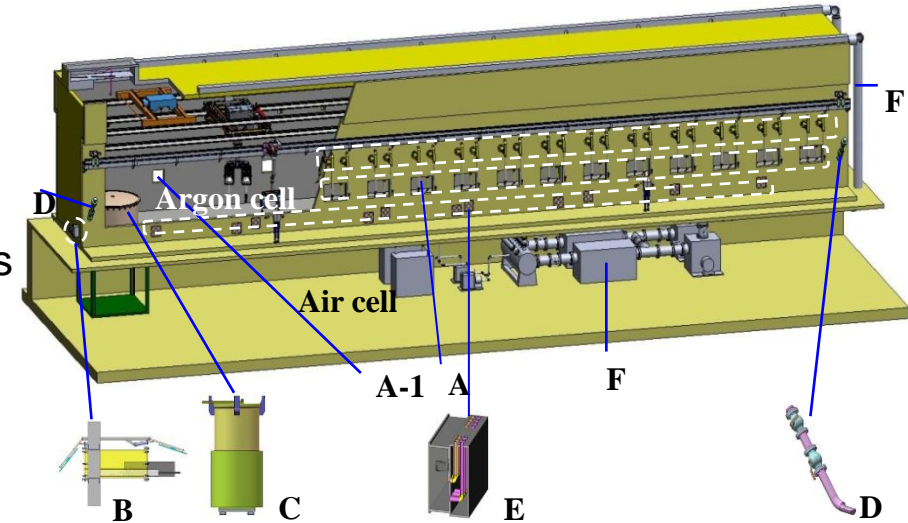
- Provide direct in-cell information or situation
- 17 on front wall (A), 5 on rear wall (A-1)

▪ Transfer Lock Systems (TLS)

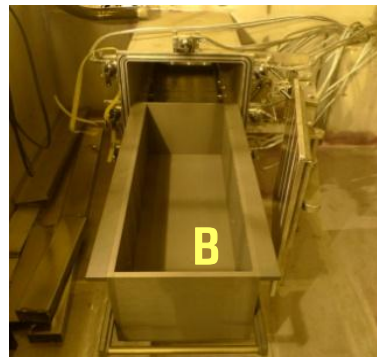
- Unique channels for connecting in-cell and out-of-cell
- Small TLS (B): transferring small, light materials or tools
- Large TLS (C): transferring large, heavy materials and components, equipment or devices

▪ Gravity tubes (D)

- Load small specimens or small tools into the cell
- Two on the left- and right-hand sides of the front wall



Small/Large TLS closed



Small TLS opened
[0.9x0.3x0.25 (LxWxH) m]



Large TLS opened
[ϕ 2.6x2.3 m]



Gravity Tube

System Components of PRIDE

- **Feed-throughs (E)**

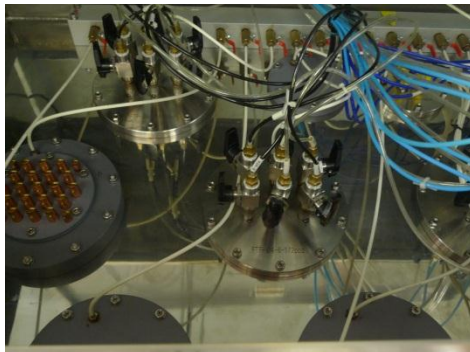
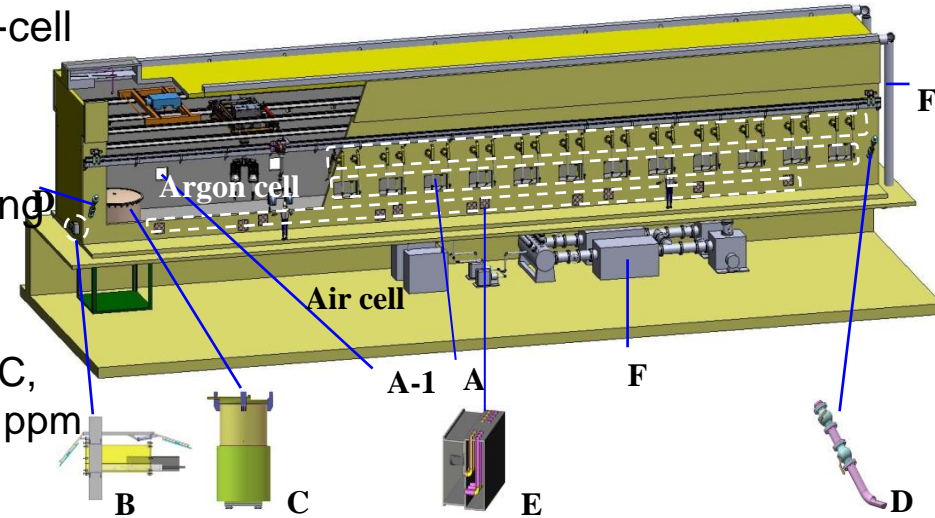
- Means to supply utilities from the out-of-cell to the in-cell
- Various types depending on the utilities required

- **Argon utility system (F)**

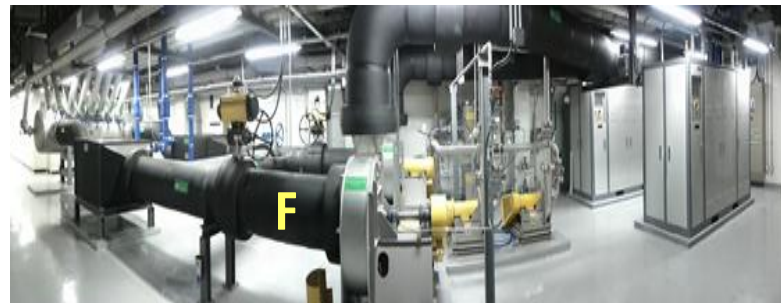
- Supplies argon gas into both the in-cell and processing equipment through feed-throughs
- Keeps the required in-cell pressure to allowable level of - 50 to 20 mmH₂O, an in-cell temperature of 25 to 40 °C, and the concentrations of oxygen and moisture below 50 ppm

- **In-cell lights**

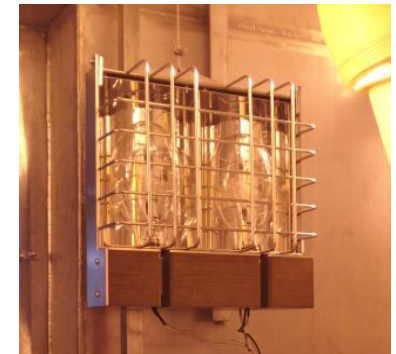
- Provide lightening in the argon cell
- Sixty-eight 400W high pressure sodium lamps



Feed-throughs



Argon utility system

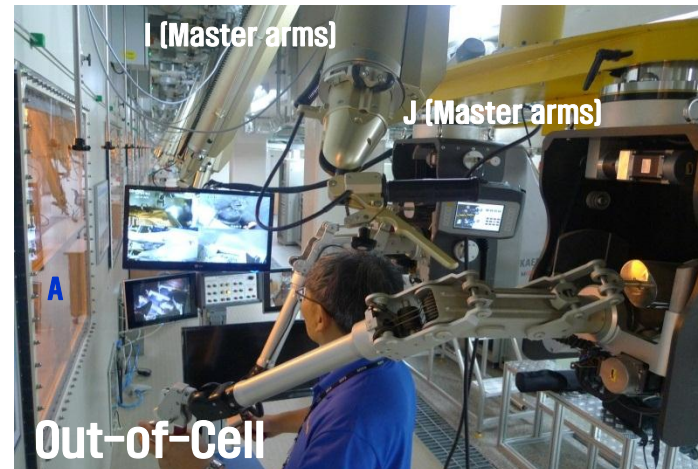
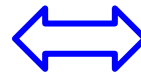
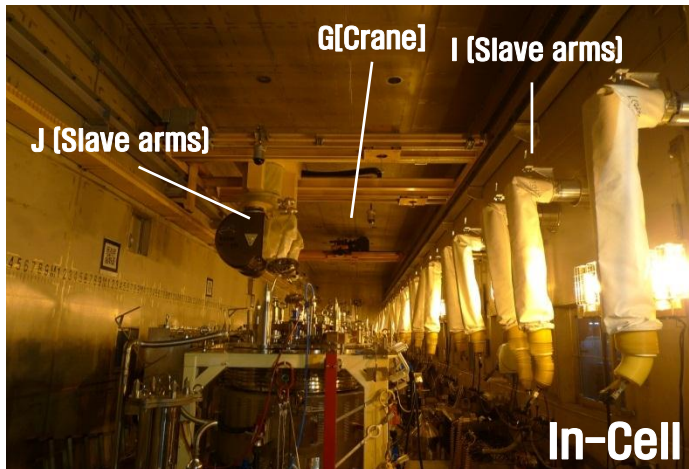
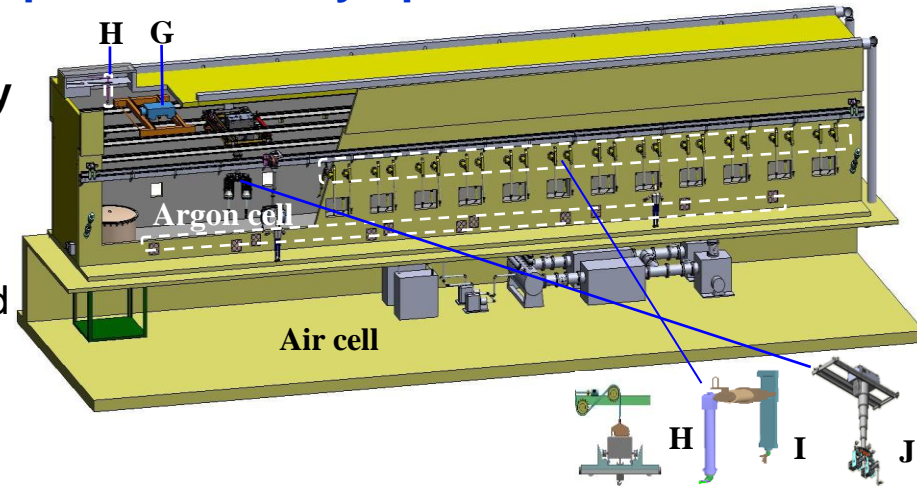


In-cell lamps

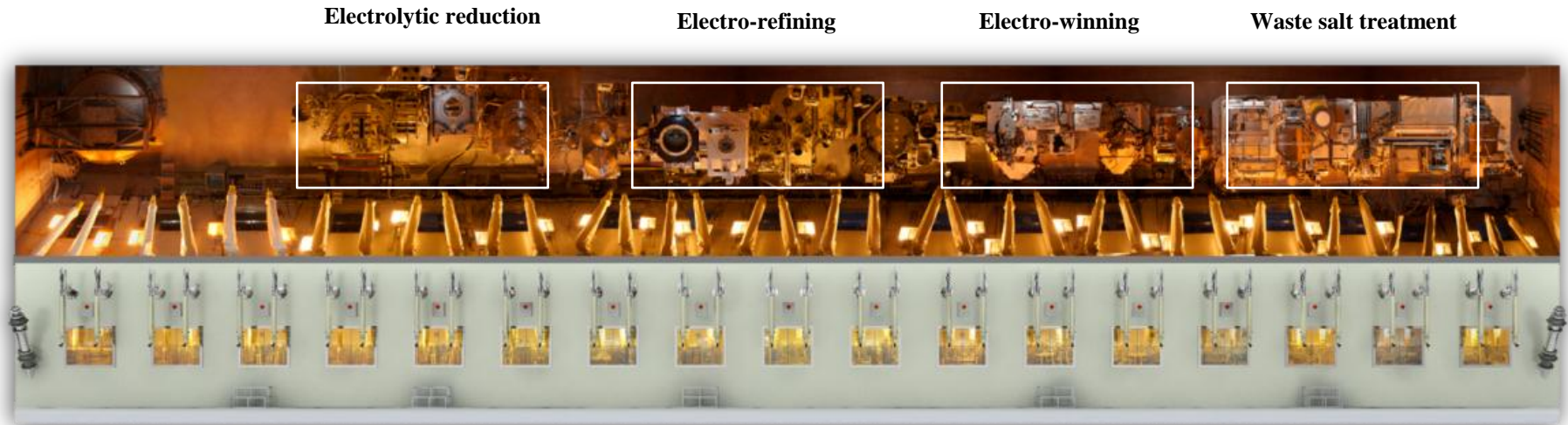
System Components of PRIDE

◆ Remote handling systems make processing equipment remotely operable and maintainable inside the cell.

- **3-ton in-cell overhead crane (G)** with a 1-ton auxiliary
 - Provides remote handling capabilities over the entire in-cell
- **3-ton blister (H)**
 - Lifts the overhead crane trolley or the BDSM trolley
 - Loads it into the large TLS for maintenance when damaged
- **Master-Slave Manipulators (MSMs, I)**
 - A total of thirty-four MSMs installed on the front wall
 - Effective/Max handling capacity: 15/25 kg
- **BDSM (Bridge transported Dual arm Servo-Manipulators, J)**
 - Electrically driven servo-manipulator with a force reflection
 - Traverses the length and width of the ceiling and moves in a vertical direction
 - Handling capacity of each arm: 25 kg



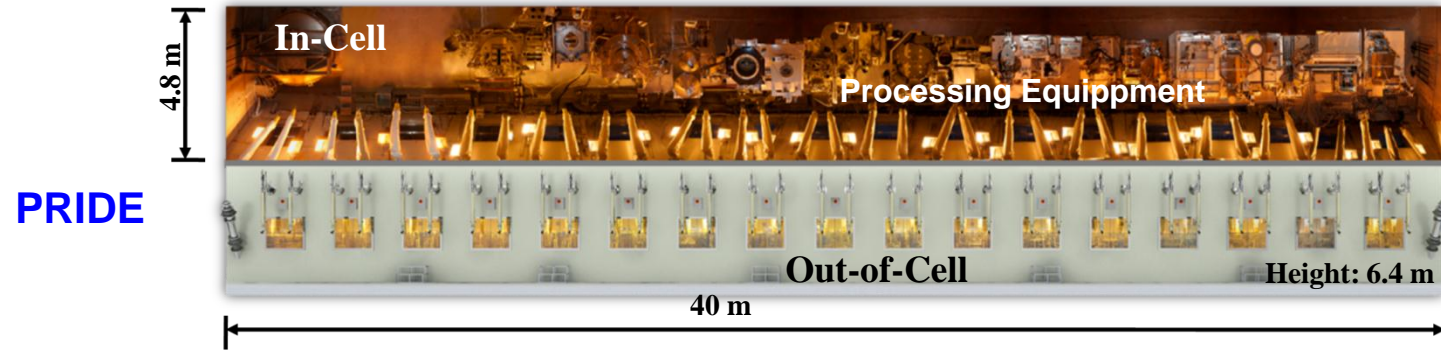
Process Equipments Installation



- **Major processing equipment installed inside the argon cell: a total of thirteen pieces**
 - Electrolytic reduction process: three pieces
 - Electro-refining process: three pieces
 - Electro-winning process: three pieces
 - Waste salt treatment process: four pieces
- **Features**
 - All processing equipment were designed and fabricated in modules to facilitate remote maintenance.
 - All processing equipment can be operated remotely by using remote handling systems.
 - All processing equipment can be maintained by using remote handling systems when damaged.

Operation

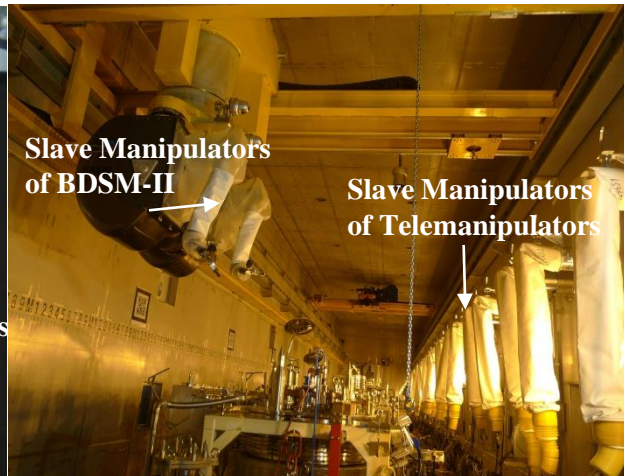
Remote Operation



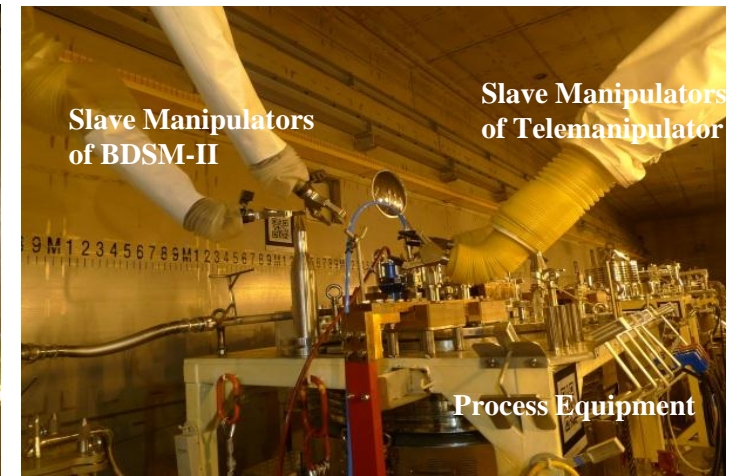
Out-of-Cell



In-Cell



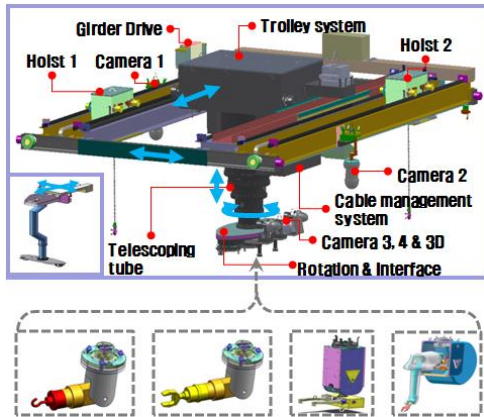
Cooperative work of Remote Manipulators



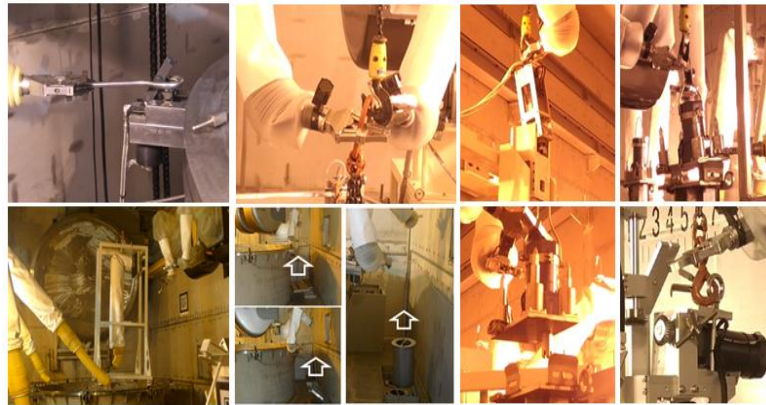
Enhancing Remote Systems

■ Test and improvement of PRIDE remote systems

- Test, modification of remote handling system (BDSM,MSM,LT,ST,Crane,etc.)
- Development of remote handling tools (Multi-purpose handling device, etc.)
- Test, evaluation of remote operability and maintainability of process equipments
- Enhance reliability of systems in Ar and salt environments
- Development of PRIDE monitoring system



BDSM and handling tools



Remote maintainability test of components using BDSM, MSM, hoist



Monitoring system

Ar System

■ Test of PRIDE Ar Cell

- Ar supply, cooling, purification and exhaust system (control 1,200 m³ volume)
- Ar cell leakage rates (below 0.003 m³/min)
- Purification (O₂ 200ppm \rightarrow 50ppm in 48 hours)
- Temperature, pressure control of Ar cell (T: \sim 1 °C, P: \sim 10 mmAq)
- Impurity control of Ar cell (O₂ : \sim 50 ppm, moisture : \sim 10ppm)



Summary

■ PRIDE facility has a large argon cell and several glove boxes

- A large steel structure argon cell : electrolytic reduction, refining, winning, RAR, salt waste treatment system
- Several glove boxes : feed material fabrication, salt waste fabrication, UCl_3 fabrication, and ingot production

■ Performance test is underway to verify the design specification

- Performance test of Ar cell and equipments
- Remote operability and maintainability tests of all equipments inside Ar cell
- Modification and enhancement of PRIDE system
- Performance test of process equipments with salts and U

2012	2013	2014	2015	2016	2017	2018	2019	2020
Blank test								
	Salt test							
		Salt, U test						
			U, Surrogate test					
					Long-term integral test			

Thank You for Your Attention

자연과 공존하는 발전,
원자력!!



Korea
Atomic
Energy
Research
Institute