MOX Fuel Fabrication Technology

Plutonium Fuel Development Center
Nuclear Fuel Cycle Engineering Laboratories
Japan Atomic Energy Agency
## History of PFDC

<table>
<thead>
<tr>
<th></th>
<th>Before PNC</th>
<th>PNC</th>
<th>JNC</th>
<th>JAEA</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>’60s</td>
<td>’70s</td>
<td>’80s</td>
<td>’90s</td>
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</tbody>
</table>
| **PFDF**         | Facility was constructed based on the technology introduced from US  
|                  | 260g Pu was introduced from US in 1966 to start research on MOX fuel in Japan  
|                  | R&D on advanced fuels and new fabrication process in progress  
|                  | ’74: Fabrication of MOX fuel for PWR (Mihama-1)  |
| **PFFF**         | Semi-automated process equipment based on the experience gained through PFDF operation was adopted  
|                  | MOX fuel fabrication for Joyo and ATR-Fugen until 2001  
|                  | ’85: Fabrication of MOX fuel for BWR (Tsuruga-1)  |
| **PFPP**         | Remote/ automated operation was adopted based on past experience  
|                  | MOX fuel fabrication for Joyo and Monju  |

### Technical support for J-MOX
- MOX test
- Consulting
- Training
Organization of PFDC

Plutonium Fuel Development Center

- Nuclear Material Handling Supervisor
- Hygiene Supervisor
- Safety Supervisor
- Shift Supervisor

- Fuel Technology Department
  - Quality Assurance Section
  - Plant Safety Review Section
  - Pu Fuel Engineering Section
  - Nucl. Mat. Management Sec.
  - Quality Control Section
  - Fuel Fabrication Section
    - Process Engineering Section
    - Fuel Technology R&D Sec.
    - Fuel Design & Evaluation Sec.
  - Waste Management Section
  - Waste Conditioning Section
  - Decommissioning Tech. Dev. Sec.
  - Plant Maintenance Section

Technical Administration Department

Safety Supervisor
Fabrication Achievements

Annual and Cumulative Production of MOX Fuel

<table>
<thead>
<tr>
<th>Fuel type</th>
<th>MOX</th>
<th>Pu Enrichment</th>
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<tbody>
<tr>
<td>Fugen</td>
<td>1.9%</td>
<td>2%</td>
</tr>
<tr>
<td>DCA</td>
<td>1.2%</td>
<td>1%</td>
</tr>
<tr>
<td>Monju</td>
<td>1.9%</td>
<td>20~30%</td>
</tr>
<tr>
<td>Joyo</td>
<td>80%</td>
<td>18~30%</td>
</tr>
<tr>
<td>others</td>
<td>2%</td>
<td>10%</td>
</tr>
<tr>
<td>Total</td>
<td>190%</td>
<td></td>
</tr>
</tbody>
</table>

<FBR>
MONJ U : 285 FAs
JOYO : 636 FAs

<ATR>
FUGEN : 773 FAs

<BWR>
Tsuruga No.1 : 2 FAs
Others : 2 FAs
TOTAL : 1698 FAs
Fuels design

**JOYO**
- Assembly Length: 2,970 mm
- Pin Length: 1,533 mm
- Stack Length: 500 mm
- Pellet Diameter: 4.6 mm
- Pellet Density: 94.0% TD
- Pu Content: 20/30 wt%
- Enrichment: 18% EU
- Pins: 127

**MONJ U**
- Assembly Length: 4,200 mm
- Pin Length: 2,813 mm
- Stack Length: 930 mm
- Pellet Diameter: 5.4 mm
- Pellet Density: 85.0% TD
- Pu Content: 20/30 wt%
- Enrichment: DU
- Pins: 169
Fabrication Process

MOX powder
PuO2 powder
UO2 powder

Weighing

Blending

Granulation

Pressing

Sintering

Grinding

Inspection

Pellet

Pellet loading

End plug welding

in glove boxes

Blending
Blend plutonium with uranium to conform to specification

Pressing
Compress MOX powder into shape of pellet

Sintering
Sinter pellet at 1700°

Inspection
Measure & inspect dimension, density and surface appearance

Pellet loading
Insert pellets into cladding tube

Assembling
Bundle fuel rods into fuel assembly

Wire wrapping

Inspection

Assembling

Inspection

Fuel assembly

Shipping

Fabrication Process in glove boxes
Powder Treatment Process

- Features of Powder Treatment -

- **Blending:**
  - Ball milling with Al$_2$O$_3$ balls and silicon rubber lining
  - Direct dilution to specified Pu concentration

- **Granulation:**
  - Rotary pressing into disks followed by crashing

- **Pressing:**
  - Hydraulic reciprocal machine with 6 punches

- **Transfer Container:**
  - Special design container with radiation fins

- **Dust Collecting:**
  - Cyclone system to reduce hold-up material

- **Scrap Recycling**
  - Jet milling
Pellet Finishing Process

- Features of Pellet Finishing -

- Sintering:
  - Continuous type furnace with maintenance capability
  - Batch type furnace
  - Multi function furnace

- Grinding:
  - Dry type system with $N_2$-gas cooling

- Inspection:
  - Remotely controlled visual inspection
  - Automated dimension and density inspection

Automatic Pellet Inspection
Product Quality

Homogeneity of Plutonium

Ceramograph

Density Distribution

Pu Fissile Content: 20.5%
Pore Former Content: 0.2%
Pu Equivalent Fissile Content: 0.2120

MONJUJOYO

JOYO MONJU

N = 20228
Average=94.38% T.D.
σ = 0.299% T.D.

N = 10133
Average=84.60% T.D.
σ = 1.004% T.D.
Fuel Assembling Process

Automated positioning welding system

Stacker crane type automated intermediate pin storage

Each fabrication station is connected by fully automated fuel pins transferring conveyor system

Remotely controlled assembly transferring and assembly storage
Material Accounting and Safeguards

Advanced Accountancy System

Near Real Time Accountancy System
Non Destructive Assay System

Containment / Surveillance System
Non Destructive Assay System

Receipt

Feed Storage → Process → Product Storage

Material Accounting

SBAS
(Super Glove Box Assay System)

PCAS
(Plutonium Canister Assay System)

WDAS
(Waste Drum Assay System)

FAAS
(Fuel Assembly Assay System)

MAGB
(Material Accountancy Glove Box Assay System)
“Short Process” / New MOX Pellet Fabrication Process under Development

- Based on Micro-wave Heating method
- Pu/ HM content is adjusted before conversion process
- Flowable MOX powder prepared by conversion process
- No additive (binder, lubricant,), no powder processing needed
- Significant improvements in economy, dose, waste,
- Applicable to MA containing fuel fabrication