



Panel2: U.S.-Japan Cooperation in R&D to Improve Safety of Existing Reactors

R&D activities for LWR-system safety in JAEA

Masahiko Osaka

Japan Atomic Energy Agency

6th Symposium on U.S.-Japan

Nuclear Energy Research Cooperation

24 February 2023, Washington DC, USA

Contents

- 1. Outline of R&D activities for LWR-system safety**
- 2. Accident Tolerant Fuel (ATF) R&D program in Japan**
 - 2.1 Overview of ATF R&D in Japan**
 - 2.2 JAEA's role in ATF R&D**
 - 2.3 Irradiation program in US test reactors**
 - 2.4 US-Japan collaboration under CNWG framework**
- 3. Summary and future prospect**

1. R&D activities for LWR-system safety in JAEA

Utilities, manufacturer, fuel vendor:
Nuclear safety enhancement
by safety design and management

Regulators:
Promote nuclear safety
culture in Operators

Utilization
promotion



Regulation

R&Ds for issue-solving

(National Project, Collaborative Researches with
Nuclear Industries)

R&Ds for issue-solving

(NRA Consignment Research)

**Nuclear Science and
Engineering Center (NSEC),
and related organizations in JAEA**

**Nuclear Safety Research
Center (NSRC)**



Basic and fundamental research:

- Cooperation with university, research institute, industries, etc. –
 - Accident Tolerant Fuel (ATF) development, material ageing issue, etc.
 - Advanced computational/experimental tools for LWR-system analysis
 - Preparation and utilizing unique infrastructure and technologies

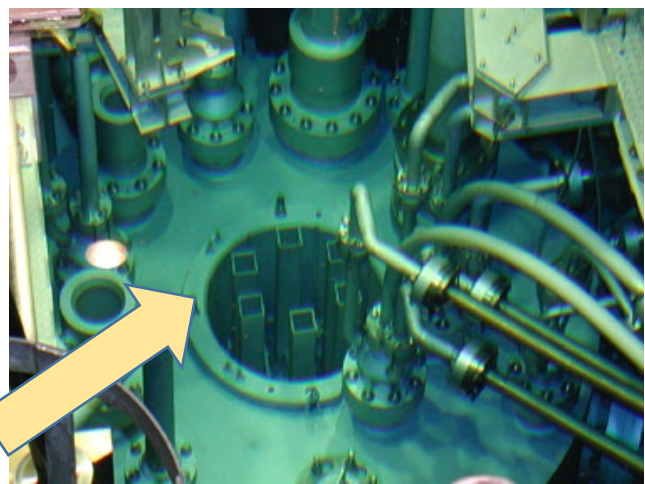
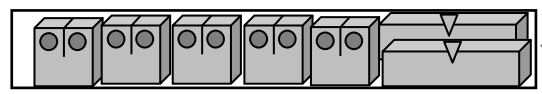
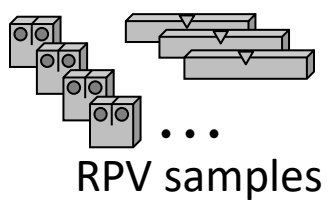


- Material ageing issue -

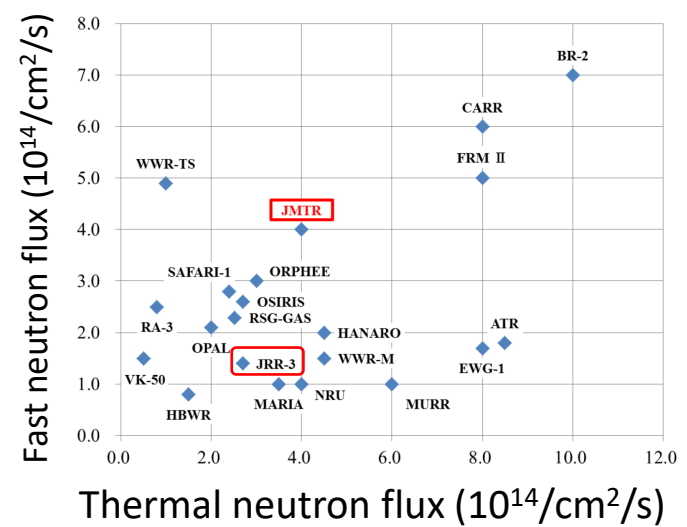
*Sponsored by METI

Irradiation of Reactor Pressure Vessel (RPV) samples in JRR-3 for enlargement of irradiation data at high dose region

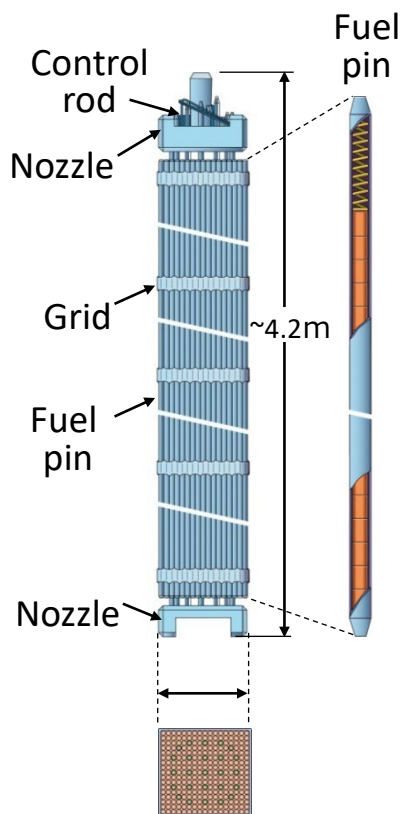
2022	2023	2024	2025
<u>Preparation</u>	<u>Design and fabrication of Irradiation capsule</u>		<u>Irradiation</u>
			<u>PIE</u>



JRR-3 core



2.1 Overview of ATF R&D in Japan



PWR Fuel Assembly

[SiC/SiC composite]

- Toshiba ESS
 - Fuel cladding for BWR & PWR
 - Channel box for BWR
- Hitachi-GE
 - Fuel cladding for BWR

[FeCrAl-ODS]

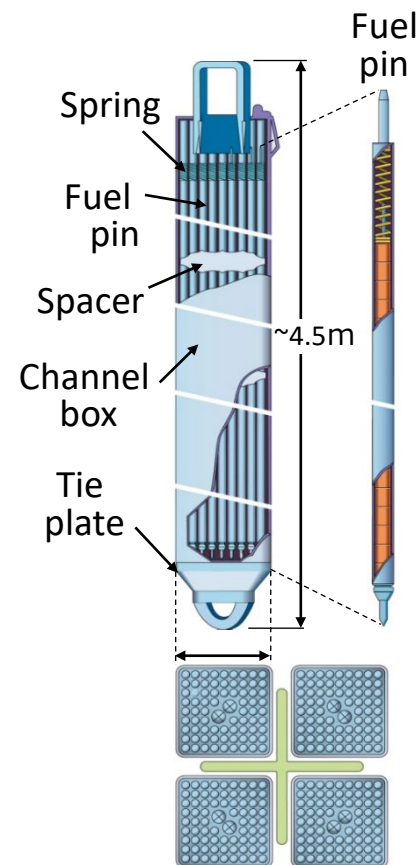
- Hitachi-GE (collaboration with GNF-J & Nuclear Fuel Development (NFD))
 - Fuel cladding for BWR

[Cr-coated Zry]

- Mitsubishi Heavy Industry (MHI) & Mitsubishi Nuclear Fuel (MNF)
 - Fuel cladding for PWR

[ATCR]

- Central Research Institute for Electric Power Industry (CRIEPI)
 - Accident Tolerant Control Rod

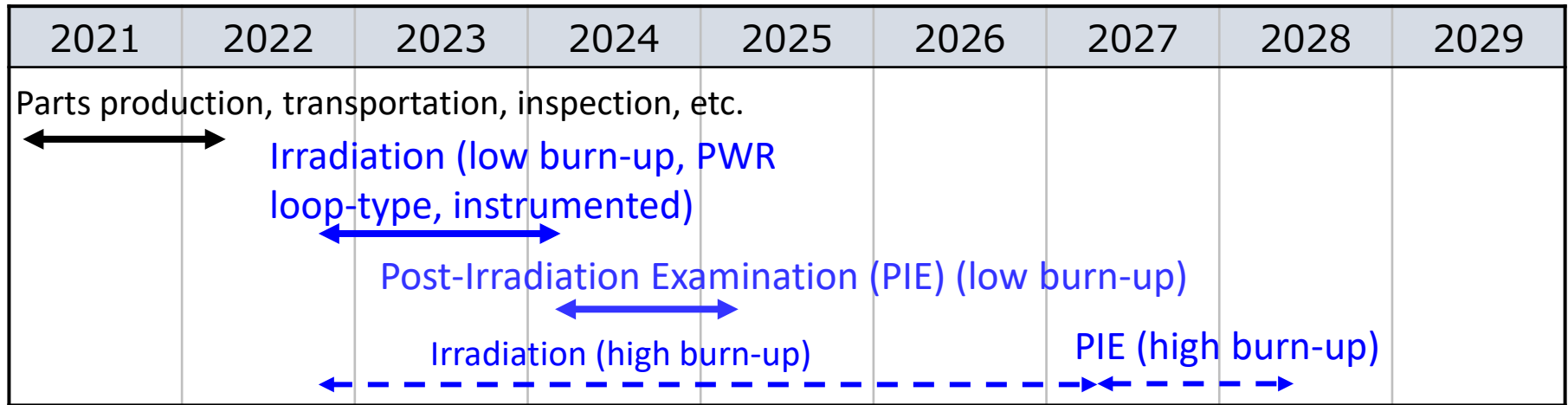


BWR Fuel Assembly

JAEA takes charge of project coordination/management of Japanese ATF R&D sponsored by METI

- Project coordination/management of Japanese ATF R&D sponsored by METI
- Development of common technological basis:
 - Irradiation test and Post Irradiation Examination (PIE) technologies
 - Development of fuel behavior analysis code
 - R&D on advanced technologies, supporting fuel behavior analysis under long-term irradiation and accident condition:
 - ✓ Quantum beam (ion, electron, etc.) irradiation combined with in-situ corrosion test
 - ✓ Improvement of out-of-pile LOCA test

- Cr-coated Zircaloy: in ATR (CNWG framework, CRADA) (Japanese fiscal year, JFY)



- FeCrAl-ODS: in ATR (CNWG framework, CRADA)
 - Preparation of the CRADA contract for the ATR irradiation
 - UO₂-fueled pins under loop-type environment, expected irradiation start from 2024 JFY
- SiC/SiC:
 - Contract signed for the MITR irradiation
 - SiC/SiC samples under loop-type environment, expected Irradiation start from 2023 JFY

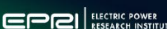
[Undergoing]

- Irradiation test at US test reactors:
 - ATR: Cr-Zircaloy and FeCrAl-ODS
 - MITR: SiC/SiC

- Participation to the annual EPRI/DOE/INL Joint Workshop

[Prospect]

- Further collaboration under CNWG framework to accelerate the ATF development in both US and Japan, e.g. transient test on ATF, advanced technology development, etc.



AGENDA

11th Annual EPRI/DOE/INL Joint Workshop on Accident Tolerant Fuel
 Location: EPRI Charlotte Office (Building 1, Room 402, 1300 West W.T. Harris Boulevard, Charlotte, NC 28262) / WebEx

Monday, 28 March 2022

Time (US EDT)	Topic	Lead
Session No. 1 – ATF Workshop (Asia Program Focus)		
6:00 pm	Welcome and Opening Remarks	Bill Gassmann (Constellation) / Dan Wachs (INL) / Rob Daum (EPRI)
6:05 pm	Overview of ATF R&D Program in Japan	Shinichiro Yamashita (JAEA)
6:20 pm	Development of Accident Tolerant SiC/SiC Cladding and Channel Box in Toshiba	Toshiki Nishimura (Toshiba)
6:35 pm	Development of Cr Coated Zirconium Alloy Fuel Cladding: Progress in 2021	Nozomu Murakami (Mitsubishi)
6:50 pm	Practical Development of Accident Tolerant FeCrAl-ODS Fuel Claddings for BWRs in Japan	Kan Sakamoto (Hitachi-GE / NFD)
7:05 pm	Compatibility between Novel Neutron Absorber and Core Structural Materials at High Temperature for Development of Accident Tolerant Control Rod	Kinya Nakamura (CRIEPI)
7:20 pm	KEPCO NF ATF R&D Program Update	Hun Jang (KNF)
7:35 pm	Development of MERCURY Code for Simulation of Multidimensional Fuel Behavior during Accident Condition	Hyochan Kim (KAERI)
7:50 pm	Closing Remarks	Bill Gassmann (Constellation) / Dan Wachs (INL) / Rob Daum (EPRI)
8:00 pm	Adjourn for Day 1	

3. Summary and future prospect

- Overview of R&D activities on LWR-system safety in JAEA was introduced.
- We are facing to the important point; The first irradiation test of Japanese ATF in collaboration with US.
 - Cr-coated Zircaloy in ATR, ready for irradiation
 - FeCrAl-ODS in ATR, under preparation of contract
 - SiC/SiC in MITR, signed on contract, irradiation expected next Japanese fiscal year
- Further collaboration expected under CNWG framework to accelerate the ATF development in both US and Japan

Thank you for your attention

Complementary slides

Outline of ATF development in Japan(1/2)

➤ Background

- In order to enhance the safety of LWR, there is need for developing new fuel with enhanced accident tolerance, e.g. less melting and/or less hydrogenating fuel (Lessons learned from Fukushima Daiichi Nuclear Power Plant Accident)

➤ Objective

- Establishment of “Technical Basis” for implementing an accident tolerant fuel (ATF) in the existing LWRs, supporting the industry-lead ATF development.

● Action Item

- Update of ATF technological information such as technological readiness level (TRL), roadmap, international trend, etc.
- Consideration of standard and criteria, followed by ATF-related licensing action
- Development of common technologies (irradiation technology, fuel behavior analysis code etc.) for accelerating ATF implementation

● Research Team

- JAEA : Project coordination, etc.
- Japanese power plant provider, fuel vendor, research institute, university : Collaborators (human resource, know-how, experience, analytical tool, etc.)
- CNWG, Int’l collaboration

● Expected Outcome

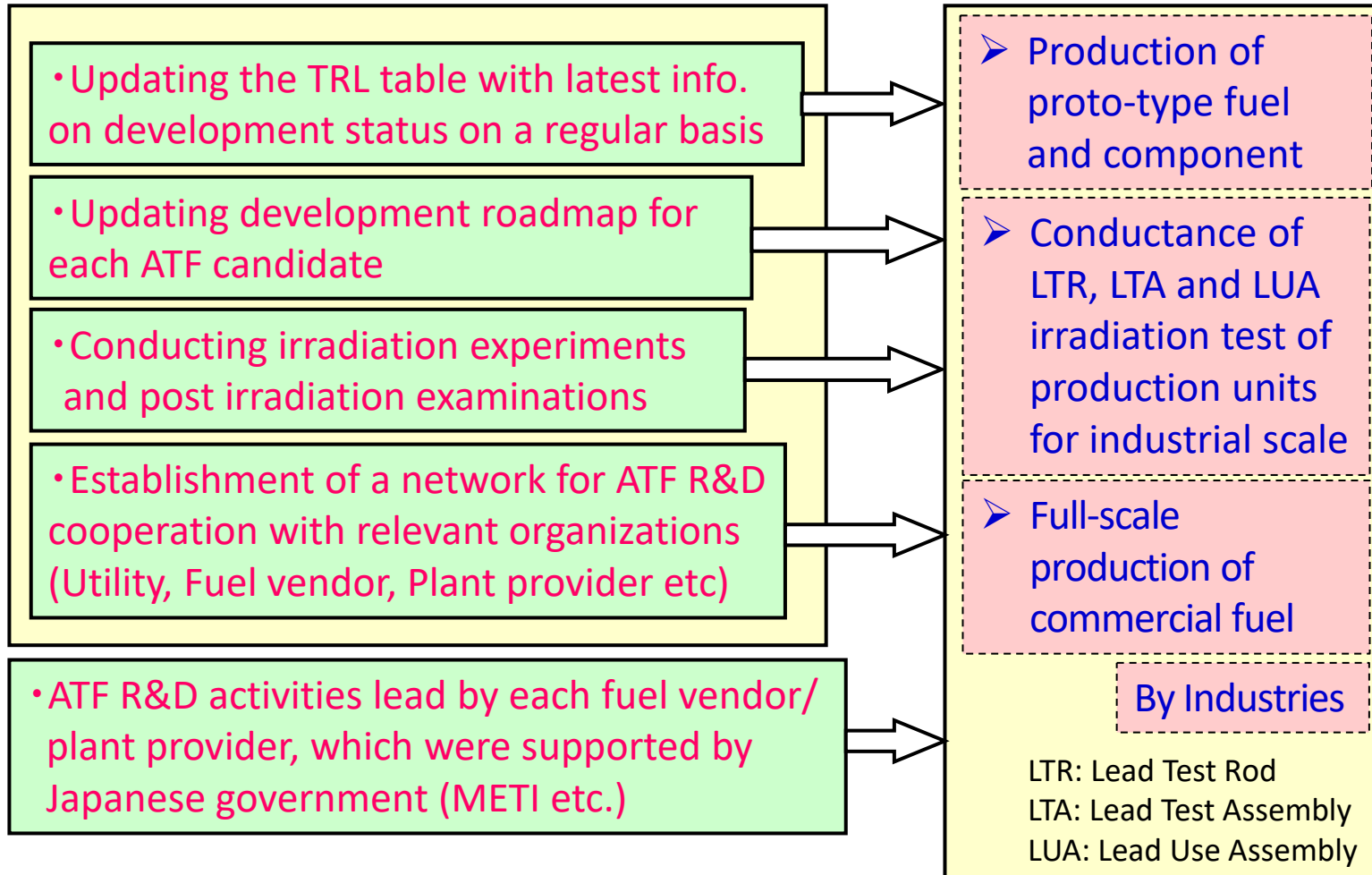
- Deployment of ATF → Enhancing LWRs safety (Decreasing potential risk in accident progression)
- Technology succession and human resource development in the field of nuclear fuel

Outline of ATF development in Japan(2/2)

Timeline to implementation of evolutionary ATF in existing LWRs

2022

2030s



Safety assessments and licensing review by the regulatory authority

Commercial use in the power plant

Irradiation experiment using HFIR

- Planning for ATF irradiation in test reactor
 - Negotiation with test reactor operators in US and Europe
 - ✓ *Halden & JMTR shutdown....*
 - ✓ *Seeking opportunity to irradiate Japanese ATF*
 - CNWG (Collaboration between US and Japan)
 - ✓ 2017- @ORNL

HFIR Irradiation of Japan-developed FeCrAl-ODS Alloys

HFIR Irradiation of Japan-developed FeCrAl-ODS Alloys

