

TRL-definition for advanced fuel concept applied for commercial LWRs in Japan

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Outline

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Background

- AESJ (Atomic Energy Society of Japan) constructing a roadmap on “safety technology of LWRs and human resources development” in JFY2014.
- Nuclear fuel division of AESJ starts discussing TRL (Technology Readiness Level) for [advanced fuel concepts applied for LWRs](#), as an useful index for considering proper R&D-step in near/intermediate/long terms of the roadmap.
- Volunteers from JAEA, CRIEPI, and plant/fuel manufacturers in Japan collaborating to define generic and specific TRL.

R&D-field to be evaluated

- Discussion started from the experience on [TRL-evaluation of P&T](#) (partitioning and transmutation) technology performed in Japan.

(K. Ikeda, M. Kurata, K. Minato, et al., *Progress in Nuclear Energy*. (2014))

- In the previous study on P&T, four kinds of R&D-field discussed, such as plant design, reprocessing, fuel manufacturing, and fuel performance.
- Regarding [advanced LWR-fuels](#), TRL should deal with not only these issues but quality assurance, fuel safety, approval/regulation, specification/standard, storage, transportation, and etc.

TRL	General definition	
Proof of performance	9	Utilization of new fuel concept in commercial reactors
	8	Quality verification for commercial operation Full loading of new concept fuel in a commercial LWR, based on new approval/regulation and new specification/standard
	7	Productization, based on new fuel concept Establishment of final fuel/process/plant design by vendors Establishment of fabrication technology for commercial fuel assembly Irradiation of lead use assembly (LUA)
Proof of principle	6	Verification of prototype fuel assembly Establishment of regulatory criteria of safety analysis Design and irradiation test of prototype fuel assembly (LTA: lead test assembly), based on new license/regulation and new specification/standard Design of fuel fabrication plant
	5	Verification of prototype fuel rod Design and Irradiation test of prototype fuel rod (LTR: lead test rod) Validation of process performance of fuel fabrication
	4	Conceptual design of prototype fuel Establishment of fuel design parameters Irradiation test of prototype fuel rod (without fuel, full scale/long size rod) Validation of component technology for fuel fabrication
Proof of concept	3	Validation of fuel concept, Sample irradiation test Determination of R&D objectives for industrial scale
	2	Embodiment of new fuel concept, Evaluation of upper limit to be achieved by new fuel concept, Evaluation of technology option
	1	Proposal of new fuel concept, Extraction of R&D subjects

- **Prototype fuel rod** (irradiation test performed in **TRL-4, 5**)

Defined as “the major design parameters are the same as those for the commercial fuel, but a part of dimension is different, especially fuel length.”

TRL-4, 5 are the key step on application to LWR.

Verification of various analysis codes and establishment of regulation/evaluation criteria is able to be performed, based on irradiation test/PIE/transient tests of the prototype fuels, which will be applied for the final approval and licensing.

- **LTR: lead test rod**

Defined as “prototype-design base fuel rod, attached in a conventional fuel assembly and irradiated in commercial LWRs.”

- **LTA: lead test assembly**

Defined as “prototype-design base fuel assembly, constructed by advanced concept of fuel rods, control rods, or other core components, and irradiated in commercial LWRs.”

TRL	Fuel Performance /Fuel Design	Fuel Fabrication/Quality Assurance	Fuel Safety (DBA/BDDBA /SA)	Plant/Thermal-hydraulics/ Neutronics	Storage/Transportation/Back-end	Approval/Regulation	Specification /Standard
9	Operation of commercial LWRs	Mass production of commercial fuel assembly	Operation of commercial LWRs	Operation of commercial LWRs			
8			Evaluation of safety performance of commercial plant	Evaluation of commercial plant performance		End of licensing review, Final approval of commercial plant	
7	LUA irradiation	LUA fabrication	Establishment of evaluation procedure for DBA/BDDBA/SA	Establishment of evaluation procedure for static/dynamic plant condition			
6	LTA irradiation Verification of fuel performance code	Process monitoring/controlling Trial manufacturing of LTA	Sim-tests for transient/LOCA/RIA conditions	Establishment of core analysis code		Estimation of design criteria for DBA/BDDBA/SA to LTA	Establishment of fuel design/manufacturing criteria
5	LTR irradiation Out-of-pile tests for prototype	Industry scale unit tests Fabrication of LTR		Estimation of plant performance		Formation of guideline for regulation	Construction of specification/standard
4	LTR irradiation without fuel	Fabrication of full scale cladding Establishment of quality inspection technology	Sim-tests for transient /LOCA/RIA (non-irr. samples)	Improvement of conventional core analysis code			
3	Sample irradiation	Fabrication of irr. samples	Clarification of R&D subjects	Clarification of R&D subjects		Sim-tests for formulating regulation	
2	Key R&D steps in TRL for advanced LWR fuels.						
1	Discussion on various effect to conventional R&D-fields, such as fuel safety analysis, plant operation, back-end, approval/regulation, specification/standard, etc., just started in JAEA by collaborating with fuel/plant manufacturers, research institutes, etc.						

Summary

- Generic and specific definition of TRL being discussed in Japan, by collaboration of JAEA, CRIEPI and fuel/plant-manufacturers, on “application of advanced fuel concept to conventional LWRs”.
- This includes not only fuel design and fuel fabrication but various other issues, which are necessary for application to LWRs.
- This must be an useful [guideline](#), when evaluating TRL of individual ATF concepts.
- [To attain TRL-4, 5](#) is a proper R&D target in the intermediate stage. (For instance, when considering gap between present status and R&D objective)