

Integrity Criteria of Spent Fuel for Dry Storage in Japan

Japan Nuclear Energy Safety Organization (JNES)

Katsuichiro KAMIMURA

kamimura-katsuichiro@jnes.go.jp

Abstract

Regulatory requirements for spent fuel integrity are as follows in Japan.

- Criticality shall be prevented.
- Integrity of spent fuel during the storage shall be maintained.
 - To prevent the failure of fuel due to cladding thermal creep
 - To prevent the degradation of cladding mechanical properties
- Fuel material properties used in the safety analyses shall have appropriate safety margin.
 - To consider the effect on mechanical properties during irradiation and storage
 - To store only sound spent fuel assemblies

The following circumstances and conditions were foreseen for ordinal dry storage including drying process of a cask.

- Max. temperature: 400- 300°C (similar or little larger to the temperature in reactor core)
- Circumferential hoop stress: larger than in reactor core (due to large inner pressure and very small outer pressure)
- Duration time: 50 years (much longer than in reactor core)
- Dual Purpose Cask: Transportation without inspection of fuel after long term dry storage (Fuel material properties used in the safety analyses shall have appropriate safety margin.)

Considering above requirements and conditions, JNES carried out the following mechanical property tests to derive fuel integrity criteria.

- Thermal Creep and Creep Rupture Test
- Hydride Reorientation and Mechanical Properties Test
- Irradiation Hardening Recovery Test

The test samples were made of the following fuel claddings irradiated in commercial reactors in Japan.

BWR Zry-2 ; RX, without Zr Liner(40GWd/t) and with Zr Liner(50GWd/t)

PWR Low Sn Zry-4; SR(48GWd/t), MDA, NDA, ZirloTM; SR (55GWd/t)

The test results showed that hydride reorientation effect on cladding mechanical properties is predominant for fuel integrity criteria.

Ring compression test was adopted as evaluation test of hydride effects on cladding mechanical properties. "Threshold of No Reorientation" is not directly applicable as an index for fuel integrity criteria. Hydride Reorientation Treatment (HRT) temperature and stress related to "Threshold of No Mechanical Property Degradation" are adopted as fuel Integrity criteria for interim dry storage.

Based on the experimental results, HRT thresholds as fuel integrity criteria for interim dry storage are summarized as below table. HRT thresholds remarkably depend on the cladding materials.

Cladding Type		Threshold for Ductility Degradation	
		Temperature ()	Hoop Stress (MPa)
BWR	40GWd/t No Liner	200	70
	50GWd/t with Liner	300	70
	55GWd/t with Liner	300	70
PWR	39GWd/t	275	100
	48GWd/t	275	100
	55GWd/t MDA	250	90
	55GWd/t ZIRLO	250	90

Applicants (designers) should take care of the following remarks when they apply the above fuel integrity criteria to designing dry storage casks.

- The conclusion derived from JNES test project satisfies the sufficient condition for preventing degradation from a conservative viewpoint about the influence of hydride reorientation.
- Therefore even if some conditions are not satisfied in cask designs, the applications are not always rejected. In this case, the applicants (designers) shall either evaluate and prove the fuel integrity with their own data, or evaluate cask safety by using absolute mechanical properties of the degraded cladding.