Transactions of the Korean Nuclear Society Spring Meeting
Gwangju, Korea, May 30-31, 2013

The international nuclear fuel failure trends

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1. Introduction

To maximize efficiency of Nuclear Power Plants, the utilities increase the cycle length, fuel burn-up, enrichments of uranium and stretch out the power up-rate. Because of these severe nuclear fuel operating conditions, following various fuel performance issues have been arising, such as Grid to Rod Fretting(GTRF) failure, fuel assembly bow and Incomplete Rod Insertion(IRI) problem, and fuel assembly handling problem caused by excessive grid growth at high burn-up. This paper presents various issues and status of worldwide fuel failure and performance.

2. The international nuclear fuel failure trends

Because of fuel vendors' efforts to improve fuel reliability, fuel failures are gradually decreased as shown in Fig.1. The vendors' efforts are focused on the following areas to reduce fuel failures.

- **Design and Materials** : Thorough testing and introduction of designs and materials that improve reliability
- **Manufacturing Process Improvement** : Continuous assessment and improvement of manufacturing process to control critical attributes
- **Fuel Cycle Risk Management** : Cycle-specific risk assessment to ensure that fuel management or plant changes do not compromise fuel reliability
- **Operations feedback** : Examinations of both failed and "healthy" fuel to assess margins and identify possible problem areas. This area also includes plant operating guidelines to maintain margins.

The number of fuel failure with GTRF is predominant in U.S. PWR plant as shown in Fig. 2. The number of plants with GTRF in specific plant classes have been decreasing as more robust fuel designs have been implemented and are now proven.

The number of U.S. PWR fuel failure and mechanisms of failure are as shown in Fig. 3.
EU PWR fuel failure trend and mechanisms are GTRF and Debris as shown in Fig.4. On the other hand, domestic fuel failure mechanism is Debris as shown in Fig.5. And domestic PWR Fuel failure rates are very low compare to those of U.S. and EU Fuel supplier as shown in Fig 6.

This means domestic fuel design is robust against GTRF failures and domestic vendor effort to reduce fuel failure is more effective and our reactor operating conditions are un-severe than U.S. such as cycle length. For high GTRF risk plant, EPRI recommended to perform risk assessment of the cycle according to the flow chart in Fig.7. On the other hand, the main fuel failure mechanism in domestic fuel is Debris. To reduce Debris failure, Prevent inclusion of Foreign Material (FM), retrieve the Debris, and filtering the debris are three main important factors as EPRI reported.

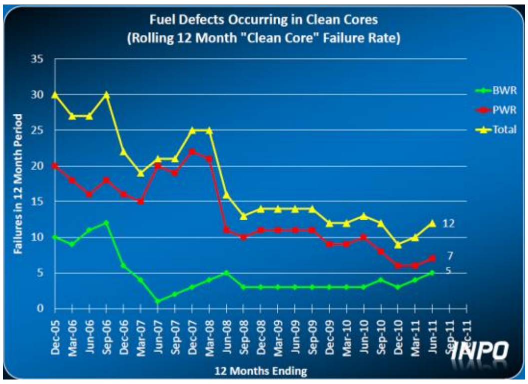

Fig. 1 Clean Core Failure Rate of U.S.

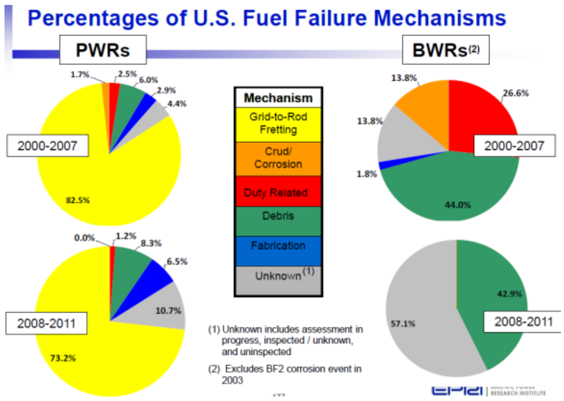

Fig. 2 Fuel Failure Mechanism of U.S.

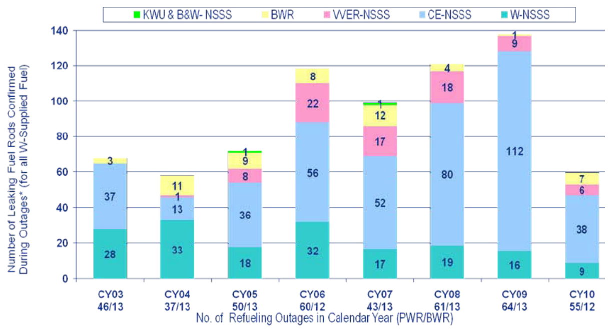

Fig. 3 Fuel Performance Vendor A

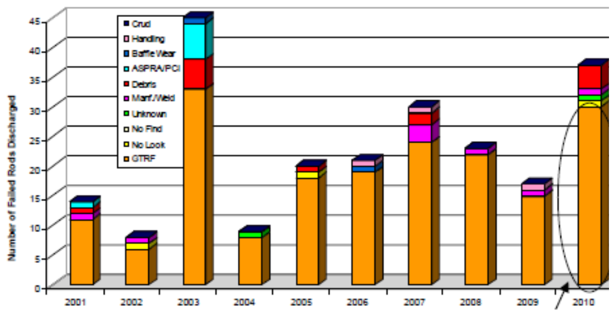

Fig. 4 Fuel Performance Vendor B

Leaking Rods : EA

Cause	2006	2007	2008	2009	2010	2011	2012	Total
Debris	0	2	2	2	0	2	1	9
Grid Fretting	0	0	0	0	1	0	0	1
Fabrication(Welding)	0	0	0	2	0	0	0	2
Handling	0	0	0	0	0	0	0	0
Corrosion	0	0	0	0	0	0	0	0
Undiagnosed	0	0	0	0	0	0	0	0
Unknown	0	0	1	0	2	0	2	5
Total	0	2	3	4	3	2	3	17
Failure Rate(Rod)	0	$3X10^{-6}$	$5X10^{-6}$	$6X10^{-6}$	$5X10^{-6}$	$3X10^{-6}$	$5X10^{-6}$	$4X10^{-6}$

Fig. 5 Fuel Performance Vendor C

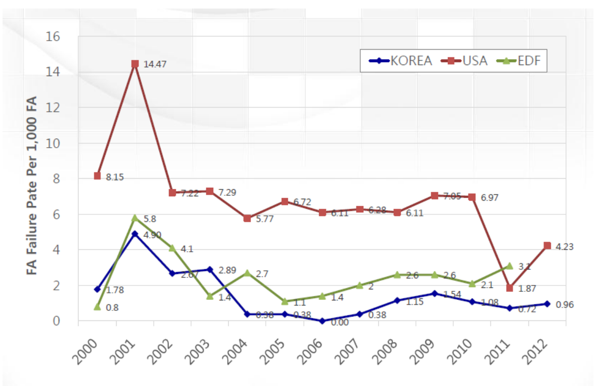

Fig. 6 Comparison of Failure Rate(per 1,000 FA)

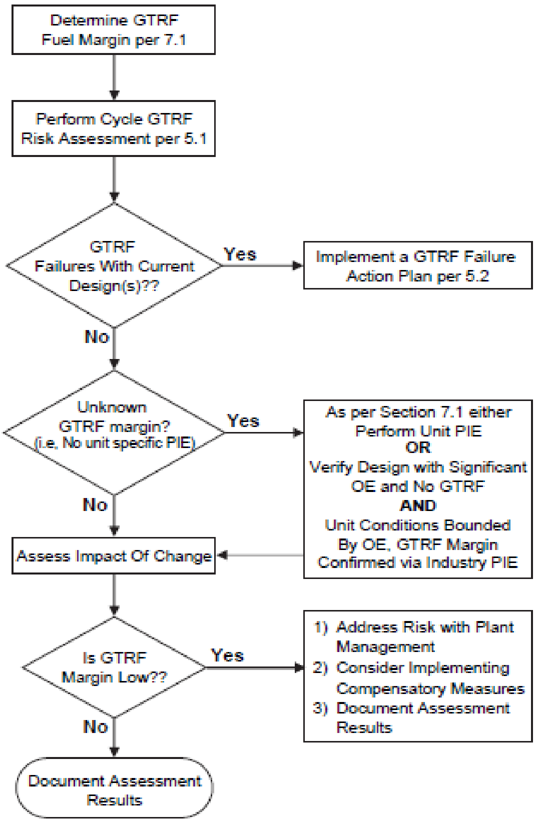

Fig. 7 GTRF Guideline Implementation Flowchart

3. Conclusions

To improve fuel reliability, fuel vendors make efforts on various areas such as robust GTRF resistance fuel design and manufacturing process improvement. To reduce debris failure, Prevent inclusion of Foreign Material (FM), retrieve the Debris, and filtering the debris are important factors.

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