

# Proposing guidelines for reliable nuclear fuel



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Some problems have had a large adverse impact on plant economics and the remedies have proved costly to the fuel suppliers.

From a utility standpoint, guidelines based on experience can be formulated to optimize fuel reliability and minimize the risk to the operator.

**Design review of new features**

An independent design review of new features is imperative.

This should include a check of vendor calculations, models, and assumptions using, where possible, a separate database of (for example) materials properties and fuel mechanical behavior based on industry experience. Particularly important are the models for critical heat flux, nucleate

pletion of a given test, as well as assuring that the test is correctly designed such that the characteristic of interest will be observed. The simulation of flow-induced vibration in a loop is a particularly difficult area because of a lack of knowledge of hydraulic forcing functions on fuel assemblies.

**Quality assurance and control**

Quality assurance is the overall system whereas quality control is a sub-set of inspection-related activities (technical surveillance) that ensure that a fabricated product meets its design specifications. There is little doubt that fuel reliability is enhanced if audits and surveillances of the fuel supplier and sub-suppliers are performance-based. Audits should be carried out on a regular basis and be scheduled to allow key aspects of the manufacturing and inspection routines to be observed.

**Plant operation and feedback**

A utility's major strength is the experience it accumulates in the operation of its own plants.

The impact of a new fuel design should be compared against the plant's own experience-base, since parameters that are not bounded are a potential risk to reliability.

In addition, this base should be expanded by involvement in information-sharing initiatives and industry schemes such as post-irradiation examination programs.

Defective fuel is sometimes not examined thoroughly, although this provides essential information as part of the "feedback" to the fuel supplier on the interaction between design and operation.

Fuel reliability has a broad definition beyond that of remaining leak-free, and this can be significantly enhanced by following some logical guidelines. ●

Reliable fuel is defined as an assembly that fulfills the following conditions:

- it meets its functional specifications;
- experiences no mechanical failure;
- has no adverse impact on expected plant operation (including safety) and,
- has a capacity to function with quantifiable margins to design and operational limits.

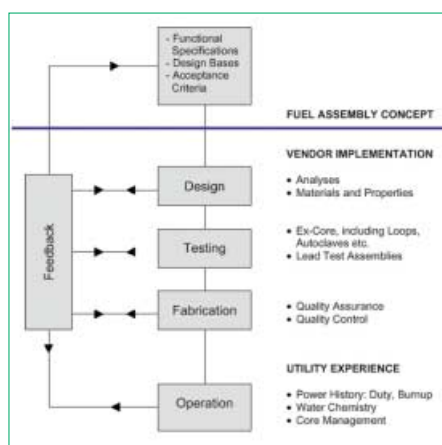
The obligation to meet these conditions is shared between the fuel supplier and the utility user in an integrated manner.

The illustration below is a "life-cycle" flowchart that shows the four factors that can affect the reliability of an assembly, stemming from the fuel system specifications that provide the basis against which the design is developed.

Design, testing and fabrication are the precursor stages to reactor operation, but each can be improved by effective and informative feedback.

New and modified design features have been continuously introduced to meet utility demands for increased burnup, more cycle flexibility, power uprating, greater operating and safety margins and reduced fuel cycle costs.

Other design changes are made to correct unreliable fuel, such as for grid-rod fretting, fuel assembly bowing, and secondary degradation.



Fuel assembly life cycle showing major factors influencing reliability

boiling, corrosion and mechanical behavior (for design limits). Finite element analysis can assess the ability of a component to meet design specifications and is a valuable technique to a utility engineer.

**Testing and lead test assembly**

Incomplete or inappropriate testing programs have certainly reduced fuel and component reliability in specific cases in the past. It is important to establish the acceptance criteria for the successful com-

**Reference**

J.E. Harbottle and M.W. Kennard, "Towards Improved Fuel Reliability", Proceedings Int. Topical meeting on light water reactor fuel performance, Park City, Utah, ANS 2000.