UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

June 23, 1977

REGULATORY GUIDE DISTRIBUTION LIST (DIVISION 1)

Regulatory Guide 1.119, "Surveillance Program for New Fuel Assembly Designs," issued for comment in June 1976, is being withdrawn. In order to broaden the scope and data base to include existing fuels, the staff now believes that fuel surveillance programs should be plant specific and handled on a case-by-case basis rather than in a detailed generic manner. Therefore, the staff's need for data from fuel surveillance programs for both existing and new fuel designs will be included in the planned update of Regulatory Guide 1.70, "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants," and reflected in the planned revision to NUREG-75/087, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants."

Regulatory guides may be withdrawn when they are superseded by the Commission's regulations, when equivalent recommendations have been incorporated in applicable and approved codes and standards, or when changing methods and techniques have made them obsolete.

Sincerely,

Robert B. Minogue

Robert B. Minogue, Director
Office of Standards Development

U.S. NUCLEAR REGULATORY COMMISSION June 1976

REGULATORY GUIDE

OFFICE OF STANDARDS DEVELOPMENT

REGULATORY GUIDE 1.119

SURVEILLANCE PROGRAM
FOR NEW FUEL ASSEMBLY DESIGNS

A. INTRODUCTION

Paragraphs (a) and (c)(3) of §50.36, "Technical Specifications," of 10 CFR Part 50, "Licensing of Production and Utilization Facilities," prescribe a surveillance program consisting of inspections and tests necessary to ensure that the quality of systems and components is maintained, that facility operation will be within safety limits, and that limiting conditions of operation will be met. This guide describes a surveillance program acceptable to the NRC staff for determining the performance of new fuel assembly designs. The program may include postirradiation destructive examination if deemed necessary. This guide applies only to those light-water-cooled fuel assemblies incorporating new design features that have been deemed significant by the NRC staff.

B. DISCUSSION

The basic objective of fuel assembly designs for light-water-cooled reactors is to provide an array of fissionable material that has high structural integrity and is capable of transferring fission-generated heat to a circulating coolant while containing fission products and fuel material over the design lifetime. Fuel assemblies of current design are made up of fuel rods consisting of cylindrical UO_2 fuel pellets stacked end to end in thin-walled tubes of zircaloy. The fundamental design basis is that the fuel assembly maintain its structural integrity for heatup, cooldown, shutdown, and power operation, including the most adverse set of operating conditions expected throughout its lifetime.

Some of the phenomena that may possibly affect the integrity of the fuel rod are thermal cycling, fission gas release to rod plenums, densification, cracking and ratcheting of the fuel pellet, pellet-clad mechanical interaction, and corrosion- or radiation-induced changes in the mechanical properties of the cladding. The integrity of the fuel rods can be ensured through proper design by using acceptable mechanical behavior models for fuel and cladding and thermal performance models for fuel rods and by maintaining an adequate margin between the limiting fuel rod stresses, strains, and temperatures and the values calculated for steady-state and transient conditions. Among other things, designers should consider limits on fuel rod bowing, linear power, internal pressure, rate of power increase, coolant temperature, and coolant pressure.

Surveillance of fuel assemblies in operating reactors has proved successful in uncovering unpredicted behavior such as fuel densification, channel box wear, and fuel rod bowing. Therefore, verification that a new fuel assembly design can meet its design and performance criteria should be determined through a comprehensive surveillance program which includes precharacterization of selected fuel assemblies. Directed postirradiation destructive examinations of fuel assembly components may also have to be performed to establish causes for unpredicted behavior of safety significance.

Precharacterization involves the examination and measurement of selected fuel rods individually and in the fuel assembly. Fuel rod measurements should include diameter and length, and assembly measurements may include rod-to-rod spacing and spacer perpendicularity.

Surveillance of fuel rod performance may include the monitoring of reactor offgas and coolant activity; wet or dry "sipping" of fuel assemblies to identify leakers; visual observations of structural integrity with various optical aids (i.e., borescope, periscope, etc.) or closed-circuit underwater TV; and remote dimensional measurements of length, diameter, and degree of bowing.

Postirradiation examinations may involve visual inspections, dimensional measurements, and both nondestructive and destructive examinations of the fuel rod, cladding, and fuel pellet.

Nondestructive examinations of the fuel rod are used to locate defects; these can include profilometry, pulse eddy current, ultrasonic, and leak tests. Gamma scanning is used to determine axial distribution of fission product activity, fuel column length, and gaps, and neutron radiography is an additional means to locate the fuel column. Analyses of internal gas composition and measurement of total gas volume are other measurements important in design verification.

Cladding examinations and tests are designed to determine physical, chemical, and mechanical changes that have occurred as a result of thermal, mechanical, and environmental exposure in the reactor. Metallographic examinations determine microstructural changes, corrosion behavior, and, for zircaloy cladding, hydride platelet orientation. Density and hardness measurements supplement the metallographic examination for determining the type of physical changes that have occurred in the cladding. Chemical analyses of the cladding are useful in correlating the physical, mechanical, and corrosion behavior of the cladding. Mechanical property testing can include the complete spectrum of tensile tests, burst tests, bend tests, and creep and fatigue tests. Fuel pellet examinations can include density and dimensional determinations plus microstructural observations.

C. REGULATORY POSITION

A surveillance program to directly observe the behavior of the actual fuel system as it performs in the reactor should be conducted in order to demonstrate the validity of the conclusions reached from the design evaluation.

The surveillance program should include visual examination of all fuel assemblies upon discharge into the spent fuel pit and precharacterization of selected fuel assemblies, with nondestructive and destructive postirradiation examinations conducted when deemed necessary. Prior to establishing the surveillance program, documentation should be prepared defining the functional characteristics of the new assembly design. The anticipated performance under all expected events and conditions should be described. The rules and procedures used for design and analysis, including safety margins, should be identified as described in Section 4.2, "Fuel System Design," of Regulatory Guide 1.70, "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants - LWR Edition."

The surveillance program should be conducted on the initial core loading that uses the new fuel assembly. The initial core loading should contain two precharacterized fuel assemblies in each of at least three regions of the core. Surveillance should be conducted on approximately one-third of the initial core fuel assemblies during each of the first three refueling periods.

The design verification program should include the following:

1. <u>Precharacterization</u>

The preselected precharacterization fuel assemblies should undergo characterization to establish baseline data to be used to facilitate the evaluation of fuel performance, dimensional changes, or any anomalies that might be evident from the subsequent surveillance program. Precharacterization should be directed at the specific parameters undergoing redesign and may include the following or other applicable examinations:

a. Assemblies

(1) Measurement of the distance between spacers.

(2) Measurement of spacing between rods.

(3) Measurement of spacer-to-fuel-rod perpendicularity.

b. Fuel Rods

(1) Overall visual examination.

(2) Measurement of length and diameter, both axial and helical profiles using profilometry.

(3) Eddy current or ultrasonic tests.

(4) X-ray or neutron radiography.

2. Surveillance

The surveillance program should consist of a general visual inspection of all the peripheral rods as they are discharged into the spent fuel pool. Approximately one-third of the initial core fuel assemblies should be inspected during each of the first three refueling periods. All pertinent data on the nuclear environment and plant operating history should be recorded. Key parameters such as power, coolant temperature, coolant pressure, rapid transients, and scrams should be collated for use in evaluating fuel assembly behavior.

The visual inspection should include observations for cladding defects, fretting, rod bowing, corrosion, crud deposition, and geometric distortion with special attention to design changes and comparison to pertinent precharacterization observations.

If any anomalies are detected during normal plant operation or the visual examinations, further investigation should be performed. Depending on the nature of the observed condition, the additional examination could include appropriate surface, dimensional, leak-test, or gamma inspections of the fuel assemblies.

In the event that these additional investigations uncover any fuel assembly containing structural defects, fuel rod failures, or abnormalities of such a nature or magnitude that fuel design limits could be exceeded during normal operation, this assembly should be subjected to destructive examinations.

3. Destructive Examinations

If the detailed surveillance examinations indicate the need for further evaluation, destructive examinations should be performed. These examinations need not be accomplished at the plant site or within the period of the refueling outage.

Prior to performing the destructive examinations, the selected assemblies should undergo whatever additional tests are necessary to establish the types of destructive examinations to be conducted. These tests can include leak tests, dye penetrant, eddy current, profilometry gamma scanning, or neutron radiography,

Again depending on the nature of the observed condition, metallographic examinations and mechanical testing may be undertaken.

a. Metallography

When examination of the fuel cladding is indicated, sections of tubing should be mounted for examination of the cladding for microstructural characteristics, corrosion or fretting behavior, oxide film thickness, hydride platelet orientation, and hardness. Areas identified in the nondestructive examinations as having clad defects should be included in the metallographic examinations. The metallographic mounting of the sections should be performed with the fuel pellet or pellet pieces maintained in their relative configuration so that the extent of any pellet-clad chemical or mechanical interaction can be established.

Standard metallographic examination of other fuel assembly components should be undertaken when deemed necessary to explain unpredicted behavior.

When examinations of the fuel pellets are indicated, they should be made using the metallographic specimens prepared for fuel cladding examinations.

Observation of fracture, pore size and porosity distribution, grain size, etc., should be noted when pertinent to establishing the cause of unpredicted behavior.

Fuel-clad gap size should be determined, and final fuel density should be measured when necessary for evaluation of the observed condition.

b. Mechanical Testing

In the event that the metallographic examinations and tests performed according to regulatory position C.3.a. indicate potentially serious mechanical degradation of the fuel rod cladding, tensile, bend, or burst tests should be performed according to ASTM E 453-72* to quantitatively confirm the degree of damage.

D. IMPLEMENTATION

The purpose of this section is to provide information to applicants and licensees regarding the NRC staff's plans for using this regulatory guide.

This guide reflects current NRC staff practice. Therefore, except in those cases in which the applicant or licensee proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the method described herein is being and will continue to be used in the evaluation of submittals in connection with applications for operating licenses, construction permits, or amendments thereto until this guide is revised as a result of suggestions from the public or additional staff review.

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*ASTM E 453-72, "Standard Recommended Practice for Examination of Fuel Element Cladding Including the Determination of Mechanical Properties." Copies may be obtained from the American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pa. 19103.