Burnup Credit for LWR Fuel

An American National Standard

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Foreword

(This foreword is not a part of American National Standard "Burnup Credit for LWR Fuel," ANSI/ANS-8.27-2015.)

Burnup credit is a term commonly used to account for an overall negative reactivity effect resulting from irradiation. In order to apply burnup credit, there needs to be both supporting analyses and implementation steps (such as procedures, burnup assignments, and verification techniques).

Including burnup credit in the design and operation enables much improved flexibility (e.g., wider range of acceptable fuel) and efficiency (e.g., higher loading capacities), as compared to spent fuel system designs based on unirradiated fuel without credit for fixed burnable absorbers. These advantages have encouraged burnup credit to be applied in the nuclear criticality safety evaluation of storage, transportation, and disposal systems containing irradiated fuel. The scope of this standard is restricted to burnup credit for commercial light water reactor fuel applications.

Burnup credit requires evaluation of the effect of irradiation on the fuel composition, which increases the *computation* complexity. However, the negative reactivity determined through burnup credit may be used to reduce the *overall* complexity of maintaining criticality safety. Several American National Standards Institute/American Nuclear Society (ANSI/ANS) standards provide guidance that is relevant to burnup credit. This standard supplements the guidance given in those standards and provides requirements and recommendations for handling the unique issues associated with the implementation of burnup credit.

The 2015 revision to this standard was limited to two clarifications in the text of the standard. First, it clarified the combined validation approach given in Sec. 5.2 by adding a second paragraph which introduces a new term, Δk_d, which is an allowance for the bias and uncertainty in bias of the change in k with irradiation. Second, the 2015 revision makes it clear that the burnup uncertainty can be statistically combined with other uncertainties. In addition to these clarifications, an appendix on boiling water reactor pool burnup credit was added.

This standard might reference documents and other standards that have been superseded or withdrawn at the time the standard is applied. A statement has been included in the reference section that provides guidance on the use of references.

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Burnup Credit for LWR Fuel

1 Introduction

The purpose of this standard[1)] is to provide guidance for criticality safety control (by analysis and implementation) that accounts for reactivity effects of fuel burnup in a UO_2-fueled light water reactor (LWR). ANSI/ANS-8.1-2014, "Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors," [1],[2)] provides broad guidance for administrative and technical practices for the prevention of criticality accidents in the handling, storing, processing, and transporting of fissionable material outside reactors. Generalized basic criteria are presented, and some single-unit limits are specified. This standard is intended to provide specific guidance relative to burnup credit and not to replace the criteria of ANSI/ANS-8.1-2014 [1].

It has often been a practice to base the criticality safety control of systems with irradiated fuel on fresh fuel conditions. Accounting for a reduction in k_{eff} due to irradiation is called "burnup credit."

Systems with fuel containing fixed burnable absorbers can increase in reactivity with irradiation. Therefore, credit for the presence of a burnable absorber must account for the change in reactivity with irradiation. This standard considers such credit for irradiated burnable absorbers a subset of burnup credit. This subset of burnup credit is often called "burnable absorber credit" (e.g., gadolinium credit). Other aspects of accounting for fixed neutron absorbers are addressed in ANSI/ANS-8.21-1995 (R2011), "Use of Fixed Neutron Absorbers in Nuclear Facilities Outside Reactors" [2].

Two additional American National Standards provide guidance relevant to validating burnup credit methods. ANSI/ANS-8.24-2007 (R2012), "Validation of Neutron Transport Methods for Nuclear Criticality Safety Calculations," [3] provides criteria for establishing the validation applicability, estimating the biases and uncertainties, and selecting appropriate subcritical margins, both within and beyond the established benchmark applicability. This standard provides additional requirements for establishing benchmarks for burnup credit applications. ANSI/ANS-19.4-1976 (R2000) (withdrawn), "A Guide for Acquisition and Documentation of Reference Power Reactor Physics Measurements for Nuclear Analysis Verification" [4], provides guidance by which reactor physics measurements from power reactors can be evaluated to determine the appropriateness of their use as reference measurements. This standard provides additional requirements for using the data from power reactors for verification and validation of burnup credit parameters and methods.

The body of this standard is broad to cover all LWR (non-mixed oxide) fuel. In order to focus on specific issues related to boiling water reactor (BWR) analysis, an appendix is attached.

2 Scope

This standard provides criteria for accounting for reactivity effects of fuel irradiation and radioactive decay in criticality safety control of storage, transportation, and disposal of commercial LWR UO_2 fuel assemblies.

[1)] The current standard, ANSI/ANS-8.27-2015, is herein referred to as "this standard."
[2)] Numbers in brackets refer to corresponding numbers in Sec. 8, "References."