Session VIII
Safety Analyses

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PSBR Safe Operating Envelope

Dan Hughes, Warren Witzig, Penn State University

INTRODUCTION

The Breazeale Reactor at the Pennsylvania State University, PSBR, updated its Safety Analysis Report (SAR), Technical Specifications (TS), and Environmental Impact Appraisal in the spring of 1997. To acquaint the reactor operators with the new proposed requirements; an aid, a safe operating envelope, was developed to assist in understanding the new technical specifications. It is believed that the resulting safe operating envelope will be a useful teaching tool, promote technical clarity of operations and reduce operator error. This envelope is analogous to similar operating aids in PWR power reactors where operational space is created among variables of power, reactor coolant temperature and pressure. For the PSBR this safe operating envelope incorporates the variables of peak fuel element temperature and the reactor core energy produced in a week.

METHODOLOGY

The maximum hypothetical accident, MHA, for the PSBR is an assumption that a fuel element cladding ruptures in air releasing volatile fission products to the reactor bay and subsequently to the reactor fence line. See Figure 1. This assumption creates conditions far more severe than are actually possible and yet is bounded by regulatory limits. As a source of fission products it is assumed that a 12w/o U-ZRH fuel element is operated in a reactor core position of Maximum Elemental Power Density (MEPD) continuously at a reactor core power of 1 Megawatt and then ruptures. Reactor core configuration is assumed that produces a MEPD of 24.7kW in a fuel element. The fission product inventory in a fuel element can now be calculated from the MEPD, the fission product yield, and the release fraction while accounting for isotope decay. This MEPD produces a maximum fuel temperature of approximately600^{o} C, however, 650^{o} C is used as a bounding fuel temperature to calculate the fission product release fraction through a cladding rupture'.

Experimental data from General Atomic's gives the relationship of fission product release fraction as a function of fuel temperature. Averaging this relationship over fuel volume and fuel temperature profile using a maximum measured fuel temperature of 650^{o} C, results in a fission product release fraction of 3.1 x 10^{-4}. Summing the activity of the volatile isotopes of krypton, xenon, bromine and iodine at the time of clad rupture and applying the release fraction gives the amount of radioactivity released to the reactor bay. Calculating the dilution in the reactor bay and subsequently in the atmosphere to the fence line, gives the activity and the total effective dose equivalent rate. Using the appropriate decay of each isotope radioactivity as a function of time, the integrated TEDE is calculated. See Table I.

Table 1 - TEDE in mSv			
Reactor Bay	**At 1 Minute**	**At 1 Hour**	**At 24 Hours**
Halogens	7.5 (750 mrem)	-	-
Noble Gases	2.7 (270 mrem)	-	-
Total	10.2 (1020 mrem)	-	-
Reactor Fence Line	**At 1 Minute**	**At 1 Hour**	**At 24 Hours**
Halogens	-	0.22 (22 mrem)	0.23 (23 mrem)
Noble Gases	-	0.02 (2 mrem)	0.03 (3 mrem)
Total	-	0.24 (24 mrem)	0.26 (26 mrem)

RESULT

A graphic description of the results in the form of a safe operating envelope is presented in Figure 2. To stay within the bounds of the NMA, the operator must maintain a peak fuel temperature as well as the MEPD below the upper curve and not exceed the maximum reactor core energy produced per week. Currently the PSBR operates at or below 30 MWHR/wk and below a peak fuel temperature of 550^{o} C. Figure 2 illustrates that at low core energy per week, a higher peak fuel temperature is allowed for a given MHA consequence. Thus, while the release fraction of fission products increases, (due to the higher fuel temperature), the fuel element fission product inventory decreases also and so one can stay within the desired NMA bounds. Care must be taken to require that the core configuration and loading are specified and fixed for the safe operating envelope since these determine the relationship between peak measured fuel temperature and MEPD.

REFERENCES

- PSBR core loading #47, PBSR-SAR, chapter IX p.36,4/24/97.
- Foushee and Peters, Summary of TRIGA Fuel Fission Product Release Experiments, GULF-EES-A10801, Sept. 1971

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Experience in Writing Safety Analyses to Meet NUREG 1537

Bob Nelson, Research Reactor Safety Analysis Services

Abstract unavailable at time of print

Overview of UFTR Safety Analysis Report and

Technical Specification Revisions

Bill Vernetson, University of Florida

Abstract

This presentation reviews the revisions submitted for the University of Florida Training Reactor (UFTR) Technical Specifications and Final Safety Analysis Report (FSAR) since submittal of the FSAR in January 1981 and relicensing of the facility effective August 30, 1982 for a period of twenty years. The objectives in seeking Technical Specification revisions are explained along with the interactive role of the licensee and the regulator in maintaining these living documents. Technical Specification as well as FSAR revisions are classified as to the type of change (major or minor, technical or administrative). Lessons learned from these Technical Specification and FSAR changes are then reviewed emphasizing their role in the professional operations of the facility. Conclusions are then drawn as to the importance and role of such changes emphasizing the broad impact they can have in allocation of facility resources and the absolute need to update these living documents on a periodic basis to assure their seminal role in the conduct of operations especially requalification and recertification training and review of facility modifications.

Depletion Calculations for the McClellan Nuclear Radiation Center

Ray Klann, Argonne National Laboratory

Dan Newell, McClellan NRC

Abstract

Depletion calculations have been performed for the McClellan reactor history from January 1990 through August 1996. A database has been generated for continuing use by operations personnel which contains the isotopic inventory for all fuel elements and fuel followed control rods maintained at McClellan.

The calculations are based on the three dimensional diffusion theory code REBUS which is available through the Radiation Safety Information Computational Center (RSICC). Burnup dependent cross sections were developed at zero power temperatures and full power temperatures using the WIMS code (also available through RSICC). WIMS is based on discretized transport theory to calculate the neutron flux as a function of energy and position in a one dimensional cell.

Based on the initial depletion calculations, a method was developed to allow operations personnel to perform depletion calculations and update the database with minimal amount of effort. Depletion estimates and calculations can be performed by simply entering the core loading configuration, the position of the control rods at the start and end of cycle, the reactor power level, the duration of the reactor cycle, and the time since the last reactor cycle. The depletion and buildup of isotopes of interest (heavy metal isotopes, erbium isotopes, and fission product poisons) are calculated for all fuel elements and fuel followed control rods in the MNRC inventory. The reactivity loss from burnup and buildup of fission product poisons and the peak xenon buildup after shutdown are also calculated. The reactivity loss from going from cold zero power to hot full power can also be calculated by using the temperature dependent burnup dependent cross sections. By calculating all of these reactivity effects, operations personnel are able to estimate the total excess reactivity necessary to run the reactor for the given cycle. This method has also been used to estimate the worth of individual control rods.

Using this approach, fuel management and core loading can be optimized such that each individual fuel element and fuel followed control rod is used to its full potential before being replaced with fresh fuel. This fuel management strategy allows a significant cost saving to MNRC by reducing fuel replacement costs and maximizing the usefulness of each element in the inventory.