September 9th, 2010

Mr. Kenneth W. Norris
26926 S. McKinley Woods Rd.
Channahon, IL 60410

Dear Mr. Norris:

On behalf of the U.S. Nuclear Regulatory Commission (NRC), I am responding to your letters, dated April 8, 2010, to Chairman Gregory B. Jaczko and the Advisory Committee on Reactor Safeguards. In the letters, you expressed your general concerns with “Industry Standards in Licensed Operator Training,” and your specific concerns with the NRC’s Generic Fundamentals Examination (GFE) Question Bank. You also reiterated your specific concerns, initially provided to us in May 2006, regarding GFE Question P415. Again, I apologize for our failure to complete our response to the specific concerns that you raised in May 2006.

In general, you presented two assertions with recommendations for our consideration:
1) Industry focus on rule-based operation has resulted in a culture shift that no longer values understanding of the fundamental scientific principles underlying power plant operation; and 2) the NRC GFE Question Bank has become obsolete and is gradually losing relevance to modern nuclear plant operation. We have completed our review and consideration of your concerns.

Regarding the first assertion, that addresses potential industry-wide operator fundamental knowledge understanding deficiencies, you indicate that the Institute of Nuclear Power Operations (INPO) should review and revise both the conduct of the its Accreditation Team Visits (ATVs) as well as the National Academy for Nuclear Training’s (NANT’s) “Guidelines for Initial Training and Qualification of Licensed Operators” in order to “drive plants toward a goal of solid operator understanding of plant operation rather than a minimal government standard for one NRC GFE.” Although the NRC is not directly involved in the conduct of the INPO ATVs or the revision processes for the NANT Guidelines, the NRC does assess the effectiveness of the INPO accreditation process and the industry’s implementation of the systems approach to training (SAT) by observing selected INPO-led ATVs and meetings of the National Nuclear Accrediting Board (NNAB). The NRC observation efforts and numerous reviews of INPO ATV plant evaluation reports have identified no significant industry-wide issues related to your concern regarding operator fundamental knowledge deficiencies and indicate that the training programs accredited by the NNAB continue to be effective, are being properly implemented in accordance with Title 10 of the *Code of Federal Regulations* (10 CFR) Parts 50 and 55, and produce safe and competent operators.

As an example, during a recent ATV observed by the NRC, the team determined that the facility’s training program met all six of the accreditation objectives as defined in ACAD 02-001, Rev. 0, “The Objectives and Criteria for Accreditation of Training in the Nuclear Power Industry.” Embedded in the SAT-based process are generic fundamentals training in reactor theory, thermodynamics, and components which provides a knowledge basis for operators and senior operators through the rest of their training program. The NRC and INPO directly observed the conduct of generic fundamentals training during this ATV. There were no deficiencies noted. The NRC recognizes the importance of this training and appreciates the level of fundamentals knowledge that is required for licensed operators to safely operate nuclear power plants. In addition to the successful completion of the GFE exam license applicants are evaluated against requirements for accredited engineering education and/or experience in the operation of nuclear power plants. The combination of the GFE exam, the background and experience eligibility requirements for licensed operator and senior operator training, and the NRC's site-specific operating and written examinations provide a reasonable assurance that licensed operators are knowledgeable in the fundamental aspects of nuclear plant operation. Detailed information regarding the NRC's role in observing and monitoring operator licensing training programs may be found on the NRC's public website at http://www.nrc.gov/reactors/operator-licensing.html.

Regarding the second assertion, the NRC acknowledges that a small number of GFE bank questions have the potential to become obsolete due to changes in nuclear power plant operations, e.g., fuel cycle management. We also agree that Question P415, and three related questions, are potentially flawed and will be removed from the GFE Pressurized Water Reactor (PWR) Question Bank, either permanently or until appropriately revised. However, since June 1992 there have been a total of 4300 questions used on the PWR GFE examinations with only 68 changes resulting from facility licensee post-examination comments. Thus, in light of this data, we do not agree that NRC's GFE question bank as a whole has become obsolete and is gradually losing relevance with the identification of a few problematic questions.

With respect to your concern that the GFE questions are "losing relevance to modern nuclear plant operation," we note that the GFE questions are designed to be "generic" and not site-specific. In general, we believe evaluation of the detailed site-specific, and often proprietary, information associated with "modern cores," is not appropriate on a fundamental knowledge examination and is more properly tested on the site-specific written examinations and operating tests. In fact, we previously have received feedback from the industry Focus Group (FG) on Operator Licensing Issues that some GFE questions require an inappropriate level of site-specific system and procedural knowledge. In response to the feedback, and after determining that the lower cognitive level (LCL) knowledge and abilities (K/As) listed in the Components and Theory Sections of NUREGs-1122 and -1123 are backed up by other higher cognitive level (HCL) K/As testable on the site-specific written examinations and operating tests, the NRC agreed in September 2002 at a public meeting with the FG to no longer develop HCL GFE questions based on these LCL K/As.

In summary, the NRC maintains that the GFE question banks are relevant for current operations at U.S. nuclear power plants. The vast majority of GFE bank questions address fundamental principles, which are not affected by typical changes in nuclear power plant operations. However, some changes in nuclear power plant operations, e.g., fuel cycle management, have the potential to affect the relevance of individual GFE bank questions. To address this possibility, the NRC GFE program provides opportunities both pre-examination and post-examination for the nuclear industry, as well as members of the general public, to bring these concerns to our attention. The NRC has, and will continue, to address concerns with individual GFE bank questions on a case-by-case basis. Thus, we do not believe that there exists a need for a significant revision to the GFE process or a review of all GFE bank questions. We have, however, carefully considered your comments on specific GFE questions and have enclosed a summary of the staff's review and actions.

Although we disagree with your assertions and conclusions regarding the overall validity of the GFE Examination Bank questions and industry-wide operator fundamental knowledge deficiencies, we will convey your concerns and recommendations without any personally identifiable information to both the industry FG and INPO for their information and consideration.

In addition, the NRC typically conducts one to two public meetings per year with both the FG and INPO. We would welcome your participation in these meetings to further discuss your concerns in this and other related areas germane to operator training issues.

Please find enclosed our response to your specific GFE related question comments. If you have any questions or further comments, please feel free to contact me at (301) 415-3254.

Sincerely,

John J. McHale, Chief **/RA/**
Operator Licensing and Training Branch
Division of Inspection and Regional Support
Office of Nuclear Reactor Regulation

Enclosure:
As stated

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John J. McHale, Chief
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Enclosure:
As stated

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Staff Response to Comments Regarding Specific GFE Questions

Question P415

A nuclear power plant has experienced a loss of coolant accident with degraded emergency core cooling flow. Core voiding is homogeneous and the core void fraction is currently 20 percent.

Which one of the following describes excore source/startup range neutron level indication as homogeneous core voiding increases from 20 percent to 100 percent of the core? (Assume the neutron detectors are located adjacent to the bottom portion of the core.)

A. Decreases continuously.

B. Decreases, then increases.

C. Increases continuously.

D. Increases, then decreases.

Answer: D.

Discussion: An assertion is made that the posted answer for the above question is incorrect. The posted answer is supported by documentation from an authoritative source, although another document from the same source appears to support a different answer.

Post-accident source range detector (SRD) response is described in Westinghouse's Mitigating Core Damage, Revision 9/83, Chapter 9, page 9, which states:

"At moderate to high voiding levels the core K_{eff} decreases and is accompanied by higher leakage due to lower attenuation. Overall this would increase the source range detector response. At very high (i.e., greater than 60 percent) voiding levels the loss of moderation would offset the increased leakage and cause a decrease in SRD response."

The documentation provided in the individual's submittal, identified in the original comment as excerpts from a 1991 Westinghouse Owners Group MCD text, describes the SRD count rate response as "continuously increasing" or "leveling off" beyond 80 percent homogeneous voiding. Thus, the 1991 Westinghouse MCD reference provides partial support for option C.

The documentation provided identifies two external references:

- NSAC/28, National Science Analysis Center, circa 1981
- ANL-81-75, Argonne National Laboratory, October 1981

ANL-81-75 is titled "Neutronic Analysis of the Three Mile Island Unit 2 Ex-Core Detector Response," and presents the results from an analysis of SRD response to core voiding from roughly thirty minutes to three hours following a reactor scram at TMI-2.

Table 1 below contains data from ANL-81-75:

Homogeneous Core Void Effects			
Void Fraction	K_{eff}	Neutron Source Strength 30 minutes after scram (n/sec)	Source Neutron Absorption Probability
0.0	0.920	2.0×10^{11}	1.57×10^{-7}
0.2	0.917	-----	6.34×10^{-7}
0.4	0.896	-----	2.85×10^{-6}
0.7	0.780	-----	3.67×10^{-5}
0.9	0.650	-----	2.46×10^{-4}
1.0	0.313	2.0×10^{9}	1.88×10^{-3}

ANL-81-75 identifies several factors that contribute to the SRD response:

- Photoneutron source strength: This was the primary source of neutrons for the first few hours after the reactor scram at TMI-2. Gamma emissions from decaying fission products interacted with deuterium in the reactor coolant, resulting in the release of high energy neutrons. In a non-voided TMI-2 core, the photoneutron source produced 2.0×10^{11} neutrons/second thirty minutes after a scram. Another important source of neutrons at TMI-2 was the relatively constant installed source which contributed about 2.0×10^{9} neutrons/second.

  Since photoneutrons come from the reactor coolant, the photoneutron source strength decreases roughly linearly as core voiding increases until it is nonexistent at 100 percent voiding. Once the photoneutron source is gone, the installed source becomes dominant, and the source neutron strength will stabilize at about 2.0×10^{9} neutrons/second. The net effect of the loss of the photoneutron source will be a decrease in the core neutron flux by a factor of 1.0×10^{-2}. If the analysis started at three hours after the scram, the initial photoneutron source strength would be lower, and the core neutron flux decrease factor would be closer to 1.0×10^{-1}.

- K_{eff}: This determines how much the source neutron strength is multiplied. Table 1 shows that the shutdown K_{eff} can decrease from 0.92 to 0.313 as homogeneous core voiding increases from 0 to 100 percent. Calculations using these values of K_{eff} show that the core neutron flux will decrease by a factor of about 1.0×10^{-1} from decreasing K_{eff} as core voiding increases from 0 to 100 percent.

- Neutron transmission probability: This determines what fraction of the core neutron flux reaches the SRD. Table 1 shows that at 0 percent core voiding the probability of a core neutron being detected by an SRD is about 2.0×10^{-7} percent. At 100 percent core voiding, the probability is about 2.0×10^{-3} percent. Therefore, the probability of core neutron detection by an SRD will increase by a factor of roughly 1.0×10^{4} as core voiding increases from 0 to 100 percent.

When the negative effects of decreasing photoneutron source strength and decreasing K_{eff} are combined, there is a total core neutron decrease factor of between 1.0×10^{-2} and 1.0×10^{-3} from complete homogeneous core voiding. When the effect of the increased neutron transmission probability is added, the rate of neutron detection by the SRDs is expected to increase by a factor of between 1.0×10^{1} and 1.0×10^{2} from complete homogeneous core voiding. This range is supported by figure 6 (below) from ANL-81-75.

The graph in figure 6 shows a curve that stops at about 90 percent core voiding. ANL-81-75 states that model calculations near 100 percent are not accurate and, therefore, are not plotted. ANL-81-75 goes on to state:

"Even though the neutron source strength is decreasing, the transmission probability (i.e., to the detector) is increasing at a greater rate. The result is a continually increasing count rate."

The figure from NSAC/28 shown in the submitted documentation shows the SRD count rate continuously increasing. This agrees in principle with ANL-81-75. However, lacking the original analysis report, no further comment can be made with regard to the NSAC/28 graph.

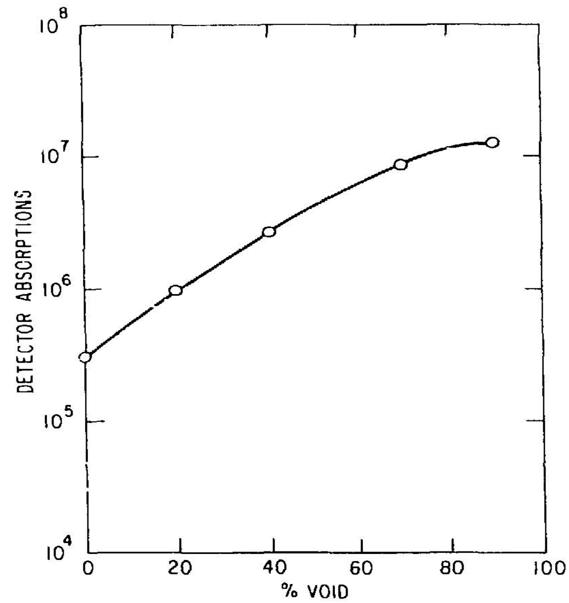


Fig. 6

Detector Absorptions vs.
Homogeneous Void Fraction

It is important to note that ANL-81-75 begins its analysis no sooner than thirty minutes after a scram, when the photoneutron source strength is decreasing at a moderate rate. If the analysis had begun sooner, the photoneutron source strength would have been decreasing at a faster rate, and the SRD response would have been different. If the analysis had begun immediately after a scram, it is possible that the SRD response would have decreased initially due to the high rate of decay of the photoneutron source strength.

There are several reasons why the findings in ANL-81-75 are not directly applicable to P415:

- ANL-81-75 uses the reactor characteristics of TMI-2 in its modeling. Some nuclear power plants do not use installed neutron sources, making the photoneutron source the dominant contributor of source neutrons for days (not just hours) following a scram.

- ANL-81-75 analyzes SRD response from thirty minutes to three hours following a reactor scram. P415 does not state a specific time period for consideration.

- ANL-81-75 converts the negative reactivity from the control rods and burnable poisons to equivalent soluble boron for modeling purposes. When core voiding occurs, much of the soluble boron will be expelled from the core, which will result in a higher than expected value for core K_{eff} from the model.

<u>Summary and Conclusion</u>: Two Westinghouse MCD texts with different publishing dates -- 1983 and 1991 -- differ in their descriptions of excore SRD response to homogeneous core voiding. Each text supports a different answer to GFE question P415.

Conclusion: Presently, a single definitive correct answer for P415 has not been determined. Therefore, P415, and similarly affected questions, will be removed from the GFE question banks.

Question P1312

A nuclear reactor is shut down at 100 cps in the source/startup range when a loss of coolant accident occurs. How will excore source/startup range neutron level indication change as homogeneous core voiding increases from 20 percent to 100 percent in a shutdown reactor?

A. Increases because more neutron leakage occurs and then continues to increase because more neutrons are available for subcritical multiplication.

B. Increases because more neutron leakage occurs and then decreases because fewer neutrons are available for subcritical multiplication.

C. Decreases because less neutron leakage occurs and then increases because more neutrons are available for subcritical multiplication.

D. Decreases because fewer neutrons are available for subcritical multiplication and then increases because more neutron leakage occurs.

Answer: B.

Same discussion and conclusion as Question P415.

Question P1612

A nuclear reactor is shut down at 100 cps in the source/startup range when a loss of coolant accident occurs. Which one of the following describes excore source/startup range count rate indication as homogeneous core voiding increases from 20 to 40 percent?

A. Increases because more neutron leakage is occurring.

B. Decreases because less neutron leakage is occurring.

C. Increases because K_{eff} is increasing.

D. Decreases because K_{eff} is decreasing.

Answer: A.

Discussion: Both the 1983 and 1991 Westinghouse MCD references described in the discussion for SRD Response Issue P415 agree on the response of excore source range detectors from 20 to 40 percent homogeneous core voiding. Therefore, this question is supported technically by both references.

Conclusion: P1612 will remain in the GFE question banks with the added phrase, “Assume that the source neutron flux level remains constant.”

Question P1811

A nuclear reactor is shut down at 100 counts per second in the source range when a loss of coolant accident occurs. How will excore source range neutron level indication change as homogeneous core voiding increases from 80 percent to 100 percent?

A. Decreases because K_{eff} is decreasing.

B. Increases because K_{eff} is increasing.

C. Decreases because a smaller fraction of the core neutron population is leaking out of the core.

D. Increases because a larger fraction of the core neutron population is leaking out of the core.

Answer: A.

Same discussion and conclusion as Question P415. Therefore, P1811 will be removed from the GFE question banks.

Question P2812

A nuclear power plant experienced a loss of coolant accident combined with a loss of emergency coolant injection flow. During the accident, the homogeneous void fraction of the coolant in the core and downcomer reached 100 percent. Then emergency coolant injection flow was restored, which caused a steady reduction in the void fraction as the reactor vessel refilled.

Which one of the following describes the expected trend in excore source/startup range neutron level indication as the homogeneous coolant void fraction decreases from 100 percent to 20 percent in the core and downcomer? (Assume the source/startup range neutron detectors are located adjacent to the bottom one-third of the core.)

A. Increase, then decrease

B. Increase continuously

C. Decrease, then increase

D. Decrease continuously

Answer: A.

Discussion: Although this question was not addressed by the individual's letter, it concerns the same technical issue. P2812 suffers from the same issue as P415.

Conclusion: Presently, a single definitive correct answer for P2812 has not been determined. Therefore, P2812 will be removed from the GFE question banks.

Question P3112

Given:

- The nuclear reactor is shut down.
- The reactor coolant system is at normal operating pressure and temperature.
- The BF_3 source/startup range detectors are properly positioned outside the reactor vessel and adjacent to the lower portion of the core.
- All BF_3 source/startup range detectors are indicating approximately 100 cps.
- A sudden loss of coolant pressure accident occurs that causes bulk boiling and homogeneous core voiding in the reactor vessel.

How and why will source/startup range detector outputs change as homogeneous core voiding increases from 0 percent to 50 percent?

A. Increase, because the detectors will experience a higher rate of neutron interactions due to the axial power distribution shifting toward the lower portion of the core.

B. Increase, because the detectors will experience a higher rate of neutron interactions due to increasing neutron leakage from the core.

C. Decrease, because the detectors will experience a lower rate of neutron interactions due to a decreasing subcritical multiplication neutron level.

D. Decrease, because the detectors will experience a lower rate of gamma interactions due to decreasing reactor coolant attenuation.

Answer: B.

<u>Discussion:</u> Although this question was not challenged by the individual's letter, it concerns the same technical issue. Both the 1983 and 1991 Westinghouse MCD references described in the discussion for SRD Response Issue Question P415 agree on the response of excore source range detectors from 0 to 50 percent homogeneous core voiding. Therefore, this question is supported technically by both references.

<u>Conclusion:</u> P3112 will remain in the GFE question banks with the added phrase to "Assume that the source neutron flux level remains constant."

I/M Plot Issue Question P969

The following data were obtained during a nuclear reactor startup:

Control Rod Units Withdrawn	Source Range Count Rate (cps)
0	20
10	25
15	28
20	33
25	40
30	50

Assuming a uniform differential control rod worth, at what approximate control rod position will criticality occur?

A. 66 to 75 units withdrawn

B. 56 to 65 units withdrawn

C. 46 to 55 units withdrawn

D. 35 to 45 units withdrawn

Answer: C.

Discussion: An assertion is made that 1/M questions should not assume a uniform differential control rod worth. The simplifying assumption of a uniform differential control rod worth enables the applicant to answer the question without actually having to create a 1/M plot, which would require an excessive amount of time and effort for a question valued at one point. This question examines the ultimate goal in producing a 1/M plot -- predicting when the reactor will become critical based on the change in count rates between reactivity additions -- while requiring a reasonable amount of effort. The performance of an actual 1/M plot is better examined as a job performance measure (JPM) on the site-specific portion of the NRC operator licensing examination.

Conclusion: P969 and similar questions will remain in the GFE question banks.

Distractor Issue Question P364

Which three of the following parameters should be closely monitored and controlled during the approach to criticality?

1. Axial flux difference (axial shape index)
2. Reactor startup rate
3. Source range (neutron) count rate
4. Rod position

A. 1, 2, 3

B. 1, 2, 4

C. 1, 3, 4

D. 2, 3, 4

Answer: D.

Discussion: An assertion is made that the question has a flaw that makes it easy to identify the correct answer.

This question was used for the first and only time on the June 1990 PWR GFE. The question had a positive discrimination value and was answered correctly by 99 percent of the applicants. The very high pass rate indicates that the question was a poor discriminator. Because of its low discrimination value and its unusual format, this question has never been reused.

That said, it is important to note that this question was selected at random from the INPO GFE question catalogs and used verbatim in accordance with the NRC's decision to use the INPO catalogs as the principal source of GFE questions during this period. Shortly afterward, the NRC decided to edit questions taken from the INPO catalogs to make them compliant with NRC question writing guidelines. Eventually, the INPO catalogs were no longer used as a source for GFE questions.

Conclusion: P364 will be removed from the GFE question banks.

Distractor Issue Question P1950

Factors that affect the probability of resonance absorption of a neutron by a nucleus include...

A. kinetic energy of the nucleus, kinetic energy of the neutron, and excitation energy of the nucleus.

B. kinetic energy of the neutron, excitation energy of the nucleus, and excitation energy of the neutron.

C. excitation energy of the nucleus, excitation energy of the neutron, and kinetic energy of the nucleus.

D. excitation energy of the neutron, kinetic energy of the nucleus, and kinetic energy of the neutron.

Answer: A.

Discussion: An assertion is made that the question has a flaw that makes it easy to identify the correct answer.

This question was used for the first time on the April 1996 PWR GFE. The question had a positive discrimination value and was answered correctly by only 78 percent of the applicants. These results indicate that the alleged flaw did not make it easy to identify the correct answer.

Conclusion: P1950 will remain in the GFE question banks.

Distractor Issue Question P2647#

A thermal neutron is about to interact with a U-238 nucleus in an operating nuclear reactor core. Which one of the following describes the most likely interaction and the effect on core K_{eff}?

A. The neutron will be scattered, thereby leaving K_{eff} unchanged.

B. The neutron will be absorbed and U-238 will undergo fission, thereby decreasing K_{eff}.

C. The neutron will be absorbed and U-238 will undergo fission, thereby increasing K_{eff}.

D. The neutron will be absorbed and U-238 will undergo radioactive decay to Pu-239, thereby increasing K_{eff}.

Answer: A.

Discussion: An assertion is made that the question has a flaw that makes it easy to identify the correct answer.

This question was used for the first time on the October 1999 PWR GFE. The question had a positive discrimination value and was answered correctly by only 51 percent of the applicants. These results indicate that the alleged flaw did not make it easy to identify the correct answer.

- Note that an editorial modification was made for the March 2010 examination and “U-238” was replaced with “the nucleus” in Answer Choices B, C, and D.

Conclusion: P2647 will remain in the GFE question banks.

Critical Boron Concentration Issue Question P1563

Refer to the graph of critical boron concentration versus burnup for a nuclear reactor core following a refueling outage (See figure below.).

Which one of the following is primarily responsible for the shape of the curve from the middle of core life to the end of core life?

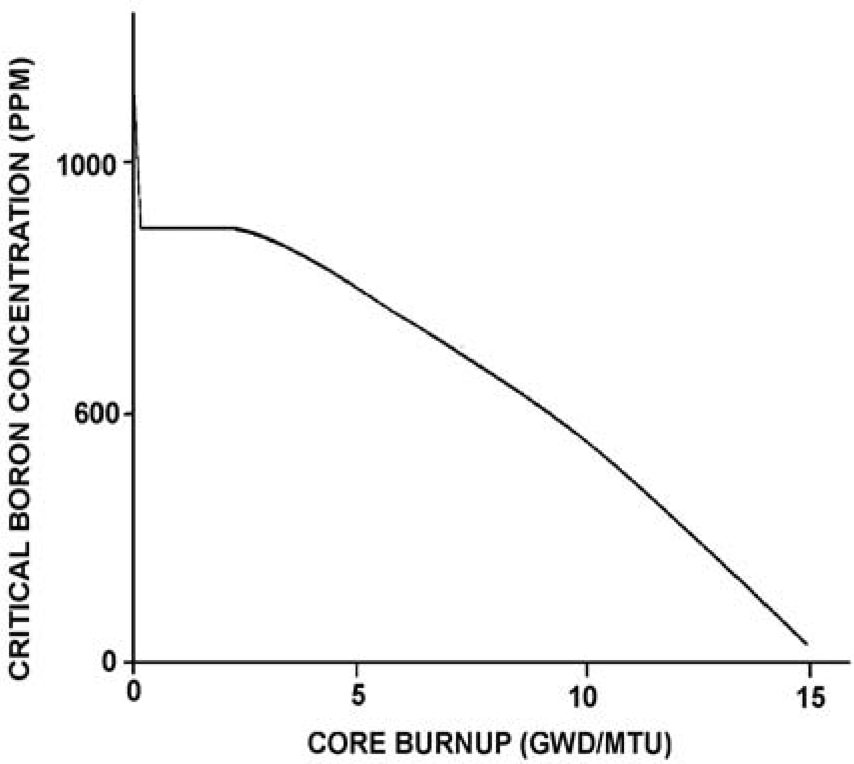
A. Fuel depletion

B. Fission product buildup

C. Burnable poison burnout

D. Conversion of U-238 to Pu-239

Answer: A.



Discussion: An assertion is made that PWR critical boron curves provided in the GFE bank questions represent older core designs (prior to 1990) instead of modern cores (1990 and later). The staff acknowledges that reactor core designs have changed over time and therefore have different critical boron curves over time. However, the overall shape of the curves from the middle of core life to the end of core life has not changed. Furthermore, the GFE is a generic fundamentals examination and is not designed to test site-specific knowledge. The NRC finds that, as written, this question examines the fundamental concepts of critical boron concentration throughout core life and is therefore appropriate for the GFE exam.

Conclusion: P1563 will remain in the GFE question bank.

Critical Boron Concentration Issue Question P1864

Refer to the graph of critical boron concentration versus burnup for a nuclear reactor core during its first fuel cycle (See figure below.). [See Figure provided for P1563 above.]

Which one of the following explains why reactor coolant critical boron concentration becomes relatively constant early in core life?

A. Buildup of fission product poisons is being offset by burnable poison burnout and fuel depletion.

B. Burnable poison burnout and fuel depletion are being offset by buildup of fission product poisons.

C. Fuel depletion is being offset by the buildup of fissionable plutonium and fission product buildup.

D. Fission product poison buildup and fuel depletion are being offset by burnable poison burnout.

Answer: D.

Discussion: An assertion is made that PWR critical boron curves "show a rise in boron concentration shortly after the compensating drop that accounts for initial Xenon-135 buildup." As discussed above, the staff acknowledges that reactor core designs have changed over time and therefore have different critical boron curves over time. However, the overall shape of the curves early in core life are still "relatively constant." The NRC finds that, as written, this question properly examines a fundamental concept of critical boron concentration early in core life that is still valid.

Conclusion: P1864 will remain in the GFE question bank.