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MEMORANDUM TO: M. Wayne Hodges, Deputy Director
Technical Review Directorate
Spent Fuel Project Office, NMSS

FROM: Donald E. Carlson, Sr. Criticality Engineer ***/RA/***
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SUBJECT: TRIP REPORT FROM THE INTERNATIONAL ATOMIC ENERGY AGENCY'S TECHNICAL COMMITTEE MEETING ON BURNUP CREDIT, JULY 10-14, 2000, IN VIENNA, AUSTRIA

This memorandum describes highlights from my participation in the Technical Committee Meeting (TCM) on Burnup Credit in Spent Fuel Management Systems, which was held July 10-14, 2000, at the International Atomic Energy Agency (IAEA) in Vienna, Austria. The TCM proceedings will be published later this year. The TCM agenda is listed as Attachment 1. Attachment 2 - the draft table of worldwide uses of burnup credit - was produced at the meeting to summarize the updated status of burnup credit in each country. My TCM paper and presentation are included as Attachment 3. All papers and presentation materials provided at the meeting are available in my office.

This TCM was the latest in a series of meetings that the IAEA has conducted in recent years to address the worldwide implementation of burnup credit. The TCM was co-chaired by Peter Dyck of the IAEA and Bill Lake of the U.S. Department of Energy (DOE). Countries represented at the meeting included Belgium, Brazil, China (first time participants), the Czech Republic, France, Germany, Hungary, Japan, Lithuania, the Russian Federation, Slovakia, South Africa, Spain, Sweden, Switzerland, Ukraine, United Kingdom, and the United States. Two representatives of the Organization for Economic Cooperation and Development's Nuclear Energy Agency (OECD/NEA) were also present. The U.S. delegation consisted of Donald Carlson, U.S. Nuclear Regulatory Commission (NRC), Spent Fuel Project Office (SFPO); Tom Doering, Electric Power Research Institute; Bill Lake, DOE and co-chairman; Dale Lancaster, consultant; Cecil Parks, Oak Ridge National Laboratory, representing the NRC's Office of Nuclear Regulatory Research (RES); and Dan Thomas, Framatome, representing DOE's Yucca Mountain Project. The TCM chairmen also invited Vanice Perin, NRC/RES, to attend as an observer while on vacation in Vienna.

As shown in the agenda (Attachment 1), the first two-and-a-half days of the TCM featured formal papers presented in six plenary sessions: International Activities, Country Reports, Regulatory Aspects, Calculations and Code Validation, Parameters Affecting Burnup Credit, and Implementation Issues. When the formal plenary presentations were completed on the third day, the participants split into four working groups dedicated to burnup credit as applied to (1) wet storage, (2) transportation, (3) reprocessing, and (4) disposal. I participated in the transportation group, which was chaired by Michaele Brady-Raap of Battelle Pacific Northwest National Laboratory, representing the OECD/NEA. In the plenary session on the final day of

the meeting, the working group chairmen led a panel discussion on the observations, conclusions, and recommendations from each group. All formal papers and presentations, as well as summaries from the working group meetings and panel discussions, will be included in the TCM proceedings.

Mr. Dyck noted at the close of the meeting that this TCM was especially successful due to its departure from the traditional management-level presentations in which each country describes its nuclear power program and why burnup credit is needed. Most of the presentations at this TCM were highly technical and issue-oriented and, together with the follow-up discussions, led to valuable technical insights as well as a clearer identification of shared technical interests and related opportunities for formal and informal collaboration among countries and individuals. For example, the technical presentations and follow-up discussions on France's experiences with burnup credit in transport casks revealed the following important points:

(1) It was noted that (a) the French shipping casks are normally unloaded inside a pool of unborated water at the La Hague reprocessing plant, and (b) the French criticality evaluations have generally assumed moderator exclusion for normal and accident conditions during transport. Cask unloading in borated water or a dry transfer facility is specified only when there has been an accident that could damage the fuel. From these observations, one can conclude that burnup credit for casks has greater risk significance in France than in the United States. For example, a sufficiently gross error in the design, fabrication, analysis, or loading of a French shipping cask could, by itself, lead to a criticality event when the cask is flooded with unborated water prior to unloading at La Hague. This contrasts with the situation in the United States, where a similar gross error could cause a criticality event only when combined with an unlikely accident that floods the cask with unborated water.

(2) In many normal and accident configurations, the basket poisons in French casks do not fully cover the bottom of the active fuel. In some normal cases, 15 cm of active fuel is allowed to overlap the bottom of the poison panels. Even larger overlaps can result from transport accidents or from the omission or incorrect selection of required spacer elements during cask loading. (It was noted that such administrative errors in the use of spacer elements have been reported in France). In determining the worst-case axial configurations of fuel and basket poisons, the French (along with the British and Swedes) are starting to consider the potential axial deformation and shifting of the fuel and basket poisons caused by transportation accidents and drop accidents. The assumed geometry changes qualitatively resemble those considered to-date in SFPO's draft guidance on axial poison coverage, but differ in certain important details (e.g., see next item). It was also noted that the modeling assumptions used in the French analysis method (i.e., uniform axial burnup equal to the average burnup in the top 50 cm of fuel) are not conservative when applied to configurations with incomplete axial poison coverage.

(3) The French are investigating a fuel damage scenario that could significantly increase reactivity near the bottom of the fuel assemblies after a design-basis cask drop or transportation accident. Results of French deceleration/drop tests on fresh fuel assemblies suggest that the bottom end fitting can deform in a way that forces the impacted fuel pins to bow permanently outward. This change in fuel geometry would significantly increase local moderation and, thus, the local reactivity of the

undermoderated fuel-pin lattice. The British and Swedish delegates have been following this issue with the French and suggested that further deceleration/drop testing and analysis should be pursued through international collaboration. I have subsequently proposed that these kinds of accident-damaged fuel geometries be discussed during NRC/RES's upcoming meetings of the PIRT Panel on Burnup Credit (PIRT = Phenomena Identification and Ranking Tables).

(4) It was confirmed that the burnup credit calculations used in France currently ignore the neutron-spectral effects of control rods and other solid absorbers on the rate of plutonium production per burnup increment. As noted below, such nonconservative depletion models can substantially underpredict plutonium production and the resulting reactivity of spent fuel. Implications are especially significant in France, where control rod insertions are routinely used for load following. It was also confirmed that the depletion calculations used for French burnup credit do not employ bias adjustments.

One of the more beneficial discussions at the TCM was centered on analyzing the reactivity effects of axial burnup profiles (i.e., end effects). My presentation for the TCM (see pages 6 and 7 in Attachment 3) noted that some of the largest axial effects occur when the top of the fuel assembly is underburned as a result of partial insertion of control rods at power. As a consequence, two important phenomena tend to increase the local reactivity in such fuel assemblies: (1) the lower burnup at the top of the spent fuel, which has been recognized and extensively studied by the international community; and (2) the increased production of fissile plutonium due to spectral hardening by the insertion of control rods during reactor operation. The increase in k-effective caused by increasing the plutonium production per burnup increment can actually exceed that associated with the reduced local burnup. Nevertheless, only the effects of reduced local burnup have been considered in the axial profile studies done to-date in the U.S. and other countries. As previously noted, the French method for calculating burnup credit currently neglects the increased plutonium production caused by control rods. As a result of the TCM presentations and discussions, the rodded-burnup phenomenon will now receive heightened attention from the international community.

Other worthwhile discussions at the TCM addressed the following areas: isotopic validation for fuels with limited benchmark data (i.e., enrichments >4 percent, burnups >40 GWd/MTU, solid poisons); uncertainties in the analysis of cooling time effects; modeling of burnable absorbers; difficulties in depletion calculations with erbium integral absorbers; needs for information on past and present uses of part-length absorbers, control rods, and burnable poisons; verification measurements for burnup; verification of initial enrichment, cooling time, and absorber-rod histories; examples of errors in cask design, fabrication, analysis, and loading; analysis for misloading events; Boral swelling; unborated water slugs in spent fuel pools; limited burnup credit for boiling-water-reactor fuels; burnup credit for mixed-oxide fuels; effects of axial fuel blankets; effects of mixed loadings and preferential loadings; uncertainties and errors in fission-product assay data; mobility of fission products in fuel; uses of small-sample reactivity measurements in criticality validation; planned experimental programs for isotopic and criticality validation (REBUS, PROTEUS, NERI-SNL, NRC-H.B.Robinson, Valduc, Minerve); uses of reactor restart criticals in validating burnup credit calculations; spent fuel subcriticality measurements for operational verification and computational validation; needs for improved nuclear cross-section evaluations and covariance data; numerical benchmarks for high-worth fixed poisons; 2D and 3D depletion codes and benchmarks; proposed training courses on burnup credit; further development of relevant IAEA advisory materials (e.g.,ST-2); economic,

risk, and regulatory aspects of burnup credit; safety margins versus subcritical margins; approval of methodologies versus specific analyses; and international coordination of burnup credit evaluations for international shipments.

In view of the many valuable insights exchanged at this meeting, I strongly recommend further participation by SFPO technical staff in these and similar international technical forums. I would be glad to discuss this recommendation and/or further details of the TCM presentations, group discussions, and side discussions with whoever is interested.

Attachments:
1. Meeting Agenda
2. Draft Table, " Worldwide Uses of Burnup Credit"
3. Technical Committee Paper on Burnup Credit & Slides

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J. Guttmann

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