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See Proposed Changes to T.S.

SUBJECT: Application for amend to License NPF-74,adding sentence to TS Section 5.3.1 to allow substitution of up to total of 80 fuel rods clad w/advanced zirconium-based alloys other than Zircaloy-4 in two fuel assemblies.Rept withheld.

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Arizona Public Service Company

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WILLIAM F. CONWAY
EXECUTIVE VICE PRESIDENT
NUCLEAR

161-04352-WFC/GAM

December 20, 1991

Docket No. STN 50-530

U. S. Nuclear Regulatory Commission
Attn: Document Control Desk
Mail Station P1-37
Washington, D. C. 20555

References: 1) Letter 161-04192-WFC/GAM, dated October 04, 1991, from W. F. Conway, Arizona Public Service Company to Document Control Desk, U. S. Nuclear Regulatory Commission: "Proposed Technical Specification Change to Section 5.3.1 Design Features of the Reactor Core Fuel Assemblies"

2) Letter dated November 21, 1991, from C. M. Thompson, U. S. Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation, to W. F. Conway, Arizona Public Service Company: "Proposed Technical Specification Change to Section 5.3.1 Design Features of the Reactor Core Fuel Assemblies"

Dear Sirs:

Subject: Palo Verde Nuclear Generating Station (PVNGS)
Unit 3
Proposed Technical Specification Change to Section 5.3.1
Design Features of the Reactor Core Fuel Assemblies
File: 91-056-026; 91-005-419.5

In accordance with 10 CFR 50.90, Arizona Public Service Company (APS) submits herewith a request to amend Facility Operating License NPF-74, for PVNGS Unit 3. The proposed amendment adds a sentence to Unit 3 Technical Specifications, Design Features, Reactor Core Fuel Assemblies, Section 5.3.1, to allow the substitution of up to a total of 80 fuel rods clad with advanced zirconium-based alloys other than Zircaloy-4 in two fuel assemblies for in-reactor performance evaluation purposes during cycles 4, 5 and 6.

With the submittal of this proposed amendment to the Unit 3 Technical Specifications, APS hereby withdraws the proposed amendment to the Unit 1 Technical Specifications (reference 1). Enclosure D contains responses to NRC comments on the PVNGS Unit 1 submittal (reference 2).

A001 1/5

Enclosure A includes:

A. Description of Proposed Technical Specification Amendment Request
B. Purpose of the Technical Specification
C. Need for the Technical Specification Amendment
D. No Significant Hazards Consideration Determination
E. Safety Analysis for the Proposed Technical Specification Amendment Request
F. Environmental Impact Consideration Determination
G. Marked-Up Technical Specification Change Page

Enclosure B includes five copies of a proprietary report entitled Safety Evaluation Report for Use of Advanced Zirconium Based Cladding Materials in PVNGS Unit 3 Batch F Demonstration Fuel Assemblies, containing specific descriptions of the elemental composition of eight advanced alloys and testing results. In accordance with 10 CFR 2.790, ABB Combustion Engineering, the owner of this report, requests that this proprietary report be withheld in whole from public disclosure on the grounds that the specific alloy information in the report is considered to be confidential commercial information. The affidavit required by 10 CFR 2.790 (b)(1) to support this request for confidentiality is also included in Enclosure B. Non-proprietary information from this proprietary report was used to prepare the Safety Analysis in Enclosure A.

The Safety Analysis in Enclosure A provides a basis for the conclusion that 10 CFR 50.46 criteria will be satisfied for the advanced alloys because the behavior of these alloys is expected to be essentially the same as that of conventional Zircaloy-4. However, an application for an exemption to 10 CFR 50.46 is included in Enclosure C, along with an exemption request for 10 CFR 50, Appendix K, and 10 CFR 50.44.

APS intends to install the two fuel assemblies containing advanced alloy clad fuel rods during the next Unit 3 refueling outage, scheduled to begin in September, 1992. The vendor does not intend to fabricate these fuel assemblies prior to NRC approval of this request. Therefore, APS is requesting NRC approval by June 1, 1992. APS is available to meet with the NRC Staff, if necessary, to support the review and approval of this amendment.

Pursuant to 10 CFR 50.91(b)(1), a copy of the proposed amendment is being forwarded to the Arizona Radiation Regulatory Agency.

If you should have any questions, please contact Michael E. Powell of my staff at (602) 340-4981.

Sincerely,

WFC/GAM/pmm

Enclosures

cc: J. B. Martin (all w/o Enclosure B)
D. H. Coe
C. M. Trammell
A. C. Gehr
A. H. Gutterman
W. A. Wright

STATE OF ARIZONA)
) ss.
COUNTY OF MARICOPA)

I, W. F. Conway, represent that I am Executive Vice President - Nuclear, that the foregoing document has been signed by me on behalf of Arizona Public Service Company with full authority to do so, that I have read such document and know its contents, and that to the best of my knowledge and belief, the statements made therein are true and correct.

W F Conway

W. F. Conway

Sworn To Before Me This 20 Day Of December, 1991.

Linda B. Keil

Notary Public

My Commission Expires

June 5, 1992

161-04532-WFC/GAM
December 20, 1991

9201020059

ENCLOSURE A

A. DESCRIPTION OF PROPOSED TECHNICAL SPECIFICATION AMENDMENT REQUEST

The Palo Verde Nuclear Generating Station (PVNGS) Unit 3 Technical Specifications, Design Features, Reactor Core Fuel Assemblies, Section 5.3.1, states the following:

> The reactor core shall contain 241 fuel assemblies with each fuel assembly containing 236 fuel rods or burnable poison rods clad with Zircaloy-4 except that limited substitution of fuel rods by filler rods consisting of Zircaloy-4 or stainless steel or by vacancies may be made if justified by a cycle specific reload analysis.

In order to allow the use of two fuel assemblies containing a total of up to 80 fuel rods clad with any of the eight advanced zirconium-based alloys as described in Table E-1, consisting of chemical compositions other than conventional Zircaloy-4, the following revision adding a sentence to Technical Specifications, Design Features Section 5.3.1 is proposed:

> The reactor core shall contain 241 fuel assemblies with each fuel assembly containing 236 fuel rods or burnable poison rods clad with Zircaloy-4 except that limited substitution of fuel rods by filler rods consisting of Zircaloy-4 or stainless steel or by vacancies may be made if justified by a cycle specific reload analysis. Substitution of up to a total of 80 fuel rods clad with zirconium-based alloys other than Zircaloy-4 may also be made in two fuel assemblies for in-reactor performance evaluation purposes, during cycles 4, 5 and 6.

B. PURPOSE OF THE TECHNICAL SPECIFICATION

Paragraph 5.3.1 of the Design Features section of the Technical Specifications describes features of the reactor core, including the alloy used to clad the fuel rods, which, if altered or modified without proper evaluation, may have a significant effect on safety. Specifically, the fuel rods are described to be clad with Zircaloy-4.

Zircaloy-4 is the specified fuel rod cladding alloy due to its proven chemical, mechanical, and thermal properties, and its behavior under Loss of Coolant Accident (LOCA) conditions.

C. NEED FOR THE TECHNICAL SPECIFICATION AMENDMENT

This Technical Specification amendment will allow the use of two fuel assemblies containing a total of up to 80 fuel rods clad with advanced zirconium-based alloys in the PVNGS Unit 3 reactor core beginning with Cycle 4, and continuing during cycles 5 and 6. The purpose is to examine the behavior of the eight alloys shown in Table E-1 under operating PWR conditions. The advanced cladding alloys, which are zirconium-tin alloys, like Zircaloy-4 but with variations in other alloying elements, have demonstrated improved corrosion resistance properties during extensive ex-reactor autoclave corrosion tests. These alloys are expected to show improved corrosion resistance compared to Zircaloy-4 under PWR operating conditions, while providing comparable mechanical and thermal properties and performance under LOCA conditions.

This advanced alloy clad demonstration program is expected to lead to the production of fuel rods that can provide improved performance margins and greater operational flexibility.

D. NO SIGNIFICANT HAZARDS CONSIDERATION DETERMINATION

The Commission has provided standards for determining whether a significant hazards consideration exists as stated in 10 CFR 50.92(c). A proposed amendment to an operating license for a facility involves a no significant hazards consideration if operation of the facility in accordance with a proposed amendment would not (1) involve a significant increase in the probability or consequences of an accident previously evaluated, (2) create the possibility of a new or different kind of accident from any accident previously evaluated, or (3) involve a significant reduction in a margin of safety.

APS has concluded that the activities associated with this amendment request meet the no significant hazards consideration standards of 10 CFR 50.92(c). A discussion of each of the above three significant hazards consideration standards is provided below.

Standard 1 -- Would not involve a significant increase in the probability or consequences of an accident previously evaluated.

The proposed amendment would allow for limited substitution of Zircaloy-4 clad fuel rods in the reactor core with fuel rods clad with advanced zirconium-based alloys. Specifically, the amendment allows for the substitution of up to 80 fuel rods with rods clad with zirconium-based alloys other than Zircaloy-4 in two fuel assemblies. The reactor core is composed of 241 fuel assemblies, each containing 236 fuel or burnable poison rods. Thus, less than 0.2% of the total number of rods in the core will be clad with the advanced zirconium-based alloys.

The fuel rods clad with the advanced zirconium-based alloys will be identical in design and dimension to the fuel rods clad with conventional Zircaloy-4. The advanced cladding materials used in the demonstration fuel assemblies were chosen based on the improved corrosion resistance exhibited in ex-reactor autoclave corrosion tests in both high-temperature water and steam environments. Fuel rods clad with similar types of advanced zirconium-based alloys have been successfully irradiated in high-temperature PWRs in Europe.

The mechanical properties of the clad made from the advanced zirconium-based alloys are comparable to Zircaloy-4. Specifically, the cladding material made from the advanced zirconium-based alloys meet all the mechanical requirements of the conventional Zircaloy-4 procurement specifications. Thus, the cladding and structural integrity of the fuel rods and fuel assemblies that have the advanced zirconium-based alloys will be maintained.

Additionally, the behavior of the new cladding material under normal operation, anticipated operational occurrences, and postulated accidents (including LOCA) was considered. Due to the similarity of the physical properties of the advanced zirconium-based alloys to Zircaloy-4, as discussed above, the advanced alloys are expected to result in clad and fuel performance similar to Zircaloy-4, such that the reload design and safety analysis limits will not be changed. Specifically, the 10 CFR 50.46 LOCA acceptance criteria will be satisfied for the advanced zirconium-based cladding.

Therefore, based on the similarity of the design and the expected performance of the fuel rods clad with the advanced zirconium-based alloys, the proposed amendment will not significantly increase the probability or the consequences of an accident previously evaluated.

Standard 2 -- Would not create the possibility of a new or different kind of accident from any accident previously evaluated.

The limited substitution of fuel rods clad with advanced zirconium-based alloys other than Zircaloy-4 will not result in any alteration to plant equipment or procedures which would introduce any new or unique operational modes or accident initiators. Additionally, as noted in the response to Standard 1 above, the design and performance criteria for fuel clad will be met.

Thus, it is concluded that the limited substitution of fuel rods clad with zirconium-based alloys other than Zircaloy-4 will not create the possibility of a new or different kind of accident from any accident previously evaluated.

Standard 3 -- Would not involve a significant reduction in a margin of safety.

As noted in the response to Standard 1 above, the design and performance of the fuel rods clad with advanced zirconium-based alloys are expected to be within those observed for fuel rods clad with conventional Zircaloy-4. This expectation is based on autoclave and other material testing results and the material similarities. Additionally, the two fuel assemblies containing the fuel rods clad with the advanced zirconium-based alloys will be positioned in the core such that the rods will not be subjected to the highest core power density identified in the Unit 3, Cycle 4 reload analysis. Thus, due to this placement scheme and the similarity in performance to Zircaloy-4, the fuel rods clad with the advanced zirconium-based alloys will not involve a significant reduction in a margin of safety.

Furthermore, the two demonstration fuel assemblies with the fuel rods clad with the advanced zirconium-based alloys will be visually examined and the thickness of the oxide layer will be measured at the end of each operating cycle to confirm satisfactory performance. In the unlikely event that unsatisfactory performance is indicated, the two demonstration fuel assemblies feature reconstitutable upper end fittings to allow for reconstitution of the fuel assembly.

As a result of the factors presented above, the limited substitution of fuel rods clad with zirconium-based alloys other than Zircaloy-4 will not significantly reduce a margin of safety.

E. SAFETY ANALYSIS FOR THE PROPOSED TECHNICAL SPECIFICATION AMENDMENT REQUEST

Introduction

The two fuel assemblies selected for this fuel rod cladding corrosion demonstration program will include a total of 80 fuel rods clad with any of the eight advanced zirconium-based alloys as described in Table E-1 with chemical composition other than conventional Zircaloy-4. The eight alloys selected are zirconium-tin alloys like Zircaloy-4, but with variations in other alloying elements. Table E-1 shows the distribution of fuel rods using the advanced, zirconium-based alloys in the two demonstration assemblies. The fuel rods containing the special cladding alloys are identical in design and dimension to the other fuel rods in the core. These rods will contain UO_2 fuel pellets with enrichments up to 4.05 weight percent, the same as the Zircaloy-4 clad fuel rods in the host assemblies. Due to the similarity of the physical properties of the advanced zirconium-based alloys to Zircaloy-4, the advanced alloys are expected to result in clad and fuel performance similar to Zircaloy-4, such that the reload design and safety analysis limits will not be changed. These assemblies will be positioned in the core such that they will experience sufficient burnup and power density to build a significant oxide layer, but will not be subject to the highest core power density identified in the Unit 3, Cycle 4 reload analysis. In addition, most of the fuel rods fabricated with the advanced cladding alloys are located on the periphery of the two demonstration assemblies. Visual examinations and eddy current oxide thickness measurements will be conducted at the end of each operating cycle to detect any abnormal behavior. The reconstitutable upper end fitting feature incorporated in the fuel assemblies will provide access to the fuel rods for reconstitution in the event that unacceptable performance is identified.

This safety analysis addresses the chemical and mechanical properties of the advanced alloys, as well as their irradiation behavior and other material properties, and discusses the behavior of the advanced alloy cladding under LOCA and non-LOCA conditions. The predicted chemical, mechanical, and material properties of the advanced alloys fall within the range of the properties of the approved Zircaloy-4 cladding under all anticipated operating conditions, including those considered in the safety analysis. On this basis, it is concluded that the fuel rod design bases currently used for the design and analysis of the standard Zircaloy-4 clad rods are also applicable to the fuel rods clad with the advanced alloys to be included in the two PVNGS Unit 3 demonstration assemblies.

Chemical and Mechanical Properties

The chemical compositions of Alloys 1, 2, 3, and 8 are essentially the same as that of Zircaloy-4 with minor deviations in composition for one element. Alloys 4, 5, 6, and 7 contain lower tin concentrations than normally used in Zircaloy-4. Further details of the compositions are given in Reference 1. The alloys were chosen on the basis of improved corrosion resistance properties demonstrated during extensive autoclave corrosion testing in 360°C water and 400°C steam (References 1 and 2).

Although the compositions of the cladding variants selected for irradiation in the two assemblies differ from the composition of Zircaloy-4, the mechanical properties in the as-fabricated state for all the variants meet the requirements that are specified for Zircaloy-4 both at room and elevated temperatures. The

mechanical properties of the as-fabricated fuel rod tubes were measured to assure compliance with the minimum strength and ductility properties of Zircaloy-4. Two steps were taken to achieve adequate strength in the as-fabricated state. One was the minor addition of solid solution alloying elements and the other was the adjustment of the final stress relief annealing temperature. The solid solution strengthener addition was particularly needed in alloys containing lower tin concentrations since a reduction in tin content is accompanied by a reduction in strength.

The advanced alloys will be evaluated under existing operating PWR conditions, therefore the reactor coolant chemistry will not require departure from current chemistry specifications. In addition, because of the material similarity of the advanced alloys to Zircaloy-4, and the small percentage of rods clad with the advanced alloys, the reactor coolant chemistry is not expected to be affected by the use of these alloys.

Niobium was chosen as a solid solution strengthener in some of the alloys since niobium addition has been shown to improve the overall in-reactor performance of zirconium-based alloys (Reference 3). The addition of niobium has also been shown to increase creep resistance of the cladding at PWR operating temperature (Reference 4). Based on in-reactor creep measurements, it was concluded that dissolved niobium (up to ~0.5 wt%) is twice as effective as tin in reducing creep under irradiation.

<u>Irradiation Behavior</u>

Alloys similar in composition to Alloys 4, 5, 6, and 7 have been successfully irradiated in two high-temperature PWRs in Europe, Goesgen and Grohnde, to extended burnups up to 60 GWd/MTU (Reference 4). Fuel rods clad with Alloy 8 have also completed four cycles of irradiation in Ringhals-3 to rod average burnups in excess of 43 GWd/MTU. With respect to aggressiveness to cladding corrosion, Ringhals-3 also belongs to the high-temperature class of PWRs.

For Alloys 1, 2, and 3, all alloying elements except one are within the range for conventional Zircaloy-4. Higher level addition of this particular element of interest beyond the upper limit specified for Zircaloy-4 has shown superior corrosion resistance in high temperature water and steam compared to Zircaloy-4, without any degradation in mechanical properties. Therefore, the in-reactor performance for these alloys is expected to be equal to or superior to that of Zircaloy-4.

<u>Other Material Properties</u>

All the other material properties of the advanced alloys relevant to the plant design bases are predicted to be essentially the same as those of Zircaloy-4. This is a direct result of adjustment in the levels of different alloying elements and appropriate changes in the final stress relief annealing temperature. All materials listed in Table E-1 have been certified to satisfy the requirements of the current ABB/CENP Zircaloy-4 cladding specification. The following properties of the advanced alloys are similar to Zircaloy-4: room and elevated temperature yield strength, tensile strength and ductility, and surface roughness. In addition, the modulus of elasticity, hardness, and in-reactor creep rate for the advanced alloys are expected to be essentially the same as that of Zircaloy-4.

The total amount of alloying elements added to zirconium in each of the alloys listed in Table E-1 is very similar to that of Zircaloy-4. The thermal conductivity of the advanced alloys is therefore expected be within the range observed for Zircaloy-4.

Cladding Behavior Under LOCA Conditions

The behavior of the new cladding materials under LOCA transient conditions was evaluated. The two cladding material properties which affect fuel rod performance during the LOCA transient are high-temperature oxidation and deformation under transient conditions (ballooning). Most of the high temperature oxidation occurs in the ß-phase since the diffusion coefficient for oxygen in ß-phase of zirconium is significantly greater than that in α-phase zirconium. Transient deformation (ballooning), on the other hand, mostly occurs in the high-temperature α-phase prior to rupture. The following discussion presents a comparison between the expected behavior of the alloys listed in Table E-1 and that of Zircaloy-4.

For Alloys 1, 2, 3, and 8 which are essentially Zircaloy-4 variants with minor compositional variations in elements X or Y, both the high-temperature oxidation behavior and ballooning strain behavior are not expected to be different from those of Zircaloy-4. The similarity in the measured properties of these alloys to that of Zircaloy-4 indicates that such minor compositional variations will not change the LOCA transient response. Therefore, LOCA models approved for Zircaloy-4 are considered applicable to these alloys. The high temperature oxidation and ballooning behavior of the remaining alloys are discussed below.

The extent of ballooning during a LOCA transient depends on the temperature at which maximum stress (and therefore, rupture) is experienced by the cladding. For the majority of the LOCA-type transients, cladding rupture is predicted to occur in the high-temperature α-phase region around 700°C. The relationship of this temperature to the α/(α+ß) phase transformation boundary temperature is important since the extent of the superplasticity elongation peak, which affects the potential for ballooning, depends on the presence of the ß-phase as well as the extent of oxidation during deformation as described below. There is a superplasticity elongation peak near the α/(α+ß) boundary in Zircaloy-4 (Reference 5). The magnitude of this peak depends on the extent of oxidation of the material prior to rupture. A higher rate of oxidation near the α/(α+ß) phase boundary region will decrease the magnitude of this elongation peak.

Among the different alloying elements added to the advanced cladding alloys listed in Table E-1, tin, oxygen, and niobium have significant solubility in α-zirconium. Tin and oxygen are α-phase stabilizers and niobium is a ß-phase stabilizer. Iron and chromium have limited solubility in α-phase and both the elements are ß-stabilizers. As a result of these considerations, changes in the levels of different alloying elements will change the α/(α+ß) phase boundary temperature. However, the magnitude of this change from the α/(α+ß) phase boundary temperature of Zircaloy-4 is estimated to be small due to the following factors: (1) the deviations in composition from Zircaloy-4 are small; (2) changes in the phase boundary temperature per unit of change in concentration for most of the elements of interest are small, and (3) the changes caused by different elements often offset each other.

In addition, the ballooning behavior is not significantly affected by small shifts in the phase boundary temperatures of zirconium alloys because of the compensating effect of oxidation rate changes. For example, a decrease in tin level, accompanied by increases in iron and chromium levels and addition of niobium is expected to lower the $\alpha/(\alpha+\beta)$ transition temperature. This will affect both the oxidation rate in the high-temperature α-phase region and the ballooning behavior. Since oxygen diffusion in the ß-phase is significantly faster than that in the α-phase, a lowering of the $\alpha/(\alpha+\beta)$ interphase temperature tends to increase the oxidation rate at the temperature of interest because of the proximity to the $\alpha/(\alpha+\beta)$ phase boundary with respect to conventional Zircaloy-4. With the lowering of the $\alpha/(\alpha+\beta)$ interphase temperature, the superplastic elongation peak is also expected to shift to lower temperatures. However, the increase in the elongation due to the shift of the superplasticity peak will be countered by the decrease in deformation due to the higher extent of oxidation. The net effect is expected to be no significant change in the ballooning behavior compared to Zircaloy-4. The minor change in the oxidation rate near the $\alpha/(\alpha+\beta)$ phase boundary is expected to have an insignificant effect on the total extent of oxidation (which is mainly controlled by the extent of oxidation in the ß-phase). The above discussion suggests that small changes in the $\alpha/(\alpha+\beta)$ phase boundary temperature that may result from the minor compositional changes introduced into the advanced cladding alloys will cause inconsequential changes in the fuel rod response to LOCA transients.

The extent of the total oxidation during the LOCA transient includes the oxidation prior to cladding rupture and oxidation occurring after rupture. Since the latter part occurs mainly in the ß-phase region where the oxygen diffusion coefficient is high, it contributes a major fraction to the total oxidation. Therefore oxidation in the ß-phase controls the extent of oxidation of the cladding during the LOCA transient. Based on the comparison of oxidation of Zircaloy-4 and zirconium-2.5 wt% niobium alloys described below, it is concluded that the niobium-containing alloys described in Table E-1 will show oxidation rates similar to that of Zircaloy-4 in this high temperature region (up to ~ 1200°C). A comparison of the high temperature (over the temperature range 1000 to 1850°C) oxidation of zirconium-2.5 wt% niobium alloy with that of Zircaloy-4 reveals that the oxidation rates of these materials are comparable and that the Baker-Just correlation conservatively overpredicts the oxidation of both types of materials (Reference 6). The Baker-Just correlation is used by the NRC to estimate the extent of high-temperature oxidation of fuel cladding during the high-temperature transients. The composition change from Zircaloy-4 to Zr-2.5% Nb is significantly greater than the niobium containing alloys included in Table E-1. It is therefore concluded that the Baker-Just correlation will overpredict the oxidation behavior of zirconium alloys containing niobium.

The ß-phase oxidation resistance of the other alloys is expected to be as good as or better than that of Zircaloy-4. It is expected that the alloying element levels adjusted to improve the corrosion resistance of the α-phase of these alloys with respect to the α-phase of Zircaloy-4 will result in an improvement of the corrosion resistance of the ß-phase of these alloys as well. It is therefore concluded that the ß-phase oxidation rate of all the alloys listed in Table E-1 will be comparable to or lower than that of Zircaloy-4 and that the Baker-Just correlation will overpredict the ß-phase oxidation of all the alloys listed in Table E-1.

Summarizing, the behavior of the alloys to be used in the PVNGS Unit 3 demonstration assemblies is expected to be essentially the same as that of conventional Zircaloy-4 under all conditions experienced during both normal operation and under the conditions existing during the LOCA transient. Therefore, the 10 CFR 50.46 criteria will be satisfied for the advanced alloys.

Cladding Behavior Under Non-LOCA Conditions

Consideration was also given to the behavior of the new cladding materials under non-LOCA conditions. These conditions include normal steady state operation, normal transients, anticipated operational occurrences, and postulated accidents other than LOCA.

As discussed previously, material properties and characteristics of the advanced alloys at the clad operating temperatures for non-LOCA conditions are expected to be similar to those of Zircaloy-4. Therefore, the properties which could impact non-LOCA conditions will be essentially the same as the current Zircaloy-4 properties used in the licensing analyses. Irradiation growth of fuel rods is also not expected to change significantly from Zircaloy-4. Irradiation growth is attributed to stress-free growth of the cladding, and pellet-cladding mechanical interaction. Since none of the important cladding properties which affect the above components of growth are expected to change appreciably from Zircaloy-4, no adverse change in irradiation growth behavior is anticipated.

The range of clad operating temperatures used for the design and licensing analyses for the non-LOCA conditions is quite small compared to the range that is covered for LOCA analyses. For normal operation and anticipated operational occurrences, the probability of fuel failure is exceedingly low because the Departure from Nuclear Boiling (DNB) Specified Acceptable Fuel Design Limit (SAFDL) must be satisfied. The DNB SAFDL is that there shall be a 95% probability at a 95% confidence level that the limiting fuel rod in the core does not experience DNB. Clad surface temperatures during nucleate boiling (no DNB) can only be a few degrees above the coolant saturation temperature. Furthermore, the heat fluxes must be below the critical heat flux at which DNB would occur. Therefore, the inside clad temperature will be less than one hundred degrees above the outside temperature. At these relatively low temperatures no phase change in the zirconium alloy cladding is expected, thus further assuring that all important material properties will be similar to Zircaloy-4. Small differences in the creep rates could influence the time for the clad to creep down on the fuel pellet, but this would have little effect on the bounding values of maximum and minimum gap conductance that are used in the transient and safety analyses.

For the postulated non-LOCA accidents, the event that separates failed rods from non-failed rods is DNB. The critical heat flux for DNB should not be affected by small differences in cladding composition, except as these differences could affect subchannel geometries as in fuel rod bow. Since the properties that are expected to influence fuel rod bow are similar to Zircaloy-4, there should be little change in rod bow. Consequently, the number of fuel failures predicted for the non-LOCA accidents would be substantially unchanged even if a large region were to be comprised of one or more of the proposed cladding variants.

Even if all rods were assumed to fail, the contribution to the total fuel failure for any accident would be negligibly small since these rods comprise less than 0.2% of the total number of rods in the core.

Based on the above considerations, cladding behavior under non-LOCA conditions is expected to remain essentially unchanged as a result of introducing a small number of cladding variants into the PVNGS Unit 3 Cycle 4 core.

Evaluation Conclusions

The preceding discussions have shown that the predicted chemical, mechanical, and material properties of the advanced alloys fall within the range of the properties of the approved Zircaloy-4 cladding under all anticipated operating conditions, including those considered in the safety analysis. On this basis, it is concluded that the fuel rod design bases currently used for the design and analysis of the standard Zircaloy-4 clad rods are also applicable to the fuel rods clad with the advanced alloys to be included in the two PVNGS Unit 3 demonstration assemblies. Furthermore, fuel rods clad with the advanced materials will be placed in specific core locations where they are not subject to the highest core power density. Thus, the nominal fuel performance characteristics of the standard Zircaloy-4 clad fuel are applicable to the rods clad with advanced cladding variants. Since the current design bases are applicable to the advanced cladding variants and the expected operating conditions are within those assumed for the standard clad rods currently licensed for PVNGS Unit 3, it is concluded that the licensing basis for PVNGS Unit 3 will not be challenged by incorporating a limited number of fuel rods using advanced cladding alloys.

References:

1. ABB-CE Combustion Engineering Nuclear Power, "Safety Evaluation Report for use of Advanced zirconium-based Cladding Materials in PVNGS Unit 1 Batch F Demonstration Fuel Assemblies", Proprietary Report, CEN-411-(V)-P, Revision 2-P, December 1991.

2. T. Isobe and Y. Matsuo, accepted for publication in ASTM STP 1132, to be published in 1991.

3. A. M. Garde, Ductile Irradiated Zirconium Alloy, US Patent No. 4,879,093, issue date November 7, 1989.

4. H. P. Fuchs, F. Garzarolli, H. G. Weidinger, R. P. Bodmer, G. Meier, O. A. Besch and R. Lisdat, ANS-ENS International Topical Meeting on LWR Fuel Performance, Avignon, France, April 1991, pp. 682-690.

5. A. M. Garde, H. M. Chung and T. F. Kassner, Acta Met. Vol. 26, 1978, pp. 153-166.

6. V. F. Urbanic, ASTM STP 633, 1977, pp 168-181.

F. ENVIRONMENTAL IMPACT CONSIDERATION DETERMINATION

The proposed amendment would allow the substitution of up to 80 fuel rods clad with zirconium-based alloys other than Zircaloy-4 in two fuel assemblies in the reactor core. The reactor core is composed of 241 fuel assemblies, each containing 236 fuel or burnable poison rods. Thus, less than 0.2% of the total number of rods in the core will be clad with the advanced zirconium-based alloys.

APS has determined that the proposed amendment involves no change in the amount or type of any effluent that may be released offsite, and that there is no increase in individual or cumulative occupational radiation exposure. As such, operation of PVNGS Unit 3 in accordance with the proposed amendment does not involve an unreviewed environmental safety question.

G. MARKED-UP TECHNICAL SPECIFICATION CHANGE PAGE

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