



UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

March 4, 2020

Mrs. Maria L. Lacal
Executive Vice President/
Chief Nuclear Officer
Mail Station 7602
Arizona Public Service Company
P.O. Box 52034
Phoenix, AZ 85072-2034

SUBJECT: PALO VERDE NUCLEAR GENERATING STATION, UNITS 1, 2, AND 3 –
EXEMPTION FROM THE REQUIREMENTS OF 10 CFR PART 50,
SECTION 50.46 AND APPENDIX K TO 10 CFR PART 50 FOR USE OF
FRAMATOME M5® ALLOY CLADDING (EPID L-2018-LLE-0010)

Dear Mrs. Lacal:

The U.S. Nuclear Regulatory Commission (NRC) has approved the enclosed exemption from specific requirements of Title 10 of the *Code of Federal Regulations* (10 CFR) Section 50.46, "Acceptance criteria for emergency core cooling systems [ECCS] for light-water nuclear power reactors," and 10 CFR Part 50, Appendix K, "ECCS Evaluation Models," for Palo Verde Nuclear Generating Station, Units 1, 2, and 3 (Palo Verde). This action is in response to Arizona Public Service Company's (APS's or the licensee's) application dated July 6, 2018 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML18187A417), as supplemented by letters dated October 18, 2018; March 1, 2019; May 17, 2019; October 4, 2019; November 26, 2019; and December 19, 2019 (ADAMS Accession Nos. ML18296A466, ML19060A298, ML19137A118, ML19277J457, ML19331A361, and ML19353C038, respectively), that requested exemption from the above regulations to use Framatome M5® alloy as a fuel rod cladding material.

The proposed request relates to the specific fuel cladding materials expressly subject to the above regulations, namely Framatome M5® alloy. In particular, APS has requested an exemption for Palo Verde to allow application of 10 CFR 50.46 and 10 CFR Part 50, Appendix K to fuel clad with a different material, namely Framatome M5® alloy. Concurrently, the licensee has requested a license amendment to allow transition to Framatome Advanced Combustion Engineering 16x16 High Thermal Performance fuel design with M5® as a fuel rod cladding material and gadolinia as a burnable absorber. The NRC staff's review of the fuel transition license amendments has been completed and is documented in a separate safety evaluation (ADAMS Accession No. ML20031C947).

The exemption is being forwarded for publication to the Office of the Federal Register.

If you have any questions, please contact me at 301-415-1564 or via e-mail at Siva.Lingam@nrc.gov.

Sincerely,

/RA/

Siva P. Lingam, Project Manager
Plant Licensing Branch IV
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket Nos. STN 50-528, STN 50-529,
and STN 50-530

Enclosures:

1. Exemption
2. Safety Evaluation

cc: Listserv

ENCLOSURE 1

EXEMPTION FOR USE OF FRAMATOME M5® ALLOY CLADDING

ARIZONA PUBLIC SERVICE COMPANY

PALO VERDE NUCLEAR GENERATING STATION, UNITS 1, 2, AND 3

DOCKET NOS. STN 50-528, STN 50-529, AND STN 50-530

NUCLEAR REGULATORY COMMISSION

Docket Nos. STN 50-528, STN 50-529, and STN 50-530

Arizona Public Service Company

Palo Verde Nuclear Generating Station, Units 1, 2, and 3

Exemption

I. Background

Arizona Public Service Company (APS, the licensee) is the holder of Renewed Facility Operating License Nos. NPF-41, NPF-51, and NPF-74, which authorizes operation of Palo Verde Nuclear Generating Station, Units 1, 2, and 3 (Palo Verde), respectively. The license provides, among other things, that the facility is subject to all rules, regulations, and orders of the U.S. Nuclear Regulatory Commission (NRC) now or hereafter in effect. The facility consists of a pressurized-water reactor (PWR) located in Maricopa County, Arizona.

By application dated July 6, 2018, as supplemented by letters dated October 18, 2018; March 1, 2019; May 17, 2019; October 4, 2019; November 26, 2019; and December 19, 2019 (Agencywide Documents Access and Management System (ADAMS) Accession Nos. ML18187A417, ML18296A466, ML19060A298, ML19137A118, ML19277J457, ML19331A361, and ML19353C038, respectively), APS, pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) Section 50.12, "Specific exemptions," requested an exemption from certain requirements of 10 CFR 50.46, "Acceptance criteria for emergency core cooling systems [ECCS] for light-water nuclear power reactors," and 10 CFR Part 50, Appendix K, "ECCS Evaluation Models," for Palo Verde. Since these regulations specifically refer only to zircaloy and ZIRLO™, an exemption would be required to apply them to fuel clad with other materials, such as Framatome M5® zirconium alloy.¹ Therefore, APS has requested such an exemption to

¹ HTP and M5® are trademarks or registered trademarks of Framatome, Inc. (formerly AREVA Inc.).

support transition to the Framatome M5[®] alloy cladding. The proposed request would not exempt Palo Verde from the requirements of 10 CFR 50.46 or 10 CFR Part 50, Appendix K regarding acceptance criteria, evaluation model features and documentation, reporting of changes or errors, etc.

The submittal from APS described above also contains the fuel transition license amendment request that is necessary to support batch loading of Framatome Advanced Combustion Engineering (CE) 16x16 High Thermal Performance (HTP[™]) fuel. This exemption is specific to the Framatome M5[®] cladding material exemption request only. The fuel transition and associated technical specification changes are subject to a concurrent review that is being documented in the safety evaluation (SE) with the license amendments (ADAMS Accession No. ML20031C947).

Precedent exemptions have also been approved for other CE plants including St. Lucie Plant, Unit Nos. 1 and 2 (ADAMS Accession Nos. ML14064A125 and ML16015A286, respectively).

II. Request/Action

By application dated July 6, 2018, as supplemented by letters dated October 18, 2018, and March 1, 2019; May 17, 2019; October 4, 2019; November 26, 2019; and December 19, 2019, APS, pursuant to 10 CFR 50.12, requested an exemption from the requirements of 10 CFR 50.46 and Appendix K to 10 CFR Part 50. The proposed exemption request would permit the application of 10 CFR 50.46 and Appendix K to 10 CFR Part 50 to fuel rods clad with Framatome M5[®] alloy at Palo Verde. Since the requirements in 10 CFR 50.46 and Appendix K to 10 CFR Part 50 are predicated upon the use of fuel clad with zircaloy or ZIRLO[™] alloy, an exemption is necessary to apply these requirements to fuel rods clad with Framatome M5[®] alloy.

The technical basis supporting the use of fuel clad with M5® in PWRs is documented primarily in Topical Report BAW-10227-P-A, Revision 1, "Evaluation of Advanced Cladding and Structural Material (M5®) in PWR Reactor Fuel," dated June 2003 (ADAMS Accession No. ML15162B043). This topical report describes Framatome's evaluation supporting the use of the M5® alloy in PWR fuel assemblies as a replacement for Zircaloy-4. This topical report discusses fundamental material properties of M5®, as well as its behavior under normal operation, anticipated transients, and postulated accident conditions.

III. Discussion

The regulation in Section 50.46(a)(1)(i) of 10 CFR states, in part:

Each boiling or pressurized light-water nuclear power reactor fueled with uranium oxide pellets within cylindrical zircaloy or ZIRLO cladding must be provided with an emergency core cooling system (ECCS) that must be designed so that its calculated cooling performance following postulated loss-of-coolant accidents conforms to the criteria set forth in paragraph (b) of this section. ECCS cooling performance must be calculated in accordance with an acceptable evaluation model and must be calculated for a number of postulated loss-of-coolant accidents of different sizes, locations, and other properties sufficient to provide assurance that the most severe postulated loss-of-coolant accidents are calculated.

Since 10 CFR 50.46 specifically refers to fuel with zircaloy or ZIRLO™ cladding, its application to fuel clad with materials other than zircaloy or ZIRLO™ requires an exemption from this section of the regulations.

The regulation in paragraph I.A.5, "Metal – Water Reaction Rate," of 10 CFR Part 50, Appendix K, states, in part:

The rate of energy release, hydrogen generation, and cladding oxidation from the metal/water reaction shall be calculated using the Baker-Just equation (Baker, L., Just, L.C., "Studies of Metal Water Reactions at High Temperatures, III. Experimental and Theoretical Studies of the Zirconium-Water Reaction," ANL-6548, page 7, May 1962).

The requirement for using the Baker-Just equation in Appendix K-conformant loss-of-coolant accident evaluation models presumes use of zircaloy or ZIRLO™ clad fuel rods.

Therefore, application of 10 CFR Part 50, Appendix K to cladding materials other than zircaloy or ZIRLO™ also requires an exemption.

The exemption request from APS relates solely to the particular types of fuel cladding materials specified in these regulations. As written, the regulations presume use of zircaloy or ZIRLO™ cladding. Thus, an exemption is necessary to apply 10 CFR 50.46 and 10 CFR Part 50, Appendix K to other cladding materials such as M5®. The proposed request would not exempt Palo Verde from any other requirements of 10 CFR 50.46 or 10 CFR Part 50, Appendix K regarding acceptance criteria, evaluation model features and documentation, reporting of changes or errors, etc.

Section 50.12 of 10 CFR states that the Commission may grant exemptions from requirements of the regulations in 10 CFR Part 50 for reasons, which are (1) the exemption is authorized by law, (2) the exemption will not present an undue risk to the public health and safety, (3) the exemption is consistent with the common defense and security, and (4) special circumstances, as defined in 10 CFR 50.12(a)(2), are present. The licensee's submittal identifies in particular that the special circumstance associated with this exemption request is that restricting application of 10 CFR 50.46 and 10 CFR Part 50, Appendix K to fuels clad with only zircaloy or ZIRLO™ is not necessary to achieve the underlying purpose of these regulations.

A. The Exemption is Authorized by Law

The NRC has the authority under 10 CFR 50.12 to grant exemptions from the requirements of Part 50 upon demonstration of proper justification. The fuel that will be irradiated at Palo Verde is clad with a zirconium-based alloy that is not expressly within the scope of 10 CFR 50.46 and 10 CFR Part 50, Appendix K. However, the NRC staff considers the acceptance criteria and methods of these regulations applicable to M5®, and the licensee will ensure that these regulations are satisfied for operation with fuel clad with M5®. Therefore, the exemption is authorized by law.

B. The Exemption Presents no Undue Risk to Public Health and Safety

The NRC-approved Topical Report BAW-10227-P-A, which concerns the properties of the M5[®] alloy, provides assurance that predicted chemical, thermal, and mechanical characteristics of M5[®] alloy cladding are acceptable under normal operation, anticipated transients, and postulated accidents. The NRC staff further found that the acceptance criteria and analytical methods from 10 CFR 50.46 and 10 CFR Part 50, Appendix K provide acceptable safety margins for fuel clad with M5[®] that are consistent with those the NRC has established for zircaloy and ZIRLO[™]. Reload cores involving M5[®] cladding will continue to be subject to the operating limits specified in the technical specifications and core operating limits report. Thus, granting this exemption request will not pose undue risk to public health and safety.

C. The Exemption is Consistent with the Common Defense and Security

The proposed exemption will allow the licensee to use an enhanced fuel rod cladding material relative to the zircaloy material for which the requirements of 10 CFR 50.46 and 10 CFR Part 50, Appendix K were originally established. In addition to its review of the exemption request described in this SE, the NRC staff has further evaluated all licensing-basis changes necessary to support loading fuel clad with M5[®] in a separate SE and documented the basis for their acceptability. Based on these reviews, the NRC staff concludes that the use of M5[®] fuel rod cladding at Palo Verde will not significantly affect plant operations and is therefore consistent with the common defense and security.

D. Special Circumstances

Neither 10 CFR 50.46 nor 10 CFR Part 50, Appendix K explicitly applies to fuel clad with M5[®]. However, the underlying purpose of 10 CFR 50.46 and 10 CFR Part 50, Appendix K is to provide requirements capable of ensuring adequate core cooling following the most limiting postulated loss-of-coolant accident. As discussed above, Framatome has demonstrated in an NRC-approved topical report (i.e., BAW-10227-P-A) that application of the acceptance criteria

and analytical methods required in 10 CFR 50.46 and 10 CFR Part 50, Appendix K to fuel clad with M5® is acceptable. Normal core reload safety analyses will further confirm on a cycle-specific basis that there is no adverse impact on ECCS performance for Palo Verde. Therefore, strict application of the material-specific requirements for fuel cladding in 10 CFR 50.46 and 10 CFR Part 50, Appendix K is not necessary to achieve the underlying purpose of ensuring adequate core cooling in this instance. Furthermore, granting an exemption to allow application of the balance of these regulations to fuel clad with M5® at Palo Verde would be consistent with the underlying regulatory purpose.

E. Supplemental Information

For more technical details, refer to the SE associated with this exemption under ADAMS Accession No. ML20022A109 (Enclosure 2).

F. Environmental Considerations

The NRC staff determined that the exemption discussed herein meets the eligibility criteria for the categorical exclusion set forth in 10 CFR 51.22(c)(9) because it is related to a requirement concerning the installation or use of facility components located within the restricted area, as defined in 10 CFR Part 20, and the granting of this exemption involves: (i) no significant hazards consideration, (ii) no significant change in the types or a significant increase in the amounts of any effluents that may be released offsite, and (iii) no significant increase in individual or cumulative occupational radiation exposure. Therefore, in accordance with 10 CFR 51.22(b), no environmental impact statement or environmental assessment need be prepared in connection with the NRC's consideration of this exemption request.

IV. Conclusions

Accordingly, the Commission has determined that, pursuant to 10 CFR 50.12, the exemption is authorized by law, will not present an undue risk to the public health and safety, and is consistent with the common defense and security. Also, special circumstances are

present. Therefore, the Commission hereby grants APS an exemption from the requirements of 10 CFR 50.46 and 10 CFR Part 50, Appendix K, to allow the use of Framatome M5[®] alloy fuel rod cladding material at Palo Verde, Units 1, 2, and 3. As stated above, this exemption relates solely to the cladding material specified in these regulations.

Dated at Rockville, Maryland, this 4th day of March 2020.

For the Nuclear Regulatory Commission.

/RA/

Craig G. Erlanger, Director,
Division of Operating Reactor Licensing,
Office of Nuclear Reactor Regulation.

ENCLOSURE 2

SAFETY EVALUATION RELATED TO 10 CFR 50.12 EXEMPTION FOR

USE OF FRAMATOME M5[®] ALLOY CLADDING

ARIZONA PUBLIC SERVICE COMPANY

PALO VERDE NUCLEAR GENERATING STATION, UNITS 1, 2, AND 3

DOCKET NOS. STN 50-528, STN 50-529, AND STN 50-530



UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

SAFETY EVALUATION RELATED TO 10 CFR 50.12 EXEMPTION FOR
USE OF FRAMATOME M5® ALLOY CLADDING
ARIZONA PUBLIC SERVICE COMPANY
PALO VERDE NUCLEAR GENERATING STATION, UNITS 1, 2, AND 3
DOCKET NOS. STN 50-528, STN 50-529, AND STN 50-530

1.0 INTRODUCTION

By application dated July 6, 2018 (Reference 1), Arizona Public Service Company (APS, the licensee), pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) Section 50.12, "Specific exemptions," requested an exemption from certain requirements of 10 CFR 50.46, "Acceptance criteria for emergency core cooling systems [ECCS] for light-water nuclear power reactors," and 10 CFR Part 50, Appendix K, "ECCS Evaluation Models," for Palo Verde Nuclear Generating Station Units 1, 2, and 3 (Palo Verde). This exemption request relates solely to the specific types of cladding materials for which 10 CFR 50.46 and Appendix K to 10 CFR Part 50 are expressly applicable, namely zircaloy and ZIRLO™. Since these regulations specifically refer only to zircaloy and ZIRLO™, an exemption would be required to apply them to fuel clad with other materials, such as Framatome M5® zirconium alloy.¹ Therefore, APS has requested such an exemption to support transition to the Framatome M5® alloy cladding. The proposed request would not exempt Palo Verde from the requirements of 10 CFR 50.46 or Appendix K to 10 CFR Part 50 regarding acceptance criteria, evaluation model features and documentation, reporting of changes or errors, etc.

The submittal from APS described above also contains a license amendment request to revise pertinent technical specifications (TSS) and other aspects of the plant licensing basis, as necessary, to support loading Framatome high thermal performance (HTP™) fuel. This safety evaluation (SE) is specific to the M5® cladding material exemption request only. The balance of the technical analysis necessary to support loading Framatome HTP™ fuel and the associated licensing basis changes are subject to a concurrent review that is being documented in a separate SE (Reference 2).

The U.S. Nuclear Regulatory Commission (NRC) has previously approved exemption requests for fuel clad with M5® that are similar to the exemption being requested by APS. As described in the licensee's submittal in 2008, the NRC staff approved for Palo Verde a temporary exemption from the requirements of 10 CFR 50.46 and Appendix K to 10 CFR Part 50 to support the implementation of a Framatome lead fuel assembly program (References 3 and 4). The licensee's exemption request further cites recent precedent exemptions from 2014 and

¹"HTP and M5®" are trademarks or registered trademarks of Framatome, Inc. (formerly AREVA Inc.).

2016 for St. Lucie Plant, Unit Nos. 1 and 2 (References 5 and 6), respectively, which are also Combustion Engineering pressurized-water reactors (PWRs).

2.0 REGULATORY EVALUATION

2.1 Regulatory Requirements

Section 50.46(a)(1)(i) of 10 CFR states, in part:

Each boiling or pressurized light-water nuclear power reactor fueled with uranium oxide pellets within cylindrical zircaloy or ZIRLO cladding must be provided with an emergency core cooling system (ECCS) that must be designed so that its calculated cooling performance following postulated loss-of-coolant accidents conforms to the criteria set forth in paragraph (b) of this section. ECCS cooling performance must be calculated in accordance with an acceptable evaluation model and must be calculated for a number of postulated loss-of-coolant accidents of different sizes, locations, and other properties sufficient to provide assurance that the most severe postulated loss-of-coolant accidents are calculated.

Since 10 CFR 50.46 specifically refers to fuel with zircaloy or ZIRLO™ cladding, its application to fuel clad with zirconium-based alloys other than zircaloy or ZIRLO™ requires an exemption from this section of the regulations.

Paragraph I.A.5, “Metal – Water Reaction Rate,” of 10 CFR Part 50, Appendix K, states, in part:

The rate of energy release, hydrogen generation, and cladding oxidation from the metal/water reaction shall be calculated using the Baker-Just equation (Baker, L., Just, L.C., “Studies of Metal Water Reactions at High Temperatures, III. Experimental and Theoretical Studies of the Zirconium-Water Reaction,” [Argonne National Laboratory] ANL-6548, page 7, May 1962).

The requirement for using the Baker-Just equation in Appendix K-conformant loss-of-coolant accident evaluation models presumes use of zircaloy or ZIRLO™ clad fuel rods. Therefore, application of 10 CFR Part 50, Appendix K, to cladding materials other than zircaloy or ZIRLO™ also requires an exemption.

The exemption request from APS relates solely to the particular types of fuel cladding materials specified in these regulations. As written, the regulations presume the use of zircaloy or ZIRLO™ fuel rod cladding. Thus, an exemption is necessary to apply 10 CFR 50.46 and Appendix K to 10 CFR Part 50 to a Framatome M5® cladding alloy other than zircaloy or ZIRLO™. The proposed request would not exempt Palo Verde from any other requirements of 10 CFR 50.46 or Appendix K to 10 CFR Part 50 regarding acceptance criteria, evaluation model features and documentation, reporting of changes or errors, etc.

Pursuant to 10 CFR 50.12, the Commission may grant exemptions from requirements of the regulations in 10 CFR Part 50 for reasons which are (1) the exemption is authorized by law, (2) the exemption will not present an undue risk to the public health and safety, (3) the exemption is consistent with the common defense and security, and (4) special circumstances, as defined in 10 CFR 50.12(a)(2), are present. The licensee's submittal identifies in particular that the special circumstance associated with its exemption request is that restricting application

of 10 CFR 50.46 and Appendix K to 10 CFR Part 50 to fuels clad with only zircaloy or ZIRLO™ is not necessary to achieve the underlying purpose of these regulations.

2.2 NRC Staff Review Objectives

The objectives for the NRC staff's review of the exemption request are to:

1. ensure that the exemption is granted in adherence with the requirements of 10 CFR 50.12, which are summarized in Section 2.1 above.
2. ensure that the acceptance criteria and prescribed methods in 10 CFR 50.46 and Appendix K to 10 CFR Part 50 are applicable to the M5® fuel cladding material.

3.0 TECHNICAL EVALUATION

Pursuant to 10 CFR 50.12, APS requested an exemption from the requirements of 10 CFR 50.46, and Appendix K to 10 CFR Part 50. The proposed exemption request would permit application of the requirements of 10 CFR 50.46 and Appendix K to 10 CFR Part 50, Appendix K to fuel rods clad with M5® at Palo Verde.

The technical basis supporting the use of fuel clad with M5® in PWRs is documented primarily in Topical Report (TR) BAW-10227-P-A, Revision 1, "Evaluation of Advanced Cladding and Structural Material (M5®) in PWR Reactor Fuel," dated June 2003 (Reference 7). This topical report describes Framatome's evaluation supporting the use of the M5® alloy in PWR fuel assemblies as a replacement for Zircaloy-4. This TR discusses fundamental material properties of M5®, as well as its behavior under normal operation, anticipated transients, and postulated accident conditions.

As identified in TR BAW-10227-P-A, the M5® alloy is a proprietary variant of zirconium alloy Zr1Nb (zirconium 1 percent Niobium). In this material, zirconium is alloyed with a small amount of niobium, in lieu of the tin used in zircaloy and ZIRLO™. Framatome stated that the M5® alloy was developed to provide enhanced performance with respect to corrosion, hydrogen pickup, axial growth, and diametral creep. While demonstrating relevant differences in certain material properties and physical behavior, TR BAW-10227-P-A identifies that the basic physical properties of M5® are quite similar to those of zircaloy.

Applicability of 10 CFR 50.46 and Appendix K to M5® Cladding

In its review of TR BAW-10227-P-A, the NRC staff evaluated the applicability of the requirements of 10 CFR 50.46 and Appendix K to 10 CFR Part 50 to Framatome's M5® cladding material.

Section 4.2 of TR BAW-10227-P-A provides Framatome's rationale for concluding that each of the acceptance criteria in 10 CFR 50.46(b) is applicable to fuel clad with M5®. In particular, Framatome concluded the following:

- (1) A peak cladding temperature limit of 2200 degrees Fahrenheit (°F) would maintain an acceptable margin for M5® against both cladding embrittlement that could cause shattering upon core quench and the metal-water reaction reaching an autocatalytic threshold. As discussed in Appendix G to TR BAW-10227-P-A, Framatome based its conclusion upon consideration of the material properties of M5®, quench tests

performed on M5[®] cladding, and high-temperature oxidation kinetics testing demonstrating consistent reaction rates between zircaloy and M5[®] at temperatures near the 2200 °F limit in 10 CFR 50.46(b)(1).

- (2) A limit on maximum local oxidation of 17 percent would, in conjunction with the peak cladding temperature limit of 2200 °F discussed above, prevent the brittle fracture of fuel rods clad with M5[®] during core quench. Appendix G to TR BAW-10227-P-A states that a series of cold-water plunge tests was performed to demonstrate that the expected oxidation threshold at which quench-induced brittle failure of M5[®] would occur is in the same range as that of zircaloy. Therefore, the 17 percent limit for maximum local oxidation would provide a level of protection for M5[®] cladding consistent with that the NRC established for zircaloy.
- (3) A limit on core-wide oxidation of 1 percent would prevent the accumulation of a combustible amount of hydrogen within the reactor building from fuel clad with M5[®]. Section 4.2 and Appendix D to TR BAW-10227-P-A state that high-temperature oxidation testing demonstrates that the behavior of M5[®] is essentially similar to that of zircaloy. Hence, Framatome concludes that essentially the same conservative margin exists when applying the Baker-Just correlation to both cladding materials.
- (4) The requirement for maintaining a coolable geometry applies to cores composed of fuel clad with M5[®]. As described in the Commission's (formerly the U.S. Atomic Energy Commission) Opinion on the rulemaking hearing concerning the ECCS acceptance criteria in 10 CFR 50.46 (Reference 8), the purpose of the limits on peak cladding temperature and maximum local oxidation is to ensure that the cladding remains sufficiently intact to retain fuel pellets in separate rods that constitute an easily coolable array. As discussed above, Framatome has concluded that the limits in 10 CFR 50.46 concerning peak cladding temperature and maximum local oxidation are appropriate for M5[®]. As described in Section 4.2 of TR BAW-10227-P-A, Framatome has also concluded that the limiting blockage associated with M5[®] cladding would remain below that which would compromise a coolable geometry.
- (5) The requirement for maintaining adequate long-term cooling applies equally to cores composed of fuel clad with M5[®]. Section 4.2 of TR BAW-10227-P-A identifies that this requirement is associated with the plant design and does not specifically relate to the fuel cladding material.

Appendix D of TR BAW-10227-P-A provides Framatome's rationale for concluding that the Baker-Just correlation may be conservatively applied to M5[®] fuel cladding. As described above, Framatome performed high-temperature testing to demonstrate that the oxidation performance of M5[®] is essentially the same as zircaloy. Hence, Framatome concluded that extending application of the Baker-Just correlation, which the NRC currently requires for calculating high-temperature oxidation of zircaloy and ZIRLO[™] in Appendix K-conformant evaluation models, to M5[®] is justified.

As documented in the NRC staff's SE on TR BAW-10227-P-A, the staff concluded that the criteria of 10 CFR 50.46 are acceptable for application to M5[®] cladding, and that the Baker-Just correlation is acceptable for calculating the metal-water reaction rate for M5[®] cladding. The technical basis for the NRC staff's conclusions is the testing and analysis Framatome performed in support of the M5[®] alloy that is summarized above and further described in the NRC staff's

relevant SE (Reference 7). Despite finding application of 10 CFR 50.46 and 10 CFR Part 50, Appendix K to M5[®] acceptable from a technical perspective, in its SE, the NRC staff noted that exemptions, such as that currently being proposed by APS for Palo Verde, would be necessary to support such applications.

Adherence to 10 CFR 50.12 Requirements

The exemption to apply 10 CFR 50.46 and 10 CFR Part 50, Appendix K to fuel clad with M5[®] at Palo Verde, satisfies the requirements of 10 CFR 50.12 as described below:

- (1) *The exemption is authorized by law.* NRC has the authority under 10 CFR 50.12 to grant exemptions from the requirements of Part 50 upon demonstration of proper justification. The fuel that will be irradiated at Palo Verde is clad with a zirconium-based alloy that is not expressly within the scope of 10 CFR 50.46 and 10 CFR Part 50, Appendix K. However, the NRC staff considers all other aspects of these regulations (e.g., acceptance criteria, prescribed methods, reporting requirements) applicable to the M5[®] cladding material, and the licensee will ensure its satisfaction for operation with fuel clad with M5[®]. As discussed below, the NRC staff determined that special circumstances exist, which support granting the proposed exemption. Furthermore, granting the exemption would not result in a violation of the Atomic Energy Act of 1954, as amended, or the NRC's regulations. Therefore, the exemption is authorized by law.
- (2) *The exemption will not present an undue risk to public health and safety.* As summarized above in Section 3.0, the NRC staff's previous review of TR BAW-10227-P-A, which concerns the properties of the M5[®] alloy, provides assurance that predicted chemical, thermal, and mechanical characteristics of M5[®]-alloy cladding are acceptable under normal operation, anticipated transients, and postulated accidents. The NRC staff further found that the acceptance criteria and analytical methods from 10 CFR 50.46 and Appendix K to 10 CFR Part 50 provide acceptable safety margins for fuel clad with M5[®] that are consistent with those the Commission has established for zircaloy and ZIRLO[™]. Reload cores involving M5[®] cladding will continue to be subject to the operating limits specified in the TSs and core operating limits report (COLR). Thus, the granting of this exemption request will not pose undue risk to public health and safety.
- (3) *The exemption is consistent with the common defense and security.* The proposed exemption will allow the licensee to use an enhanced fuel rod cladding material relative to the zircaloy material for which the requirements of 10 CFR 50.46 and Appendix K to 10 CFR 50 were originally established. In addition to its review of the exemption request described in this SE, the NRC staff has further evaluated all licensing-basis changes necessary to support loading fuel clad with M5[®] in a separate SE and documented the basis for their acceptability (Reference 2). Based on these reviews, the NRC staff concludes that the use of M5[®] fuel rod cladding at Palo Verde will not significantly affect plant operations. Further, the exemption does not involve security requirements and does not create a security risk. Therefore, the exemption is consistent with the common defense and security.
- (4) *Special circumstances are present.* Neither 10 CFR 50.46 nor Appendix K to 10 CFR 50 explicitly applies to fuel clad with M5[®]. However, the underlying purpose of 10 CFR 50.46 and Appendix K to 10 CFR Part 50 is to provide requirements capable of ensuring adequate core cooling following the most limiting postulated loss-of-coolant

accident. As discussed above, Framatome has demonstrated in an NRC-approved topical report (i.e., BAW-10227-P-A, Reference 7) that application of the acceptance criteria and analytical methods required in 10 CFR 50.46 and Appendix K to fuel clad with M5® is acceptable. Normal core reload safety analyses will further confirm on a cycle-specific basis that there is no adverse impact on ECCS performance for Palo Verde. Therefore, strict application of the material-specific requirements for fuel cladding in 10 CFR 50.46 and 10 CFR Part 50, Appendix K is not necessary to achieve the underlying purpose of ensuring adequate core cooling in this instance. Furthermore, granting an exemption to allow application of the balance of these regulations to fuel clad with M5® at Palo Verde would be consistent with the underlying regulatory purpose.

4.0 ENVIRONMENTAL CONSIDERATIONS

The NRC staff determined that the exemption discussed herein meets the eligibility criteria for the categorical exclusion set forth in 10 CFR 51.22(c)(9) because it is related to a requirement concerning the installation or use of a facility component located within the restricted area, as defined in 10 CFR Part 20, and the granting of this exemption involves: (i) no significant hazards consideration, (ii) no significant change in the types or a significant increase in the amounts of any effluents that may be released offsite, and (iii) no significant increase in individual or cumulative occupational radiation exposure. Therefore, in accordance with 10 CFR 51.22(b), no environmental impact statement or environmental assessment need be prepared in connection with the NRC's consideration of this exemption request. The basis for the NRC staff's determination is discussed as follows with an evaluation against each of the requirements in 10 CFR 51.22(c)(9).

Requirements in 10 CFR 51.22(c)(9)(i)

The NRC staff evaluated the issue of no significant hazards consideration, using the standards described in 10 CFR 50.92(c), as presented below:

1. Does the proposed exemption involve a significant increase in the probability or consequences of an accident previously evaluated?

Response: No.

The proposed exemption to allow the use of M5® fuel rod cladding does not involve a significant increase in the probability or consequences of an accident previously evaluated.

For the set of previously evaluated accidents, their probability is governed by the failure or malfunction of equipment or components other than the fuel rod cladding. The fuel rod cladding itself is not an accident initiator and does not affect the accident probability. Therefore, the change in fuel rod cladding material does not affect the probability of previously evaluated accidents.

The proposed exemption does not involve a significant increase in the consequences of previously evaluated accidents. This conclusion is demonstrated by the analysis submitted by the licensee in support of the proposed use of M5® cladding that the NRC staff has reviewed in support of the proposed license amendment. The licensee's analysis shows that

fuel clad with M5[®] material performs comparably to fuel cladding materials that have been used previously, and in particular satisfies the acceptance criteria in 10 CFR 50.46(b) for the LOCA event.

Therefore, the proposed exemption does not involve a significant increase in the probability or consequences of an accident previously evaluated.

2. Does the proposed exemption create the possibility of a new or different kind of accident from any accident previously evaluated?

Response: No.

The use of M5[®] fuel rod cladding does not create the possibility of a new or different kind of accident from any previously evaluated. The fuel rod cladding is not an accident initiator. As described above in the staff's technical evaluation, the use of M5[®] cladding has been assessed by the licensee and vendor, and has been found to exhibit comparable or enhanced behavior relative to the zircaloy cladding material specifically identified in 10 CFR 50.46 and Appendix K to 10 CFR 50. The NRC staff has previously reviewed this information in its safety evaluation approving TR BAW-10227(P)(A). Use of Framatome fuel with M5[®] cladding in Palo Verde reactor cores is compatible with the plant design and does not introduce any new safety functions for plant structures, systems, or components. Furthermore, the introduction of M5[®] cladding does not affect any accident mitigation systems and does not introduce any new accident initiation methods.

Therefore, the proposed exemption does not create the possibility of a new or different kind of accident than any previously evaluated.

3. Does the proposed exemption involve a significant reduction in a margin of safety?

Response: No.

The proposed exemption does not involve a significant reduction in the margin of safety. The licensee's analysis of the spectrum of postulated LOCA events for fuel rods clad with M5[®] exhibits results comparable to those for the fuel currently in use at Palo Verde for the small-break LOCA event, and increased margin for the large-break LOCA event. Furthermore, as discussed above in the staff's technical evaluation, the fuel vendor has generically evaluated the performance of M5[®] cladding relative to the zircaloy cladding specifically identified in 10 CFR 50.46 and Appendix K to 10 CFR 50. The vendor concluded that the performance of the M5 cladding material is quite similar to or enhanced relative to zircaloy-4. The NRC staff has performed a review of these conclusions and documented in its safety evaluation on TR BAW-10227(P)(A) that the M5[®] material properties and mechanical design methodology are in accordance with applicable regulations and regulatory guidance.

Therefore, the proposed exemption does not involve a significant reduction in a margin of safety.

Based on the above, the NRC staff concludes that the proposed exemption presents no significant hazards consideration under the standards set forth in 10 CFR 50.92(c), and, accordingly, a finding of no significant hazards consideration is justified (i.e., satisfies the provision of 10 CFR 51.22(c)(9)(i)).

Requirements in 10 CFR 51.22(c)(9)(ii)

The proposed exemption would allow the use of M5[®] fuel rod cladding material in the reactors. The use of the M5[®] fuel rod cladding material will not significantly change the types of effluents that may be released offsite, or significantly increase the amount of effluents that may be released offsite. Therefore, the provision of 10 CFR 51.22(c)(9)(ii) is satisfied.

Requirements in 10 CFR 51.22(c)(9)(iii)

The proposed exemption would allow the use of the M5[®] fuel rod cladding material in the reactors. The use of the M5[®] fuel rod cladding material will not significantly increase individual occupational radiation exposure, or significantly increase cumulative occupational radiation exposure. Therefore, the provision of 10 CFR 51.22(c)(9)(iii) is satisfied.

Based on the above, the NRC staff concludes that the proposed exemption meets the eligibility criteria for the categorical exclusion set forth in 10 CFR 51.22(c)(9). Therefore, in accordance with 10 CFR 51.22(b), no environmental impact statement or environmental assessment need be prepared in connection with the NRC's proposed issuance of this exemption.

5.0 CONCLUSIONS

Based on the NRC staff's regulatory and technical evaluation of the proposed exemption request, as documented above, the staff concludes that (1) the proposed application of 10 CFR 50.46 and Appendix K to 10 CFR 50 to fuel clad with M5[®] is acceptable for Palo Verde and (2) the underlying intent of 10 CFR 50.46 and Appendix K to 10 CFR 50 will continue to be satisfied for the planned operation of Palo Verde with fuel clad with M5[®] under the proposed exemption. Therefore, the NRC staff concludes that, pursuant to 10 CFR 50.12(a), the proposed exemption allowing application of 10 CFR 50.46 and 10 CFR Part 50, Appendix K to fuel clad with M5[®] at Palo Verde is justified.

6.0 REFERENCES

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3. Bauer, S. A., for Mims, D. C., APS , letter to U.S. Nuclear Regulatory Commission, “Palo Verde Nuclear Generating Station (PVNGS) Unit 1; Docket No. STN 50-528; Request for Temporary Exemption from the Provisions of 10 CFR 50.46 and 10 CFR 50, Appendix K for Lead Fuel Assemblies,” dated March 8, 2008 (ADAMS Accession No. ML080790524).
4. Singal, B. S., U.S. Nuclear Regulatory Commission, letter to Randall K. Edington, Arizona Public Service Company, “Palo Verde Nuclear Generating Station, Unit 1 – Temporary Exemption from the Requirements of 10 CFR Part 50, Section 50.46 and Appendix K for Lead Fuel Assemblies (TAC No. MD8330), dated October 14, 2008 (ADAMS Package Accession No. ML082730004).
5. Regner, L. M., U.S. Nuclear Regulatory Commission, letter to Mr. Mano Nazar, NextEra Energy, “St. Lucie Plant, Unit 1 – Exemption from the Requirements of 10 CFR Part 50, Section 50.46 and Appendix K to 10 CFR Part 50 to Allow the use of M5® Alloy Rod Cladding (TAC No. MF1820),” dated March 31, 2014 (ADAMS Accession No. ML14064A125).
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7. Framatome ANP, “Evaluation of Advanced Cladding and Structural Material (M5) in PWR Reactor Fuel, Topical Report BAW-10227-P-A, Revision 1, dated June 2003 (ADAMS Package Accession No. ML15162B043).
8. U.S. Atomic Energy Commission, Opinion of the Commission, In the Matter of Rulemaking Hearing on “Acceptance Criteria for Emergency Core Cooling Systems for Light-Water-Cooled Nuclear Reactors,” (CLI-73-39, 6 AEC 1085), dated December 28, 1973 (ADAMS Accession No. ML120960378; not publicly available).

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Date: March 4, 2020

SUBJECT: PALO VERDE NUCLEAR GENERATING STATION, UNITS 1, 2, AND 3 –
EXEMPTION FROM THE REQUIREMENTS OF 10 CFR PART 50,
SECTION 50.46 AND APPENDIX K TO 10 CFR PART 50 FOR USE OF
FRAMATOME M5® ALLOY CLADDING (EPID L-2018-LLE-0010)
DATED MARCH 4, 2020

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