



**UNITED STATES  
NUCLEAR REGULATORY COMMISSION  
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS  
WASHINGTON, DC 20555 - 0001**

March 26, 2018

Mr. Victor McCree  
Executive Director for Operations  
U.S. Nuclear Regulatory Commission  
Washington, DC 20555-0001

**SUBJECT:** SAFETY EVALUATION FOR TOPICAL REPORT APR1400-F-M-TR-13001-P, REVISION 1, "PLUS7 FUEL DESIGN FOR THE APR1400"

Dear Mr. McCree:

During the 651<sup>st</sup> meeting of the Advisory Committee on Reactor Safeguards, March 8-9, 2018, we met with representatives of the NRC staff, Korea Electric Power Corporation (KEPCO), and Korea Hydro & Nuclear Power Company, Ltd., (KHNP) to review the safety evaluation for topical report APR1400-F-M-TR-13001-P, Revision 1, "PLUS7 Fuel Design for the APR1400." Our APR1400 Subcommittee reviewed these and the other referenced documents during meetings on May 18, 2017 and January 24, 2018. This topical report was submitted by KHNP in conjunction with its affiliate company, KEPCO, in support of APR1400 design certification.

**CONCLUSION and RECOMMENDATION**

1. There is reasonable assurance use of the PLUS7 fuel design is acceptable for the APR1400, provided the conditions and limitations identified in the safety evaluation are met.
2. The staff should issue their safety evaluation.

**BACKGROUND**

The PLUS7 fuel, jointly developed by Westinghouse Electric Corporation and KEPCO, includes additional features beyond the Westinghouse Guardian fuel design to promote mixing and improve heat transfer between the fuel and the coolant, increasing the thermal margin to departure from nucleate boiling. Fuel rod design was evaluated using NRC-approved codes considering cladding stress, strain, fatigue, and oxidation/hydriding; rod internal pressure, cladding collapse, fuel pellet overheating (melting), and pellet to cladding interaction. All of the fuel rod design criteria were met up to the maximum allowable fuel rod average burnup of 60 GWD/MTU.

## DISCUSSION

As of 2017, over 5000 PLUS7 fuel assemblies have been produced and placed in service. The South Korean Shin-Kori Unit 3, the first APR1400 plant, began commercial operation using a full core of PLUS7 fuel assemblies in December 2016.

Pool side examinations (PSEs) were conducted on four lead test assemblies (LTAs). Hot cell examinations of LTAs were completed after irradiation. PSE and hot cell examination results demonstrated that design requirements were met.

The degradation of fuel thermal conductivity with burnup has been accounted for through a fuel temperature penalty that was conservatively determined based on comparison with experimental data at various burnups.

The staff concludes that there is reasonable assurance that the PLUS7 fuel design is acceptable, provided the following conditions and limitations are met:

1. The topical report does not address the evaluation of the fuel assembly for seismic and LOCA loads. The evaluation of the fuel assembly for seismic and LOCA loads will be addressed in APR1400 Design Control Document, Tier 2, Section 4.2.
2. The staff's approval is limited to a maximum peak rod average burnup of 60 GWD/MTU.
3. The fuel centerline temperature penalty is based on the operating parameters (e.g., peak linear heat generation rate) covered by the topical report. The temperature penalty would need to be reevaluated for any core designs not bounded by these operating parameters.

Section 3.2.3 (Cladding Fatigue) presents the results of a stylized analysis to assess the anticipated fatigue life of the cladding. One of the key assumptions in the analysis is an estimate of the number of fatigue cycles that the cladding will experience during exposure. The analysis assumes daily 10 to 100% power changes for the life of the cladding. Use of the term "load follow" to describe this analysis may be misinterpreted to mean that the fuel has been analyzed for "load follow," which it has not. Rather, the analysis is a stylized method to calculate a conservative fatigue usage factor that is then compared to the limit of 0.9. The staff should clarify in the draft SE how the term "load follow" was considered in their evaluation of the PLUS7 fuel design.

## SUMMARY

There is reasonable assurance that the use of the PLUS7 fuel design is acceptable for the APR1400, provided the conditions and limitations identified in the safety evaluation are met. The staff should issue their safety evaluation.

Sincerely,

/RA/

Michael L. Corradini  
Chairman

## REFERENCES

1. U.S. Nuclear Regulatory Commission, "Safety Evaluation by the Office of New Reactors Topical Report (TR) APR1400-F-M-TR-13001, Revision 1, 'PLUS7 Fuel Design for the APR1400,' Korea Hydro & Nuclear Power Co. LTD Project No. PROJ0782," December 22, 2017 (ML17348A152).
2. Korea Electric Power Corporation & Korea Hydro & Nuclear Power Co., Ltd, APR1400-F-M-TR-13001-P, "PLUS7 Fuel Design for the APR1400," Revision 1, August 2017 (ML17223B420).
3. Korea Electric Power Corporation and Korea Hydro & Nuclear Power Company, Ltd., APR1400 Design Control Document Tier 1," Revision 1, March 2017 (ML17096A325).

**REFERENCES**

1. U.S. Nuclear Regulatory Commission, "Safety Evaluation by the Office of New Reactors Topical Report (TR) APR1400-F-M-TR-13001, Revision 1, 'PLUS7 Fuel Design for the APR1400,' Korea Hydro & Nuclear Power Co. LTD Project No. PROJ0782," December 22, 2017 (ML17348A152).
2. Korea Electric Power Corporation & Korea Hydro & Nuclear Power Co., Ltd, APR1400-F-M-TR-13001-P, "PLUS7 Fuel Design for the APR1400," Revision 1, August 2017 (ML17223B420).
1. Korea Electric Power Corporation and Korea Hydro & Nuclear Power Company, Ltd., APR1400 Design Control Document Tier 1," Revision 1, March 2017 (ML17096A325).

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