AREVA

Shearon Harris Unit 1 GAIA Lead Test Assembly Licensing Analysis

ANP-3389NP
Revision 0

Summary Report

June 2015

AREVA Inc.

Nature of Changes

Item	Section(s) or Page(s)	Description and Justification
1	All	Initial Issue

Contents

List of Tables

Nomenclature

Acronym	Definition
FA	Fuel Assembly
FR	Fuel Rod
Gd_2O_3	Gadolinia
GT	Guide Tube
GWd/MTU	Gigawatt-Days per Metric Ton of Uranium
HMP	High Mechanical Performance
HTP	High Thermal Performance
IGM	Intermediate GAIA Mixers
kW/ft	Kilowatt per Foot
LHGR	Linear Heat Generation Rate
LOCA	Loss-of-Coolant Accident
LTA	Lead Test Assembly
LTP	Lower Tie Plate
Mlbm/hr	Mega-pound-mass per Hour
MWd/MTU	Megawatt-Days per Metric Ton of Uranium
MWt	Megawatt-thermal
NRC	U. S. Nuclear Regulatory Commission
PWR	Pressurized Water Reactor
psia	Pounds per Square Inch Absolute
RCCA	Rod Control Cluster Assembly
SAR	Safety Analysis Report
UO_2	Uranium Dioxide
UTP	Upper Tie Plate

1.0 INTRODUCTION

Shearon Harris Unit 1 Cycle 20 will contain eight (8) GAIA Lead Test Assemblies (LTAs) loaded in non-power limiting core locations. This report provides a design description and summary of licensing analyses for the GAIA LTAs. The GAIA design retains many of the proven features of the preceding HTP™ family of designs. The GAIA design features are described in Section 3.1 of this report. The evaluations for the co-resident AREVA Inc. designed fuel to be operated in the core during Cycle 20 are contained in separate reports.

2.0 SUMMARY AND CONCLUSIONS

Mechanical design analyses of the Shearon Harris GAIA LTA fuel design have been performed using NRC-approved mechanical design analysis methodology (References 1 and 2). The analyses address the AREVA Inc. PWR generic mechanical design criteria (References 3 and 4). Fuel assembly seismic analyses were performed using current AREVA Inc. methodology (Reference 5). Additional changes have been made to the NRC approved methods to address the impact of the thermal conductivity degradation with burnup and to address the impact of burnup on the seismic behavior of the fuel. The methods used for these evaluations are consistent with the methods previously reviewed by the NRC for other applications.

The analyses (Reference 6) demonstrate that the mechanical design criteria for the fuel rod and fuel assembly design are satisfied for Cycle 20. In addition to cycle specific evaluations, Post Irradiation Examination will be performed to confirm acceptable behavior prior to operation in Cycles 21 and 22.

The GAIA LTA thermal-hydraulic, neutronics and safety analyses have been performed and results are reported in the Cycle 20 SAR (Reference 7). The analyses address the AREVA Inc. PWR generic thermal-hydraulic, neutronics and safety analysis design criteria (References 3 and 4).

3.0 DESIGN EVALUATION

3.1 *Mechanical Design Description*

The GAIA LTA design retains many of the proven features of the preceding HTP™ family of designs. It contains a 17X17 array with six (6) structural spacer grids with a new mixing vane design for improved thermal hydraulic performance. Fuel rod stability is based upon the HTP™ spacer grid spring line contact with springs located at the four corners of each cell. The structural grids are fabricated with M5® alloy. Additionally, three (3) intermediate GAIA mixers (IGMs) are incorporated, based on the proven AFA-3G mid span mixing grid design, to further augment thermal hydraulic performance. The IGMs are also fabricated with M5® alloy. HMP™ end grids are located at the lower and upper ends of the fuel assembly. These grids are made of Alloy 718 with proven operating experience in the HTP™ fuel assembly design platform. The upper HMP™ end grid is [

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The GAIA structural mixing vane spacer grid and the IGMs are connected to increased diameter MONOBLOC™ guide tubes through resistance welds. The guide tubes and instrumentation tube are fabricated from AREVA's advanced Q12™ quaternary, low creep, structural alloy. The Alloy 718 HMP spacers are secured in place by a spacer sleeve (capture ring) above and below each HMP spacer at all 24 guide tubes and the instrumentation tube.

The GAIA LTA design features the GRIP™ bottom nozzle assembly for maximum filtering efficiency and serviceability as well as a reconstitutable top nozzle which is typical of the nozzles used on Advanced W17 fuel.

The fuel rod design incorporates M5® alloy as cladding material and an increased uranium loading for fuel cycle optimization in reload quantities. The chemical composition of M5® and its microstructure provide enhanced resistance to corrosion and very low hydrogen uptake.

Fuel pellets are pressed and sintered with dished ends, a slightly tapered land area, and an end chamfer. Resinter density change, moisture content, and surface quality of the finished pellets are stringently controlled during fabrication to attain theoretical nominal densities of up to [ ]% and ensure the performance of the fuel during operation. The GAIA LTAs have a nominal and maximum theoretical density of [ ]% and [ ]%, respectively.

Table 3-1 shows the GAIA LTA fuel design parameters.

3.2 *Mechanical Design Evaluation*

For Cycle 20, the GAIA LTA fuel design was evaluated using approved mechanical design methods as described in References 1 and 2. Fuel assembly seismic analyses were performed using current AREVA Inc. methodology (Reference 5). Additional changes have been made to the NRC approved methods to address the impact of the thermal conductivity degradation with burnup and to address the impact of burnup on the seismic behavior of the fuel. The methods used for these evaluations are consistent with the methods previously reviewed by the NRC for other applications. Table 3-2 provides a summary of the reactor information that was used for the mechanical design evaluations. All mechanical design criteria were satisfied for Cycle 20 operation.

3.3 *Thermal-Hydraulic and Safety Evaluations*

The criteria for the thermal-hydraulic and safety evaluations for the Cycle 20 operation and analysis results are included in the Cycle 20 Safety Analysis Report (Reference 7). The analyses address the AREVA Inc. PWR generic thermal-hydraulic and safety analysis design criteria (References 3 and 4). All thermal-hydraulic and safety analysis design criteria were satisfied for Cycle 20 operation.

3.4 *Neutronics Evaluation*

The criteria for the neutronics design evaluations for the Cycle 20 operation and analysis results are included in the Cycle 20 Safety Analysis Report (Reference 7). The analyses address the AREVA Inc. PWR generic neutronics design criteria (References 3 and 4). All neutronic design criteria were satisfied for Cycle 20 operation.

3.5 *SER Restrictions and Limitations Review*

A thorough review of NRC approved Topical Report SER restrictions and limitations used in the analysis of the GAIA LTAs was performed (Reference 8). This review confirmed that analyses of the GAIA LTAs would conform to the Topical Reports referenced in the Harris Plant Technical Specifications.

Table 3-1: GAIA LTA Fuel Assembly and Component Description

Characteristic	Material	Value
Fuel Assembly		
Fuel Assembly Pitch, in		8.466
Array		17×17
Number of Fuel Rods		264
Fuel Rod Pitch, in		0.496
Fuel Rod-to-Rod Spacing, in		0.122
Guide / Instrument Tubes		
Guide Tubes	Q12™	24
Outside Diameter, in		0.496
Inside Diameter, in		0.451
Lower Outside Diameter, in		0.496
Lower Inside Diameter, in		0.397
Instrument Tube	Q12™	1
Outside Diameter, in		0.496
Inside Diameter, in		0.451
Overall Assembly Length, in		159.86
Spacers		
GAIA V10	M5®	6
Envelope, in (nominal)		[ ]
HMP	Alloy 718	2
Envelope, in (nominal)		[ ]
IGM	M5®	3
Envelope, in (nominal)		[ ]
LTP Envelope (GRIP), in (nominal)	Stainless Steel	[ ]
UTP Envelope, in (nominal)	Stainless Steel & Alloy 718	[ ]
Fuel Rod		
Cladding	M5®	
Cladding Outside Diameter, in		0.374
Cladding Inside Diameter, in		0.329
Fuel Column	UO_2 or UO_2/Gd_2O_3	
Pellet Diameter, in		0.3225
Active Fuel Length, in		144.0
Central Enriched Length, in		132.0(UO_2)/123.0(Gd_2O_3)
Upper and Lower Blanket Lengths, in		6.0(UO_2)/10.5(Gd_2O_3)
Density, % of theoretical		[ ]
Fill Gas Pressure, psia	Helium	[ ]
Plenum Spring Length (Unrestrained), in	Alloy X-750	[ ]

Table 3-2: Reactor Operating Conditions for GAIA LTA Mechanical Evaluations

Parameter	Value
Core Thermal Power, MWt	2948
System Pressure, psia	2250
Number of Assemblies	157
Nominal Total Core Flow Rate, Mlbm/hr	112.4
Core Inlet Temperature, °F	556.9
Core Outlet Temperature, °F	626.5
Maximum Overpower, %	118
Fraction of Heat from Fuel Rods	0.974
Core Average LHGR, kW/ft	5.93
Maximum Peak Power Factor, F_q^T	2.41
Maximum Rod Peaking Factor, Fdh^T	1.66
Peak Assembly Burnup, GWd/mtU	59.8
Peak Rod Burnup, GWd/mtU	62.0

4.0 POST IRRADIATION EXAMINATION PLAN

The Post Irradiation Examinations planned for the GAIA LTAs are summarized in Table 4-1. These examinations will confirm the anticipated performance levels of the GAIA fuel assembly and its components. The scope of examinations may be increased or decreased based on results obtained and other observations at the time. As normally expected, the examination scope is also subject to change based on operational considerations of the Plant Licensee.

Table 4-1: Post Irradiation Examinations Planned for the GAIA LTAs

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5.0 REFERENCES

1. XN-NF-82-06(P)(A) Revision 1 and Supplements 2, 4, and 5, *Qualification of Exxon Nuclear Fuel for Extended Burnup*, Exxon Nuclear Company, October 1986.

2. ANF-88-133(P)(A) and Supplement 1, *Qualification of Advanced Nuclear Fuels' PWR Design Methodology for Rod Burnups of 62 GWd/MTU*, Advanced Nuclear Fuels Corporation, December 1991.

3. EMF-92-116(P)(A) Revision 0, *Generic Mechanical Design Criteria for PWR Fuel Designs*, Siemens Power Corporation, February 1999.

4. BAW-10240(P)(A), Revision 0, Incorporation of M5™ Properties in Framatome ANP Approved Methods, Framatome ANP, May 2004.

5. BAW-10133PA, Revision 1, Addendum 1 and Addendum 2, Mark-C Fuel Assembly LOCA-Seismic Analysis, Framatome, October 2000.

6. ANP-3362P, Revision 1, PWR Fuel Design Criteria Review for Shearon Harris Unit 1 GAIA Lead Test Assemblies SHA1-20L, AREVA Inc., February 2015.

7. ANP-3364, Revision 1, Harris Unit 1 Nuclear Plant Cycle 20 Safety Analysis Report, AREVA Inc., April, 2015.

8. ANP-3322, Revision 0, Harris Plant Topical Report SER Limitations and Restrictions for GAIA Lead Fuel Assemblies, AREVA Inc., August, 2014.