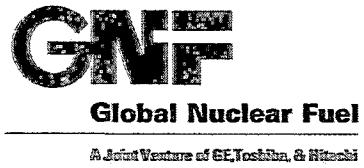
Edwin I. Hatch Nuclear Plant – Unit 1
Information Reports for Lead Test Assemblies

Enclosure 2

Non-Proprietary Report NEDC-33884, Revision 0

GNF FeCrAl ATF Lead Test Assembly



Global Nuclear Fuel

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Non-Proprietary Information – Class I (Public)

GNF FeCrAl ATF Lead Test Assembly for Edwin I. Hatch Nuclear Plant, Unit 1

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REVISION HISTORY

Revision	Date	Description of Change
0	10/2017	Initial Release

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ACRONYMS

Term	Definition
ATF	Accident Tolerant Fuel
COLR	Core Operating Limits Report
DOE	United States Department of Energy
GE	General Electric
GNF	Global Nuclear Fuel – Americas, LLC
HNP-1	Edwin I. Hatch Nuclear Plant, Unit 1
LTA	Lead Test Assembly
LTR	Lead Test Rod
NRC	United States Nuclear Regulatory Commission
OLMCPR	Operating Limit Minimum Critical Power Ratio
PLR	Part Length Rod
SAFDL	Specified Acceptable Fuel Design Limit
SNC	Southern Nuclear Operating Company, Inc.
SRLR	Supplemental Reload Licensing Report
TMOL	Thermal Mechanical Operating Limit

Abstract

Southern Nuclear Operating Company, Inc. (SNC) plans to load four (4) Lead Test Assemblies (LTAs) as part of the Edwin I. Hatch Nuclear Plant, Unit 1 (HNP-1) Reload 28 Cycle 29 during the 2018 refueling outage. These bundles, also referred to as Accident Tolerant Fuel (ATF) LTAs, are conventional GNF2 assemblies in which a limited number of fuel rods are replaced with GNF FeCrAl clad Lead Test Rods (LTRs). These LTAs are planned to be in operation as part of a joint program with Global Nuclear Fuel – Americas, LLC (GNF) on behalf of the United States Department of Energy's (DOE's) ATF program.

This report contains information that is to be provided to the United States Nuclear Regulatory Commission (NRC). Included in this report are a description of GNF FeCrAl and the ATF LTAs, a discussion of the licensing analyses, a description of the LTA program objectives, and measurements planned for the assemblies.

1.0 Introduction

SNC plans to load four (4) LTAs as part of the HNP-1 Reload 28 Cycle 29 during the 2018 refueling outage. These bundles, also referred to as ATF LTAs, are planned to be in operation as part of a joint program with GNF on behalf of the DOE.

This report contains information that is to be provided to the NRC to comply with Reference 1, which provides guidelines to be followed to license LTAs. Included in this report are a description of the ATF LTAs, a discussion of the licensing analyses, a description of the program objectives, and any applicable measurements planned for the LTAs.

The LTA design is described in Section 2 along with the GNF FeCrAl cladding material that is the aspect to be tested. The subject LTAs are GNF2 bundles with less than eight Zircaloy clad rods replaced with segmented FeCrAl clad rods. No other aspects of the bundle are modified. LTR segments may be fueled or empty. The fuel material in fueled segments is conventional UO_2.

Section 3 describes the licensing analyses that will be performed. Section 4 states the objectives of the LTA program and describes the measurements planned.

2.0 GNF FeCrAl and ATF LTA Description

As part of the DOE's ATF program, GNF and collaborating partners are developing a ferrous metallic FeCrAl alloy with a ferritic structure as an alternative fuel rod cladding material to contemporary zirconium based alloys. Model alloys with substantially improved resistance to the metal-water reaction under accident conditions have been under investigation since the Great Earthquake of Eastern Japan that occurred on March 11, 2011.

2.1 GNF FeCrAl

GNF FeCrAl encompasses a broad range of alloying elements, the principal being iron, chrome, aluminum and molybdenum as described in Table 2-1. GNF FeCrAl is a ferrous alloy with a chrome concentration in the stainless steel range and containing aluminum. GNF FeCrAl has demonstrable resistance to corrosion at normal reactor operating conditions (i.e., 300°C water) as well as at off-normal conditions, including accident conditions (i.e., very high temperature steam approaching the material melting temperature). GNF FeCrAl has a body-centered-cubic ferritic structure that promotes resistance to stress corrosion cracking at high temperature.

In addition to its oxidation resistance, GNF FeCrAl exhibits good thermal and mechanical properties that are important for fuel rod function and is suitable for conventional manufacturing processes.

2.2 Lead Test Assembly Description

The LTA is essentially a standard production GNF2 fuel assembly as described in Reference 2 in which several normal full length fuel rods are replaced with full length rods comprised of segments that may be partially fueled segments clad with GNF FeCrAl as depicted in Figures 2-1 and 2-2 or unfueled segments. The fuel pellet material for fueled segments is conventional UO_2. The outside diameter is the same as a normal GNF2 fuel rod. As such, the thermal hydraulic characteristics in the active region of the assembly can be treated as normal fuel. As illustrated in Figure 2-3, the LTRs are restricted to interior positions in the bundle that operate at lower power than peripheral locations. For fueled segments, this provides inherent margin relative to the limiting rods within the bundle which accommodates uncertainties in irradiated material properties. The LTAs may contain reference Zircaloy clad segmented rods to serve as the comparison basis for relative measurements.

Table 2-1 Nominal GNF FeCrAl Alloy Composition

Alloy	Iron (Fe)	Chrome (Cr)	Aluminum (Al)	Molybdenum (Mo)
GNF FeCrAl	Bal	10 - 22	4 - 6	1.75 - 3.5

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Figure 2-1 Rod Segment Schematic for Fueled Segments

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Figure 2-2 Segmented Rod Axial Arrangement (Fueled)

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Figure 2-3 Allowable Lead Test Rod Locations

3.0 Licensing Analyses

For specified engineering evaluations (e.g., fuel rod thermal mechanical), the ATF LTAs have been, or will be, analyzed using the NRC approved methods described in Reference 3. These methods (e.g., PRIME) are capable of analyzing the GNF FeCrAl clad LTRs and LTA performance; however, irradiated material properties data is incomplete, which is the motivation for installing the LTAs. As such, these methods cannot be considered qualified, or approved for this application. To adequately conform to standard Specified Acceptable Fuel Design Limits (SAFDLs), the following conservatisms are introduced:

- Fuel rod engineering evaluations to establish the LTR Thermal Mechanical Operating Limits (TMOLs) will apply appropriately conservative treatments in response to uncertainties in irradiated material properties.
- The LTRs shall be limited in number to eight (8), or less, within an LTA. The LTRs are restricted to interior locations within the bundle resulting in inherent power suppression.
- The LTAs shall be installed in core locations that are not limiting with respect to thermal limits.

The LTRs have the same fuel rod outside diameter as a normal fuel rod in the active region of the assembly, and the effect of the mechanical interface between segments has been evaluated as not significantly affecting the liquid film. Therefore, GEXL17 is applicable to the analysis and monitoring of the LTAs. While the axial heat flux distribution is not continuous due to the presence of non-fueled portions of the segments, this results in a reduction in film evaporation and increased margin to boiling transition for the LTRs. The Operating Limit Minimum Critical Power Ratio (OLMCPR) established for the reload fuel will be confirmed to be applicable to the LTAs as GEXL17 is applied to the prediction of boiling transition (i.e., critical power ratio). Additionally, as stated above, the LTAs shall be installed in non-limiting core locations resulting in increased margin. Normal reload licensing analyses will be performed for the LTAs for each cycle of their operation. Preliminary evaluations confirm that the presence of the LTAs containing a small number of GNF FeCrAl clad segmented rods is inconsequential to the characteristics of the core.

Plant-dependent, cycle-independent evaluations (e.g., control rod drop accident, fuel handling accident, loss-of-coolant accident, and fuel storage) shall be performed to assure conformance to established regulatory requirements. It is recognized that the aforementioned regulatory requirements are, to some extent, specific to Zircaloy cladding; however, they are considered adequate and appropriate for this purpose.

SNC intends to insert the subject LTAs into HNP-1 and to operate Cycle 29 under the provisions of Technical Specification 4.2.1 and in concert with 10 CFR 50.59, where applicable, and in conjunction with the LTA requirements stipulated in Reference 3 (GESTAR II); however, cycle-specific analyses to establish fuel operating limits are not yet complete. When cycle-specific analyses are complete, GNF and SNC will document the results in each respective Supplemental Reload Licensing Report (SRLR). SNC will update the HNP-1 Core Operating Limits Report (COLR) accordingly.

4.0 LTA Program Objectives and Planned Inspections

The purpose of this LTA program is to prepare specimens for post-irradiation examination and testing to characterize material properties and performance and support alloy optimization and fuel rod design for potential reload application.

Poolside surveillance is planned throughout the irradiation period and selected harvesting of segments for laboratory examination is expected. The frequency and extent of these surveillances and rod removal evolutions will necessarily depend upon the operational constraints at the station as determined by SNC and the evolving goals of the DOE's ATF program.

5.0 References

1. Letter, T. A. Ippolito (NRC) to R. E. Engel (GE), "Lead Test Assembly Licensing," MFN-182-81, September 23, 1981.
2. Global Nuclear Fuel, "GNF2 Advantage Generic Compliance with NEDE-24011-P-A (GESTAR II)," NEDC-33270P, Revision 8, April 2017.
3. Global Nuclear Fuel, "General Electric Standard Application for Reactor Fuel (GESTAR II)," NEDE-24011-P-A-25, August 2017.