5

Date Received for Clearance Process (MM/YY/DD)
6/19/02

INFORMATION CLEARANCE FORM

A. Information Category
cw
☒ Abstract ☐ Journal Article
☐ Summary ☐ Internet
☐ Visual Aid ☐ Software
☑ Full Paper ☐ Report
☐ Other ______

B. Document Number N/A HNF-11406-FP

C. Title
"FFTF - A History of Safety and Operational Excellence"

D. Internet Address

E. Required Information

1. Is document potentially Classified? ☒ No ☐ Yes (MANDATORY)
D.B. Klos
Manager's Signature Required

If Yes ______ ☐ No ☐ Yes Classified
ADC Signature Required

2. References in the Information are Applied Technology ☒ No ☐ Yes
Export Controlled Information ☒ No ☐ Yes

3. Does Information Contain the Following: (MANDATORY)
a. New or Novel (Patentable) Subject Matter? ☒ No ☐ Yes
If "Yes", Disclosure No.: ______
b. Information Received in Confidence, Such as Proprietary and/or Inventions?
☒ No ☐ Yes If "Yes", Affix Appropriate Legends/Notices.
c. Copyrights? ☒ No ☐ Yes If "Yes", Attach Permission.
d. Trademarks? ☒ No ☐ Yes If "Yes", Identify in Document.

4. Is Information requiring submission to OSTI? ☒ No ☐ Yes

5. Release Level? ☒ Public ☐ Limited

F. Complete for a Journal Article

1. Title of Journal

G. Complete for a Presentation

1. Title for Conference or Meeting American Nuclear Society 2002 Winter Meeting
2. Group Sponsoring American Nuclear Society
3. Date of Conference 11/17/2002
4. City/State Washington, D.C.
5. Will Information be Published in Proceedings? ☐ No ☒ Yes
6. Will Material be Handed Out? ☐ No ☒ Yes

H. Author/Requestor
D. L. Nielsen DL Nielsen
(Print and Sign)

Responsible Manager
D. B. Klos D.B. Klos
(Print and Sign)

I. Reviewers

	Yes	Print	Signature	Public Y/N (If N, complete J)
General Counsel	☒	K. Norris		[✓ Y] / N
Office of External Affairs	☑	J. Holloway	JW Holloway	[✓ Y] / N
DOE-RL	☐	O.A. Farabee		[✓ Y] / N
Other	☒	Douglas A Gantt, Applied Technology	DA Gantt	[✓ Y] / N
Other	☐			Y / N

J. If Information Includes Sensitive Information and is not to be released to the Public indicate category below.

☐ Applied Technology
☐ Personal/Private
☐ Proprietary
☐ Business-Sensitive
☐ Predecisional
☐ UCNI
☐ Protected CRADA
☐ Export Controlled
☐ Procurement-Sensitive
☐ Patentable
☐ Other (Specify) ______

Information Clearance Approval

APPROVED FOR RELEASE
OFFICIAL DOCUMENT
cw
Date 6/26/02

K. If Additional Comments, Please Attach Separate Sheet

HNF-11406-FP
Revision 0

FFTF - A History of Safety and Operational Excellence

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management
Project Hanford Management Contractor for the
U.S. Department of Energy under Contract DE-AC06-96RL13200
Fluor Hanford
P.O. Box 1000
Richland, Washington

HNF-11406-FP
Revision 0

FFTF - A History of Safety and Operational Excellence

D.L. Nielsen
Fluor Hanford, Inc.

Date Published
June 2002

To Be Presented at
American Nuclear Society 2002 Winter Meeting

American Nuclear Society
Washington, D.C.

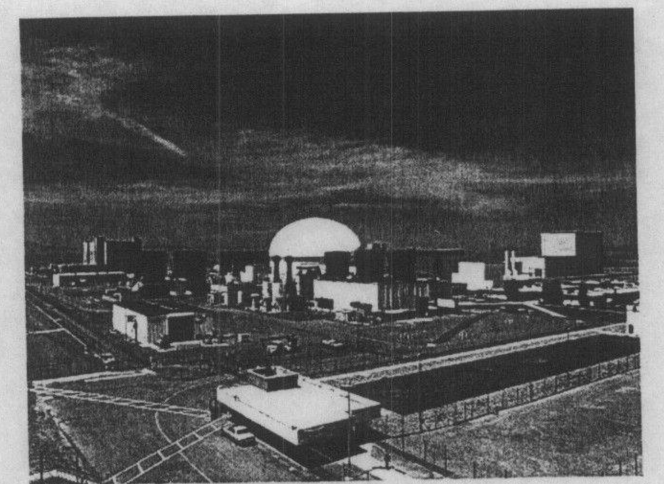
November 17, 2002

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Project Hanford Management Contractor for the
U.S. Department of Energy under Contract DE-AC06-96RL13200
Fluor Hanford
P.O. Box 1000
Richland, Washington

Chris Willingham 6/26/02
Release Approval Date

FFTF – A History of Safety and Operational Excellence



Authors
D. B. Klos
T. M. Burke
D. L. Nielsen

Introduction

The Fast Flux Test Facility (FFTF) is a 400-megawatt, sodium-cooled, fast neutron flux reactor owned by the United States Department of Energy (DOE) at the Hanford Site. The reactor was designed and built in the late 1970s and brought on line in 1982 during a period when world interest in development of a liquid metal breeder reactor was high. For approximately 10 years, FFTF operated successfully as a national research facility testing advanced nuclear fuels, materials, components, active and passive reactor safety technologies, and gaining operating experience for the next generation of nuclear reactors. FFTF also produced a wide variety of high purity medical isotopes, made tritium for the U.S. fusion research program, and provided international testing support. The reactor was last operated in 1992 and is proceeding with deactivation.

FFTF Safety Features and Accomplishments

FFTF was built to modern reactor standards and has many features which contribute to a high level of plant safety. Prior to the shutdown of FFTF, DOE was performing a Probabilistic Risk Assessment (PRA) for operation. Preliminary results (based on 50% completion) indicated that the probability of occurrence of a severe accident at FFTF was approximately 100 times less than at a typical commercial light water reactor due to its unique design and safety features. It is the only DOE reactor that was built in accordance with the standards established by the American National Standards Institute and American Society of Mechanical Engineers. FFTF made significant contributions to development of new standards and codes for special applications of fast reactor technology. Prior to initial operation, the Nuclear Regulatory Commission (NRC) and the Advisory Committee on Reactor Safeguards (ACRS) performed an extensive review of the plant design and Final Safety Analysis Report, the same review process that commercial reactors undergo.

Liquid-metal-cooled reactors and FFTF in particular have a number of important safety characteristics inherent in their design. The sodium coolant used in FFTF has a very high thermal conductivity (approximately 100 times higher than water) and during normal operation, and even under most accident conditions, the fuel cladding operated only a few degrees above the coolant temperature. A major concern for water-cooled reactors is the loss-of-coolant accident (LOCA). Sodium has a very high boiling point (>1600 degrees Fahrenheit) and thus the reactor and associated cooling systems operate at essentially atmospheric pressure. As a result, for almost all accident scenarios, there was no concern about boiling away the coolant, and thus overheating the fuel. When combined with the incorporation of guard vessels around each major component of the primary heat transport system and the use of elevated piping outside of the guard vessels, multiple independent and highly unlikely failures would be required to lose the coolant from the core. Operating at essentially atmospheric pressure reduces the probability of leakage and significantly reduces the leak rate in the unlikely event that a leak does develop. The plant was designed with special mitigative features to ensure safety, even if a leak were to occur (e.g., inerting of cells). The Reactor Shutdown System was extremely reliable and met modern commercial reactor design standards. Both redundancy and diversity were incorporated into the system to ensure an automatic reactor shutdown (scram) when any of the key operating parameters exceeded established values. The FFTF core was designed to ensure that the overall power coefficient was negative throughout the operating range. This means that any perturbation to the reactivity of the core tended to be self-correcting and self-limiting. Heating of the core reduced the reactivity, thus drove it to a lower power level. FFTF was designed to perform emergency core cooling by natural circulation of the sodium coolant. No active equipment, such as pumps, was required. The natural circulation tests conducted confirmed that the operating characteristics of properly-designed liquid metal systems, coupled with the excellent heat transfer properties of sodium, provide for inherently safe, reliable, and self-regulating heat removal under emergency conditions.

FFTF has proven to be extremely robust and flexible, allowing it to be used for a variety of purposes beyond its original mission. Extensive instrumentation and characterization of the reactor and heat transport system supported a wide variety of tests that were performed to demonstrate the safety characteristics of Liquid Metal Reactors (LMRs). Instrumentation measured the coolant flow and temperature at the exit of each core subassembly and specially instrumented assemblies could be installed within the core region to provide detailed core operating data. For example, fueled open test assemblies placed thermocouples within the core region during verification of the natural circulation decay heat removal process. These capabilities were also used during later testing performed to provide additional detailed information on the reactivity feedback characteristics of the reactor and during demonstration testing of devices designed to further enhance the inherent safety of LMRs. These devices, called Gas Expansion Modules (GEMs), used natural forces to introduce negative reactivity in case of a loss of flow accident.

FFTF provided important operational data on the performance of liquid sodium as a heat transport medium and demonstrated the reliability and efficiency of pumps, valves and other vital liquid metal reactor components. FFTF demonstrated that thin-walled stainless steel clad fuel pins have an extremely low failure rate in a high temperature sodium environment. The reference driver fuel system performance was outstanding to goal burnups of 100,000 MWd/MTM (over 40,000 mixed oxide fuel pins were irradiated with only a single failure). A three year driver fuel system (Core Demonstration Experiment) exceeded 238,000 MWd/MTM burnup. The reactor achieved an operational efficiency factor over 90 percent (100% was achieved for two of the years) during its 10 years of operation.

FFTF produced many results that went beyond original expectations. Proof testing of core components showed that their lifetimes could be increased by factors of three to five. Operational tests showed that the passive safety features of liquid metal cooled reactors provide from 50 to 100 percent additional margin for plant protection systems. Operational experience demonstrated the reliability of the tag gas system used to locate failed fuel pins.

Conclusions

FFTF demonstrated the safety, reliability and maintainability of the LMR through its 10 years of operating excellence. It was considered a premiere nuclear research facility and had the versatility to support multiple research activities and provide irradiation services to researchers both nationally and internationally.