Conf-821205--2

UCRL- 88174
PREPRINT

UCRL--88174

DE83 000744

The Spent-Fuel Test-Climax: A Progress Report

W. C. Patrick
L. B. Ballou

MASTER

NWTS Program Information Meeting
Las Vegas, Nevada
December 14-16, 1982

September 20, 1982

Lawrence Livermore National Laboratory

THE SPENT FUEL TEST-CLIMAX: A PROGRESS REPORT

W. C. Patrick and L. B. Ballou
Lawrence Livermore National Laboratory

Introduction

The Spent Fuel Test-Climax (SFT-C) is being conducted under the technical direction of the Lawrence Livermore National Laboratory (LLNL) for the U.S. Department of Energy[1]. The test was funded as part of the Nevada Nuclear Waste Storage Investigations (NNWSI) beginning in June 1978. Facility construction[2] and spent fuel handling system fabrication[3] provided for emplacement of eleven spent fuel assemblies from an operating commercial nuclear power plant into test storage in April-May 1980 (Fig. 1).

We are pursuing both operational and technical objectives at the SFT-C. The principal operational objective is to demonstrate the safe and reliable packaging, handling, and storage of spent nuclear reactor fuel in a deep geologic media and to retrieve the fuel afterward. Packaging of the spent fuel at the Engine Maintenance, Assembly and Disassembly (EMAD) facility, initial emplacement 420m below surface in the Climax granitic stock, and three subsequent exchanges of fuel canisters between EMAD and the SFT-C has demonstrated that application of straightforward engineering practices provides a safe and highly reliable system with no significant radiation exposure to the operating personnel.

Broad interest has been shown in the engineering and demonstration aspects of the test. Through August 1982, 287 tours for approximately 3800 representatives of technical, public interest, and governmental organizations from 23 countries have been conducted at the facility.

The primary technical objectives of the test are simulation of the thermal effects occurring in a panel of a large repository and comparison of the relative effects on the granitic host rock of heat alone versus heat in combination with ionizing radiation. Other technical objectives direct project activities toward instrument evaluation, ventilation effects, thermal and thermomechanical response of a jointed rock mass, and computer model validation. Since these technical objectives also address issues in other media, the SFT-C compliments NWTS research programs in other geologic media. Early results of the technical measurements program at the SFT-C are provided by Carlson, et al.[4]

Recent Findings

An extensive field measurements program provides data to address test objectives. Laboratory studies provide data on critical phenomena which may be masked by the high variability of in situ conditions.

The reliable performance of the data acquisition system and instrumentation are essential to meeting the technical objectives of the test and are therefore evaluated here. The HP-1000 based data acquisition system which records data from nearly 1000 instruments is functioning reliably; the monthly average of the functionally disabled index (FDI) has not exceeded $\sim$ 10% since May 1980. This high degree of reliability is a direct result of utilizing two computers which augment each other's performance -- the FDI for

*This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under contract No. W-7405-Eng-48.

an individual computer often exceeded 25%. System accuracy has been within a ±4 microvolt and a ±9.2 milliohm window for DC voltage and resistance, respectively[6]. Over 6 million data records have been acquired for analysis.

Instrumentation has also functioned reliably with two exceptions. First, a group of linear potentiometers failed by becoming nonlinear in resistance. Second, nearly all of 18 vibrating-wire stressmeters failed due to internal corrosion[7]. Replacement of these transducers has occurred and instrument evaluation continues.

Near- and intermediate-field temperature measurements show that conditions in the repository model cell closely approximate those calculated (Fig. 2). This indicates a high level of success in modeling heat transfer in the rock mass. We are currently investigating possible sources of the 1-5°C differences observed[6].

Ventilation and dewpoint measurements indicate that about 13.3% (75 WM•h) of the input energy to the SFT-C was removed in the ventilation airstream; as compared to about 1/3 calculated. Of this total, 74% was removed as sensible heat and 26% was removed as latent heat of vaporization. The latter is the result of removing 31,000ℓ of water from the facility in the airstream during the first 1 1/2 years of spent-fuel storage. Measured heat removal rates vary significantly from those calculated (Fig. 3), indicating that we are inadequately modeling the complexities of heat transfer into the airstream and out of the facility through the ventilation system[6].

Agreement between measured and calculated displacements has been quite good[8]. Displacements in most locations have not exceeded 2 mm, as measured over distances of 3.5 to 6 m (Fig. 4). The good agreement observed to date implies that geologic features are not as significant during the heated phase of the experiment as they were during the mine-by experiment.

Acoustic emission (AE) monitoring records the occurrence of small-scale fracturing in the granite. These AE "events" are typically the result of stress-induced fractures a few centimetres in length. Background rates of 2-3 events per week were recorded. This rate increased dramatically to 15-20 events per week shortly after the spent fuel was emplaced and the heaters were energized. With the exception of two periods of activity in excess of 10 events per week, rates have returned to a low rate of a few events per week[6,9]. As expected, no instability of boreholes or underground openings has occurred as a result of this small-scale fracturing.

Radiation-dose-to-granite measurements have indicated several problems in current measurement technology in a high dose, elevated temperature environment. Annealing and fading effects during and after irradiation lead to complex calibrations for the dosimeters and high levels of variability in the data[10]. Due to this variability, comparison with pre-test dose calculations has not been meaningful to date.

Laboratory investigations of Climax granite indicate a statistically significant degradation in uniaxial compressive strength (∿20%) and Young's modulus (5-10%) after gamma irradiation at a total dose of 13 MGy. Brazilian tensile strength of the same material was not measurably affected by the same treatment[5].

Future Plans

The SFT-C was originally planned to be a 3-5 year test. The technical measurements support a storage phase duration of three years, since essentially all of the thermal and thermomechanical response of the rock will have been recorded by that time. We therefore plan to retrieve the spent fuel and place it in lag storage at EMAD in FY 1983.

We will continue to monitor the response of the facility during an approximately six-month cool-down period. Post-test sampling and analysis of geologic and man-made materials will follow. Field activities will be completed by the end of FY 1984 and final test documentation will be completed by mid-FY 1985. Plans for the future utilization of the SFT-C facility are being considered.

References

1. Technical Concept for a Test of Geologic Storage of Spent Reactor Fuel in the Climax Granite, Nevada Test Site; L. D. Ramspott, et al., LLNL UCRL-52796, June 1979.

2. Excavation and Drilling Activities Associated with a Spent Fuel Test Facility in Granitic Rock; W. C. Patrick and M. C. Mayr; LLNL UCRL-53227, November 1981.

3. Spent Fuel Handling System for a Geologic Storage Test at the Nevada Test Site; J. E. Duncan, P. A. House, and G. W. Wright; LLNL UCRL-83728, May 1980.

4. Spent Fuel Test-Climax Technical Measurements Interim Report FY 1980; R. C. Carlson, et al., LLNL UCRL-53064, December 1980.

5. The Effect of Gamma Irradiation on the Strength of Climax Stock Granite; W. B. Durham, LLNL UCRL-87475 March 1982.

6. Spent Fuel Test-Climax: Technical Measurements Interim Report FY 1981; W. C. Patrick, et al., LLNL UCRL-53294, April 1982.

7. Instrumentation Report #2: Identification, Evaluation, and Remedial Actions Related to Transducer Failures at the Spent Fuel Test-Climax; W. C. Patrick, R.C. Carlson, and N. L. Rector, LLNL UCRL-53251, November 1981.

8. Calculated and Measured Drift Closure During the Spent Fuel Test in Climax Granite; J. L. Yow, Jr., and T. R. Butkovich; LLNL UCRL-87179, April 1982.

9. "ASP: An Automated Seismic Processor for Microearthquake Networks", T. V. McEvilly and E. L. Majer, Bull. Seismol. Soc. Am., v. 72, #1, 1982.

10. Climax Spent Fuel Dosimetry Progress Report, September 1980-September 1981, W. Quam and T. DeVore, LLNL Contractor Report UCRL-15419, EG&G 1183-2432, 1981.

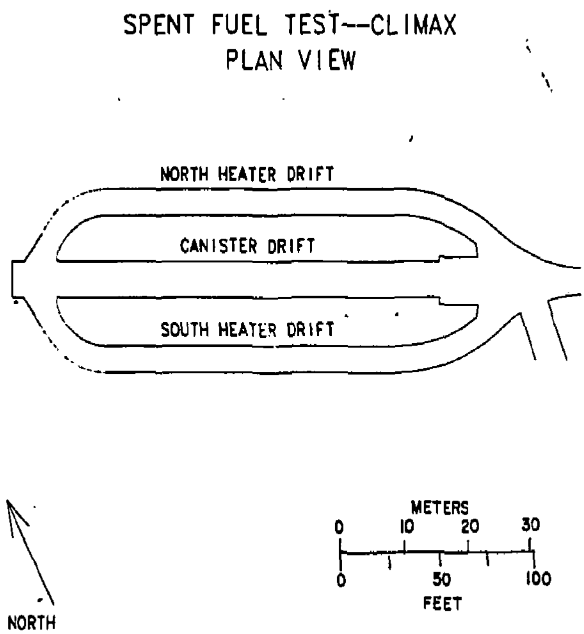

Fig. 1 - Plan view of the Spent Fuel Test-Climax.

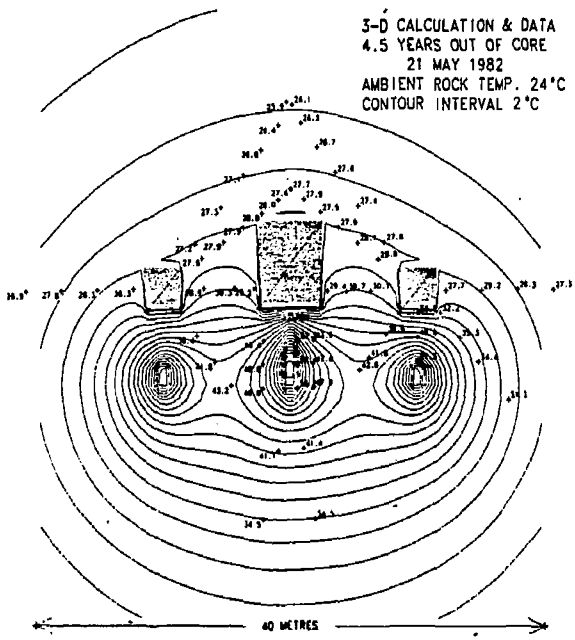

Fig. 2 - Measured temperatures and calculated temperature contours for a cross-section through the Spent Fuel Test-Climax.

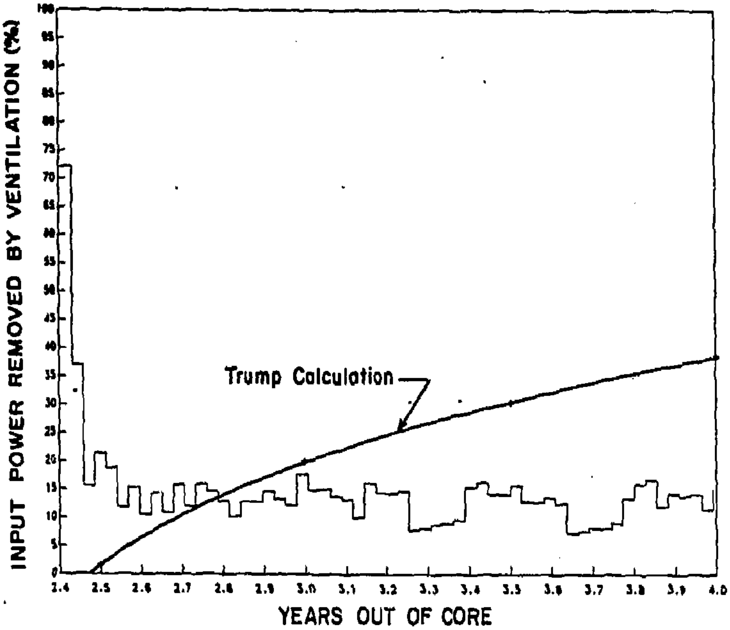

Fig. 3 – Measured and calculated percentages of input power which are removed by ventilation.

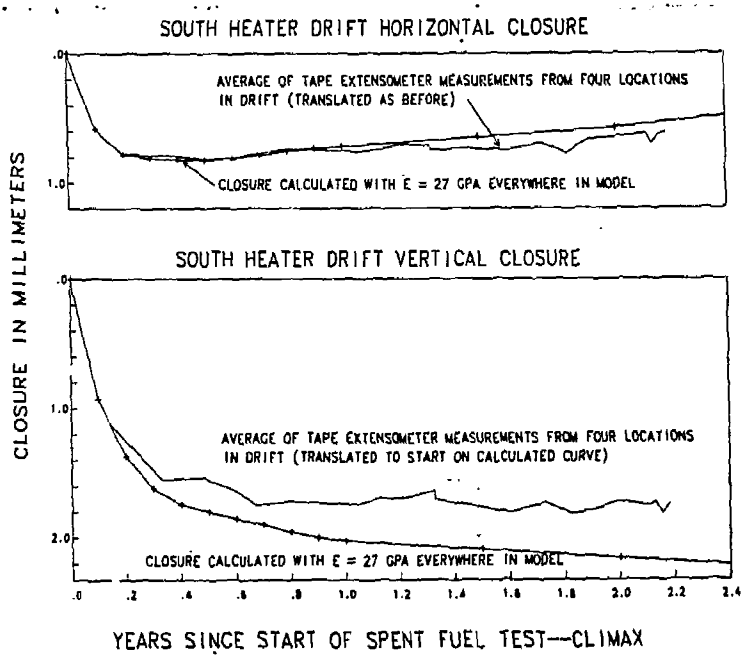

Fig. 4 – Measured and calculated closures of the south heater drift.

Technical Information Department · Lawrence Livermore Laboratory
University of California · *Livermore, California 94550*