FAST FLUX TEST FACILITY

THE FIRST THREE YEARS

HANFORD ENGINEERING DEVELOPMENT LABORATORY OPERATED BY WESTINGHOUSE HANFORD COMPANY, A SUBSIDIARY OF WESTINGHOUSE ELECTRIC CORPORATION PREPARED FOR THE U.S. DEPARTMENT OF ENERGY UNDER CONTRACT NO. DE-AC06-76FF02170

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preface

The concept of nuclear fission as a source of unlimited energy was made popular by H.G. Wells in 1913. Science fiction became scientific fact in 1934, when Enrico Fermi in Italy split the uranium atom, and the race to produce energy from spontaneous fission reactions began.

In 1943, experiments conducted with plutonium indicated that it was theoretically possible for the fission process to produce more fuel than was consumed. Over the next twenty years, the United States Atomic Energy Commission (AEC) initiated the technological development necessary to turn this theory into reality. The concept of "breeding" fuel, as it was called, was demonstrated in 1953 when more plutonium 239 was produced than uranium 235 was consumed in a fast neutron environment.

During the 1960s, steady growth in both population and power consumption prompted national interest in a nuclear power plan that would provide for long-term growth of the U.S. economy. In 1962, the AEC recommended a national breeder reactor program to intensify development of breeder technology through experiments in fast neutron physics. In 1966, the Fast Flux Test Facility was authorized to develop and test the fuels, materials and reactor components for use in fast breeder reactors.

The sodium-cooled FFTF is the largest test reactor of its kind in the world. This is the story of its conception in 1965, its design and construction in the 1970s, and its operation during **The First Three Years,** 1982 to 1985.

acknowledgments

FFTF Administration acknowledges with thanks the efforts of the Westinghouse Hanford Company management and technical staffs for reviewing drafts of this document and making many helpful comments and suggestions.

The First Three Years was produced by Senior Technical Editor Nancy Kenny and Senior Illustrator Ron Wick of Communications Services.

The Fast Flux Test Facility. ➔

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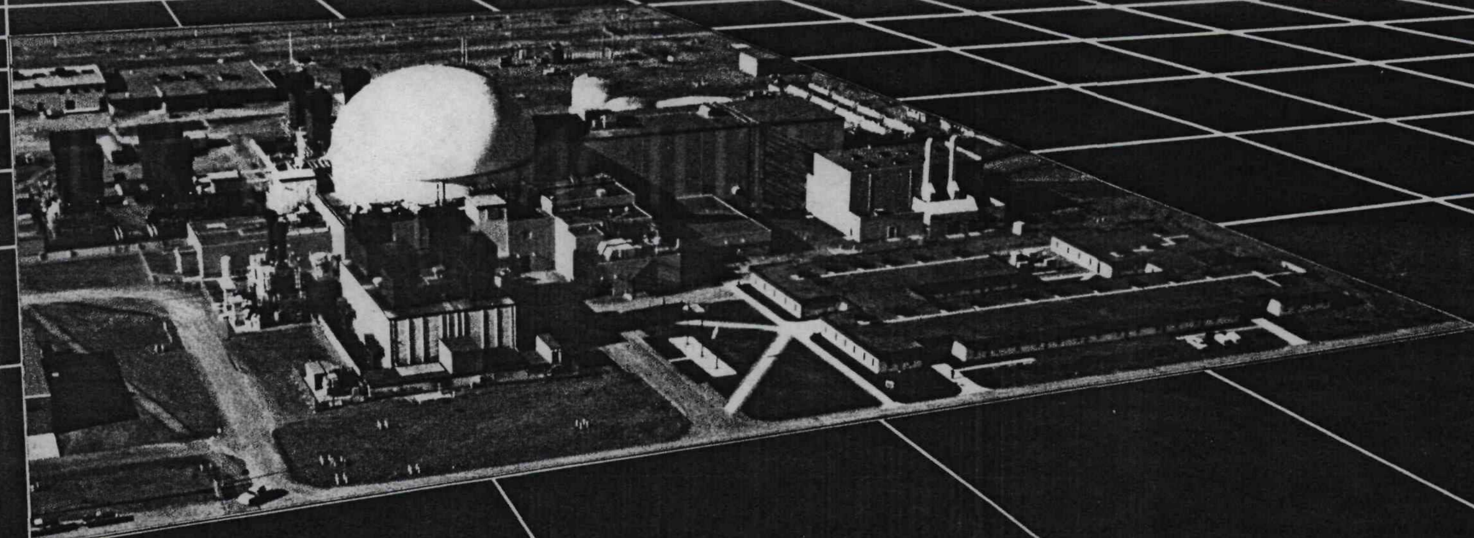
FAST FLUX TEST FACILITY



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mission and major accomplishments

The plan to build a breeder reactor began to take shape in 1967 when the Hanford site at Richland, Washington was chosen as the home of the first large-scale breeder test reactor. The plan was culminated on April 30, 1982, with dedication of the Fast Flux Test Facility (FFTF).

In 1970, the Department of Energy selected Westinghouse Hanford Company, a wholly owned subsidiary of the Westinghouse Electric Corporation, to manage the design, construction, and operation of the FFTF as part of the Hanford Engineering Development Laboratory. The Advanced Reactors Division of the Westinghouse Electric Corporation, Pittsburgh, Pennsylvania, was the reactor designer; and Bechtel Power Corporation, San Francisco, California, was the architect-engineer and construction manager. In addition, more than 300 companies across the nation provided components, materials, and fuel for the FFTF.

mission

The primary mission of the FFTF is to test full-size nuclear fuels and components typical of those to be found in a commercial liquid metal reactor. To accomplish this mission, the Department of Energy established two fundamental objectives:

- First, the reactor plant technology would support the liquid metal reactor industry by developing fuel assemblies, control rods, and other core components whose life-spans could be proven to be economical in commercial, power-generating applications.
- Second, the reliability of the FFTF would be proven by matching or exceeding the operational performance of commercial light water plants. Safe, reliable, and economic operation of the FFTF would be achieved through administrative controls, technical specifications, and operating procedures.

In its first three years, the FFTF has met and exceeded many of these goals. For example, the plant operated for 113 consecutive days at power, with 101 consecutive days at full power in Cycle 4; it achieved cycle capacity factors as high as 99.5 percent, and yearly capacity factors of 41, 57, and 66 percent in 1982, 1983 and 1984, respectively.

This high level of operating efficiency has provided vital data on the performance of liquid sodium as a safe and efficient heat transport medium and has confirmed the reliability of many of its large-scale components.

accomplishments

Fuel performance during this time was extraordinary with no failures in the more than 30,000 commercially produced driver fuel pins irradiated to date. An experimental full-size assembly has achieved 129,000 megawatt days per metric ton of metal (MWd/MT) of burnup and a standard driver assembly has reached 119,000 MWd/MT. Fuel systems capable of operating lifetimes three to four times longer than earlier fuel systems are currently under irradiation.

The FFTF was named one of the "Ten Outstanding Engineering Achievements of 1982" by the National Society of Professional Engineers. The facility was cited specifically for "achievements in high-temperature structural design, seismic design, mechanical properties and fabrication, nondestructive testing, and coolant technology." Also noted were FFTF's excellent safety record and high standards of quality throughout construction and operation.

EFPD is equivalent full-power days.

AVAILABILITY FACTOR is a measure of the time the plant is available to conduct irradiation testing activities in a given period.

CAPACITY FACTOR is a measure of the plant's performance at full power over a given period of time. It is the number of megawatt days achieved, divided by the product of calendar days in the reporting period and a small correction for periods of high ambient temperatures.

Nationally known leaders were included among the speakers at the April 30, 1982 dedication ceremonies at the Fast Flux Test Facility site, 13 miles north of Richland, Washington. Here, John Nolan, president of Westinghouse Hanford Company, speaks to the crowd of more than one thousand. ➔


Visitor Center

background

The FFTF provides tests of reactor fuels and materials in a controlled, instrumented, fast flux environment to satisfy the diverse needs of liquid metal technology development.

The FFTF plant is an 86,103 sq. ft. complex of buildings and equipment arranged around a reactor containment building. The reactor is located in a shielded cell in the center of the containment building. Heat is removed from the reactor by liquid sodium circulating under low pressure through three primary coolant loops. (This is in contrast to conventional reactor plants that use water circulated under high pressure.) An intermediate heat exchanger separates radioactive sodium in the primary system from nonradioactive sodium in the secondary system. Three secondary sodium loops transport reactor heat from the intermediate heat exchangers to the air-cooled tubes of the twelve dump heat exchangers.

Instrumentation and control equipment provides monitoring and automatic control of the reactor and heat removal facilities; automatic reactor shutdown (scram) if preset limits are exceeded; and computerized collection, handling, retrieval, and processing of operating and test data.

Onsite utilities and services include emergency generation of electrical power, heating and ventilation, radiation monitoring, fire protection, and auxiliary cooling sytems for plant equipment and components.

The FFTF is the only U.S. liquid metal reactor built and maintained to American Society of Mechanical Engineers codes. Complementary standards have been developed for safety, testing, and quality assurance issues involved in breeder reactor technology.

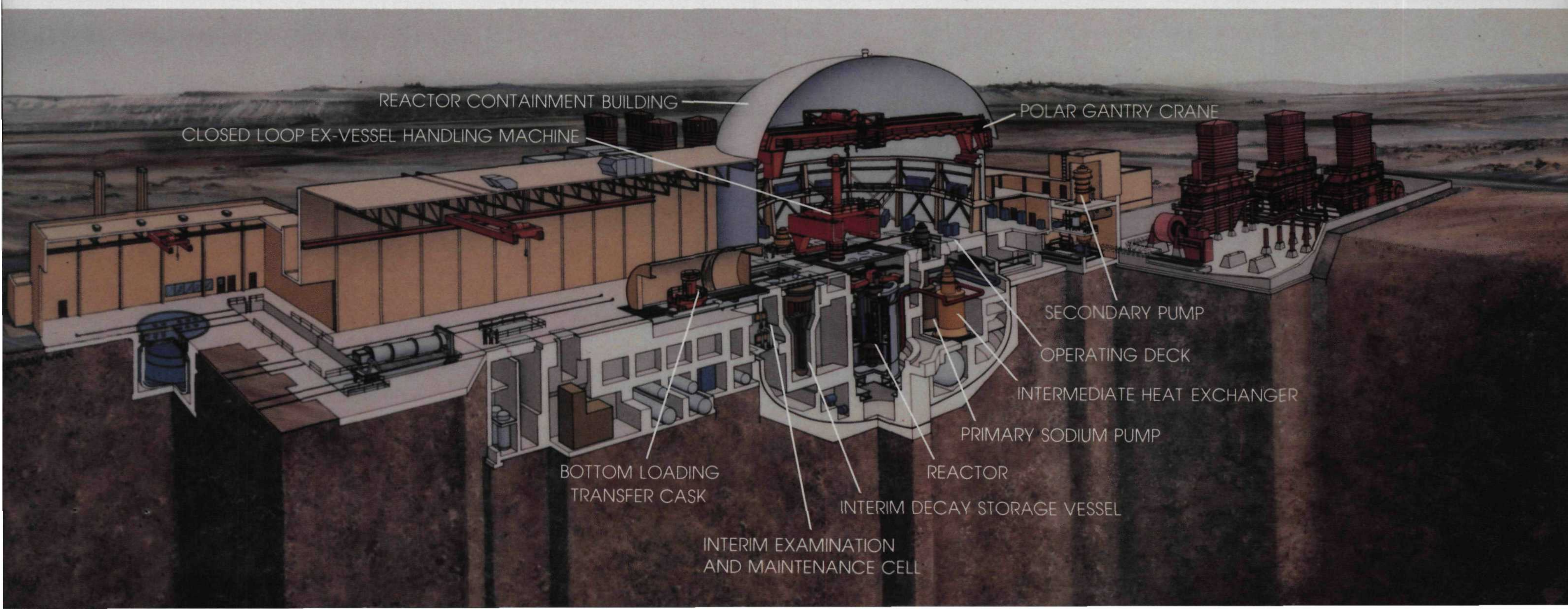
The FFTF includes facilities for receiving, conditioning, storing, and installing core components and test assemblies. Examination and packaging capabilities for offsite shipment are provided, as well as for radioactive waste disposal.

Approximately 250 employes are assigned to the FFTF plant organization. They perform reactor operations; refueling, examination and decontamination; engineering; physics and irradiation testing; planning and scheduling; procedures and document control; operational analysis and support. An additional 200 employes offer support in the areas of maintenance, training, quality assurance, and radiation monitoring.

The Fast Flux Test Facility is located on the U.S. Government's Department of Energy Hanford Site near Richland, Washington. ➧

Reactor Containment Building Cutaway showing the location of major components. ➧


REACTOR CONTAINMENT
BUILDING
REACTOR SERVICE
BUILDING
DUMP HEAT
EXCHANGERS
FUEL STORAGE
FACILITY
COOLING
ADS AND TOWERS
INCONTAINMENT
CHILLED WATER
EQUIPMENT BUILDING
WATER TANKS


REACTOR CONTAINMENT BUILDING
CLOSED LOOP EX-VESSEL HANDLING MACHINE
POLAR GANTRY CRANE
SECONDARY PUMP
OPERATING DECK
INTERMEDIATE HEAT EXCHANGER
PRIMARY SODIUM PUMP
REACTOR
BOTTOM LOADING
TRANSFER CASK
INTERIM DECAY STORAGE VESSEL
INTERIM EXAMINATION
AND MAINTENANCE CELL

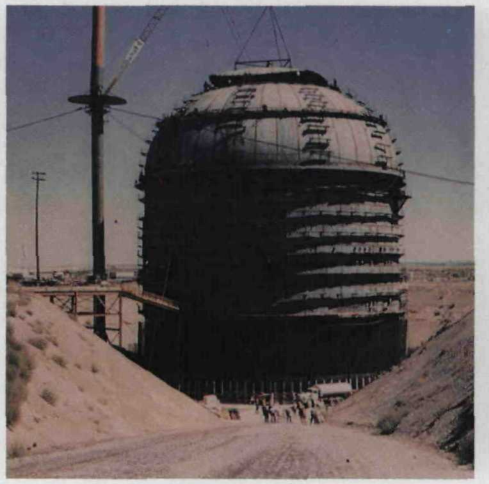
major construction milestones

1965 -	April	conceptual design development authorized
1967 -	January	richland, washington chosen as site
1969 -	September	construction site grading started
1970 -	November	groundbreaking commenced
1971 -	January	excavation for containment vessel completed
1972 -	August	top head placed on containment vessel
1973 -	April	rebar installed for reactor cavity
	November	concrete roof slab and walls of control building completed
1974 -	November	reactor vessel lowered into place
	December	main support structure and reactor vessel installed
1975 -	January	polar gantry crane placed inside reactor containment building
	July	*reactor vessel closure head installed*
	August	first primary pump placed into containment
1976 -	January	installation of lower reactor internals completed
	May	reactor component installation completed
	October	last dump heat exchanger erected
1977 -	January	first secondary sodium pump installed
	June	last primary sodium pump installed
	October	all twelve dump heat exchangers completed
1978 -	May	integrated leak rate test of reactor containment vessel completed
	July	sodium fill of secondary heat transport system (HTS) started
	September	reactor construction completed
	December	sodium fill of FFTF completed with fill of primary loops and reactor vessel
1979 -	February	maximum isothermal system temperature (MIST) testing of HTS started
	March	natural circulation test conducted in HTS and MIST testing completed
	May	secondary HTS natural circulation test conducted
	June	installation of control rods in reactor completed
	July	reactor service building extension construction underway
	November	fuel loading of reactor started
1980 -	February	reactor criticality achieved

Site drilling, September 1969.

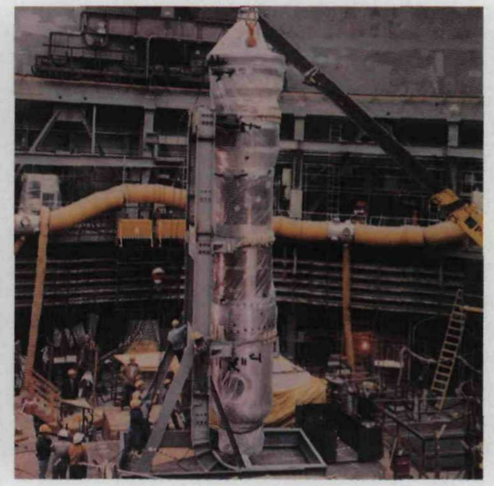
Excavation Complete, January 1971.

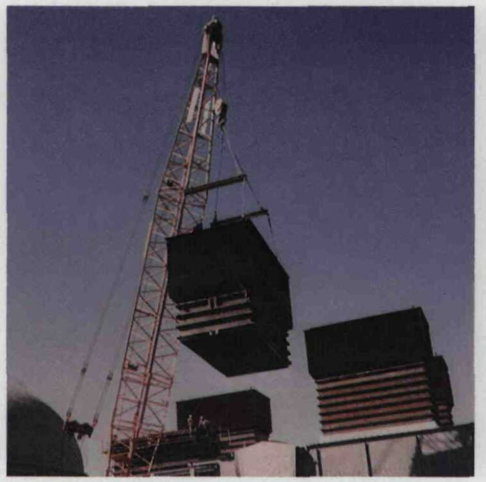
Dome placed, August 1972.



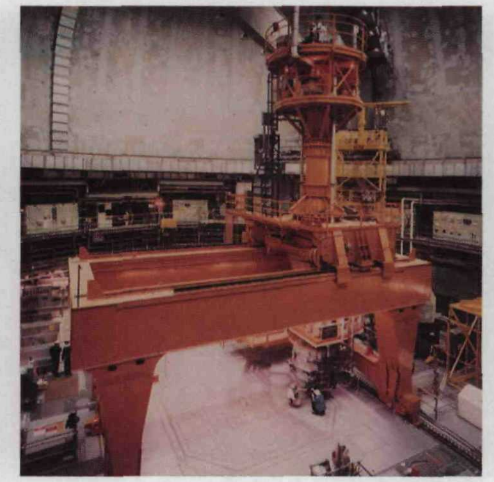
Reactor vessel placed, December 1974.

First pump installed, September 1975.

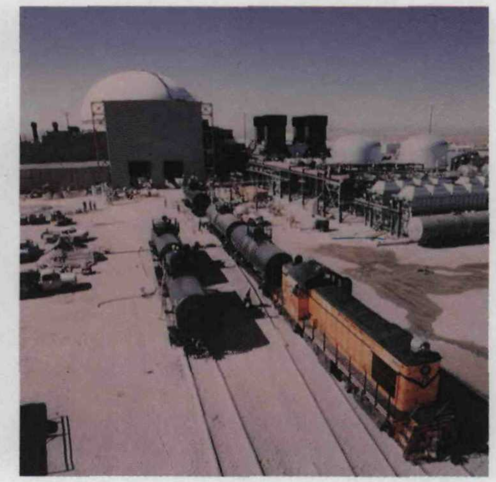




Last DHX erected, October 1976.



Closed-Loop Ex-Vessel Handling Machine installed, April 1978.



Sodium fill started, July 1978.

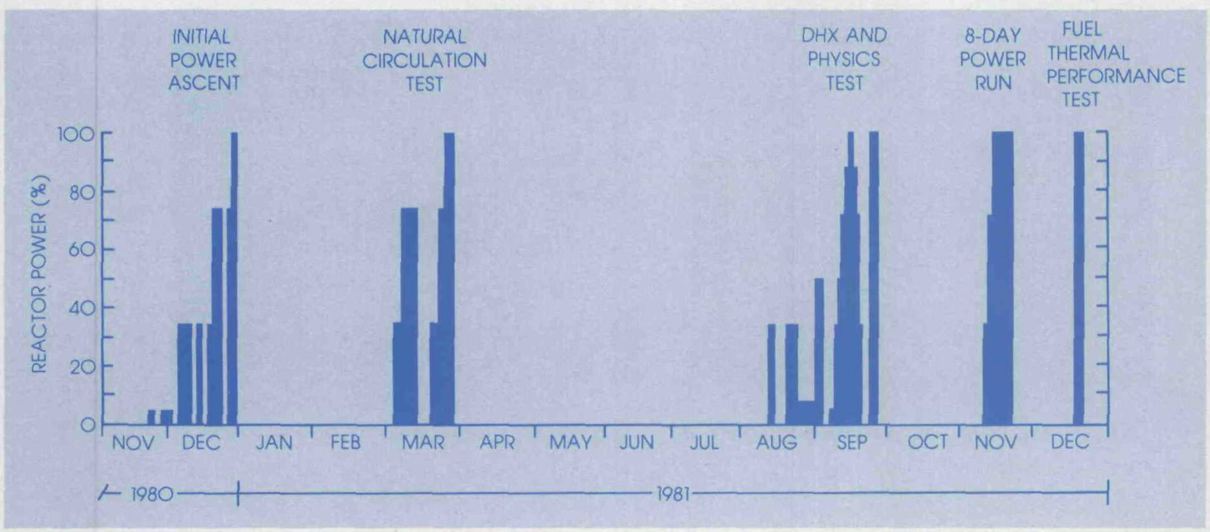
acceptance testing

Field testing began on plant systems as early as 1974, but the rigorous testing required to bring the plant to power operation began in 1978 with preparations for the sodium fill of the heat transport systems. In the following two years, over 160 acceptance tests were conducted.

Plant acceptance testing was divided into five phases. The first two phases verified component and system readiness before beginning sodium fill (December 1978) and fuel loading (November 1979). Phase III (December 1979) established inert atmospheres in the heat transport system and the cells containing primary sodium piping, and finally introduced sodium into both the primary and secondary coolant systems.

Initial criticality (February 1980) took place during Phase IV. Phase V (December 1980) brought the plant to full power, characterized the reactor core, and completed the final tests of the plant coolant systems.

Successful completion of the natural circulation test at full power (March 1981) was clearly a major milestone for the FFTF project and represented a significant contribution to liquid metal technology. The test confirmed that the low-pressure, high-temperature operating characteristics of liquid-metal systems, coupled with the excellent heat transfer properties of sodium, provide an inherently safe, reliable, and self-regulating emergency heat removal system. This test was the final major acceptance test of the reactor and the heat transport system design features.



HISTOGRAM

Extensive reactor core characterization measurements were then made to provide the neutron and gamma spectra, fission rates, and other physics data needed to design and evaluate tests to be irradiated in the FFTF. Initial measurements used active sensor thimbles located near the center of the core. Follow-on measurements were made using passive foil experiments that were widely distributed throughout the core in two separate irradiation periods, one at low power and the other at high power.

All nuclear parameters were well within the operating envelope. Temperature and power coefficients were substantially negative. Stability margins were large and reproducible. Reactivity measurements remained well within limits and in good agreement with predicted values.

The entire acceptance test program provided extensive insight into the details of sodium, control, and inert gas system operations, as well as into the operating characteristics of liquid metal reactors. Significant advances were made in structural and seismic analyses, as well as core performance analysis.

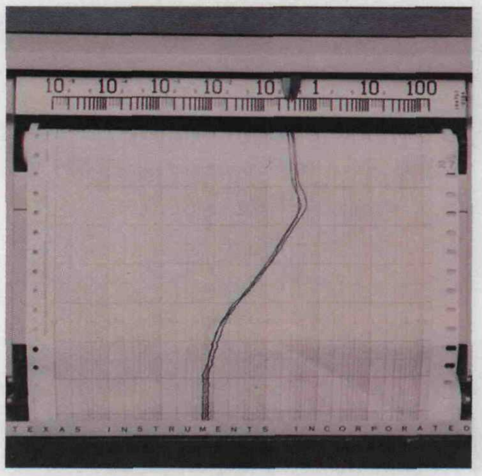
Plant system performance during the 32 equivalent full-power day (EFPD) testing program fully confirmed the design bases for systems and components.

The reactor plant acceptance test program ended with FFTF's first operating cycle on April 16, 1982.

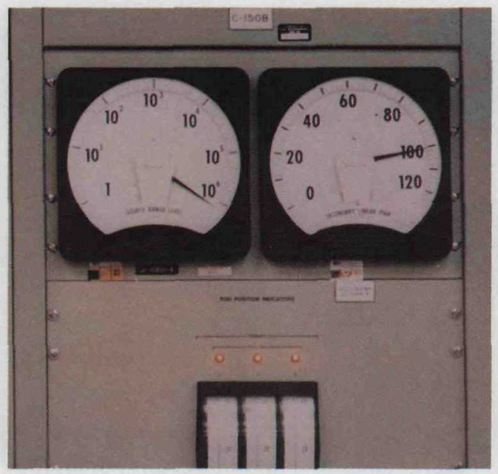
Phase I, Component readiness.

Phase II, System readiness.

Phase III, Sodium fill.



Phase IV, Initial criticality.



Phase V, Full power.

plant performance

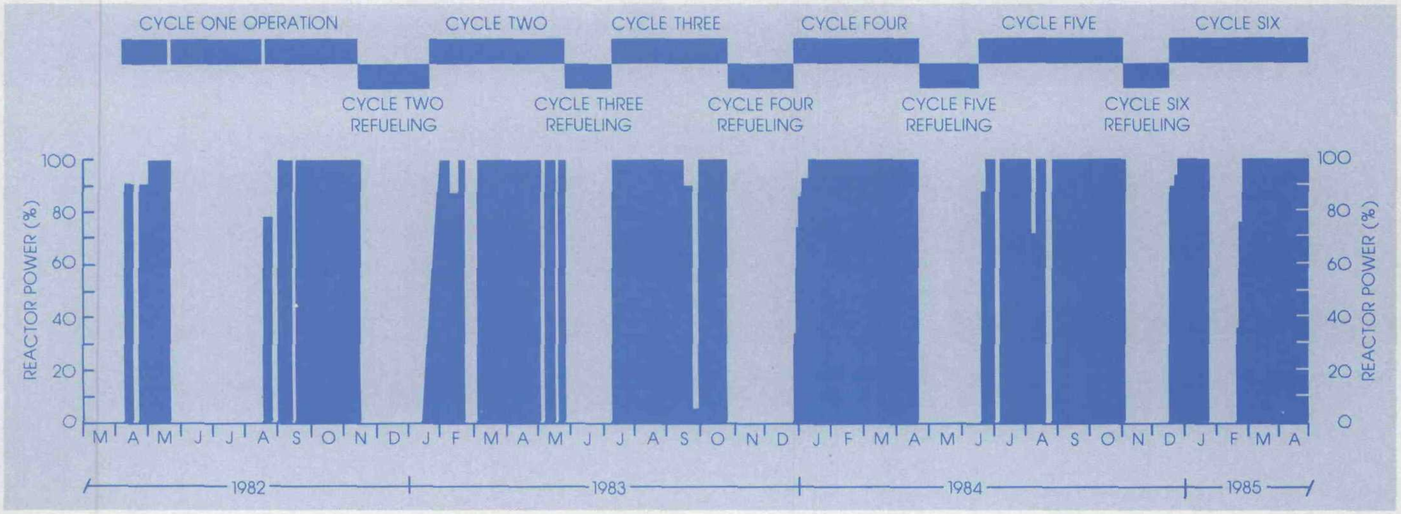
operating statistics

	CYCLE 1	CYCLE 2	CYCLE 3	CYCLE 4	CYCLE 5	CYCLE 6 (TO 3/1/85)
EFPD FOR CYCLE:	101.5	100.5	101.5	109.5	122.7	35.3
TOTAL PLANT EFPD AT END OF CYCLE:	134.3	234.8	336.3	445.8	568.5	603.8
CYCLE CAPACITY FACTOR (%):	50.3	83.1	93.5	99.5	93.5	52.9
AVAILABILITY FACTOR (%):	53.0	90.6	99.0	100.0	94.6	57.5
MAXIMUM FUEL BURNUP AT END OF CYCLE (MWd/MT):	35,000	60,000	81,000	105,000	129,000	135,000 (PROJECTED)

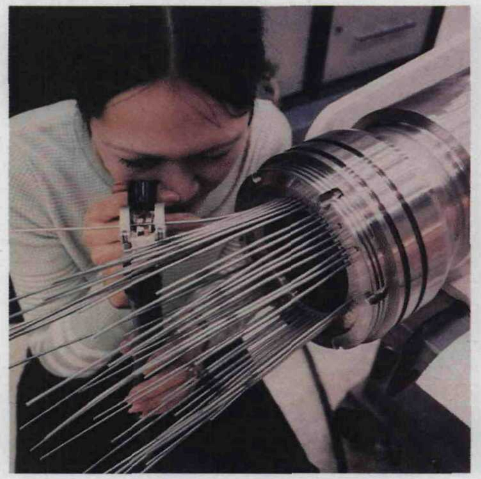
annual operational performance

	1982*	1983	1984
CAPACITY FACTOR (%):	40.5	56.9	66.4
AVAILABILITY FACTOR (%):	42.8	61.1	67.6

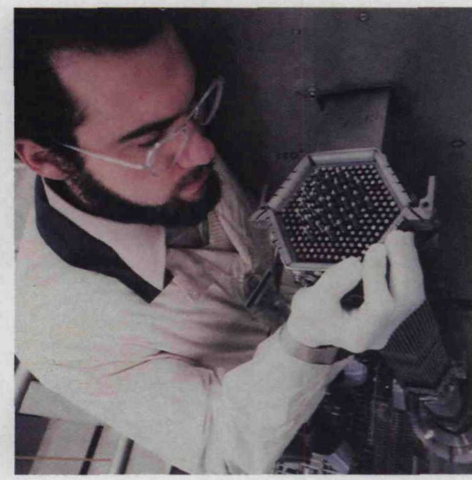
* Reporting began at start of Cycle 1, April 16, 1982



A technician inspects welds on instrument leads on a FOTA – a standard FFTF driver fuel assembly modified to house temperature sensors.



The top of a test assembly pin bundle, before irradiation, is examined by a technician. Extended end caps on 31 retrievable pins allow grappling in the IEM Cell during disassembly.



Glovebox activities are monitored by technicians using gloveports to minimize personnel radiation.

Technicians bend instrumented leads on a FOTA to precise angular and rotational specifications, thus avoiding interference and still fitting the leads within the fuel duct.

Control room watchstanders operate the plant's numerous controls, instrumentation and computers required for plant operation.

One of 40 capsules to be irradiated in MOTA-1 – an international experiment containing materials from the United States, France, Germany and Japan – is assembled by a technician.

plant operation

The first three years of FFTF's operation were characterized by improving system reliability and increasing yearly capacity factors. This performance is indicative of the plant's ability to operate safely and reliably, and supports plans to achieve annual capacity factors as high as 80 percent in the future.

Each of the six operating cycles completed in the first three years brought its own "firsts" or unique operational challenges.

Cycle 1 brought the first use of the tag gas monitoring system when an experimental test assembly developed a pin-hole leak in one of its 217 pins. The system allowed the identification of a leaking assembly through the use of a unique mixture of isotopes placed in the fuel pins during their manufacture. This same identification process was also used in Cycles 4 and 5. A 12-week midcycle shutdown was required to perform maintenance on one of the heat transport system pumps after its shaft had become solidly bound with sodium.

Perhaps the most interesting observation made during the 102-EFPD cycle was that of an increasing pressure drop across the reactor core. As expected, this anomaly continued throughout subsequent operating cycles but at a significantly reduced rate. It has not impacted plant operation.

Cycle 2 introduced the first interactive, temperature-controlled experiment into the reactor. The Materials Open Test Assembly (MOTA) is a special 40-ft-long experiment containing over 2500 material test specimens in 40 separate canisters. A computerized control system allows individual canister temperatures to be measured and independently adjusted in relation to surrounding sodium temperatures. These measurements permit a more accurate correlation between irradiation effects and temperatures than had been previously possible. These correlations are an essential step in the development and demonstration of an extended-life fuel assembly.

During a planned midcycle shutdown, a special power-to-melt test was inserted into the reactor. A controlled, rapid startup was used to induce limited fuel melting in the experiment. The test provided confirmation that limited centerline fuel melting at initial startup would not affect the lifetime of the fuel pins.

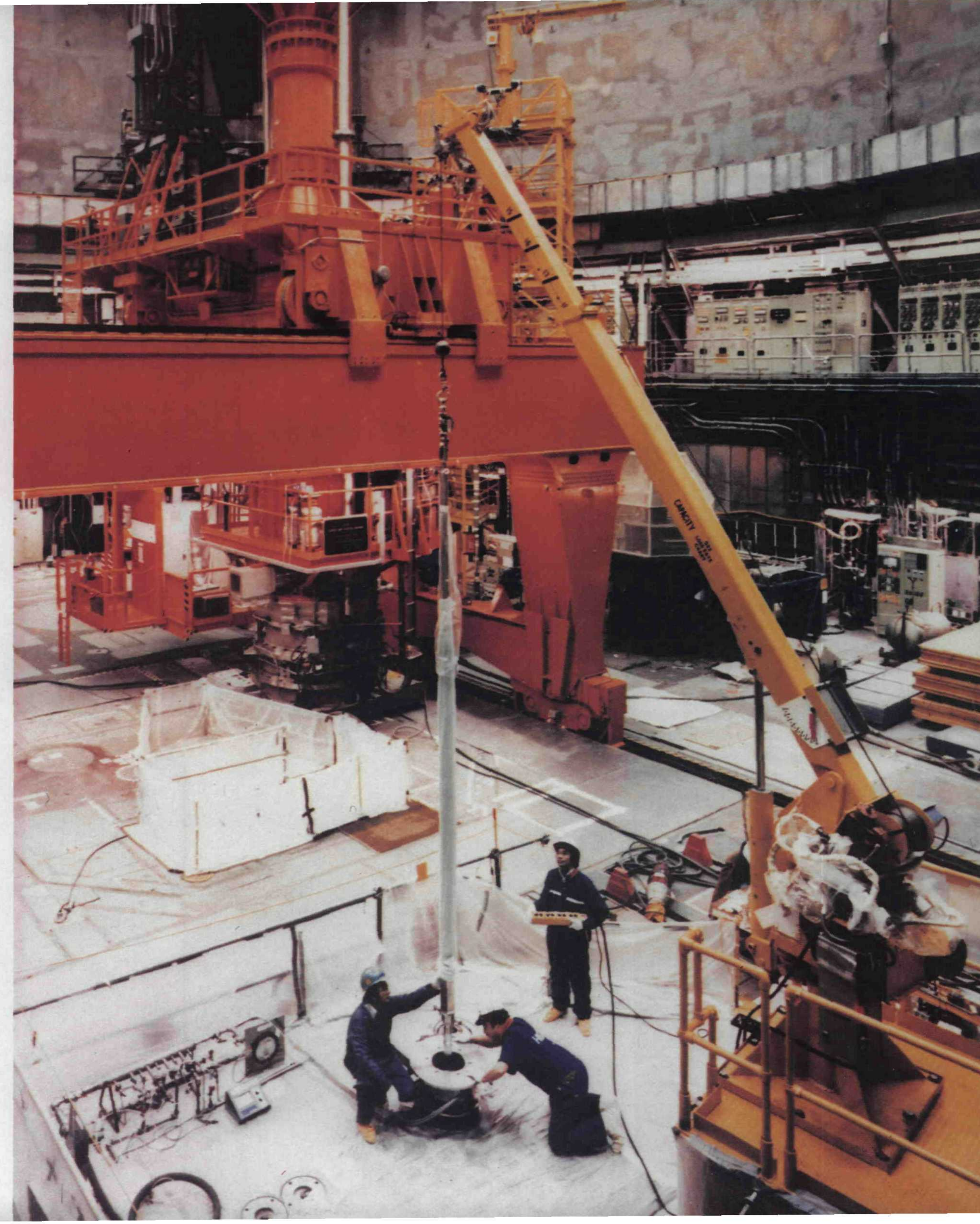
Cycle 3 brought three of the FFTF reference fuel assemblies to their goal burnup of 80,000 MWd/MT. This was a major milestone in FFTF's test program, since it verified the integrity of the fuel design and set the stage for further testing to extend fuel lifetime.

Cycle 4 was completed on April 23, 1984, establishing a world record for breeder reactor operation - 101 consecutive days of full-power operation. This milestone in breeder performance clearly showed the inherent reliability of the plant's fuel system and components and its ability to operate for extended periods. Selected fuel assemblies reached over 100,000 MWd/MT at the end of this cycle.

Cycle 5 was the longest cycle of the plant's operation at 123 EFPD and marked the achievement of two fuel-related milestones: an experimental full-size assembly reached a burnup of 129,000 MWd/MT and a driver assembly reached 119,000 MWd/MT. The latter achievement exceeded the design burnup goal by 50 percent.

Cycle 6 is in progress at our 3-year point. The plant was shut down after 29 EFPD to obtain additional data on performance of the radial reflector assemblies that surround the fueled region of the reactor core. These data will permit a better understanding of irradiation-induced distortion of reflectors. The plant returned to power after the 27-day midcycle outage. Performance of the plant and core components remains excellent.

Between operating cycles, the reactor is shut down for refueling and maintenance. During these periods (which range for 30 to 60 days depending on the nature of the refueling changes to the core) approximately one-third of the fuel, absorber assemblies, and experiments are replaced. Numerous other activities, including in-service inspections, preventive maintenance, instrument calibrations, and routine maintenance are also performed during this time.



fuel performance

The FFTF's driver fuel -- a blend of uranium and plutonium oxides -- has performed flawlessly throughout the five years of startup testing and steady-state operation.

Examinations are underway on standard driver assemblies removed at the end of each major operating period. The ducts, end hardware, and pins are visually in excellent condition with no sign of wear, corrosion, or deterioration.

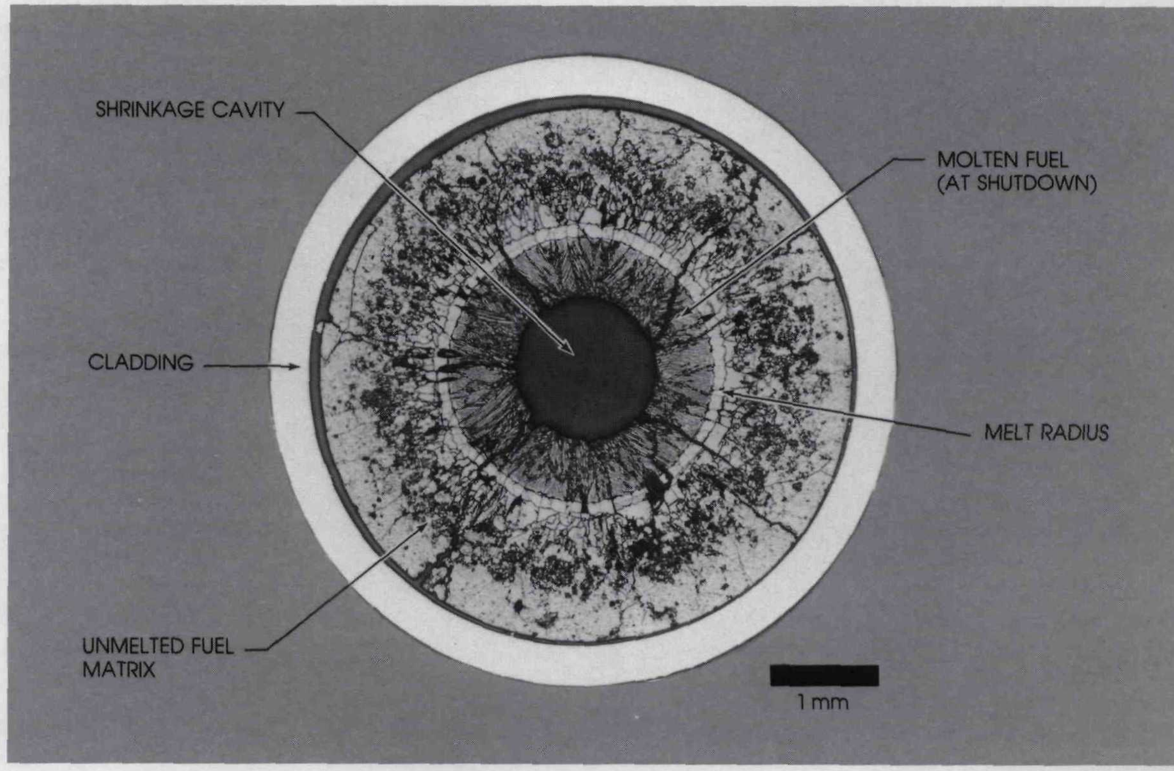
Of particular interest during the first six cycles were the effects of irradiation-induced growth, dilation, and bow on these assemblies and how these phenonema would affect our ability to insert and remove assemblies during the outages. A special test using the In-Vessel Fuel Handling Machine was conducted to measure the length of the assemblies while in the core. All measurements taken during these tests agreed with predicted values.

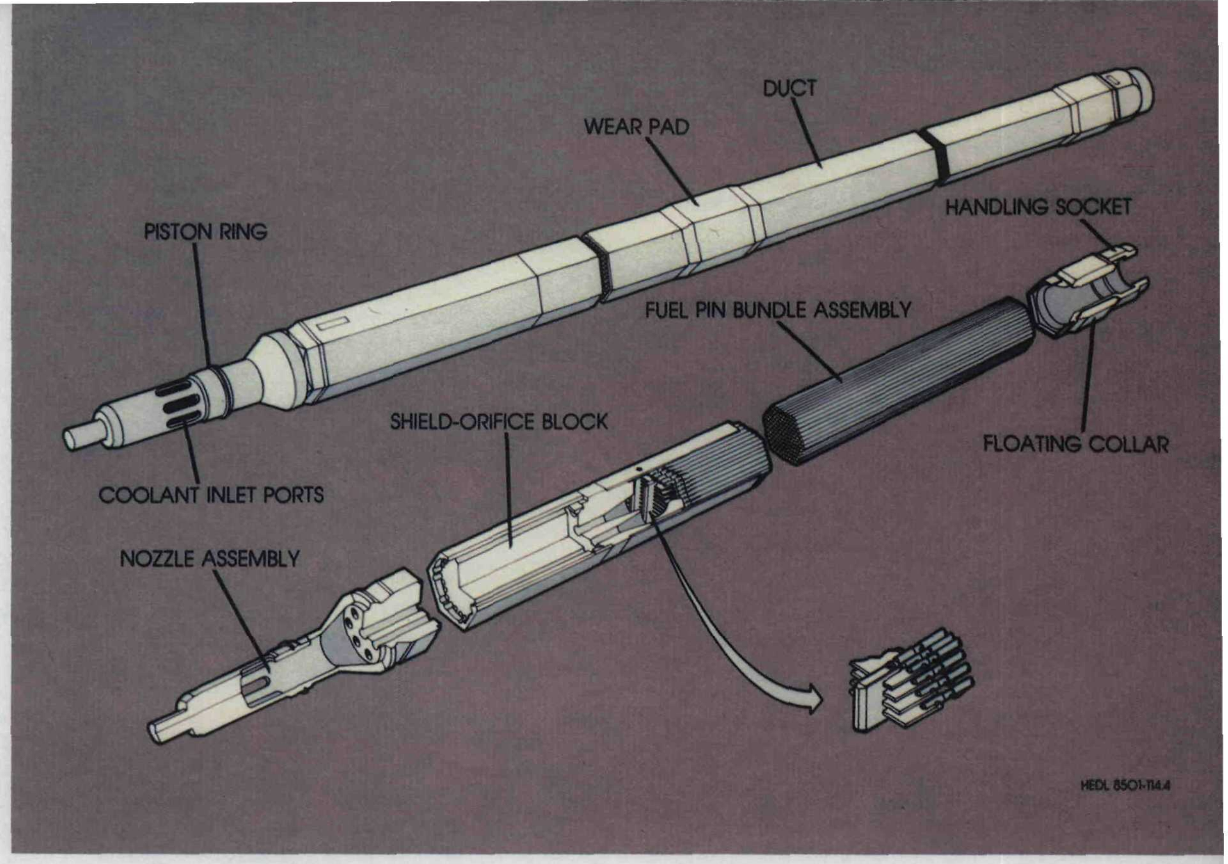
Actual examinations of some of these assemblies in the Interim Examination and Maintenance Cell after removal from the reactor provided further confirmation of the performance models. Duct bow is small, as expected, but duct elongation and lateral expansion (dilation) are both approaching limits for the particular mechanical design of the FFTF core. Dilation of the duct is the more restrictive limit, since it can cause interaction with adjacent fuel assemblies and, therefore, increase the force necessary to pull a dilated duct from the core.

Two special driver fuel assemblies, instrumented with thermocouples to measure temperatures at various positions within the fuel bundles, were removed at the end of the third cycle and one at the end of the fourth. Data from these tests proved conclusively that natural circulation is established quickly in the core and thus prevents over-heating in the event that flow from the pumps is interrupted.

Other special fuel tests conducted during FFTF's first three years of operation established the maximum pin power and provided valuable data for use in designing other fuel systems for liquid metal reactors. Still another test remains in the reactor to determine if any decrease in lifetime is likely to occur from operation at these maximum powers.

The photograph below is a typical ceramograph of a fuel pin showing a void caused by melting in the central part of the fuel pellet. In a special test, centerline melting was intentionally induced to verify design methods used in establishing operating limits for use in the plant. While fuel melting is not normally permitted, follow-on tests showed that limited fuel melting could be permitted safely and with operational benefits.





FFTF's driver fuel consists of mixed-oxide ~25 wt% PuO_2 in uranium natural UO_2 fuel pellets that are slightly less than 0.2 in. in diameter by ~0.25-in. long. It is housed in AISI 316 stainless steel, and 20% cold-worked tubes that are 0.230-in. in outer diameter with a wall thickness of 0.015 in. A 36-in. length stack of pellets is included in a single tube that is ~8-ft long and hermetically sealed.

These sealed tubes (fuel pins) are wrapped with 20% cold-worked 316 stainless steel wire to separate the pins and to provide a channel for the sodium coolant to flow by and extract the heat. These pins are assembled into bundles of 217 pins contained in a hexagonally shaped 20% cold-worked 316 stainless steel duct.

The driver fuel assembly is completed by welding a handling socket to the top and shield-coolant inlet nozzle to the bottom, resulting in a component that is ~12 ft long and ~4.5 in. in diameter.

interim examination and maintenance cell

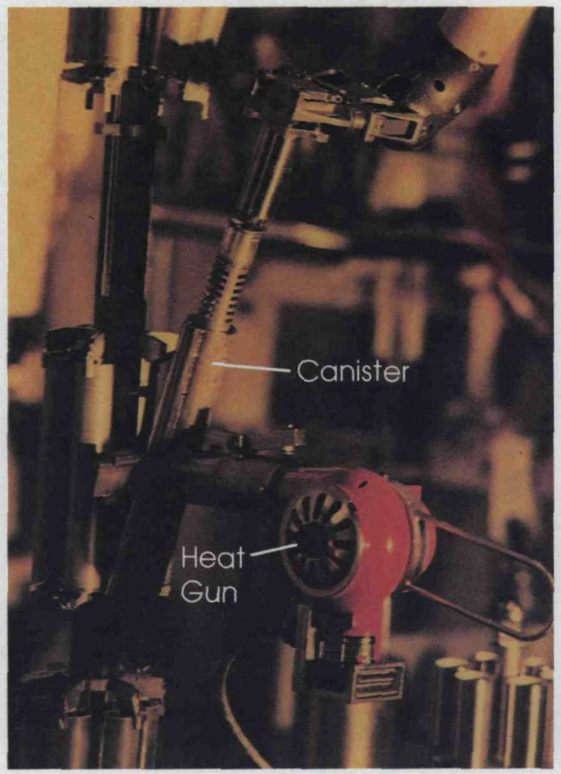
Disassembly of FFTF experiments in the Interim Examination and Maintenance (IEM) Cell using remote-handling techniques is the first step in the postirradiation examination process. The IEM Cell is located in the Containment Building and is a shielded hot-cell complex used to perform nondestructive examinations of test assemblies and core components. Such examinations, performed in a controlled argon atmosphere, include dimensional checks, weighings, and visual inspections. The IEM Cell is also used to perform limited maintenance on plant equipment.

A core component measuring system in the IEM Cell uses *computer-controlled equipment* to map the profile of core components by measuring duct bow, twist, length, and dilation to accuracies of ±0.01 inch. The data obtained are used to refine theories on material behavior under high-neutron fluence and to predict and better understand neutron-induced dilation of core components.

The disassembly process for normal-length (12-ft) fuel assemblies requires cutting the duct from the inlet nozzle (base) assembly and pulling the duct off the fuel pins. This process varies depending on the extent of duct dilation occurring in the center of the fuel region. Both horizontal and vertical duct cutting on assemblies having dilations in excess of 0.020 in. have been successfully performed in the IEM Cell using computer-controlled robotic techniques.

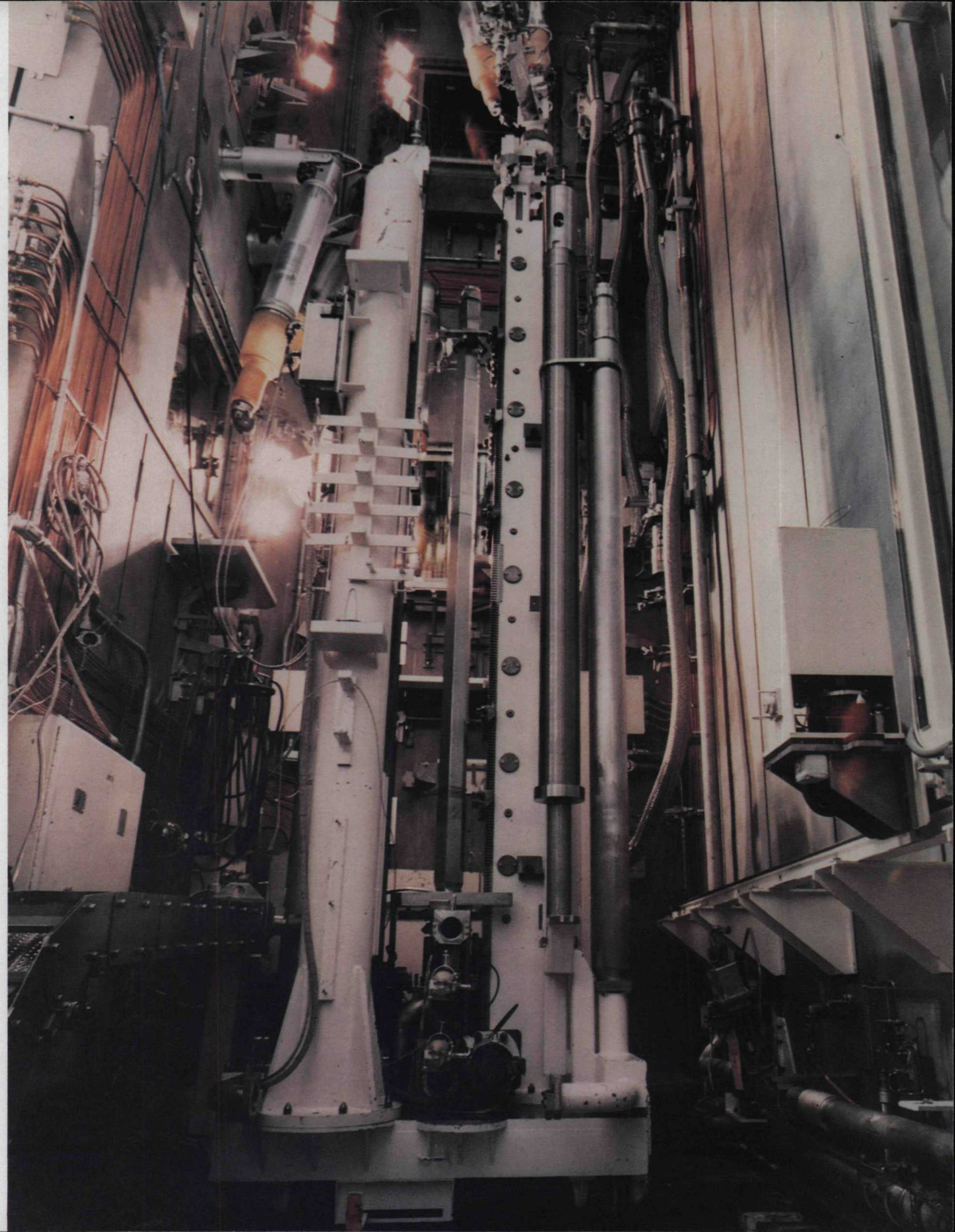
Another unique capability of the IEM Cell was demonstrated following Cycle 3 during the remote disassembly and reconstitution of a Materials Open Test Assembly (MOTA). Using an industrial heat gun to warm the 40 canisters and free them from solidified sodium (shown in the accompanying picture), test canisters were removed from one MOTA stalk, examined, and placed into another. The newly constituted MOTA was returned to the reactor for irradiation in Cycle 4.

Intensive training of IEM Cell operators and technicians in a mockup facility contributed significantly to the successful performance during disassembly/reassembly operations in the IEM Cell.



As the top of the unlatched MOTA canister is moved away from the stalk, a special industrial heat gun is used to blow hot argon around the canister and to melt residual sodium remaining in the canister envelope.

The IEM Cell equipment shown is used to make nondestructive examinations of test assemblies and core components under controlled argon atmospheric conditions. ➔



FFTF: its future mission

The liquid metal reactor is an excellent candidate for an advanced, simpler, inherently safe, economic, nuclear power plant. One major future mission of FFTF is directed at extending the technology and experience base that can lead to this advanced reactor, and transferring this technology to industry.

long-life cores

One of the most vital steps leading to this advanced nuclear power plant is the proof-testing of "extended-life" fuel systems -- those having in-core residence times of three to five years. Demonstration of these core systems in the FFTF will begin in 1986. It will capitalize on improved materials that are more resistant to radiation damage and knowledge of fuel assembly behavior gained through evaluation of FFTF core performance. A partial core loading of long-life core components, known as the Core Demonstration Experiment (CDE), will provide a large-scale proof test of core components and will yield a threefold increase in lifetime.

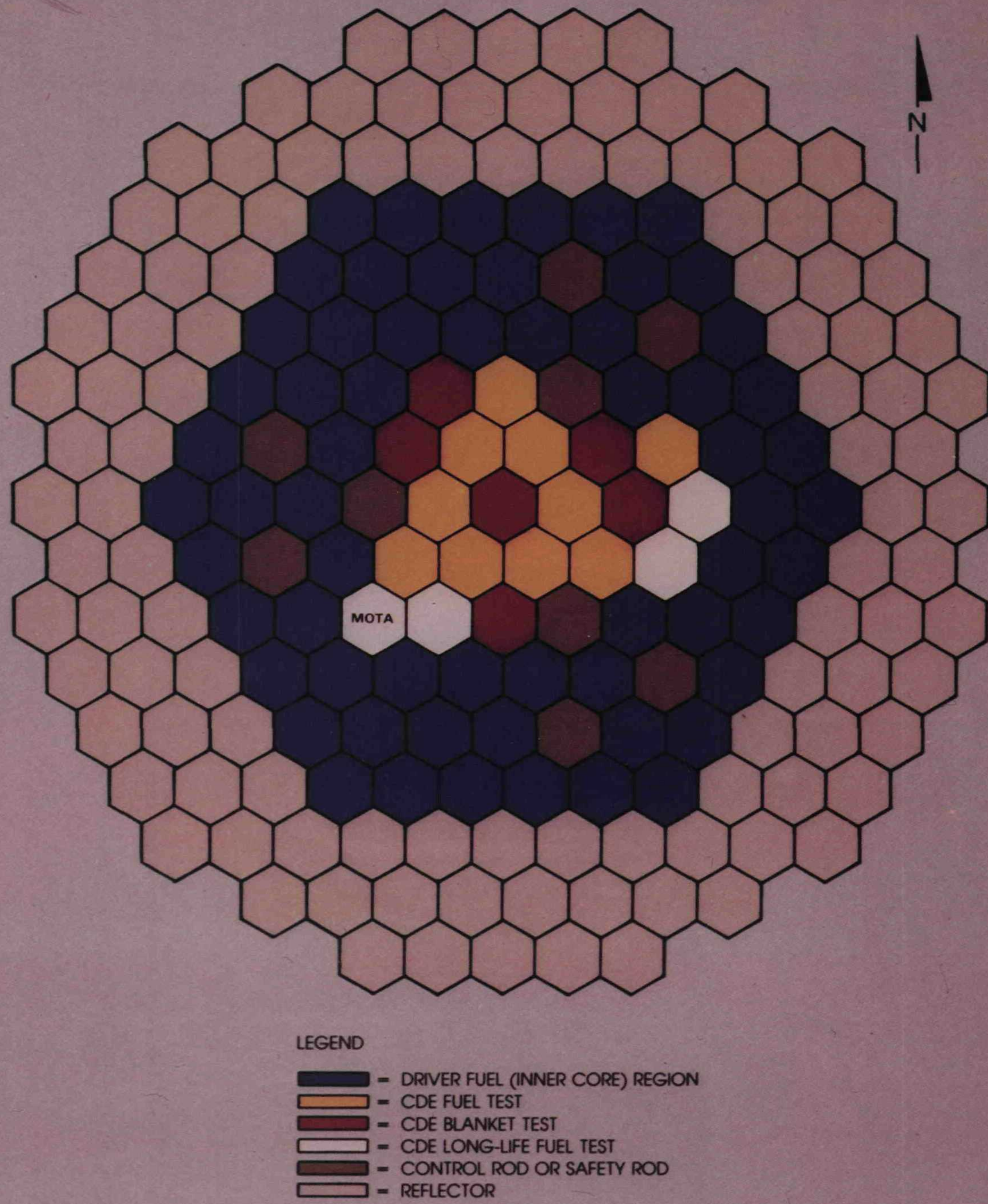
The extension of fuel and component life results in significantly reduced costs including fuel fabrication and inventory, reprocessing and waste disposal, operations and maintenance, and associated capital costs.

inherent safety demonstration

In conjunction with long-life cores, the next generation of reactors will need to demonstrate their ability to be inherently safe during operation and during off-normal events. Improved inherent safety characteristics include passive (self-protecting) features that ensure reactor shutdown and core cooling, provide additional margin for plant protection systems, and provide additional time for corrective action. Testing to demonstrate these innovative safety characteristics and features is planned for FFTF in the near future.

advanced engineering and controls

Testing of advanced control and control room concepts is now being evaluated for FFTF, including various techniques applying artificial intelligence, "expert systems," and automated reasoning. In addition, development of a system capable of detecting off-normal plant events, analyzing their causes, and prompting corrective actions by reactor operators is under development. This will enhance the already proven Master Information and Data Acquisition System (MIDAS), an extensive data base of plant equipment and operating data.



Proposed Core Demonstration Experiment Loading.

FFTF and its environment

FFTF's operation and its impact on the environment has been carefully evaluated during its three years of operation.

The handling, storage, and transportation of radioactive wastes are controlled in accordance with strict procedures to ensure the safety of plant personnel and the public. The Westinghouse Hanford Company operates FFTF with maximum exposure goals far lower than those permitted by Department of Energy regulations. Results of this policy -- called ALARA (As Low As Reasonably Achievable) -- have been exceptional and produced not a single incident in which the self-imposed limits have been compromised.

The ALARA policy covers two broad areas: personnel exposure and waste management.

personnel exposure

During the first three years of operation, the average radiation exposure to plant operators, maintenance personnel, and fuel handlers was about 1% of that allowed by Department of Energy regulations. As shown in the table, the maximum exposure to any one individual working at the plant was 260 millirem, less than 10% of the limit for nuclear power plant workers and only 35 millirem more than the average U.S. citizen. (The average citizen receives 225 millirem of radiation each year. The largest contributor is from the interaction of cosmic rays with the atmosphere and is highly dependent on the individual's geographic location. Medical sources (such as chest and dental X-rays, which range from 100-200 mrem each) are the second largest contributors.)

waste management

Control of radioactive materials and wastes is accomplished by a system in which radioactive materials are permitted only in tightly controlled zones and may leave these zones only under procedures that ensure safety, protection, and accountability.

Radioactive wastes, both solid and liquid, are transported in special containers to one of the areas at the Hanford site established for disposal of these wastes. To date 2,927 ft^3 of solid waste, resulting from routine decontamination activities, have been removed from the FFTF. The total activity concentration for this waste was only 1.0 Ci. Liquid wastes, generated from washing experiments for inspection and disassembly, have totalled 23,755 gallons and have contained 1.04 Ci.

Gaseous wastes are the only wastes discharged from the FFTF directly to the environment. Continuous monitoring has shown that the discharge activity is below the background level of 1.2 Ci/day.

personnel exposure summary *

Exposure-(mrem)	1982	1983	1984
USDOE Limits for individuals	5000	5000	5000
Average per individual	36	11	37
Highest Individual	200	200	260

* Values are in addition to background radiation.