Form No. 10-300 (Rev. 10-74)

UNITED STATES DEPARTMENT OF THE INTERIOR
NATIONAL PARK SERVICE

NATIONAL REGISTER OF HISTORIC PLACES INVENTORY -- NOMINATION FORM

FOR NPS USE ONLY
RECEIVED
DATE ENTERED

SEE INSTRUCTIONS IN *HOW TO COMPLETE NATIONAL REGISTER FORMS*
TYPE ALL ENTRIES -- COMPLETE APPLICABLE SECTIONS

1 NAME

HISTORIC
X-10 REACTOR, GRAPHITE REACTOR

AND/OR COMMON
X-10 Reactor, Graphite Reactor

2 LOCATION

STREET & NUMBER Building 3001, Southeast of Bethel Valley Road
Oak Ridge National Laboratory — NOT FOR PUBLICATION

CITY, TOWN Oak Ridge — VICINITY OF

CONGRESSIONAL DISTRICT Third

STATE Tennessee CODE 047 COUNTY Roane CODE 145

3 CLASSIFICATION

CATEGORY	OWNERSHIP	STATUS	PRESENT USE	
__DISTRICT	X PUBLIC	X OCCUPIED	__AGRICULTURE	X MUSEUM
__BUILDING(S)	__PRIVATE	__UNOCCUPIED	__COMMERCIAL	__PARK
X STRUCTURE	__BOTH	__WORK IN PROGRESS	__EDUCATIONAL	__PRIVATE RESIDENCE
__SITE	**PUBLIC ACQUISITION**	**ACCESSIBLE**	__ENTERTAINMENT	__RELIGIOUS
__OBJECT	__IN PROCESS	X YES: RESTRICTED	__GOVERNMENT	__SCIENTIFIC
	__BEING CONSIDERED	__YES: UNRESTRICTED	__INDUSTRIAL	__TRANSPORTATION
		__NO	__MILITARY	__OTHER:

4 OWNER OF PROPERTY

NAME
United States Atomic Energy Commission (operated by Union Carbide Corp.)

STREET & NUMBER

CITY, TOWN Washington — VICINITY OF

STATE District of Columbia

5 LOCATION OF LEGAL DESCRIPTION

COURTHOUSE, REGISTRY OF DEEDS, ETC. United States Atomic Energy Commission

STREET & NUMBER

CITY, TOWN Washington

STATE D.C.

6 REPRESENTATION IN EXISTING SURVEYS

TITLE None

DATE

__FEDERAL __STATE __COUNTY __LOCAL

DEPOSITORY FOR SURVEY RECORDS

CITY, TOWN

STATE

7 DESCRIPTION

CONDITION		CHECK ONE	CHECK ONE
X EXCELLENT	__DETERIORATED	__UNALTERED	X ORIGINAL SITE
__GOOD	__RUINS	X ALTERED	__MOVED DATE______
__FAIR	__UNEXPOSED		

DESCRIBE THE PRESENT AND ORIGINAL (IF KNOWN) PHYSICAL APPEARANCE

The X-10 Reactor is located within Building 3001 of the Oak Ridge National Laboratory at Oak Ridge, Tennessee. Interpretive displays have been set up in the building immediately to the east of the reactor. The other portions of the building are still in active use and are handled as restricted areas. A fenced walkway connects the reactor display with visitor parking located outside the Laboratory proper on the southern side of Bethel Valley Road.

The full reactor measures 38 feet wide, 47 feet deep, and 32 feet high. At its center is the moderator, composed of blocks of graphite four inches square and four feet long, stacked to form a 24-foot cube, whose purpose is to slow the speed of neutrons as an aid to fissioning (splitting of atoms). The moderator is encased in a seven-foot-thick shield of Barytes concrete with an air inlet and exit manifold on the east and west sides, respectively. The loading face of the reactor (east), measuring 30 by 33 feet, is broken by the openings of 1,248 diamond-shaped, parallel fuel channels on eight inch centers. The loading elevator, essentially a railed rectangular platform, allowed personnel to reach all the channels for hand loading. Only 800 of the channels were ever used.

Fuel for the X-10 was natural uranium, contained in gas-tight, cylindrical aluminum jackets. Fuel slugs were 4.1 inches long and approximately 1 inch in diameter. When loaded each channel contained from 24 to 54 slugs. The reactor originally went critical (fission occurred) with some 30 tons of fuel but in the later years of its operation contained as much as 54 tons. To load the reactor, the step-tapered shield plugs (which absorbed radiation) were removed from the eastern end of each fuel channel and the slugs were inserted manually. Once inside the reactor, the slugs were positioned within the moderator with long rods, assembled to the necessary length. To unload, the rods were used to push the slugs through the moderator to the exit manifold (west). There they fell onto a neoprene slab and were guided down a chute to a canal of water 20 feet deep. The water acted as a radiation shield, and the slugs were stored there until transferred to an adjacent chemical separations building for final processing.

With a sufficient amount of uranium in the reactor, the start of a nuclear chain reaction was spontaneous. Thus a safety system was necessary to insure adequate control at desired power levels and instant shutdown in case of an emergency. The safety system of the X-10 consisted of seven control rods, composed of materials which absorbed neutrons, preventing them from striking and splitting other atoms. Three 8-foot cadmium and steel safety rods penetrated the reactor vertically. These were attached to steel cables which wound on drums operated by electric motors through an electromagnetic clutch. If power to the clutch was lost, the drums were free to turn, allowing the rods to drop by gravity into the reactor core, thus "scramming" or shutting it down. The other four rods, made of boron and steel, penetrated the reactor core horizontally from the north side. Two were designated "shim" rods and were moved by hydraulic pistons. Mechanical accumulators filled with sand provided an emergency hydraulic reserve in case of a power failure. The

(continued)

8 SIGNIFICANCE

PERIOD	AREAS OF SIGNIFICANCE -- CHECK AND JUSTIFY BELOW			
__PREHISTORIC	__ARCHEOLOGY-PREHISTORIC	__COMMUNITY PLANNING	__LANDSCAPE ARCHITECTURE	__RELIGION
__1400-1499	__ARCHEOLOGY-HISTORIC	__CONSERVATION	__LAW	X SCIENCE
__1500-1599	__AGRICULTURE	__ECONOMICS	__LITERATURE	__SCULPTURE
__1600-1699	__ARCHITECTURE	__EDUCATION	__MILITARY	__SOCIAL/HUMANITARIAN
__1700-1799	__ART	__ENGINEERING	__MUSIC	__THEATER
__1800-1899	__COMMERCE	__EXPLORATION/SETTLEMENT	__PHILOSOPHY	__TRANSPORTATION
X 1900-	__COMMUNICATIONS	__INDUSTRY	__POLITICS/GOVERNMENT	__OTHER (SPECIFY)
		X INVENTION		

SPECIFIC DATES 1943-1963 BUILDER/ARCHITECT N/A

STATEMENT OF SIGNIFICANCE

The X-10 Reactor, which went into operation at the Oak Ridge National Laboratory, Oak Ridge, Tennessee, on November 4, 1943, was the world's first full-scale nuclear reactor and the first to produce significant amounts of heat energy and measurable amounts of plutonium. X-10 was also the first reactor to produce radioactive isotopes for medical therapy (1946) and served for many years as the principal atomic research facility in the United States. X-10 was shut down in 1963 and opened to the public in 1968 (Monday through Friday, 12 to 4; Saturday, 9 to 3). The reactor is now maintained by the Nuclear Division of the Union Carbide Corporation, which operates the Oak Ridge National Laboratory for the United States Atomic Energy Commission.

HISTORICAL BACKGROUND

The construction of the Oak Ridge National Laboratory's X-10 Reactor was, in effect, the result of two events, the discovery in 1939 that uranium atoms, when bombarded with neutrons, would split into approximately equal halves releasing enormous amounts of energy, and the successful operation on December 2, 1942, of CP-1 (Chicago Pile-1) at the University of Chicago, demonstrating that a nuclear reaction could be self-sustaining and controlled. On the basis of the Chicago experiments, it was decided to proceed with a major national effort to produce fission bombs.

A major problem was that of separating enough of the uranium-235 isotope from natural uranium, or of creating enough of the artificial isotope plutonium-239, to provide the necessary fissionable materials. Because of the urgency of the work, the ordinary procedure of completing pilot-plant tests before undertaking full-scale production was not followed. Instead, plans were made for the sumultaneous construction during 1943 of a large-scale production plant at Hanford, Washington, and of a pilot plant in Tennessee which would carry out research on plutonium production and supply the first gram quantities of purified plutonium. The Los Alamos Scientific Laboratory in New Mexico was established to pursue development of the bomb itself.

Land for the pilot plant, the X-10 Reactor, was acquired late in 1942 between Clinton, Kingston, and Oliver Springs, Tennessee, under the pretense (for reasons of security) of establishing a Kingston Demolition Range. The Army Corps of Engineers immediately began construction of a town, Oak Ridge, and of administrative buildings. The reactor was completed on October 16,

(continued)

9 MAJOR BIBLIOGRAPHICAL REFERENCES

Oak Ridge National Laboratory. "Oak Ridge National Laboratory Graphite Reactor" (1963).

Oak Ridge National Laboratory. "The Graphite Reactor" (1975).

10 GEOGRAPHICAL DATA

ACREAGE OF NOMINATED PROPERTY less than one acre

UTM REFERENCES

	ZONE	EASTING	NORTHING		ZONE	EASTING	NORTHING
A	16	742010	3979100	B			
C				D			

VERBAL BOUNDARY DESCRIPTION

The boundaries of the national historic landmark designation for the X-10 Reactor (Graphite Reactor) at Oak Ridge, Tennessee, are limited to that portion of Oak Ridge National Laboratory's Building 3001 (from the foundation up) containing the Reactor pile and shield, loading elevator, control room, and work platforms on the north and south reactor faces. Specific lines are shown in red on the accompanying floor plan entitled Oak Ridge National Laboratory, General Second Floor Plan, Bldg. No. 3001, Visitor's Access, approved WR Winsbro, ABF 2/19/68. A plan of the second floor is used since the control room is located at that level.

LIST ALL STATES AND COUNTIES FOR PROPERTIES OVERLAPPING STATE OR COUNTY BOUNDARIES

STATE	CODE	COUNTY	CODE
STATE	CODE	COUNTY	CODE

11 FORM PREPARED BY

NAME / TITLE
Polly M. Rettig, Historian, Landmark Review Project; original form prepared by staff historian, 11/65

ORGANIZATION
Historic Sites Survey, National Park Service

DATE
12/8/75

STREET & NUMBER
1100 L Street, N.W.

TELEPHONE
202-523-5464

CITY OR TOWN
Washington

STATE
D.C. 20240

12 STATE HISTORIC PRESERVATION OFFICER CERTIFICATION

THE EVALUATED SIGNIFICANCE OF THIS PROPERTY WITHIN THE STATE IS:

NATIONAL ___ STATE ___ LOCAL ___

As the designated State Historic Preservation Officer for the National Historic Preservation Act of 1966 (Public Law 89-665), I hereby nominate this property for inclusion in the National Register and certify that it has been evaluated according to the criteria and procedures set forth by the National Park Service.

FEDERAL REPRESENTATIVE SIGNATURE N/A National Historic Landmark

TITLE DATE

FOR NPS USE ONLY

I HEREBY CERTIFY THAT THIS PROPERTY IS INCLUDED IN THE NATIONAL REGISTER

DATE 4/24/79

DIRECTOR, OFFICE OF ARCHEOLOGY AND HISTORIC PRESERVATION

ATTEST: William Lebovich DATE 2/22/79

~~KEEPER OF THE NATIONAL REGISTER~~

(NATIONAL HISTORIC LANDMARKS)

(NATIONAL HISTORIC LANDMARKS)

remaining two "regulating" rods were identical to the shim rods but were driven by electric motors.

Operation of the X-10 was directed from the control room on the second floor level at the southeast corner of the reactor structure. Under usual conditions, the reactor operated around the clock with weekly shutdowns of about 10 hours each for refueling. During startup, the safety rods were withdrawn completely. Then one shim rod was withdrawn and the other set at a predetermined position. The reactor went critical and was raised to the desired power level by withdrawing the regulating rods as necessary. When the desired power level was reached, the reactor was placed in "servo" control, which maintained that level by automatically adjusting the partially withdrawn shim rod. The X-10 was originally intended to operate at a level of 1,000 kilowatts, but over-design made it possible eventually to reach a power level of 4,000 kilowatts.

Since the fission process generated tremendous amounts of heat, an air cooling system was used to hold the fuel slugs at a maximum temperature of 536 degrees Fahrenheit and the moderator at a maximum temperature of 280 degrees Fahrenheit. Two fans (55,000 cfm each) were used to draw atmospheric air through the inlet manifold, across the moderator, and out the exit manifold. Since atmospheric air was used, higher power levels could be reached on cool days than on warm. After passing through the reactor, the air went to a filter house, where more than 99 percent of the radioactive particles (fission products, graphite, concrete, etc.), down to 1/25,000th of an inch in diameter, were removed. The cooling air then was expelled through a 200-foot stack.

Research facilities built into the southern face of the reactor could accomodate more than 36 radiation experiments at one time and expose 1,000 samples or target materials (usually the oxides or metals of the elements) simultaneously for radioisotope production. The target materials, in aluminum capsules, were placed in graphite blocks, or "stringers", and inserted into the reactor. Following irradiation, the stringers were pulled into lead shields ("coffins") which prevented exposure of personnel to radiation. The capsules were then transferred to shielded carriers and taken to processing areas. The southern face of the reactor also contained special tunnels, held at room temperature, for irradiation of biological specimens; the same tunnels were used to expose natural materials such as soybeans and peanut seeds for mutation studies.

The X-10 operated for the last time on November 4, 1963, and was opened to the public in 1968. No significant alterations were made in the reactor before it was placed on display. Metal ladders which had provided access to the control room and work platforms were replaced by stairs for the convenience of visitors. Interpretive material, including cross-section models and audio-visual equipment, have been installed at the loading face (east). Mannequins on the elevator depict personnel loading the fuel channels.

1943, and on November 3, at 4:30 p.m. loading of fuel slugs was begun under the supervision of Enrico Fermi, who had been responsible for the CP-1 project. Because it was expected that 50 to 60 tons of fuel would be loaded by hand, two loading crews worked in shifts. At 5 a.m. the following day, November 4, 1943, the X-10 Reactor went critical (fission occurred) after some 30 tons of fuel had been loaded. On December 20, the first batch of irradiated fuel, 65 slugs, was delivered to an adjacent chemical plant for final isolation of the plutonium; the amount produced was about six milligrams. The initial shipment of plutonium was made on January 3, 1944, and by the end of that month 110 milligrams had been sent to Chicago. On February 26, between one and two grams was delivered to Los Alamos.

By 1945, the X-10 Reactor was a routinely-operating device for plutonium production. As military demands slackened, increasing amounts of time were devoted to research. Since equipment for detection and measurement of radiation was not commercially available, major efforts went into the development and manufacture of various radiation instruments. The reactor itself could accomodate more than 36 radiation experiments and expose 1,000 samples or target materials simultaneously for radioisotope production. Target samples were usually the oxides or metal of the elements though some items like piston rings and cylinder liners were irradiated for use in wear studies. In 1946 X-10 became the first reactor to produce radioisotopes for medical therapy; the initial shipment (Carbon-14) was sent to the Barnard Free Skin and Cancer Hospital in St. Louis, Missouri, on August 2. Also available to researchers were tunnels (held at room temperature) for irradiation of biological specimens; these facilities were likewise used to irradiate soybeans, popcorn, and peanut seeds for mutation studies.

The X-10 Reactor remained in operation until November 4, 1963 (twenty years to the day). After some minor alterations (replacement of ladders by stairs, etc.) and installation of interpretive equipment, on August 29, 1968, X-10 became the only United States Atomic Energy Commission-owned reactor open to the public on a regular basis. Visitors are admitted (to the immediate area of the reactor only) from 12 to 4, Monday through Friday, and 9 to 3 Saturday.