APPENDIX 1

TRIGA Mark I Reactor

General Data

Below ground; fixed core; graphite reflector.
100 kW to 2,000 kW steady state power level.
Up to 6,400,000 kW pulsing power level.
8.0×10^{13} n/cm^2 s maximum thermal flux (<0.21 eV) at 2000 kW.
9.6×10^{13} n/cm^2 s maximum fast flux (10 keV) at 2000 kW.
$UZrH_{1.6}$ fuel elements using uranium enriched to 20%.

The below-ground TRIGA Mark I is extremely simple in physical construction. It is a graphite-reflected core capable of operating up to 2,000 kW steady state and pulsing routinely and reproducibly with reactivity insertions up to 3.2% δk/k. The reactor core rests at the bottom of an aluminium tank. Surrounding earth and demineralised water provide the required radial and vertical shielding. No special containment building is necessary and installation in existing buildings is often feasible. The Mark I TRIGA can be installed in a circular pool or in a large, oblong pool for greater experimental access to the reactor core. Core cooling is achieved through natural convection, eliminating the need for an expensive and restrictive forced cooling system.

TRIGA Mark II Reactor

General Data

Above ground; fixed core; graphite reflector; 4 beam tubes; thermal column.
250 kW to 2,000 kW steady state power level with natural convection cooling (3,000 kW with forced cooling).
Up to 6,400,000 kW pulsing power level.
8.0×10^{13} n/cm^2 s maximum thermal flux (<0.21 eV) at 2,000 kW.
9.6×10^{13} n/cm^2 s maximum fast flux (>10 keV) at 2,000 kW.
$UZrH_{1.6}$ fuel elements using uranium enriched to 20%.

The TRIGA Mark II, which provides experimental capabilities greater than the TRIGA Mark I, is an above-ground fixed-core research reactor. Its core, identical to that of the TRIGA Mark I, is located in a pool surrounded by a concrete shield structure which is above the reactor room floor. The pool water provides natural convection cooling. The Mark II features include:

- Thermal Column - a graphite thermal column, 1.2 m by 1.2 m by 1.65 m, extending from the reflector through the concrete structure, provides a source of well-thermalised neutrons suitable for physical research or biological irradiation. A movable high-density concrete door with a removable 20-cm concrete plug shields the outer face of the column.

- Beam Ports - four 15-cm-diameter horizontal beam ports, extending through the concrete shield to the face of the reflector, permit the extraction of core radiations, or the insertion of specimens for irradiation. Two of the beam tubes extend radially to the reflector, a third penetrates the reflector to the core's edge, and the fourth is tangent to the core.

TRIGA Mark III Reactor

General Data

Above ground; movable core; beam tubes; thermal columns; exposure room; removable core-irradiation facilities.
1,000 kW to 2,000 kW steady state power level with natural convection cooling (3,000 kW with forced cooling).
Up to 6,400,000 kW pulsing power level.
6.6×10^{13} n/cm^2 s maximum thermal flux (<0.21 eV) at 2,000 kW.
6.2×10^{13} n/cm^2 s maximum fast flux (>10 keV) at 2,000 kW.
$UZrH_{1.6}$ fuel elements using uranium enriched to 20%.

The TRIGA Mark III, the most versatile of the standard TRIGA series, is available in either above- or below-ground configurations. Its water-reflected movable core greatly increases the reactor's flexibility. The core can be moved to one end of the pool for experiments in an adjacent dry, walk-in exposure room, or to the opposite end for experiments involving the thermal column and beam ports. The ability to move the radioactive core away from the experimental facilities greatly eases set-up of experiments.

The reactor tank is approximately 7.5 m long by 7.5 m deep, with a maximum width of 3 m at the center. Because it is natural convection cooled up to 2000 kW, the reactor can be operated anywhere in the pool. Reactor facilities include:

- Two Thermal Columns with internal void - a graphite thermal column, 1.2 m by 1.2 m by 3 m, extends from the periphery of the reactor core through the concrete shield structure. A 0.9 m by 0.9 m by 1.05 m Hohlraum space is provided in this horizontal thermal column with a vertic al thermal column directly above. Four ports through the concrete shielding allow access to the two thermal columns.

- Beam Ports - four 15-cm-diameter horizontal beam ports penetrate the concrete shield and the reactor pool water to the edge of the core shroud, and two 20-cm-diameter through beam ports intersect in the thermal column adjacent to the core.

- Walk-in Exposure Room - This room is 3 m wide by 3.6 m long by 2.9 m high and easily accommodates very large experiments. Access to the room is provided by several 15-cm-diameter conduits and a motor-driven concrete door.

INTERNATIONAL

Country	Location	TRIGA Model	Power Steady State kW(t)	Pulsing MW(t)	Status	Initial Criticality
Austria	Federal Ministry of Education, *Wien*	Mark II	250	250	Operating	1962
Bangladesh	Atomic Energy Research Establishment, *Dhaka*	Mark II	3,000	3,900	Operating	1986
Brazil	University of Minas Gerais, *Belo Horizonte*	Mark I	100		Operating	1960
Colombia	Institute of Nuclear Science & Alternative Energy, *Bogota*	Conversion	100		Operating	1997
England	Imperial Chemical Industries, *Billingham*	Mark I	250		Decommissioned	1971
Finland	The State Institute for Technical Research, *Helsinki*	Mark II	250	250	Operating	1962
Germany	Univ. of Frankfurt, *Frankfurt*	Conversion	1,000		Decommissioned	1977
	Medical College Hannover, *Hannover*	Mark I	250		Shutdown	1973
	German Cancer Research Center, *Heidelberg*	Mark I	250		Shutdown	1966
	Johannes Gutenberg Univ., *Mainz*	Mark II	100	250	Operating	1965
	Association for Radiation Research, *Munich*	Mark III	1,000	2,000	Decommissioned	1972
Indonesia	National Atomic Energy Agency, *Bandung*	Mark II	2000		Operating	1997
	National Atomic Energy Agency, *Yogyakarta*	Mark II	250		Operating	1979
Iran	Nuclear Research Center, Tehran	Conversion	5,000		Suspended	
Italy	University of Pavia, *Pavia*	Mark II	250	250	Operating	1965
	ENEA Cassaccia Research Center, *Rome*	Mark II	1,000		Operating	1960
Japan	Japan Atomic Energy Research Institute, *Tokai-mura*	ACPR	300	22,000	Operating	1975
	Musashi Institute of Technology, *Tokyo*	Mark II	100		Operating	1963
	Rikkyo University, *Yokosuka*	Mark II	100		Operating	1961
Korea	Korea Advanced Energy Research Institute, *Seoul*	Mark II	250		Shutdown	1962
	Korea Advanced Energy Research Institute, *Seoul*	Mark III	2,000	2,000	Shutdown	1972
Malaysia	Malasysian Inst. for Nuclear Technology, *Kuala Lumpur*	Mark II	1,000	1,200	Operating	1982
Mexico	National Institute for Nuclear Research, *Mexico City*	Mark III	1,000	2,000	Operating	1968
Morocco	National Institute for Nuclear Science & Energy, Rabat	Mark II	2,000		Under Construction	2005
Philippines	Philippine Atomic Energy Commission, *Quezon City*	Conversion	3,000	1,000	Operating	1988
Romania	Institute for Nuclear Research, *Pitesti*	ACPR	500	22,000	Operating	1979
	Institute for Nuclear Research, *Pitesti*	MPR 16	14,000		Operating	1979
Slovenia	Jozef Stefan Nuclear Institute, *Ljubljana*	Mark II	250		Operating	1966
Taiwan	National Tsing Hua University, *Taipei*	Conversion	1,000		Operating	1977
Thailand	Office of Atoms for Peace, *Bangkok*	Conversion	1,000		Operating	1977
	Ongkharak Nuclear Research Center, *Bangkok*	MPR 10	10,000		Under Construction	2005
Turkey	Technical University of Istanbul, *Istanbul*	Mark II	250	250	Operating	1979
Viet Nam	Institute of Nuclear Research, *Dalat*	Mark II	250		Decommissioned	1963
Zaire	Nuclear Science Commission, *Kinshasa*	Mark II	1,000	1,600	Operating	1972
	Nuclear Science Commission, *Kinshasa*	Mark I	50		Shutdown	1959

UNITED STATES

Country	Location	TRIGA Model	Power Steady State kW(t)	Pulsing MW(t)	Status	Initial Criticality
Arizona	University of Arizona, *Tucson*	Mark I	250	300	Operating	1958
Arkansas	Arkansas Technical Univ., *Russelville*	Mark I	250	2,000	Suspended	
California	General Atomic, *San Diego*	Mark I	250	1,000	Shutdown	1958
	General Atomic, *San Diego*	Mark F	1,500	6,400	Shutdown	1960
	General Atomic, *San Diego*	Mark III	2,000		Decommissioned	1966
	University of California, Davis, *Sacramento*	Mark II	2,300	1,200	Operating	1990
	Norair Division of Northrop Corp., *Hawthorne*	Mark F	1,000	1,600	Decommissioned	1963
	University of California, *Berkeley*	Mark III	1,000	1,200	Decommissioned	1966
	University of California, *Irvine*	Mark I	250	250	Operating	1969
	Aerotest Operation, *San Ramon*	Conversion	250		Operating	1965
Colorado	U.S. Geological Survey, *Denver*	Mark I	1,000	1,200	Operating	1969
Idaho	Argonne Nat'l. Lab. West (HFEF, INEL), *Idaho Falls*	Conversion	250		Operating	1977
Illinois	University of Illinois, *Urbana*	Mark II	1,500	6,500	Shutdown	1960
	University of Illinois, *Urbana*	LOPRA	10		Shutdown	1971
Kansas	Kansas State University, *Manhattan*	Mark II	250	250	Operating	1962
Maryland	Harry Diamond Labs. (U.S. Army), *Forest Glen*	Mark F	250	1,000	Decommissioned	1961
	AFRRI, *Bethesda*	Mark F	1,000	3,300	Operating	1962
	University of Maryland, *College Park*	Conversion	250		Operating	1974
Michigan	The Dow Chemical Company, *Midland*	Mark I	300		Operating	1967
	Michigan State University, *East Lansing*	Mark I	250		Decommissioned	1969
Nebraska	Veterans Administration Hospital, *Omaha*	Mark I	18		Shutdown	1959
New Mexico	Sandia Nat'l. Laboratories, *Albuquerque*	ACPR	600	12,000	Operating	1967
New York	Columbia University, *New York*	Mark II	250	250	Suspended	
	Cornell University, *Ithaca*	Mark II	500	250	Shutdown	1962
Oregon	Oregon State University, *Corvallis*	Mark II	1,000	3,200	Operating	1967
	Reed College, *Portland*	Mark I	250		Operating	1968
Pennsylvania	Pennsylvania State University, *University Park*	Mark III	1,000	2,000	Operating	1965
Puerto Rico	Puerto Rico Nuclear Center, *Mayaguez*	Conversion	2,000		Decommissioned	1972
Texas	Texas A&M University, *College Station*	Conversion	1,000	2,000	Operating	1968
	University of Texas, *Austin*	Mark I	250		Decommissioned	1963
	University of Texas, *Austin*	Mark II	1,100	1,600	Operating	1992
Utah	University of Utah, *Salt Lake City*	Mark I	250		Operating	1975
Washington	Westinghouse-Hanford-300 Area, *Richland*	Mark I	1,000		Shutdown	1977
	Washington State University, *Pullman*	Conversion	1,000	2,000	Operating	1967
Wiconsin	University of Wisconsin, *Madison*	Conversion	1,000	2,000	Operating	1967