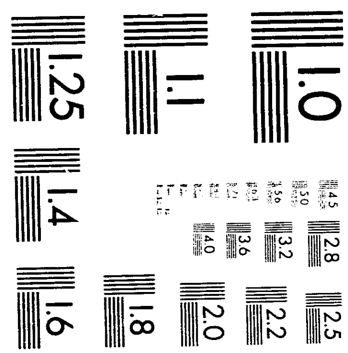
1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0
4.5
5.0

Conf-931018--14 PPPL-CFP--2963

Decommissioning The Tokamak Fusion Test Reactor

P. T. Spampinato† and G. R. Walton
Princeton Plasma Physics Laboratory
P.O. Box 451, Princeton, New Jersey 08543

ABSTRACT

The Tokamak Fusion Test Reactor (TFTR) at Princeton Plasma Physics Laboratory (PPPL) will complete its experimental lifetime with a series of deuterium-tritium pulses in 1994. As a result, the machine structures will become radioactive, and vacuum components will also be contaminated with tritium. Dose rate levels will range from less than 1 mr/h for external structures to hundreds of mr/h for the vacuum vessel. Hence, decommissioning operations will range from hands on activities to the use of remotely operated equipment. After 21 months of cooldown, decontamination and decommissioning (D&D) operations will commence and continue for approximately 15 months. The primary objective is to render the test cell complex re-useable for the next machine, the Tokamak Physics Experiment (TPX). This paper presents an overview of decommissioning TFTR and discusses the D&D objectives.

INTRODUCTION

TFTR is the major experiment in the Department of Energy's (DOE) Magnetic Fusion Energy Program. Until now, TFTR experimental operations essentially involved only hydrogen plasmas. Therefore, the machine still has full "hands-on" accessibility even though the vacuum vessel and some machine components have become mildly activated and tritium contaminated [1]. Additional activation and contamination will occur when TFTR proceeds with tritium-fuelled experiments. Completion of the D-T pulses is scheduled for September 1994. At that time, D&D activities will commence with a Safe Shutdown period followed by dismantling, packaging, and shipping activities. The nature of D-T operations is such that all waste generated will be low level radioactive waste (LLRW).

PROJECT OBJECTIVES

A. *Technical Objectives*

The primary objective of the D&D Project is to remove activated and contaminated systems and components, and render the TFTR facility suitable for construction and operation of the Tokamak Physics Experiment. Specific objectives are:

- safely disassemble activated and tritium-contaminated components and various ancillary systems in the test cell complex;
- apply remote disassembly and handling techniques to a large scale fusion facility;
- package disassembled components in accordance with DOE and Department of Transportation regulations;
- transport the packages to an approved DOE repository for LLRW disposal.

The baseline approach presented in the TFTR Preliminary Decontamination & Decommissioning Plan is the basis for the feasibility of achieving the technical objectives [2]. This plan was reviewed by an independent DOE panel in January 1992 which concluded that the technical approach was well developed, and the cost and schedule estimates were detailed and reasonable.

The TFTR D&D technical objectives are similar to those planned in the future for other large fusion facilities that will use D-T, namely, the Joint European Torus (JET) in Europe [3]. In addition, this experience will provide valuable input during the design phase of the International Thermonuclear Experimental Reactor (ITER).

B. *Schedule Objectives*

The major schedule milestones for the D&D Project are listed below:

- Conceptual Design Review — April 1994
- Issue Updated D&D Plan — June 1994
- Preliminary Design Review — February 1995
- Final Design Review — February 1996
- Begin D&D Operations — July 1996
- TPX Beneficial Occupancy — March 1998
- Project Closeout — June 1998

FACILITY DESCRIPTION

The portion of the TFTR facility involved in the D&D Project includes the test cell, test cell basement, hot cell, and mockup building. The machine systems and components that will require D&D include the tokamak machine, structure, diagnostics, neutral beamlines, ICRF system, pellet injectors, vacuum pumping system, cryogenic systems, and the machine area cooling fluid

†Grumman Corporation

systems. The tritium storage and delivery system, tritium clean-up system, and tritium boundary HVAC will be left intact for reuse by TPX.

A. Test Cell

The test cell shown in Figures 1 and 2 is a heavily shielded concrete structure, with interior dimensions of 150 ft. x 114 ft. x 54.5 ft. high, which houses the tokamak, neutral beamlines, diagnostic systems, and auxiliary equipment. The test cell is constructed of reinforced concrete with wall, roof, and floor thicknesses having been determined by both structural and radiation shielding requirements. The north and south walls of the test cell support a 110/25-ton capacity bridge crane. The test cell floor is designed to support the static weight of the TFTR machine (approximately 2,000 tons) in a 39 ft. diameter in the center of the building, and a live load of 3,500 lbs/ft^2 for the area outside the center bay.

B. Hot Cell

The hot cell shown in Fig. 1 has interior dimensions of 60 ft. x 114 ft., and a ceiling height of 54.5 ft. The floor is at the same level as that of the adjacent test cell. Construction is of reinforced concrete throughout, with the floor slab 3 ft. thick, the roof 5 ft.-6 in. thick, the north and south walls 4 ft. thick and the east and west walls 3 ft. thick. The hot cell will not be activated nor contaminated and will permit unlimited personnel access. It will be the main area for packaging LLRW containers.

The structural floor slab and the transport system are designed to support and permit movement of the weight of a fully assembled neutral beamline. The hot cell contains a 75/15-ton overhead crane. The observation gallery has radiation shield windows and was designed for operating through-the-wall manipulators on the north and east walls of the cell.

C. Mock Up Building

The mock up building is located to the north of the test cell as shown in Fig. 1. It contains a 40-ton bridge crane, and will be the main staging area for health physics operations. This building is the primary means of ingress/egress for all D&D operations in the test cell. The mock up building also contains the control room for remotely operated equipment and tools.

D. Basement Areas

Space for a variety of functions is located at the basement level below the main experimental areas. Basement space below the test cell has been assigned to diagnostic equipment, high voltage equipment, vacuum pumping equipment, electric bus runs for power supply to the machine, coil cooling fluid piping for the magnetic field coils, the tritium vault, tritium cleanup equipment and air handling equipment. D&D operations in the basement will be limited to the systems directly under the machine, vacuum pumping piping.

D&D APPROACH

The current D&D baseline is presented in detail in [2]. It represents a conservative approach with regard to cost and schedule because it is based on totally dismantling, cutting up, and packaging all systems that make up the tokamak machine, and shipping the waste containers to the furthest repository from the PPPL site. Approximately 150 truckloads will carry almost 500 containers to DOE's Hanford Disposal Site. DOE packaging and shipping criteria, as well as Hanford's waste acceptance criteria will be followed [4].

Removal of the TFTR machine platform and the supporting columns located in the basement will not be required since they will be utilized by TPX. The dose-equivalent at the machine platform after completion of D&D operations is estimated to be 7 μSv/hr (0.7 mrem/hr).

DECONTAMINATION

The baseline approach, i.e. TFTR operates with tritium and generates a total of $2x10^{21}$ neutrons [6], corresponds to a "worst case" scenario with respect to D&D. It is assumed that all components connected to the torus vacuum will be tritium contaminated. In addition, the majority of the tritium inventory remaining in the torus will be bound in the graphite tiles and codeposited on the vessel walls with eroded carbon from the tiles. Based on experimental measurements, it is assumed that 35% of the tritium put into the machine will be retained in the torus [6]. In addition, the neutral beamline enclosures are assumed to be tritium contaminated because the beamline cryogenic panels pump the plasma exhaust. Inventory estimates for the beamlines yield a maximum value of 0.2 g of tritium [6]. Decontamination of the neutral beams is expected to be difficult because of the complex configuration and large surface areas of the internal beamline components.

To the extent possible, decontamination of systems

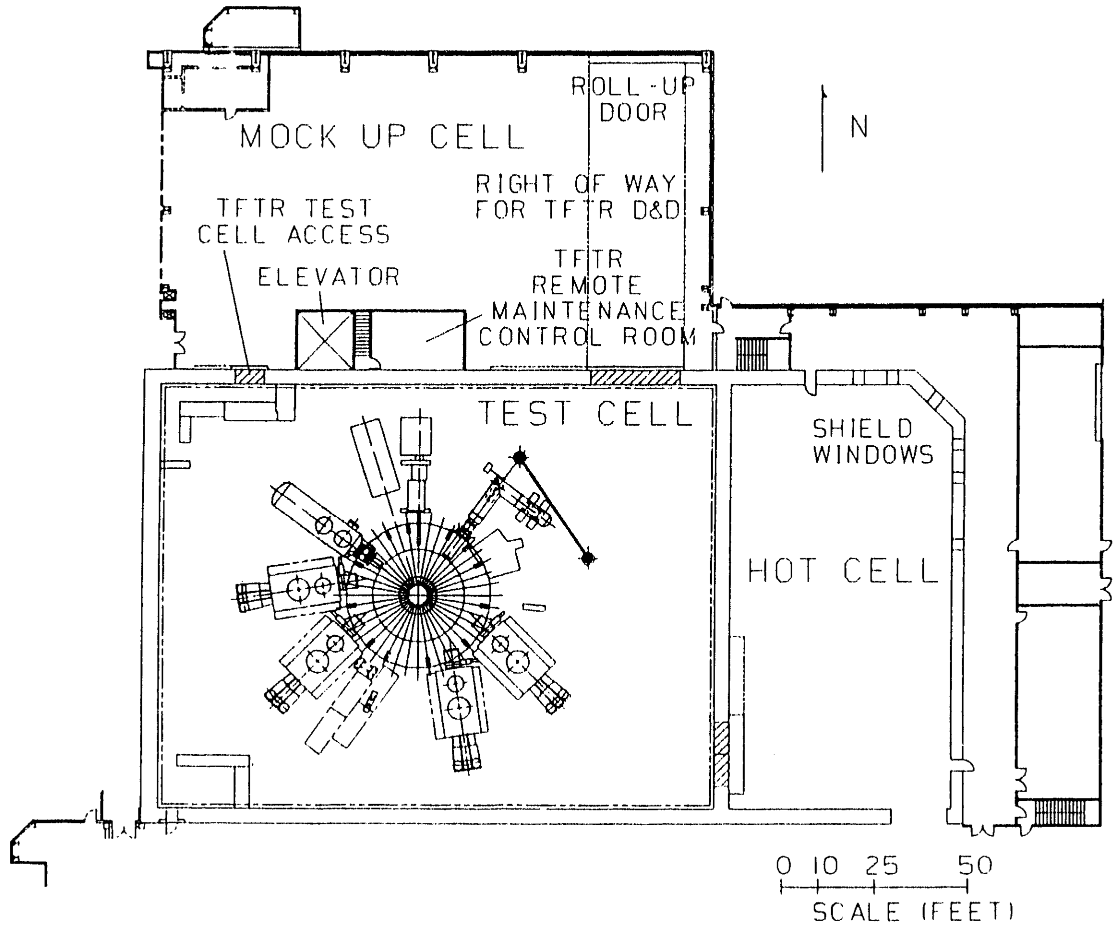

Fig. 1 TFTR Facility Plan View.

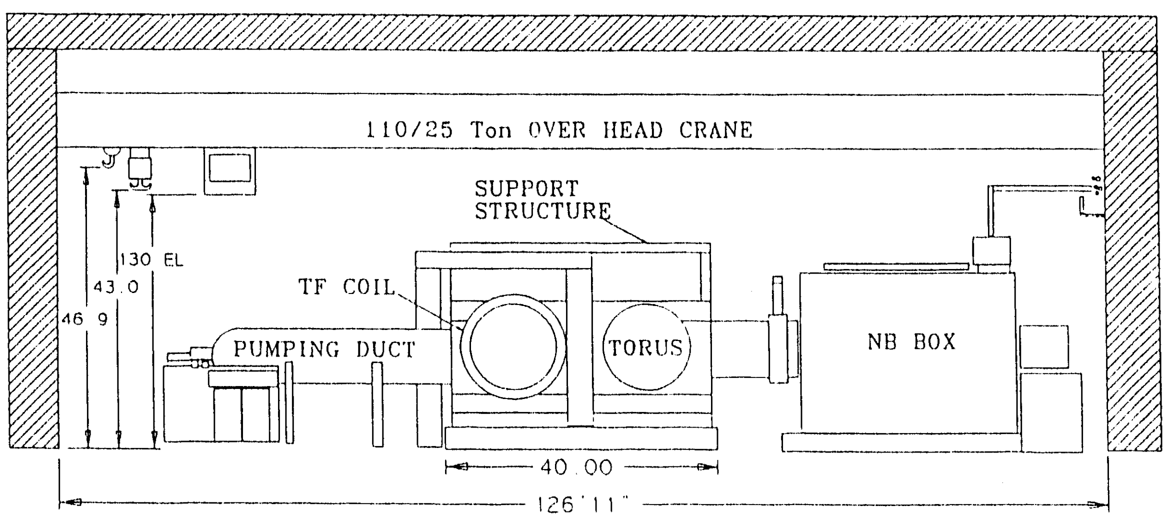

Fig. 2 TFTR Facility Elevation View.

will be completed prior to disassembly and dismantlement tasks. Decontamination will continue as required throughout D&D operations to reduce personnel exposures and waste generated.

ACTIVATION LEVELS

Table I gives the contact dose rate at various machine locations for different cooling periods [2]. These values are dominated by ^{54}Mn, ^{58}Co, and ^{60}Co radioisotopes which are activation products of the stainless steel and inconel components. Refer to Fig. 2 for the component locations.

Table I.
TFTR Calculated Activation Levels After Generation of 2 x 10^{21} D-T Neutrons.

Cooling Time	InsideVV Port Cover µSv/hr (mem/hr)	Outboard side of TF Coil Case µSv/hr (mrem/hr)	Outboard of Support Column µSv/hr (mrem/hr)
6 mos.	2E4 (2000)	1.6E3 (160	60 (6)
1 yr.	8E3 (800)	700 (70)	20 (2)
2 yr.	2.6E3 (260)	240 (24)	6 (0.6)
5 yr.	800 (80)	40 (4)	1 (0.1)

Based on the dose rate figures above, all dismantling work from the TF coils to the center of the machine will be performed using remotely operated equipment and tools. It is anticipated that D&D of the vacuum vessel will require use of the TFTR Maintenance Manipulator Arm (MMA), an articulated boom equipped with a master/slave servomanipulator for in-vessel component removal and torus dismantling. Plasma arc cutting is the primary technique being considered to perform dismantling. Confinement tents will be used to limit the spread of contamination during these operations.

PROGRESS AND NEXT STEPS

The D&D Project is: revising the baseline to include alternative approaches for dismantling tokamak systems and cutting the torus; investigating the possibility of recycling up to 500 tonnes of stainless and copper materials; and is considering alternative approaches to waste packaging and shipping. The results of this work will form the basis for the conceptual design review in March 1994. Early in FY 1994, a solicitation will be made for a Technical Support Contractor to complement the engineering and planning activities, and a Technical Review Board will be selected. Small and large scale cutting demonstrations are also planned in FY 1994 to establish the cutting approach.

CONCLUSIONS

A baseline approach has been established based on the Project's Preliminary D&D Plan. Radiological inventory estimates were made to determine exposure to personnel, waste generation, and handling and disposal methods. Calculations of radioactive material inventories for the tokamak components indicate that the D&D waste will be Class A LLRW [5]. Waste resulting from TFTR D&D operations will consist of stainless steel and aluminum structures, diagnostic components, stainless piping, copper coils and buses, resin beds, filters, solidified radioactive liquids, and anti-C materials. Packaging and transportation will comply with DOE Orders, PPPL Procedures, and waste repository acceptance criteria. The amount of radioactive waste generated during D&D, including all packaging materials, will be more than 2500 tons. The total neutron induced radioactivity inventory to be disposed of is estimated to be 50 TBq (1400 Ci).

REFERENCES

[1] G. R. Walton, D. K. Owens and G. W. Barnes, "In-Vessel Activities and Radioactive Contamination Control During the 1987 TFTR Shutdown," Proc. of the 15th Symp. on Fusion Technology, Utrecht, The Netherlands, 1988, North Holland, Amsterdam, Vol. 1, p. 8, 1989.

[2] G. R. Walton and J. C. Commander, "The Preliminary Decontamination and Decommissioning Plan for the Tokamak Fusion Test Reactor", D&D 00012 DDOC, Princeton Plasma Physics Laboratory, February 1993.

[3] R. Hancox, "Approaches to the Decommissioning of the Joint European Torus", Proc. of the ANS Fifth Topical on Robotics and Remote Systems, Knoxville, TN, April 1993.

[4] "Hanford Site Radioactive Solid Waste Acceptance Criteria", WHC-EP-0063-3 September 1992.

[5] L. P. Ku, "Radioactivity Concentration for TFTR Components," Internal Memo EAD-3832, Princeton Plasma Physics Laboratory, July 26, 1990.

[6] "TFTR D-T Plan," OPR-R-12, Princeton Plasma Physics Laboratory, 1991.

This work is supported by the U.S. DOE under contract number DE-AC02-76-CHO3073.

DATE
FILMED
12/7/93
END