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Abstract

The Burning Plasma Experiment (BPX) is phased to start construction of conventional facilities in July 1994, in conjunction with the conclusion of The Tokamak Fusion Test Reactor (TFTR) project. This paper deals with the conceptual design of the BPX Conventional Facilities, for which Functional and Operational Requirements (F&ORs) were developed. Existing TFTR buildings and utilities will be adapted and used to satisfy the BPX Project F&ORs to the maximum extent possible. However, new conventional facilities will be required to support the BPX project. These facilities include: The BPX building; Site improvements and utilities; the Field Coil Power Conversion (FCPC) building; the TFTR modifications; the Motor Generator (MG) building; Liquid Nitrogen (LN₂) building; and the associated Instrumentation and Control (I&C) systems. The BPX building will provide for safe and efficient shielding, housing, operation, handling, maintenance and decontamination of the BPX and its support systems. Site improvements and utilities will feature a utility tunnel which will provide space for all utility services--including pulse power duct banks and liquid nitrogen coolant lines. The FCPC building will house eight additional power supplies for the Toroidal Field (TF) coils. The MG building will house two MG sets larger than the existing TFTR MG sets. This paper also addresses the conventional facility cost estimating methodology and the rationale for the construction schedule developed.

Introduction

The Burning Plasma Experiment (BPX) Conventional Facilities are baselined about the current BPX tokamak conceptual design which features a 2.6 m major radius machine, wedged design, capable of operation at 9 Tesla and 11.8 Meg-Ampere. In addition to housing the BPX tokamak, the conventional facilities are baselined to house major support systems and ancillary equipment. The conventional facilities are shown in Figure 1 BPX Facilities Site Plan. They include:

- BPX Building
- Field Coil Power Conversion (FCPC) Building
- Motor Generator (MG) Building
- Liquid Nitrogen (LN₂) Building
- Site Improvements and Utilities

The site layout permits maximum utilization of existing Tokamak Fusion Test Reactor (TFTR) buildings, utilities and pulse power supplies. The conventional facilities baseline cost estimate was developed based upon the conceptual design drawings and description and using "bottoms up" cost estimating techniques. The construction schedule was prepared using networking techniques such as Critical Path Method (CPM) and Program Evaluation and Review Technique (PERT).

Figure 1. BPX facilities site plan.

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Conventional Facilities Description

The BPX is phased to start construction of conventional facilities in July 1994, in conjunction with the conclusion of the TFTR program. The existing TFTR buildings and utilities will be adapted and used to satisfy the BPX Project's Functional and Operational Requirements (F&ORs) to the maximum extent possible.

The majority of the BPX conventional facilities will be contained in four new buildings to be located in the vicinity of the existing TFTR test cell. The new buildings include: The BPX building with approximately 132,000 square feet of floor space to be located west of and adjacent to the existing TFTR test cell; the Motor Generator (MG) building with approximately 56,000 square feet of floor space, located west of the existing TFTR MG building; the Field Coil Power Conversion (FCPC) building with approximately 7,500 square feet of floor space to be located west of and adjacent to the BPX building; and the Cryogenic Systems building (LN₂ Liquefaction) with approximately 26,000 square feet of floor space to be located north of the BPX building.

The existing PPPL facilities to be modified include: the Research Equipment Storage Area (RESA) building; the neutral beam power conversion (NBPC) building; the TFTR basement corridor and wall; the CICADA tunnel, and the existing TFTR Mockup building, and demolition and removal of an existing cooling tower.

The RESA building will be modified to provide the required head room and overhead crane capacity to support BPX coil winding activities and remote maintenance mockup activities. The CICADA tunnel will be modified to accommodate the BPX building and the utilities tunnel. The NBPC building will be modified to accommodate up to 16 Ion Cyclotron Resonance Heating (ICRH) power supplies. The TFTR basement wall will be modified to provide: space for ICRH power cable trays; and interconnection through the TFTR basement wall to the BPX basement, and openings through the west wall of the TFTR mockup building.

Site improvements will include: road access connections, service sidewalks and parking, new cryogenics storage and transfer yards, shielded test cell atmosphere holdup line, substation expansion yards and fencing.

The BPX support utilities will be located in new underground utility corridors. Space will be provided for the following utilities: fire protection water; potable water; steam and condensation; plant air; sanitary sewer; storm sewer; perimeter ground drains; pulse power ducts; facility power; and liquid and gaseous nitrogen.

BPX Building

The BPX building includes the test cell complex which will house the tokamak within a large radiation-shielded, reinforced concrete center cell. See Figures 2 through 5 for plans and sections through the building.

Figure 2. BPX Basement Plan

Figure 5. Section B-B.

The test cell configuration provides a center cell to house the BPX Tokamak with fixed wall and floor shielding and a rolling shield roof over the center cell. The roof shield is closed during tokamak pulsing, and can be opened during shutdown for maintenance. North and south cell space provides for systems which must be close to the tokamak, but which require protection from ionizing radiation. The Diagnostic Neutral Beam system and the Tritium Fuel Pellet Injection systems will be located in the north cell; various diagnostics will occupy the south cell space. A 425-ton overhead bridge crane and an overhead remote manipulator will reside in a high bay space over the test cell and will service the test cell spaces and the maintenance cells. The rolling shield roof over the center cell will protect the high bay areas from ionizing radiation and allow hands-on maintenance of systems located in that space. The north and south cell areas will have fixed roofs allowing their occupancy during periods when the tokamak is not operating and the center cell is open for remote maintenance. Access to the north and south cell areas will be by overhead access hatches and transverse shielded personnel door openings. All systems which require hands-on maintenance will be located external to the center cell.

Outside air leakage into the center cell during the sealed period will be controlled through use of tritium-sealed doors and penetrations, and bubble-tight HVAC valves.

MG Building

The MG building will be sized to accommodate two new MG sets slightly larger than the existing TFTR MG sets. A laydown area equal in space to one MG set will be provided. The MG building will also include high bay, low bay and basement areas equivalent to those spaces in the existing TFTR MG control room will also be provided. The MG building layout shall provide for future expansion by a factor of 1.5.

FCPC Building

The FCPC building will be sized to accommodate eight power supplies aligned in an east-west direction to the west of the new BPX building. The building will have two stories with a full height cable raceway along the intersection with the west wall of the BPX building. The FCPC building layout shall provide for future expansion by a factor of 1.5.

Cryogenic Systems Building

The Cryogenic Systems building will be sized to accommodate a cryogenic refrigeration plant. The plant will consist of ten compressor units, each with about 6,500 hp input power. The ten units will be aligned in two rows of five units. The building will be a single story high bay structure and will include a control room and a maintenance area. The Cryogenic Systems building layout shall provide for future expansion by a factor of 1.3.

Significant Facility Features

Concern for laboratory and public safety is an overriding design and construction consideration. The proposed concept adequately addresses the need for effective radiation shielding, structural integrity (to withstand the required seismic, wind, and light aircraft impact loadings), tritium confinement, solid and liquid radioactive waste handling, and gaseous emission controls. The facilities conceived are intended to limit personnel radiation exposure to As Low As Reasonably Achievable (ALARA). The public's safety will be enhanced by providing a controlled area boundary, within which public access will be restricted by means of a security fence with guarded entry points and appropriate remote and local monitoring.

A rolling shield roof over the center cell will be employed to protect the overhead bridge crane and bridge mounted remote maintenance manipulator from ionizing radiation during operation of the BPX machine. This configuration would also permit minimum test cell and building height design, consistent with the requirement to stow the crane far enough away from the center of the Tokamak to minimize magnetic field perturbation during BPX operation.

The aforementioned facility features are intended to meet the Conventional Facilities F&ORs of the BPX Project in a safe and cost-effective way. Whenever possible, conventional materials and construction techniques will be used. The few special materials and equipment required are all commercially available.

Cost Estimate and Schedule

The total construction cost of the BPX Conventional Facilities has been estimated at 122 million in 1991 dollars. The cost estimate methodology utilized is known

as "Bottoms-up" cost estimating and consisted of: Detailed labor and material take-off based upon conceptual design drawings; analyses of construction methods; development of work crews, wage rates and benefits; and material costs obtained from local and national vendors. Contractor overhead and profit was applied to the direct construction costs obtained. The cost estimating summary is shown in Table 1.

Preliminary design by PPPL will continue through September 1992 followed by Title I design to be initiated in October 1992. The design and construction of the BPX

conventional facilities is planned to be phased to start construction of conventional facilities in July 1994 in conjunction with the shutdown of the TFTR. The design and construction schedule will be paced by the availability of funding, with facilities construction completion anticipated in December 1999. Partial beneficial occupancy of the test cell and basement by others for the assembly and installation of the BPX machine and other auxiliary systems would occur starting in July 1998. The construction schedule was prepared using CPM and PERT networking techniques. A summary schedule is shown by Figure 6.

Table 1. Burning plasma experiment conventional facilities estimated project cost summary

<u>WBS No.</u>	<u>Description</u>	<u>Const. Cost</u>
TA	Facilities Mgt. & Adm.	2,212
TB	BPX Building	65,870
TBA	Add Pellet Injector Room	210
TBB	Lower BPX Bldg. 15 ft.	7,530
TC	Site Improvements & Util.	16,639
TD	FCPC Building	1,108
TF	Switchyard	477
TG	Motor Generator Bldg.	18,179
TH	TFTR Facility Modification	2,487
TJ	Liquefaction Bldg.	4,539
TO	Facilities I&C System	2,463
	TOTAL PROJECT COST	121,714
	(First Qt. of 1991 \$)

Figure 6. Conventional facilities construction schedule.

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