

STATUS OF PBFA II ENGINEERING

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SUMMARY

PBFA II is a 36-module accelerator of roughly 3 1/2 times the power and energy of PBFA I. It is presently in the final design stage and is expected to become operational in early 1986.

In the two years since the PBFA II project was initiated, rapid progress has been made in many areas. Design limitations in each of the major accelerator sections have been identified. A baseline configuration was developed and has been updated twice. A demonstration experiment (DEMON) was designed and constructed to serve as a prototype module. Results from this experiment are now enabling us to quantify the design limitations and are helping us move toward completion of the accelerator design.

Major engineering issues in PBFA II include the size, weight, and support of the accelerator, switching synchronization, switching method, component placement, component peak mechanical stresses, accelerator access, experimental shot rate limitations, fault modes, and activation and maintenance of the target chamber.

Along with these technical issues, we have pursued accelerator engineering approaches and quality assurance activities which will be central to constructing and operating PBFA II successfully. These will be tested soon: the structure which will house the accelerator will be completed in July 1983, and construction of the accelerator tank will begin in the same month.

INTRODUCTION

PBFA II is a superpower generator designed to perform ignition scaling studies in the late 1980's for the inertial confinement fusion program. The objective of the accelerator is to provide energetic light ion beams of sufficient power intensity for target implosion experiments. This will be accomplished through the steps in PBFA II pulse generation, compression, and transmission listed in Table I. A conceptual drawing of the accelerator is shown in Figure 1. Pulse generation takes place in the transformer-oil-insulated energy storage section; pulse compression predominantly takes place in the demineralized-water-insulated section; pulse transmission and spatial compression predominantly take place in the central vacuum section.

1. DC charge of 1400  $\mu$ f to +100kV and 1400  $\mu$ f to -100kV in two minutes
2. Marx circuit erection and discharge of the 14 MJ stored in about 1  $\mu$ sec
3. High voltage connection of the Marx outputs to water-insulated intermediate storage capacitors
4. Synchronized, laser-triggered gas switching of the energy into water-insulated, pulse forming lines
5. Compression of the power pulse to 40 ns FWHM using water-switched elements
6. Spatial convolution and transmission of the pulse to a vacuum insulator stack
7. Spatial convolution in vacuum and transmission of the pulse to an ion diode

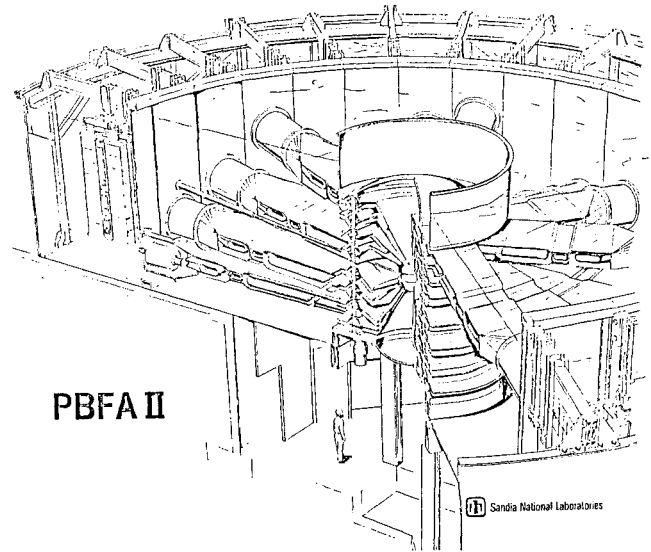


FIGURE 1: PBFA II

At present, the accelerator engineering design is at the midway point. Technical design limitations have been identified, many issues have been resolved, but others remain. A list of milestones passed to date is presented in Table II.

PBFA-II MILESTONES

CONCEPTUAL DESIGN	MAY 1981
FIRST ROUND OF LAYOUTS	JUNE 1981
CHOICE OF BASELINE WATER-LINE CONFIGURATION	JULY 1981
DECISION TO PROCEED WITH DEMONSTRATION (DEMON) EXPERIMENT	AUGUST 1981
DEMON TANK DESIGN COMPLETED	NOVEMBER 1981
PBFA-II PHASE B MODIFICATIONS INCORPORATED	DECEMBER 1981
DEMON MARX DESIGN COMPLETED	JANUARY 1982
PBFA-II TANK DESIGN COMPLETED	MAY 1982
DEMON TANK CONSTRUCTED	MAY 1982
DEMON MARX INSTALLED	JUNE 1982
DEMON TRANSFER SWITCH INSTALLED	AUGUST 1982
PBFA-II TANK CONTRACT AWARDED	NOVEMBER 1982
DEMON PULSE FORMING SECTION INSTALLED	MARCH 1983
PBFA-II TANK STEEL EMBEDMENTS INSTALLED	APRIL 1983
COMPLETION OF PHASE B	JULY 1983
BEGINNING OF PBFA-II TANK CONSTRUCTION	JULY 1983

TABLE II: PBFA II Milestones

TABLE I. PBFA II Accelerator Operation

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# Report Documentation Page

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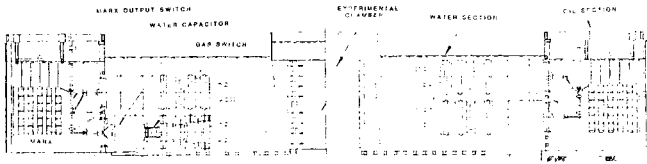


FIGURE 5: Elevation View Of The PBFA II Accelerator

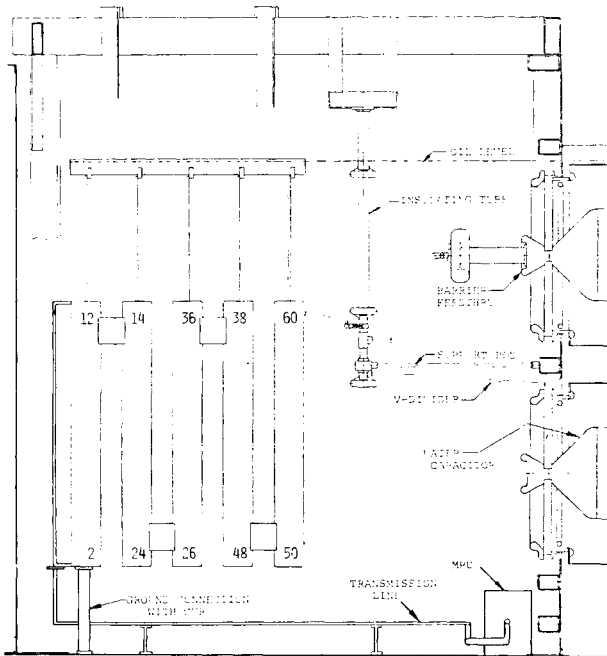


FIGURE 6: PBFA II Energy Storage Section

Component Mechanical Stresses

Significant design limitations in the area of mechanical stresses have to include, besides fluid weights, the water shock due to water switching internal to the coaxial PFL structure (about 100 psi), the water shock at the tank floor, and both the pulsed and static stresses at the vacuum insulator stack. An example of these latter stresses is given in Figure 7.

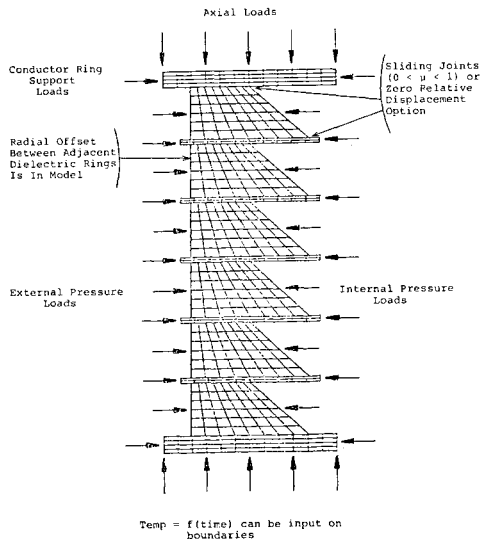


FIGURE 7: PBFA II Vacuum Interface Static Stress Analysis

Accelerator Access

PBFA II has been designed with maintenance as a foremost consideration. The large pit beneath the accelerator, placement of components, and work platforms in each section of the accelerator will contribute to improved maintenance capability and higher data recovery.

Experimental Shot Rate

The experimental shot rate limitations which can be foreseen at this time include refurbishment and replacement of the diode, alignment of the diode within a large insulator stack, diagnostics placement, and target chamber evacuation. Mechanical removal of small bubbles from high electrical stress areas in the water-dielectric pulse forming section will still be necessary due to entrapment of entrained air during filling, but will be minimized by a deaeration loop included in the water processing system.

Fault Modes

The fault modes of highest consequence in PBFA II which can be postulated are shown in Table IV. The mechanical and electrical design of these elements has taken into account reasonable factors of safety, and design is continuing.

1. Marx Generator Prefire
2. Oil/Water Barrier Tear, Rupture, Or Burn-Through
3. Water Arc
  - Within A PFL
  - At A Gas Switch
  - At The Vacuum Insulator
4. Vacuum Insulator Rupture
5. "Instantaneous" Loss Of Vacuum
6. Dropping A Major Component Due To
  - Crane Failure
  - Hardware Failure
  - Operator Error

TABLE IV: Significant "Recognized" Accelerator Fault Modes

Activation and Maintenance of the Target Chamber

If ignition is achieved on PBFA II, the neutron dose to the diode, diagnostics, vacuum interface dielectric and grading rings and vacuum covers will be significant. The heaviest dose will be incident upon the diode, which will also require the most frequent refurbishment. Aluminum will be used to the greatest extent possible, rather than steel or brass, so that hands-on maintenance may begin within 24 hours of a major neutron-producing shot. For high-level shots, neutron activation could be a significant limitation on the possible shot rate.

PBFA II ACCELERATOR ENGINEERING APPROACH

The elements of accelerator engineering which we are using during the PBFA II design and construction period are shown in Table V. Key items in the list include criteria reviews and sequential design and drawing reviews. These reviews are instrumental in resolving design issues before moving to the next level of hardware development. Evolution of accelerator hardware for a multimodular accelerator typically proceeds through several stages, as listed in Table VI. In several instances on PBFA II, engineered

- Pre-conceptual Design
- Conceptual Design
  - Criteria development
  - Criteria review
- Preliminary Design
  - PDR
- Final Design
  - FDR
- Final Drafting
- Drawing Sign-off
- Procurement
- Fabrication
  - Field Monitoring
- Delivery & Inventory
  - Inspection
- Assembly and Installation
- Subsystem Tests
- System Tests
  - Final documentation

TABLE V: Elements Of Accelerator Engineering

1. Research Hardware
2. Engineered Hardware
3. Prototype Hardware
4. Production Hardware

TABLE VI: Stages Of Hardware Evolution

hardware and prototype hardware are the same. In cases where significant modification is required after a test series, they are separate.

### Engineering Modeling

We have learned that an attractive means of determining component layouts, resolving interface conflicts, and uncovering errors in final drawings early, quickly, and at minimal cost is available through scale modeling. Different types of models suit different needs. A brief description of model types and utilization is given in Table VII.

1. Block Models
  - Used during conceptual design phase to plan and lay out components, and to begin system layout drawings
  - Primary use: Space utilization
2. Preliminary Models
  - Used during preliminary design phase to display and test various hardware concepts
  - Primary use: Component and system integration
3. Check Models
  - Used during final design phase to check accuracy of engineering drawings
  - Primary use: Uncover errors

TABLE VII: Types Of Engineering Design Models

### Quality Assurance

In a project of the scope of PBFA II, quality assurance is an essential prerequisite for meeting cost, performance, and schedule objectives. Quality control of hardware during fabrication is only a small portion of quality assurance. The remaining elements are listed in Table VIII. First and most important among these is the dedication of highly skilled engineers, without whom execution of a major project is impossible.

1. Highly-Skilled, Dedicated Engineers
2. Drawing Control
3. Check Modelling
4. Technical Award Criteria For Procurement Of Key Items
5. Survey Of Qualified Vendors For Procurement Of Major Items
6. Early And Frequent Vendor Site Visits

TABLE VIII: Major QA Elements

### CONCLUSION

In conclusion, there are three points to be made relative to the status of PBFA II engineering:

1. We are mid-way in the design of the accelerator and tank construction is now beginning.
2. Most of the important accelerator limitations have been identified and solutions to design problems are being developed.
3. We are attempting to maximize our chances of performing ignition scaling studies on PBFA II later in this decade, and are eagerly looking forward to the excitement of the next few years.