THE OAK RIDGE TNS/PEPR PROGRAM IS CONSIDERING MODIFIED PHYSICS AND ENGINEERING CRITERIA TO EASE REMOTE MAINTENANCE PROBLEMS*

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Early work on The Next Step Program at Oak Ridge consisted of Systems Trade Studies to evaluate the device cost sensitivities for several tokamak configurations. The result of this effort is the baseline design[1] shown in Figures 1 and 2. Some of the key parameters and major components are listed in Table 1.

Table 1. Some System Parameters of the Baseline Design

Number of TF Coils	20
TF Coil Conductor	Nb_3Sn
TF Coil Vertical Bore (m)	7.6
TF Coil Horizontal Bore (m)	4.9
Plasma Minor Radius, a (m)	1.2
Plasma Major Radius, R (m)	5.0
Plasma Elongation, δ (-)	1.6
Aspect Ratio, A (-)	4.2
Field at TF Coil, B_m (T)	10.9
Field on Axis, B_t (T)	5.3
Plasma Current, I_p (MA)	4.9
Total Volt-Seconds	51.6
Plasma Volume, V_p (m^3)	227.6
Neutron Wall Load (MW/m^2)	1.28
Total Fusion Power (MW)	698
Fusion Power Density (MW/m^3)	2.6
Neutral Beam Power (MW)	50.0
Steady State Burn Time (s)	16.0
Time Between Pulses (s)	300.0
Shielding	Stainless Steel with Borated Water
Neutral Beam Injectors	5 @ 150 keV
HV Pumping	9 Cryo-pumps
Fueling	1 Pellet Injector

Development of the baseline drawings focussed attention on the difficulties of machine disassembly. This task is complicated by limited access between TF coils, by the location of equilibrium field coils within the bore of the toroidal coils, and by the requirement for remote cutting, welding, and leak detection of the torus.

Our FY78 work is studying several design options to minimize these mechanical engineering problems.

1. The original field ripple requirement of 1% led to a configuration with 20 TF coils. In this design, removal of the vacuum vessel/shield segments cannot be achieved without also removing adjacent magnets[1] as shown in Figure 2. Recent developments regarding plasma sensitivity to these magnetic perturbations indicate that increased ripple may be tolerated, resulting in a reduced number of toroidal coils. This may allow segments of the machine to be removed between coils, resulting in a stationary installation of the toroidal magnets. This is desirable from a maintenance aspect, as the coils are expected to have a much longer operating life than the first wall components.

2. Disassembly of the device, even with the additional access, is still a complex operation with some question of reliability. The high levels of activation and the ultra high operating vacuums in the toroidal vessel require remote cutting, welding, and leak detection for the conventional tokamak design. We are studying the vacuum building concept[2-3] as an option to relieve these severe requirements. A bi-level containment building modeled after the NASA Space Power Facility at the Lewis Research Center is being studied.

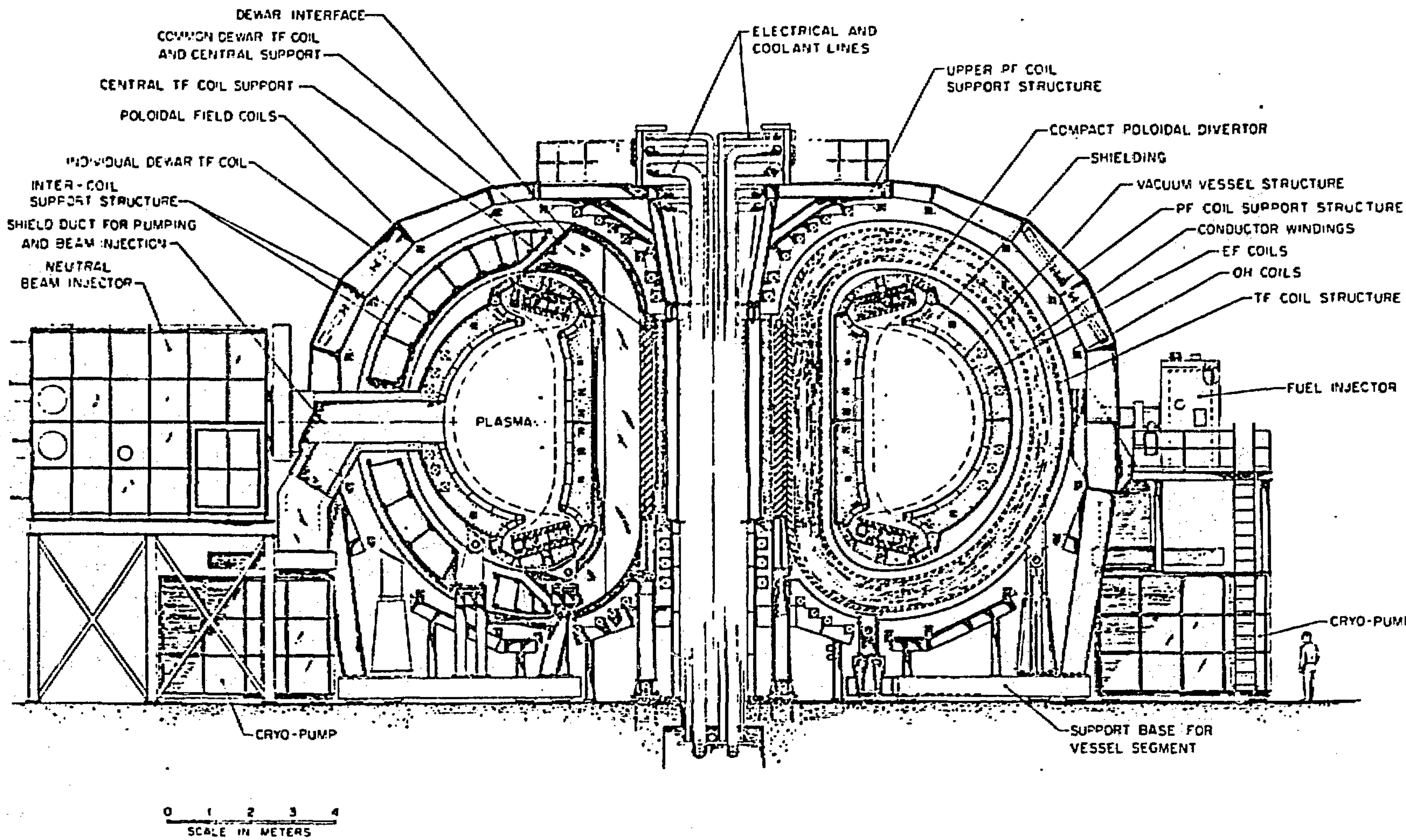
By operating TNS in this vacuum environment, the welded vessel segments may be replaced by mechanically bolted flanges incorporating deformable ring seals. Conductance leaks across these joints are thought to be tolerable and can be handled by the cryo-pumping system. In addition, elimination of the vacuum dewars for the superconducting coils is also part of this study.

3. Disassembling the segments now appears more feasible; however, their removal is complicated by the entrapment of the poloidal field coils (Fig. 1).[1] The iron-core option, instead of the present air-core transformer, is being studied. A portion of this work will consider placement of the equilibrium field coils outside of the TF coil bore and may indicate that some, or possibly all, of these poloidal coils must be superconducting. The cost implications regarding power supplies and power conversion will be evaluated along with questions concerning plasma stability. From a mechanical point of view, it is desirable to locate no coils within the TF bore.

4. The maintenance operations on the device fall into two categories, scheduled and unscheduled. Within these classes, major components must be handled fully remotely, semi-remotely, or by direct contact. Determining which of these modes for handling, as well as needed equipment, requires establishing zones of activation using realistic neutronic analyses. We recognize the need for three-dimensional models, but within budget constraints, two-dimensional models are being considered to develop a topology of zones of maintenance. Presently, our activation levels are based on a simplified one-dimensional study which does not

account for major penetrations to the plasma. These more detailed neutronic calculations will, in addition to accurately mapping activation, allow us to begin considering shield optimization vs. cost and maintainability.

The four areas discussed are not presented as absolute answers to these complex problems, but are thought to be viable solutions relaxing near impossible constraints. The close working relationship between physics and engineering is bringing about realistic compromises leading to a feasible tokamak device.



ELEVATION (CUTAWAY)

Fig. 1. Oak Ridge TNS/PEPR Baseline Design.

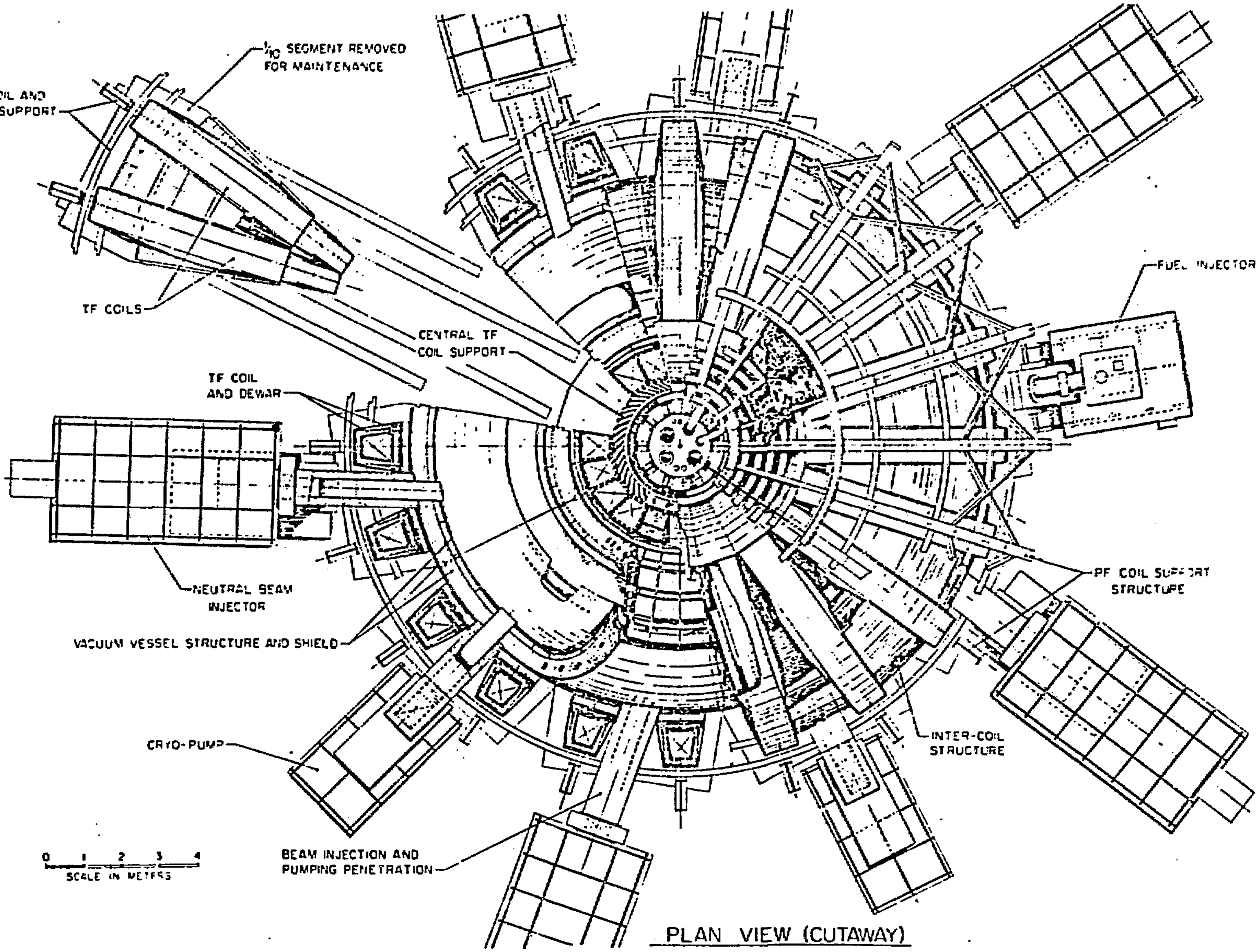


Fig. 2. Oak Ridge TNS/PEPR Baseline Design

REFERENCES

1. D. Steiner et al, "Oak Ridge TNS Program: Context, Scope, and Baseline Design of the FY 1978 Activities," ORNL/TM-6201, in press.

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3. D. Steiner et al, "ORNL Fusion Power Demonstration Study: Interim Report," ORNL/TM-5813.