CONF-841010--12

FUSION ENGINEERING DESIGN CENTER

"TMRBAR" POWER BALANCE CODE FOR TANDEM MIRROR REACTORS

CONF-841010--12

DE85 003333

General

- Coupled, multi-region, zero dimensional power balance code.
- Configured for (a) MARS (quadrupole) mode and (b) TARA/ MINIMARS (octupole-Axisymmetric) mode.
- Outputs include plasma parameters (densities temperatures, potentials, absorbed powers, etc.) and system engineering power balance parameters (recirculating powers, thermal powers, etc.)

Central Cell Physics

- Fuel ion particle/energy balance.
- Electron energy balance.
- Alpha particle balance.
- Global charge balance.
- Hot alpha prompt losses:
  - (a) Non-adiabaticity
  - (b) FLR losses to halo.
- Pressure balance.

*Research sponsored by the Office of Fusion Energy, U.S. Department of Energy, under contract DE-AC05-84OR21400 with Martin Marietta Energy Systems, Incorporated.

MINIMARS SUMMARY DATA FOR FIXED NET ELECTRIC POWER

FUSION POWER, Q, WALL LOADING

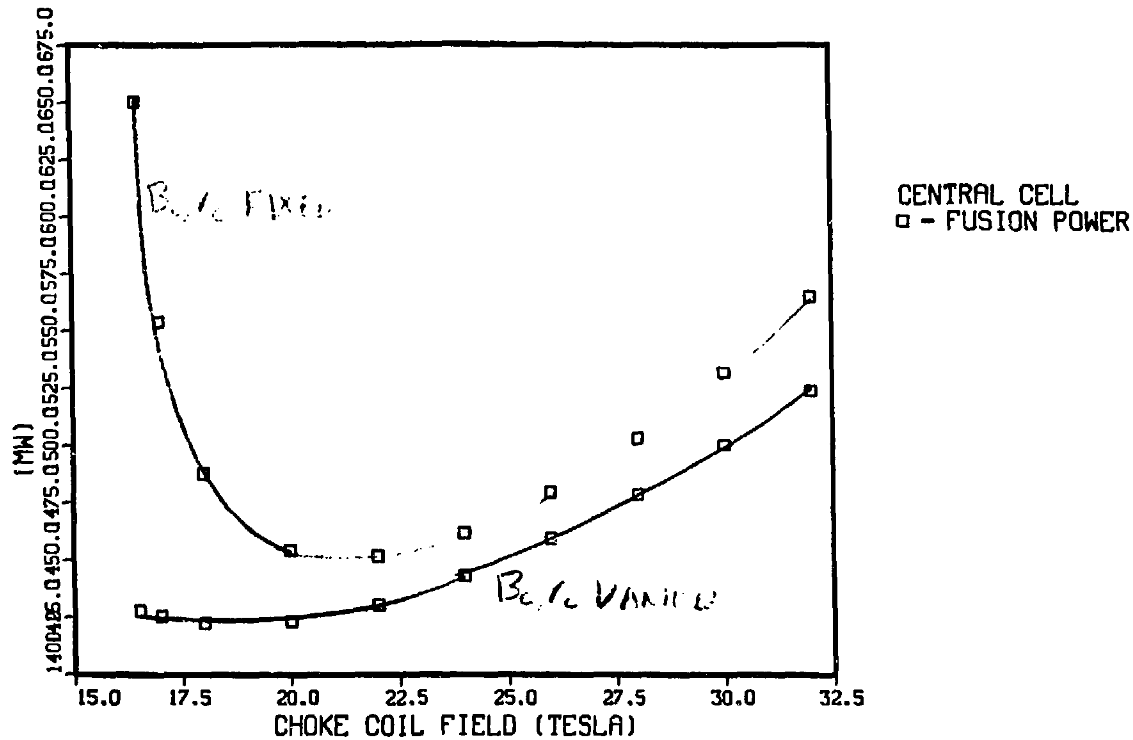
CASE	PNETEL (MW)	PFUS (MW)	PFUS/VCC (MW/M3)	QPHYS	Q	QENGR	GAMMA (MW/M2)
OOP1	600.000	1929.417	13.631	29.263	8.239	2.281	2.308
OOP2	600.000	1650.268	14.530	37.634	12.351	3.038	2.461
OOP3	600.000	1554.044	15.629	42.146	15.446	3.545	2.647
OOP4	600.000	1487.471	17.611	45.954	18.770	4.051	2.982
OOP5	600.000	1454.012	20.141	50.586	21.690	4.378	3.411
OOP6	600.000	1451.500	21.584	55.659	23.537	4.416	3.655
OOP7	600.000	1461.296	22.597	60.978	25.064	4.327	3.827
OOP8	600.000	1479.025	23.388	66.364	26.425	4.169	3.961
OOP9	600.000	1502.879	24.031	71.764	27.680	3.976	4.070
OOP10	600.000	1531.856	24.557	77.173	28.862	3.770	4.159
OOP11	600.000	1565.310	24.982	82.611	29.993	3.564	4.231
OOP12	600.000	1430.765	11.855	54.371	23.084	4.632	2.218
OOP13	600.000	1427.685	12.442	55.937	23.491	4.678	2.288
OOP14	600.000	1425.303	13.040	57.544	23.903	4.717	2.357
OOP15	600.000	1422.426	14.274	60.907	24.747	4.774	2.494
OOP16	600.000	1423.025	16.893	68.266	26.512	4.809	2.759
OOP17	600.000	1430.305	19.698	76.579	28.386	4.761	3.010
OOP18	600.000	1442.671	22.688	85.946	30.368	4.654	3.245
OOP19	600.000	1458.961	25.821	96.481	32.457	4.512	3.462
OOP20	600.000	1478.317	29.066	108.267	34.648	4.352	3.659
OOP21	600.000	1500.116	32.368	121.369	36.929	4.185	3.836
OOP22	600.000	1523.894	35.682	135.861	39.296	4.018	3.990

CASE	CLENGTH (M)	ELACELL (M)	CRADIUS (CM)	RCHOKE (CM)	BBAR (TESLA)	BVAC0C (TESLA)	ENC E14CM-3
OOP1	148.947	10.024	55.000	23.239	16.000	3.300	2.055
OOP2	119.516	10.028	55.000	22.834	16.500	3.300	2.126
OOP3	104.632	10.041	55.000	22.448	17.000	3.300	2.212
OOP4	88.877	10.045	55.000	21.728	18.000	3.300	2.364
OOP5	75.963	9.962	55.000	20.467	20.000	3.300	2.555
OOP6	70.765	9.835	55.000	19.395	22.000	3.300	2.663
OOP7	68.049	9.710	55.000	18.469	24.000	3.300	2.738
OOP8	66.545	9.597	55.000	17.660	26.000	3.300	2.797
OOP9	65.809	9.495	55.000	16.945	28.000	3.300	2.845
OOP10	65.640	9.405	55.000	16.307	30.000	3.300	2.884
OOP11	65.933	9.323	55.000	15.734	32.000	3.300	2.916
OOP12	97.601	9.873	62.737	23.237	16.000	2.536	2.156
OOP13	95.858	9.833	61.728	22.634	16.500	2.567	2.208
OOP14	94.281	9.795	60.748	22.060	17.000	2.597	2.260
OOP15	91.590	9.721	58.850	20.982	18.000	2.657	2.363
OOP16	87.714	9.580	55.290	19.072	20.000	2.773	2.567
OOP17	85.407	9.447	52.021	17.432	22.000	2.884	2.767
OOP18	84.280	9.322	49.006	16.006	24.000	2.990	2.964
OOP19	84.097	9.202	46.246	14.759	26.000	3.092	3.155
OOP20	84.672	9.088	43.727	13.664	28.000	3.189	3.340
OOP21	85.873	8.978	41.448	12.701	30.000	3.291	3.515
OOP22	87.608	8.872	39.392	11.851	32.000	3. 68	3.680

B_c, r_c VARIED

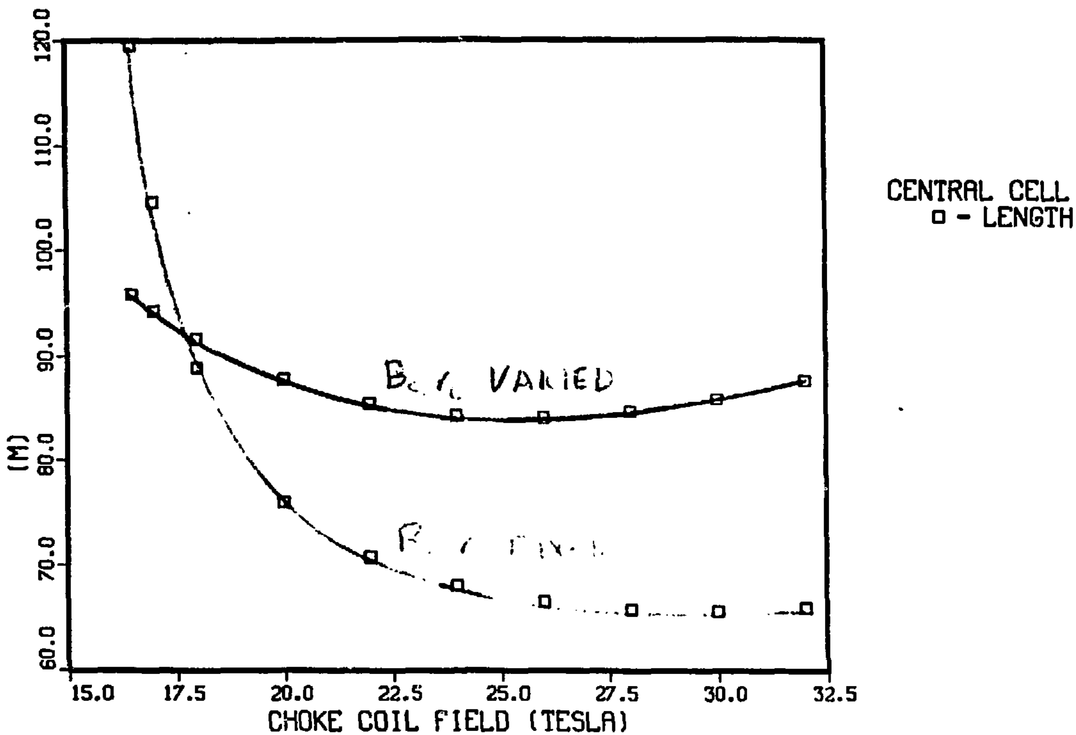
B_c, r_c VARIED

MINIMARS

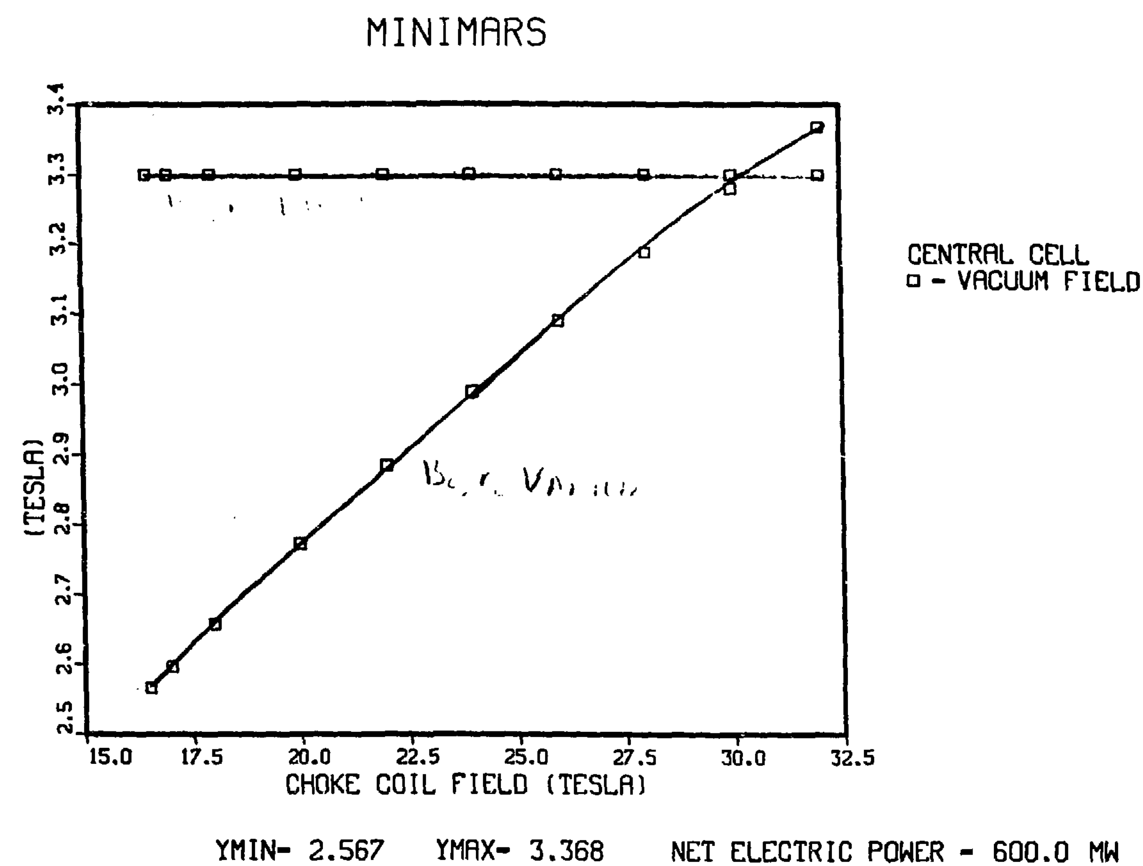


YMIN= 1422. YMAX= 1650. NET ELECTRIC POWER = 600.0 MW

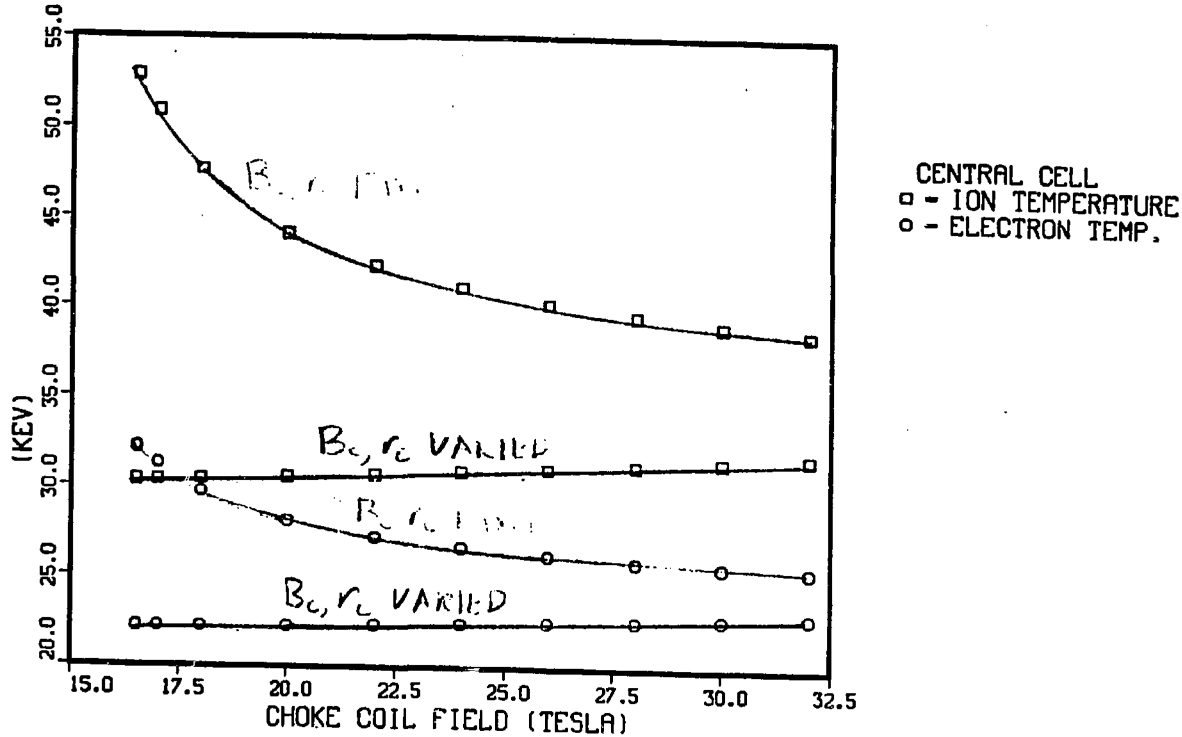
MINIMARS



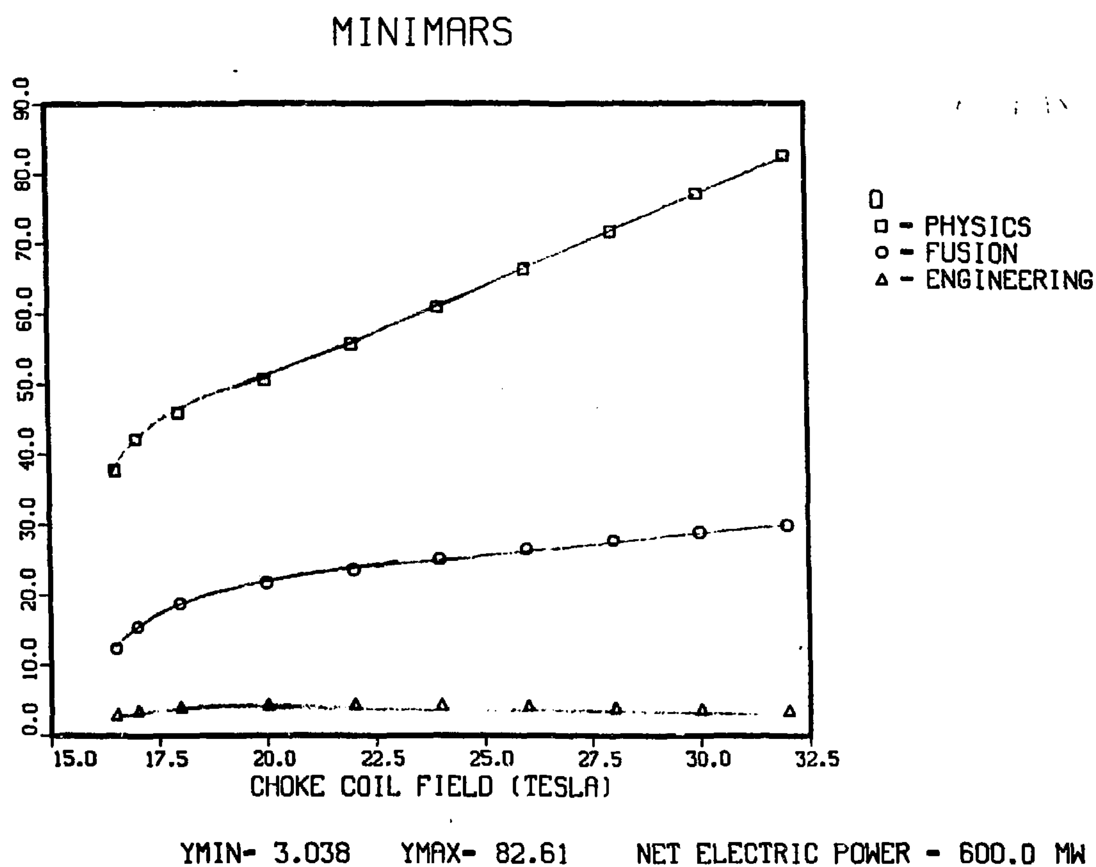
YMIN= 65.64 YMAX= 119.5 NET ELECTRIC POWER = 600.0 MW

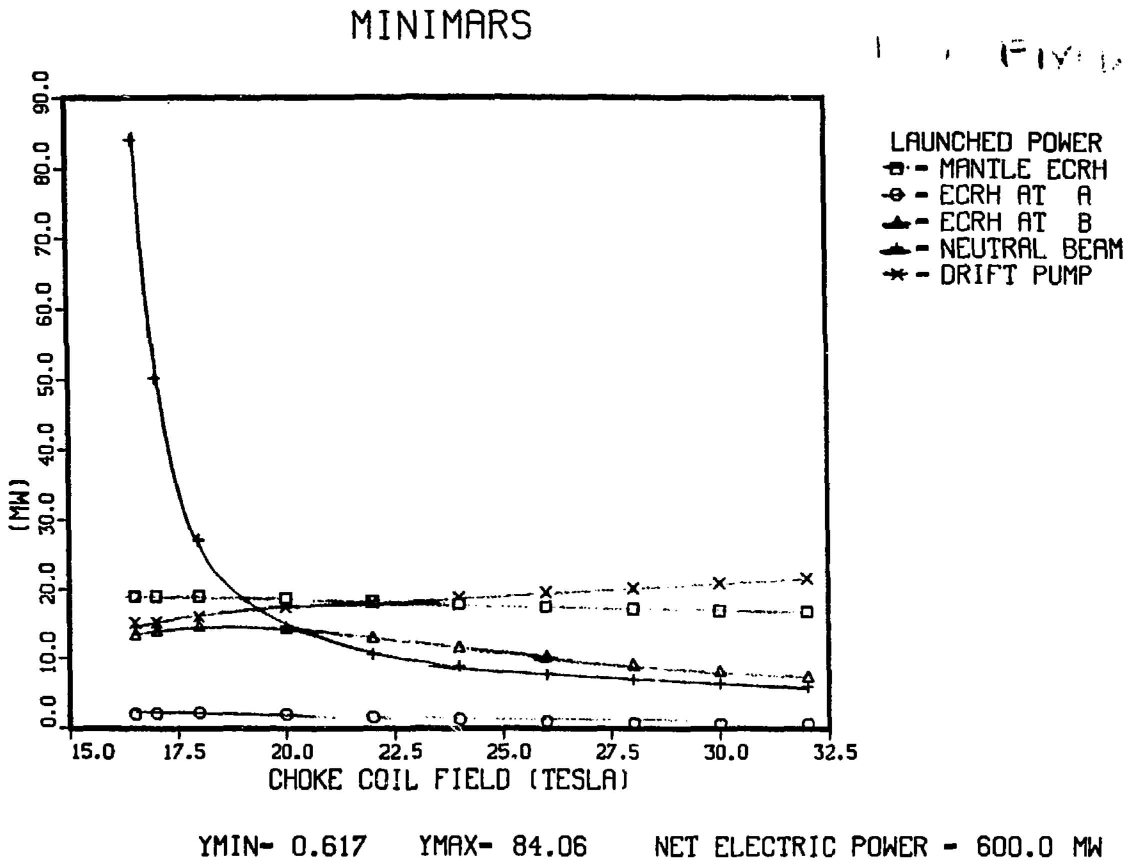

MINIMARS
3.4
3.3
3.2
3.1
3.0
2.9
2.8
2.7
2.6
2.5
(TESLA)
15.0
17.5
20.0
22.5
25.0
27.5
30.0
32.5
CHOKE COIL FIELD (TESLA)
CENTRAL CELL
□ - VACUUM FIELD
YMIN- 2.567 YMAX- 3.368 NET ELECTRIC POWER - 600.0 MW

MINIMARS

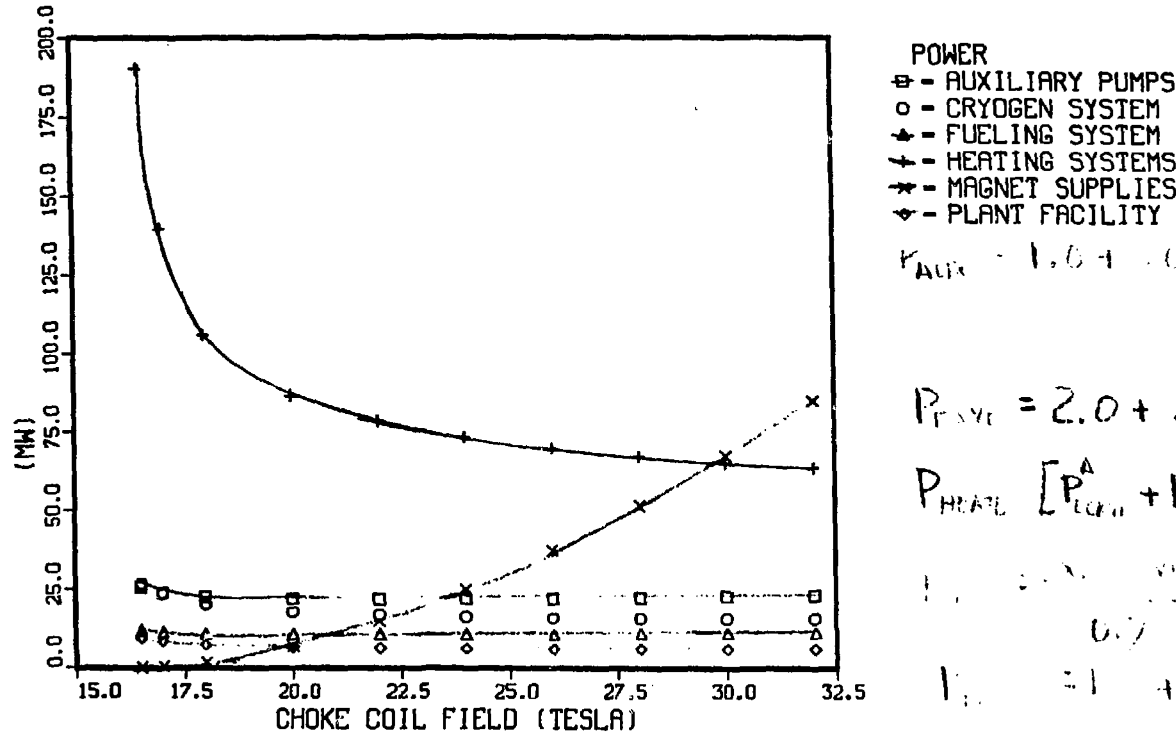


YMIN= 22.19 YMAX= 52.87 NET ELECTRIC POWER = 600.0 MW

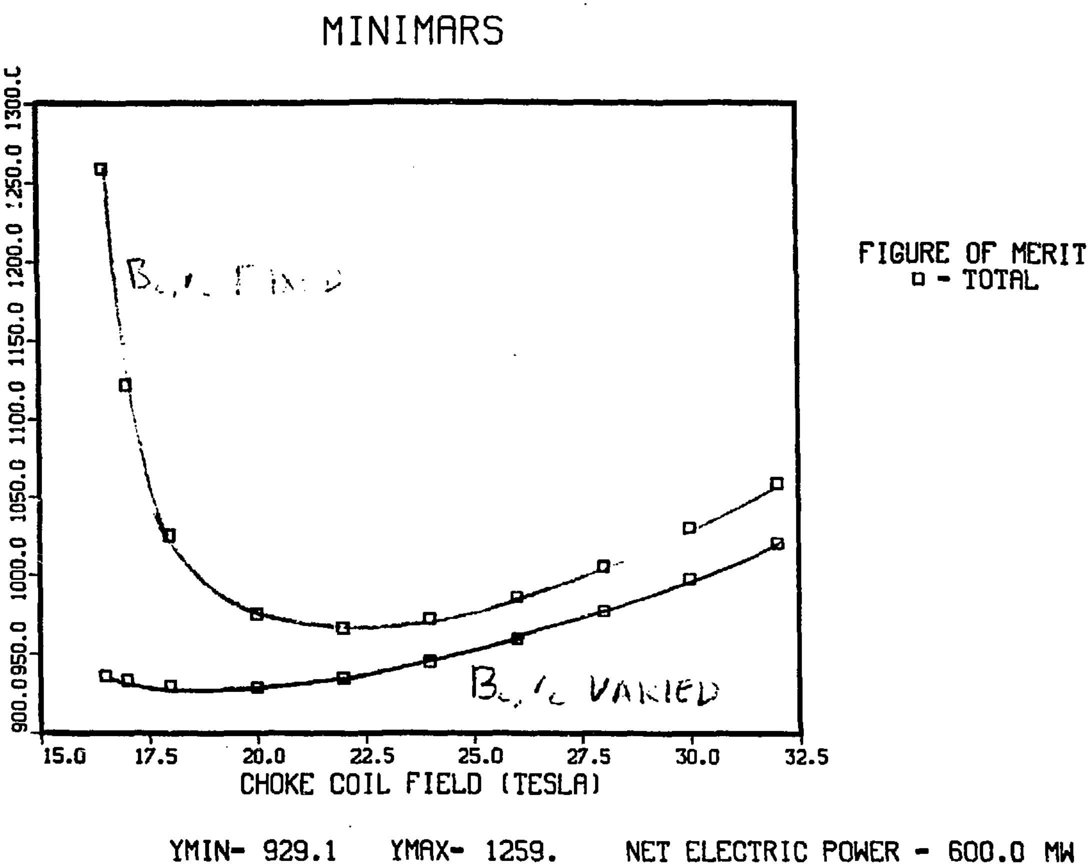

MINIMARS
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
15.0
17.5
20.0
22.5
25.0
27.5
30.0
32.5
CHOKE COIL FIELD (TESLA)
0
□ - PHYSICS
○ - FUSION
Δ - ENGINEERING
YMIN= 3.038 YMAX= 82.61 NET ELECTRIC POWER = 600.0 MW

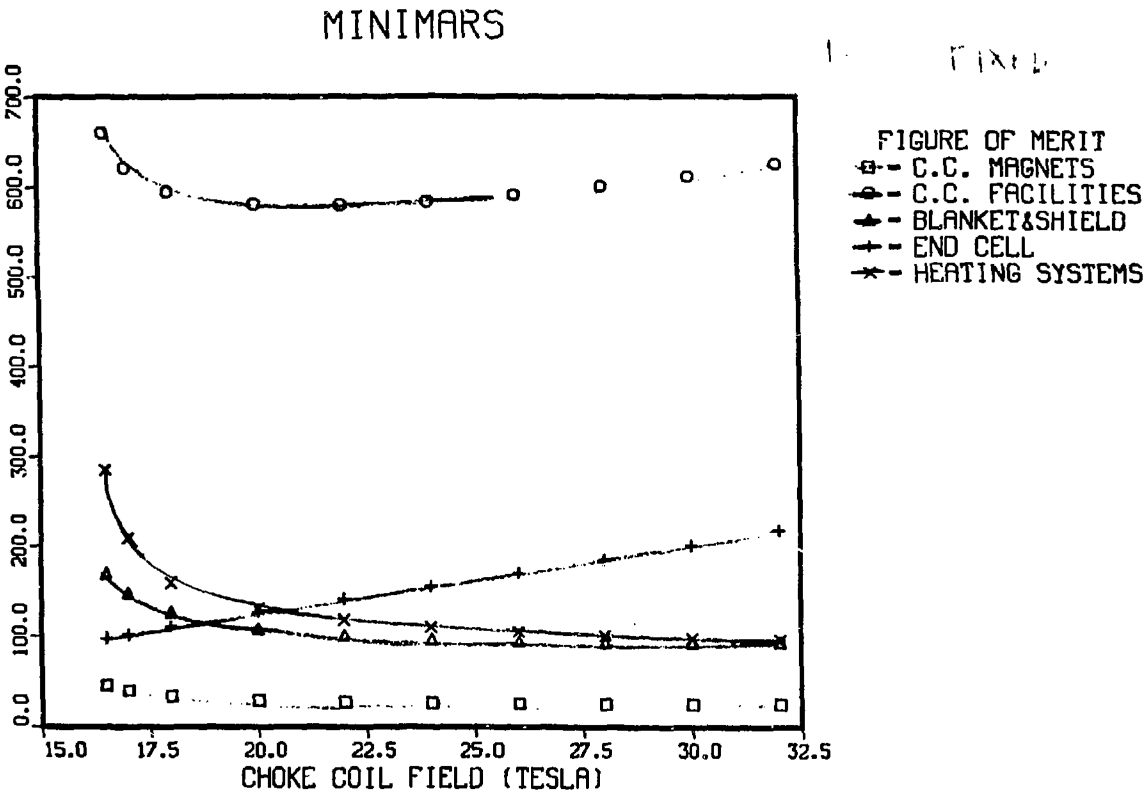

MINIMARS
LAUNCHED POWER
MANTLE ECRH
ECRH AT A
ECRH AT B
NEUTRAL BEAM
DRIFT PUMP
(MW)
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
15.0
17.5
20.0
22.5
25.0
27.5
30.0
32.5
CHOKE COIL FIELD (TESLA)
YMIN= 0.617 YMAX= 84.06 NET ELECTRIC POWER = 600.0 MW

MINIMARS



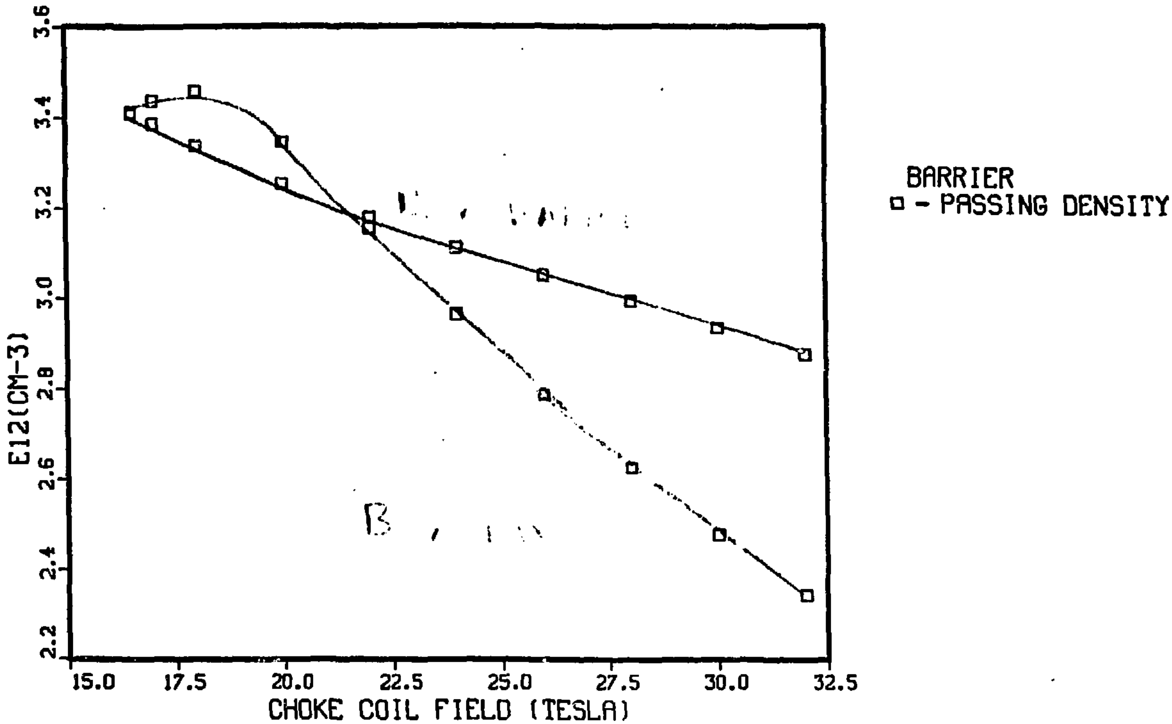
YMIN- 0.121   YMAX- 190.4   NET ELECTRIC POWER - 600.0 MW


MINIMARS
900.0
950.0
1000.0
1050.0
1100.0
1150.0
1200.0
1250.0
1300.0
15.0
17.5
20.0
22.5
25.0
27.5
30.0
32.5
CHOKE COIL FIELD (TESLA)
FIGURE OF MERIT
□ - TOTAL
YMIN- 929.1 YMAX- 1259. NET ELECTRIC POWER - 600.0 MW



YMIN= 25.18 YMAX= 660.1 NET ELECTRIC POWER = 600.0 MW

MINIMARS



YMIN= 2.343 YMAX= 3.457 NET ELECTRIC POWER = 600.0 MW

MINIMARS SUMMARY DATA FOR FIXED NET ELECTRIC POWER AND WALL LOADING

FUSION POWER, Q, WALL LOADING

CASE	PNETEL (MW)	PFUS (MW)	PFUS/VCC (MW/M3)	QPHYS	Q	QENGR	GAMMA (MW/M2)
0113A	600.001	1531.841	3.395	85.930	33.422	4.276	0.761
0113	600.000	1472.281	7.169	95.688	32.474	4.641	1.209
0112	600.000	1591.836	11.831	249.150	70.932	4.213	1.000
0111	600.000	1436.049	15.362	102.488	34.702	4.999	2.000
0110	600.000	1424.346	18.999	64.665	25.815	4.779	3.000
0118	600.000	1454.348	21.078	44.393	20.327	4.243	4.000
0117	600.000	1525.761	25.438	38.875	18.596	3.656	5.000
0123G	2000.000	4814.462	6.452	423.165	58.326	5.215	1.000
0123E	2000.000	4542.017	11.513	253.056	46.439	6.200	2.000
0123D	2000.000	4467.152	11.374	119.542	34.191	6.231	3.000
0123B	2000.000	4458.329	19.153	136.110	36.626	6.374	4.000
0122B	2000.000	4464.076	24.701	123.794	35.367	6.289	5.000
0122F	2000.000	4515.333	49.505	122.904	35.328	5.941	8.000
0122H	2000.000	4723.556	41.396	55.587	23.607	4.754	10.000

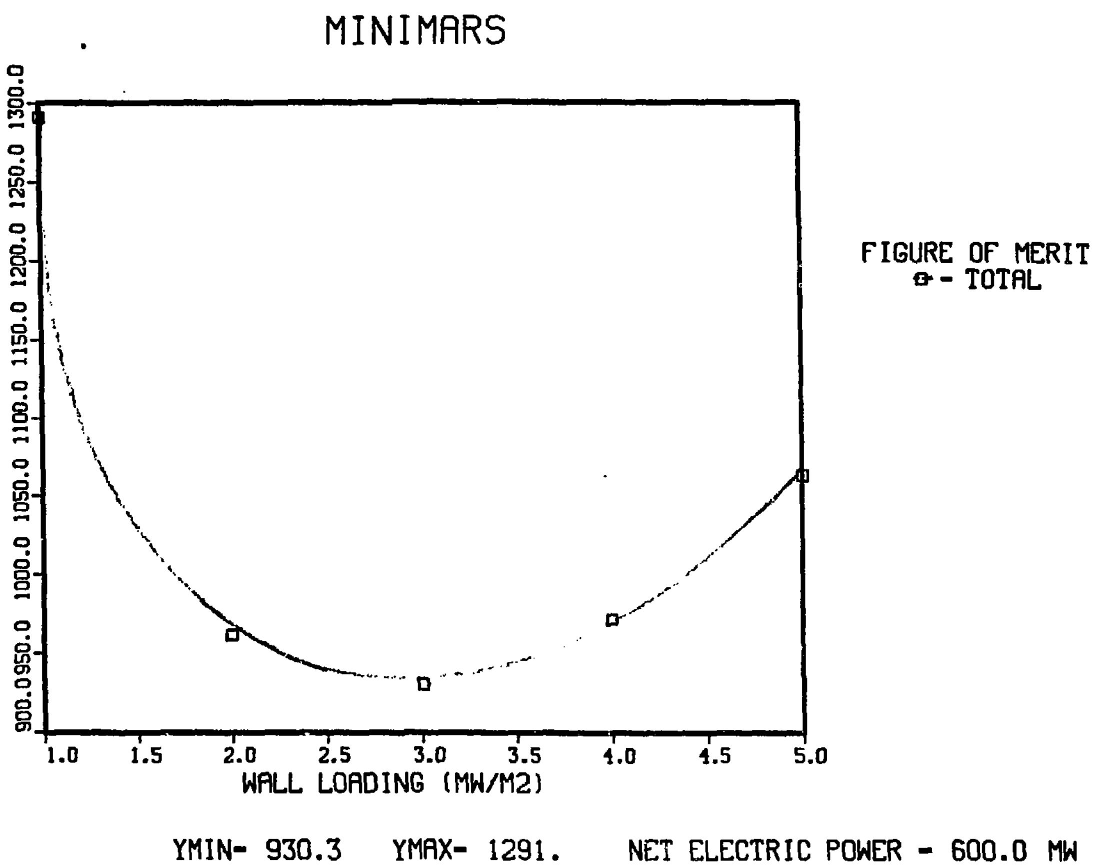
P_{elec}^{net} 2000 MW

CASE	CLENGTH (M)	ELACELL (M)	CRADIUS (CM)	RCHOKE (CM)	BBAR (TESLA)	BVAC0C (TESLA)	ENC E14CM-3
0113A	229.844	9.273	79.051	24.698	14.861	1.668	1.467
0113	176.797	9.190	60.808	20.015	16.754	2.020	2.084
0112	348.364	8.497	35.063	13.684	16.706	2.347	2.485
0111	135.998	9.205	46.776	17.169	18.206	2.654	2.518
0110	83.613	9.659	53.423	18.779	20.057	2.876	2.698
0118	58.516	10.065	61.265	20.523	22.091	3.042	2.750
0117	49.755	10.217	61.945	19.826	25.924	3.363	2.905
0123G	734.471	8.894	56.867	19.860	15.545	2.041	1.795
0123E	354.304	9.433	59.534	20.781	17.574	2.458	2.209
0123D	180.823	10.298	83.149	27.167	18.587	2.502	2.130
0123B	165.504	10.153	66.910	22.650	20.397	2.882	2.724
0122B	138.679	10.273	64.407	21.729	21.864	3.091	3.068
0122F	108.027	10.266	51.842	17.158	27.280	3.698	4.301
0122H	68.997	11.170	72.554	22.854	28.221	3.717	3.754

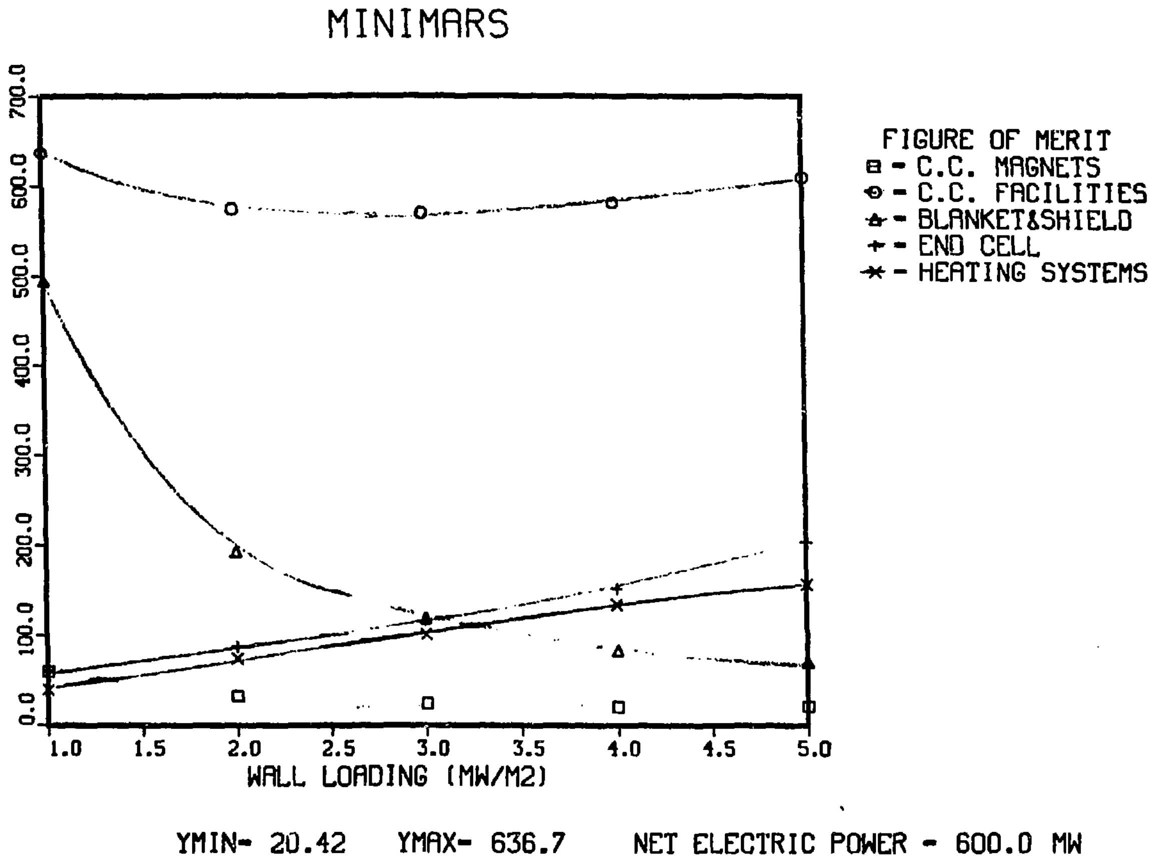
P_{elec}^{net} 600 MW

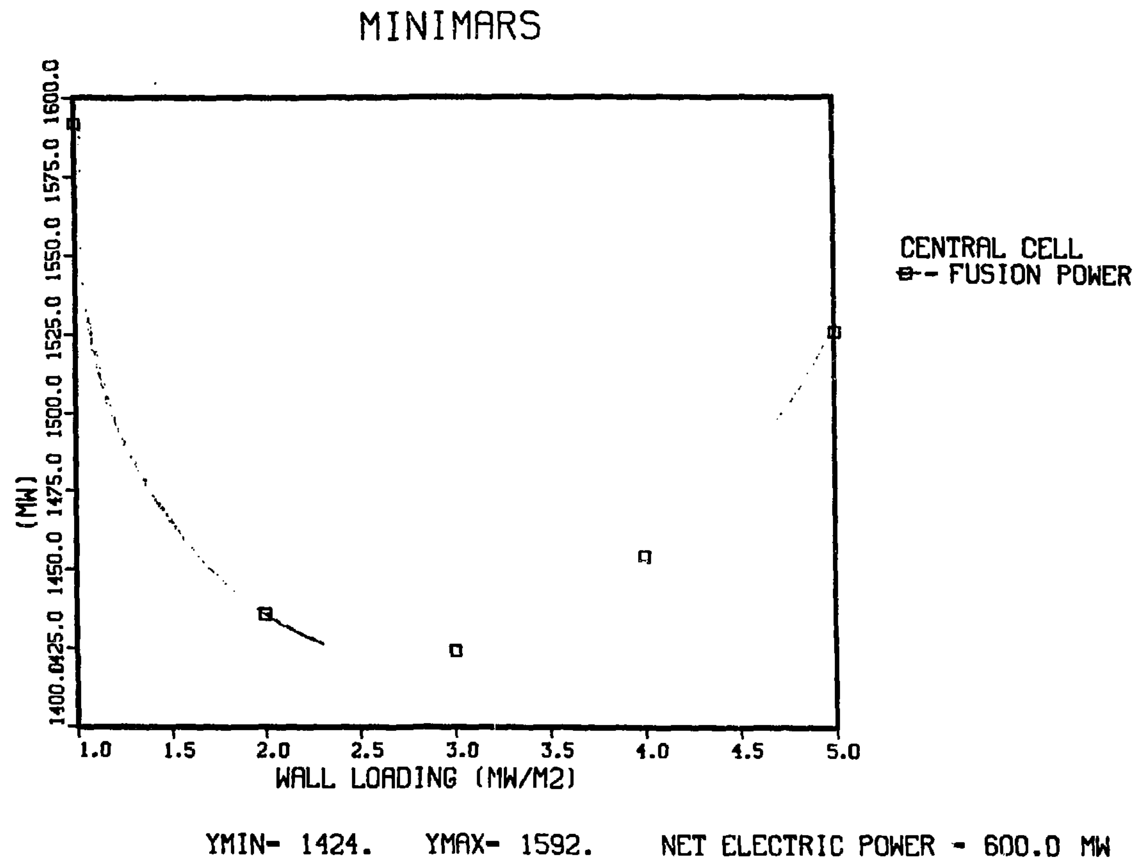
P_{elec}^{NET} = 2000 MW

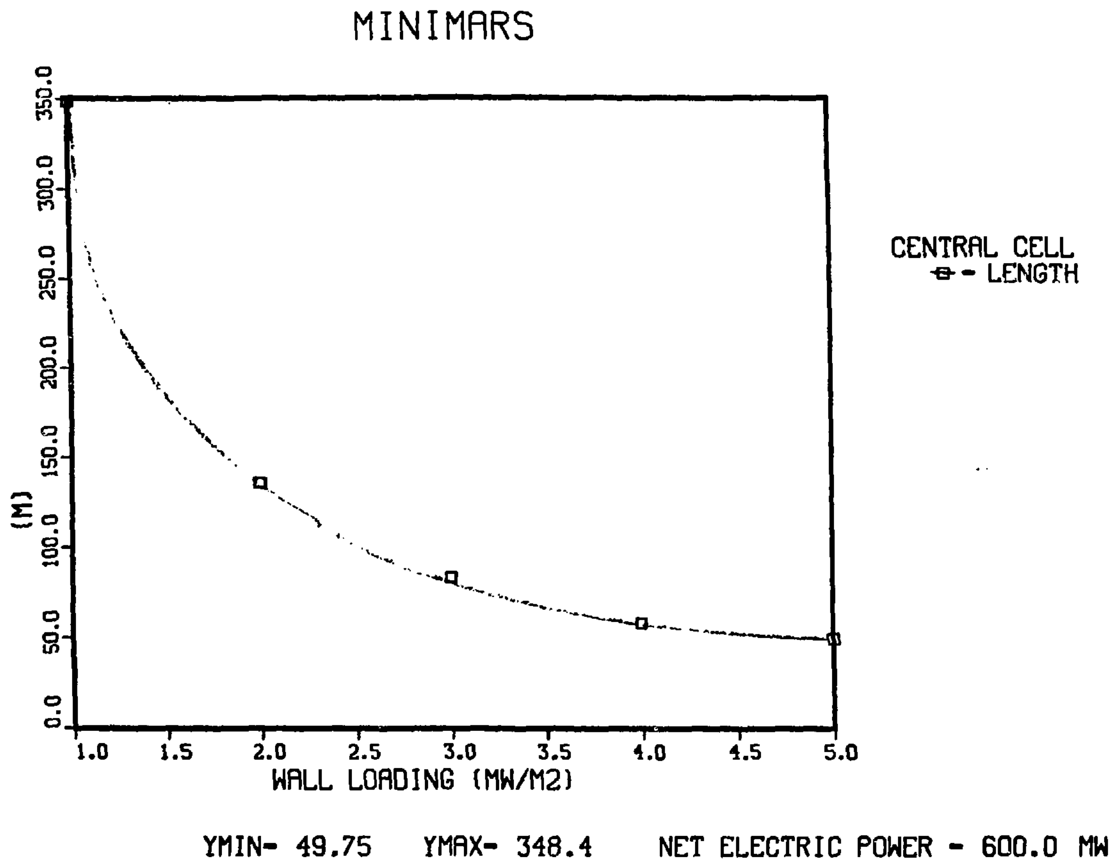
CASE	TC (KEV)	TEC (KEV)	BETAB	PINJMW (MW)	PABSMW (MW)	CALPH	SLOSH
0113A	19.362	17.213	0.330	45.834	17.827	0.032	1.184
0113	20.001	17.334	0.330	45.338	15.386	0.030	1.255
0112	22.481	19.807	0.339	22.442	6.389	0.040	1.381
0111	28.429	21.730	0.330	41.382	14.012	0.037	1.384
0110	31.326	22.593	0.330	55.175	22.026	0.034	1.465
0118	34.789	23.795	0.330	71.548	32.761	0.029	1.527

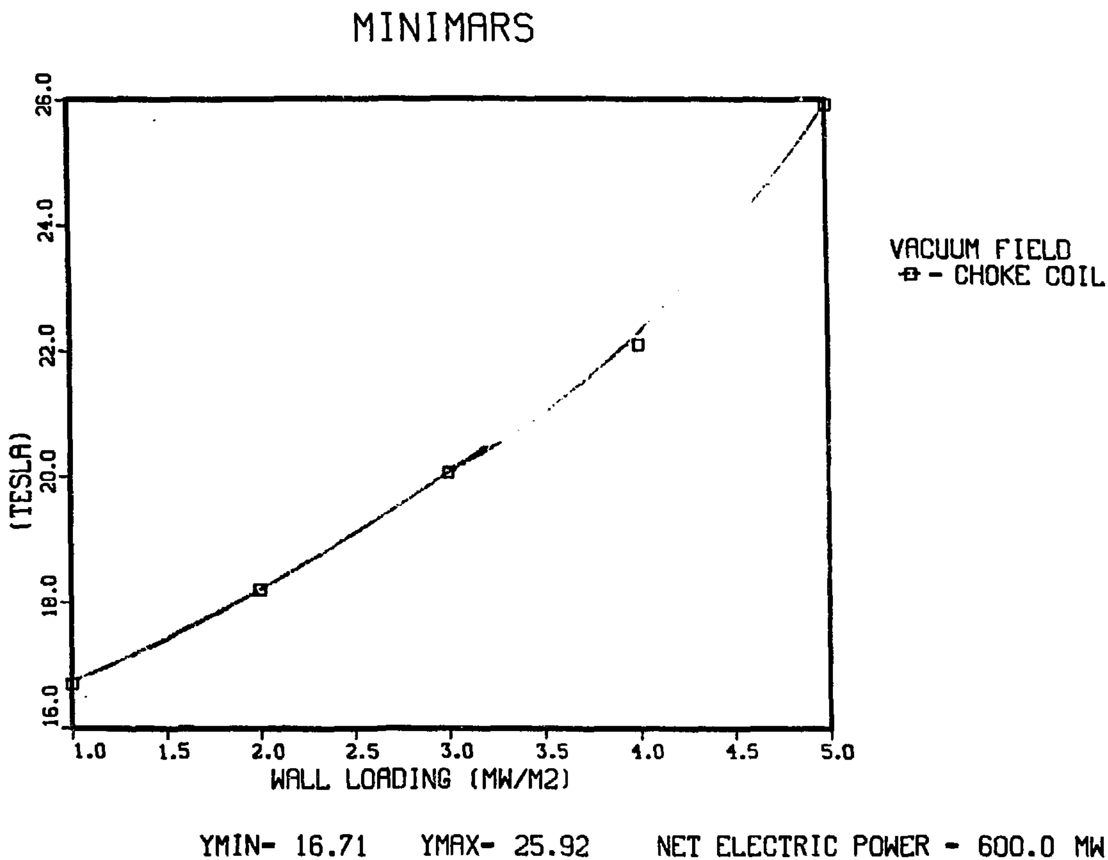


MINIMARS
900.0
950.0
1000.0
1050.0
1100.0
1150.0
1200.0
1250.0
1300.0
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
WALL LOADING (MW/M2)
FIGURE OF MERIT
- TOTAL
YMIN- 930.3 YMAX- 1291. NET ELECTRIC POWER - 600.0 MW


MINIMARS
700.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
WALL LOADING (MW/M2)
FIGURE OF MERIT
C.C. MAGNETS
C.C. FACILITIES
BLANKET&SHIELD
END CELL
HEATING SYSTEMS
YMIN= 20.42 YMAX= 636.7 NET ELECTRIC POWER = 600.0 MW

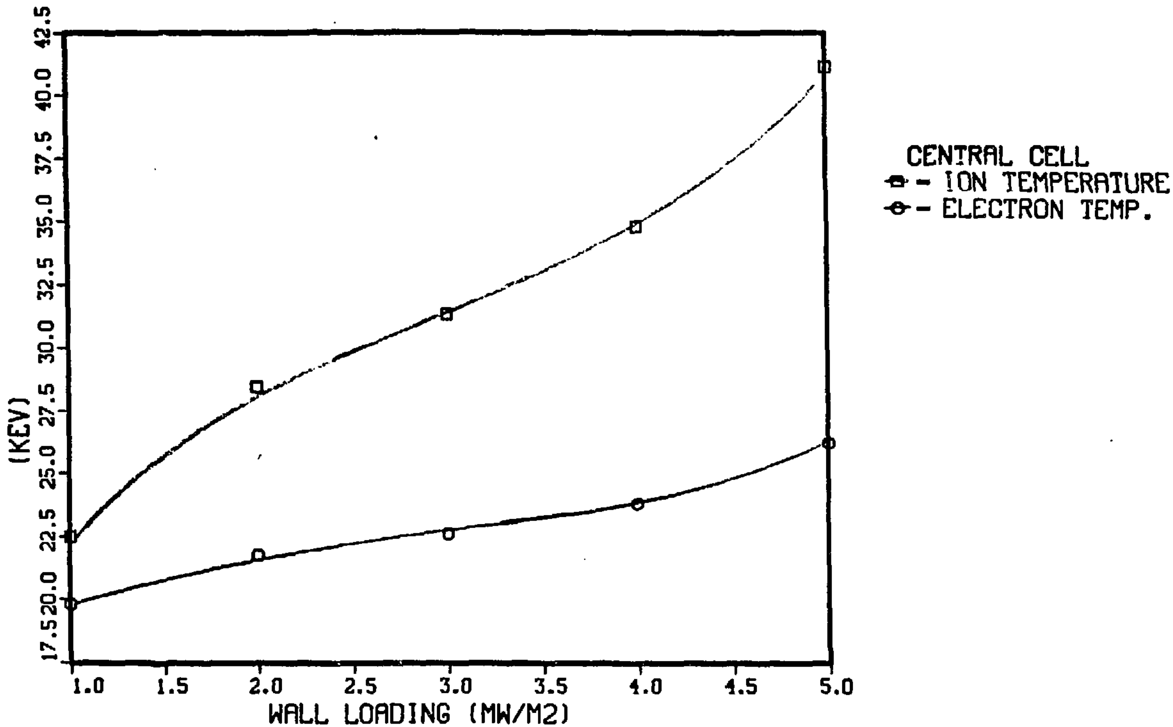

MINIMARS
(MW)
1400.0
1425.0
1450.0
1475.0
1500.0
1525.0
1550.0
1575.0
1600.0
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
WALL LOADING (MW/M2)
CENTRAL CELL
FUSION POWER
YMIN= 1424. YMAX= 1592. NET ELECTRIC POWER = 600.0 MW


MINIMARS
CENTRAL CELL
LENGTH
(M)
0.0
50.0
100.0
150.0
200.0
250.0
300.0
350.0
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
WALL LOADING (MW/M2)
YMIN= 49.75 YMAX= 348.4 NET ELECTRIC POWER = 600.0 MW

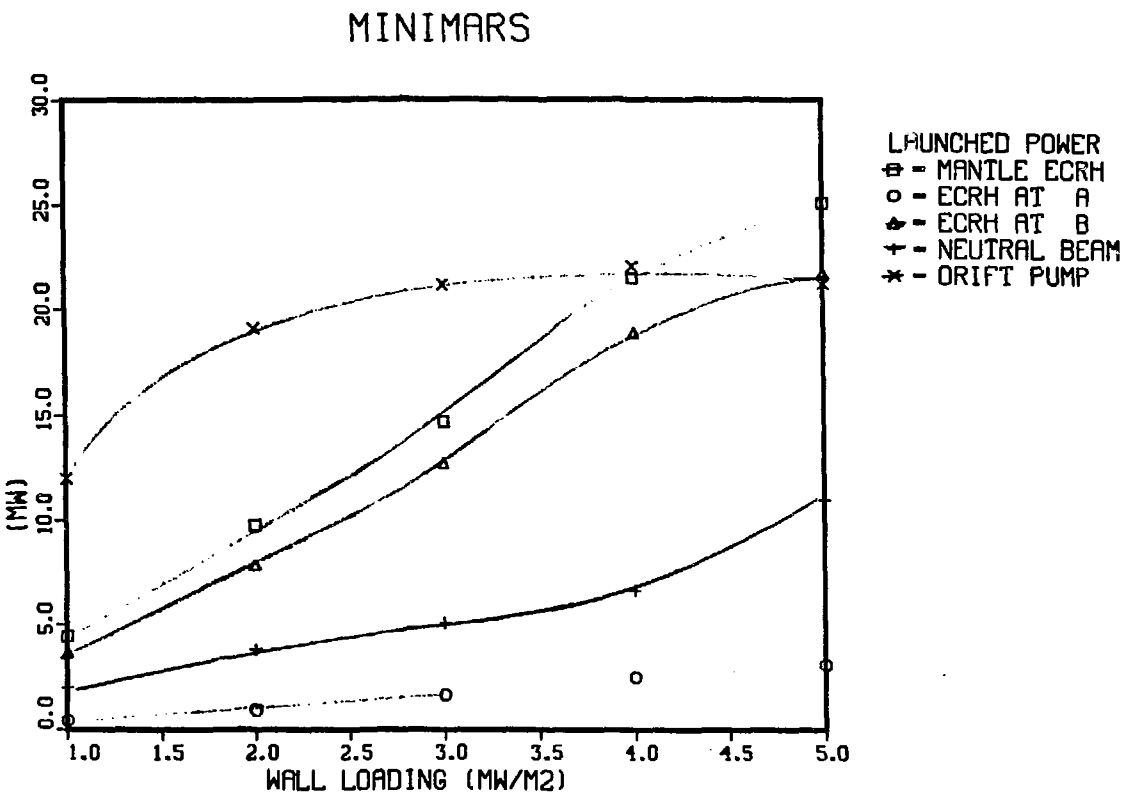


MINIMARS
26.0
24.0
22.0
20.0
18.0
16.0
(TESLA)
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
WALL LOADING (MW/M2)
VACUUM FIELD
- CHOKE COIL
YMIN= 16.71
YMAX= 25.92
NET ELECTRIC POWER = 600.0 MW

MINIMARS

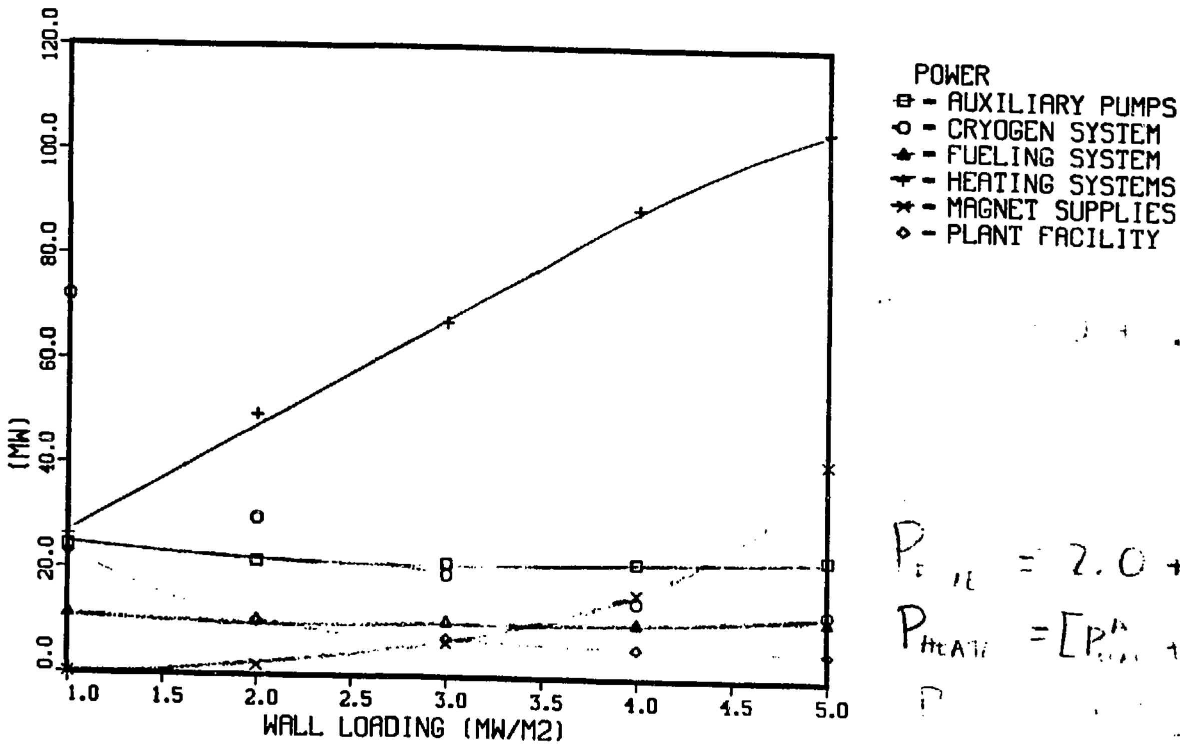


YMIN= 19.81 YMAX= 41.16 NET ELECTRIC POWER = 600.0 MW



YMIN= 0.423 YMAX= 25.08 NET ELECTRIC POWER = 600.0 MW

MINIMARS

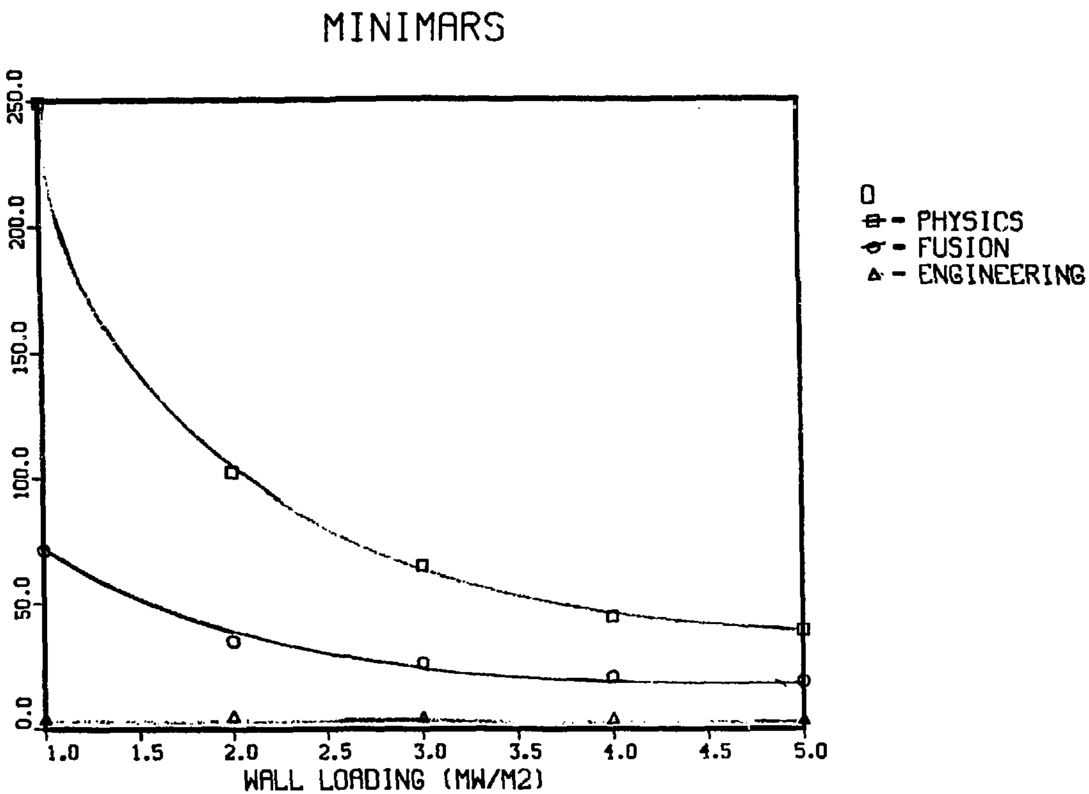


YMIN= 0.144 YMAX= 104.6 NET ELECTRIC POWER = 600.0 MW

.017 x P

P = 2.0 + .006 x P

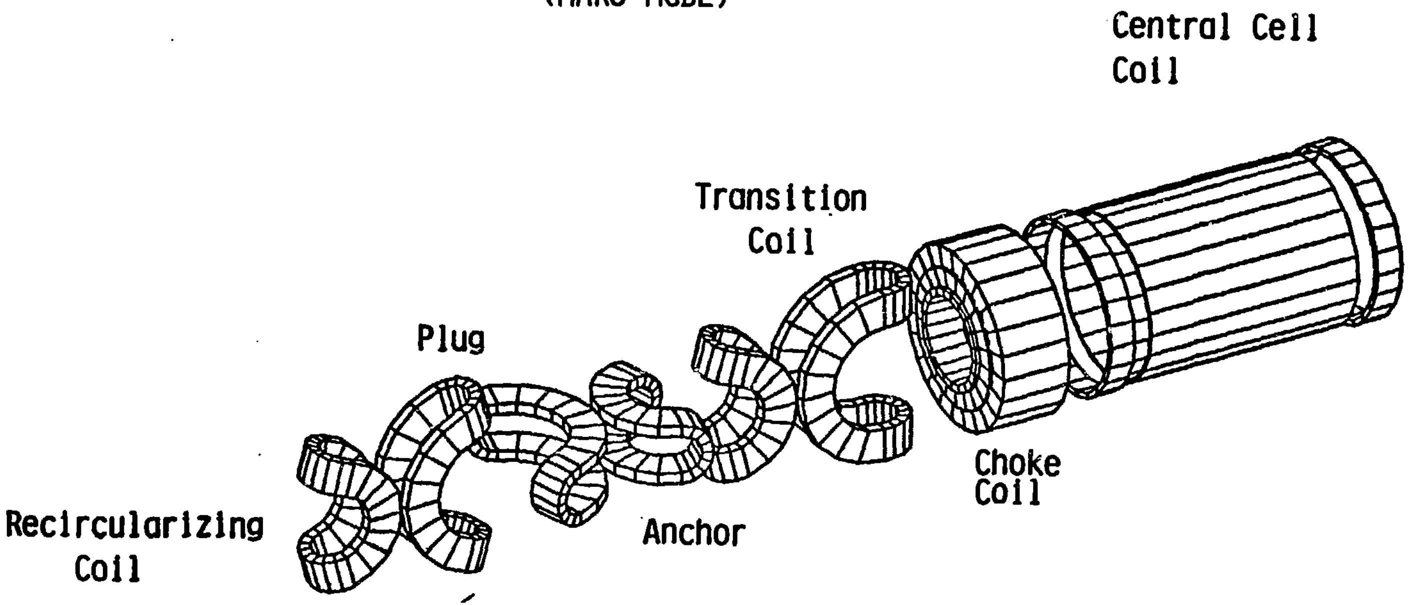
$P_{HEAT} = [P + P + P + P$

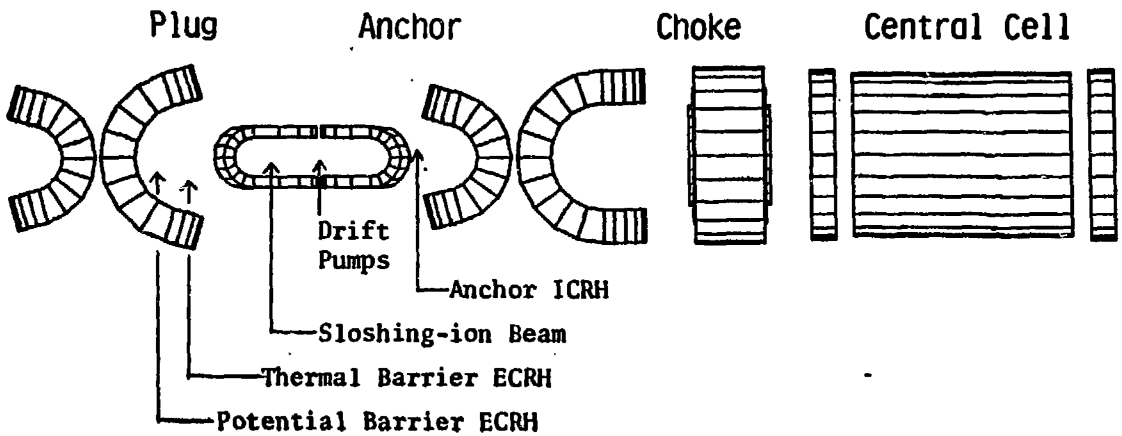


YMIN= 3.656 YMAX= 249.2 NET ELECTRIC POWER - 600.0 MW

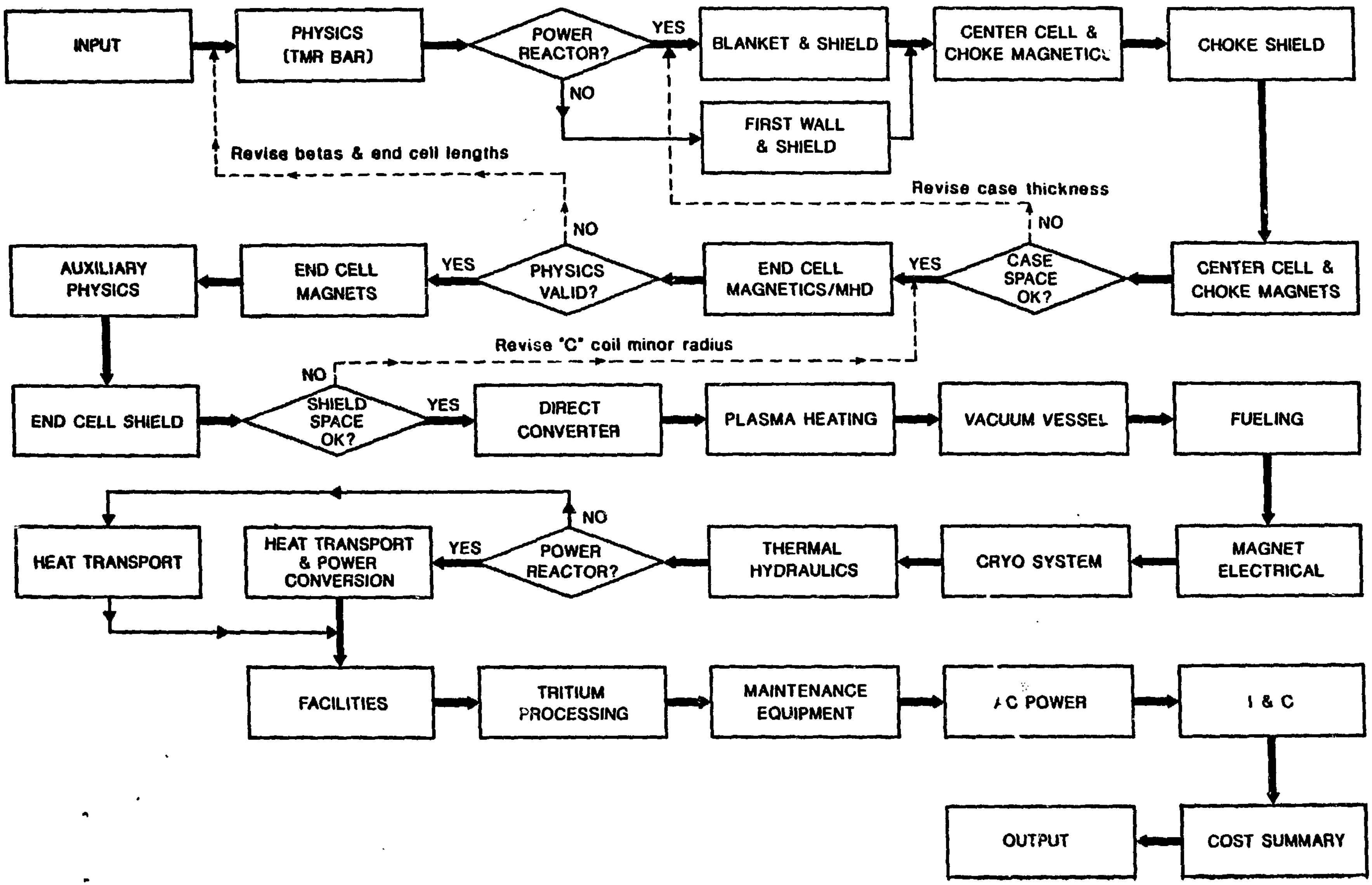
FPD-II TYPE QUADRUPOLE MAGNET SET

(MARS-MODE)





TANDEM MIRROR REACTOR SYSTEMS CODE FLOW DIAGRAM



EXAMPLE CODE EXECUTION

Costs

	Case 1	Case 2
Blanket	30.3	29.4
Shield	65.5	61.9
Choke Shield	4.0	4.2
Magnets	175.4	167.0
End Cell Shield	2.5	3.8
Direct Convertor	5.2	3.9
Plasma Heating	65.8	75.0
Fueling	6.3	7.6
Magnet Electrical	12.8	12.5
Cryoplant	81.8	90.5
Main Heat Transport	96.1	97.2
Auxiliary Heat Transport	17.8	20.0
Power Conversion	99.6	99.7
Facilities/equipment	287.3	283.7
Fuel Processing	218.4	218.6
Maintenance Equipment	66.2	66.0
AC Power	26.9	28
I&C	64.3	64.2
Vacuum Vessel	98.7	80.2
	1424.9 M$	1413.4 M$

EXAMPLE CODE EXECUTION

Parameters

	Case 1	Case 2
Fusion Power (mw)	1000	1000
R_{CHOKE}, (m)	0.14	0.16
R_{PLASMA} (m)	0.46	0.53
L_{cc} (m)	124.1	111.9
β_{cc}	0.60	.583
Ti (keV)	29.0	32.0
Plasma Heating (mw)	25.9	32.7
W_L (mw/m^2)	1.52	1.53
Δ_B (m)	0.7	0.7
Δ_S (m)	0.74	0.75
$\Delta_{S\ Bio}$ (m)	1.52	1.53
$P_{e\ net}$	388	366
Q	3.44	2.91

BASIC 14 PHYSICS VARIABLES:

(1)	Transition Plasma B field	BPLAOT
(2)	B_{ro} Plasma B field	BPI
(3)	B_a Peak Plasma B Field	BPLAOA
(4)	$g = (n_{pass} + n_{trap})/n_{pass}$	XLILG
(5)	$g_\alpha = (n_{pass_\alpha} + n_{trap,\alpha})/n_{pass,\alpha}$	XLILGA
(6)	Transition Potential	ETAT $= \phi_t/T_{ec}$
(7)	Geodesic Curvature Potential Maximum	ETAPI $= \phi_{ro}/T_{ec}$
(8)	Sloshing Ion Point Potential	ETAAP $= \phi_{a'}/T_{ec}$
(9)	Barrier Potential	ETAB $= \phi_b/T_{ec}$
(10)	Inboard Mirror Peak Potential	ETAMP $= \phi_{mp}/T_{ec}$
(11)	Central Cell Ion Confining Potential	ETAC $= \phi_c/T_c$
(12)	Central Cell Electron Temperature	TEC
(13)	Central Cell Alpha Fraction	CALPH C_α
(14)	Central Cell Floating Potential	ETAE $= \phi_e/T_{ec}$

OPTIONAL/OPTIMIZATION VARIABLES

(15)	Central Cell Length	CLENGTH
(16)	Central Cell Ion Temperature	TC
(17)	Central Cell Radius	CRADIUS
(18)	Barrier Beta	BETAB
(19)	Warm electron heating point mirror ratio	SLOSH $= B_a/B_b$
(20)	Central Cell Vacuum B field	BVACOC
(21)	Choke Coil Vacuum B field	BBAR
(22)	$\bar{E}_{hot} - T_{e,warm}$	DELTEW

NOTE: variables may have upper/lower bounds
any physics input constant may be changed into a variable

BASIC 14 PHYSICS CONSTRAINTS

(1) $B_{plasma,t} = B_{vac.,t}(1 - \beta_t)^{1/2}$ (transition)

(2) $B_{plasma,} = B_{vac.,}(1 - \beta\ )^{1/2}$ (geodesic curvature maximum)

(3) $B_{plasma,a} = B_{vac.,a}(1 - \beta_a)^{1/2}$ (potential peak)

(4) Global Charge Balance
(5) Alpha Particle Balance
(6) Quasi-neutrality in Transition (t)
(7) Quasi-neutrality at Geodesic Curvature Maximum ( )
(8) Quasi-neutrality at Sloshing Ion Injection Point (a')
(9) Quasi-neutrality at Thermal Barrier (b)
(10) Quasi-neutrality at Inboard Plug Mirror Peak (mp)
(11) Quasi-neutrality in the Central Cell (c)
(12) Electron Energy Balance
(13) Ion Trapping Rate in (b), (t) = Removal Rate
(14) Ion Energy Balance

OPTIONAL EXTERNAL CONSTRAINTS

(15) Fixed Net Electric Power
(16) Fixed Wall Loading
(17) $\Delta T \geq \bar{E}_{hot} - T_{e,warm}$

MINISYSTEMS CODE

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0 OBJECTIVE

MINIMIZE A USER-SPECIFIED SYSTEM FIGURE OF MERIT BY VARIATION OF UP TO 22 PLASMA ENGINEERING PARAMETERS SUBJECT TO A USER-SPECIFIED SET OF CONSTRAINTS.

0 RELATIONSHIP TO THE FULL TMRSC:

RUNS IN OPTIMIZATION MODE TO EXPLORE PLASMA ENGINEERING PARAMETER SPACE IN A SINGLE RUN. REQUIREMENTS ARE TO (A) OBTAIN REASONABLE OBJECTIVE PARAMETER BASELINES IN THE FIRST FEW MONTHS OF THE STUDY AND (B) PROVIDE A BASIS FOR SINGLE POINT RUNS OF THE FULL CODE WHEN AVAILABLE.

0 FIGURES OF MERIT FOR MINIMIZATION:

1. TOTAL SYSTEM CAPITAL COST
2. CENTRAL CELL IGNITION LENGTHS (USEFUL FOR IGNITION ETR'S)
3. TOTAL PLUG ECRH POWER
4. OTHERS-----?

"TMRBAR" POWER BALANCE CODE FOR TANDEM MIRROR REACTORS

General

- Coupled, multi-region, zero dimensional power balance code.
- Configured for (a) MARS (quadrupole) mode and (b) TARA/ MINIMARS (octupole-Axisymmetric) mode.
- Outputs include plasma parameters (densities temperatures, potentials, absorbed powers, etc.) and system engineering power balance parameters (recirculating powers, thermal powers, etc.)

Central Cell Physics

- Fuel ion particle/energy balance.
- Electron energy balance.
- Alpha particle balance.
- Global charge balance.
- Hot alpha prompt losses:
  - (a) Non-adiabaticity
  - (b) FLR losses to halo.
- Pressure balance.

OPTIMIZATION PROCEDURE

(1) Find Feasible Starting Point

- Solve 14 nonlinear physics constraint equations.
  May fix T_C, central cell length or fusion power if
  no external constraints are used.

- Solve using a modified Newton's method:
  Plug warm electron temperature equation.
  Minimization of mantle ECRH vs. mantle hot
  electron energy.

- Solve optional external constraints.
  Fixed net electric power.
  Fixed wall loading.
  Fixed $\Delta T = (\bar{E}_{hot} - T_{e,warm})$

(2) Select Optimization Function

- May minimize or maximize any combination of
  physics variables.
  For example:
  Minimize cost figure of merit.
  Minimize neutral beam power.
  Minimize total rf power.
  Minimize central cell length.
  Maximize fusion power.
  Maximize wall loading.

OPTIMIZATION PROCEDURE (con't)

(3) If Optimization Finds an Infeasible Point

- Attempts to find a feasible point using all physics and external constraints.
  If unsuccessful, reduces the number of constraints by 1 until a solution is found or the number of constraints < 14

(4) Output From Both Starting and Final Points is Stored

- Formatted output file is created.
- Namelist file created.
  Can be used as the input file for the next run.
- Namelist file created for plotting.
  Can combine this file with previous run files and plot the cumulative results using a separate plotting code and make a summary output file.
- Output file created.
  Contains physics variables and constraint equations values for each iteration to be plotted if iteration diagnostic information is required.

COST FIG. OF MERIT IN CURRENT USE

$$\text{F.O.M} = \underbrace{C_1\, B_C^2\, L_C\, r_{C,mag}^2}_{\text{C. Cell Magnets}} + \underbrace{C_2\, L_C}_{\text{C. Cell blnkt. \& shield}} + \underbrace{C_3 L_C}_{\text{Building}} + \underbrace{C_4 P_{fusion}}_{\text{B.O.P.}}$$

(F.O.M = Capital Cost)

$$+ \underbrace{C_5 B^2_{end\ cell}\, V_{end\ cell}}_{\text{choke coil and end cell magnets}} + \underbrace{C_6\, P_{heat.,\ wall\ plug}}_{\text{Plasma Heating Systems}}$$

$r_{c,mag} = r_c + r_{halo} + r_{blnkt} + r_{shield}$

$B_{end\ cell} = (B_{choke} + B_{outer\ mirror})/2$

$V_{end\ cell} = r^2_{outer\ mirror}\, L_{end\ cell}$

$C_1 = 7.19 \times 10^{-3}$ M\$ T^{-2} m^{-3}

$C_2 = 0.93$ M\$ m^{-1}

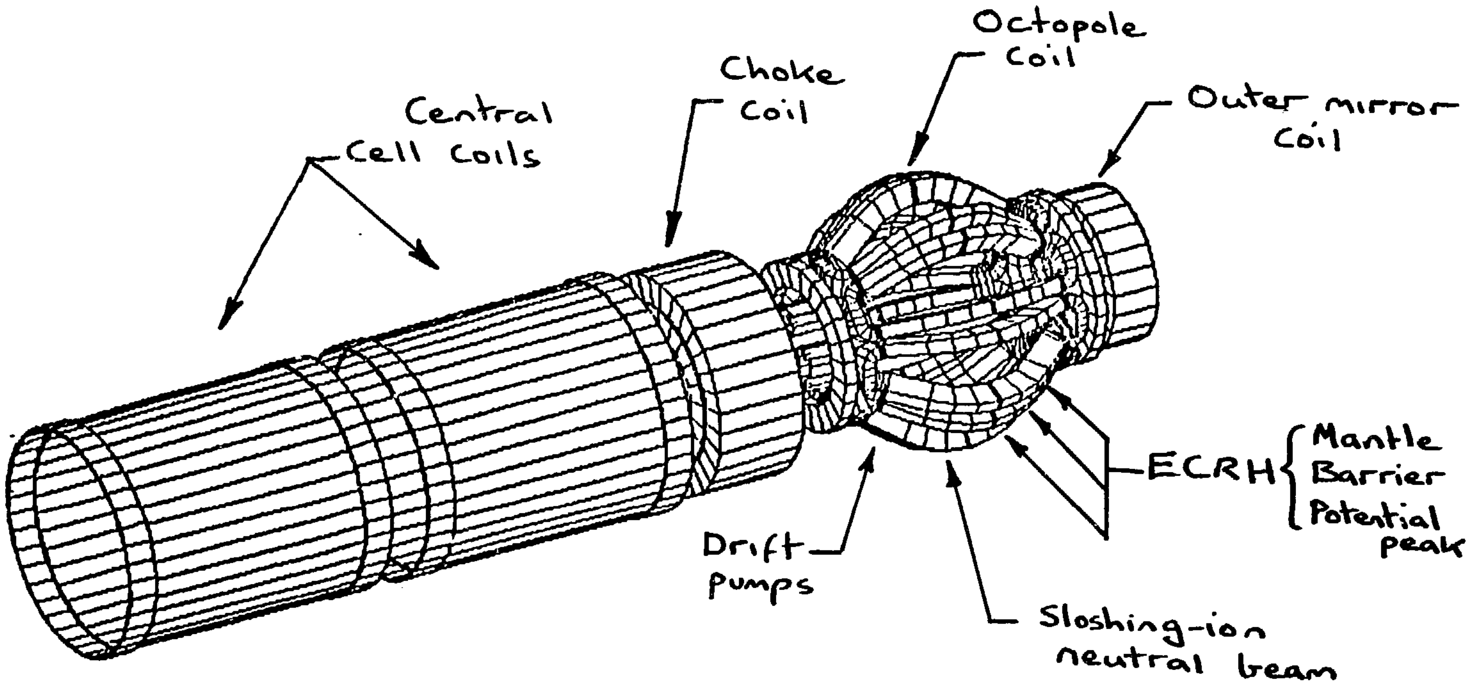
$C_3 = 0.5$ M\$ m^{-1}

$C_4 = 0.4$ M\$/MW_{fusion}

$C_5 = 2.67 \times 10^{-2}$ M\$ T^{-2} m^{-3}

$C_6 = 1.5$ M\$ $1MW_{wall\ plug}$

OCTOPOLE (MINIMARS-MODE) MAGNET SET



OCTOPOLE VERSUS QUADRUPOLE END PLUGS - A COMPARISON OF MARS AND MINIMARS

ADVANTAGES

O SHORTER END CELL MAGNET LENGTHS:

- SHORTER CENTRAL CELL LENGTHS FOR IGNITION; SMALLER REACTOR SIZES.

- CHEAPER, MORE COMPACT, END CELL MAGNET CONFIGURATION.

O SIMPLE MIRROR CONFIGURATION WITH (NEARLY) AXISYMMETRIC* MAGNETIC FLUX BUNDLE IN END CELL:

- REDUCED RADIAL DRIFTS.

- SIMPLIFIED CORE PLASMA POWER BALANCE COMPUTATION - ONLY ONE END-CELL MIRROR REGION.

*CORE PLASMA ONLY; MANTLE IS NON-AXISYMMETRIC.

DISADVANTAGES

O ACCESS PROBLEMS IN COMPACT END PLUG (INTEGRATION OF SEVEN MAJOR SUBSYSTEMS)

O HOT ELECTRON MANTLE WITH ADDITIONAL ECRH SYSTEM REQUIRED IN END CELL.

O OCTOPOLE MAGNET HAS COMPLEX WINDING GEOMETRY AND CONSTRUCTION.

O AXISYMMETRY MAKES DRIFT PUMPING OF TRAPPED IONS MORE DIFFICULT.

MACHINE BASELINES BASED ON PRELIMINARY TRADE STUDIES WITH MINI-SYSTEMS CODE

BASIS: MINIMIZATION OF COST FIGURE OF MERIT SUBJECT TO 600 MW_E FIXED NET ELECTRIC POWER.

	BCHOKE		
	20 T	22 T	24 T
GENERAL			
NET ELECTRIC POWER, MW	600	600	600
FUSION POWER, MW	1423	1430	1443
Q	68	77	86
COLD DT FUELING CURRENT, KA	1.12	1.12	1.11
CENTRAL CELL			
L_C, M	87.7	85.4	84.3
B_C, T	2.77	2.88	2.99
$\langle \beta_C \rangle$	0.6	0.6	0.6
R_C, M	0.553	0.520	0.490
R_{WALL}, M	0.748	0.707	0.671
β, MW/M^2	2.76	3.00	3.25
CHOKE COIL			
B_{CHOKE}	20	22	24
$B_{S/C}$, T	16	16	16
B_{INSERT}, T	4	6	8
P_{INSERT}*, MW	~6.44	~13.2	~21.6
END PLUG			
β_{PLUG}	0.33	0.33	0.33
β_{MANTLE}	0.9	0.9	0.9
END PLUG* MIRROR LENGTH, M	9.58	9.45	9.32
PLUG MINIMUM FIELD* T	1.5	1.5	1.5
MANTLE MINIMUM FIELD*, T	1.4	1.4	1.4
ABSORBED POWERS - BOTH ENDS			
P_{NB}, MW	0.672	0.597	0.533
F_{TRAP}	0.140	0.133	0.127
P_{ECRH-A}, MW	1.10	0.955	0.835
P_{ECRH-B}, MW	7.97	7.08	6.28
P_{ECRH-M}, MW	11.1	10.1	9.15
TOTAL INJECTED POWER	20.8	18.7	16.8