MINIMARS CONFIGURATION DESIGN

PRESENTED AT
TRW
JANUARY 28, 1986

D. C. LOUSTEAU
FUSSION ENGINEERING DESIGN CENTER
OAK RIDGE, TENNESSEE

AREAS COVERED

* SET OF "OHLGA" PLOTS OF NEW END CELL COIL ARRANGEMENT WITH PLASMA SURFACES

* ACCESS FOR NEUTRAL BEAM AND RF INJECTION

* COMPLETE LOAD DEFINITION ON END CELL COILS

* INTRACOIL STRUCTURE FOR ALL COILS

NOT YET ADDRESSED

* SHIELDING

* ASSEMBLY AND INTERCOIL STRUCTURE

* CAD DRAWINGS
ISOMETRIC MINIMARS END CELL COILS REV 4 (MM78)
CUTAWAY END CELL \( \theta = 45^\circ \)
END CELL COILS WITH HALO AND MANTLE
END CELL COILS WITH MANTLE AND HALO (ROTATED 45°)
## Comparison of Axial Loads on End Cell Coils

(In Newtons) in Normal Operation*

<table>
<thead>
<tr>
<th>CASE</th>
<th>CHOKE COIL</th>
<th>SMALL OCTOPOLE</th>
<th>LARGE OCTOPOLE</th>
<th>MIRROR SET</th>
<th>NET LOAD</th>
</tr>
</thead>
<tbody>
<tr>
<td>ORIGINAL</td>
<td>1.2E7</td>
<td>-2.9E7</td>
<td>-1.54E8</td>
<td>1.12E8</td>
<td>-5.9E6</td>
</tr>
<tr>
<td>(EXTERNAL MIRROR COILS)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>REVISIONED</td>
<td>-2.1E7</td>
<td>-1.8E7</td>
<td>-3.51E8</td>
<td>2.93E8</td>
<td>-9.7E7</td>
</tr>
<tr>
<td>(INTERNAL MIRROR COILS)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Fault conditions have not been calculated for revised set, but were shown to increase the net load a factor of 10 in the initial case.
COMPARISON OF AXIAL FORCES IN INDIVIDUAL COILS
(IN NEWTONS)

- AXIAL FORCE ON COILS DECREASE WITH "Z"
- A SMALL RADIUS ON AFT MOST COIL LOWERS THE NET FORCE
THE MAJOR PROBLEM IS THE AXIAL TIE OF THE CHOKE SET TO THE LARGE OCTOPOLE

<table>
<thead>
<tr>
<th>LOAD AT INTERFACE (LBS)</th>
<th>NUMBER OF 3&quot; BOLTS REQD</th>
</tr>
</thead>
<tbody>
<tr>
<td>ORIGINAL 2.6E7</td>
<td>40</td>
</tr>
<tr>
<td>REVISED 8.8E7</td>
<td>135</td>
</tr>
</tbody>
</table>

FEASIBILITY OF USING THIS NUMBER OF BOLTS IS TBD.
MOVEMENT OF SMALL OCTOPOLE AWAY FROM LARGE OCTOPOLE REDUCES THE RADIAL PRESSURE ON SMALL OCTOPOLE CROSSOVER

<table>
<thead>
<tr>
<th></th>
<th>TOTAL RADIAL FORCE PER CROSSOVER (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOW &quot;Z&quot; END</td>
<td>NEW: 1.06E7</td>
</tr>
<tr>
<td></td>
<td>OLD: 0.95E7</td>
</tr>
<tr>
<td>HIGH &quot;Z&quot; END</td>
<td>NEW: 0.83E7</td>
</tr>
<tr>
<td></td>
<td>OLD: 1.00E7</td>
</tr>
</tbody>
</table>
A 5" DEEP BOX BEAM WITH 2" THICK WALLS IS REQUIRED TO HOLD SMALL OCTOPOLE
HOWEVER, RADIAL FORCES ON LARGE OCTOPOLE CROSSES
ARE CORRESPONDINGLY INCREASED

\[ F_R = 5.0 \times 10^7 \text{N} \]
\[ F_R = 3.7 \times 10^7 \text{N} \]

NEW
(12/85)

OLD
(8/85)
A 15-1/2” deep box with 3” thick walls is required at leading edge of large octopole.
THE MIRROR SET INCREASES THE RADIAL LOAD ON THE "LARGE Z" CROSOVERS OF THE LARGE OCTOPOLE

\[
\begin{array}{l|c}
\text{LOWER STEP} & 5.98 \times 10^7 \\
\text{MIDDLE STEP} & 3.58 \times 10^7 \\
\text{TOP STEP} & 0.84 \times 10^7 \\
\hline
\text{TOTAL} & 10.40 \times 10^7 \\
\end{array}
\]

THIS IS TWICE THE LOAD ON THE "SMALL Z" END
A full width 15" deep box ring is also required at aft end of large octopole.

[Diagram showing measurements and dimensions related to the box ring.]
MAGNETIC PRESSURE IN OUTER MIRROR COILS
A 2-D (STANSOL) analysis has been run to determine approximate stress levels in mirror coils

* Only one case run (n Z = 56)
* Coil modelled as large number of copper/steel composite (30% SST) windings bounded by a 2" thick SST case
* No axial effects considered
* Field and current profiles of MINIMARS base case used

Conclusions

* Maximum stress of 100 KSI calculated in steel winding sheath
* 3-D effects and other Z locations will result in higher stresses
* Modification of present arrangement required
ADVANTAGES OF "INNER" MIRROR COIL ARRANGEMENT

* ALLOWS FOR DISASSEMBLY OF LARGE OCTOPOLE WINDOW FRAMES WITHOUT DISPLACING OF MIRROR COILS

* NO SHARP RADIAL LOAD REVERSALS ON LARGE OCTOPOLE CROSSOVERS

* REDUCED RADIAL LOADS ON MIRROR COILS (UNDER THE OCTOPOLE)

* THE LARGE OCTOPOLE IS IN FREE SPACE WHERE THERE IS ROOM TO INCREASE THE STRUCTURE REQUIRED TO SUPPORT IT