Two Approaches to Achieving Higher Performance in FIRE have been Investigated. Each meets Q=10 based on the ITER Database Scaling:

**Bucked and Wedged Option**
- **Q=10**
- 200 MW Fusion Power
- Nuclear Heat is Same as the Baseline
  - \( R_0=2.0 \text{ m, } A=0.525 \text{ m} \)
  - 11.5 T TF and 7.6 MA Ip
- 24.5 Sec. Pulse Length (to 370°K)
- B&W Allows Higher TF Field and Higher Currents in the CS and More Freedom in Selecting CS Bias for the Same Machine Size
- OFHC Copper is Used in CS and TF
  - Allows Savings in Power Supply Costs

**FIRE* - Increased \( R_0 \) and \( A \)**
- **Q=10**
- 150 MW Fusion Power
- Nuclear Heat Goes Down
  - \( R_0=2.14, A=0.595 \text{ m} \)
  - 10 T TF and 7.7MA Ip
- 20 Sec. Pulse Length (to 370°K)
- Larger Build Allows Higher Plasma Current.
  - Slight Increase in CS Radial Build Provides Needed V-s. (There is Some Margin)
  - Performance is achieved with 68% IACS Be Cu TF. Higher Conductivity BeCu Could Be Used
**FIRE* - FIRE with a Slight Increase In Major Radius to 2.14m**

The FIRE* Scenario uses CS1 a little more and CS2 a little less at Precharge, which removes CS2 as the limiting coil at this time point (which was the case in the baseline). This allows a bias towards Precharge, and a lower EOB stress. This and slight increase in CS OD provides needed V-s for 7.7 MA Ip

At Precharge, the stress Factor of Safety for CS1 is 1.07 and the F.S is .1.6 at EOB.

CS Temperatures are not limiting. CS 1 only reaches 143 deg. (with an 80K start).

There is a Substantial Margin in V-s

The TF flattop went from 18.5 to 20 sec. with the 11 MW/m^3 Nuclear Heat Scaled Down by 150/200.

**Analyzed FIRE* TF Model build:**
- Inner Leg IR: 0.910153m
- Inner Leg OR: 1.3996m
- Rp: 2.14m
- Outer Leg IR: 3.6926
- Outer Leg OR: 4.3379

The TF Von Mises of 490 MPa is fine for the 68% IACS BeCu TF which has a 700 MPa yield and the torsional shear in the TF inner leg is not changed from the baseline FIRE torsional shears.

If FIRE* is chosen Other BeCu alloys with better IACS and a lower yield can be considered to have the TF match the CS pulse length capability.

**FIRE* has Margin in Both CS and TF Stresses, and/or Pulse Length**
FIRE Bucked and Wedged
Ro=2.0 11.5T TF, 7.25 Ip, OFHC Copper Coils

From Elastic Analysis, Major Stresses In CS and TF Remain below 1.5 Sm.

OFHC 60% CW
1.5Sm (Based on lesser of 2/3 Sy or 1/2 Su)

<table>
<thead>
<tr>
<th>Temp=85</th>
<th>Temp=176</th>
<th>Temp=292</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.5Sm=347</td>
<td>1.5Sm=305</td>
<td>1.5Sm=262</td>
</tr>
</tbody>
</table>

CS Stresses Allowed Consideration of an Increase in Ip to 7.6 MA

Because There are Small Regions of Plasticity In FIRE baseline, B&W FIRE and FIRE*, Elastic-Plastic Analysis is also Used to Qualify the Coil System

SOD R#57 Von Mises Stress, TF is Cold <176 deg K

EOC Von Mises Stress, Mid Plane is Approaching RT
FIRE Bucked and Wedged Analysis Run Summary

Bucked and Wedged FIRE is Qualified for 11.5 T and 7.6 MA Ip With Variations in Friction Coefficient and Ring Load

Copper IACS=100%, Packing Fraction=.85 Sliding Gaps Everywhere, Mu as Noted, $\beta_N = 2.0$, TF End Temperature is 337K

<table>
<thead>
<tr>
<th>Run</th>
<th>Date</th>
<th>Bt</th>
<th>Ip</th>
<th>Flat-top</th>
<th>Triangularity</th>
<th>Elongation</th>
<th>Mu</th>
<th>CS2/CS3 Tst</th>
<th>CS1 Peak Temp</th>
<th>Ring Load</th>
<th>TF E Limit MPa</th>
<th>CS E Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>65</td>
<td>11-25</td>
<td>12.0</td>
<td>7.6</td>
<td>21</td>
<td>.8</td>
<td>.3</td>
<td>120</td>
<td>275</td>
<td>1.0</td>
<td>270</td>
<td>216</td>
<td></td>
</tr>
<tr>
<td>64</td>
<td>11-20</td>
<td>11.5</td>
<td>7.6</td>
<td>21</td>
<td>.8</td>
<td>.3</td>
<td>120</td>
<td>275</td>
<td>1/4</td>
<td>270</td>
<td>216</td>
<td></td>
</tr>
<tr>
<td>63</td>
<td></td>
<td>11.5</td>
<td>7.6</td>
<td>21</td>
<td>.8</td>
<td>.25</td>
<td>120</td>
<td>275</td>
<td>1.0</td>
<td>270</td>
<td>216</td>
<td></td>
</tr>
<tr>
<td>62</td>
<td></td>
<td>11.5</td>
<td>7.6</td>
<td>21</td>
<td>.8</td>
<td>.3</td>
<td>120</td>
<td>275</td>
<td>1/2</td>
<td>270</td>
<td>216</td>
<td></td>
</tr>
<tr>
<td>61</td>
<td></td>
<td>11.5</td>
<td>7.6</td>
<td>21</td>
<td>.8</td>
<td>.2</td>
<td>120</td>
<td>275</td>
<td>1.0</td>
<td>270</td>
<td>216</td>
<td></td>
</tr>
<tr>
<td>60</td>
<td></td>
<td>11.5</td>
<td>7.6</td>
<td>21</td>
<td>.8</td>
<td>.3</td>
<td>120</td>
<td>275</td>
<td>1.0</td>
<td>270</td>
<td>216</td>
<td></td>
</tr>
<tr>
<td>57</td>
<td></td>
<td>11.5</td>
<td>7.25</td>
<td>21</td>
<td>.7</td>
<td>.3</td>
<td>100</td>
<td>1.0</td>
<td>270</td>
<td>No E-P</td>
<td></td>
<td></td>
</tr>
<tr>
<td>56</td>
<td></td>
<td>12</td>
<td>7.7</td>
<td>15</td>
<td></td>
<td>.3</td>
<td>100</td>
<td>1.0</td>
<td>270</td>
<td>No E-P</td>
<td></td>
<td></td>
</tr>
<tr>
<td>49</td>
<td></td>
<td>11.5</td>
<td>7.7</td>
<td>15</td>
<td></td>
<td>100</td>
<td>1.0</td>
<td>270</td>
<td>No E-P</td>
<td>No E-P</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Run #56 PF coil currents from Kessel PF Flux Shifted 5V Packing Fraction=.85 (pfk7.inp)
Run #57 PF coil currents from Kessel, 10-19-2000 Elastic-Plastic TF and CS TF End Temperature is 337K
Run #60 PF coil currents from Kessel, 11-7-2000, Packing Fraction=.85 (pfk9.inp)
A NUL time point has been added. Stress levels are about the same as reported in the Oct. phone call. Peak TF Von Mises is 330 MPa, and TF plastic strains are below .4% Nul CS von Mises is 210 MPa and this is the worst through-out the shot including SOF in which the CS1 currents are -14.84 MA, up from -13.08 MA
FIRE* Stresses
TF Inner Leg Torsional Shear Stress

ANSYS 5.5.3
DEC 11 2000
08:47:15
NODAL SOLUTION
STEP=4
SUB = 1
TIME=4
STZ = (AVG)
RYS=12
PowerGraphics
EFACE=1
AVRES=Mat
DMX = 0.229E+08
SMX = 0.146E+08
SMN = 0.144E+09
SMZ = 0.162E+09
.
TF Inner Leg Torsional Shear Stress

ANSYS 5.5.3
DEC 11 2000
08:47:15
NODAL SOLUTION
STEP=6
SUB = 1
TIME=6
STZ = (AVG)
RYS=12
PowerGraphics
EFACE=1
AVRES=Mat
DMX = 0.229E+08
SMX = 0.146E+08
SMN = 0.144E+09
SMZ = 0.162E+09