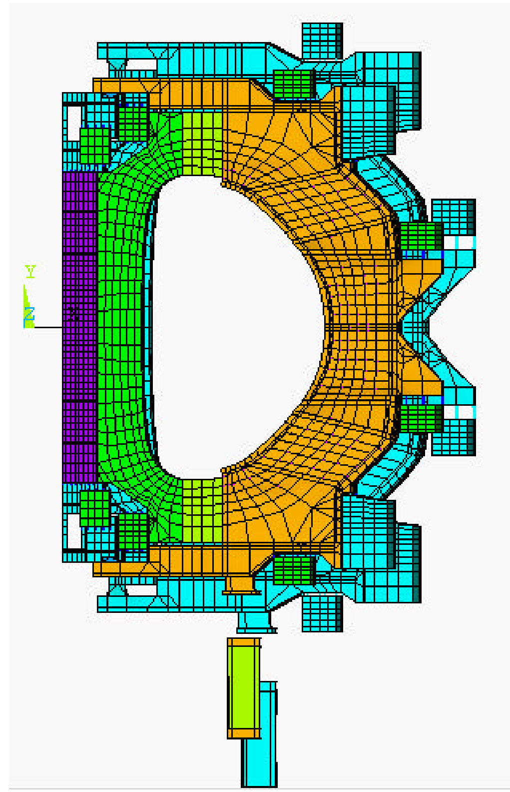
RESPONSES ON MAGNET STRUCTURAL DESIGN

NSO PAC 2 Meeting Agenda MIT PlasmaFusion Center
Building NW17, Room 218 175 Albany Street
1:45 pm Optimizing Design Point (Thome/Schultz/Titus)

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	FIRE* - Increased Ro and A
Q=10 200 MW Fusion Power Nuclear Heat is Same as the Baseline	Q=10 150 MW Fusion Power Nuclear Heat Goes Down
Ro=2.0m, A=.525 m 11.5T TF and 7.6 MA Ip	Ro=2.14, A=.595m 10T TF and 7.7MA Ip
24.5 Sec. Pulse Length (to 370°K)	20 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	Larger Build Allows Higher Plasma Current. Slight Increase in CS Radial Build Provides Needed V-s . (There is Some Margin)
OFHC Copper is Used in CS and TF - Allows Savings in Power Supply Costs	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



Baseline FIRE Model in front of FIRE* which is blue in this plot

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.

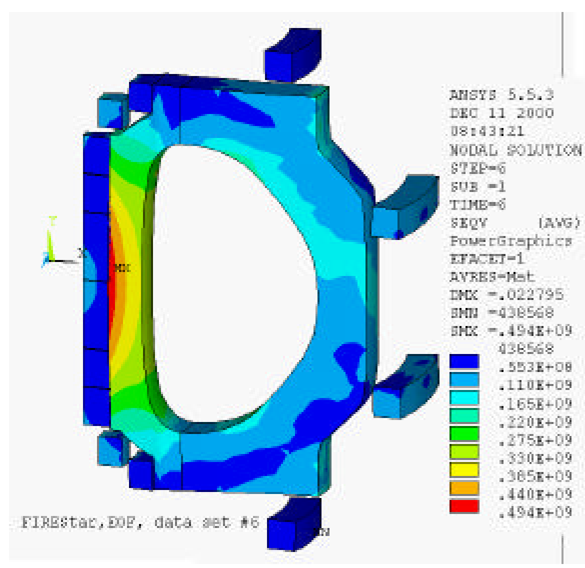
CS Temperatures are not limiting. CS 1 only reaches 143 deg. (with an 80K start).

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	**.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.

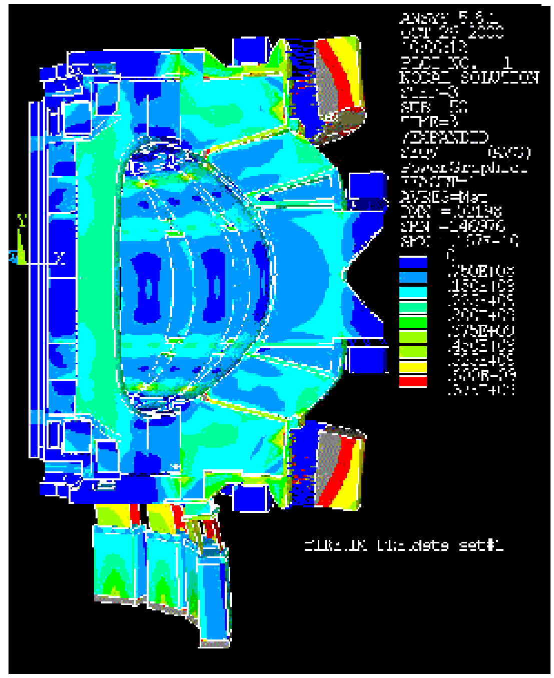
FIRE* has Margin in Both CS and TF Stresses, and /or Pulse Length

FIRE Bucked and Wedged
Ro=2.0 11.5T TF, 7.25 Ip , OFHC Copper Coils

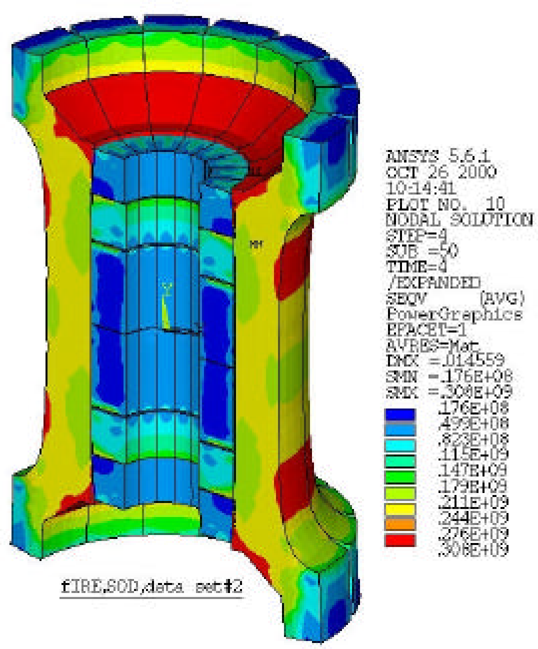
From Elastic Analysis, Major Stresses In CS and TF Remain below 1.5 Sm.

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

Temp=85 1.5Sm=347	Temp=176 1.5Sm=305	Temp=292 1.5Sm=262



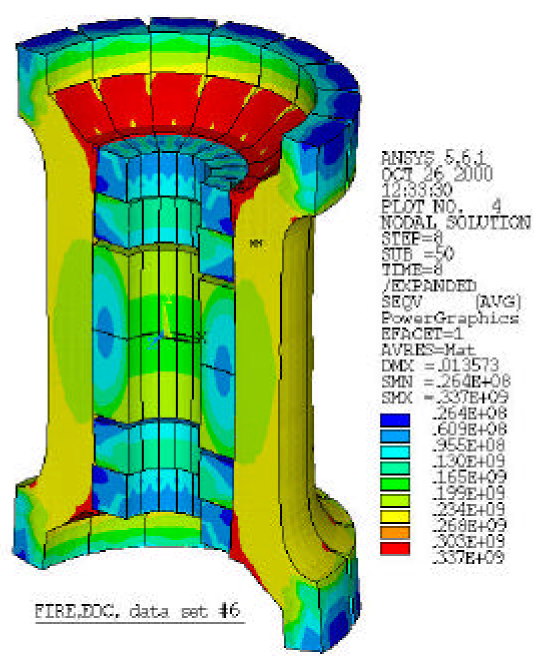
Four Sector Symmetry Expansion, - Von Mises, Stress Contours " Notice Low Stress in CS and TF



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

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



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, betaN = 2.0,TF End Temperature is 337K

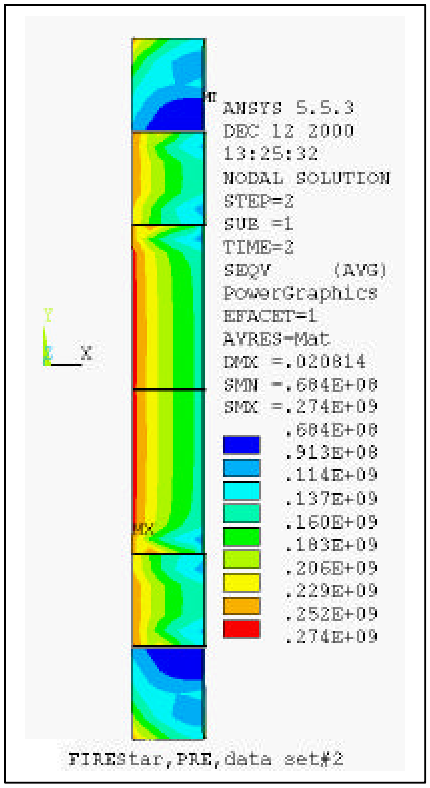
Run	Date	Bt	Ip	Flat-top	Triangularity	Elongation	Mu	CS2/CS3 Tst	CS1 Peak Temp	Ring Load	TF E Limit MPa	CS E Limit
65	11-25	12.0	7.6	21	.8		.3	120	275	1.0	270	216
64	11-20	11.5	7.6	21	.8		.3	120	275	1/4	270	216
63		11.5	7.6	21	.8		.25	120	275	1.0	270	216
62		11.5	7.6	21	.8		.3	120	275	1/2	270	216
61	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

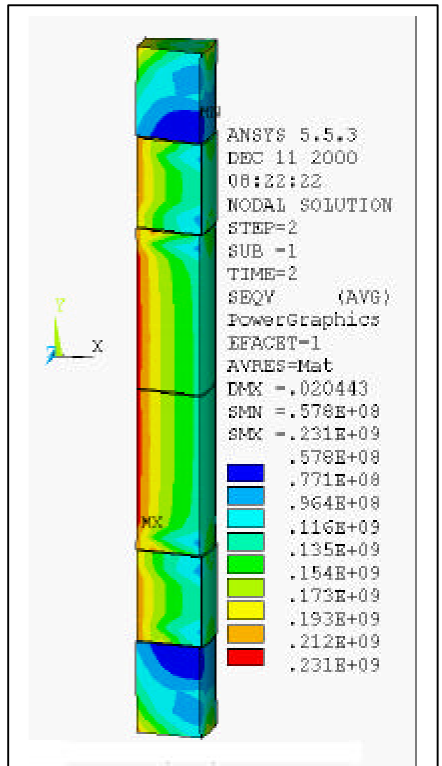
Run #56 PF coil currents from Kessel PF Flux Shifted 5V Packing Fraction=.85 (pfk7.inp)

Run #57 PF coil currents from Kessel, 10-19-2000 Elastic-Plastic TF and CS
TF End Temperature is 337K

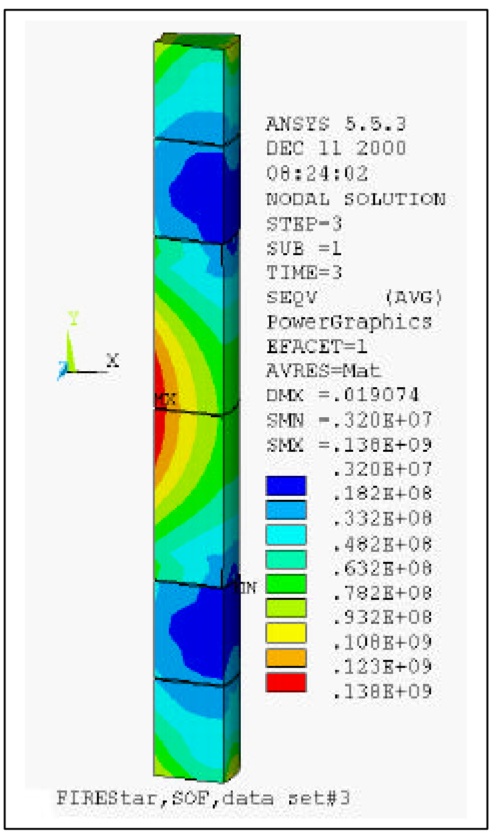
Run #60 PF coil currents from Kessel, 11-7-2000, Packing Fraction=.85 (pfk9.inp)
A NUL time point has been added. Stress levels are about the same as reported in the Oct. phone call. Peak TF Von Mises is 330 MPa, and TF plastic strains are below .4% Nul CS von Mises is 210 MPa and this is the worst through-out the shot including SOF in which the CS1 currents are -14.84 MA, up from -13.08 MA

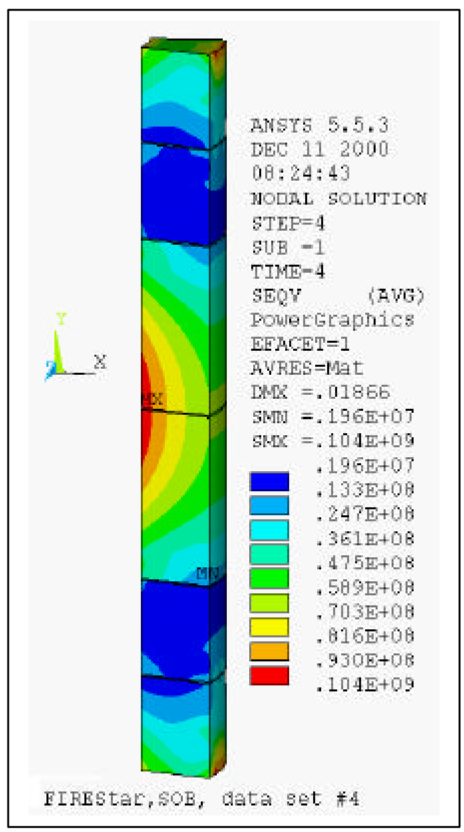
FIRE* Stresses

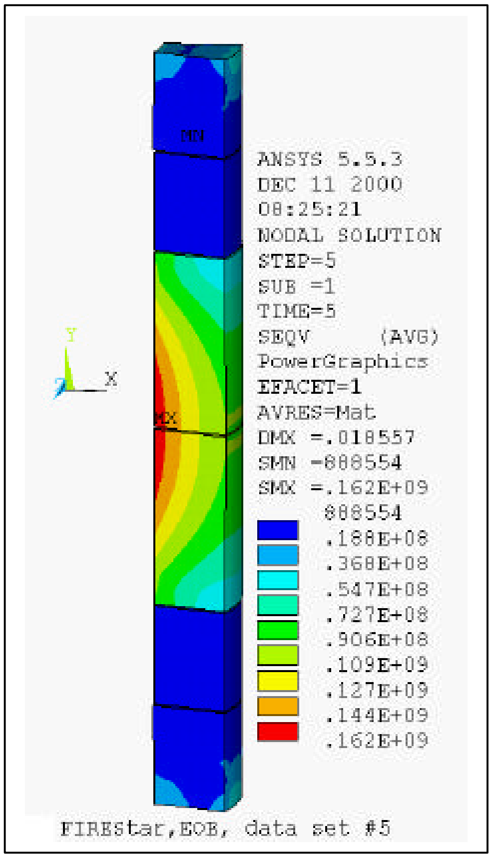


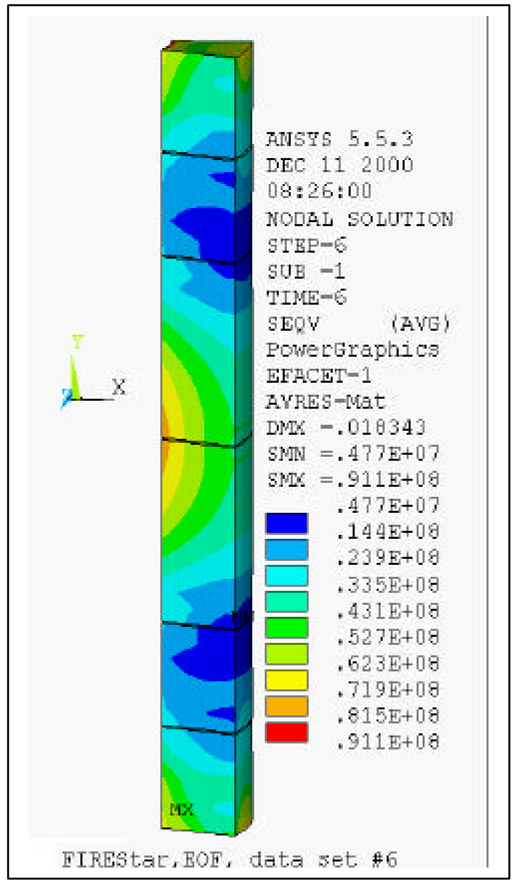


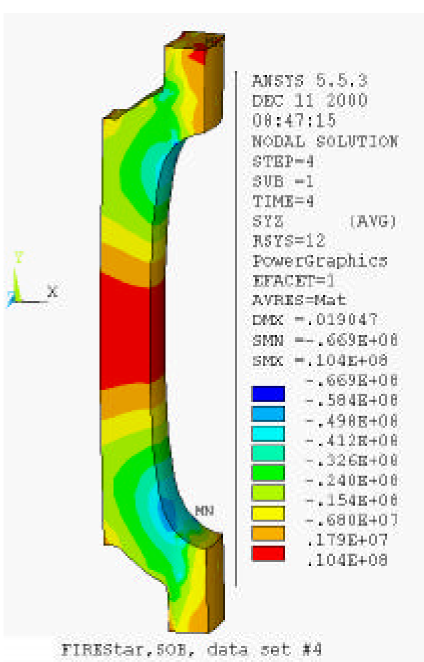
FIREStar SOD











TF Inner Leg Torsional Shear Stress