A.1 Coil Set Definition

The coil set used in this analysis corresponds to the c07r00 coil set. This data in this section (A.1) is provided in order to define the coil geometry on which the technical data in following sections is based. This section does not define requirements for coil geometry.

A.1.1 Modular Coil Build

	M1	M2	M3
Length_m	7.358	7.173	6.661
NumWP	2	2	2
GroundWrap_mm	0.9652	0.9652	0.9652
TurnInsulation_mm	0.2032	0.2032	0.2032
InsideChillPlate_mm	1.016	1.016	1.016
OutsideChillPlate_mm	1.016	1.016	1.016
ConductorHeight_in	0.391	0.391	0.391
ConductorHeight_mm	9.931	9.931	9.931
ConductorWidth_in	0.350	0.350	0.350
ConductorWidth_mm	8.890	8.890	8.890
ConductorAspectRatio	1.12	1.12	1.12
InsulatedConductorHeight_mm	10.338	10.338	10.338
InsulatedConductorWidth_mm	9.296	9.296	9.296
Minimum Bend Radius Parallel To Tee_in	2.450	3.010	3.150
Minimum Bend Radius Parallel To Tee_mm	62.230	76.454	80.010
Allowance For Keystoning In Width_mm	1.155	0.959	0.920
Minimum Bend Radius Normal To Tee_in	2.530	2.660	3.080
Minimum Bend Radius Parallel To Tee_mm	64.262	67.564	78.232
Allowance For Keystoning In Height_mm	0.914	0.874	0.764
TurnsHigh	10	10	9
TurnsWide	4	4	4
TotalInsulatedConductorHeight_mm	103.378	103.378	93.040
Total Allowance For Keystoning in Height_mm	9.143	8.736	6.874
Total Tolerance Buildup in Height_mm	1.982	1.982	1.880
Total Ground Wrap Buildup in Height_mm	1.930	1.930	1.930
Total Chill Plate Buildup in Height_mm	2.032	2.032	2.032
Total Height_mm	118.465	118.058	105.757
BundleHeight_mm	118.643	118.643	108.306
Bundle Height - Total Height_mm	0.178	0.585	2.549

TotalInsulatedConductorWidth_mm	37.186	37.186	37.186
Total Allowance For Keystoning in Width_mm	0	0	0
Total Tolerance Buildup in Width_mm	1.253	1.253	1.253
Total Ground Wrap Buildup in Width_mm	1.930	1.930	1.930
Total Chill Plate Buildup in Width_mm	2.032	2.032	2.032
Total Width_mm	42.401	42.401	42.401
BundleWidth_mm	42.545	42.545	42.545
Bundle Width - Total Width_mm	0.143622014	0.143622014	0.143622014
Number of turns connected in parallel	4	4	4
Turns (electrical)	20	20	18
ConductorLength_m	73.577	71.728	59.945
Serve Thickness_mils	4	4	4
Serve Thickness_mm	0.102	0.102	0.102
Copper Height_mm	9.728	9.728	9.728
Copper Width_mm	8.687	8.687	8.687
Conductor Area (w/o serve)_mm2	338.028	338.028	338.028
CopperVolumeFraction	0.785	0.785	0.785
Area correction	-0.0552	-0.0552	-0.0552
CopperArea_mm2	250.704	250.704	250.704
Length correction	0.058	0.058	0.058
Resistance correction for helical current path	0.120	0.120	0.120

A.1.2 TF Coil Build

The TF conductor was modeled as a rectangular conductor of uniform thickness and width in each turn to calculate derived requirements. Conductor dimensions correspond to the dimensions of the smallest turn. The actual condcutor geometry features a wedged section in the inboard region and a larger rectangular section outboard.

	TF
Length_m	8.657
NumberCoils	18
TurnsHigh	6
TurnsWide	2
Turns	12
ConductorLengthPerDP_m	103.881
BundleHeight_mm	84.887
BundleWidth_mm	100.838
BundleArea_mm2	8559.815
BundleArea_m2	0.009
GroundWrap_mm	0.762
TurnInsulation_mm	1.270
PancakeInsulation_mm	0
ConductorHeight_mm	11.354
ConductorWidth_mm	48.133
CornerRadius_mm	2.5
CornerArea_mm2	5.365
CoolingHoleWidth_mm	6.812
CoolingHoleHeight_mm	19.253
CoolingArea_mm2	121.199
ConductorArea_mm2	419.928
CopperArea_mm2	419.928

A.1.3 PF Coil Builds

	PF1	PF2	PF3	PF4	PF5	PF6
Rpf_m	0.219	0.219	0.219	0.522	2.223	2.720
Rpf_in	8.625	8.625	8.625	20.549	87.527	107.105
Zpf_m	0.240	0.719	1.199	1.583	1.530	0.954
Zpf_in	9.438	28.313	47.188	62.340	60.250	37.562
Length_m	1.376	1.376	1.376	3.279	13.969	17.093
TurnsHigh	18	18	18	10	6	7
TurnsWide	4	4	4	8	4	2
Turns	72	72	72	80	24	14
Construction	Helically Wound	Helically Wound	Helically Wound	Helically Wound	Helically Wound	Helically Wound
BundleHeight_mm	426.441	426.441	426.441	249.453	160.960	183.083
BundleHeight_in	16.789	16.789	16.789	9.821	6.337	7.208
BundleWidth_mm	96.876	96.876	96.876	188.417	96.876	51.105
BundleWidth_in	3.814	3.814	3.814	7.418	3.814	2.012
BundleArea_mm2	41312	41312	41312	47001	15593	9356
BundleArea_m2	0.041	0.041	0.041	0.047	0.016	0.009
GroundWrap_mm	3.048	3.048	3.048	3.048	3.048	3.048
TurnInsulation_mm	1.067	1.067	1.067	1.067	1.067	1.067
PancakeInsulation_mm	0.762	0.762	0.762	0.762	0.762	0.762
ConductorHeight_in	0.787	0.787	0.787	0.787	0.787	0.787
ConductorHeight_mm	19.990	19.990	19.990	19.990	19.990	19.990
ConductorWidth_in	0.787	0.787	0.787	0.787	0.787	0.787
ConductorWidth_mm	19.990	19.990	19.990	19.990	19.990	19.990
CornerRadius_in	0.040	0.040	0.040	0.040	0.040	0.040
CornerRadius_mm	1.016	1.016	1.016	1.016	1.016	1.016
CornerArea_mm2	0.886	0.886	0.886	0.886	0.886	0.886
CoolingHoleDia_in	0.354	0.354	0.354	0.354	0.354	0.354
CoolingHoleDia_mm	8.992	8.992	8.992	8.992	8.992	8.992
CoolingArea_mm2	63.499	63.499	63.499	63.499	63.499	63.499
ConductorArea_mm2	335.207	335.207	335.207	335.207	335.207	335.207
CopperArea_mm2	335.207	335.207	335.207	335.207	335.207	335.207
1Vs_OH_MAT	2.517	2.517	1.915	0.963	0.032	0.019

A.2 Coil Inductance Matrix (Henries)

	M1	M2	M3	PF1	PF2	PF3	PF4	PF5	PF6	TF	Plasma
M1	1.24E-02	2.83E-03	1.25E-03	-5.52E-05	9.15E-06	3.78E-05	1.22E-04	-2.29E-04	-2.82E-04	8.68E-03	-1.63E-05
M2	2.83E-03	9.23E-03	2.32E-03	2.21E-05	-1.04E-05	-5.07E-06	-1.27E-05	-4.51E-05	-6.27E-05	6.68E-03	-1.08E-05
M3	1.25E-03	2.32E-03	7.90E-03	1.02E-04	-8.50E-06	-3.48E-05	-1.66E-04	-2.03E-04	-6.19E-05	4.68E-03	-8.60E-06
PF1	-5.52E-05	2.21E-05	1.02E-04	3.03E-03	4.76E-04	7.20E-05	1.47E-04	1.68E-04	1.19E-04	0.00E+00	8.92E-06
PF2	9.15E-06	-1.04E-05	-8.50E-06	4.76E-04	2.63E-03	4.28E-04	3.22E-04	1.75E-04	1.14E-04	0.00E+00	6.78E-06
PF3	3.78E-05	-5.07E-06	-3.48E-05	7.20E-05	4.28E-04	2.61E-03	1.14E-03	1.82E-04	1.04E-04	0.00E+00	4.40E-06
PF4	1.22E-04	-1.27E-05	-1.66E-04	1.47E-04	3.22E-04	1.14E-03	1.53E-02	1.14E-03	5.90E-04	0.00E+00	1.82E-05
PF5	-2.29E-04	-4.51E-05	-2.03E-04	1.68E-04	1.75E-04	1.82E-04	1.14E-03	1.29E-02	3.49E-03	0.00E+00	4.81E-05
PF6	-2.82E-04	-6.27E-05	-6.19E-05	1.19E-04	1.14E-04	1.04E-04	5.90E-04	3.49E-03	6.26E-03	0.00E+00	3.97E-05
TF	8.68E-03	6.68E-03	4.68E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.90E-02	1.51E-06
Plasma	-1.63E-05	-1.08E-05	-8.60E-06	8.92E-06	6.78E-06	4.40E-06	1.82E-05	4.81E-05	3.97E-05	1.51E-06	2.68E-06

A.3 Reference Scenario Data

A.3.1 Current Waveforms

Conductor currents are given in amperes. Maxima for all reference scenarios are shown in blue, minima in red.

0.5T First Plasma Scenario	**t(s)**	**M1**	**M2**	**M3**	**PF1**	**PF2**	**PF3**	**PF4**	**PF5**	**PF6**	**TF**	**Plasma**
	-0.600	**0**	**0**	**0**	0	0	0	0		0	0	**0**
	0.000	11218	10435	10435	570	570	570	**9361**		-1122	-1043	**0**
	0.100	11218	10435	10435	570	570	570	**9361**		-1122	-1043	**0**
	0.170	10227	10276	10276	5907	5907	5907	4530		2036	-325	-35310
	0.265	10227	10276	10276	9172	9172	9172	5618		2287	-325	-35310
	0.270	10227	10276	10276	9344	9344	9344	5676		2301	-325	-35310
Maximum		11218	10435	10435	9344	9344	9344	9361		2301	0	0
Minimum		0	0	0	0	0	0	0		-1122	-1043	-35310
I2t (A2-s)		9.26E+07	8.26E+07	8.31E+07	1.71E+07	1.69E+07	1.68E+07	4.96E+07		1.50E+06	4.89E+06	0
tESW (s)		0.74	0.76	0.76	0.20	0.19	0.19	0.57		0.28	4.49	0

Field Line Mapping Scenario	**t(s)**	**M1**	**M2**	**M3**	**PF1**	**PF2**	**PF3**	**PF4**	**PF5**	**PF6**	**TF**	**Plasma**
	-0.600	**0**	**0**	**0**				0		0	0	
	0.000	11218	10435	10435				9170		-1166	-1043	
	0.100	11218	10435	10435				9170		-1166	-1043	
	0.200	11218	10435	10435				9170		-1166	-1043	
	1.600	11218	10435	10435				9170		-1166	-1043	
	3.000	11218	10435	10435				9170		-1166	-1043	
Maximum	0	11218	10435	10435				9170		0	0	
Minimum	0	0	0	0				0		-1166	-1043	
I2t (A2-s)	0	4.50E+08	3.89E+08	3.89E+08				2.94E+08		4.70E+06	7.75E+06	
tESW (s)	0	3.58	3.57	3.57				3.50		3.46	7.12	

1.7T Ohmic Scenario	t(s)	M1	M2	M3	PF1	PF2	PF3	PF4	PF5	PF6	TF	Plasma
	-0.700	0	0	0	0	0	0	0	0	0	0	0
	0.000	38141	35504	35453	1135	1135	5100	3391	8499	-7428	-3548	0
	0.100	38141	35504	35453	1135	1135	5100	3391	8499	-7428	-3548	0
	0.140	34772	35327	34508	10058	10058	9877	1063	1242	5774	-1106	-120052
	0.240	34772	35327	34508	13553	13553	12537	2267	1378	5912	-1106	-120052
	0.440	34772	35327	34508	20544	20544	17857	4675	1648	6187	-1106	-120052
Maximum		38141	35504	35453	20544	20544	17857	4675	8499	6187	0	0
Minimum		0	0	0	0	0	0	0	0	-7428	-3548	-120052
I2t (A2-s)		1.40E+09	1.30E+09	1.26E+09	1.58E+08	1.56E+08	1.09E+08	2.18E+07	3.88E+07	4.60E+07	1.09E+08	
tESW (s)		0.96	1.03	1.00	0.37	0.37	0.34	1.00	0.54	0.83	8.64	

1.7T High Beta Scenario	t(s)	M1	M2	M3	PF1	PF2	PF3	PF4	PF5	PF6	TF	Plasma
	-0.700	0	0	0	0	0	0	0	0	0	0	0
	0.000	38141	35504	35453	6378	6378	9090	5197	8702	-7222	-3548	0
	0.100	38141	35504	35453	6378	6378	9090	5197	8702	-7222	-3548	0
	0.140	34772	35327	34508	15301	15301	13867	2869	1445	5981	-1106	-120052
	0.240	32795	32587	30018	14853	14853	12749	710	2889	6987	3760	-178272
	0.440	32795	32587	30018	15552	15552	13281	951	2916	7015	3760	-178272
Maximum		38141	35504	35453	15552	15552	13867	5197	8702	7015	3760	0
Minimum		0	0	0	0	0	0	0	0	-7222	-3548	-178272
I2t (A2-s)		1.35E+09	1.22E+09	1.14E+09	1.37E+08	1.35E+08	1.20E+08	1.33E+07	4.36E+07	4.93E+07	1.79E+08	
tESW (s)		0.92	0.97	0.91	0.57	0.56	0.63	0.49	0.58	0.95	12.66	

2T High Beta Scenario	t(s)	M1	M2	M3	PF1	PF2	PF3	PF4	PF5	PF6	TF	Plasma
	-0.850	0	0	0	0	0	0	0	0	0	0	0
	0.000	40908	41561	40598	10966	10966	10961	953	1609	1334	-1301	0
	0.050	40908	41561	40598	10966	10966	10961	953	1609	1334	-1301	0
	0.097	40908	41561	40598	18616	18616	16782	3587	1724	7060	-1301	-141238
	0.192	38583	38338	35315	18010	18010	15407	1020	3420	8241	4424	-209732
	0.197	38583	38338	35315	18027	18027	15420	1026	3420	8242	4424	-209732
Maximum		40908	41561	40598	18616	18616	16782	3587	3420	8242	4424	0
Minimum		0	0	0	0	0	0	0	0	0	-1301	-209732
I2t (A2-s)		1.51E+09	1.53E+09	1.42E+09	1.67E+08	1.67E+08	1.38E+08	3.31E+06	7.15E+06	1.67E+07	2.44E+08	
tESW (s)		0.90	0.89	0.86	0.48	0.48	0.49	0.26	0.61	0.25	12.49	

1.2T Long Pulse Scenario	t(s)	M1	M2	M3	PF1	PF2	PF3	PF4	PF5	PF6	TF	Plasma
	-0.400	0	0	0	0	0	0	0	0	0	0	0
	0.000	26923	25062	25026	5222	5222	6964	3916	6171	-5070	-2504	0
	0.100	26923	25062	25026	5222	5222	6964	3916	6171	-5070	-2504	0
	0.128	24545	24937	24359	11512	11512	10330	2270	1048	4250	-780	-84743
	0.228	23150	23003	21189	11299	11299	9619	782	2071	4964	2654	-125839
	1.728	23150	23003	21189	16542	16542	13609	2588	2274	5171	2654	-125839
Maximum		26923	25062	25026	16542	16542	13609	3916	6171	5171	2654	0
Minimum		0	0	0	0	0	0	0	0	-5070	-2504	-125839
I2t (A2-s)		1.30E+09	1.26E+09	1.08E+09	4.51E+08	4.51E+08	3.12E+08	1.58E+07	2.11E+07	5.31E+07	9.14E+07	
tESW (s)		1.80	2.00	1.72	1.65	1.65	1.69	1.03	0.55	1.99	12.97	

320kA Ohmic Scenario	t(s)	M1	M2	M3	PF1	PF2	PF3	PF4	PF5	PF6	TF	Plasma
	-0.600	**0**	**0**	**0**	0	0	0	0	**0**	0	0	**0**
	0.000	34772	35327	34508	**-22660**	**-22660**	**-15021**	-10206	130	-125	-1106	**0**
	0.100	34772	35327	34508	**-22660**	**-22660**	**-15021**	-10206	130	-125	-1106	**0**
	0.206	34200	32057	32184	11334	11334	-9474	**-14891**	4924	4826	2191	**-320775**
	0.306	34200	32057	32184	14829	14829	-6814	-13687	5059	4963	2191	**-320775**
	0.506	34200	32057	32184	**21820**	**21820**	-1495	-11280	5330	5238	2191	**-320775**
Maximum		34772	35327	34508	21820	21820	0	0	5330	5238	2191	0
Minimum		0	0	0	-22660	-22660	-15021	-14891	0	-125	-1106	-320775
I2t (A2-s)		1.27E+09	1.19E+09	1.15E+09	4.17E+08	4.03E+08	1.37E+08	1.48E+08	1.58E+07	1.19E+07	1.41E+08	
tESW (s)		1.05	0.95	0.96	0.81	0.79	0.61	0.67	0.55	0.43	29.45	

Ref. Scenario Summary		M1	M2	M3	PF1	PF2	PF3	PF4	PF5	PF6	TF	Plasma
Maximum		40908	41561	40598	21820	21820	17857	9361	8702	8242	4424	0
Minimum		0	0	0	-22660	-22660	-15021	-14891	0	-7428	-3548	-320775
Maximum I2t (A2-s)		1.51E+09	1.53E+09	1.42E+09	4.51E+08	4.51E+08	3.12E+08	2.94E+08	4.36E+07	5.31E+07	2.44E+08	
tESW (s) at max current		0.90	0.89	0.86	0.88	0.88	0.98	1.33	0.58	0.78	12.49	

A.3.2 Temperature History

Coil temperatures are in Kelvin. Maxima for all reference scenarios are shown in blue.

A.3.2.1 Temperature History For Room Temperature Operation

0.5T First Plasma Scenario	t(s)	M1	M2	M3	PF1	PF2	PF3	PF4	PF5	PF6	TF
	-0.600	295	295	295	295	295	295	295	295	295	295
	0.000	299	299	299	295	295	295	296	295	295	295
	0.100	300	300	300	295	295	295	297	295	295	295
	0.170	301	300	300	295	295	295	297	295	295	295
	0.265	302	301	301	295	295	295	297	295	295	295
	0.270	302	301	301	295	295	295	297	295	295	295
	2.451	303	302	302	**296**	**296**	**296**	297	**295**	295	295
Dissipated Energy (J)		6.04E+06	5.26E+06	4.42E+06	**1.85E+05**	**1.83E+05**	**1.82E+05**	1.34E+06	**1.53E+03**	3.76E+04	3.79E+05
											1.80E+07

Field Line Mapping Scenario	t(s)	M1	M2	M3	PF1	PF2	PF3	PF4	PF5	PF6	TF
	-0.600	295	295	295	295	295	295	295	295	295	295
	0.000	299	299	299	295	295	295	296	295	295	295
	0.100	300	300	300	295	295	295	297	295	295	295
	0.200	301	300	301	295	295	295	297	295	295	295
	1.600	317	314	314	295	295	295	302	295	295	295
	3.000	333	327	327	295	295	295	308	295	295	295
	5.181	**334**	**328**	**328**	295	295	295	**309**	295	**295**	**295**
Dissipated Energy (J)		**3.13E+07**	**2.61E+07**	**2.18E+07**	1.67E+02	2.45E+02	5.12E+03	**8.21E+06**	1.41E+02	**1.16E+05**	**5.99E+05**
											8.81E+07

Summary		M1	M2	M3	PF1	PF2	PF3	PF4	PF5	PF6	TF
Max Final Temperature		334	328	328	296	296	296	309	295	295	295
Max Dissipated Energy (J)		3.13E+07	2.61E+07	2.18E+07	1.85E+05	1.83E+05	1.82E+05	8.21E+06	1.53E+03	1.16E+05	5.99E+05
											8.81E+07

A.3.2.2 Temperature History For LN2 Operation

1.7T Ohmic Scenario	t(s)	M1	M2	M3	PF1	PF2	PF3	PF4	PF5	PF6	TF
	-0.700	85	85	85	80	80	80	80	80	80	80
	0.000	96	95	95	80	80	80	80	80	80	80
	0.100	100	98	98	80	80	80	80	80	80	80
	0.140	101	99	99	80	80	80	80	80	80	80
	0.240	104	102	102	80	80	80	80	80	80	80
	0.440	111	108	108	81	81	81	80	80	80	80
	2.621	119	116	115	82	82	81	80	80	80	81
Dissipated Energy (J)		1.86E+07	1.65E+07	1.32E+07	1.97E+05	1.94E+05	1.33E+05	6.85E+04	1.51E+05	1.30E+05	9.65E+05
											5.01E+07

1.7T High Beta Scenario	t(s)	M1	M2	M3	PF1	PF2	PF3	PF4	PF5	PF6	TF
	-0.700	85	85	85	80	80	80	80	80	80	80
	0.000	96	95	95	80	80	80	80	80	80	80
	0.100	100	98	98	80	80	80	80	80	80	80
	0.140	101	99	99	80	80	81	80	80	80	80
	0.240	104	102	102	80	80	81	80	80	80	80
	0.440	110	107	106	81	81	81	80	80	80	80
	2.621	118	114	112	81	81	81	80	**80**	80	81
Dissipated Energy (J)		1.76E+07	1.51E+07	1.15E+07	1.68E+05	1.67E+05	1.45E+05	4.04E+04	**1.70E+05**	1.40E+05	1.61E+06
											4.67E+07

2T High Beta Scenario	t(s)	M1	M2	M3	PF1	PF2	PF3	PF4	PF5	PF6	TF
	-0.850	85	85	85	80	80	80	80	80	80	80
	0.000	103	105	104	81	81	81	80	80	80	80
	0.050	105	107	106	81	81	81	80	80	80	80
	0.097	107	109	108	81	81	81	80	80	80	80
	0.192	111	113	112	81	81	81	80	80	80	80
	0.197	112	114	112	81	81	81	80	80	80	80
	2.378	**123**	**123**	**120**	82	82	81	80	80	80	**82**
Dissipated Energy (J)		**2.08E+07**	**2.06E+07**	**1.55E+07**	2.06E+05	2.06E+05	1.67E+05	1.05E+04	2.91E+04	4.99E+04	**2.22E+06**
											5.97E+07

1.2T Long Pulse Scenario	t(s)	M1	M2	M3	PF1	PF2	PF3	PF4	PF5	PF6	TF
	-0.400	85	85	85	80	80	80	80	80	80	80
	0.000	88	87	87	80	80	80	80	80	80	80
	0.100	89	89	89	80	80	80	80	80	80	80
	0.128	89	89	89	80	80	80	80	80	80	80
	0.228	91	90	90	80	80	80	80	80	80	80
	1.728	112	112	107	84	84	83	80	80	81	80
	3.909	116	115	110	**85**	**85**	**83**	80	80	**81**	81
Dissipated Energy (J)		1.69E+07	1.57E+07	1.07E+07	**5.68E+05**	**5.68E+05**	**3.82E+05**	4.79E+04	8.30E+04	**1.52E+05**	8.14E+05
											8.81E+07

320kA Ohmic Scenario	t(s)	M1	M2	M3	PF1	PF2	PF3	PF4	PF5	PF6	TF
	-0.600	85	85	85	80	80	80	80	80	80	80
	0.000	92	93	93	82	82	81	80	80	80	80
	0.100	95	96	95	82	82	81	80	80	80	80
	0.206	98	99	98	83	83	81	81	80	80	80
	0.306	101	101	101	83	83	81	81	80	80	80
	0.506	107	106	106	83	83	81	81	80	80	80
	2.687	115	113	112	84	84	81	**82**	80	80	81
Dissipated Energy (J)		1.63E+07	1.46E+07	1.16E+07	5.29E+05	5.09E+05	1.62E+05	**4.75E+05**	6.44E+04	3.45E+04	1.27E+06
											4.56E+07

Summary		M1	M2	M3	PF1	PF2	PF3	PF4	PF5	PF6	TF
Max Final Temperature		123	123	120	85	85	83	82	80	81	82
Max Dissipated Energy (J)		2.08E+07	2.06E+07	1.55E+07	5.68E+05	5.68E+05	3.82E+05	4.75E+05	1.70E+05	1.52E+05	2.22E+06
											5.97E+07

A.3.3 Electrical Power Requirements

A.3.3.1 Power Supply and Cabling Requirements

Power supply requirements for the reference scenarios have been calculated based on the following assumptions:

[1] All coils of the same type (e.g. all M1 coils) are connected in series. All coils in the same circuit are connected in series.
Circuit configurations are defined in the table below.

[2] All coils of the same type have a single CLR connected in series with the coils. Each CLR has an inductance of 267 micro-H and a resistance of 100 milli-ohms.

[3] DC power will be carried from D-site to the test cell via 1000MCM cables approximately 750 feet in length (each way).
Cables per pole in each circuit are defined in the table below.
A resistance of 8.1 milli-ohms per cable (per 750 length) was assumed.
An inductance of 132 micro-Henries per cable pair (supply and return) was assumed.

[4] TFTR power supply sections (PSS) will be used. Each PSS has an open circuit voltage of 1012.85V and a maximum current of 28kA.
When operated in parallel, the maximum rated current has been reduced by 10%.

[5] Circuits with a single cable per pole shall be designed for a maximum current of 28 kA and a DC current rating of at least 770A.
Circuits with two cables per pole shall be designed for a maximum current of 50 kA and a DC current rating of at least 1540A.

Changes in the capability required are shown in red

Description	Scenarios	Circuit 1	Circuit 2	Circuit 3	Circuit 4	Circuit 5	Circuit 6	Circuit 7	Circuit 8	Circuit 9	Total	
	First Plasma		M2,M3	PF1/2/3								
Initial capability required	Field Line Mapping	M1	M2	M3	PF4	PF6	TF					
33 MW	Series PSS per branch	2	2	2	2	2	2				14	PSS
90 MVA	Cables per pole	1	1	1	1	1	1				12	Cables
108 MJ	Branches	1	1	1	1	2	1					
	Branch configuration					Anti-parallel						
	1.7T Ohmic											
	1.7T High Beta											
	2T High Beta											
	1.2T Long Pulse											
Ultimate capability required	320kA High Current	M1	M2	M3	PF4	PF6	TF	PF1/2	PF3	PF5		
169 MW	Series PSS per branch	2	2	2	2	2	4	4	2	2	38	PSS
389 MVA	Cables per pole	2	2	2	1	1	1	1	1	1	24	Cables
112 MJ	Branches	2	2	2	1	2	2	2	1	1		
	Branch configuration	Parallel	Parallel	Parallel		Anti-parallel	Anti-parallel	Anti-parallel				

A.4 Cryogenic System Requirements

A.4.1 Pulsed Heat Loads

Pulsed heat loads for the modular coils calculated on a temperature rise from 85K to 125K in each modular coil.
Pulsed heat loads for the TF and PF coils calculated on the basis of the worst case scenario for each coil.
Total heat loads calculated by summing the above.

Pulsed heat Loads	M1	M2	M3	PF1	PF2	PF3	PF4	PF5	PF6	TF
Initial Temperature (K)	85	85	85	80	80	80	80	80	80	80
Max Temperature (K)	123	123	120	85	85	83	82	80	81	82
Energy Deposited (J)	2.08E+07	2.06E+07	1.55E+07	5.68E+05	5.68E+05	3.82E+05	4.75E+05	1.70E+05	1.52E+05	2.22E+06
										5.97E+07

LN2 Consumption		Tsat (K)	Psat (MPa)	hfg (kJ/kg)	Mass per pulse (kg)	Density (kg/m3)	(m3/kg)	Volume (m3)	(liters)	(gallons)	
Per shot		78	0.107717028	198.7356959	300.4664314	805.7325273	0.001241107	0.372910887	372.910887	99	per shot
Time between shots (minutes)	15										
Hours per day	8										
Full pwr shots per day	32									3152	per day
Operating days per week	5									15762	per week

A.4.2 Parasitic Heat Loads

Heat leakages to the cold mass calculated on the basis of numbers provided by cognizant engineers based on nominal VV operating temperatures of 40C and bakeout temperatures of 150C with the cold mass at 80K.

Normal Operation	Heat Load (kW)		Flow rate (kg/s)	Vol flow rate (m3/s)	s/week	Volume (m3)	(liters)	(gallons)	
Cryostat gaseous nitrogen circulation	7.4								
Through cryostat		3.4							
Through ports		2.6							
From VV to modular coil shell		1.4							
Modular coil liquid nitrogen cooling (from VV)	3.7								
Combined	11.2		0.05618853	6.9736E-05	604800	42.17630785	42176.30785	11142	per week
VV heating required to maintain VV temperature	*7.8*								

Bakeout	Heat Load (kW)		Flow rate (kg/s)	Vol flow rate (m3/s)	s/week	Volume (m3)	(liters)	(gallons)	
Cryostat gaseous nitrogen circulation	9.6								
Through cryostat		3.4							
Through ports		4.0							
From VV to modular coil shell		2.2							
Modular coil liquid nitrogen cooling (from VV)	5.7								
Combined	15.3		0.076986673	9.55487E-05	604800	57.78783672	57787.83672	15266	per week
VV heating required to maintain VV temperature	*11.9*								

A.4.3 Heat Loads For Cooling the Cold Mass from RT to 80K

Cold mass	75000	kg
Cryogen requirements	0.43	kg of LN2 per kg of SS assuming evaporation enthalpy only per http://gperinic.home.cern.ch/gperinic/cooldown.htm
	32250	kg based on evaporation enthalpy only
	10574	gallons

A.4.4 LN2 Delivery Requirements

	gallons per truck	trucks	
Pulsed heat loads only	6500	2.4	per week
Parasitic loads only			
Normal		1.7	per week
Bakeout		2.3	per week
Cooldown only		1.6	