

A.1 Coil Set Definition

A.1.1 Current Centroid Locations

Coil centroids are defined by the c08r00 coil set.

A.1.2 Turns per Coil

| | M1 | M2 | M3 | PF1 | PF2 | PF3 | PF4 | PF5 | PF6 | TF | Plasma |
|-------|----|----|----|-----|-----|-----|-----|-----|-----|----|--------|
| Turns | 20 | 20 | 18 | 72 | 72 | 72 | 80 | 24 | 14 | 12 | 1 |

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 Reference Equilibria (amp-turns per coil)

| Equilibrium ID | M1 | M2 | M3 | PF1 | PF2 | PF3 | PF4 | PF5 | PF6 | TF | Plasma | Comment |
|----------------|----------|----------|----------|----------|----------|-----------|-----------|-----------|-----------|-----------|---------|------------------|
| 1 | 7.63E+05 | 7.10E+05 | 6.38E+05 | 0.00E+00 | 0.00E+00 | 3.05E+05 | 2.40E+05 | 2.03E+05 | -1.05E+05 | -4.26E+04 | 0 | iota>0.5 |
| 2 | 6.95E+05 | 7.06E+05 | 6.21E+05 | 0.00E+00 | 0.00E+00 | 1.60E+05 | -1.92E+05 | 2.42E+04 | 1.07E+04 | -1.33E+04 | 0 | iota<0.5 |
| 3 | 6.95E+05 | 7.06E+05 | 6.21E+05 | 0.00E+00 | 0.00E+00 | 1.60E+05 | -1.92E+05 | 2.05E+04 | 7.53E+04 | -1.33E+04 | -120000 | 120kA, zero beta |
| 4 | 6.59E+05 | 6.54E+05 | 5.43E+05 | 0.00E+00 | 0.00E+00 | 1.05E+05 | -3.54E+05 | 5.58E+04 | 9.00E+04 | 4.53E+04 | -179000 | 179kA, full beta |
| 5 | 6.82E+05 | 6.40E+05 | 5.78E+05 | 0.00E+00 | 0.00E+00 | -1.30E+06 | -1.50E+06 | 1.07E+05 | 6.12E+04 | 2.62E+04 | -320000 | 320kA, zero beta |
| 6 | 6.69E+05 | 6.44E+05 | 5.57E+05 | 0.00E+00 | 0.00E+00 | -1.14E+05 | -2.09E+05 | -3.27E+05 | 2.60E+05 | 3.77E+04 | -160000 | 160kA, zero beta |
| 7 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.94E+05 | 0 | 0.5T TF |
| 8 | 2.00E+05 | 2.00E+05 | 1.80E+05 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.12E+03 | 0 | First Plasma S1 |
| 9 | 2.00E+05 | 2.00E+05 | 1.80E+05 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.12E+03 | -26000 | First Plasma S2 |

A.3.2 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 |
|----------------------------|--------|----------|----------|----------|----------|----------|----------|----------|-----|----------|----------|--------|
| | -1.550 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0.000 | 10000 | 10000 | 10000 | 0 | 0 | 0 | 0 | 0 | 0 | 93 | 0 |
| | 0.050 | 10000 | 10000 | 10000 | 0 | 0 | 0 | 0 | 0 | 0 | 93 | 0 |
| | 0.120 | 10000 | 10000 | 10000 | 4869 | 4869 | 4869 | 1478 | | 385 | 93 | -25999 |
| | 0.123 | 10000 | 10000 | 10000 | 4973 | 4973 | 4973 | 1510 | | 393 | 93 | -25999 |
| | 0.130 | 10000 | 10000 | 10000 | 5217 | 5217 | 5217 | 1584 | | 413 | 93 | -25999 |
| Maximum | | 10000 | 10000 | 10000 | 5217 | 5217 | 5217 | 1584 | | 413 | 93 | 0 |
| Minimum | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | -25999 |
| I2t (A2-s) | | 1.59E+08 | 1.40E+08 | 1.40E+08 | 2.11E+07 | 3.01E+07 | 2.74E+07 | 4.10E+06 | | 3.95E+04 | 1.67E+07 | 0 |
| tESW (s) | | 1.59 | 1.40 | 1.40 | 0.77 | 1.10 | 1.01 | 1.63 | | 0.23 | 1933.76 | 0 |

| Field Line Mapping Scenario | t(s) | M1 | M2 | M3 | PF1 | PF2 | PF3 | PF4 | PF5 | PF6 | TF | Plasma |
|-----------------------------|--------|------|----------|----------|----------|-----|-----|-----|-----|-----|----|----------|
| | -0.300 | 0 | 0 | 0 | | | | | | | | 0 |
| | 0.000 | 2000 | 2000 | 2000 | | | | | | | | 19 |
| | 0.100 | 2000 | 2000 | 2000 | | | | | | | | 19 |
| | 0.200 | 2000 | 2000 | 2000 | | | | | | | | 19 |
| | 2.600 | 2000 | 2000 | 2000 | | | | | | | | 19 |
| | 10.100 | 2000 | 2000 | 2000 | | | | | | | | 19 |
| Maximum | | 0 | 2000 | 2000 | | | | | | | | 19 |
| Minimum | | 0 | 0 | 0 | | | | | | | | 0 |
| I2t (A2-s) | | 0 | 4.36E+07 | 4.26E+07 | 4.22E+07 | | | | | | | 1.83E+05 |
| tESW (s) | | 0 | 10.91 | 10.65 | 10.55 | | | | | | | 530.03 |

| 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 | -25123 | -25123 | -9698 | -7752 | 8284 | -8997 | -3548 | 0 |
| | 0.100 | 38141 | 35504 | 35453 | -25123 | -25123 | -9698 | -7752 | 8284 | -8997 | -3548 | 0 |
| | 0.140 | 34772 | 35327 | 34508 | -16185 | -16185 | -6754 | -9327 | 743 | 4396 | -1106 | -120052 |
| | 0.240 | 34772 | 35327 | 34508 | -12683 | -12683 | -4812 | -7829 | 766 | 4609 | -1106 | -120052 |
| | 0.440 | 34772 | 35327 | 34508 | -5681 | -5681 | -928 | -4832 | 814 | 5033 | -1106 | -120052 |
| Maximum | | 38141 | 35504 | 35453 | 0 | 0 | 0 | 0 | 8284 | 5033 | 0 | 0 |
| Minimum | | 0 | 0 | 0 | -25123 | -25123 | -9698 | -9327 | 0 | -8997 | -3548 | -120052 |
| I2t (A2-s) | | 1.40E+09 | 1.30E+09 | 1.26E+09 | 4.03E+08 | 4.07E+08 | 5.92E+07 | 5.06E+07 | 3.74E+07 | 5.26E+07 | 1.15E+08 | |
| tESW (s) | | 0.96 | 1.03 | 1.01 | 0.64 | 0.64 | 0.63 | 0.58 | 0.54 | 0.65 | 9.16 | |

| 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 | -14619 | -14619 | -3872 | -3256 | 8356 | -8360 | -3548 | 0 |
| | 0.100 | 38141 | 35504 | 35453 | -14619 | -14619 | -3872 | -3256 | 8356 | -8360 | -3548 | 0 |
| | 0.140 | 34772 | 35327 | 34508 | -5681 | -5681 | -928 | -4832 | 814 | 5033 | -1106 | -120052 |
| | 0.240 | 32795 | 32587 | 30018 | -6129 | -6129 | -1953 | -7029 | 2272 | 6030 | 3760 | -178272 |
| | 0.440 | 32795 | 32587 | 30018 | -5429 | -5429 | -1565 | -6729 | 2277 | 6073 | 3760 | -178272 |
| Maximum | | 38141 | 35504 | 35453 | 0 | 0 | 0 | 0 | 8356 | 6073 | 3760 | 0 |
| Minimum | | 0 | 0 | 0 | -14619 | -14619 | -3872 | -7029 | 0 | -8360 | -3548 | -178272 |
| I2t (A2-s) | | 1.35E+09 | 1.22E+09 | 1.15E+09 | 1.28E+08 | 1.29E+08 | 9.28E+06 | 3.44E+07 | 3.92E+07 | 5.23E+07 | 1.85E+08 | |
| tESW (s) | | 0.93 | 0.97 | 0.91 | 0.60 | 0.60 | 0.62 | 0.70 | 0.56 | 0.75 | 13.10 | |

| 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 | -14574 | -14574 | -5468 | -9062 | 1085 | 18 | -1301 | 0 |
| | 0.050 | 40908 | 41561 | 40598 | -14574 | -14574 | -5468 | -9062 | 1085 | 18 | -1301 | 0 |
| | 0.097 | 40908 | 41561 | 40598 | -6912 | -6912 | -1218 | -5783 | 956 | 5908 | -1301 | -141238 |
| | 0.192 | 38583 | 38338 | 35315 | -7518 | -7518 | -2469 | -8401 | 2671 | 7076 | 4424 | -209732 |
| | 0.197 | 38583 | 38338 | 35315 | -7501 | -7501 | -2459 | -8394 | 2671 | 7077 | 4424 | -209732 |
| Maximum | | 40908 | 41561 | 40598 | 0 | 0 | 0 | 0 | 2671 | 7077 | 4424 | 0 |
| Minimum | | 0 | 0 | 0 | -14574 | -14574 | -5468 | -9062 | 0 | 0 | -1301 | -209732 |
| I2t (A2-s) | | 1.52E+09 | 1.54E+09 | 1.43E+09 | 1.44E+08 | 1.43E+08 | 1.96E+07 | 7.00E+07 | 3.34E+06 | 1.04E+07 | 2.52E+08 | |
| tESW (s) | | 0.91 | 0.89 | 0.86 | 0.68 | 0.67 | 0.65 | 0.85 | 0.47 | 0.21 | 12.85 | |

| 1.2T Long Pulse Scenario | t(s) | M1 | M2 | M3 | PF1 | PF2 | PF3 | PF4 | PF5 | PF6 | TF | Plasma |
|--------------------------|--------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|---------|
| | -0.500 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0.000 | 26923 | 25062 | 25026 | -14027 | -14027 | -4790 | -3885 | 5873 | -6126 | -2504 | 0 |
| | 0.100 | 26923 | 25062 | 25026 | -14027 | -14027 | -4790 | -3885 | 5873 | -6126 | -2504 | 0 |
| | 0.128 | 24545 | 24937 | 24359 | -7725 | -7725 | -2716 | -5001 | 549 | 3328 | -780 | -84743 |
| | 0.228 | 23150 | 23003 | 21189 | -7939 | -7939 | -3383 | -6508 | 1579 | 4038 | 2654 | -125839 |
| | 1.728 | 23150 | 23003 | 21189 | -2687 | -2687 | -470 | -4260 | 1615 | 4356 | 2654 | -125839 |
| Maximum | | 26923 | 25062 | 25026 | 0 | 0 | 0 | 0 | 5873 | 4356 | 2654 | 0 |
| Minimum | | 0 | 0 | 0 | -14027 | -14027 | -4790 | -6508 | 0 | -6126 | -2504 | -125839 |
| I2t (A2-s) | | 1.34E+09 | 1.29E+09 | 1.11E+09 | 1.06E+08 | 1.06E+08 | 1.19E+07 | 5.45E+07 | 1.72E+07 | 4.51E+07 | 9.58E+07 | |
| tESW (s) | | 1.85 | 2.05 | 1.77 | 0.54 | 0.54 | 0.52 | 1.29 | 0.50 | 1.20 | 13.60 | |

| 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 | -22700 | -22700 | -10368 | -12115 | 852 | -610 | -1106 | 0 |
| | 0.100 | 34772 | 35327 | 34508 | -22700 | -22700 | -10368 | -12115 | 852 | -610 | -1106 | 0 |
| | 0.206 | 34200 | 32057 | 32184 | 11354 | 11354 | -11802 | -13936 | 4563 | 5068 | 2191 | -320775 |
| | 0.306 | 34200 | 32057 | 32184 | 14855 | 14855 | -9860 | -12438 | 4587 | 5280 | 2191 | -320775 |
| | 0.506 | 34200 | 32057 | 32184 | 21858 | 21858 | -5975 | -9441 | 4634 | 5705 | 2191 | -320775 |
| Maximum | | 34772 | 35327 | 34508 | 21858 | 21858 | 0 | 0 | 4634 | 5705 | 2191 | 0 |
| Minimum | | 0 | 0 | 0 | -22700 | -22700 | -11802 | -13936 | 0 | -610 | -1106 | -320775 |
| I2t (A2-s) | | 1.27E+09 | 1.19E+09 | 1.15E+09 | 4.16E+08 | 4.02E+08 | 8.83E+07 | 1.43E+08 | 1.28E+07 | 1.34E+07 | 1.48E+08 | |
| tESW (s) | | 1.05 | 0.95 | 0.97 | 0.81 | 0.78 | 0.63 | 0.73 | 0.60 | 0.41 | 30.90 | |

| 0.5T TF | t(s) | M1 | M2 | M3 | PF1 | PF2 | PF3 | PF4 | PF5 | PF6 | TF | Plasma |
|-------------------|--------|----|----|----|-----|-----|-----|-----|-----|-----|----------|--------|
| | -0.800 | | | | | | | | | | 0 | |
| | 0.000 | | | | | | | | | | 16204 | |
| | 0.100 | | | | | | | | | | 16204 | |
| | 0.200 | | | | | | | | | | 16204 | |
| | 0.300 | | | | | | | | | | 16204 | |
| | 0.500 | | | | | | | | | | 16204 | |
| Maximum | | | | | | | | | | | 16204 | |
| Minimum | | | | | | | | | | | 0 | |
| Current direction | | | | | | | | | | | 1.00E+00 | |
| I2t (A2-s) | | | | | | | | | | | 4.30E+08 | |
| tESW (s) | | | | | | | | | | | 1.64 | |

| Ref. Scenario Summary | M1 | M2 | M3 | PF1 | PF2 | PF3 | PF4 | PF5 | PF6 | TF | Plasma |
|-------------------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|---------|
| Maximum | 40908 | 41561 | 40598 | 21858 | 21858 | 5217 | 1584 | 8356 | 7077 | 16204 | 0 |
| Minimum | 0 | 0 | 0 | -25123 | -25123 | -11802 | -13936 | 0 | -8997 | -3548 | -320775 |
| Max I2t (A2-s) | 1.52E+09 | 1.54E+09 | 1.43E+09 | 4.16E+08 | 4.07E+08 | 8.83E+07 | 1.43E+08 | 3.92E+07 | 5.26E+07 | 4.30E+08 | |
| tESW (s) at max current | 0.91 | 0.89 | 0.86 | 0.66 | 0.64 | 0.63 | 0.73 | 0.56 | 0.65 | 1.64 | |

A.3.3 Temperature History

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

A.3.3.1 Temperature History For Initial Operation

| 0.5T First Plasma Scenario | t(s) | M1 | M2 | M3 | PF1 | PF2 | PF3 | PF4 | PF5 | PF6 | TF |
|----------------------------|--------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| | -0.600 | 80 | 80 | 80 | 80 | 80 | 80 | 80 | 0 | 80 | 80 |
| | 0.000 | 81 | 82 | 82 | 80 | 80 | 80 | 80 | 0 | 80 | 80 |
| | 0.100 | 81 | 82 | 82 | 80 | 80 | 80 | 80 | 0 | 80 | 80 |
| | 0.170 | 82 | 82 | 82 | 80 | 80 | 80 | 80 | 0 | 80 | 80 |
| | 0.265 | 82 | 82 | 82 | 80 | 80 | 80 | 80 | 0 | 80 | 80 |
| | 0.270 | 82 | 82 | 82 | 80 | 80 | 80 | 80 | 0 | 80 | 80 |
| | 3.451 | 83 | 83 | 83 | 80 | 80 | 80 | 80 | 0 | 80 | 80 |
| Dissipated Energy (J) | | 1.21E+06 | 1.04E+06 | 8.55E+05 | 2.52E+04 | 3.66E+04 | 3.29E+04 | 1.29E+04 | 0.00E+00 | 1.20E+02 | 1.61E+05 |
| | | | | | | | | | | | 3.37E+06 |

| Field Line Mapping Scenario | t(s) | M1 | M2 | M3 | PF1 | PF2 | PF3 | PF4 | PF5 | PF6 | TF |
|-----------------------------|--------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| | -0.300 | 80 | 80 | 80 | 0 | 0 | 0 | 0 | 0 | 0 | 80 |
| | 0.000 | 80 | 80 | 80 | 0 | 0 | 0 | 0 | 0 | 0 | 80 |
| | 0.100 | 80 | 80 | 80 | 0 | 0 | 0 | 0 | 0 | 0 | 80 |
| | 0.200 | 80 | 80 | 80 | 0 | 0 | 0 | 0 | 0 | 0 | 80 |
| | 2.600 | 80 | 80 | 80 | 0 | 0 | 0 | 0 | 0 | 0 | 80 |
| | 10.100 | 81 | 81 | 81 | 0 | 0 | 0 | 0 | 0 | 0 | 80 |
| | 11.422 | 81 | 81 | 81 | 0 | 0 | 0 | 0 | 0 | 0 | 80 |
| Dissipated Energy (J) | | 3.23E+05 | 3.09E+05 | 2.54E+05 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.76E+03 |
| | | | | | | | | | 0.00E+00 | | 8.88E+05 |

| Summary | | M1 | M2 | M3 | PF1 | PF2 | PF3 | PF4 | PF5 | PF6 | TF |
|---------------------------|--|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| Max Final Temperature | | 83 | 83 | 83 | 80 | 80 | 80 | 80 | 0 | 80 | 80 |
| Max Dissipated Energy (J) | | 1.21E+06 | 1.04E+06 | 8.55E+05 | 2.52E+04 | 3.66E+04 | 3.29E+04 | 1.29E+04 | 0.00E+00 | 1.20E+02 | 1.61E+05 |
| | | | | | | | | | | | 3.37E+06 |

A.3.3.2 Temperature History For Other Scenarios

| 1.7T Ohmic Scenario | t(s) | M1 | M2 | M3 | PF1 | PF2 | PF3 | PF4 | PF5 | PF6 | TF |
|-----------------------|--------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| | -0.700 | 85 | 85 | 85 | 85 | 85 | 85 | 85 | 85 | 85 | 85 |
| | 0.000 | 96 | 95 | 95 | 88 | 88 | 85 | 85 | 85 | 85 | 85 |
| | 0.100 | 100 | 98 | 98 | 89 | 89 | 86 | 85 | 85 | 85 | 85 |
| | 0.140 | 101 | 99 | 99 | 89 | 89 | 86 | 85 | 85 | 85 | 85 |
| | 0.240 | 104 | 102 | 102 | 89 | 89 | 86 | 85 | 85 | 86 | 85 |
| | 0.440 | 110 | 108 | 108 | 90 | 90 | 86 | 85 | 85 | 86 | 85 |
| | 3.621 | 119 | 116 | 115 | 90 | 90 | 86 | 86 | 85 | 86 | 86 |
| Dissipated Energy (J) | | 1.84E+07 | 1.63E+07 | 1.30E+07 | 5.88E+05 | 5.94E+05 | 8.11E+04 | 1.87E+05 | 1.72E+05 | 1.75E+05 | 1.34E+06 |
| | | | | | | | | | | | 5.09E+07 |

| 1.7T High Beta Scenario | t(s) | M1 | M2 | M3 | PF1 | PF2 | PF3 | PF4 | PF5 | PF6 | TF |
|-------------------------|--------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| | -0.700 | 85 | 85 | 85 | 85 | 85 | 85 | 85 | 85 | 85 | 85 |
| | 0.000 | 96 | 95 | 95 | 86 | 86 | 85 | 85 | 85 | 85 | 85 |
| | 0.100 | 100 | 98 | 98 | 86 | 86 | 85 | 85 | 85 | 85 | 85 |
| | 0.140 | 101 | 99 | 99 | 86 | 86 | 85 | 85 | 85 | 85 | 85 |
| | 0.240 | 104 | 102 | 102 | 86 | 86 | 85 | 85 | 85 | 85 | 85 |
| | 0.440 | 110 | 107 | 106 | 86 | 86 | 85 | 85 | 85 | 86 | 85 |
| | 3.621 | 118 | 114 | 112 | 86 | 86 | 85 | 85 | 85 | 86 | 87 |
| Dissipated Energy (J) | | 1.75E+07 | 1.50E+07 | 1.13E+07 | 1.78E+05 | 1.79E+05 | 1.26E+04 | 1.30E+05 | 1.81E+05 | 1.75E+05 | 2.19E+06 |
| | | | | | | | | | | | 4.68E+07 |

| 2T High Beta Scenario | t(s) | M1 | M2 | M3 | PF1 | PF2 | PF3 | PF4 | PF5 | PF6 | TF |
|-----------------------|--------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| | -0.850 | 85 | 85 | 85 | 85 | 85 | 85 | 85 | 85 | 85 | 85 |
| | 0.000 | 103 | 105 | 104 | 86 | 86 | 85 | 85 | 85 | 85 | 85 |
| | 0.050 | 105 | 107 | 106 | 86 | 86 | 85 | 85 | 85 | 85 | 85 |
| | 0.097 | 107 | 109 | 108 | 86 | 86 | 85 | 85 | 85 | 85 | 85 |
| | 0.192 | 111 | 113 | 112 | 87 | 86 | 85 | 85 | 85 | 85 | 85 |
| | 0.197 | 111 | 114 | 112 | 87 | 86 | 85 | 85 | 85 | 85 | 85 |
| | 3.378 | 122 | 123 | 120 | 87 | 87 | 85 | 86 | 85 | 85 | 87 |
| Dissipated Energy (J) | | 2.06E+07 | 2.04E+07 | 1.52E+07 | 2.00E+05 | 1.99E+05 | 2.66E+04 | 2.60E+05 | 1.63E+04 | 3.72E+04 | 3.00E+06 |
| | | | | | | | | | | | 5.99E+07 |

| 1.2T Long Pulse Scenario | t(s) | M1 | M2 | M3 | PF1 | PF2 | PF3 | PF4 | PF5 | PF6 | TF |
|--------------------------|--------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------------------|
| | -0.500 | 85 | 85 | 85 | 85 | 85 | 85 | 85 | 85 | 85 | 85 |
| | 0.000 | 88 | 88 | 88 | 86 | 86 | 85 | 85 | 85 | 85 | 85 |
| | 0.100 | 90 | 89 | 89 | 86 | 86 | 85 | 85 | 85 | 85 | 85 |
| | 0.128 | 90 | 90 | 90 | 86 | 86 | 85 | 85 | 85 | 85 | 85 |
| | 0.228 | 91 | 91 | 91 | 86 | 86 | 85 | 85 | 85 | 85 | 85 |
| | 1.728 | 113 | 112 | 108 | 86 | 86 | 85 | 86 | 85 | 85 | 85 |
| | 4.909 | 117 | 116 | 111 | 86 | 86 | 85 | 86 | 85 | 85 | 86 |
| Dissipated Energy (J) | | 1.73E+07 | 1.60E+07 | 1.09E+07 | 1.48E+05 | 1.48E+05 | 1.63E+04 | 2.04E+05 | 7.95E+04 | 1.52E+05 | 1.12E+06 8.88E+05 |

| 320kA Ohmic Scenario | t(s) | M1 | M2 | M3 | PF1 | PF2 | PF3 | PF4 | PF5 | PF6 | TF |
|-----------------------|--------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------------------|
| | -0.600 | 85 | 85 | 85 | 85 | 85 | 85 | 85 | 85 | 85 | 85 |
| | 0.000 | 92 | 93 | 93 | 87 | 87 | 85 | 85 | 85 | 85 | 85 |
| | 0.100 | 95 | 96 | 95 | 88 | 88 | 86 | 86 | 85 | 85 | 85 |
| | 0.206 | 98 | 98 | 98 | 88 | 88 | 86 | 86 | 85 | 85 | 85 |
| | 0.306 | 101 | 101 | 101 | 88 | 88 | 86 | 86 | 85 | 85 | 85 |
| | 0.506 | 107 | 106 | 106 | 89 | 89 | 86 | 86 | 85 | 85 | 85 |
| | 3.687 | 115 | 113 | 112 | 90 | 90 | 86 | 87 | 85 | 85 | 86 |
| Dissipated Energy (J) | | 1.62E+07 | 1.45E+07 | 1.15E+07 | 6.25E+05 | 6.01E+05 | 1.23E+05 | 5.39E+05 | 6.24E+04 | 4.64E+04 | 1.74E+06 0.00E+00 |

| 0.5T TF | t(s) | M1 | M2 | M3 | PF1 | PF2 | PF3 | PF4 | PF5 | PF6 | TF |
|-----------------------|--------|----|----|----|-----|-----|-----|-----|-----|-----|----------------------|
| | -0.800 | | | | | | | | | | 85 |
| | 0.000 | | | | | | | | | | 86 |
| | 0.100 | | | | | | | | | | 86 |
| | 0.200 | | | | | | | | | | 86 |
| | 0.300 | | | | | | | | | | 86 |
| | 0.500 | | | | | | | | | | 87 |
| | 4.287 | | | | | | | | | | 89 |
| Dissipated Energy (J) | | | | | | | | | | | 5.26E+06 5.26E+06 |

| Summary | | M1 | M2 | M3 | PF1 | PF2 | PF3 | PF4 | PF5 | PF6 | TF |
|---------------------------|--|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------------------|
| Max Final Temperature | | 122 | 123 | 120 | 90 | 90 | 86 | 87 | 85 | 86 | 89 |
| Max Dissipated Energy (J) | | 2.06E+07 | 2.04E+07 | 1.52E+07 | 6.25E+05 | 6.01E+05 | 1.23E+05 | 5.39E+05 | 1.81E+05 | 1.75E+05 | 5.26E+06 5.99E+07 |

A.3.4 Electrical Power Requirements

A.3.4.1 Power Supply and Cabling Requirements and Modeling Assumptions

The facility shall initially be configured to satisfy the First Plasma and Field Line Mapping Scenarios. Existing C-site power supplies shall be used. The mapping of power supplies to coils is shown in the table below. (Ref. 040818_CD4withCsiteSupplies_4_MZ.pdf)

| | | Max current | Max voltage |
|-----------|-----------------------|-------------|-------------|
| M1+M2+M3 | Robicon 20 | 20 kA | 500 V |
| TF | Robicon 5 | 5 kA | 300 V |
| PF1 + PF2 | 2 Robicon-5 in series | 5 kA | 600 V |
| PF3 | Robicon-5 | 5 kA | 300 V |
| PF4 | UCLA | 5 kA | 500 V |
| PF5 | -- | -- | -- |
| PF6 | Robicon-10 | 10 kA | 200 V |

For the remaining reference scenarios, DC power will be brought over from D-site.

Power supply requirements for these 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 cables approximately 750 feet in length (each way). Required DC current ratings and cables per pole in each circuit are defined in the table below. 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 is reduced by 10%.
- [5] Required DC ratings are based on a pulse repetition time of 15 minutes.

| Ultimate capability required | 1.7T Ohmic 1.7T Hi Beta 2T Hi Beta 1.2T Long Pulse 320kA | M1 | M2 | M3 | PF4 | PF6 | TF | PF1/2 | PF3 | PF5U | PF5L | |
|------------------------------|--|-------------------|----------------|----------|----------|---------------|---------------|---------------|----------|----------|----------|-----------|
| | | 139 MW 408 MVA | Max I2t (A2-s) | 1.52E+09 | 1.54E+09 | 1.43E+09 | 1.43E+08 | 5.26E+07 | 4.30E+08 | 4.07E+08 | 8.83E+07 | |
| | tESW (s) | 0.91 | 0.89 | 0.86 | 0.73 | 0.65 | 1.64 | 0.64 | 0.63 | 0.56 | 0.56 | |
| 110 MJ | Required DC rating (A) | 1299 | 1306 | 1259 | 398 | 242 | 691 | 672 | 313 | 209 | 209 | 26 Cables |
| | Cables per pole | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | |
| | Series PSS per branch | 2 | 2 | 2 | 2 | 2 | 4 | 4 | 2 | 2 | 2 | 40 PSS |
| | Branches | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 1 | 1 | 1 | |
| | Branch configuration | Parallel | Parallel | Parallel | | Anti-parallel | Anti-parallel | Anti-parallel | | | | |

A.4 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.

A.4.1 Maximum Temperature and Energy Deposition

| Pulsed heat Loads | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
|--------------------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| Initial Temperature (K) | 85 | 85 | 85 | 85 | 85 | 85 | 85 | 85 | 85 | 85 |
| Max Temperature (K) | 122 | 123 | 120 | 90 | 90 | 86 | 87 | 85 | 86 | 89 |
| Energy Deposited (J) | 2.06E+07 | 2.04E+07 | 1.52E+07 | 6.25E+05 | 6.01E+05 | 1.23E+05 | 5.39E+05 | 1.81E+05 | 1.75E+05 | 5.26E+06 |
| | | | | | | | | | | 5.99E+07 |

A.4.2 LN2 Consumption During Pulsed Operation

| Max 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 | 0.1093654 | 198.3014 | 302.2074662 | 805.735019 | 0.001241103 | 0.375070537 | 375.070537 | 99 per shot |
| Time between shots (minutes) | 15 | | | | | | | | |
| Hours per day | 8 | | | | | | | | |
| Full pwr shots per day | 32 | | | | | | | | 3171 per day |
| Operating days per week | 5 | | | | | | | | 15853 per wk |
| Field Line Mapping LN2 | | | | | | | | | |
| Per shot | | | | 4 | | | | | 1 per shot |
| Time between shots (minutes) | 10 | | | | | | | | |
| Hours per day | 8 | | | | | | | | |
| Full pwr shots per day | 48 | | | | | | | | 70 per day |
| Operating days per week | 5 | | | | | | | | 352 per wk |
| First Plasma LN2 | | | | | | | | | |
| Per shot | | | | 17 | | | | | 6 per shot |
| Time between shots (minutes) | 120 | | | | | | | | |
| Hours per day | 8 | | | | | | | | |
| Full pwr shots per day | 4 | | | | | | | | 22 per day |
| Operating days per week | 5 | | | | | | | | 111 per wk |

A.4.2 LN2 Delivery Requirements

| | Gallons per Truck 6500 | Trucks |
|------------------------|------------------------|---------------|
| Pulsed heat loads only | | |
| Max pulsed heat loads | | 2.44 per week |
| Field line mapping | | 0.05 per week |
| First Plasma | | 0.02 per week |
| Parasitic loads only | | |
| Normal | | 2.12 per week |
| 150C Bakeout | | 2.86 per week |
| 350C Bakeout | | 3.52 per week |
| Cooldown only | | 1.63 |