

## **APPENDIX II**

### **Summary of Stresses for Design Cases for a CANDU 6 Reactor Structure Assembly**

#### **II-1 ALLOWABLE STRESSES**

Material Properties and allowable stresses for the various service conditions are listed in Tables II-1, II-2 and II-3.

#### **II-2 STRESS SUMMARIES**

Summaries of the magnitude and location of maximum stress intensities are given in Tables II-4 to II-16 for the following components, which are divided into several major groups.

##### **II-2.1 CALANDRIA VESSEL - STRESS INTENSITIES - Tables II-4 to II-9**

- a. Calandria main shell
- b. Calandria subshell
- c. Calandria annular plate
- d. Calandria side tubesheets of end shields
- e. Calandria tubes (center location)
- f. Calandria tubes (bottom location)

**II-2.2        END SHIELD - STRESS INTENSITIES - Tables II-10 to II-13**

- a.     Fuelling Machine Tubesheets
- b.     Lattice Tubes (Center Location)
- c.     Lattice Tubes (Bottom Location)
- d.     End Shield Shell

**II-2.3        END SHIELD SUPPORTS - STRESS INTENSITIES - Tables II-14 & II-15**

- a.     Support Shell
- b.     Support Plate

**II-2.4        RCU NOZZLES ON CALANDRIA SHELL - Table II-16**

Table II-1  
Material Properties

| Parameter                                                                                        | Austenitic Stainless Steel <sup>(1)</sup>                                           | Zirconium Alloy Grade R60802 <sup>(2)(3)</sup>                           |                                                                          |                                                                          |                                                                          |
|--------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|--------------------------------------------------------------------------|--------------------------------------------------------------------------|--------------------------------------------------------------------------|--------------------------------------------------------------------------|
|                                                                                                  | Type 304L                                                                           | @68°F<br>20°C                                                            | @200°F<br>93°C                                                           | @225°F<br>107°C                                                          | @260°F<br>127°C                                                          |
| Ultimate Tensile Strength (min)<br>MPa (psi)                                                     | 482.6<br>(70,000)                                                                   | 415<br>(60,190)                                                          | 348.6<br>(50,560)                                                        | 335.3<br>(48,630)                                                        | 315.4<br>(45,740)                                                        |
| Yield Strength (min)<br>S <sub>y</sub> MPa (psi)                                                 | 172.3<br>(25,000)                                                                   | 300<br>(43,510)                                                          | 257.6<br>37,360                                                          | 249.5<br>(36,180)                                                        | 237.9<br>(34,500)                                                        |
| Modulus of Elasticity<br>Transverse, E <sub>T</sub><br>Longitudinal, E <sub>L</sub><br>GPa (psi) | 186.16 at 149°C<br>(27.0 x 10 <sup>6</sup> at 300°F)                                | 98.9<br>(14.34 x 10 <sup>6</sup> )<br>94.8<br>(13.75 x 10 <sup>6</sup> ) | 95.1<br>(13.79 x 10 <sup>6</sup> )<br>89.4<br>(12.97 x 10 <sup>6</sup> ) | 94.3<br>(13.68 x 10 <sup>6</sup> )<br>88.4<br>(12.89 x 10 <sup>6</sup> ) | 89.1<br>(12.92 x 10 <sup>6</sup> )<br>87.4<br>(12.67 x 10 <sup>6</sup> ) |
| Poisson's Ratio:<br>Transverse, ν <sub>T</sub><br>Longitudinal, ν <sub>L</sub>                   | 0.27                                                                                | .345<br>.375                                                             | .345<br>.375                                                             | .345<br>.375                                                             | .346<br>.375                                                             |
| Coefficient of thermal expansion,<br>(m/mC° (in/in°F))                                           | 17.0 x 10 <sup>-6</sup> , 21°C to 149°C<br>(9.0 x 10 <sup>-6</sup> , 70°F to 300°F) | 5.3 x 10 <sup>-6</sup> (2.94 x 10 <sup>-6</sup> )                        | 5.3 x 10 <sup>-6</sup> (2.94 x 10 <sup>-6</sup> )                        | 5.3 x 10 <sup>-6</sup> (2.94 x 10 <sup>-6</sup> )                        | 5.3 x 10 <sup>-6</sup> (2.94 x 10 <sup>-6</sup> )                        |
| Density lb/in <sup>3</sup><br>(kg/m <sup>3</sup> )                                               | 8030<br>(.29)                                                                       | 6550<br>(0.237)                                                          | -                                                                        | -                                                                        | -                                                                        |

- Notes: (1) ASME Code, 1989 Edition with 1989 Addenda, Section III Appendices, Table I-1.2 and Ref. 2  
 (2) CAN/CSA-N285.6 Series 88, Table 7.1, Standard N285.6.7  
 (3) Wolsong 2 Design Specification for Calandria Assembly AECL CANDU, 86-31200-DS-001, Rev. 0.

Table II-2  
Allowable Stress Limits  
(Design, Level 'A' and 'B' Service Conditions)

| Stress Category        | Basic Stress Intensity/Allowable Limits | Austenitic Stainless Steel (Type 304L up to 149°C(300°C)) | Zirconium Alloy Grade R60802 at 100°C (212°F) |
|------------------------|-----------------------------------------|-----------------------------------------------------------|-----------------------------------------------|
| $P_m$                  | $S_m$                                   | 115.14 MPa<br>(16,700 psi)                                | 112 MPa<br>(16,200 psi)                       |
| $P_L$                  | $1.5 S_m$                               | 172.71 MPa<br>(25,050 psi)                                | 168 MPa<br>(24,300 psi)                       |
| $P_m$ or $(P_L) + P_b$ | $1.5 S_m$                               | 172.71 MPa<br>(25,050 psi)                                | 168 MPa<br>(24,300 psi)                       |
| $P_L + P_b + Q$        | $3 S_m$                                 | 343 MPa<br>(50,100 psi)                                   | 335 MPa<br>(48,600 psi)                       |

$P_m$  = General Primary Membrane Stress

$P_L$  = Local Primary Membrane Stress

$P_b$  = Primary Bending Stress

$Q$  = Secondary Stress

$S_m$  = Stress Intensity

Table II-3  
Allowable Stress Intensity Limits  
(Level "C" Service Condition)

| Stress Category | Basic Stress Intensity Limits | Austenitic Stainless Steel (304L) Up to 149°C (300°F) | Zirconium Alloy Grade R60802 at 127°C (260°F) |
|-----------------|-------------------------------|-------------------------------------------------------|-----------------------------------------------|
| $P_m$           | $1.2 S_m$ or $S_y^*$          | 138.17 MPa<br>(20,040 psi)                            | 237.9<br>(34,500 psi)                         |
| $P_L$           | $1.8 S_m$ or $1.5 S_y^*$      | 207.26 MPa<br>(30,060 psi)                            | 356.45 MPa<br>(51,700 psi)                    |
| $P_L + P_b$     | $1.8 S_m$ or $S_y^*$          | 207.26 MPa<br>(30,060 psi)                            | 356.45 MPa<br>(51,700 psi)                    |

Table II-4  
Calandria Main Shell  
Stress Summary

| Loading Condition | Operating Condition and Location | Stress <sup>1</sup> Category | Allowable Stress Intensity MPa (psi) | Maximum Stress Intensity MPa (psi) |
|-------------------|----------------------------------|------------------------------|--------------------------------------|------------------------------------|
| Design Condition  | DC 7558                          | $P_m$                        | 115.14 (16700)                       | 10.8 (1572)                        |
|                   | DC 17532                         | $P_L$                        | 172.71 (25050)                       | 11.6 (1681)                        |
|                   | DC 17326                         | $P_m + P_b$                  | 172.71 (25050)                       | 31.1 (4514)                        |
|                   | DC 6867                          | $P_L + P_b$                  | 172.71 (25050)                       | 28.8 (4184)                        |
|                   |                                  |                              |                                      |                                    |
|                   |                                  |                              |                                      |                                    |
| Service Level A   | LA6 17327                        | $P_m + P_b + Q$              | 345.43 (50100)                       | 86.6 (12565)                       |
|                   | LA6 6868                         | $P_L + P_b + Q$              | 345.43 (50100)                       | 83.9 (12163)                       |
| Service Level B   | LB4 17316                        | $P_m + P_b + Q$              | 345.43 (50100)                       | 85.8 (12443)                       |
|                   | LB4 6929                         | $P_L + P_b + Q$              | 345.43 (50100)                       | 83.7 (12136)                       |
| Service Level C   | LC3 7904                         | $P_m$                        | 138.17 (20040)                       | 101.9 (14784)                      |
|                   | LC3 6969                         | $P_L$                        | 207.26 (30060)                       | 179.0 (25960)                      |
|                   | LC3 7899                         | $P_m + P_b$                  | 207.26 (30060)                       | 179.8 (26079)                      |
| Test Conditions   | TC1 7966                         | $P_m$                        | 115.14 (16700)                       | 43.1 (6244)                        |
|                   | TC1 6928                         | $P_L$                        | 172.71 (25050)                       | 48.0 (6966)                        |
|                   | TC2 7966                         | $P_m + P_b$                  | 172.71 (25050)                       | 55.8 (8097)                        |
|                   | TC2 6932                         | $P_L + P_b$                  | 172.71 (25050)                       | 60.6 (8788)                        |

Table II-5  
Calandria Subshell  
Stress Summary

| Loading Condition | Operating Condition and Location | Stress Category | Allowable Stress Intensity MPa (psi) | Maximum Stress Intensity MPa (psi) |
|-------------------|----------------------------------|-----------------|--------------------------------------|------------------------------------|
| Design Condition  | DC 16250                         | $P_m$           | 115.14 (16700)                       | 9.5 (1385)                         |
|                   | DC 16248                         | $P_L$           | 172.71 (25050)                       | 9.6 (1390)                         |
|                   | DC 16325                         | $P_m + P_b$     | 172.71 (25050)                       | 10.4 (1562)                        |
|                   | DC 16034                         | $P_L + P_b$     | 172.71 (25050)                       | 14.4 (2093)                        |
| Service Level A   | LA1 16258                        | $P_m + P_b + Q$ | 345.43 (50100)                       | 115.1 (16700)                      |
|                   | LA1 16235                        | $P_L + P_b + Q$ | 345.43 (50100)                       | 117.8 (17091)                      |
| Service Level B   | LB4 16258                        | $P_m + P_b + Q$ | 345.43 (50100)                       | 163.8 (23752)                      |
|                   | LB4 16235                        | $P_L + P_b + Q$ | 345.43 (50100)                       | 166.5 (24143)                      |
| Service Level C   | LC3 16256                        | $P_m$           | 138.17 (20040)                       | 57.1 (8277)                        |
|                   | LC3 16247                        | $P_L$           | 207.26 (30060)                       | 127.4 (18479)                      |
|                   | LC3 16242                        | $P_m + P_b$     | 207.26 (30060)                       | 66.7 (9671)                        |
| Test Conditions   | TC1 16262                        | $P_m$           | 115.14 (16700)                       | 29.7 (4305)                        |
|                   | TC1 16348                        | $P_L$           | 172.71 (25050)                       | 29.8 (4329)                        |
|                   | TC1 16210                        | $P_m + P_b$     | 172.71 (25050)                       | 38.5 (5580)                        |
|                   | TC1 16142                        | $P_L + P_b$     | 172.71 (25050)                       | 38.9 (5637)                        |

Table II-6  
Calandria Annular Plate  
Stress Summary

| Loading Condition | Operating Condition and Location |       | Stress Category | Allowable Stress Intensity<br>MPa (psi) | Maximum Stress Intensity<br>MPa (psi) |
|-------------------|----------------------------------|-------|-----------------|-----------------------------------------|---------------------------------------|
| Design Condition  | DC                               | 16656 | $P_m$           | 115.14 (16700)                          | 14.6 (2122)                           |
|                   | DC                               | 6756  | $P_L$           | 172.71 (25050)                          | 14.8 (2145)                           |
|                   | DC                               | 16702 | $P_m + P_b$     | 172.71 (25050)                          | 15.8 (2285)                           |
|                   | DC                               | 16434 | $P_L + P_b$     | 172.71 (25050)                          | 44.6 (6461)                           |
| Service Level A   | LA1                              | 16652 | $P_m + P_b + Q$ | 345.43 (50100)                          | 136.2 (19750)                         |
|                   | LA6                              | 16434 | $P_L + P_b + Q$ | 345.43 (50100)                          | 166.1 (24095)                         |
| Service Level B   | LB1                              | 16652 | $P_m + P_b + Q$ | 345.43 (50100)                          | 140.8 (20417)                         |
|                   | LB1                              | 16434 | $P_L + P_b + Q$ | 345.43 (50100)                          | 160.5 (23284)                         |
| Service Level C   | LC3                              | 16652 | $P_m$           | 138.17 (20040)                          | 66.8 (9690)                           |
|                   | LC3                              | 16646 | $P_L$           | 207.26 (30060)                          | 170.7 (24754)                         |
|                   | LC3                              | 16652 | $P_m + P_b$     | 207.26 (30060)                          | 85.5 (11968)                          |
| Test Conditions   | TC1                              | 16693 | $P_m$           | 115.14 (16700)                          | 27.6 (4006)                           |
|                   | TC1                              | 16739 | $P_L$           | 172.71 (25050)                          | 28.5 (4138)                           |
|                   | TC1                              | 16693 | $P_m + P_b$     | 172.71 (25050)                          | 46.5 (6740)                           |
|                   | TC1                              | 16542 | $P_L + P_b$     | 172.71 (25050)                          | 82.8 (12015)                          |

Table II-7  
Calandria Tubesheet  
Stress Summary

| Loading Condition | Operating Condition and Location |       | Stress Category | Allowable Stress Intensity<br>MPa (psi) | Maximum Stress Intensity<br>MPa (psi) |
|-------------------|----------------------------------|-------|-----------------|-----------------------------------------|---------------------------------------|
| Design Condition  | DC                               | 13764 | $P_m$           | 115.14 (16700)                          | 21.2 (3079)                           |
|                   | DC                               | 13775 | $P_L$           | 172.71 (25050)                          | 21.1 (3060)                           |
|                   | DC                               | 13469 | $P_m + P_b$     | 172.71 (25050)                          | 43.4 (6289)                           |
|                   | DC                               | 13470 | $P_L + P_b$     | 172.71 (25050)                          | 50.8 (7371)                           |
| Service Level A   | LA3                              | 11496 | $P_m + P_b + Q$ | 345.43 (50100)                          | 217.4 (31527)                         |
|                   | LA1                              | 13470 | $P_L + P_b + Q$ | 345.43 (50100)                          | 223.5 (32419)                         |
| Service Level B   | LB4                              | 11496 | $P_m + P_b + Q$ | 345.43 (50100)                          | 241.6 (35047)                         |
|                   | LB4                              | 13470 | $P_L + P_b + Q$ | 345.43 (50100)                          | 265.0 (38440)                         |
| Service Level C   | LC3                              | 11515 | $P_m$           | 138.17 (20040)                          | 118.7 (17220)                         |
|                   | LC3                              | 13773 | $P_L$           | 207.26 (30060)                          | 136.5 (19795)                         |
|                   | LC3                              | 11496 | $P_m + P_b$     | 207.26 (30060)                          | 182.7 (26493)                         |
| Test Conditions   | TC1                              | 13426 | $P_m$           | 115.14 (16700)                          | 21.3 (3088)                           |
|                   | TC1                              | 13405 | $P_L$           | 172.71 (25050)                          | 21.1 (3062)                           |
|                   | TC2                              | 13469 | $P_m + P_b$     | 172.71 (25050)                          | 45.2 (6550)                           |
|                   | TC2                              | 13470 | $P_L + P_b$     | 172.71 (25050)                          | 52.8 (7651)                           |

\* The maximum stress intensities reported in this table envelopes the maximum stresses in local lattice pitch model at centre and bottom locations.

Table II-8  
Calandria Tube (Center Location)  
Stress Summary

| Loading Condition | Operating Condition and Location |       | Stress Category | Allowable Stress Intensity<br>MPa (psi) | Maximum Stress Intensity<br>MPa (psi) |
|-------------------|----------------------------------|-------|-----------------|-----------------------------------------|---------------------------------------|
| Design Condition  | DC                               | 10486 | $P_m$           | 111.70 (16200)                          | 109.0 (15811)                         |
|                   | DC                               | 10402 | $P_L$           | 167.54 (24300)                          | 104.8 (15198)                         |
|                   | DC                               | 10486 | $P_m + P_b$     | 167.54 (24300)                          | 145.5 (21109)                         |
| Service Level A   | LA6                              | 10486 | $P_m + P_b + Q$ | 335.09 (48600)                          | 146.1 (21189)                         |
|                   | LA6                              | 10411 | $P_L + P_b + Q$ | 335.09 (48600)                          | 146.3 (21226)                         |
| Service Level B   | LB1                              | 10486 | $P_m + P_b + Q$ | 335.09 (48600)                          | 156.5 (22705)                         |
|                   | LB1                              | 10411 | $P_L + P_b + Q$ | 335.09 (48600)                          | 157.1 (22780)                         |
| Service Level C   | LC1                              | 10486 | $P_m$           | 237.87 (34500)                          | 159.7 (23166)                         |
|                   | LC1                              | 10411 | $P_L$           | 356.46 (51700)                          | 135.7 (19675)                         |
|                   | LC1                              | 11095 | $P_m + P_b$     | 356.46 (51700)                          | 243.6 (35330)                         |
| Test Conditions   | TC1                              | 11679 | $P_m$           | 111.70 (16200)                          | 38.9 (5643)                           |
|                   | TC1                              | 11015 | $P_L$           | 167.54 (24300)                          | 34.9 (5060)                           |
|                   | TC1                              | 10919 | $P_m + P_b$     | 167.54 (24300)                          | 113.3 (18295)                         |

Table II-9  
Calandria Tube (Bottom Location)  
Stress Summary

| Loading Condition | Operating Condition and Location |       | Stress Category | Allowable Stress Intensity<br>MPa (psi) | Maximum Stress Intensity<br>MPa (psi) |
|-------------------|----------------------------------|-------|-----------------|-----------------------------------------|---------------------------------------|
| Design Condition  | DC                               | 11841 | $P_m$           | 111.70 (16200)                          | 110.3 (15999)                         |
|                   | DC                               | 11780 | $P_L$           | 167.54 (24300)                          | 115.3 (16717)                         |
|                   | DC                               | 11841 | $P_m + P_b$     | 167.54 (24300)                          | 146.3 (21216)                         |
| Service Level A   | LA6                              | 11846 | $P_m + P_b + Q$ | 335.09 (48600)                          | 147.8 (21441)                         |
|                   | LA6                              | 11858 | $P_L + P_b + Q$ | 335.09 (48600)                          | 151.0 (21914)                         |
| Service Level B   | LB1                              | 11846 | $P_m + P_b + Q$ | 335.09 (48600)                          | 154.6 (22427)                         |
|                   | LB1                              | 11862 | $P_L + P_b + Q$ | 335.09 (48600)                          | 160.2 (23230)                         |
| Service Level C   | LC1                              | 11862 | $P_m$           | 237.87 (34500)                          | 171.4 (24861)                         |
|                   | LC1                              | 11780 | $P_L$           | 356.46 (51700)                          | 178.3 (25865)                         |
|                   | LC1                              | 10919 | $P_m + P_b$     | 356.46 (51700)                          | 271.3 (39344)                         |
| Test Conditions   | TC1                              | 11679 | $P_m$           | 111.70 (16200)                          | 40.6 (5893)                           |
|                   | TC1                              | 11783 | $P_L$           | 167.54 (24300)                          | 40.4 (5861)                           |
|                   | TC1                              | 10919 | $P_m + P_b$     | 167.54 (24300)                          | 126.7 (18386)                         |

Table II-10  
Fuelling Tubesheet  
Stress Summary

| Loading Condition | Operating Condition and Location | Stress Category | Allowable Stress Intensity MPa (psi) | Maximum Stress Intensity MPa (psi) |
|-------------------|----------------------------------|-----------------|--------------------------------------|------------------------------------|
| Design Condition  | DC 14165                         | $P_m$           | 115.14                               | 19.0 (2754)                        |
|                   | DC 14170                         | $P_L$           | (16700)                              | 18.4 (2672)                        |
|                   | DC 4379                          | $P_m + P_b$     | 172.71 (25050)                       | 27.4 (3969)                        |
|                   | DC 14036                         | $P_L + P_b$     | 172.71 (25050)                       | 47.3 (6863)                        |
|                   |                                  |                 | 172.71 (25050)                       |                                    |
| Service Level A   | LA1 4384                         | $P_m + P_b + Q$ | 345.43 (50100)                       | 152.2 (22080)                      |
|                   | LA1 14036                        | $P_L + P_b + Q$ | 345.43 (50100)                       | 149.8 (21731)                      |
| Service Level B   | LB4 4384                         | $P_m + P_b + Q$ | 345.43 (50100)                       | 170.5 (24723)                      |
|                   | LB4 14036                        | $P_L + P_b + Q$ | 345.43 (50100)                       | 168.1 (24374)                      |
| Service Level C   | LC3 13135                        | $P_m$           | 138.17                               | 125.1 (18148)                      |
|                   | LC3 14170                        | $P_L$           | (20040)                              | 193.2 (28028)                      |
|                   | LC3 4384                         | $P_m + P_b$     | 207.26 (30060)                       | 154.8 (22453)                      |
|                   |                                  |                 | 207.26 (30060)                       |                                    |
| Test Conditions   | TC1 14361                        | $P_m$           | 115.14                               | 19.7 (2856)                        |
|                   | TC1 14373                        | $P_L$           | (16700)                              | 19.4 (2821)                        |
|                   | TC2 4379                         | $P_m + P_b$     | 172.71 (25050)                       | 48.9 (7086)                        |
|                   | TC2 14067                        | $P_L + P_b$     | 172.71 (25050)                       | 50.3 (7301)                        |
|                   |                                  |                 | 172.71 (25050)                       |                                    |

\* The maximum stress intensities reported in this table envelopes the maximum stresses in local lattice pitch model at centre and bottom locations.

Table II-11  
Lattice Tube (Centre Location)  
Stress Summary

| Loading Condition | Operating Condition and Location | Stress Category | Allowable Stress Intensity MPa (psi) | Maximum Stress Intensity MPa (psi) |
|-------------------|----------------------------------|-----------------|--------------------------------------|------------------------------------|
| Design Condition  | DC 12031                         | $P_m$           | 115.14                               | 271.2 (10331)                      |
|                   | DC 12308                         | $P_L$           | (16700)                              | 103.3 (14977)                      |
|                   | DC 12031                         | $P_m + P_b$     | 172.71 (25050)                       | 282.7 (11988)                      |
|                   | DC 12308                         | $P_L + P_b$     | 172.71 (25050)                       | 111.0 (16095)                      |
|                   |                                  |                 | 172.71 (25050)                       |                                    |
| Service Level A   | LA6 12339                        | $P_m + P_b + Q$ | 345.43 (50100)                       | 118.3 (17155)                      |
|                   | LA1 12308                        | $P_L + P_b + Q$ | 345.43 (50100)                       | 111.6 (16190)                      |
| Service Level B   | LB4 12031                        | $P_m + P_b + Q$ | 345.43 (50100)                       | 123.6 (18404)                      |
|                   | LB4 12306                        | $P_L + P_b + Q$ | 345.43 (50100)                       | 118.0 (19836)                      |
| Service Level C   | LC3 12326                        | $P_m$           | 138.17                               | 102.8 (14905)                      |
|                   | LC3 12316                        | $P_L$           | (20040)                              | 298.9 (14353)                      |
|                   | LC3 12339                        | $P_m + P_b$     | 207.61 (30060)                       | 136.3 (19762)                      |
|                   |                                  |                 | 207.61 (30060)                       |                                    |
| Test Conditions   | TC2 12470                        | $P_m$           | 115.14                               | 13.4 (1944)                        |
|                   | TC2 12185                        | $P_L$           | (16700)                              | 12.7 (1845)                        |
|                   | TC2 12347                        | $P_m + P_b$     | 172.71 (25050)                       | 18.0 (2615)                        |
|                   | TC2 12178                        | $P_L + P_b$     | 172.71 (25050)                       | 17.3 (2509)                        |
|                   |                                  |                 | 172.71 (25050)                       |                                    |

Table II-12  
Lattice Tube (Bottom Location)  
Stress Summary

| Loading Condition | Operating Condition and Location |       | Stress Category | Allowable Stress Intensity<br>MPa (psi) | Maximum Stress Intensity<br>MPa (psi) |
|-------------------|----------------------------------|-------|-----------------|-----------------------------------------|---------------------------------------|
| Design Condition  | DC                               | 12326 | $P_m$           | 115.14 (16700)                          | 85.2 (12345)                          |
|                   | DC                               | 12308 | $P_L$           | 172.71 (25050)                          | 76.7 (11122)                          |
|                   | DC                               | 12326 | $P_m + P_b$     | 172.71 (25050)                          | 105.1 (15246)                         |
|                   | DC                               | 12306 | $P_L + P_b$     | 172.71 (25050)                          | 86.8 (12590)                          |
| Service Level A   | LA1                              | 12326 | $P_m + P_b + Q$ | 345.43 (50100)                          | 126.7 (18373)                         |
|                   | LA1                              | 12306 | $P_L + P_b + Q$ | 345.43 (50100)                          | 147.5 (21391)                         |
| Service Level B   | LB4                              | 12025 | $P_m + P_b + Q$ | 345.43 (50100)                          | 145.8 (21143)                         |
|                   | LB4                              | 12306 | $P_L + P_b + Q$ | 345.43 (50100)                          | 174.1 (25237)                         |
| Service Level C   | LC3                              | 12326 | $P_m$           | 138.17 (20040)                          | 127.4 (18481)                         |
|                   | LC3                              | 12308 | $P_L$           | 207.61 (30060)                          | 115.6 (16759)                         |
|                   | LC3                              | 12326 | $P_m + P_b$     | 207.61 (30060)                          | 156.3 (22665)                         |
| Test Conditions   | TC2                              | 12466 | $P_m$           | 115.14 (16700)                          | 55.3 (8016)                           |
|                   | TC2                              | 12491 | $P_L$           | 172.71 (25050)                          | 57.2 (8302)                           |
|                   | TC2                              | 12466 | $P_m + P_b$     | 172.71 (25050)                          | 58.3 (8462)                           |
|                   | TC2                              | 12482 | $P_L + P_b$     | 172.71 (25050)                          | 63.9 (9275)                           |

Table II-13  
End Shield Shell  
Stress Summary

| Loading Condition | Operating Condition and Location | Stress Category | Allowable Stress Intensity MPa (psi) | Maximum Stress Intensity MPa (psi)         |
|-------------------|----------------------------------|-----------------|--------------------------------------|--------------------------------------------|
| Design Condition  | DC 14616                         | $P_m$           | 115.14 (16700)                       | 32.2                                       |
|                   | DC 14619                         | $P_L$           | 172.71 (25050)                       | (4666)                                     |
|                   | DC 14603                         | $P_m + P_b$     | 172.71 (25050)                       | 18.6                                       |
|                   | DC 14637                         | $P_L + P_b$     | 172.71 (25050)                       | (2698)<br>52.6<br>(7631)<br>31.3<br>(4537) |
| Service Level A   | LA1 14603                        | $P_m + P_b + Q$ | 345.43 (50100)                       | 177.0 (25674)                              |
|                   | LA1 14605                        | $P_L + P_b + Q$ | 345.43 (50100)                       | 153.7 (22287)                              |
| Service Level B   | LB4 14616                        | $P_m + P_b + Q$ | 345.43 (50100)                       | 208.7 (30275)                              |
|                   | LB4 14605                        | $P_L + P_b + Q$ | 345.43 (50100)                       | 185.4 (26888)                              |
| Service Level C   | LC3 14616                        | $P_m$           | 138.17 (20040)                       | 78.6 (11395)                               |
|                   | LC3 14619                        | $P_L$           | 207.61 (30060)                       | 143.6 (20824)                              |
|                   | LC3 14603                        | $P_m + P_b$     | 207.61 (30060)                       | 103.2 (14973)                              |
| Test Conditions   | TC2 14613                        | $P_m$           | 115.14 (16700)                       | 28.0                                       |
|                   | TC2 14619                        | $P_L$           | 172.71 (25050)                       | (4057)                                     |
|                   | TC2 14603                        | $P_m + P_b$     | 172.71 (25050)                       | 17.5                                       |
|                   | TC2 14637                        | $P_L + P_b$     | 172.71 (25050)                       | (2533)<br>46.8<br>(6785)<br>30.6<br>(4440) |

Table II-14  
Support Shell  
Stress Summary

| Loading Condition             | Operating Condition and Location | Stress Category | Allowable Stress Intensity MPa (psi) | Maximum Stress Intensity MPa (psi) |
|-------------------------------|----------------------------------|-----------------|--------------------------------------|------------------------------------|
| Design Condition <sup>5</sup> | DC 15050                         | $P_m$           | 115.14 (16700)                       | 20.5 (2969)                        |
|                               | DC 15050                         | $P_m + P_b$     | 172.71 (25050)                       | 33.2 (4812)                        |
| Service Level A               | LA6 5225                         | $P_m + P_b + Q$ | 345.43 (50100)*                      | 163.5 (23721)                      |
| Service Level B               | LB3 5225                         | $P_m + P_b + Q$ | 345.43 (50100)*                      | 168.2 (24390)                      |
| Service Level C               | LC3 5225                         | $P_m$           | 172.71 (25050)                       | 140.7 (20403)                      |
|                               | LC3 5225                         | $P_m + P_b$     | 259.07 (37575)**                     | 210.4 (30516)                      |
| Test Conditions               | TC2 15050                        | $P_m$           | 153.14 (22211)                       | 21.1 (3060)                        |
|                               | TC2 15051                        | $P_m + P_b$     | 229.71 (33317)                       | 39.7 (5762)                        |

Calculated stresses are envelope of all primary loads.

\* Minimum of  $2 S_Y$  or  $S_U$  at temperature, see Table NF-3522 (b) -1, Note 5

\*\* Maximum local stress intensity is limited to  $3 S_m$  (50100 psi)

Table II-15  
Support Plate  
Stress Summary

| Loading Condition    | Operating Condition and Location | Stress Category      | Allowable Stress Intensity MPa (psi) | Maximum Stress Intensity MPa (psi) |
|----------------------|----------------------------------|----------------------|--------------------------------------|------------------------------------|
| Design Condition (4) | DC 15864<br>DC 15505             | $P_m$<br>$P_m + P_b$ | 115.14 (16700)<br>172.71 (25050)     | 13.2 (1918)<br>21.00 (3049)        |
| Service Level A      | LA5 15505                        | $P_m + P_b + Q$      | 345.43 (50100)                       | 206.6 (29948)                      |
| Service Level B      | LB2 15505                        | $P_m + P_b + Q$      | 345.43 (50100)                       | 206.5 (29952)                      |
| Service Level C      | LC3 15881<br>LC3 15612           | $P_m$<br>$P_m + P_b$ | 172.71 (25050)<br>259.07 (37575)     | 101.5 (14727)<br>148.1 (21486)     |
| Test Conditions      | TC1 15863<br>TC2 15505           | $P_m$<br>$P_m + P_b$ | 153.14 (22211)<br>229.71 (33317)     | 16.5 (2397)<br>38.1 (5531)         |

Calculated stresses are envelope of all primary loads.

\* Minimum of  $2 S_Y$  or  $S_U$  at temperature, see Table NF-3522 (b) -1, Note 5

\*\* Maximum local stress intensity is limited to  $3 S_m$  (50100 psi)

Table II-16  
Nozzle Stresses

| Stress <sup>1</sup><br>Category                | Allowable Stress<br>MPa (psi) | Nozzles                      |                                        |                                        |
|------------------------------------------------|-------------------------------|------------------------------|----------------------------------------|----------------------------------------|
|                                                |                               | Adjuster Nozzle<br>MPa (psi) | Pressure Relief<br>Nozzle<br>MPa (psi) | Moderator Inlet<br>Nozzle<br>MPa (psi) |
| $P_m$ <sup>2</sup><br>(Level C)                | $1.2 S_m = 138.17$<br>(20040) | 14.73<br>(2136)              | 28.2<br>(4085)                         | 88.8<br>(12877)                        |
| $P_m + P_b$ <sup>2</sup><br>(Level C)          | $1.8 S_m = 207.61$<br>(30060) | 39.9<br>(5786)               | 132.6<br>(19231)                       | 195.3<br>(28323)                       |
| $P_m + P_b + Q$ <sup>3</sup><br>Levels A and B | $3 S_m = 345.43$<br>(50100)   | (14.1)<br>(2044)             | 44.4<br>(6433)                         | 320.6<br>(46,495)                      |

$P_m$  = Primary membrane stress intensity

$P_b$  = Primary bending stress intensity

$Q$  = Secondary stress intensity (include local stress)

1 Local primary membrane stress intensity ( $P_L$ ) conservatively taken as  $P_m$

2  $P_m$  and  $P_m + P_b$  include DBE nozzle loads for level C

3  $P_m + P_b + Q$  does not include DBE loads (envelope Levels A and B)