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U.S. Nuclear Regulatory Commission
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Subject: **Response to Portion of NRC Request for Additional Information Letter No. 237 Related to the ESBWR Design Certification – Containment Systems – RAI Number 6.2-180 S01**

The purpose of this letter is to submit the GE Hitachi Nuclear Energy (GEH) response to the U.S. Nuclear Regulatory Commission (NRC) Request for Additional Information (RAI) sent by NRC letter No. 237 (Reference 1). GEH response to RAI Number 6.2-180 S01 is addressed in Enclosure 1. DCD markups associated with this response are provided in Enclosure 2. Please note that GEH's preliminary response teleconference with the Staff on May 7, 2009 resulted in the following additional items to be addressed in this response:

1. The RAI response was not clear about the uniformity of temperature across the liner thickness in the DW evaluation.
2. The 1.58 bottom plate stress margin in the WW airspace evaluation is not consistent with DCD Tier 2, Table 3G.1-37.
3. It is not clear to the Staff why the ascending trend of TRACG temps does not extend beyond 72 hours.
4. A quantitative evaluation of the thermal growth effect of the structure needs to be added.

Please note that GEH has addressed items 1 through 3 above in this response. GEH will submit a revised response to this RAI when the results for item 4 become available.

If you have any questions or require additional information, please contact me.

Sincerely,

Richard E. Kingston
Vice President, ESBWR Licensing

Reference:

1. MFN 08-626, Letter from U.S. Nuclear Regulatory Commission to Robert E. Brown, GEH, *Request For Additional Information Letter No. 237 Related To ESBWR Design Certification Application*, dated August 5, 2008

Enclosures:

1. Response to Portion of NRC Request for Additional Information Letter No. 237 Related to ESBWR Design Certification Application – Containment Systems – RAI Number 6.2-180 S01
2. Response to Portion of NRC Request for Additional Information Letter No. 237 Related to ESBWR Design Certification Application – Containment Systems – RAI Number 6.2-180 S01 – DCD Markups

cc:	AE Cubbage	USNRC (with enclosures)
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Enclosure 1

MFN 08-341 Supplement 1

Response to Portion of NRC Request for Additional Information Letter No. 237 Related to ESBWR Design Certification Application[1]

Containment Systems

RAI Number 6.2-180 S01

[1] The original response previously submitted under MFN 08-341 is included (without DCD updates) to provide historical continuity during review.

NRC RAI 6.2-180

DCD, Tier 2, Revision 3, Section 6.2.1.1.2 states that "[f]or a postulated DBA, the calculated maximum DW temperature and absolute pressure remain below their design values, shown in Table 6.2-1." However, DCD Table 6.2-5 shows that the "short-term" drywell temperature exceeding the design value for the following accidents: (1) main steam line break and bottom head drain line based on standard TRACG evaluation model and (2) feedwater line break for based on both standard TRACG evaluation model and bounding values model. This table also shows that the short-term peak drywell temperature predicted for the main steam line break based on the standard TRACG evaluation model (174.7°C (346.8°F)) is more limiting than that based on the bounding values model (170.8°C (339.6°F)).

A. *Please correct or explain this apparent discrepancy in the DCD. Also, please explain why it is acceptable for the drywell temperature to exceed its design value.*

B. *Please explain why the short-term peak drywell temperature for the main steam line break predicted by the standard TRACG evaluation model is more limiting than that based on the bounding values model.*

GEH Response

A. The temperatures shown on DCD Tier 2, Revision 3, Table 6.2-5 represent the temperature at a single location in the TRACG evaluation. The selected location is not representative of the bulk drywell temperature used in the structural analysis. As a result, local temperatures near the break location can exceed the bulk design temperature used to determine the global structural response. DCD Tier 2, Subsection 6.2.1.1.2 will be revised to state that the bulk temperature remains below the design value. DCD Tier 2, Table 6.2-5 and Table 3H-8 values will be replaced with the bulk temperature rather than those of a single location, because this represents the temperature that is used in the structural analysis.

   For some cases, at about 1000 seconds into the transient, the drywell bulk temperature is much lower than the peak design temperature but slightly higher than the temperature transient profile considered in the structural analysis. The higher temperatures last for no more than 800 seconds. No impact on structural design is expected, and the effect on the structural analysis documented in DCD Tier 2, Appendix 3G will be taken into account in the detailed design stage.

B. The bounding main steam line break analysis is that which produces the greatest pressure within the containment, not necessarily the highest temperature. In the ESBWR, the peak containment pressure is obtained after several hours, but the peak containment temperature occurs within the first 5 seconds due to heating from the steam discharge. The initial conditions leading to the higher long-term containment pressure increase result in lower initial flow out the break, and thus lower initial increase in containment pressure and temperature.

DCD Impact

Markups of DCD Tier 2, Appendix 3G; Table 3H-8; Subsection 6.2.1.1.2; Figures 6.2-9b1, 6.2-9b2, 6.2-9b3, 6.2-10b1, 6.2-10b2, 6.2-10b3, 6.2-11b1, 6.2-11b2, 6.2-11b3, 6.2-12b1, 6.2-12b2, 6.2-12b3, 6.2-13b1, 6.2-13b2, 6.2-13b3, 6.2-14b1, 6.2-14b2, and 6.2-14b3; and Appendix 6E were provided in MFN 08-341, which was transmitted to the NRC on April 25, 2008.

NRC RAI 6.2-180, Supplement 1

In the response to RAI 6.2-180, GEH stated that for some cases into the transient the drywell bulk temperature is slightly higher than the temperature transient profile considered in the structural analysis. GEH also stated that no impact on structural design is expected, and the effect on structural analysis documented in DCD Tier 2, Appendix 3G, will be taken into account in the detailed design stage. A quantitative evaluation should be performed by GEH as a basis for concluding that the use of a higher thermal transient profile will not impact the structural design. Also, the affected results in DCD Tier 2, Appendix 3G should be annotated to reflect that these results are not based on the latest thermal transient profile identified in the DCD, and that a quantitative evaluation has been performed to conclude that final analysis results will not impact the structural design.

GEH Response

A quantitative evaluation is performed to demonstrate that the thermal transient profiles calculated by TRACG do not invalidate the structural design analysis using the thermal loads presented in DCD Tier 2 Subsection 3G.1.5.2.1.6. The following six break cases in the event of a LOCA are examined:

MSLA:	Main Steamline Break inside Containment – nominal
MSLCB:	Main Steamline Break inside Containment – containment bounding
FWLA:	Feedwater Line Break – nominal
FWLCB:	Feedwater Line Break – containment bounding
GDL:	GDCS Injection Line – nominal
BDL:	Bottom Drain Line – nominal

The TRACG calculated bulk temperature curves (including consideration of uncertainties) of these break cases are bounded by the design temperature curves considered in the structural analysis at all locations except for the drywell (DW), wetwell (WW) airspace and RB upper pools. Evaluation details of the DW and WW where the design temperature is not bounding are presented below.

1. Drywell

The TRACG temperature curves in the DW are compared with the design temperature curve (labeled ENV) in Figures 6.2-180(1) through 6.2-180(3) for short-term, medium-term and long-term break cases, respectively. It is observed that the MSLA and MSLCB cases result in the highest temperature in the short term ($t < 0.1$ hr); the FWLA and FWLCB cases result in the highest temperature in the medium term ($0.3 < t < 0.5$ hr); and the BDL case results in the highest temperature in the long term ($t > 0.5$ hr). The GDL case is not bounding over any time interval for the DW.

The MSLA case is the most critical because it has the highest temperature at 193°C (379°F) as compared to the 171°C (340°F) peak design temperature. However, this exceedance occurs very early in the transient and is very short in duration. It should be noted that the TRACG results are bulk fluid temperatures. The actual temperatures in the structures are lower than the fluid temperatures due to heat transfer effects at the surface. The beneficial effects of reduced surface heat transfer are ignored in the structural design analysis in which the design temperature curve was directly applied to the structure assuming an infinite value for the heat transfer coefficient.

To show that the actual structural temperature is lower than the fluid temperature, a transient 1-D heat transfer analysis is performed for the DW liner (6.4 mm (0.25 in) thick) with the inside liner face subjected to the bulk fluid temperature and the outside liner face (which is at the liner-concrete interface) perfectly insulated for the MSLA transient up to 0.1 hr. A conservative heat transfer coefficient derived from TRACG results is applied at the inside liner face. The results of this heat transfer analysis show that the maximum temperature uniformly across the liner thickness and at the concrete surface is 167°C (333°F), which is less than the 171°C (340°F) peak temperature used in the structural design. The 167°C (333°F) temperature at the concrete surface is also within the 177°C (350°F) limit stipulated in ASME Code Section III, Division 2, Subarticle CC-3440 for an accident or any other short-term period.

Besides the containment liner, there are other steel structures subjected to the DW temperature. They consist of containment metal components not backed by concrete (such as the DW head) and containment internal steel structures (such as the diaphragm floor (D/F), vent wall (VW), GDCS pool wall and reactor shield wall). Since these steel structures are thicker than the liner plate and one face of the liner plate is conservatively assumed to be fully insulated in the heat transfer analysis described above, the calculated 167°C (333°F) maximum temperature is also applicable to all steel structures for which the design temperature is higher at 171°C (340°F). It should be noted that the design stress analyses performed for the D/F and VW ignores the infill concrete; the steel plates on the DW side are designed to 171°C (340°F) peak design temperature and the steel plates on the WW airspace side are designed to 130°C (266°F) peak design temperature. The WW temperature is discussed separately below.

As opposed to steel structures, concrete structures react to temperature loading very slowly. The more important consideration is how much heat is penetrating into the concrete as the accident progresses. The integrated TRACG curves versus the integrated design temperature curve over the 72-hr duration are shown in Figures 6.2-180(4) through 6.2-180(6) for short-term, medium-term and long-term break cases, respectively. The accumulated heat input at 72 hours, which is the most critical timing for concrete response when the thermal gradient across the thickness is largest, is less than that of the design temperature curve for all breaks. At the very early stage of the transient up to about 0.6 hr, however, some breaks result in higher accumulated heat input but they are inconsequential to structural design since the duration is too short for heat penetrating into the concrete.

2. Wetwell Airspace

The TRACG temperature curves in the airspace of the WW are compared with the design temperature curve (labeled ENV) in Figures 6.2-180(7) through 6.2-180(9) for short-term, medium-term and long-term break cases, respectively. The peak temperatures calculated by TRACG are less than the 130°C (266°F) peak design temperature up to 0.1 hr for all break cases except for FWLA and FWLCB. The slightly higher FWLA and FWLCB temperatures (134°C (273°F) maximum) are fluid temperatures, and the actual temperatures in the structures are expected to be lower for short-duration heat buildup in view of the heat transfer analysis described above for the DW. At the late stage of the transient approaching 72 hours, the TRACG temperatures reach a maximum value of about 137°C (279°F) at 72 hours associated with MSLCB. It is about 13% higher than the 121°C (250°F) design temperature. The impact on the structural design is evaluated assuming that the existing total stresses of the abnormal and abnormal/extreme environmental load combinations, which include the accident thermal load, are increased by 13%. This approach is very conservative since stresses other than thermal are not affected by the 13% increase in the WW airspace temperature. The design margins of the affected structures, D/F, VW, containment liner and Reinforced Concrete Containment Vessel (RCCV), are presented below.

The structural elements of the D/F on the WW side are the bottom plate and the web and flange plates of the supporting radial beams. Their existing maximum stresses are summarized in DCD Tier 2 Table 3G.1-37. The bottom plate stresses reported in this table have a minimum stress margin (defined to be the ratio of the allowable to calculated stresses) equal to 1.35 associated with tensile stress under the normal load condition. The stress margin for the abnormal and abnormal/extreme environmental conditions is higher. This provides ample design margin against 13% higher temperature load. As noted in DCD Tier 2 Table 3G.1-37 for the radial web plate (lower web) and bottom flange, the thermal stress associated with extreme and abnormal load conditions meets deformation limits of AISC N690 Subsection Q1.5.7.2 and the total stress excluding thermal stress satisfies the allowable stress limit in Table Q1.5.7.1 of AISC N690. With a 13% increase in the total stresses for these plates, the resulting deformation is still within 27% of the allowable ductility. Hence, the D/F structure has adequate margins to accommodate a 13% temperature increase in the WW airspace.

The stress summary of the VW is provided in DCD Tier 2 Table 3G.1-39. The smallest stress margin is 1.4. The outside cylinder is on the WW side and its stress margin is 1.8. The stress margin is sufficient to accommodate a 13% temperature increase in the WW airspace.

The maximum strains of the containment liners are in DCD Tier 2 Table 3G.1-35. The smallest strain margin is 1.22 for the cylinder, which includes the portions in the WW airspace. The strain margin is sufficient to accommodate 13% temperature increase in the WW airspace.

The thermal response of the RCCV, being a concrete structure, is a function of heat input accumulated over time. As shown in Figures 6.2-180(10) through 6.2-180(12), the integrated TRACG temperature curves are bounded by the integrated design temperature curve for all breaks after 0.0003 hr. Prior to 0.0003 hr the TRACG accumulated heat input is higher but has no impact on structural design since the duration is too short for significant heat to penetrate into the concrete. It should be further noted that the ascending trend of TRACG temperatures does not extend beyond 72 hours in accordance with DCD Tier 2 Figure 6.2-14e2. The change in the temperature trend and reduction in temperature in DCD Tier 2 Figure 6.2-14e2 is due to operation of the PCCS vent fans, which reduce the non-condensable gas concentration in the PCCS heat exchangers, increasing heat removal.

Furthermore, for a very conservative check, the concrete and rebar stresses of the RCCV provided in DCD Tier 2 Tables 3G.1-29 through 3G.1-33 for abnormal and abnormal/extreme environmental conditions are examined for design margins. At the WW airspace the smallest stress margin is 1.14 for the outer layer rebars near the WW top. Therefore, the RCCV has sufficient margin even if the combined stresses were increased by 13%, which is the same amount as the 13% temperature increase in the WW airspace.

3. Conclusions

On the basis of the evaluations described above, it can be concluded that the TRACG calculated LOCA temperatures do not invalidate the DW and WW structural design analysis.

The above evaluation will be added in DCD Revision 6 as new DCD Tier 2 Section 3G.5, "Structural Evaluation for TRACG Calculated LOCA Temperatures", and this new section will be referenced in DCD Tier 2 Subsections 3G.1.5.2.1.6 and 6.2.1.1.2.

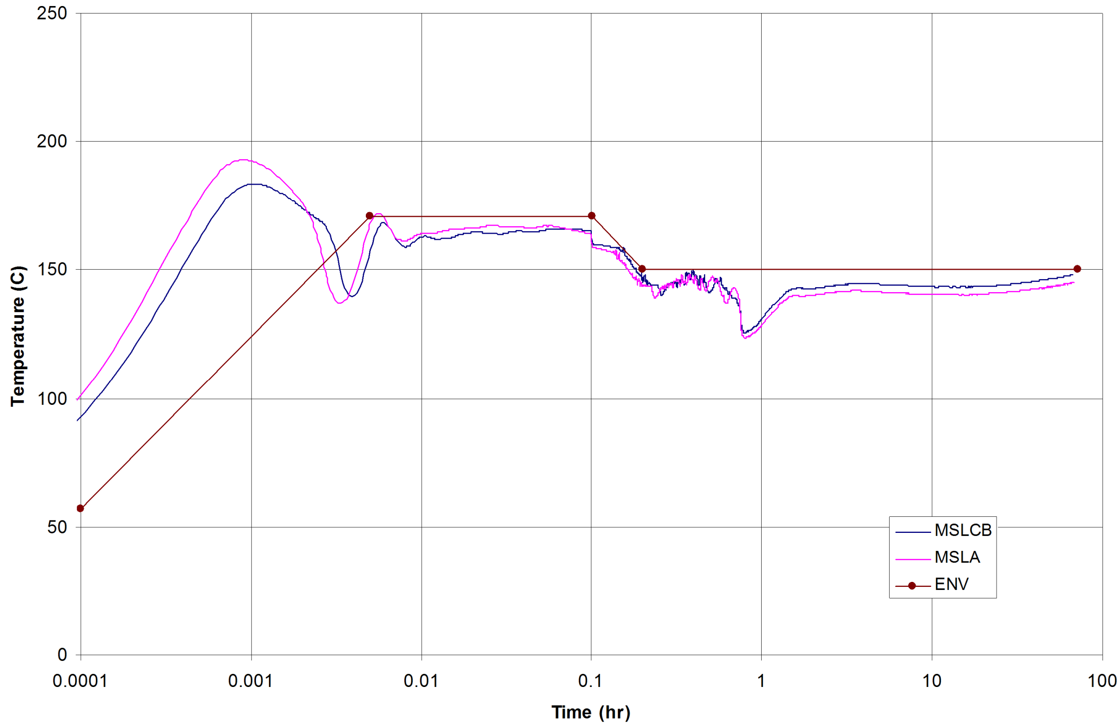

Figure 6.2-180(1) DW Design Temperature Curve (ENV) vs. TRACG Short-Term Bounding Temperature Curve

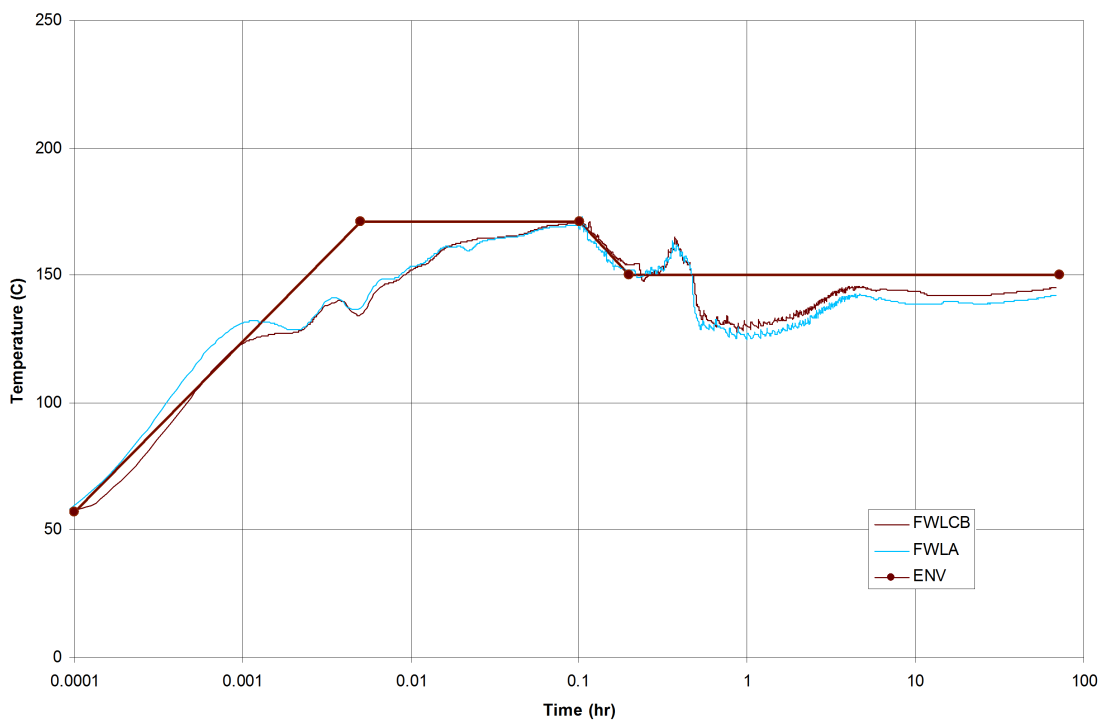

Figure 6.2-180(2) DW Design Temperature Curve (ENV) vs. TRACG Medium-Term Bounding Temperature Curve

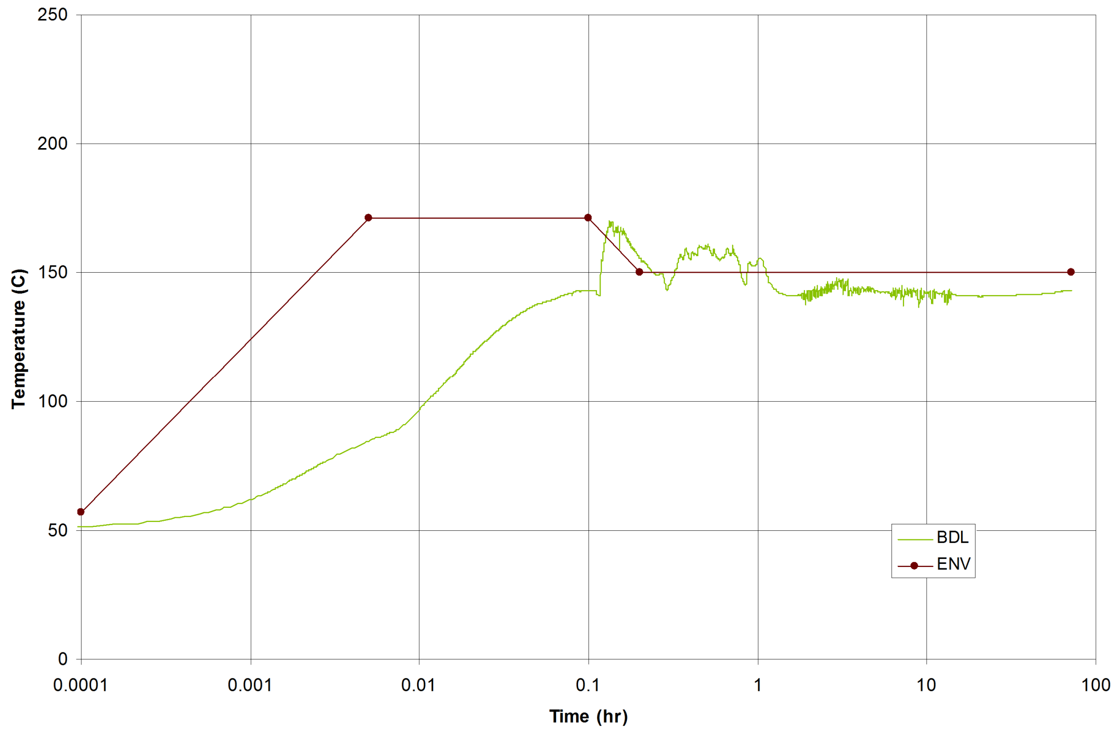

Figure 6.2-180(3) DW Design Temperature Curve (ENV) vs. TRACG Long-Term Bounding Temperature Curve

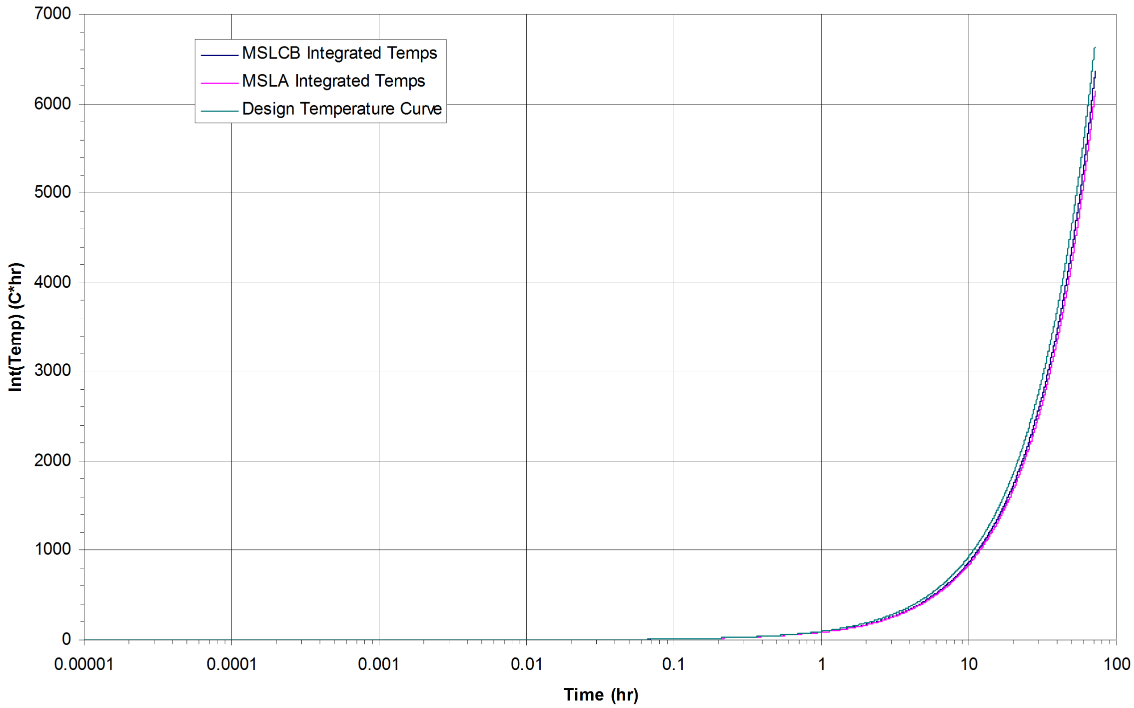

Figure 6.2-180(4) DW Integrated Design Temperature Curve vs. TRACG Short-Term Bounding Temperature Curve

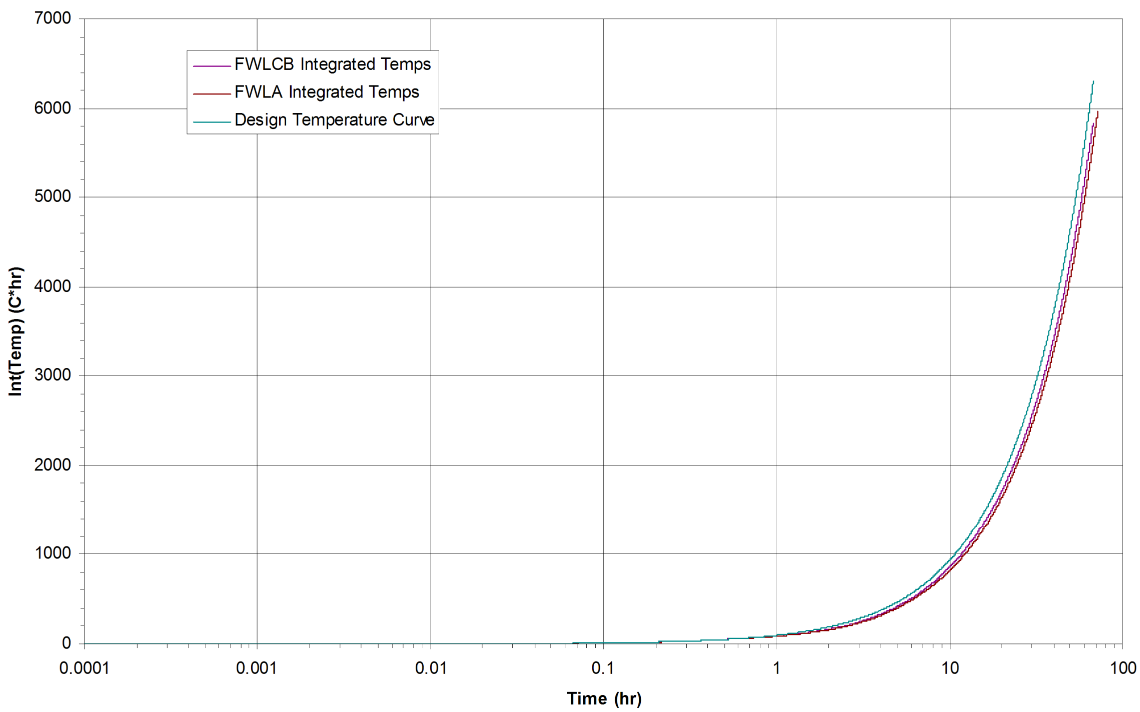

Figure 6.2-180(5) DW Integrated Design Temperature Curve vs. TRACG Medium-Term Bounding Temperature Curve

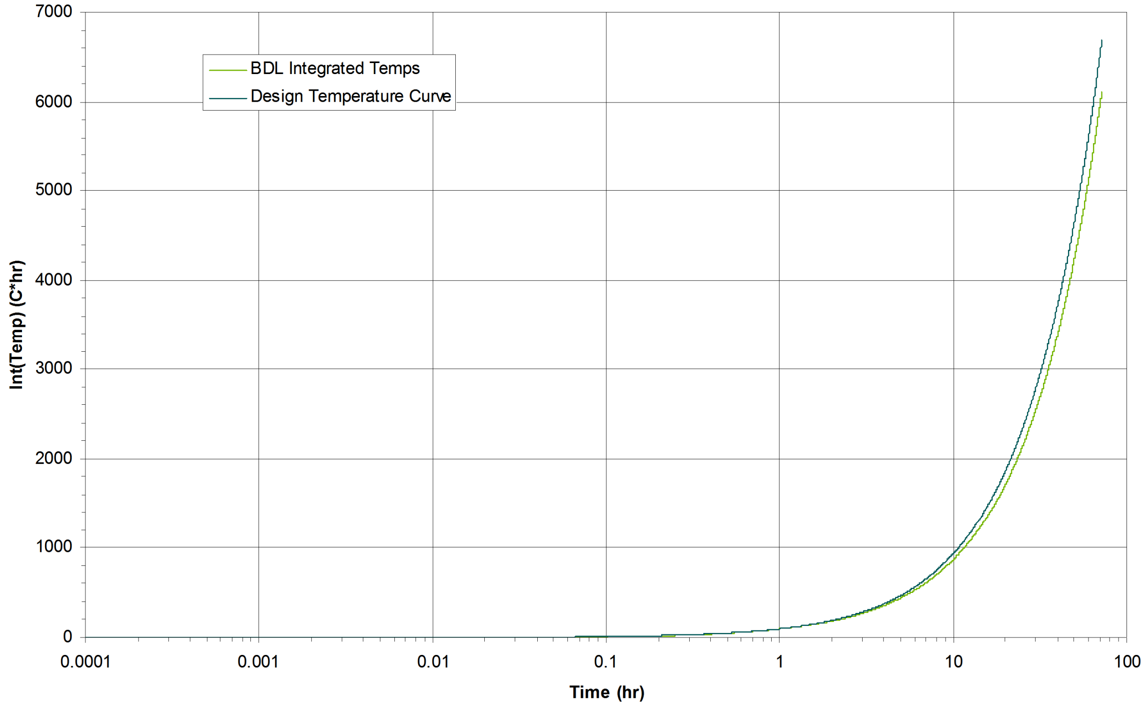

Figure 6.2-180(6) DW Integrated Design Temperature Curve vs. TRACG Long-Term Bounding Temperature Curve

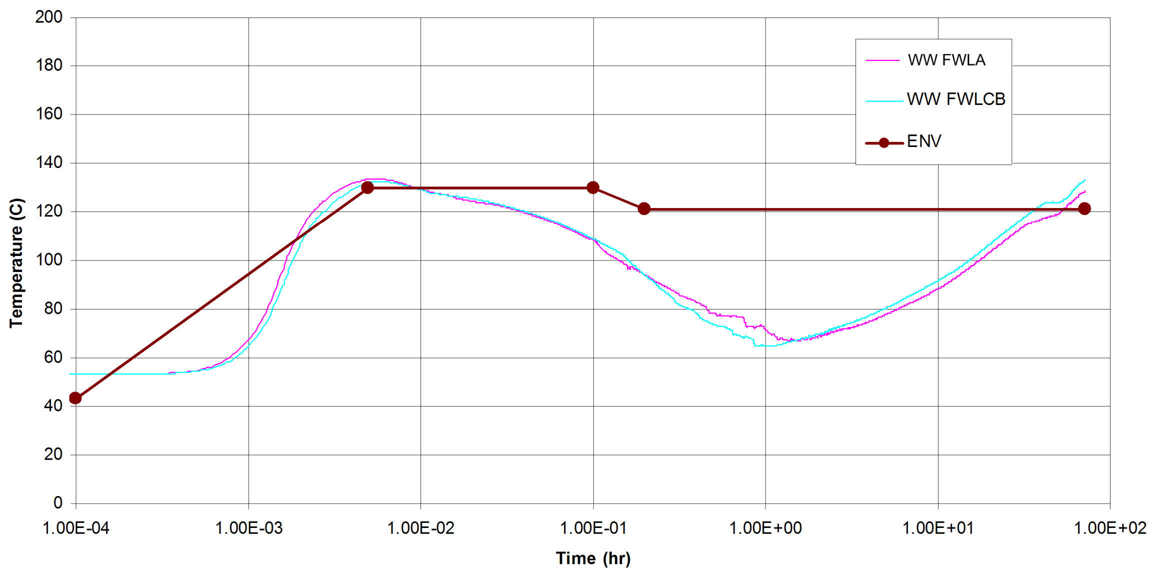

Figure 6.2-180(7) WW Design Temperature Curve (ENV) vs. TRACG Short-Term Bounding Temperature Curve

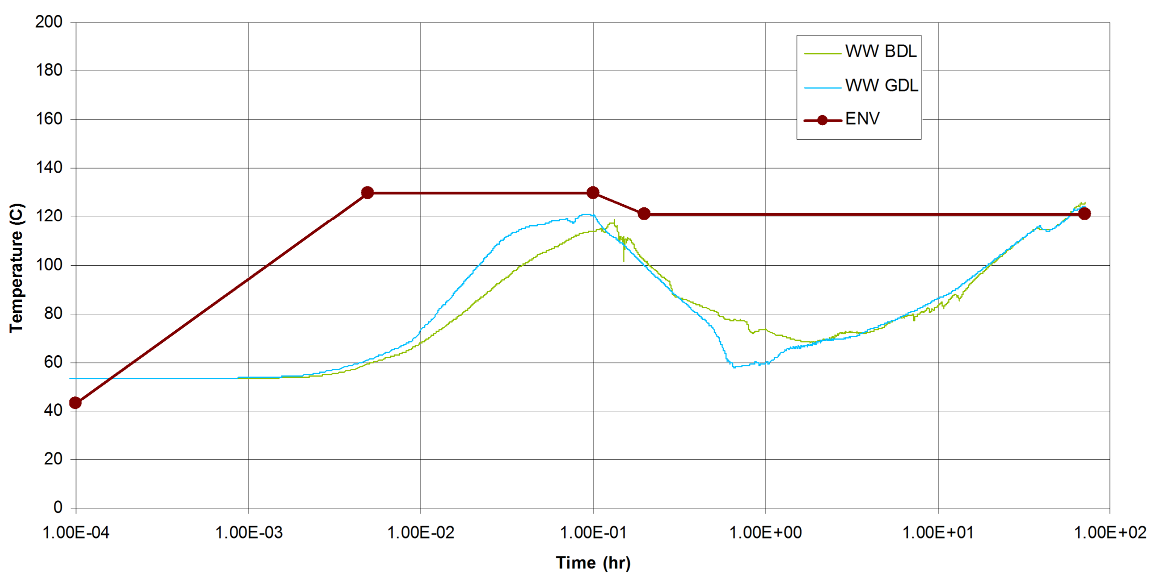

Figure 6.2-180(8) WW Design Temperature Curve (ENV) vs. TRACG Medium-Term Bounding Temperature Curve

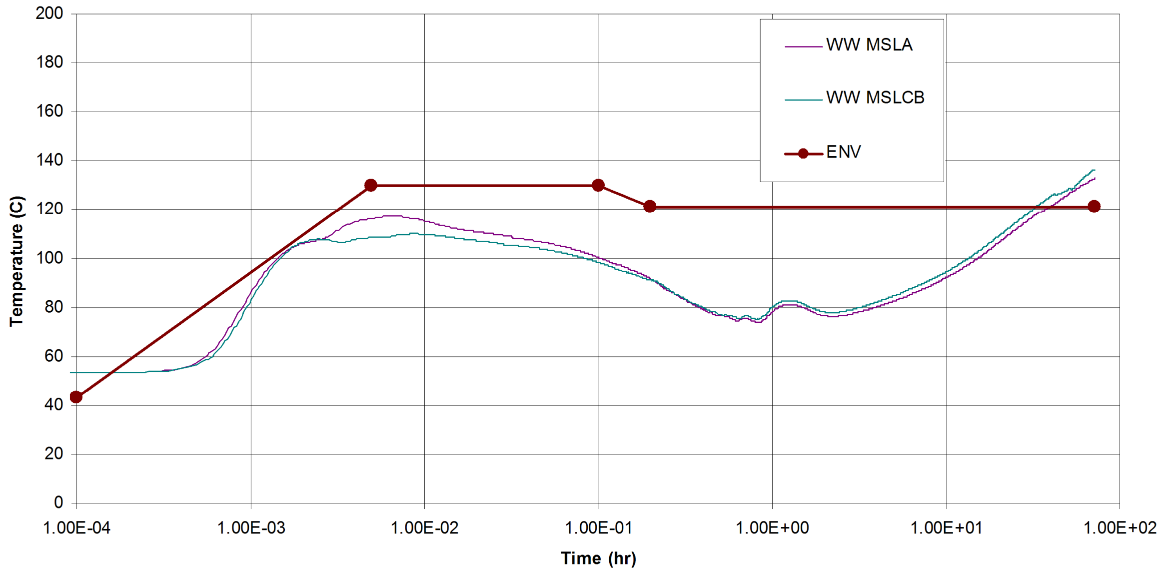

Figure 6.2-180(9) WW Design Temperature Curve (ENV) vs. TRACG Long-Term Bounding Temperature Curve

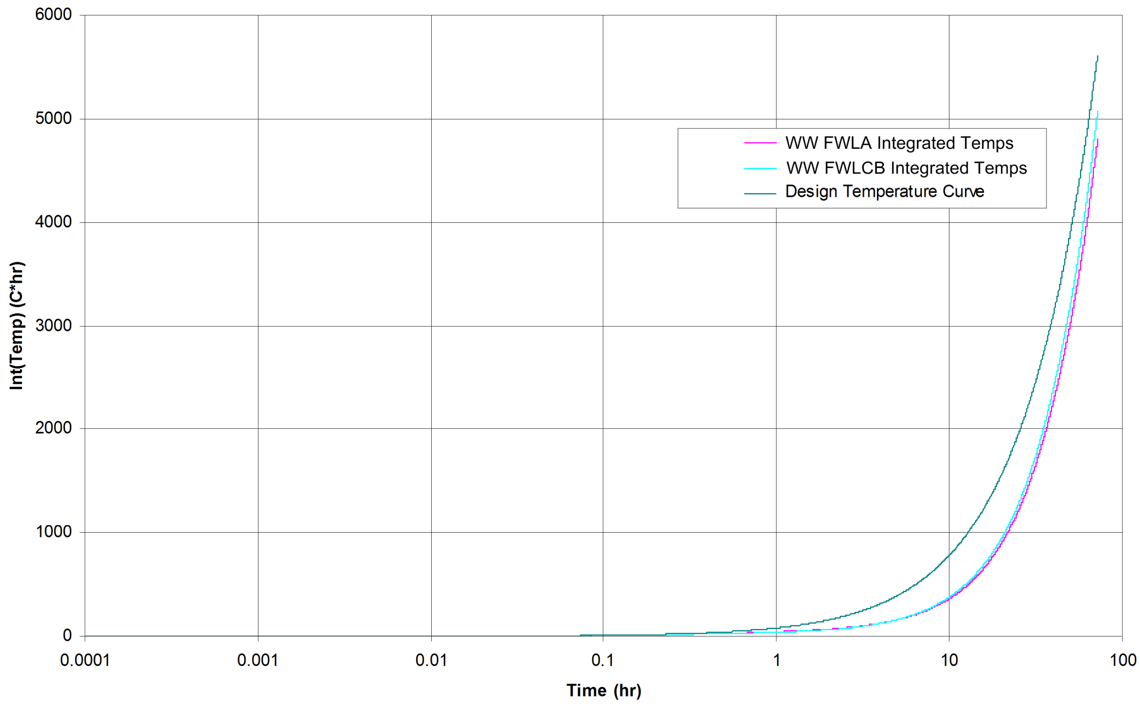

Figure 6.2-180(10) WW Integrated Design Temperature Curve vs. TRACG Short-Term Bounding Temperature Curve

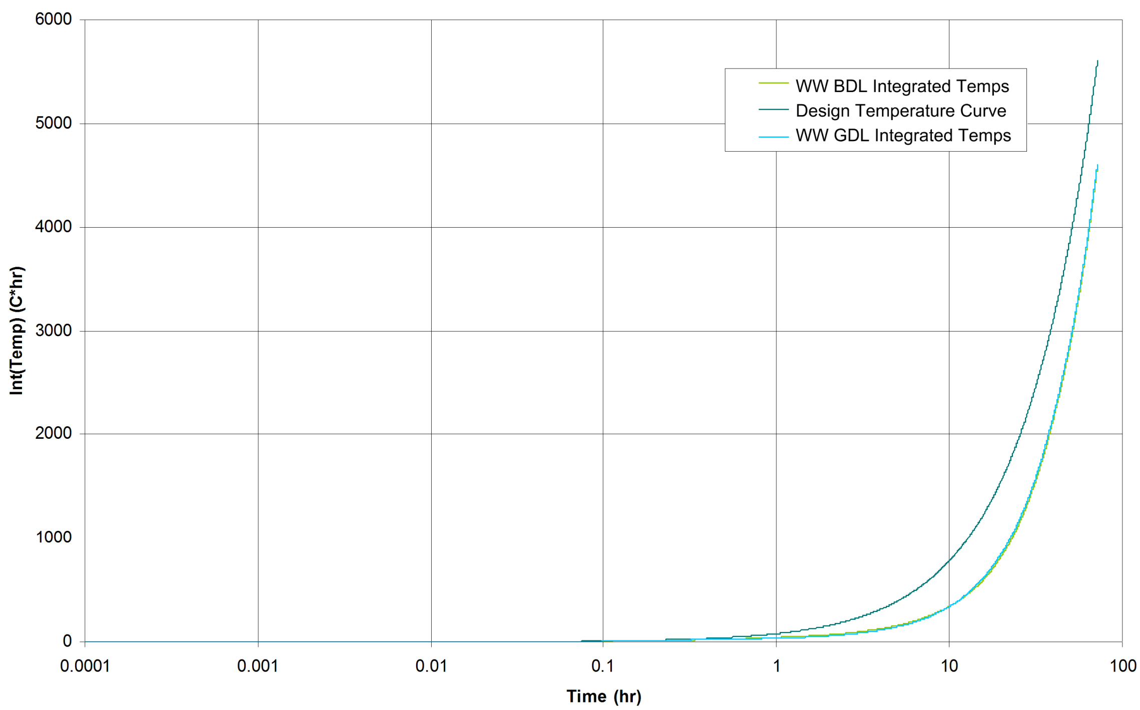

Figure 6.2-180(11) WW Integrated Design Temperature Curve vs. TRACG Medium-Term Bounding Temperature Curve

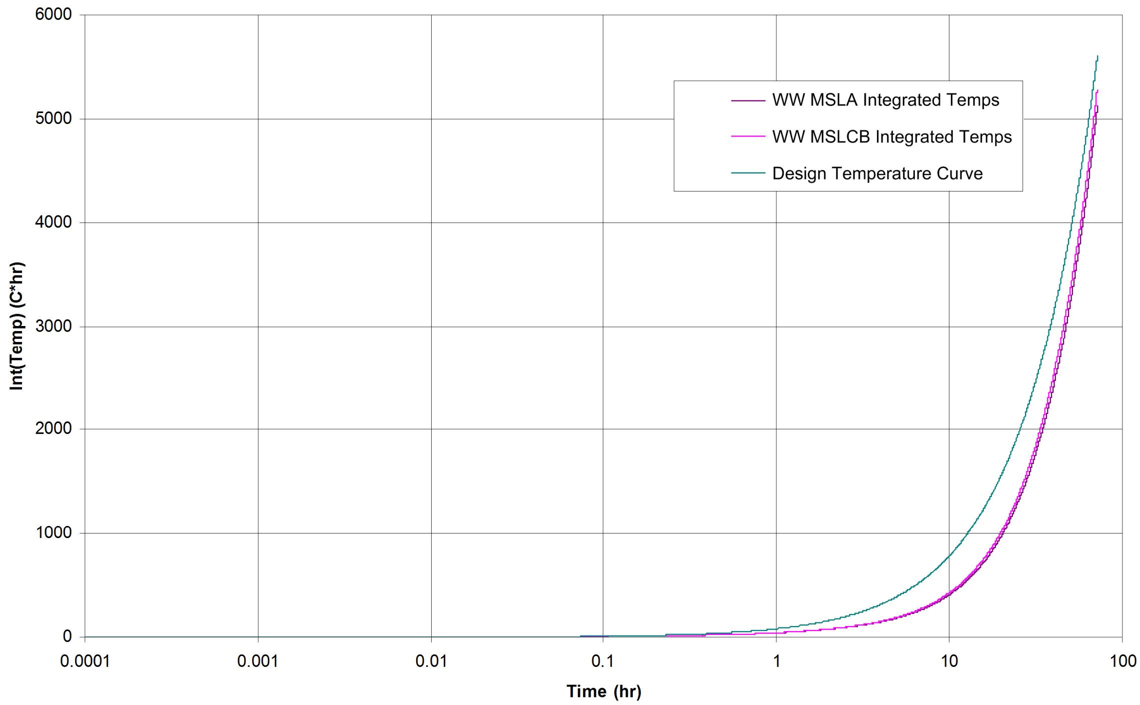

Figure 6.2-180(12) WW Integrated Design Temperature Curve vs. TRACG Long-Term Bounding Temperature Curve

DCD Impact

DCD Tier 2 Subsections 3G.1.5.2.1.6 and 6.2.1.1.2 will be revised and new DCD Tier 2 Section 3G.5 will be added as noted in the attached markups.

Enclosure 2

MFN-08-341, Supplement 1

Response to Portion of NRC Request for Additional Information Letter No. 237 Related to ESBWR Design Certification Application

Containment Systems

RAI Number 6.2-180 S01

DCD Markups

3G.1.5.2.1.3 Lateral Soil Pressure at Rest

The lateral soil pressure at rest is applied to external walls below grade and is based on soil properties given in Table 3G.1-2. Pressures to be applied to the walls are provided in Figure 3G.1-19.

3G.1.5.2.1.4 Wind Load (W)

The wind load is applied to the roof slabs and external walls above grade and is based on basic wind speed given in Table 3G.1-2.

3G.1.5.2.1.5 Tornado Load (W_t)

The tornado load is applied to the roof slabs and external walls above grade and its characteristics are given in Table 3G.1-2. The tornado load, W_t, is further defined by the following combinations:

$W_t = W_w$

$W_t = W_p$

$W_t = W_m$

$W_t = W_w + 0.5W_p$

$W_t = W_w + W_m$

$W_t = W_w + 0.5W_p + W_m$

where,

W_t = Total Tornado Load

W_w = Tornado Wind Load

W_p = Tornado Differential Pressure Load

W_m = Tornado Missile Load

3G.1.5.2.1.6 Thermal Loads

Thermal loads are evaluated for the normal operating conditions and abnormal (Loss-of-Coolant-Accident [LOCA]) conditions. Figure 3G.1-20 shows the section location for temperature distributions for various structural elements, and Table 3G.1-6 shows the magnitude of equivalent linear temperature distribution.

The evaluation method of temperature effect on the concrete design is based on ACI 349-01 Commentary Figure RA.1.

Two cases, winter and summer, are considered in the analysis.

Stress-free temperature is 15.5°C (60°F).

The structural evaluation for TRACG calculated LOCA temperatures is described in Section 3G.5.

3G.5 STRUCTURAL EVALUATION FOR TRACG CALCULATED LOCA TEMPERATURES

A quantitative evaluation is performed to demonstrate that the thermal transient profiles calculated by TRACG do not invalidate the structural design analysis using the thermal loads presented in Subsection 3G.1.5.2.1.6. The following six break cases in the event of a LOCA are examined:

MSLA: Main Steamline Break inside Containment – nominal

MSLCB: Main Steamline Break inside Containment – containment bounding

FWLA: Feedwater Line Break – nominal

FWLCB: Feedwater Line Break – containment bounding

GDL: GDCS Injection Line – nominal

BDL: Bottom Drain Line – nominal

The TRACG calculated bulk temperature curves (including consideration of uncertainties) of these break cases are bounded by the design temperature curves considered in the structural analysis at all locations except for the drywell (DW), wetwell (WW) airspace and RB upper pools. Evaluation details of the DW and WW where the design temperature is not bounding are presented below.

3G.5.1 Drywell

The TRACG temperature curves in the DW are compared with the design temperature curve (labeled ENV) in Figures 3G.5-1 through 3G.5-3 for short-term, medium-term and long-term break cases, respectively. It is observed that the MSLA and MSLCB cases result in the highest temperature in the short term (t < 0.1 hr); the FWLA and FWLCB cases result in the highest temperature in the medium term (0.3 < t < 0.5 hr); and the BDL case results in the highest temperature in the long term (t > 0.5 hr). The GDL case is not bounding over any time interval for the DW.

The MSLA case is the most critical because it has the highest temperature at 193°C (379°F) as compared to the 171°C (340°F) peak design temperature. However, this exceedance occurs very early in the transient and is very short in duration. It should be noted that the TRACG results are bulk fluid temperatures. The actual temperatures in the structures are lower than the fluid temperatures due to heat transfer effects at the surface. The beneficial effects of reduced surface heat transfer are ignored in the structural design analysis in which the design temperature curve was directly applied to the structure assuming an infinite value for the heat transfer coefficient.

To show that the actual structural temperature is lower than the fluid temperature, a transient 1-D heat transfer analysis is performed for the DW liner (6.4 mm (0.25 in) thick) with the inside liner face subjected to the bulk fluid temperature and the outside liner face (which is at the liner-concrete interface) perfectly insulated for the MSLA transient up to 0.1 hr. A conservative heat transfer coefficient derived from TRACG results is applied at the inside liner face. The results of this heat transfer analysis show that the maximum temperature uniformly across the liner thickness and at the concrete surface is 167°C (333°F), which is less than the 171°C (340°F) peak temperature used in the structural design. The 167°C (333°F) temperature at the concrete surface is also within the 177°C (350°F) limit stipulated in ASME Code Section III, Division 2, Subarticle CC-3440 for an accident or any other short-term period.

Besides the containment liner, there are other steel structures subjected to the DW temperature. They consist of containment metal components not backed by concrete (such as the DW head) and containment internal steel structures (such as the diaphragm floor (D/F), vent wall (VW), GDCS pool wall and reactor shield wall). Since these steel structures are thicker than the liner plate and one face of the liner plate is conservatively assumed to be fully insulated in the heat transfer analysis described above, the calculated 167°C (333°F) maximum temperature is also applicable to all steel structures for which the design temperature is higher at 171°C (340°F). It should be noted that the design stress analyses performed for the D/F and VW ignores the infill concrete; the steel plates on the DW side are designed to 171°C (340°F) peak design temperature and the steel plates on the WW airspace side are designed to 130°C (266°F) peak design temperature. The WW temperature is discussed separately below.

As opposed to steel structures, concrete structures react to temperature loading very slowly. The more important consideration is how much heat is penetrating into the concrete as the accident progresses. The integrated TRACG curves versus the integrated design temperature curve over the 72-hr duration are shown in Figures 3G.5-4 through 3G.5-6 for short-term, medium-term and long-term break cases, respectively. The accumulated heat input at 72 hours, which is the most critical timing for concrete response when the thermal gradient across the thickness is largest, is less than that of the design temperature curve for all breaks. At the very early stage of the transient up to about 0.6 hr, however, some breaks result in higher accumulated heat input but they are inconsequential to structural design since the duration is too short for heat penetrating into the concrete.

3G.5.2 Wetwell Airspace

The TRACG temperature curves in the airspace of the WW are compared with the design temperature curve (labeled ENV) in Figures 3G.5-7 through 3G.5-9 for short-term, medium-term and long-term break cases, respectively. The peak temperatures calculated by TRACG are less than the 130°C (266°F) peak design temperature up to 0.1 hr for all break cases except for FWLA and FWLCB. The slightly higher FWLA and FWLCB temperatures (134°C (273°F) maximum) are fluid temperatures, and the actual temperatures in the structures are expected to be lower for short-duration heat buildup in view of the heat transfer analysis described above for the DW. At the late stage of the transient approaching 72 hours, the TRACG temperatures reach a maximum value of about 137°C (279°F) at 72 hours associated with MSLCB. It is about 13% higher than the 121°C (250°F) design temperature. The impact on the structural design is evaluated assuming that the existing total stresses of the abnormal and abnormal/extreme environmental load combinations, which include the accident thermal load, are increased by 13%. This approach is very conservative since stresses other than thermal are not affected by the 13% increase in the WW airspace temperature. The design margins of the affected structures, D/F, VW, containment liner and Reinforced Concrete Containment Vessel (RCCV), are presented below.

The structural elements of the D/F on the WW side are the bottom plate and the web and flange plates of the supporting radial beams. Their existing maximum stresses are summarized in Table 3G.1-37. The bottom plate stresses reported in this table have a minimum stress margin (defined to be the ratio of the allowable to calculated stresses) equal to 1.35 associated with tensile stress under the normal load condition. The stress margin for the abnormal and abnormal/extreme environmental conditions is higher. This provides ample design margin against 13% higher temperature load. As noted in Table 3G.1-37 for the radial web plate (lower web) and bottom flange, the thermal stress associated with extreme and abnormal load conditions meets deformation limits of AISC N690 Subsection Q1.5.7.2 and the total stress excluding thermal stress satisfies the allowable stress limit in Table Q1.5.7.1 of AISC N690. With a 13% increase in the total stresses for these plates, the resulting deformation is still within 27% of the allowable ductility. Hence, the D/F structure has adequate margins to accommodate a 13% temperature increase in the WW airspace.

The stress summary of the VW is provided in Table 3G.1-39. The smallest stress margin is 1.4. The outside cylinder is on the WW side and its stress margin is 1.8. The stress margin is sufficient to accommodate a 13% temperature increase in the WW airspace.

The maximum strains of the containment liners are in Table 3G.1-35. The smallest strain margin is 1.22 for the cylinder, which includes the portions in the WW airspace. The strain margin is sufficient to accommodate 13% temperature increase in the WW airspace.

The thermal response of the RCCV, being a concrete structure, is a function of heat input accumulated over time. As shown in Figures 3G.5-10 through 3G.5-12, the integrated TRACG temperature curves are bounded by the integrated design temperature curve for all breaks after 0.0003 hr. Prior to 0.0003 hr the TRACG accumulated heat input is higher but has no impact on structural design since the duration is too short for significant heat to penetrate into the concrete. It should be further noted that the ascending trend of TRACG temperatures does not extend beyond 72 hours in accordance with Figure 6.2-14e2. The change in the temperature trend and reduction in temperature in Figure 6.2-14e2 is due to operation of the PCCS vent fans, which reduce the non-condensable gas concentration in the PCCS heat exchangers, increasing heat removal.

Furthermore, for a very conservative check, the concrete and rebar stresses of the RCCV provided in Tables 3G.1-29 through 3G.1-33 for abnormal and abnormal/extreme environmental conditions are examined for design margins. At the WW airspace the smallest stress margin is 1.14 for the outer layer rebars near the WW top. Therefore, the RCCV has sufficient margin even if the combined stresses were increased by 13%, which is the same amount as the 13% temperature increase in the WW airspace.

3G.5.3 Conclusions

On the basis of the evaluations described above, it can be concluded that the TRACG calculated LOCA temperatures do not invalidate the DW and WW structural design analysis.

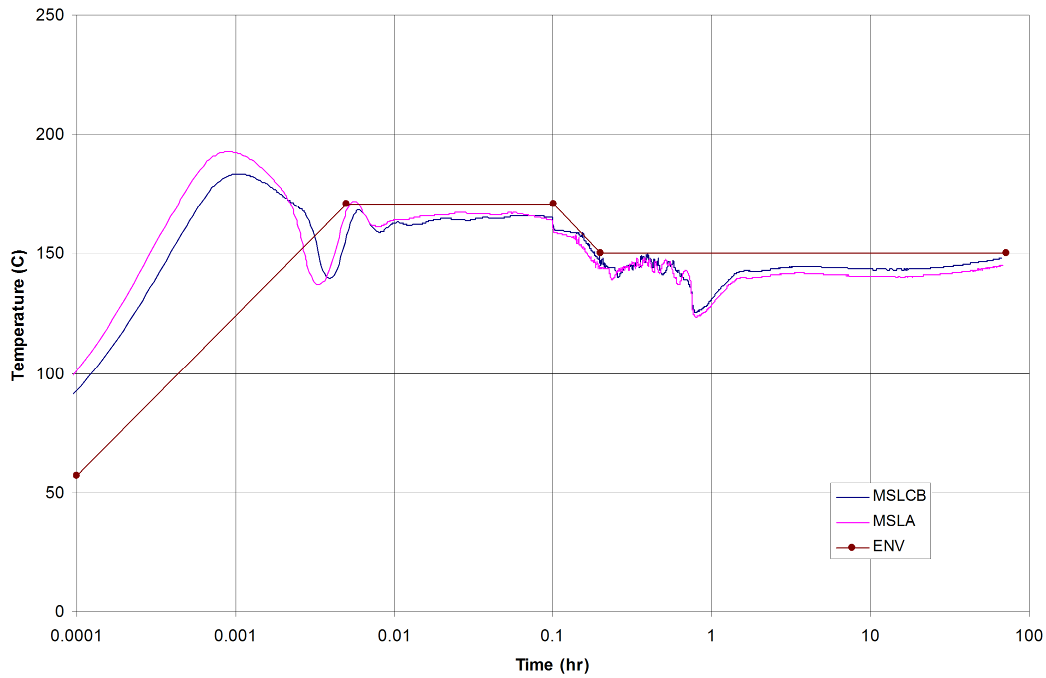

Figure 3G.5-1. DW Design Temperature Curve (ENV) vs. TRACG Short-Term Bounding Temperature Curve

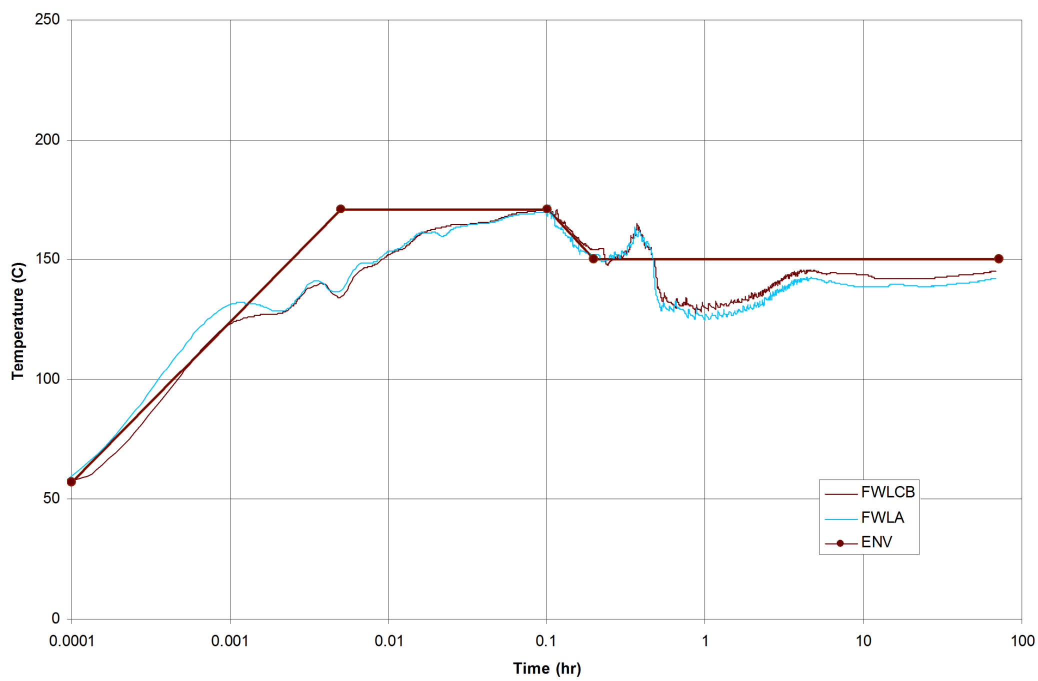

Figure 3G.5-2. DW Design Temperature Curve (ENV) vs. TRACG Medium-Term Bounding Temperature Curve

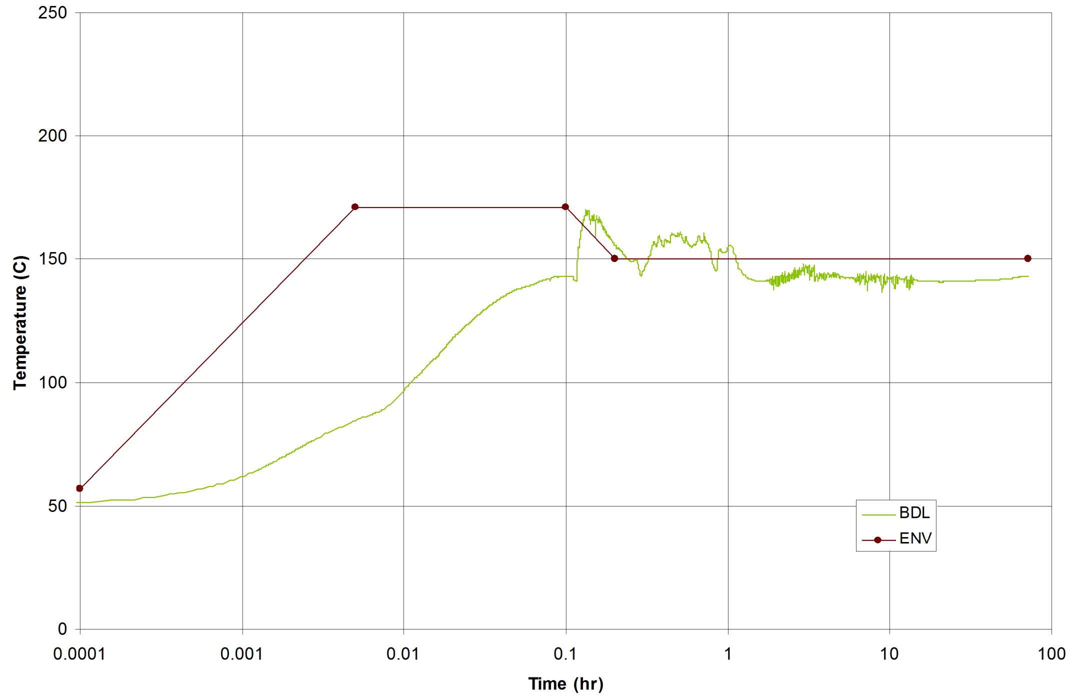

Figure 3G.5-3. DW Design Temperature Curve (ENV) vs. TRACG Long-Term Bounding Temperature Curve

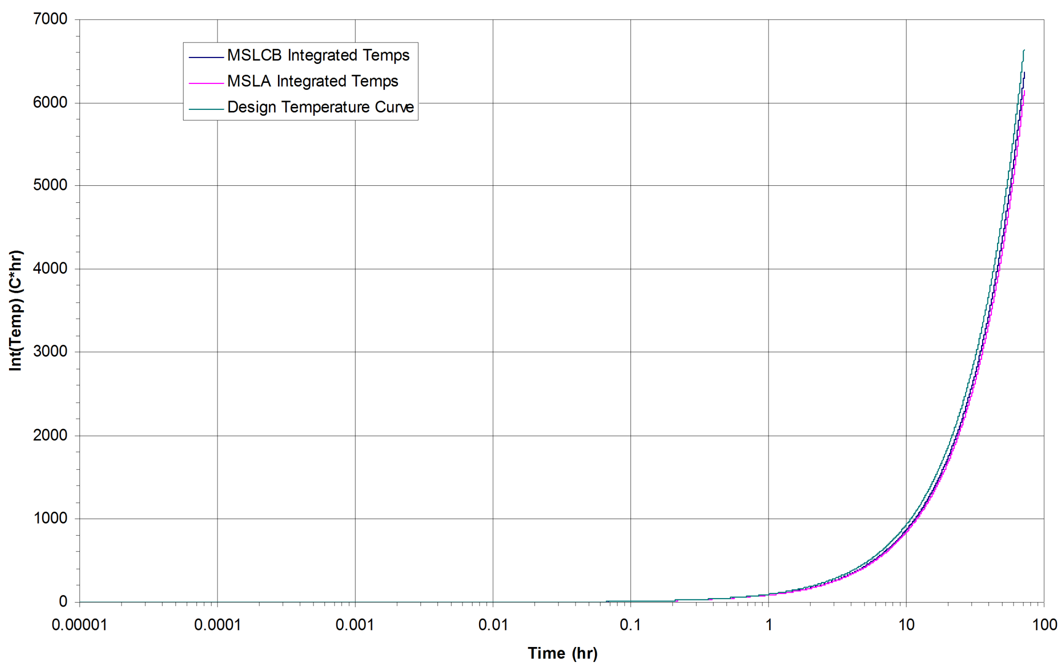

Figure 3G.5-4. DW Integrated Design Temperature Curve vs. TRACG Short-Term Bounding Temperature Curve

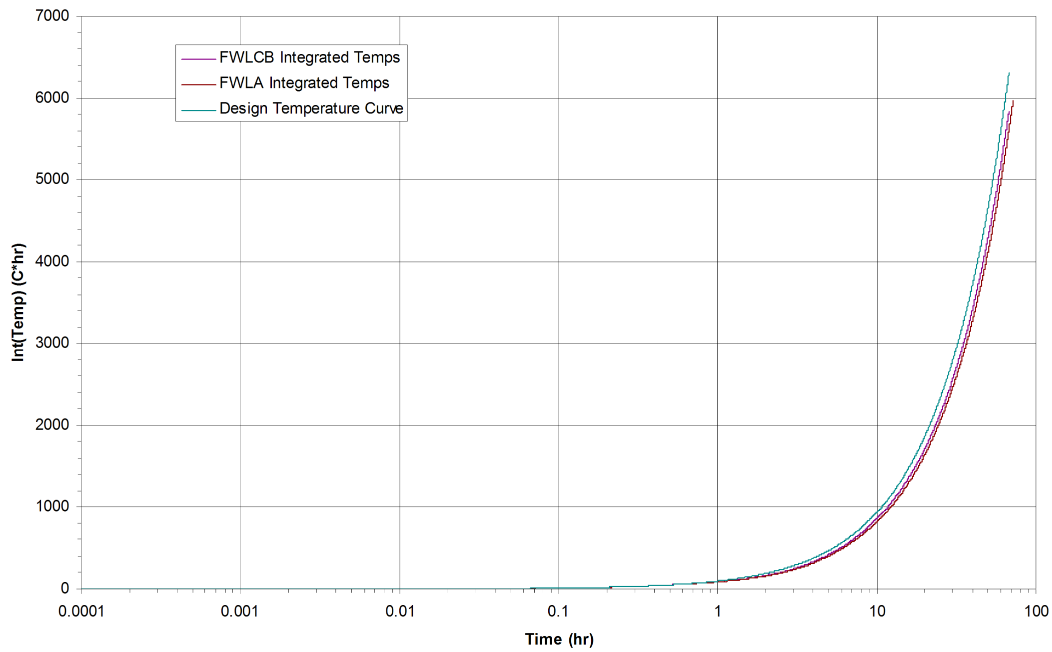

Figure 3G.5-5. DW Integrated Design Temperature Curve vs. TRACG Medium-Term Bounding Temperature Curve

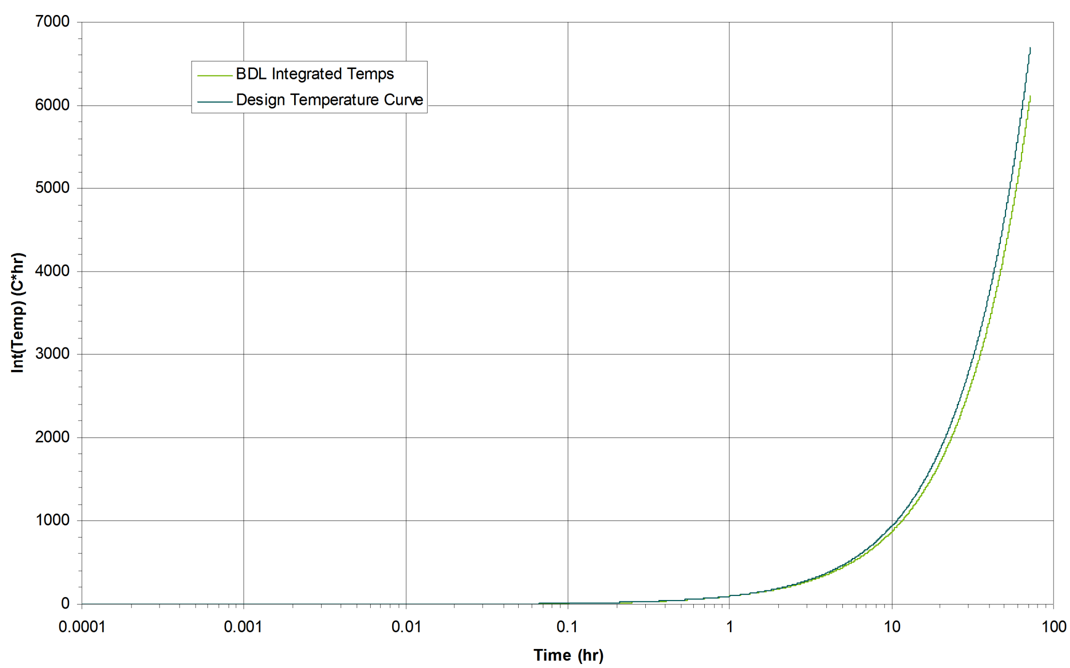

Figure 3G.5-6. DW Integrated Design Temperature Curve vs. TRACG Long-Term Bounding Temperature Curve

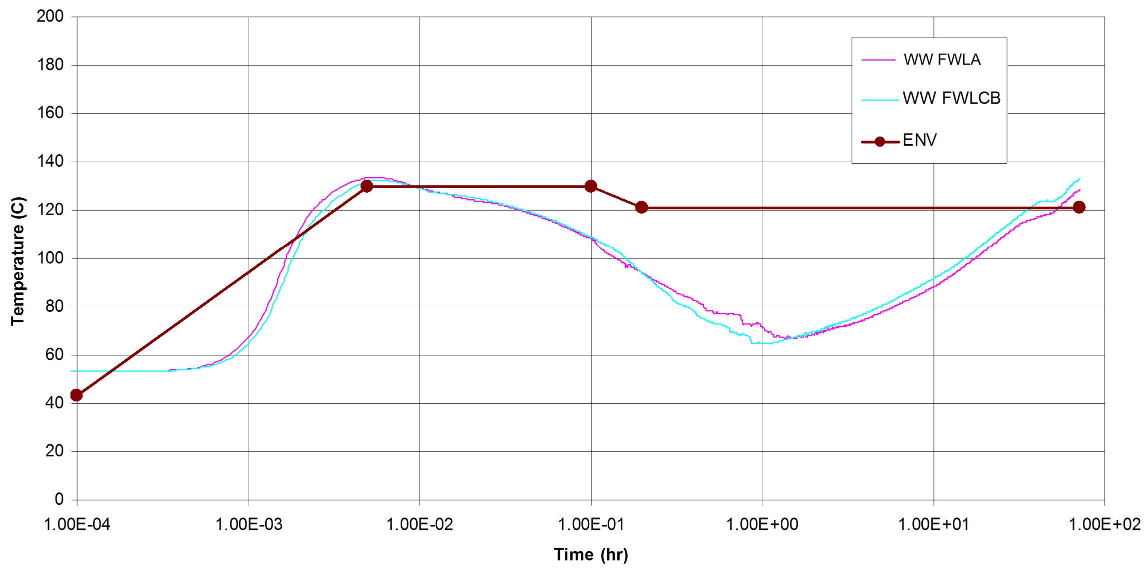

Figure 3G.5-7. WW Design Temperature Curve (ENV) vs. TRACG Short-Term Bounding Temperature Curve

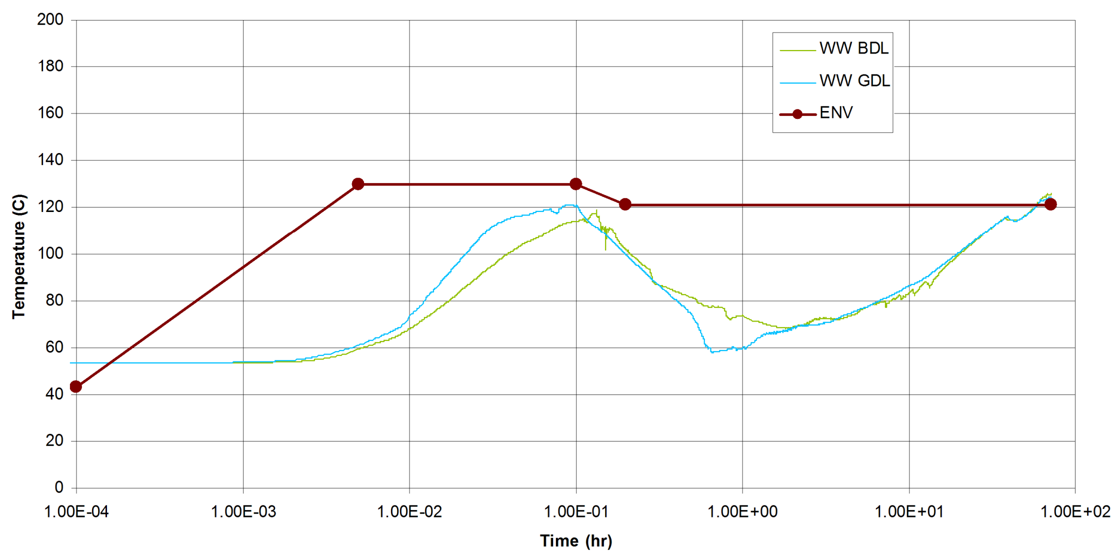

Figure 3G.5-8. WW Design Temperature Curve (ENV) vs. TRACG Medium-Term Bounding Temperature Curve

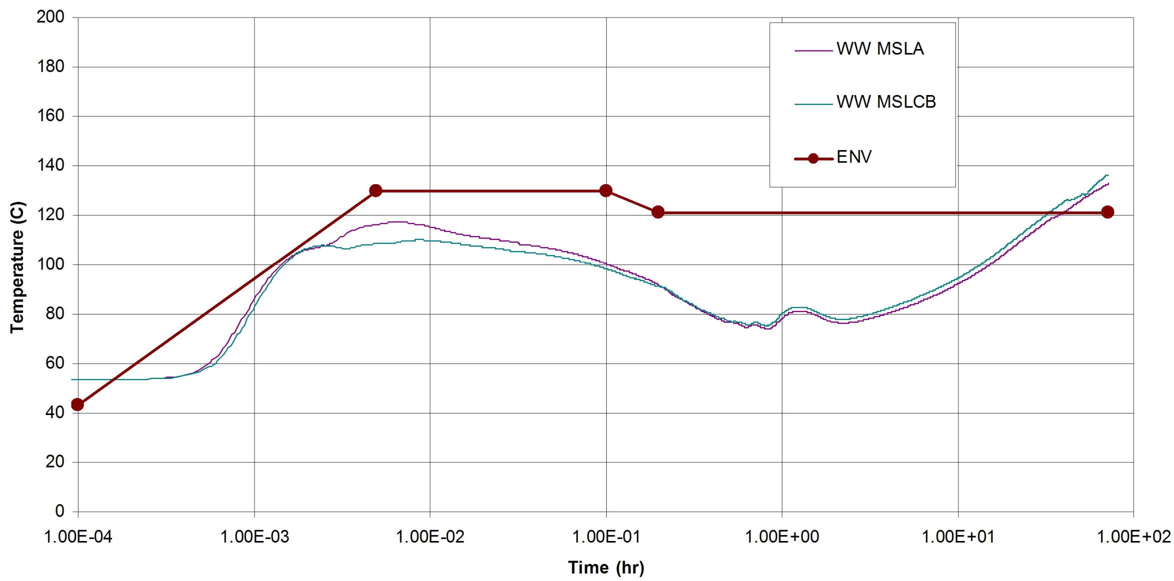

Figure 3G.5-9. WW Design Temperature Curve (ENV) vs. TRACG Long-Term Bounding Temperature Curve

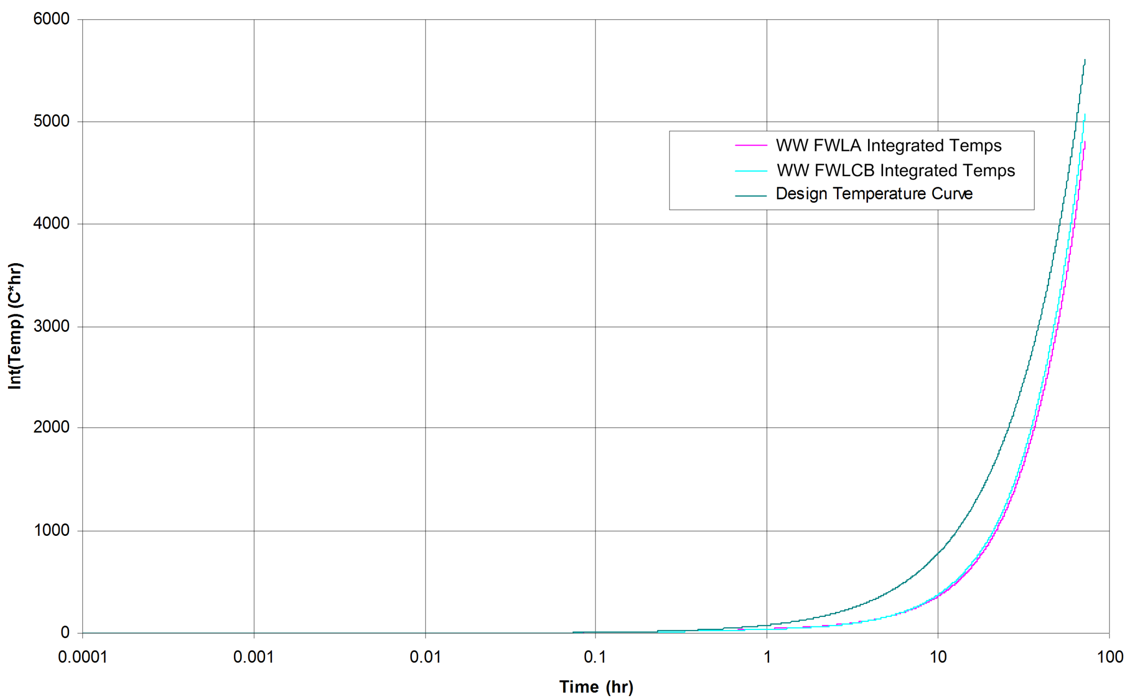

Figure 3G.5-10. WW Integrated Design Temperature Curve vs. TRACG Short-Term Bounding Temperature Curve

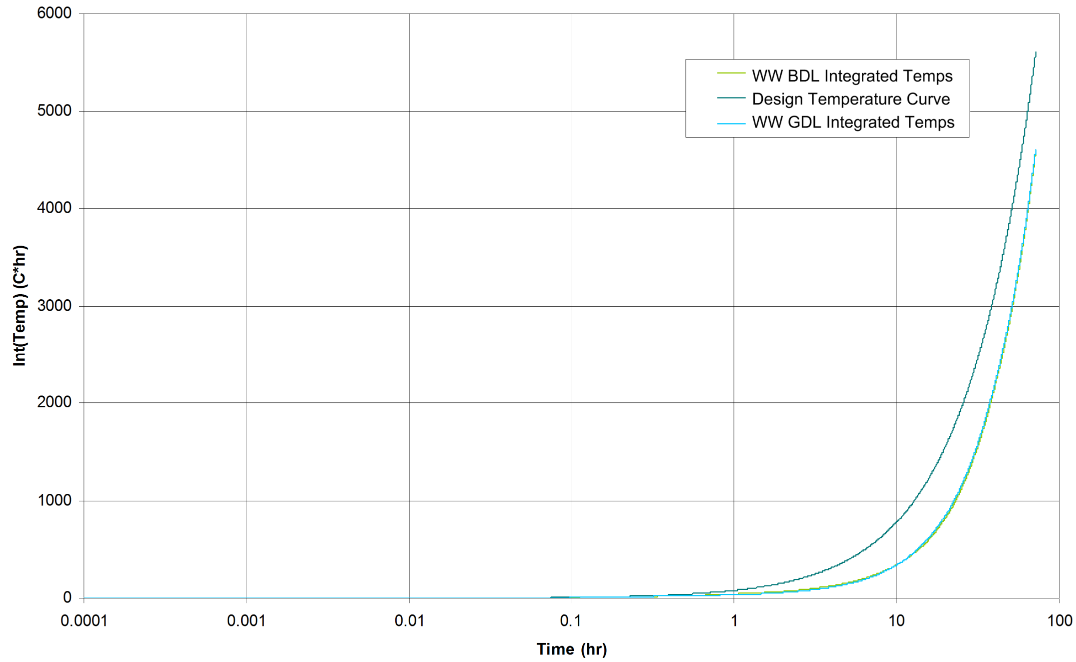

Figure 3G.5-11. WW Integrated Design Temperature Curve vs. TRACG Medium-Term Bounding Temperature Curve

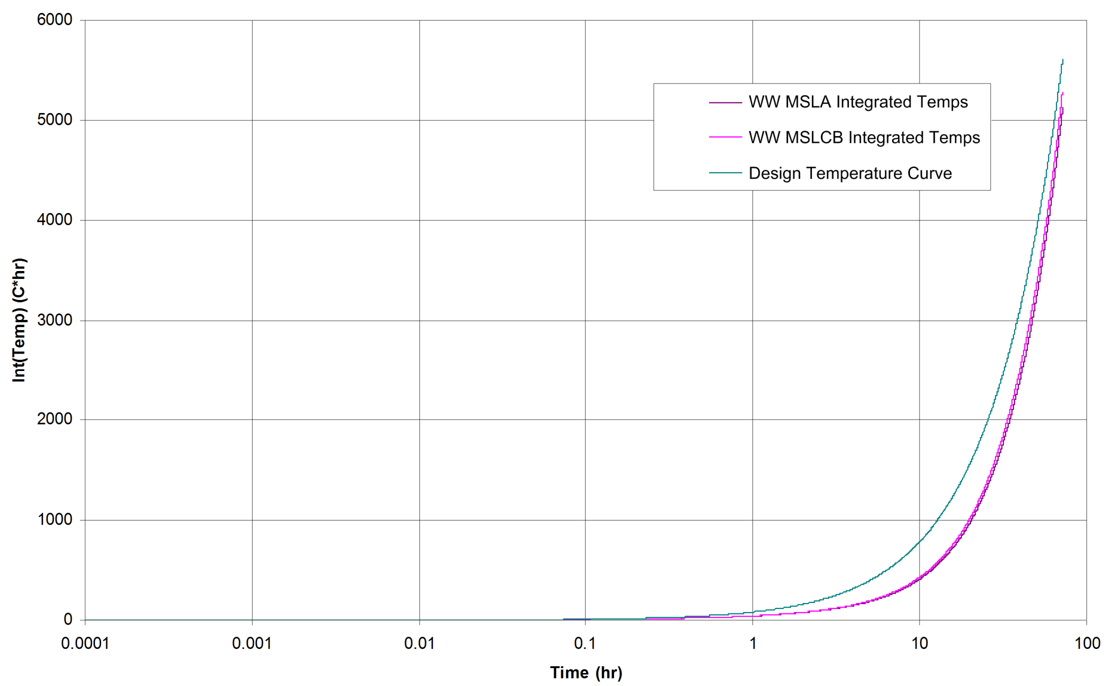

Figure 3G.5-12. WW Integrated Design Temperature Curve vs. TRACG Long-Term Bounding Temperature Curve

The DW/WW Vent System directs LOCA blowdown flow from the DW into the suppression pool.

The containment structure consists of the following major structural components: RPV support structure (pedestal), diaphragm floor separating DW and WW, suppression pool floor slab, containment cylindrical outer wall, cylindrical vent wall, containment top slab, and DW head. The containment cylindrical outer wall extends below the suppression pool floor slab to the common basemat. This extension is not part of containment boundary, however, it supports the upper containment cylinder. The reinforced concrete basemat foundation supports the entire containment system and extends to support the RB surrounding the containment. The refueling bellows seal extends from the lower flange of the reactor vessel to the interior of the reactor cavity. This extension is also not part of the containment boundary, however, it provides a Seismic Category I seal between the upper DW and reactor well during a refueling outage.

The design parameters of the containment and the major components of the containment system are given in Tables 6.2-1 through 6.2-4. A detailed discussion of their structural design bases is given in Section 3.8.

Drywell

The DW (Figure 6.2-1) comprises two volumes: (1) an upper DW volume surrounding the upper portion of the RPV and housing the main steam and feedwater piping, GDCS pools and piping, PCCS piping, ICS piping, SRVs and piping, Depressurization Valves (DPVs) and piping, DW coolers and piping, and other miscellaneous systems; and (2) a lower DW volume below the RPV support structure housing the lower portion of the RPV, fine motion control rod drives, other miscellaneous systems and equipment below the RPV, and vessel bottom drain piping.

The upper DW is a cylindrical, reinforced concrete structure with a removable steel head and a diaphragm floor constructed of steel girders with concrete fill. The RPV support structure separates the lower DW from the upper DW. There is an open communication path between the two DW volumes via upper DW to lower DW connecting vents, built into the RPV support structure. Penetrations through the liner for the DW head, equipment hatches, personnel locks, piping, electrical and instrumentation lines are provided with seals and leak-tight connections.

The DW is designed to withstand the pressure and temperature transients associated with the rupture of any primary system pipe inside the DW, and also the negative differential pressures associated with containment depressurization events, when the steam in the DW is condensed by the PCCS, the GDCS, the FAPCS, and cold water cascading from the break following post-LOCA flooding of the RPV.

For a postulated DBA, the calculated ~~maximum bulk~~ DW ~~temperature and absolute~~ pressure in Table 6.2-5 ~~remain~~ is below the~~ir~~ design value~~s,~~ shown in Table 6.2-1. The structure stresses are evaluated in Section 3G.5 considering the DW fluid temperature transients for multiple break locations.

Three vacuum breakers are provided between the DW and WW. The vacuum breaker is a process-actuated valve, similar to a check valve, (Figure 6.2-28). The purpose of the DW-to-WW vacuum breaker system is to protect the integrity of the diaphragm floor slab and vent wall between the DW and the WW, and the DW structure and liner, and to prevent back-flooding of the suppression pool water into the DW. The vacuum breaker is provided with