DCP/NRC1379

ENCLOSURE 1

ERRATA FOR

WCAP-14845, Rev 3.
"Scaling Analysis for AP600 Containment Pressure During Design Basis Accidents"

[redacted]

Enclosure 1

Table 4-1 Containment Time Constants - DECLG LOCA Post-blowdown		
Containment Hierarchical Level	Time Constant Symbol and Definition	Numerical values at 1200 seconds, (sec.)
Containment system	$\tau_{system} = V_{containment}/Q_0$	5045
	$\tau_{conduction} = \rho_{sh} C_p \delta / h$	256
Large scale flow structures	$\tau_{plume\ entrainment} = V_{containment}/Q_{e,plume}$	337
	$\tau_{wall\ entrainment} = V_{containment}/Q_{e,wall}$	418
Wall boundary layer control volume	$\tau_{residence\ time} =$ ~~Q_{BL}/V_{BL}~~ V_{BL}/Q_{BL}	~~16.0~~ 17.6
	$t_f = \sqrt{\frac{vH}{g\beta(\Delta T)\alpha}}$	0.5 to 1.2
	$\tau_{diffusion\ layer\ penetration} = \delta_m^2 / D_V$	0.5

Where the particular values used in the above table, obtained from Reference 37 except where noted in the text, are:

$V_{containment}$ = total containment free volume, 1.7×10^6 ft^3 (changes less than 10% during the transient).

Q_0 = source (break) flow of steam, 337 ft^3/sec.

ρ_{sh} = density of containment shell material, 490.7 lbm/ft^3.

C_p = containment shell material specific heat capacity, 0.107 BTU/lbm-F.

δ = containment shell thickness, 0.1354 ft. (1.625 inches).

h = equivalent total heat transfer coefficient based on the temperature difference from containment gas to shell surface. 100 BTU/hr-ft^2-F.

k = containment shell thermal conductivity, 23.6 BTU/hr-ft-F.

$Q_{e,plume}$ = volumetric entrainment rate for gas into the rising source plume, 5050 ft^3/sec.

$Q_{e,wall}$ = volumetric entrainment rate for gas into the falling wall boundary layer, 4065 ft^3/sec.

Q_{BL} = volumetric flow rate out of the bottom of the wall boundary layer, ($Q_{e,wall}$ - $Q_{condensed}$), where $Q_{condensed} = Q_0$ at quasi-steady conditions, 3728 ft^3/sec.

V_{BL} = volume occupied by the wall boundary layer, 65,500 ft^3.

v = kinematic viscosity of the boundary layer mixture, ranged from 2.3x10-4 (steam) to 2.4x10-4 (air) ft^2/sec.

H = height of the wall boundary layer, 121 ft.

$$P_{air} = \frac{T_{abs}}{T_{init,abs}} P_{air,init} \qquad P_{stm} = P_{total} - P_{air}$$

(62)

6.3.1 Rate of Pressure Change (RPC) Equation

An RPC equation can be written by combining the equation for the rate of change of internal energy, Equation (46) with conservation of energy, Equation (55) and conservation of gas mass, Equation 48:

$$\text{real gas:} \quad \left(\frac{c_p}{ZR} + \rho \left.\frac{\partial h}{\partial P}\right|_{\rho} - 1\right) V \frac{dP}{dt} = \dot{m}_{g,brk}\left((h_{g,brk} - h_{stm}) + \frac{c_p}{ZR}\frac{P_{stm}}{\rho_{stm}}\right) + \dot{m}_f \frac{c_p}{ZR}\frac{P}{\rho_f}$$

$$+ \sum_j \left[\dot{m}_{stm,j}\left((h_{stm,j} - h_{stm}) + \frac{c_p}{ZR}\frac{P_{stm}}{\rho_{stm}}\right) + h_{q,j}A_j(T_{if,j} - T)\right]$$

$$\text{ideal gas:} \quad \frac{c_v}{R} V \frac{dP}{dt} = \dot{m}_{g,brk}\left((h_{g,brk} - h_{stm}) + \frac{c_p}{R}\frac{P_{stm}}{\rho_{stm}}\right) + \dot{m}_f \frac{c_p}{R}\frac{P}{\rho_f}$$

$$+ \sum_j \left[\dot{m}_{stm,j}\left((h_{stm,j} - h_{stm}) + \frac{c_p}{R}\frac{P_{stm}}{\rho_{stm}}\right) + h_{q,j}A_j(T_{if,j} - T)\right]$$

(63)

The ideal gas form results from the real gas form with $Z = 1$ and $\partial h/\partial P = 0$.

Following the work of Wulff (Reference 12, Section 4.1), the symbol X is used to represent compliance, the coefficient that multiplies the right hand term VdP/dt. The symbol $\Lambda = (c_p/ZR)P_{stm}/\rho_{stm}$ represents the mechanical response function, the pressure response to mass injection. It can be shown that $(c_r/ZR)P_{stm}/\rho_{stm} = \rho\, \partial h/\partial \rho\,|_P$, the mechanical response function defined by Wulff (Reference 12, Section 4.1). With these substitutions:

$$XV\frac{dP}{dt} = \dot{m}_{g,brk}(h_{g,brk} - h_{stm}) + \Lambda\dot{m}_{g,brk} + / \quad \frac{\rho_{stm}}{tm}\frac{P}{\rho_f}$$

$$+ \sum_j \dot{m}_{stm,j}(h_{stm,j} - h_{stm}) + \Lambda\sum_j \dot{m}_{stm,j} + \sum_j h_{q,j}A_j(T_{if,j} - T)$$

(64)

sinks are always small. The pi groups clearly show the importance of mass transfer as the process that dominates the rate of pressure change after blowdown.

Volumetric compliance, $\pi_{p,\tau}$, is always a significant factor that mitigates the rate of pressure rise.

Table 8-5 Containment and Heat Sink Pressure Scaling Pi Group Values**

Pi Group		Blowdown	Refill	Peak Pressure	Long Term	MSLB
Containment	$\pi_{p,\tau}$	0.75	0.74	0.75	0.74	0.74
	$\pi_{p.g.brk.wmec}$	1.00	0.00*	1.00*	1.00	1.00
	$\pi_{p.g.brk.enth}$	0.03	0.00	0.03	0.02	0.03
Drops	$\pi_{p.mec.d}$	0.05	-0.04	0.01	0.00	–
Pool	$\pi_{p.mec.p}$	0.04	0.00	0.03	0.07	–
Steel	$\pi_{p.q.st}$	-0.01	-0.25	-0.09	-0.00	-0.10
	$\pi_{p.mec.st}$	-0.05	-1.41	-0.69	-0.02	-0.44
Concrete	$\pi_{p.q.cc}$	0.00	-0.01	0.00	-0.01	-0.03
	$\pi_{p.mec.cc}$	-0.01	-0.08	-0.02	-0.09	-0.12
Jacketed Concrete	$\pi_{p.q.jc}$	0.00	-0.08	-0.03	-0.01	-0.02
	$\pi_{p.mec.jc}$	-0.02	-0.46	-0.23	-0.18	-0.08
Evaporating Shell	$\pi_{p.q.es}$	–	–	-0.07	-0.08	–
	$\pi_{p.mec.es}$	–	–	-0.43	-0.90	–
Subcooled Shell	$\pi_{p.q.ss}$	–	–	0.00	-0.01	–
	$\pi_{p.mec.ss}$	–	–	-0.01	-0.06	–
Dry Shell	$\pi_{p.q.ds}$	0.00	-0.10	-0.01	-0.01	-0.07
	$\pi_{p.mec.ds}$	-0.02	-0.61	-0.03	-0.08	-0.37

* Refill was scaled with the same pressure normalization used for peak pressure.

** The pi groups $\pi_{p,f,work}$, $\pi_{p,q,d}$, $\pi_{p,q,p}$, $\pi_{p,enth,d}$, $\pi_{p,enth,p}$, $\pi_{p,enth,st}$, $\pi_{p,enth,cc}$, $\pi_{p,enth,jc}$, $\pi_{p,enth,es}$, $\pi_{p,enth,ss}$ and $\pi_{p,enth,ds}$ have no values greater than 0.005, so are not listed in this table.

14 REFERENCES

1. DELETED

2. "AP600 Standard Safety Analysis Report," Westinghouse Electric Corporation.

3. M. J. Loftus, D. R. Spencer, J. Woodcock, "Accident Specification and Phenomena Evaluation for AP600 Passive Containment Cooling System," WCAP-14812, Rev. ~~1~~ 2, ~~June 1997~~ April 1998, Westinghouse Electric Corporation.

4. J. Woodcock, et al., "WGOTHIC Code Description and Validation," WCAP-14382, May 1995, Westinghouse Electric Corporation.

5. "WGOTHIC Application to AP600," WCAP-14407, Rev. ~~1~~ 3, ~~July 1997~~ April 1998, Westinghouse Electric Corporation.

6. Letter, B. A. McIntyre (Westinghouse) to T. R. Quay (US NRC), "GOTHIC Version 4.0 Documentation," DCP/NRC0410, September 21, 1995.

7. Letter, B. A. McIntyre (Westinghouse) to T. R. Quay (US NRC), "Updated GOTHIC Documentation," DCP/NRC0419, October 12, 1995.

8. Letter, B. A. McIntyre (Westinghouse) to T. R. Quay (US NRC), "AP600 WGOTHIC Comparison to GOTHIC," DCP/NRC0429, November 13, 1995.

9. R. P. Ofstun, "Experimental Basis for the AP600 Containment Vessel Heat and Mass Transfer Correlations," WCAP-14326, Rev. ~~1~~ 3, ~~May 1997~~ April 1998, Westinghouse Electric Corporation.

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13. Letter, N. J. Liparulo (Westinghouse) to R. W. Borchardt (US NRC), "AP600 Passive Containment Cooling System Preliminary Scaling Report," NTD-NRC-94-4246, July 28, 1994. (Superseded by WCAP-14845).

27. P. F. Peterson, "Scaling and Analysis of Mixing in Large Stratified Volumes," *International Journal of Heat and Mass Transfer*, Vol. 37, Supplement 1, pp 97-106, 1994.

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29. W. D. Baines and J. S. Turner, "Turbulent Buoyant Convection from a Source in a Confined Region," *Journal of Fluid Mechanics*, Vol. 37, Part 1, pp 51-58, (1969).

30. W. Wulff, "Integral Methods for Simulating Transient Conduction in Nuclear Reactor Components," *Nuclear Engineering and Design* 151 (1994) 113-129.

31. W. A. Stewart and A. T. Pieczynski, "Tests of Air Flow Path for Cooling the AP600 Reactor Containment," WCAP-13328, 1992, Westinghouse Electric Company.

32. F. P. Incropera and D. P. DeWitt, *Fundamentals of Heat and Mass Transfer*, Second Edition, John Wiley & Sons.

33. K. R. Chun and R. A. Seban, "Heat Transfer to Evaporating Liquid Films," *Journal of Heat Transfer*, November 1971.

34. WCAP-13307, "Condensation in the Presence of a Noncondensable Gas-Experimental Investigation," Westinghouse Electric Corporation.

35. S. S. Kutateladze, I. I. Gogonin, N. I. Grigoreva, A. R. Dorokhov, "Determination of Heat Transfer Coefficient with Film Condensation of Stationary Vapor on a Vertical Surface," *Thermal Engineering*, 27 (4), 1980.

36. A. Bejan, Convection Heat Transfer, John Wiley and Sons, 1984, pp 159-164.

37. "WGOTHIC Application to AP600," WCAP-14407, Rev. ~~2~~ 3, Appendix 9.D ~~(To be Issued)~~ April 1998

38. Not Used.

39. G. Yadigaroglu, Derivation of General Scaling Criteria for BWR Containment Tests, International Conference on Nuclear Engineering, Vol. 2. ASME 1996.

40. H. Fossett, Some Observations on the Time Factor in ~~Making~~ Mixing Processes, Fluid Mechanics of Mixing, ASME, 1973.

Westinghouse
Electric Corporation

Energy Systems

Box 355
Pittsburgh Pennsylvania 15230-0355

DCP/NRC1415
NSD-NRC-98-5759
Docket No.: 52-003

August 17, 1998

Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, DC 2055

ATTENTION: T. R. Quay

SUBJECT: RESPONSE TO NRC LETTERS CONCERNING REQUEST FOR WITHHOLDING INFORMATION

Reference:

1. Letter, Donohew to Liparulo, "Request for withholding information from public disclosure for Westinghouse AP600 design letters of November 21, 1994," dated August 1, 1995.

2. Letter, McIntyre to Quay, "Status review of AP600 proprietary submittals," dated September 18, 1995.

3. Letter, Jackson to Liparulo, "Request for withholding information from public disclosure for Westinghouse AP600 design letters of June 20, 19954," dated November 16, 1995.

4. Letter, McIntyre to Quay, "WCAP-14845, 'Scaling analysis for AP600 containment pressure during design basis accidents', Rev 3. errata," DCP/NRC1379, dated June 9, 1998.

5. Letter, McIntyre to Quay, "Errata to WCAP-14407, Rev 3, 'WGOTHIC application to AP600'," DCP/NRC1395, dated July 14, 1998.

6. Letter, McIntyre to Quay, "Response to NRC letter of August 23, 1995, 'Request for withholding information in the design certification application for the AP600'," DCP/NRC1400, dated July 22, 1998.

Dear Mr. Quay:

Reference 1 provided the NRC assessment of the Westinghouse claim that proprietary information was provided in a letter dated November 21, 1994, that contained presentation materials from the November 15 through 17, 1994, meeting where the AP600 passive containment cooling system was discussed. The NRC assessment was that some, but not all, of the material was sufficiently specific to

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Enclosure 2

the AP600 and the AP600 passive containment cooling testing to reveal distinguishing aspects of the passive containment cooling system and improve a competitors advantage. Our 1995 request, Reference 2, indicated that the material provided in the Westinghouse letter of November 21, 1994, was presentation material that was intended for clarification only, not part of the formal review material and requested that the material be returned to Westinghouse. At the time this subject was being discussed with the NRC technical staff, the information was considered to be proprietary by Westinghouse since it contained information that had commercial value to Westinghouse. If this presentation material was indeed used by the staff in development of the AP600 final safety evaluation report, then at this time, almost four years later, this information will no longer considered to be proprietary by Westinghouse.

Reference 3 provided the NRC assessment of the Westinghouse claim that proprietary information was provided in a letter dated June 20, 1995, which provided a copy of WCAP-14382, "WGOTHIC Code Description and Validation." The NRC assessment was that all of the material identified as proprietary, with the exception of Figure 8-19, "Large scale PCS Instrumentation Elevations" would be accepted as proprietary by the NRC. The Reference 3 pointed out that this same figure was nonproprietary on page 3-12 of WCAP-14382. Figure 8-19, therefore, will no longer considered to be proprietary by Westinghouse.

Westinghouse has been verbally informed by the NRC that the Westinghouse letter of June 9, 1998, (reference 4), appeared to contain proprietary information that was not clearly identified other than being marked "Westinghouse Proprietary Class 2" on the page and also that there was no affidavit included with the letter. The June 9, 1998, letter contained errata for WCAP-14845, Revision 3, which is a proprietary report and for WCAP-14846, Revision 3, which is the nonproprietary version of WCAP-14845. In accordance with Westinghouse company policy, each page of a proprietary report has "Westinghouse Proprietary Class 2" on the page header. Specific information that is proprietary is then indicated with brackets. It is possible that there will be no information on a page that is marked as being proprietary. In the case of the June 9, 1998, letter, none of the errata pages for WCAP-14845 contained Westinghouse proprietary information, thus no affidavit was necessary and the letter can be placed in the NRC public document room.

Westinghouse has been verbally informed by the NRC that the Westinghouse letter of July 14, 1998, (reference 5), appeared to contain proprietary information that was not clearly identified other than being marked "Westinghouse Proprietary Class 2" on the page and also that there was no affidavit included with the letter. The July 14, 1998, letter contained errata for WCAP-14407, Revision 3, which is a proprietary report. In accordance with Westinghouse company policy, each page of a proprietary report has "Westinghouse Proprietary Class 2" on the page header. Specific information that is proprietary is then indicated with brackets. It is possible that there will be no information on a page that is marked as being proprietary. In the case of the July 14, 1998, letter, none of the errata pages for WCAP-14407 contained Westinghouse proprietary information, thus no affidavit was necessary and the letter can be placed in the NRC public document room.

On August 14, 1998, Westinghouse was verbally informed by the NRC that the information contained in Chapter 18 of Revision 0 of the AP600 Standard Safety Analysis Report (SSAR) that was submitted to the NRC on June 26, 1992, and was requested to be withdrawn by Reference 6, forms the basis of the Chapter 18 of the AP600 Final Safety Evaluation report that will soon be issued by the NRC and therefore cannot be withdrawn without seriously affecting the FSER issuance date. To maintain this information as proprietary, Westinghouse would have to provide a marked proprietary version and a corresponding nonproprietary version of this material. Reference 6 pointed out that Chapter 18 has been entirely reformatted since the SSAR was submitted originally as a result of Westinghouse significantly changing the approach being taken to human factors as a part of design certification. As a result, the information in Revision 0 through 8 of the SSAR is essentially no longer applicable to the AP600 design certification process, except for the information contained in Subsection 18.9.8.1 - Development of emergency operating procedures and Tables 18.9.8-1 through 18.9.8-37 - Emergency response guidelines, which was declared to be nonproprietary in Reference 6. Given the desire to complete the AP600 FSER and Final Design Approval in a timely manner, Westinghouse will no longer consider the material in Chapter 18 of Revisions 0 through 8 of the SSAR to be proprietary.

This response addresses the proprietary issues delineated in the references.

Brian A. McIntyre, Manager
Advanced Plant Safety and Licensing

jml

cc: J. W. Roe - NRC/NRR/DRPM
J. M. Sebrosky - NRC/NRR/DRPM
W. C. Huffman - NRC/NRR/DRPM
H. A. Sepp - Westinghouse

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