Westinghouse Electric Corporation
Energy Systems

Box 355
Pittsburgh Pennsylvania 15230-0355

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Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

ATTENTION: MR. T. R. QUAY

SUBJECT: UPDATED GOTHIC DOCUMENTATION

Dear Mr. Quay:

During the August 16, 1995 meeting between Westinghouse and the Containment Systems and Severe Accident Branch, Westinghouse took an action to provide updated GOTHIC documentation and a description of the significant differences in the solver portions of GOTHIC and Westinghouse-GOTHIC. Attachment 1 to this letter summarizes significant differences between the two codes. The updated GOTHIC documentation, applicable to Westinghouse-GOTHIC except as noted in this transmittal, was issued in NTD-NRC-95-4563.

The Westinghouse Electric Corporation copyright notice is also attached.

Please contact John C. Butler on (412) 374-5268 if you have any questions concerning this transmittal.

Brian A. McIntyre, Manager
Advanced Plant Safety and Licensing

/nja

cc: T. J. Kenyon, NRC
D. Jackson, NRC
J. Kudrick, NRC
E. Throm, NRC
P. Boehnert, ACRS
N. J. Liparulo, Westinghouse

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ATTACHMENT TO LETTER NTD-NRC-95-4577

GOTHIC DESCRIPTION

Introduction

This submittal summarizes the differences that have been identified through a comparison of the currently configured version of Westinghouse-GOTHIC_S, Version 1.2, and the QA-reviewed EPRI version of GOTHIC_S, Version 4.0, and the Westinghouse-GOTHIC_S models that are not used in the analysis of the AP600 and supporting tests.

Tables 1 and 2 provide a preliminary listing of those differences that represent a change in the actual calculations of the code. Differences such as comments or optimization of a given calculation are not included in the table since these types of changes do not alter the actual calculations. In addition, differences related to incorporating the Westinghouse passive cooling heat and mass transfer logic are omitted from the table since they are fully described in WCAP-14382.

Also included is a compilation of those models available in Westinghouse-GOTHIC_S code that were not used in the analysis of the AP600 containment. These models were also not used during supporting analysis of large scale and single effects test analyses, and can therefore be excluded from the AP600 review.

This submittal completes a commitment to describe the significant differences between GOTHIC Version 4.0 and Westinghouse GOTHIC_S Version 1.2, and to provide updated documentation applicable to Westinghouse-GOTHIC_S.

The EPRI Quality Assurance reviewed GOTHIC solver Version 4.0 has been compared to WGOTHIC solver version 1.2. The WGOTHIC solver is based on GOTHIC Version 3.4c which was a recent predecessor to the version of the solver supplied for the final design review. Version 3.4d was the basis for the design review of the code package. Incorporation of the comments from the design review resulted in the creation of GOTHIC_S Version 4.0.

Since the two versions have very close revision numbers it was expected that the differences would be few and minor. The tables below summarize the differences that were found between the two codes. The result of the comparison is that the largest difference between the two code versions is the incorporation of the Westinghouse passive cooling routines and logic. The incorporation of the passive cooling routines involved new subroutines along with links back into the GOTHIC_S mass and energy equations.

In all routines there were differences in the comments, optimization of calculations, etc. This caliber of differences will not affect the code and are not reflected in the table below; only those differences that alter the calculations in the solver are presented below. Differences resulting from the incorporation of the Westinghouse passive cooling system models are not reflected in the tables. These differences are discussed in detail in WCAP-14382.

The first table consists of those differences that have been determined to have a negligible impact on the code and resultant calculations. The criteria used to conclude that these differences are insignificant were first, the differences between the two versions are numerically small, or second, the differences are in models and routines that are not exercised in the analyses supporting the AP600.

The second table contains those differences that may have an effect on the calculations made to support the AP600 containment design. These differences are slightly more substantial with respect to the AP600 and require additional evaluation; however, it is judged that these differences will also have a negligible effect on the results of the analyses and will therefore not alter the conclusions that have been drawn from those analyses. The basis for this is that the entire GOTHIC Code Qualification document was regenerated using Version 4.0 of the solver. The results of the re-analyses are essentially the same as those contained in the Version 3.4 Code Qualification Document.

Table:1 Identified Differences Between GOTHIC_S Version 4.0 and WGOTHIC_S Version 1.2 Determined to be Negligible

ROUTINE	DESCRIPTION	GOTHIC Version 4.0	WGOTHIC Version 1.2
blkdat.f	Coefficient used to calculate saturated liquid enthalpy	0.005245502294	0.005245502284
boiling.f	Film thickness calculation for use in calculating the single phase liquid heat transfer coefficient	$\{0.5*d_h*(1.-(1-liq\_frac)^{0.5})\}/wet\_frac$	$\{0.25*d_h*liq\_frac\}/wet\_frac$

Table:1 Identified Differences Between GOTHIC_S Version 4.0 and WGOTHIC_S Version 1.2 Determined to be Negligible

ROUTINE	DESCRIPTION	GOTHIC Version 4.0	WGOTHIC Version 1.2
boiling.f	Version 4.0 deleted the logic setting the minimum single liquid and vapor heat transfer coefficient to $3.66*k/d_h$	hspl=(0.023*rel$^{.8}$*prl$^{.4}$)*xkliq/de hspv=(.023*reg$^{.8}$*prmix$^{.4}$)*cmix/de	hspl=max(3.66,.023*rel$^{.8}$*prl$^{.4}$)*xkliq/de hspv=max(3.66,.023*reg$^{.8}$*prmix$^{.4}$)*cmix/de
condin.f	Corrected conversion factor from Watts/m^2 to Btu/hr*ft^2 when specifying a fixed surface heat flux	0.08805	0.317
intfr.f	Corrected the calculation of the average small bubble radius	rbub=min(rbub,0.5*d_{hyd},0.02)	rbub=min(rbub,1.0*d_{hyd},0.04)
intfr.f	Deleted a small bubble heat transfer coefficient calculation option	hshlv=(2.0+0.74*reb$^{0.5}$*prl$^{0.333}$)*ykf*dbubi	hshlv=max[(2.0+0.74*reb$^{0.5}$*prl$^{0.333}$)*ykf*dbubi, rlp*(hlt-hf)*ykf*dbubi/(rvp*(hf-hg))]
intfr.f	Corrected the minimum droplet interfacial drag coefficient	cdd=4.0	cdd=0.45
intfr.f	Added logic to determine terminal velocities for droplets in various regimes	laminar solid sphere distorted drop limit	drop limit
intfr.f	Reinstituted droplet deentrainment on horizontal surfaces	Available	Not available
solids.f	Version 4.0 permits a time dependent multiplier on the ice heat transfer coefficient.		
tpress.f	Calculation of liquid and vapor strain rates	d32l(jj,j)=d32l(jj,j)+0.25*dvdzl d32v(ii,j)=d32v(ii,j)+0.25*dvdzv	d32l(jj,j)=d32l(jj,j)+0.125*dvdzl d32v(ii,j)=d32v(ii,j)+0.125*dvdzv

Table:2 Identified Differences Between GOTHIC_S Version 4.0 and WGOTHIC_S Version 1.2 Judged to be Insignificant

ROUTINE	DESCRIPTION	GOTHIC Version 4.0	WGOTHIC Version 1.2
heat.f	Modified the method used to calculate the minimum effective film thickness	[0.5*d_h*(1.-(1-liq_frac)$^{0.5}$)]/wet_frac	[0.25*d_h*liq_frac]/wet_frac
heat.f	Corrected modifier on smoothing method for the Uchida correlation	htcvu=htcvu+(htcvt-htcvu)*exp$^{(-0.025*tpast)}$	htcvu=htcvu+(htcvt-htcvu)*exp$^{(-0.05*tpast)}$
heat.f	Removed old time weighting from direct wall condensation and Tagami	htcvs(isd,n)=xvap*hvl	htcvs(isd,n)=(xvap*hvl)$^{0.1}$*max(one,htcvs(isd,n))$^{0.9}$

Table:2 Identified Differences Between GOTHIC_S Version 4.0 and WGOTHIC_S Version 1.2 Judged to be Insignificant

ROUTINE	DESCRIPTION	GOTHIC Version 4.0	WGOTHIC Version 1.2
newdlt.f	Gravity driven flow time step limit logic increased	delgmx=delt*0.5/dgmx	delgmx=delt*1.0/dgmx
post3d.f	Version 1.2 forces the change in vertical mass flow per change in pressure to zero for all cells connected to a pressure boundary condition.		
post3d.f	Version 4.0 recalculates gas densities during update for temporal and phase change calculation		
setin.f	Revised the lower limit for the Uchida heat transfer coefficient	humin=2.	humin=15.

The following list of GOTHIC_S Version 4.0 models were not used in the analysis of the AP600 containment and supporting analyses of tests using the WGOTHIC_S Version 1.2:

Gido-Koestel Condensation
Tube and Rod Conductors
Components
- Pumps and Fans
- Valves
- Heat Exchangers
- Vacuum Breakers
- Spray Nozzles
- Coolers
- Volumetric Fans

Coupled Boundary Conditions