December 1, 2003

Mr. Gordon Bischoff, Manager
Owners Group Program Management Office
Westinghouse Electric Company
P.O. Box 355
Pittsburgh, PA 15230-0355

SUBJECT: FINAL SAFETY EVALUATION FOR TOPICAL REPORT WCAP-15996-P, "TECHNICAL DESCRIPTION MANUAL FOR THE CENTS CODE" (TAC NO. MB6982)

Dear Mr. Bischoff:

On December 13, 2002, and February 19, 2003, the Westinghouse Owners Group (WOG) submitted Topical Report (TR) WCAP-15996-P, "Technical Description Manual for the CENTS Code" to the staff. On October 6, 2003, an NRC draft safety evaluation (SE) regarding our approval of WCAP-15996-P was provided for your review and comments. By letter dated October 31, 2003, the WOG commented on the draft SE. The staff's disposition of the WOG's comments on the draft SE are discussed in the attachment to the final SE enclosed with this letter. The red-line and strikeout version of the SE, along with numbering the lines of the SE, was very helpful in reviewing your comments. In the future, it would be helpful if you numbered the comments in the table in addition to providing the SE line numbers.

The staff has found that WCAP-15996-P is acceptable for referencing in licensing applications for Westinghouse and Combustion Engineering designed pressurized water reactors to the extent specified and under the limitations delineated in the report and in the enclosed SE. The SE defines the basis for acceptance of the report. The dose model portion of the CENTS code is being reviewed separately and will be the subject of a separate SE.

Our acceptance applies only to material provided in the subject report. We do not intend to repeat our review of the acceptable material described in the report. When the report appears as a reference in license applications, our review will ensure that the material presented applies to the specific plant involved. License amendment requests that deviate from this topical report will be subject to a plant-specific review in accordance with applicable review standards.

In accordance with the guidance provided on the NRC website, we request that the WOG publish an accepted version of this topical report within three months of receipt of this letter. The accepted version shall incorporate this letter and the enclosed SE between the title page and the abstract. It must be well indexed such that information is readily located. Also, it must contain in appendices historical review information, such as questions and accepted responses, draft SE comments, and original report pages that were replaced. The accepted version shall include a "-A" (designating accepted) following the report identification symbol.

If the NRC's criteria or regulations change so that its conclusions in this letter, that the topical report is acceptable, is invalidated, the WOG and/or the licensees referencing the topical report will be expected to revise and resubmit its respective documentation, or submit justification for the continued applicability of the topical report without revision of the respective documentation.

Sincerely,

/RA/

Herbert N. Berkow, Director
Project Directorate IV
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Project No. 694

Enclosure: Safety Evaluation

cc w/encl:
Mr. J. S. Galembush, Acting Manager
Regulatory Compliance and Plant Licensing
Westinghouse Electric Company
P.O. Box 355
Pittsburgh, PA 15230-0355

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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

TOPICAL REPORT WCAP-15996-P, "TECHNICAL DESCRIPTION MANUAL FOR THE CENTS CODE"

WESTINGHOUSE OWNERS GROUP

PROJECT NO. 694

1.0 INTRODUCTION

By letters dated December 13, 2002, and February 19, 2003, the Combustion Engineering Owners Group (now part of the Westinghouse Owners Group [WOG]) submitted Topical Report (TR) WCAP-15996-P, "Technical Description Manual for the CENTS Code" (References 1 and 2), to the NRC staff for review and approval of the transient analysis methodology described therein for licensing applications with regard to both Combustion Engineering- (CE) and Westinghouse-designed pressurized water reactors (PWRs). By letter dated June 13, 2003, the WOG provided responses to the staff's request for additional information (RAI) (Reference 3). WCAP-15996-P is an update of CENPD-282-P-A (Reference 4); the latter was previously reviewed and approved by the staff for application to CE-designed PWRs (Reference 5), and subsequently the staff extended this approval to Westinghouse-designed PWRs (Reference 6). Central to the methodology described and discussed at length in both submittals is the CENTS computer code. This review focuses on, although is not limited to, the changes made to the CENTS code, between the approved version described in CENPD-282-P-A and the improved version described in WCAP-15996-P. The changes were made to more accurately model plant systems and transient behavior of the reactor system. To assist the staff in the review, the WOG prepared a "Roadmap" that identified the changes made to the original TR, CENPD-282-P-A, and the rationale for the changes. This review relies to a great extent, although not exclusively, on the submitted "Roadmap."

TR WCAP-15996-P will, on approval, supercede CENPD-282-P-A; the latter was previously found acceptable by the staff for referencing in licensing actions with respect to the calculation of transient behavior in PWRs. CENPD-282-P-A may continue to be utilized as it was originally approved by the NRC. In particular, the evaluation and approval of the models in the CENTS code, central to the CENPD-282-P-A methodology, are limited to non-loss-of-coolant accident (LOCA) licensing analyses. That is, CENTS is not approved for demonstrating compliance to 10 CFR 50.46 acceptance criteria. It is, however, acceptable when used to model small breaks in the primary system that can be classified as LOCAs for the purpose of demonstrating compliance to non-LOCA regulatory acceptance criteria. For example, CENTS is used to evaluate the dose consequences of steam generator tube rupture and letdown line break events. The qualification of the previous versions of the CENTS code was based on CENTS predictions of startup measurements, operating transients, and comparisons to calculations made with the staff-approved design codes CESEC, CEFLASH-4AS, and RELAP 5/MOD 3. Since model upgrades to the CENTS code are under review, the staff evaluated differences in the predictions of the originally approved code version and those of the upgraded CENTS version described in WCAP-15996-P for the most limiting design basis events. The basis for the approval of WCAP-15996-P is that any variance from previous results due to the model changes precludes exceeding the safety-related limits on which the approved CENPD-282-P-A methodology was based.

2.0 REGULATORY EVALUATION

Section 50.34 of Title10 of the *Code of Federal Regulations* (10 CFR) contains requirements for the analysis of abnormal plant operating events by licensees. NUREG-0800, "Review of Safety Analysis Reports for Nuclear Power Plants," provides guidelines to licensees and the staff for evaluating these types of events. Section 50.71 requires licensees to update the final safety analysis report (FSAR) for a given plant periodically. Included in the FSAR are the descriptions of abnormal events and accidents for which a given plant is analyzed. These are typically referred to as Chapter 15 analyses, corresponding to Chapter 15 of NUREG-0800.

The CENTS code is intended to provide analysis capability in the areas of engineering, operations and training. It also is intended to provide evaluation capabilities for transient events, accidents, operator actions, design and scoping studies. Under this review, it is specifically being evaluated for non-LOCA Chapter 15 analyses for PWRs.

3.0 SUMMARY OF WCAP-15996-P

The WOG submittals identified the specific changes that have been incorporated into the CENTS code since its previous approval. These modifications can be grouped into two classes: those that do not have an impact on the computed results and those that do affect the computed results.

In the former class are the editorial changes to the descriptions in CENPD-282-P-A with regard to the models of the bubble rise velocity used in the heat transfer coefficient for bubble condensation and the annulus bubble release rate. Both changes bring the text in the TR into conformance with the correct and previously approved coding in the CENTS code. The staff approves these changes. Westinghouse also requested a clarification of the restriction on the use of the CENTS code for application to control element assembly (CEA) ejection licensing analyses. With regard to CEA ejection licensing analyses, the safety evaluation for CENPD-282-P-A states, "... CENTS is not approved for performing CEA ejection licensing analyses." The rationale for this restriction is stated as "Benchmarking for the CEA ejection transient has not been provided...." A sui generis application of the CENTS code to a CEA ejection event has been reviewed and approved by the staff (Reference 7). The staff will continue to entertain, on a case-by-case basis, such analyses for review.

The WOG has added a new dose assessment model to the CENTS computer code that has the capability to calculate offsite dose due to an accident condition. Westinghouse has indicated that this model is essentially the same as the currently employed hand-calculated assessments used to determine dose consequences. The WOG has indicated that the benefit offered by the incorporation of the new dose model is the improved accuracy afforded by performing more exact iodine tracking and release calculations.

NRC review of this new dose assessment model is ongoing. Pending final approval, applicants may use the new model. Until such time as the new CENTS dose assessment model is approved by the NRC, the NRC will review each licensee’s dose assessment on a case-by-case basis.

3.1 Model Changes

To technically justify those upgrades to the CENTS code that provide new modeling capabilities or provide more detail and accuracy for existing models, and, thereby have an impact on the computed results, the WOG performed benchmark testing. There are four such modifications to the CENTS code considered in this review; review of the fifth, a modification in the dose model, is ongoing as discussed in Section 3.0.

3.1.1 Core Channel Heat Transfer Model Upgrade

The original channel enthalpy model ignores the heat capacity of the fluid, and is based on the assumption that the change in the enthalpy over a computational section is negligible relative to the transport-time constant over the section. The new version of the CENTS code allows for a time-dependent change in the enthalpy in a computational section by taking into account the heat capacity of the liquid. The differential equation for the rate of change of enthalpy in a computational section is solved analytically. Thus, this new option not only takes into account the heat capacity of the fluid, but also precludes any numerical instability that might be introduced through a finite-difference solution for large time steps.

3.1.2 Steam Generator (SG) Tube Nodalization Model with Sectional Coolant Enthalpy

The updated SG model consists of an increase in the number of active-tube nodes per SG. Within each of the active-tube nodes of each SG tube, an internal calculation tracks a detailed temperature profile for the coolant and the tubes. For this purpose, each tube node is divided into multiple subsections; the number of sections in each tube node is specified via input. This more detailed nodalization of the primary side of the SG is provided as an option to support the enhanced tube heat transfer model described above.

3.1.3 Multiple Node Reactor Pressure Vessel (RPV) Downcomer Model

The updated CENTS code contains an option for a more detailed nodalization in the reactor vessel downcomer. This modification, by introducing both axial and azimuthal nodalization, improves the simulation of the asymmetric effects in the loops of the reactor coolant system (RCS).

3.1.4 Detailed Main Feedwater Model

For the previously approved simplified feedwater line model, the feedwater flowrate delivered by the pumps is specified directly by the control system for each SG. The model feeds the indicated flows to the SGs unless a feedwater line break has occurred. In the latter case, the break flow from the feedwater lines is calculated by the homogeneous equilibrium model, or if the flow is choked, by the Henry-Fauske correlation.

The updated CENTS code allows discrete main feedwater (MFW) and auxiliary feedwater (AFW) models. This capability enables accurate, time-dependent transient simulation of the MFW and AFW systems. The models are predicated on the availability of a network of discrete MFW and AFW components and piping through user developed and specified input. Thus, the system network is adaptable to different plant designs.

4.0 EVALUATION

Benchmark testing consisted of code comparisons for six events:

1. Main Steamline Break
2. Feedwater Line Break
3. Control Element Assembly Withdrawal from Sub-critical Conditions
4. Control Element Assembly Withdrawal from Hot Zero Power Conditions
5. Reactor Coolant Pump Seized Rotor
6. SG Tube Rupture

These are viewed as the most limiting design basis events in this review.

To test that all the minor code modifications and error corrections made since 1994 have not had a significant net effect, the above six cases were run with the new version of the CENTS code with the upgrade models described above deactivated. No significant variances in the results were observed when compared to the results from the previously approved version. They are judged to preclude exceeding the safety-related limits on which the approval of the CENPD-282-A methodology is based. The staff accepts that the new version of the CENTS code (with the model upgrades described above deactivated) is comparable to the previously accepted version and that it continues to be acceptable to use CENTS in this manner.

The model upgrades in the new version of the code consist, as a whole, of a more realistic description of physical phenomena and a more detailed description of system components. As such, they will lead to more realistic and accurate results. These results may be noticeably different from those obtained with the previously approved version. To demonstrate that the new models lead to correct results, a second set of comparisons for the same general scenarios was made with all the CENTS upgrade models activated. To isolate the effect of the individual upgrades and evaluate their phenomenological behavior, the upgrades were also separately activated.

The new models in the CENTS code induce the following main changes in the results of the six benchmark cases.

4.1 Main Steamline Break

The new models cause a slightly more severe and rapid blowdown of the affected SG which results in a deeper drop in the core temperatures. This drop in core temperature has a reactivity worth of +0.0023 $\Delta\rho$ compared to the upgraded version with model changes deactivated. This change in reactivity is far from sufficient to induce a return to power; it is conservative. The staff accepts that the CENTS code with the new models continues to give conservative results for this event.

4.2 Feedwater Line Break

The upgrade models, together and individually, result in greater system flow to the intact SG. This results in lower long-term RCS temperatures and pressures, and less swell into the pressurizer. The regulatory acceptance criterion for this event, with a limiting single failure, is that the peak RCS pressure must be less than 120 percent of the RCS design pressure. The staff accepts that the CENTS code with the new models continues to give conservative results with respect to this criterion for this event.

4.3 Control Element Assembly Withdrawal from Sub-critical Conditions

The only upgrade that has a significant effect on the results in this event is the channel heat transfer model. The improved modeling of the core fluid heat capacity reduces the positive moderator temperature reactivity feedback, and, thereby, lowers the peak power from ~119 percent to ~105 percent of nominal. The improved modeling reduces the code conservatism, however, it is physically based and is acceptable to the staff.

4.4 Control Element Assembly Withdrawal from Hot Zero Power Conditions

As in the previous event, the only upgrade that has a significant effect on the results is the channel heat transfer model. The improved modeling of the core fluid heat capacity reduces the positive moderator temperature reactivity feedback, and, thereby, lowers the peak power from ~106 percent to ~101 percent of nominal. It is acceptable to the staff as described above.

4.5 Reactor Coolant Pump Seized Rotor

The comparison of results between the upgraded CENTS code with models deactivated and activated shows good agreement, and, thereby, precludes exceeding safety-related limits on which the approved CENPD-282-P-A methodology was based. It is therefore acceptable to the staff.

4.6 SG Tube Rupture

The SG tube rupture event is a penetration of the barrier between the RCS and the main steam system due to the failure of a steam generator U-tube. The integrity of the barrier between the RCS and the main steam system is significant from the radiological release standpoint. The limiting event considered is a double-ended rupture of a SG tube with concurrent loss of alternating current (AC) power. Both phenomenologically and quantitatively, the comparison of thermal-hydraulic plant response parameters between the CENTS code with and without the upgraded model is excellent. The safety-related consequences for this event are mainly predicated on the dose model. The dose model portion of the CENTS code is presently under review by the staff as discussed in Section 3.0.

Although this review is based solely on the results of the above comparisons of benchmark calculations, the WOG has submitted results of a comparative analysis of a main steamline break event and a feedwater line break computed with CENTS with upgrades and RELAP5/MOD3 (Reference 8). The agreement is good, and, furthermore, gives some insight into the effectiveness of the model upgrades in the CENTS code.

5.0 CONCLUSIONS

The staff has reviewed TR WCAP-15996-P and the supporting documentation sent in response to the staff's request for additional information. On the basis of this review, the staff approves the transient methodology described in WCAP-15996-P for referencing in licensing actions with respect to the calculation of transient behavior in PWRs designed by CE and by Westinghouse, subject to the limitations stated below. These limitations were placed on the approval of the CENPD-282-P-A methodology and apply to WCAP-15996-P methodology, approved herein. This does not include approval of the CENTS code dose model. The dose model portion of the CENTS Code is under NRC review at this time. The CENTS code dose model will be evaluated separately.

1. <u>CENTS departure from nucleate boiling ratio (DNBR) analysis</u>: The CENTS DNBR calculation for determining overall trends in thermal margin should not be used for licensing analyses. The DNBR licensing analyses should be performed with the presently approved CE DNBR methods.

2. <u>Limitation to CE and Westinghouse Type Plants</u>: The application of CENTS is limited to PWRs of CE and Westinghouse design.

3. <u>LOCA and Severe Accident Analysis</u>: Adequate benchmarking of the CENTS LOCA and severe accident capabilities has not been provided. Consequently, CENTS should not be used for performing LOCA or severe accident licensing analyses. CENTS is not approved for demonstrating compliance to 10 CFR 50.46 criteria. It is; however, acceptable for use in modeling small breaks in the primary system that can be classified as LOCAs for the purpose of demonstrating compliance to non-LOCA regulatory acceptance criteria.

4. <u>Three-Dimensional Core Neutronics</u>: Benchmarking for the CENTS three-dimensional core neutronics capability has not been provided. Consequently, licensing applications of CENTS should be based on a point kinetics model.

5. <u>CEA Ejection Analyses</u>: This review does not give general approval for the application of CENTS simulations of a CEA ejection transient for licensing analyses. The staff will consider and review such requests on a case-by-case basis. This portion of the CENTS code remains under review at this time.

6.0 REFERENCES

1. Letter, G. S. Pavis (CEOG) to USNRC Document Control Desk, "Submittal of Combustion Engineering Owners Group Reports: WCAP-15996-P, and WCAP-15996-NP, entitled 'Technical Description Manual for the CENTS Code'," CEOG-02-256, December 13, 2002.

2. Letter, G. S. Pavis (CEOG) to USNRC Document Control Desk, "Submittal of Combustion Engineering Owners Group Reports: WCAP-15996-P, Volume 4 and WCAP-15996-NP, Volume 4 entitled 'Technical Description Manual for the CENTS Code'," WOG-03-76, February 19, 2003.

3. Letter, R. H. Bryan (WOG) to USNRC Document Control Desk, "Response to Request for Additional Information Related to the Westinghouse CENTS Topical Report (WCAP-15996-P)," WOG-03-305, June 13, 2003.

4. CENPD-282-A, Rev. 0, "Technical Description Manual for the CENTS Code."

5. Letter, M. J. Virgilio (NRC) to S. A. Toelle (ABB-CE), "Acceptance for Referencing of Licensing Topical Report CENPD-282-P, 'Technical Manual for the CENTS Code'," March 17, 1994.

6. Letter, R. C. Jones (NRC) to S. A. Toelle (ABB-CE), "Acceptance for Referencing of Licensing Topical Report CENPD-282-P, Vol. 4, 'Technical Manual for the CENTS Code'," February 24, 1995.

7. Letter, L. R. Wharton (NRC) to G. R. Overbeck (APS), "Palo Verde Nuclear Generating Station, Units 1, 2, and 3 - Issuance of Amendments re: Various Administrative Controls (TAC Nos. ME1668, MB1669, and MB1670)," October 15, 2001.

8. RELAP5/MOD3 Code Manual, NUREG/CR5535, INEL-95/0174, Vol. 1.

Attachment: Disposition of Comments on Draft SE

Principal Contributor: Yuri Orechwa

Date: December 1, 2003

DISPOSITION OF COMMENTS RECEIVED FROM WOG ON
THE DRAFT SAFETY EVALUATION OF WCAP-15996

This table identifies and tracks the resolution of comments received from the WOG on October 31, 2003.

Comment Number	Comment Description A = comment accepted; PA = comment partially accepted; R = comment rejected
1	Suggest incorporating reference for submittal of CENTS Volume 4. A
2	Suggest incorporating reference for submittal of CENTS RAI responses. A
3	Update reference numbers due to previous incorporation of additional references. A
4	Request for clarification of the intent of the word “supercede” on Line #29. A
5	Suggest incorporating a more specific statement regarding CENTS usage with respect to analysis of LOCAs. A
6	Editorial R – staff prefers original wording.
7	Suggest incorporating a more complete statement regarding staff-approved design codes against which CENTS was originally benchmarked. Also, suggest deleting reference. A
8	Editorial A
9	Suggest incorporating a more specific statement regarding CENTS usage. PA
10	Suggest incorporating specific reference to the sui generis application the SE refers to and also update reference number. PA
11	Suggest incorporating a more specific constraint clarification regarding use of CENTS for a portion of a CEA ejection evaluation, as indicated. R – This comment involves an item that is still under review.
12	Suggest incorporating a more specific statement regarding the dose model assessment. A
13	Suggest incorporating a more specific section title. A
14	Suggest changing section title to eliminate proprietary information. A
15	Suggest deleting text to eliminate proprietary information. A
16	Change "channel" to “tube” to clarify that it is steam generator and not core heat transfer that is being discussed. A
17	If SE statement is a limitation, it would seem to follow that it should be included in the Conclusion section where the NRC lists limitations. A

DISPOSITION OF COMMENTS RECEIVED FROM WOG ON
THE DRAFT SAFETY EVALUATION OF WCAP-15996

Comment Number	**Comment Description** **A = comment accepted; PA = comment partially accepted;** **R = comment rejected**
18	Suggest incorporating a more specific clarification regarding use of updated CENTS version in a manner which replicates the previously accepted version of the code. A
19	Editorial PA
20	Suggest incorporating a more specific statement regarding the dose model assessment. PA
21	Update reference number A
22	Suggest incorporating a more specific statement regarding the dose model assessment. PA
23	Suggest incorporating a more specific statement regarding CENTS usage with respect to analysis of LOCAs. A
24	Suggest incorporating a more specific constraint clarification regarding use of CENTS for a portion of a CEA ejection evaluation, as indicated. R – This item involves an issue still under review.
25	Correction of submittal reference. A
26	Incorporation of submittal reference for CENTS Volume 4. A
27	Incorporation of submittal reference for CENTS RAI responses. A
28	Update reference number. A
29	Update reference number. A
30	Update reference number and correct document number. A
31	Incorporate reference for CEA ejection event sui generis application. A
32	Incorporate reference for RELAP5/MOD3. A

DISPOSITION OF COMMENTS RECEIVED FROM WOG ON
THE DRAFT SAFETY EVALUATION OF WCAP-15996

Comment Number	Comment Description A = comment accepted; PA = comment partially accepted; R = comment rejected
33	Incorporate reference for CENPD-190-A, CEA ejection methodology. A
34	Delete incorrect reference to CEFLASH-4AS. A
35	RELAP5/MOD3 reference is now Reference 8. A