UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

In the Matter of	)	
UNITED STATES DEPARTMENT OF ENERGY	)	Docket No. 50-537
PROJECT MANAGEMENT CORPORATION	)	
TENNESSEE VALLEY AUTHORITY	)	
(Clinch River Breeder Reactor Plant)	)	

APPLICANT'S UPDATED RESPONSE TO
NATURAL RESOURCES DEFENSE COUNCIL, INC.,
AND SIERRA CLUB INTERROGATORIES (THIRD,
SEVENTH, EIGHTEENTH, AND NINETEENTH SETS)

Pursuant to 10 CFR paragraph 2.740b, the United States Department of Energy, Project Management Corporation, and the Tennessee Valley Authority (the Applicants) hereby update their updated responses to the Natural Resources Defense Council, Inc., and the Sierra Club Third, Seventh, Eighteenth, and Nineteenth Sets of Interrogatories previously submitted by Applicants on April 28, 1982; April 30, 1982; May 4, 1982; and June 15, 1982; respectively.

DS03

THIRD INTERROGATORY SET

QUESTION II (GENERAL)

Request for the following information is based on our concerns with respect to Validation (iii) and (iv) above. In the Applicant's answers to the generic questions (b) and c) below, the Applicant is requested to be responsive to these concerns.

With respect to each statement, assertion or assumption from Section F6.2 of the PSAR identified below, please provide the following information (unless noted otherwise). (NOTE: The following numbered Interrogatories are identified by the page and/or paragraph number from the PSAR in parenthesis.) [Where appropriate, the parts of the question have been restated to reflect the protocol for discovery agreed to by Applicants, Staff, and Intervenors NRDC et al.]

e) Explain whether Applicants are presently engaged in or intend to engage in any further research or work which may affect Applicants' answer. This answer need be provided only in cases where Applicants intend to rely upon ongoing research not included in Section 1.5 of the PSAR at the LWA or construction permit hearings on the CRBR. Failure to provide such an answer means that Applicants do not intend to rely upon the existence of any such research at the LWA or construction permit hearings on the CRBR.

ANSWER II (GENERAL)

(e) The Applicants have defined the areas of ongoing work in Section 1.5 of the PSAR and Appendix A of CRBRP-3. No other work is in progress which is expected to change Applicants' answer in this area for the CP hearing.

QUESTION II-15

(F6.2-95, par. 2) Generic answers (a) and (b) are not required.

(c) Provide more detailed models of possible phenomena and events taking place between clad melting and fuel dispersal above the gas plenum region, giving estimates of the time sequence of events, material description, movements and relocations.

ANSWER II-15(c)

Presently available models of the phenomena and events taking place between clad melting and fuel dispersal during the initial stages of core disruption are those used by the Applicant in CRBRP-GEFR-00103, CRBRP-GEFR-00523, and J. E. Cahalan, et al. analysis[1], i.e., SAS3D, PLUTO 1, and PLUTO 2. The Applicants'

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1 J. E. Cahalan, et al., "An Assessment of the Unprotected LOF Accident at EOC-4 in the CRBRP Heterogeneous Core Design," contained in HQ:S:82:162, J. R. Longenecker to P. S. Check, "Additional Information on Energetics Analysis for the CRBRP," Dec. 23, 1982.

updated analysis of fuel penetration into assembly rod structure is given in Section 8.2.2 of CRBRP-GEFR-00523.

SEVENTH INTERROGATORY SET

NOTE: Question 15 pertains to a postulated fuel assembly flow blockage accident.

QUESTION 15(a)

Has this accident (with and without SCRAM) been analyzed (calculated) to determine the course it could take (see p. F3-19).

ANSWER 15(a)

This event has not been analyzed since a complete flow blockage is precluded by the design. However, the consequences are considered to be enveloped by the TOP and LOF events analyzed in detail in CRBRP-GEFR-00523.

Since the Fermi blockage incident, major changes have been introduced in the design of fuel assemblies and the inlet structures to preclude fuel assembly inlet blockage. The design of the inlet nozzle of the fuel assembly and the inlet module and module liner are presented in Sections 4.2.1 and 4.2.2 of the PSAR, respectively.

QUESTION 25(s)

What is the status of the computer investigation proposed by Boudreau, et al., at Los Alamos? Have any been issued in report (including draft) form? If so, please provide these.

ANSWER 25(s)

The SIMMER code development suggested by Boudreau, *et al.*, is still in progress. Results have been published in NUREG-CR-3224, "An Assessment of CRBR Core Disruptive Accident Energetics," T. G. Theofanous and C. R. Bell, Los Alamos National Laboratory, March 1983.

EIGHTEENTH INTERROGATORY SET

I. Contentions 1, 2, 3

INTERROGATORY 11

The November 9, 1978 letter from William P. Gammill of the NRC Staff to Lochlin W. Caffey summarizes the Staff's position regarding the major unresolved CRBR safety issues at the time the CRBR licensing proceeding was suspended. Briefly describe Applicants' position in regard to Items I A, B, C, D, J; II A, B, C, D; III A, B; IV C, H, I; V A, B; VI A; VII A, B, C, D; VIII A, B, C; IX A, B, C, D, F, G, H.

RESPONSE 11

I. GENERAL

A. Control Room Design Conformance with CRBRP Criterion 17

2. PSAR Section 3.1.3.1 and Section 7.4.4 provided (Amendment No. 32 and 75) functional requirements for remote control (Remote Shutdown System) which are believed to satisfy the remote reactor control requirements of NRC and CRBRP Design Criteria 17. These sections were expanded further in the response to NRC Question CS421.17 (Amendment No. 72).

III. THERMAL-HYDRAULIC DESIGN

A. Natural Circulation and Low Sodium Flows

The Project, in response to NRC Question 001.580 in Amendment No. 32, committed to analyses and testing which will confirm the natural circulation capabilities of CRBRP. Additionally, the Project has supplied pre-test predictions of natural circulation tests at FFTF in February 1981, using CRBRP methodologies and computer codes. A report will be prepared consolidating these pre-test predictions and post-test analyses for submittal to NRC with the FSAR for review at the Operating License stage. PSAR Section 5.75, "Natural Circulation," was added to the PSAR in Amendment 75 to discuss CRBRP natural circulation capabilities.

IV. MECHANICAL/STRUCTURAL DESIGN

C. Control Rod Systems

The PSAR, amended in Amendment 76, reflects the current design of the SCRDMs.

VIII. SYSTEMS

A. Fire Protection System

2. The Project has made a preliminary determination of fire hazards which was submitted in Amendment No. 48. The Project is preparing a detailed fire hazards analysis which will be included in the FSAR.

IX. ACCIDENT ANALYSIS

G. Instrumentation to Follow the Course of an Accident

1. The Project has completed a detailed review and evaluation of Regulatory guide 1.97, Rev. 2. This is documented in PSAR Section 7.5.11 and Q/R CS760.6.

H. Risk Associated with Nearby Industrial Activities

The proposed Exxon facility was removed from the NRC docket in 1980 and is no longer considered as having a potential impact on the CRBRP. An updated discussion of nearby Industrial Facilities was provided in Section 2.2 of the PSAR in Amendment 76.

NINTEENTH SET OF INTERROGATORIES

QUESTION NINETEEN

19. With respect to the following request for information, we are concerned with four distinct validations relative to the models and computer codes.

i) Validation that the code's output is the correct numerical calculations that should result from a given set of input data and the model assumptions;

ii) Validation of the models against actual experimental data;

iii) Validation that the models can be extended to the CRBRP; and

iv) Validation that the input assumptions for the CRBR case are adequate with respect to the CDA analysis, i.e., are supported by experimental evidence. By "adequate" here and below, we mean that the calculations will not underestimate the CDA work potential (i.e., forces and resulting energetics of a CDA) or overestimate the containment capability of the reactor with respect to a CDA.

I. With respect to each of the following codes and each subroutine of each of the following codes:

(A) SAS-3D

(B) SAS-4A

(C) EPIC (if not included in SAS-3D or SAS-4A, please provide the following information:

(1) Complete, current documentation (i.e., a writeup) of the codes and the subroutines.

(2) Identify, by name and affiliation, the author, or authors, of each model, subroutine, or portion of each subroutine, which each contributed or worked on.

(3) Identify by name and affiliation (including organization, division, branch, title, etc.) each Applicant employee or consultant that has intimate working knowledge of the code and each subroutine, or parts thereof, including its validity. Where more than one person is involved, delineate which portion of the code or subroutine with which each has an intimate working knowledge.

(4) Describe fully the procedures by which Applicants have assured themselves and continue to assure themselves, that the various computer programs (codes) accurately reproduce the models (see Validation i) above.

(5) Indicate which models (including subroutines, or portions of subroutines) have not been validated as described in Validation i).

(6) Indicate the models (including subroutines, or portions of subroutines) or assumptions that have not been validated as described in Validation i).

(7) For each model, portion of the model, or assumption that has been validated (against experimental (or other) data, see Validation ii) above, describe fully

   (a) the procedure by which it was validated,

   (b) the results, including all uncertainties and limitations of the validation,

   (c) the source of the experimental or other data that was used in the validation.

(8) Explain fully

   (a) all instabilities in the numerical performance in the models,

   (b) what causes them,

   (c) how they are avoided, and

   (d) the extent to which this introduces uncertainties in the calculations and limit the validity of the models.

(9) To the extent that any answers to the above questions are based on referenced material not previously provided, please supply the references.

(10) Explain whether Applicants are presently engaged in or intend to engage in any further research or work which may affect the answer. Identify such research or work.

(11) Identify the expert(s), if any, whom Applicants intend to have testify on the subject matter questioned. State qualifications of each such expert.

II. With respect to the Interrogatories identified above where final information was not provided, please provide the following information:

i) What is Applicants' present (preliminary) assessment in these areas?

ii) What are the uncertainties that prevent Applicants from making a final assessment in these areas?

iii) What is the precise information that Applicants require to resolve these uncertainties?

iv) Are Applicants presently engaged in other research related to these areas? Do Applicants intend to engage in such research in the future?

III. Please identify each and every routine in

(1) the entire SAS-3D code;

(2) the entire SAS-4A code;

(3) the entire EPIC code (if not included in the SAS-3D or SAS-4D codes).

Separately, for each routine identified above, please supply the following information:

(a) Was the routine verified by comparison with other codes, or by comparison with the results of hand calculations, or by comparison with what sound engineering judgment deemed to be physically reasonable?

(b) If the routine was verified by comparison with other codes, how was the other code or codes verified? Identify the other code or codes.

(c) If the answer to (a) or (b) above is that the routine was verified by hand calculations, please supply the hand calculations or the appropriate documentation , i.e.,

(i) the name(s) of the individual(s) who performed the calculations and made the comparison; and

(ii) the laboratory notebook, memorandum, or other written record that documents the comparison.

(d) If the answer to (a) or (b) above is that the subroutine was verified by comparison with what sound engineering judgment deemed to be physically reasonable, please describe in detail the nature of and basis for the engineering judgment. In addition, supply:

(i) the name(s) of the individual(s) who rendered the judgment and made the comparison; and

(ii) the laboratory notebook, memorandum, or other written record that documents the comparison.

(e) Did the author(s) of the models actually perform the coding? If not, identify the programmer(s).

(4) How do Applicants <u>continue</u> to assure themselves that the overall code and its subroutines accurately reproduces the models as described in the PSAR and its references?

(5) Please identify and provide all intra-laboratory memoranda generated by personnel in the Accident Analysis Section, the Coolant Dynamics Section, and other Sections of the ANL Reactor Analysis and Safety Division that critique or otherwise evaluate the models developed by other personnel in these respective sections, limited to the development of any and all models and subroutines that are

identified in 1) above. Also provide all subsequent memoranda that are responses to criticisms or evaluations identified above or that represent a continuation of the dialogue related to the model evaluation.

ANSWER I(A)

(1) References 6, 7, 8, 9, and 10 on page 11-1 of CRBRP-GEFR-00523, "An Assessment of HCDA Energetics in the CRBRP Heterogeneous Reactor Core," S. K. Rhow, et al., describe the SAS3A code, the fuel-coolant interaction model, the clad motion model and the fuel motion model in the SAS3A code. The SAS3A sodium film motion model is documented in: G. Hoppner, "Sodium Flow Motion Model of SAS3A," ANL/RAS 74-22, 1974. The SAS3A primary loop model is documented in: Ref. 30 in CRBRP-GEFR-00103. The SAS3D code, now being used, evolved from SAS3A which evolved from the SAS2A code which evolved from the SAS1A code. Documentation for the SAS3A code is applicable to the SAS3D code. The SAS2A code is documented in Reference 7 in CRBRP-GEFR-00523, and SAS1A is documented in ANL-7607, "SAS1A, A Computer Code for the Analysis of Fast Reactor Power and Flow Transients," by D. R. MacFarlane, et al.
A User's Manual for SAS3D Release 1.0, "A Preliminary User's Guide to Version 1.0 of the SAS3D LMFBR Accident Analysis Computer Code," J. E. Cahalan, D. R. Ferguson, et al., ANL, July 1977, describes the release code. The SASBLOK algorithms used in

the SAS3A and SAS3D codes are documented in CRBRP-GEFR-00103, "An Analysis of Hypothetical Core Disruptive Events in the Clinch River Breeder Reactor Plant," J. L. McElroy, et al. Modifications and additions to the SAS3D code made for specific CRBRP applications are documented in CRBRP-GEFR-00523 and in "An Assessment of the Unprotected LOF Accident at EOC-4 in the CRBRP Heterogeneous Core Design," J. E. Cahalan, et al., ANL, December, 1982.

(2) The SAS3D code is a complex code system which has been developed over a period of years by the Reactor Analysis and Safety Division of Argonne National Laboratory. The SASBLOK algorithm was developed by the General Electric Company. The principal contributors to SAS3D code development are identified as authors of the references in Response 1.

(3) The following staff members of Argonne National Laboratory and General Electric have a working knowledge of the codes, including their range of applicability and the efforts that have been made to validate them: L. Walter Deitrich, Associate Director, Reactor Analysis and Safety Division, Argonne National Laboratory; David P. Weber, Manager, Accident Analysis Section, Reactor Analysis and Safety Division, Argonne National Laboratory; Dennis M. Switick, Manager, Safety Analysis, General Electric Advanced Reactor Systems Department.

(4) The entire SAS3D code, including all subroutines, have been checked and rechecked to assure that the numerical algorithms which are implemented in them to solve the equation sets, which constitute these codes, behave in a stable fashion

(both individually and collectively) and produce accurate solutions to the original equation sets. This was carried out by comparing SAS3D results with the output from other codes, with the results of hand calculations, and with what sound engineering judgement deemed to be physically reasonable.

(5) All models have been validated as discussed in (4) above.

(6) - (7) The experimental basis for the SAS3A code as of April 1974 has been documented in the paper, "Current Status and Experimental Basis of the SAS LMFBR Accident Analysis Code System," Proc. Am. Nucl. Soc. Fast Reactor Safety Conf., Beverly Hills, California, CONF-740401, pp. 1303-1318. Additional comparisons of the SAS3A code with experiments have been made since that time and are documented in the following references:

(1) Ref. 32 in CRBRP-GEFR-00103.

(2) Ref. 59 in CRBRP-GEFR-00103.

(3) Ref. 8 in CRBRP-GEFR-00523, pp. 54-62.

(4) Ref. 28 in CRBRP-GEFR-00103, pp. 64-100.

(5) L. W. Deitrich, "Analysis of Transient Fuel Failure Mechanisms, Selected ANL Programs," Presented at the International Working Group on Fast Reactors Specialists' Meeting on Fuel Failure Mechanisms, Seattle, Washington, May 11-16, 1975.

(6) E. Barts, et al., "Summary and Evaluation, Fuel Dynamic Loss-of-Flow Experiments (Tests L2, L3, and L4)," ANL 75-57, September 1975.

The experimental basis for the SAS3A is applicable to SAS3D and additional experimental basis is documented in the following:

(1) Ref. 35 in CRBRP-GEFR-00523.

(2) "Final Report on the SLSF In-pile Experiment P3A," T. E. Kraft and L. R. Kelman, ANL/RAS 81-20, June, 1981.

(3) W. A. Ragland, "LMFBR Loss-of-Flow Simulations in the Sodium Loop Safety Facility," ASME Paper (80-C2/NE-22, presented at the Century 2 Nuclear Engineering Conference, San Francisco, August 19-21, 1980.

(4) Documents cited on page AA-63 in Applicants' Response to Interrogatory Set III, Question II-5(C)(iii) as Numbers 5, 6, and 8 through 16.

It should be noted that many of the models used in SAS3D are parametric in nature. Justification for the particular parameters used in the analysis is given in CRBRP-GEFR-00103, CRBRP-GEFR-00523, in PSAR Amendment 72 (Responses to Questions QS760.178A1, A2, and A3), and in "An Assessment of the Unprotected LOF Accident at EOC-4 in the CRBRP Heterogeneous Core Design," by J. E. Cahalan, et al., ANL, December, 1982. Because of this parametric nature of the SAS3D code, it can be used to draw valid conclusions relative to the course of hypothetical accidents in an LMFBR even though each subroutine may not have

been completely validated by experiments, since parameters can be varied to determine the sensitivity of the results to variations in parameters.

(8) Mathematically, practically all of the models in SAS3D consist of sets of coupled ordinary differential or integro-differential equations in time or of coupled partial differential equations in space and time. Numerically, these equation sets are solved by applying appropriate linearization and finite-differencing techniques. Some of these temporal finite-differencing techniques are fully implicit and are unconditionally stable. Other models, such as that which treats the time-dependent radial heat transport from the fuel pin into the coolant, have their equation sets solved by semi-implicit temporal finite-differencing techniques. It is well known that solutions obtained by semi-implicit differencing can exhibit bounded oscillations if time steps which are too large are taken. Thirdly, some equation sets, such as the SLUMPY compressible hydrodynamics equations, are solved with fully explicit methods. Here, taking time steps that are too large can produce solutions which become unstable.

Throughout SAS3D, provisions have been made to insure that the time step sizes being used for advancing the various solutions in time are kept sufficiently small so that the solutions behave stably and are accurate. These time step sizes are chosen by monitoring both the solutions and their rates of change and applying step size selection criteria based on both known analytical constraints, where they are available, and on

experience gained in applying the code to a variety of situations. These step size selection criteria are explained in detail in the references provided in part 1 above. It is still possible, however, to occasionally force a model in the SAS3D code to utilize a time step size which is so large that stability problems result. It is also possible for the user to try to utilize SAS3D to analyze cases which are not intended to be modeled by SAS3D. In these cases, the results predicted by SAS3D may tend to become unrealistic and physically meaningless. Both of these problems can and are generally dealt with by carefully scrutinizing the computer output and comparing it against engineering judgement.

(9) The reference documents have been or will be made available for inspection and copying.

(10) The Applicants are currently analyzing this area and have documented the planned program of research in Appendix A to CRBRP-3, Vol. 1. Applicants have not yet determined whether they will rely on the results of future analysis.

(11) At the present time, the Applicants have not determined the experts, if any, whom they intend to have testify on the subject matter questioned at construction permit hearings.

ANSWER I(B)

Applicants have employed limited portions of the SAS4A code in recent licensing-related calculations for CRBRP. These calculations involved using the PLUTO2 code as it is incorporated into SAS4A as a module. The PLUTO2 code used in SAS4A is the

same physical and mathematical model as the PLUTO2 code used previously as a stand-alone code for licensing calculations. Answers to parts 1 through 11 of this question pertaining to PLUTO2 as a stand-alone code were provided by Applicants in "Applicants Updated Response #1 to Natural Resources Defense Council, Inc., and Sierra Club Interrogatories (Second, Third, Fourth, Fifth, and Sixth Sets)" on pages AA-10 through AA-13. Major portions of the SAS4A code have not been used in licensing calculations, including the LEVITATE, CLAP, PRIMAR-4, FLXSHP, GEOMAP, and TSBOIL modules, and material related specifically to these modules is not included in this response, although these modules are included in documentation.

(1) Interim documentation of SAS4A is available in:

"The SAS4A LMFBR Accident Analysis Computer Code -- A Phenomenological and Computational Summary," Reactor Analysis and Safety Division, ANL February, 1981.

"A Preliminary User's Guide to the SAS4A LMFBR Accident Analysis Computer Code," D. P. Weber, ed., Reactor Analysis and Safety Division, ANL, Feburary, 1981.

H. U. Wider, _et al_., "Status and Validation of the SAS4A Accident Analysis Code System," Proc. LMFBR Safety Topical Mtg., Lyon, France, July 19-23, 1982, pg. 11-13.

(2) The principal contributors to development of SAS4A are the authors and contributors to documentation cited above.

(3) The following staff members of Argonne National Laboratory have a working knowledge of the code, including its range of applicability and the efforts that have been made to validate it: L. Walter Deitrich, Associate Director, Reactor Analysis and Safety Division, and David P. Weber, Manager,

Accident Analysis Section, Reactor Analysis and Safety Division, Argonne National Laboratory.

(4) The relevant parts of the SAS4A code have been checked and rechecked throughout their development to assure that the numerical algorithms which are implemented in them to solve the equation sets which consitute these codes behave in a stable fashion (both individually and collectively) and produce accurate solutions to the original equation sets. This was carried out by comparing results from SAS4A models with the output of other codes, with the results of hard calculations, and with what sound engineering judgement deemed to be physically reasonable.

(5) All models of importance in Applicants' application of SAS4A to CRBRP have been validated as discussed above.

(6) - (7) The experimental basis for the SAS4A code is summarized in:

> H. U. Wider, <u>et al.</u>, "Status and Validation of the SAS4A Accident Analysis Code System," Proc. LMFBR Safety Topical Mtg., Lyon, France, July 19-23, 1982, pg. 11-13.

The major module used by the Applicant in CRBRP licensing is PLUTO2. The experimental basis for PLUTO2 is summarized in "Applicants Updated Response #1 to Natural Resources Defense Council, Inc., and Sierra Club Interrogatories (Second, Third, Fourth, Fifth, and Sixth Sets)," pages AA-11 and AA-12, and in PSAR Amendment 72, Response to Question CS760.178A1.

(8) Mathematically, practically all of the models in SAS4A consist of sets of coupled ordinary differential or integro-differential equations in time or of coupled partial

differential equations in space and time. Numerically, these equation sets are solved by applying appropriate linearization and finite-differencing techniques. Some of these temporal finite-differencing techniques are fully implicit and are unconditionally stable. Other models, such as that which treats the time-dependent radial heat transport from the fuel pin into the coolant, have their equation sets solved by semi-implicit temporal finite-differencing techniques. It is well known that solutions obtained by semi-implicit differencing can exhibit bounded oscillations if time steps which are too large are taken. Thirdly, some equation sets, such as the PLUTO2 compressible hydrodynamics equation, are solved with fully explicit methods. Here, taking time steps that are too large can produce solutions which become unstable.

Throughout SAS4A, provisions have been made to insure that the time step sizes being used for advancing the various solutions in time are kept sufficiently small so that the solutions behave stably and are accurate. These time step sizes are chosen by monitoring both the solutions and their rates of change and applying step size selection criteria based on both known analytical constraints, where they are available, and on experience gained in applying the code to a variety of situations. These step size selection criteria are explained in detail in the references provided in part 1 above. It is still possible, however, to occasionally force a model in the SAS4A code to utilize a time step size which is so large that stability problems result. It is also possible for the user to try to

utilize SAS4A to analyze cases which are not intended to be modeled by SAS4A. In these cases, the results predicted by SAS4A may tend to become unrealistic and physically meaningless. Both of these problems can and generally dealt with by carefully scrutinizing the computer output and comparing it against engineering judgement.

(9) The reference documents have been or will be made available for inspection and copying.

(10) The Applicants are currently analyzing this area and have documented the planned program of research in Appendix A to CRBRP-3, Vol. 1. Development of the SAS4A code, together with verification and validation activities, is expected to continue under the LMFBR base technology program, and Applicants will remain cognizant of these activities. Applicants have not yet determined whether they will rely on the results of future analysis or developments related to SAS4A.

(11) At the present time, the Applicants have not determined the experts, if any, whom they intend to have testify on the subject matter questioned at construction permit hearings.

ANSWER I(C) (1 through 11)

The EPIC code has not been used by the Applicants nor are there any plans to use the code in the future. A comparison of EPIC with PLUTO2 was carried out (Reference 25 of CRBRP-GEFR-00523) which showed that the codes show good agreement if several of the advanced PLUTO2 features are not used.

ANSWER II (i through iv)

This part of question 19 makes reference to the preceding part of question 19, namely 19 (I), which relates principally to code validation. Validation of the SAS code is an ongoing, continuous process as more data and analyses become available. The Applicants' planned research program, documented in Appendix A to CRBRP-3, Vol. 1, partly relates to SAS. In addition, in the normal course of its ongoing evaluation, the Applicants maintain awareness of other research and development work related to phenomena and models in the SAS3D and SAS4A codes. Results from these R&D programs are factored into code validation and application to the extent that the results are applicable. With respect to validation of the SAS3D code, the Applicants' present assessment is that the code is adequately validated. With respect to validation of the SAS4A code, the Applicants' present assessment is that the code is adequately validated for the use to which it has been put in CRBRP licensing.

ANSWER III(1)

A list of subroutines in the SAS3D code was provided by Applicants in "Applicants Updated Response #1 to Natural Resources Defense Council, Inc., and Sierra Club Interrogatories (Second, Third, Fourth, Fifth, and Sixth Sets)" in the response to Set VI, Question I(A)(1), pages AA-114 through AA-121. No change to this list is required. However, in the course of studies reported in PSAR Amendment 72 (Responses to Questions

CS760.178), and in "An Assessment of the Unprotected LOF accident of EOC-4 in the CRBRP Heterogeneous Core Design," J. E. Cahalan, et al., ANL, December, 1982, modifications to several subroutines were made. These subroutines are:

FISGAS	TSC6	BLOWUP	SLUMP2
PRIMAR	TSC83	TSCINT	TSOV50
PRIMUP	TSC84	TSCSET	TSPLOT
TSCA	INPUT2	FALLON	CLAZAS
TSCB	TSC8	FALL2	FBKCLZ
TSC3	TSPRINT	MAPDRV	TSHTR
TSC4A	TSOV45	DEFORM	TSC41A
TSC43A	INPOT1	FK	GETRDY
TSC5	TSOV47	KFUEL	REZONE

Parts (a), (b), (c), and (d) of this interrogatory are being responded to as a whole. Any checkout of new or extensively-modified coding does not generally proceed on a subroutine-by-subroutine basis. Rather, it is carried out at the very least on a model-by-model basis, where each model (fuel motion, clad motion, coolant dynamics, etc., in the case of SAS3D) could consist of a number of whole subroutines plus parts of others (where it is coupled to the rest of the code). The collection of subroutines comprising one of these models is generally referred to in the SAS vernacular as a module. Thus, in the case of SAS3D as in the case of many other large-scale codes, the checkout proceeded on a module-by-module basis.

Comparisons of the output of SAS3D modules and the entire code with the output of other codes, with simple hand calculations, and with what engineering judgement deemed to be reasonable have been and continue to be carried by the model and

code developers. However, except as explained in the next paragraph, such efforts are not formally or informally documented.

The documentation that exists is in the form of the references provided in the updated response to interrogatory I(A)(1) of the Nineteenth Set of Interrogatories. These reports serve to document the mathematical bases and provide a broad overview of the computational algorithms associated with each of the models and the code as a whole. It is implicit in the publication of these reports that the authors have satisfied themselves that the FORTRAN programming in the code is correct.

Applicants note that code comparison activities have been carried out by the Whole Core Accident Comparative Calculations (WAC) Group over the past four years. Several codes or parts thereof have been included in these comparisons. SAS3D has been included in the comparisons, principally as used by the NRC representatives (SAS3D/EPIC) and by the FRG (KFK) representatives. The relevant WAC activities are documented in items 275 through 283 of the listings of Argonne National Laboratory memoranda submitted with "Applicants Supplemental Updated Response #1...," dated April 30, 1982; "Applicants Second Supplemental Updated Response #1...," dated May 24, 1982, and "Applicants Response to NRDC, Inc., and Sierra Club Nineteenth Set of Interrogatories," pg. 21. Applicants have not relied on these calculations as part of their verification and validation of SAS3D. However, Applicants maintain cognizance of these activities.

(e) It is standard practice within the Accident Analysis Section of the Reactor Analysis and Safety Division of Argonne National Laboratory that the authors of the SAS3D models, as identified by the authors listed in the documents referenced in the above paragraph, do their own coding and subsequently actually perform or directly supervise any subsequent modifications to that coding.

ANSWER III(2)

The list of subroutines in the entire SAS4A code is given in Table 1. These subroutines make up the modules which are the units on which verification and validation procedures are generally carried out, although in some cases it is possible and desirable to work with smaller units within the modules.

Parts (a), (b), (c), and (d) of this interrogatory are being responded to as a whole. Checkout of the coding for SAS4A does not generally proceed on a subroutine-by-subroutine basis. Rather, it is carried out at the very least on a model-by-model basis, where each model could consist of a number of whole subroutines plus parts of others (where it is coupled to the rest of the code). The collection of subroutines comprising one of these models is generally referred to in the SAS vernacular as a module. In some cases, it is possible and useful to verify SAS4A code performance on smaller units than modules, but in general, the checkout has proceeded at the level of modules or substantial portions of modules.

Comparisons of the output of SAS4A modules and portions thereof with the output of other codes, with simple hand calculations, and with what engineering judgement deems to be reasonable have been and continue to be carried out by the model and code developers. However, except as explained in the next paragraph, such efforts are not formally or informally documented.

Documentation which presently exists is in the form of the references provided in the updated response to interrogatory 1(B)1 of the Nineteenth Set of Interrogatories. These reports serve to document the mathematical bases and provide a broad overview of the computational algorithms associated with each SAS4A module and the code as a whole. In addition, performance of analysis using the SAS4A code and its modules is documented. It is implicit in publication of analyses cited in these reports that the authors have satisfied themselves that the FORTRAN programming in the code is correct.

Applicants note that code comparison activities have been carried out by the Whole Core Accident Comparative Calculations (WAC) Group over the past several years. Several codes or parts thereof including SAS4A, have been included in these comparisons. Documentation of these activities may be found in:

> P. C. Cacciabue, et al., "Comparative Analysis of Fuel Characterizatio- Approaches and Transient Evaluation of a Hypothetical TOP Accident in an Irradiated LMFBR," Proc. LMFBR Saftey Topical Meeting, Lyon, France, July 19-23, 1982, pg. 11-25.

(e) It is standard practice within the Accident Analysis Section of the Reactor Analysis and Safety Division of Argonne National Laboratory that the authors of the SAS4A models, as identified in the documents referenced in the above paragraph and in Answer I(B) above, do their own coding and, subsequently, actually peform or directly supervise any subsequent modifications to that coding.

ANSWER III(3)

The EPIC code has not been used by the Applicants nor are there any plans to use the code in the future. A comparison of EPIC with PLUTO2 was carried out (Reference 25 of CRBRP-GEFR-00523) which showed that the codes show good agreement if several of the advanced PLUTO2 features are not used.

ANSWER III(4)

The Applicant continues to assure itself that the overall code and its subroutines accurately reproduce the models as described in CRBRP-GEFR-00523, in the responses to Questions CS760.178A1, A2, and A3, and in "An Assessment of the Unprotected LOF Accident at EOC-4 in the CRBRP Heterogeneous Core Design," by J. E. Cahalan, et al., ANL, December, 1982, and their references by careful inspection of the output results for every case analyzed and by comparison of the output results for each case analyzed with the results of previous cases which are similar in part or in whole to the particular case analyzed. In addition,

the computer system messages are checked to assure that the job was properly executed, without error, by the computer system.

ANSWER III(5)

A list of memoranda applicable to SAS3D and its predecessors was provided in "Applicants Supplemental Updated Response #1...," dated April 30, 1982, "Applicants Second Supplemental Updated Response #1..., dated May 24, 1982, and "Applicants Response to Natural Resources Defense Council, Inc., and Sierra Club Nineteenth Set of Interrogatories," Sierra Club Nineteenth Set of Interrogatories," page 21. This list is being updated to include recent memoranda applicable to SAS3D and those applicable to SAS4A. Documents referred to in the update will be made available for inspection and copying at Argonne National Laboratory.

Table 1. SAS4A Subroutines

Library B32490.SAS4A.JAN83.SOURCE

with Additional Routines

ALPHC	EGFUTE	LQGSFM
ALPHF	EGSETE	L6HGAP
AOUT	EKT	L6LEMO
AP	ERROR	L6PREA
AVGVAL	EXPAND	L6RUTS
BIGTO	FAILUR	L7LEMO
BLKPRM	FEEDBK	L8LEMO
BS	FEQUAT	MAIBM
BYPSTM	FGASL6	MAIN
CAVITY	FK	MOMEN
CCLAD	FLTSET	NAPROP
CFUEL	FOUT	NODEPR
CG	FSIGMA	NUCHEK
CHIN	FSWELL	OUTNGF
CKVLFL	FUINIT	OUTPLF
CL	GRGROW	OUTPLN
CLADSW	GRVHED	OUTPT2
CLDFAL	HBFND	OUTPT3
CLDFALA	HBSMPL	OUTPUT
CMCOPY	HGAP	PAR
COREFL	HVAP	PIPEFL
CRAKER	IHXSHF	PIPTMP
CRDTMP	IHXTBF	PKPAGE
CRED	INCPVF	PKSTEP
CROEF	INITST	PLCOOL
CSIGMA	INPDRV	PLFREZ
CUTBAK	INPEDT	PLHTR
CVTEMP	INPLNF	PLIF
DATMOV	INTIRP	PLINPT
DATOUT	INTRP	PLMACO
DEFINI	INTSET	PLMISC
DEFORM	INVRT3	PLMOCO
DENSIT	IOUT	PLNAEN
DFORM3	KCLAD	PLOTIX
DOPC	KFUEL	PLOUT
DRACSF	LEABLA	PLREZO
DRACTF	LECLIN	PLSAIN
DTCFND	LEDISR	PLSET
DTHFND	LEFREZ	PLSET2
DTMFND	LEFUVA	PLSTR
DTNFND	LEGEOM	PLTECS
DTPFND	LEIF	PLUDRV
DUMDEF	LEMACO	PLVOFR
DUMMY	LEMISC	PL1PIN
DYNALL	LEMOCO	PL2PIN
DYNALL2	LENAEN	PMCHEK

ECLADF
EDTCOO
EDTGEO
EDTIPM
EDTIPN
EDTOPC
EDTPMC
EDTPMH
EDTPRI
EDTPNA
EDTPMC
EFUELF

LEPLIN
LEREZO
LESAIN
LESET2
LESEVA
LESRME
LEVDRV
LEVOFR
LE1PIN
LE2PIN
LINES
LIQCV
LIQFIN
LOCHEX

PMPBLF
PMSTRT
POINEX
POINST
POOLFL
PORMIG
POWINT
PREA
PRESDR
PRESPL
PRIMAR
PRIMR1
PRIMUP
PRMADJ

PRMEND
PRMPRT
PRSRZF
PRSTEP
PSAT
PSHORT
PUMPFL
PUMPFN
PUTB
PUTM
PUTPNT
P4EDT
READEC
READIN
REED
REINIT
RELAX
RELGAS
REMFOR
REMSTR
RESTAR
RHOEND
RHOF
RHOL
RHOLNA
RHOS
RHOV
RNGPOS
RUPSKF
RUPSRF
SDRCST
SEEK
SELECT
SHAPE
SIGFRA
SIOERR
SIONU6
SODFRC
SOLID
SSADHX

SSPRPL
SSPRSR
SSPUMP
SSP4CV
SSP4PR
SSP4TH
SSSCLP
SSSTDR
SSSTGN
SSSTG1
SSTHRM
SSVALV
START
STATCF
STEPFN
STEPGS
STEPLQ
STEPTM
STGNFL
SUBSIZ
TABFIS
TBSCAN
TEFUEG
TENA
TESEEG
TIMER
TSAT
TSBOIL
TSCA
TSCA1
TSCA2
TSCBUB
TSCC
TSCINT
TSCLD1
TSCLD2
TSCLO
TSCMPO
TSCMP1
TSCNV1

TSC86
TSC9
TSDRCS
TSDRIV
TSGRAF
TSHTN1
TSHTN2
TSHTN3
TSHTN4
TSHTN5
TSHTRN
TSHTRV
TSIHX
TSIHXC
TSILLB
TSINIT
TSNEUT
TSOV45
TSPK
TSPLOT
TSPRNT
TSPRPL
TSSTGN
TSSTG1
TSTHRM
T4A3D
T41A3D
T42A3D
UTS
VALVAJ
VALVFL
VISC
WRITEC
WTSC84
XKL
YELDPT
YLDCF
LETRAN
LESOEN
LELUME

SSARDX	TSCNV2	PLSET1
SSBYPS	TSCNV3	
SSCKVL	TSCNV4	
SSCOOL	TSCNV5	
SSDRAC	TSCNV7	
SSDRIV	TSCNV8	
SSFUEL	TSCSET	
SSHTR	TSC2	
SSIHX	TSC21	
SSIHXC	TSC3	
SSINIT	TSC31	
SSIN01	TSC43A	
SSLQSG	TSC5	
SSNEUT	TSC6	
SSPK	TSC7	
SSPLOT	TSC8	
SSPMLP	TSC82	
SSPRIM	TSC83	
SSPRM4	TSC84	
SSPRNT	TSC85	

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

In the matter of UNITED STATES DEPARTMENT OF ENERGY PROJECT MANAGEMENT CORPORATION TENNESSEE VALLEY AUTHORITY	DOCKET NO. 50-537

AFFIDAVIT OF ALVIN R. MELLER

Alvin R. Meller, being duly sworn, deposes and says as follows:

1 That he is employed as Chief, Licensing Branch, Public Safety Division, CRBRP Project, and that he is duly authorized to answer Interrogatory 11 in the Eighteenth Set of Interrogatories.

2. That the above-mentioned and attached answers are true and correct to the best of his knowledge and belief.

Alvin R Meller
(Signature)

Subscribed and sworn to before me this 4th day of April 1983.

Inez W. Minor
(Notary Public)

My Commission expires ______________________.

My Commission Expires April 28, 1984

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

In the matter of	)	
UNITED STATES DEPARTMENT OF ENERGY	)	DOCKET NO. 50-537
PROJECT MANAGEMENT CORPORATION	)	
TENNESSEE VALLEY AUTHORITY	)	

AFFIDAVIT OF L. WALTER DEITRICH

L. Walter Deitrich, being duly sworn, deposes and says as follows:

1. That he is employed by the Reactor Analysis and Safety Division of Argonne National Laboratory, 9700 So. Cass Avenue, Argonne, Illinois 60439, as Associate Division Director.

2. That he is duly authorized to answer the Interrogatory numbered 19 of NRDC's Nineteenth Set of Interrogatories.

3. That the above-mentioned and attached answers are true and correct to the best of his knowledge and belief.

(Signature)

Subscribed and sworn to before me this 31st day of March 1983.

Notary Public

My Commission expires: 7/3/84

to: Ruth Welles - MLB
From: Dianne Turner - CRBRP

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

In the matter of

UNITED STATES DEPARTMENT OF ENERGY)
PROJECT MANAGEMENT CORPORATION)
TENNESSEE VALLEY AUTHORITY)

DOCKET NO. 50-537

AFFIDAVIT OF DENNIS M. SWITICK

Dennis M. Switick, being duly sworn, deposes and says as follows:

1. That he is employed by the General Electric Company as Manager, Safety Analysis, Advanced Reactor Systems Department, 310 De Guigne Drive, Sunnyvale, California 94086.

2. That he is duly authorized to answer the interrogatories numbered II General (e), II-15(c) of NRDC's Third Set and 25(s) of NRDC's Seventh Set of Interrogatories.

3. That the above-mentioned and attached answers are true and correct to the best of his knowledge and belief.

Dennis M. Switick
(Signature)

Subscribed and sworn to before me this 4th day of April, 1983.

OFFICIAL SEAL
E. N. STOUT
NOTARY PUBLIC CALIFORNIA
SANTA CLARA COUNTY
My Commission Expires Nov. 22, 1983

E N Stout
Notary Public

My Commission expires 11/22/83

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of UNITED STATES DEPARTMENT OF ENERGY PROJECT MANAGEMENT CORPORATION TENNESSEE VALLEY AUTHORITY (Clinch River Breeder Reactor Plant)	Docket No. 50-537

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Commissioner James Cotham
Tennessee Department of Economic
and Community Development
Andrew Jackson Building, Suite 1007
Nashville, Tennessee 37219

George L. Edgar
Attorney for
Project Management Corporation

DATED: April 11, 1983

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