NRC FORM 189 (Rev. 04-83)

U.S. NUCLEAR REGULATORY COMMISSION

PROJECT AND BUDGET PROPOSAL FOR NRC WORK

Date of Proposal: August 1983

■ New
□ Revision No.

Project Title: SEVERE FUEL DAMAGE MODEL DEVELOPMENT

FIN: A6360

NRC Office: Office of Nuclear Regulatory Research (RES), Division of Accident Evaluation (DAE)

NRC B&R Number: 60 19 02 01

DOE Contractor: EG&G Idaho, Inc.

Contractor Account Number: I-744

Site: IDAHO NATIONAL ENGINEERING LABORATORY (INEL)

DOE B&R Number: 40 10 01 060

COGNIZANT PERSONNEL	ORGANIZATION	FTS PHONE NUMBER	PERIOD OF PERFORMANCE
NRC Project Manager: G. P. Marino	NRC/RES	427-4266	Starting Date: 10/01/83
Other NRC Technical Staff: J. T. Han	NRC/RES	427-4260	Completion Date: 09/30/84
DOE Project Manager: D. Majumdar	DOE-ID	583-1805	
Contractor-Project Manager: F. Aguilar	EG&G Idaho	583-9395	
Principal Investigator(s): F. Aguilar	EG&G Idaho	583-9395	

STAFF YEARS OF EFFORT (Round to nearest tenth of a year)	FY -1983	FY -1984	FY -1985	FY -1986	FY -1987
Direct Scientific/Technical	4.9	5.3	4.9		
Other Direct (Graded)	1.2	0.1	0.1		
TOTAL DIRECT STAFF YEARS	6.1	5.4	5.0	4.2	3.9
COST PROPOSAL ($000)					
Direct Salaries	190	187	176		
Material and Services (Excluding ADP)	24	44	21		
ADP Support	143	140	202		
Subcontracts	0	0	0		
Travel Expenses — Foreign	0	6	0		
Travel Expenses — Domestic	7	12	11		
Indirect Labor Costs — Direct Labor Overhead	156	159	153		
Indirect Labor Costs — Common Support	107	108	105		
Other (Specify) FY-1982 = $2K (carryover)	35	(37)	0		
Other (Specify)	0	0	0		
General and Administrative (14.0%)	88	93	92		
TOTAL OPERATING COST	750	712	760	645	600
Capital Equipment	0	0	0	0	0
TOTAL PROJECT COST	750*	712	760	645	600

FY 19 84 MONTHLY FORECAST EXPENSE

Total Forecast Expense $ 749K

October	November	December	January	February	March
62	63	62	63	62	63
April	**May**	**June**	**July**	**August**	**September**
62	63	62	63	62	62

APPROVAL AUTHORITY-SIGNATURE: F. Aguilar by [illegible]

Date: 8/12/83

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* Includes $37K from B2861

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PDR FOIA
ALVAREZ85-110 PDR

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DOE Proposing Organization: IDAHO OPERATIONS OFFICE (ID)

FORECAST MILESTONE CHART: Scheduled to Start - △——▲ - Completed (Shown in Quarter Year)

PROVIDE ESTIMATED DOLLAR COST FOR EACH TASK FOR EACH FISCAL YEAR

TASK		FY-1983				FY-1984				FY-1985				FY-1986				FY-1987			
		1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th
SCDAP/MOD0	Schedule	▲———																			
	Cost	465K																			
SCDAP/MOD1 Development	Schedule	△———								——▲											
	Cost	107K				484K				200K											
SCDAP/MOD1 Enhancement	Schedule									△———								——▲			
	Cost									165K				150K				100K			
SCDAP User Support	Schedule	△———																——▲			
	Cost	72K				144K				195K				270K				225K			
Maintenace and Configuration Control	Schedule	△———																——▲			
	Cost	71K				121K				200K				225K				275K			
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	Cost																				
SUBTOTAL		715K				749K				760K				645K				600K			
CARRYOVER FY-1982 = $2K		35K				(37K)				0K				0K				0K			
TOTAL ESTIMATED PROJECT COST		750K				712K				760K				645K				600K			

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Project Title

SEVERE FUEL DAMAGE MODEL DEVELOPMENT

DOE Proposing Organization: IDAHO OPERATIONS OFFICE (ID)

PROJECT DESCRIPTION: (Provide narrative descriptions of the required topics in numerical order. If an item is not applicable, list title and so state.)

(1) Objective of Proposed Work

The Modeling Severe Fuel Damage Project provides for development and maintenance of a mechanistic computer code, SCDAP, to predict the core, vessel, and system thermal-mechanical-chemical behavior of a light-water reactor during severe reactor accidents. The individual models and integrated code developed in this project are the focal point of knowledge gained from the Nuclear Regulatory Commission's (NRC) Severe Fuel Damage Program as well as from industry and foreign sponsored research. The analytical tools are used by several NRC programs to support such activities as experimental programs designed to provide data for understanding severe accident phenomena, formulating regulatory policies and guides concerning severe reactor accidents, identifying dominant accident sequences, auditing licensee submittals, and developing and benchmarking risk assessment codes.

(2) Summary of Prior Efforts

FY-1983:

SCDAP/MOD0

The intact component subcode, bundle thermal-hydraulics subcode, and the debris behavior models along with the MATPRO materials properties package developed in A6050 were incorporated into the SCDAP driver logic to form the SCDAP/MOD0 library. The SCDAP/MOD0 library was tested by comparing code calculations to a limited amount of experimental data and to calculations of other computer codes including the TRAC-B01 code, the FRAP-T code, and the MARCH code. Predictions were made for two severe fuel damage tests including the Severe Fuel Damage (SFD) scoping test performed in October 1982 and the SFD 1-1 test to be performed in the Power Burst Facility (PBF). The calculated results compared well with the data for the scoping test in both temperature and hydrogen generation. Informal reports were prepared and issued which describe the overall SCDAP/MOD0 code and its use, the SCDAP/MOD0 user's manual, and the results of the SCDAP/MOD0 checkout and testing, the SCDAP/MOD0 Developmental Assessment (DA) report.

The second version of SCDAP/MOD0, Version 1, was released. This version included an extension of the liquefaction, flow, and solidification model to include melting and flow of UO_2 and ZrO_2. The version also included enhancements in the input and output, the addition of a graphics package, and

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(2) Summary of Prior Efforts (Continued)

FY-1983: (Continued)

SCDAP/MOD0 (Continued)

a limited restart capability. An addendum to the SCDAP/MOD0 user's manual was issued describing the new user information and a report describing the liquefaction, flow, and solidification model extension was issued.

Two modeling features were added to SCDAP/MOD0/V1 thus creating SCDAP/MOD0 Version 2. These were a simplified boiloff thermal-hydraulics and the PARAGRASS fission gas release model for intact region fission gas release analysis. The simplified boiloff thermal-hydraulics model is a quasi-steady model based on the work of Sun and includes three region analysis (subcooled, two-phase, and superheated). The model also includes component-to-component radiation. The PARAGRASS model tracks fission product generation, coalescence, migration to grain boundaries, and the release of fission products from the fuel matrix for volitile fission products. Only the intact region PARAGRASS and not the debris gas release analysis was included in SCDAP/MOD0/V2.

Two changes were made to SCDAP/MOD0/V2. The debris region gas release model using PARAGRASS was added to Version 3 of SCDAP/MOD0. This completed the implementing of PARAGRASS in SCDAP for volitile fission products. An automated time step control algorithm was added which improved the usability and reduced the execution cost of SCDAP during the time period from before rapid oxidation begins until the problem end time.

SCDAP/MOD1 Development

The conceptual design on the SCDAP/MOD1 computer code was completed. This set forth the plan to extend SCDAP/MOD0 to both vessel and system analysis. The fuel bundle capability of SCDAP/MOD0 will be supplemented with models for the upper and lower plenum, in-vessel radiation, and fission product release models for condensibles, thus providing a vessel capability (SCDVESSEL). Work began on these modeling efforts and will be completed on October 31, 1983. Coupling with the RELAP5 system code will provide both the system capability and a two-dimensional flow capability in the vessel. This work was also started during FY-1983 and will be completed during FY-1984. The

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(2) Summary of Prior Efforts (Continued)

FY-1983: (Continued)

SCDAP/MOD1 Development (Continued)

preliminary designs of SCDAP/MOD1 architecture, data management, and Input/Output, the in-vessel radiation model, the plenum behavior models, and the simplified cladding deformation model were completed. The coding and testing of the architecture and dynamic dimensioning were completed. A sensitivity study was performed using SCDAP/MOD0/V2 to gain understanding of the importance of the major modeling categories including materials properties and oxidation.. The results of this study will feed directly into the model maintenance activities during FY-1984.

SCDAP User Support

User support was provided to Power Burst Facility (PBF) personnel in support of both the Severe Fuel Damage scoping test and the SFD 1-1 experiment. During the conducting of the Scoping Test (SFD-ST), SCDAP was used to make last minute calculations of expected temperatures when higher than planned coolant flow rates were required. This was valuable in the successful completion of the test. Support was also provided to PBF personnel for planning the PBF Series 2 experiments. Support was provided to Severe Accident Sequential Analysis (SASA) personnel using SCDAP for Pressurized Water Reactor (PWR) and Boiling Water Reactor (BWR) risk dominant sequence analysis. SCDAP/MOD0 was transmitted to both the United Kingdom (United Kingdom Atomic Energy Authority, Winfrith) and Germany (KfK) and thus user support was provided both in implementing SCDAP on their systems and in interpreting results.

Maintenance and Configuration Control

Maintenance of SCDAP/MOD0 was provided. This included correcting minor modeling and coding errors which were discovered either during acceptance testing of updates or during application of SCDAP to untested cases by PBF and SASA personnel. Logs of deficiency, development, and incorporation information were maintained for SCDAP to assure the quality of both the development process and the computer code.

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(3) Work to be Performed and Expected Results

FY-1984:

Summary

The project consists of developing and maintaining the SCDAP code and providing user support. The development includes the addition of models in fission product release, transport, and deposition; plenum behavior; in-vessel radiation; cladding deformation; linkage of these models to SCDAP/MOD0, and modifying RELAP5 for the SCDAP/RELAP5 linkage. Coding features will include restart, graphics, input, and output similar to those of RELAP5. The first version of SCDAP/MOD1 will be a basic SCDVESSEL capability. The second will be a system capability. A developmental assessment of the second version of SCDAP/MOD1 will be performed and documentation of this effort will be issued. Maintenance activities will include correcting modeling and coding errors. User support will involve support of the PBF, Advanced Circular Research Reactor (ACRR), and Nuclear Reactor Universal (NRU) experimental programs with emphasis on the PBF Severe Fuel Damage integral tests. The support will also include support of SASA personnel who will be using SCDAP to calculate risk dominant severe accident sequences and of foreign users.

SCDAP/MOD1 Development

Development will include the addition of models in fission product release, transport, and deposition; plenum behavior; and linkage of these models to SCDAP/MOD0. For fission products, interim models for the release of tellurium, ruthenium, strontium, and barium from fuel assemblies will be added to existing models for the release of Xenon, Krypton, Cesium, and Iodine. These models will be based on Table 5.1 of NUREG-0956 (the CORSOR code). Additional models for uranium dioxide, cladding, control rod, and structure aerosol mass releases will be produced. For plenum behavior, models developed during FY-1983 for the upper and lower plenum which are based on material area to volume ratios will be incorporated into SCDAP/MOD1. For the linkage with RELAP5, four capabilities will be added to RELAP5--convective heat transfer logic, extended water properties, varying geometry, and soluble and noncondensible transport fields. The noncondensible and solute fields will be ideal mixtures like the single specie noncondensible and boron fields that are in RELAP5/MOD2. A

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(3) Work to be Performed and Expected Results (Continued)

FY-1984: (Continued)

SCDAP/MOD1 Development (Continued)

developmental assessment (DA) will be performed on the first version of SCDAP/MOD1 which will include the above mentioned models in addition to other improvements based on findings during the DA. This DA will be targeted primarily at the newly added models and at using available data from the first two PBF SFD experiments (SFD-ST, and SFD 1-1) and data from the SFD 1-3 experiment if available. Hagen experimental data will also be used and, if data is available from the ACRR and NRU experiments, this data will also be used.

A report describing the DA results will be issued along with a document describing the SCDAP/MOD1 code and how the code is used.

SCDAP User Support

Technical Assistance will be provided to users of the SCDAP code. Considerable user assistance is expected due to the fact that the SCDAP/MOD1 code, which will be internally released during the period, will include many new features. Analysts will have to be educated on how to use SCDAP/MOD1 and on how to interpret results. PBF support will comprise the majority of this support because of the post test analysis for the SFD-ST and SFD 1-1 tests and pretest and posttest analysis for SFD 1-3 and SFD 1-4 tests being conducted during FY-1984. Also, PBF personnel will continue to use SCDAP for planning the Series 2 experiments. Additionally, the SASA program will continue to use SCDAP for analysis of risk dominant sequences for both BWR and PWR reactors and foreign users including those from the United Kingdom, Germany, (and Japan) will be implementing and using SCDAP.

Maintenance and Configuration Control

Maintenance of SCDAP/MOD0 and SCDAP/MOD1 will be provided. This will include correcting minor modeling and coding errors which are discovered either during testing of updates or during application of SCDAP to new untested cases. Maintenance will also include addressing and correcting problems in

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(3) Work to be Performed and Expected Results (Continued)

FY-1984: (Continued)

Maintenance and Configuration Control (Continued)

SCDAP which are discovered by PBF, SASA, foreign, and other SCDAP users. Improvements identified during the sensitivity study performed during FY-1983 will be incorporated. A log of code shortcomings and deficiencies will be maintained along with quality assurance documentation which tracks development of modeling and coding features, testing of the features, and incorporation of those features into SCDAP.

FY-1985:

Summary

The project consists of developing, enhancing, and maintaining the SCDAP code and providing user support. Development will include a link with TRAC-PF1, a data link with MELPROG, and the addition of fission product release, transport, and deposition models. Model enhancement activities will involve incorporation of model improvements which are shown to be needed based on experimental data. Maintenance activities will include correcting of discovered modeling and coding errors. User support will involve support of the PBF, ACRR, and NRU experimental programs and to SASA personnel and to code applications personnel supporting NRC rule making hearings for severe fuel damage issues using SCDAP. Support for foreign users participating in the NRC Severe Fuel Damage Program will continue.

SCDAP/MOD1 Development

A link between SCDAP and TRAC-PF1 similar to that of SCDAP and RELAP5 will be established. This will provide a version of SCDAP which will have three-dimensional thermal-hydraulics capability. A data link with MELPROG will be established. This will involve obtaining MELPROG/MOD0 from Sandia National Laboratory (SNL), implementing the code on the Idaho National Engineering Laboratory (INEL) system, creating a restart tape for MELPROG, and then running MELPROG with cooperation from SNL.

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(3) Work to be Performed and Expected Results (Continued)

FY-1985: (Continued)

SCDAP/MOD1 Development (Continued)

Models for initial aerosol size distribution and growth, heterogeneous vapor chemical reactions with metal surfaces, thermophoretic deposition of aerosol particles, and vapor-wall-aerosol mass transfer will be added to SCDAP. These models will be based on TRAP-MELT subroutines but the detailed coding will be modified to allow economical implementation of the models in SCDAP. In addition, models for particle inertial impaction at pipe bends, radionuclide decay, and volumes which are not well-mixed will be added to SCDAP to support experimental program requirements.

SCDAP/MOD1 Enhancement

Model enhancement activities will include the incorporation of model improvements which are shown to be needed based on available experimental data. Data from PBF, ACRR, NRU, and separate effects tests will be gathered and the data compared to SCDAP calculations to establish needed model enhancements and those which can be implemented within the budget will be incorporated.

SCDAP User Support

SCDAP user support will continue increasing as more users will be using SCDAP during FY-1985. PBF will continue to use SCDAP in support of the Series 1 and Series 2 experiments both in pretest and posttest analysis and planning.

SASA personnel will continue using SCDAP in the analysis of risk dominant sequences of both PWR and BWR plants and foreign users (United Kingdom, Germany, and Japan) will be implementing and using versions of SCDAP/MOD1.

Maintenance and Configuration Control

Maintenance of SCDAP/MOD1 will be provided. This will include correcting minor modeling and coding errors which are discovered either during testing of updates or during application of SCDAP to new untested cases. Maintenance will also include addressing and correcting problems in SCDAP which are

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(3) Work to be Performed and Expected Results (Continued)

FY-1985: (Continued)

Maintenance and Configuration Control (Continued)

discovered by PBF, SASA, foreign, and other SCDAP users. A log of code shortcomings and deficiencies will be maintained along with quality assurance documentation which tracks development of modeling and coding features, testing of the features, and incorporation of those features into SCDAP.

(4) Description of Any Follow-On Effort

FY-1986, FY-1987, and Beyond:

The major efforts for the SCDAP/MOD1 code will be user support and maintenance with some continuing effort in model enhancements based on experimental data from PBF, ACRR, NRU, and separate effects experiments. During FY-1986 user support will remain high. Demands from rule-making hearings, support for the SASA program, and support for the experimental programs will continue. Maintenance of the existing models by correcting modeling and coding errors and improving code efficiency will continue. Model enhancements activities will involve adding needed models and incorporating model improvements based on data from PBF, ACRR, NRU, and separate effects experimental data which becomes qualified during this time period. Beyond FY-1987 user support and maintenance activities will drop to minimum levels.

(5) Relationship to Other Projects

This project is closely associated with the Fuel Behavior Model Development Project A6050 from which several of the basic transient fuel behavior models and all of the materials properties correlations and models are derived. Independent assessment of SCDAP is performed as part of this project. Modeling input is also derived from research programs being conducted on fuel behavior at Argonne National Laboratory (ANL), Battelle Columbus Laboratories, Pacific Northwest Laboratory, Oak Ridge National Laboratory (ORNL), and SNL. Experimental data needed for the SCDAP activity are derived from PBF, ACRR, and NRU as well as from ORNL and ANL.

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(5) Relationship to Other Projects (Continued)

SCDAP is used by several of the programs in NRC, such as the Severe Accident Sequence Analysis and Risk Code Development Programs, for performing deterministic analysis of core behavior during severe accidents to predict hydrogen and fission product release, etc.. and for benchmarking the more simplistic MARCH and MELCOR risk assessment codes.

(6) Reporting Schedule

FY-1983:

L. J. Siefken, Liquefaction-Flow-Solidifcation Model (LIQSOL), EGG-CDD-5708, Revision 1 (November 1982).

G. A. Berna et al., SCDAP/MODO: A Computer Code for the Analysis of LWR Fuel Bundle Behavior During Severe Accident Transients, WR-NSMD-82-078 (December 1982).

E. R. Carlson and L. J. Siefken, LIQSOL Model Embellishment, WR-NSMD-83-008 (March 1983)

G. A. Berna, SCDAP/MODO: A Computer Code for the Analysis of LWR Fuel Bundle Behavior During Severe Accident Transients, WR-NSMD-82-078, Addendum (March 1983).

W. E. Driskell et al., Developmental assessment of the Severe Core Damage Analysis Package: SCDAP/MODO, EGG-NTAP-6212 (March 1983).

C. M. Allison, Revised SCDAP Conceptual Design and Development Plan, EGG-NSMD-6205 (April 1983).

L. J. Siefken, Coolant Boil-Off and Component-to-Component Radiation Models for SCDAP, IS-NSMD-83-012 (June 1983).

G. A. Berna and F. M. Haggag, SCDAP/MODO: A Computer Code for the Analysis of LWR Fuel Bundle Behavior During Severe Accident Transients, WR-NSMD-82-068, Addendum Revision 1 (June 1983).

G. A. Berna, SCDAP/MOD1 Development Plan, IS-NSMD-83-024, (July 1983).

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(6) Reporting Schedule (Continued)

FY-1984:

M. S. Sohal, Core-Wide Radiation, (To be Published 1983).

G. M. Beers et al., SCDAP/MOD1 Architecture, Data Management and I/O, (To be Published 1983).

C. M. Allison, SCDAP/MOD1 Plenum Behavior Models, (To be Published 1983).

G. A. Berna et al., SCDAP/MOD1: A Computer Code for the Analysis of Severe Core Damage Accidents, (To be Published 1984).

C. M. Allison et al., SCDAP/MOD1 Developmental Assessment, (To be Published 1984).

(7) Description of Major Non-Labor Costs

The major items in the materials category that require operating funds during FY-1984 through FY-1985 are computer services for computer code development and development assessment and services for production of project documentation.

	($000) FY-1984	FY-1985
ADP Support (Computer)	$ 140	$ 202
Material and Services (Publication of Reports)	$ 44	$ 21

(8) List New Capital Equipment Required

Not Applicable.

(9) Describe Special Facilities Required

Not Applicable.