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**Developing Engineering Analysis
Capabilities at a Nuclear Utility**

by

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SUMMARY

During the design and construction of a nuclear power plant, Architectural and Engineering (A/E) firm(s) and the Nuclear Steam Supply System (NSSS) use a large staff of analytical and design personnel to provide the technical specifications needed for the plant to function and satisfy Nuclear Regulatory Commission (NRC) requirements. During this design process, thousands of calculations are performed, some using large sophisticated computer programs. Once the plant is operational, the utility assumes the large responsibility for plant design. Utility personnel must understand the fundamentals of operating the plant, the technical information in the Updated Safety Analysis Report (USAR), all calculations used to design the plant and the input for all design specification documents. Without this knowledge, the utility personnel cannot successfully perform modifications or new analyses required by the NRC (e.g., Probabilistic Risk Assessment (PRA) and Motor Operated Valve (MOV) programs) and maintain the safe and reliable operation of the plant.

Due to the nature of the design basis (many calculations, drawings, and specifications), it is important to separate design and analysis from day-to-day operational activities. It is the responsibility of senior utility management to distribute duties. Plant Staff is responsible for daily operations and the Engineering Department is responsible for daily technical support and long term technical activities. The proper distribution of responsibilities and resources will help ensure adequate support to the plant and the development of a good design and analysis capability. Using this capability in a

focused way will produce good economical decisions that will lead to increased capacity factor and reduced operation and maintenance expenses.

Engineering analysis at a nuclear plant has several disciplines: mechanical engineering, structural/civil engineering, nuclear engineering, nuclear physics, chemical engineering and sometimes, electrical engineering personnel. Engineering analysis disciplines are divided into specialties consisting of Core Analysis/Reactor Engineering, Thermal/Hydraulic (T/H) Analysis, Nuclear Safety and Reliability Analysis, Shielding and Radiological Analysis and Structural Analysis. At River Bend Station (RBS), operated by Gulf States Utilities (GSU), the Engineering Department was formed in line with these engineering disciplines. The Engineering Analysis (EA) Section has three groups, i.e., Core Analysis (CA), PRA/Radiological Analysis, and T/H Analysis. The Structural Analysis group is located in the Design Engineering Section and the Reliability Analysis group is located in the Reliability Systems Group.

In 1987, the goal of the EA Section was to perform 80 percent of the analytical work in-house. Normally most of this work is performed by A/E's, NSSS firms or consultants. The task of performing this work by the utility is very difficult since site related daily work (i.e., "fire drills") requires many resources. Through the process of dedicating specific individuals to perform the long term work load (e.g., reload safety analysis independent review and methods development, Individual Plant Examination, analytical work for technical specification changes, etc.) the analytical production capability has been developed and maintained as well as

daily support requirements.

Currently, the EA section at RBS can effectively perform most jobs normally performed by consultants, NSSS firms and A/E firms. Besides performing long term assignments, much of the EA section's attention is focused on direct plant activities since the primary function of the Engineering Department is to ensure the safe and reliable operation of the plant.

If all the proper factors have been considered, a good analytical group should be and can be developed on site to support all facets of plant support including nuclear fuels, regulatory concerns, probabilistic risk assessment, engineering evaluations, root cause evaluations, and daily technical support for the plant.

INTRODUCTION

In the 1970's and 1980's, A/E and NSSS engineering firms spent significant time and effort to develop the ability to analyze design, operation and reactor safety aspects of nuclear power plants. This effort included, quality assurance to satisfy 10CFR50 Appendix B for calculations and computer programs, training of specialized staff to perform the calculations and the development of computer programs to speed up and refine the calculation performance. Also many consultants and material vendors that provided services to the utilities, A/E and NSSS suppliers formed their design and analysis capabilities. All analyses and documents provided by these groups form the basis for the plant design. Besides the functional and operational design basis, the NRC mandated many deterministic requirements that equipment had to satisfy. Accident availability of safety equipment was ensured by simulation, usually through the use of computers, of accident and steady state conditions. Many calculations have been performed to provide input into documents such as, Technical Specifications, Final Safety Analysis Report (FSAR), equipment specifications, equipment qualification, heating ventilation and air conditioning (HVAC), chemical control, electrical design, structural design and piping design. Many of these areas use standard engineering practices to determine the design of a nuclear power station, i.e., structural design, piping design, electrical design, chemical control and HVAC, while other design and analysis areas are specific to nuclear plant design, i.e., USAR, equipment qualification for accidents and technical specification. In terms of general power plant designs, all the different types of power plants (e.g., nuclear and fossil) may have common areas of design and analysis such as balance of plant design. The major differences between nuclear design and other power plant designs are the nuclear core versus more conventional heat generation and

the preponderance of nuclear regulations and requirements that must be followed. Much of this regulation has been reflected in the calculations and analyses that are performed to develop the plant design.

For RBS, there are approximately 100,000 calculations that form the basis of the plant design and safety analysis. The calculations are divided primarily into three production areas, i.e., General Electric (NSSS), Stone & Webster (A/E) and outside vendors (others).

After the construction of RBS was completed in 1985 and GSU assumed design responsibilities, the laborious task of transferring the calculations and design drawings began. It also became evident that some expertise or understanding of the calculations and modifying the calculations was needed. This requirement was recognized by GSU management and an effort was started to develop the ability to perform 80-90 percent of the design and analysis work at RBS with GSU personnel.

Some of this effort was consolidated early in 1990 by forming the PRA/Radiological Analysis, T/H Analysis and CA groups together in the EA Section.

This paper will present a perspective on how an engineering analysis organization can be developed at the site of an operating nuclear utility. Ideas given here are focused at the nuclear industry but can also be used for other industrial operations. The paper has two major sections. The first section provides a description on developing engineering analysis capabilities and the second section describes the Engineering Analysis Section at River Bend Station.

DEVELOPING ENGINEERING ANALYSIS CAPABILITIES

In developing EA capabilities, there are several areas that are of paramount importance. These areas are listed in order of priority below:

1. Establish credibility in solving and supporting plant problems.
2. Transfer of technology from consultants and vendors.
3. Develop yearly goals and schedules within your financial and workforce limits to support the plant and long term development activities.
4. Allocate your personnel resources to ensure that you take care of day to day requests and that long term goals can also be met.
5. Develop procedures to provide quality assurance (QA) for performing calculations,

verification and validation of computer programs.

6. Develop or purchase computer programs to replace established computer programs that have been used by consultants or vendors to license the plant.
7. Verify and validate the necessary computer programs. Document all calculations.
8. Establish a means to let management know who you are and how you have helped save resources and how you have supported the plant.
9. Establish good tracking methods.
10. Develop schedules and set goals to replace most consultants, contractors and vendor services.
11. Improve computer capability and automate computer usage, i.e., reduce the time required to develop input and get output.

Establish Credibility

Establishing credibility can be very difficult for an analytical group. Personnel in analytical groups typically desire significant time to think through problems. Unfortunately, at the plant, problems require solving in a very short time. Good approximations and short cuts must be developed to provide reasonable solutions quickly. Early in the development of EA capabilities much of the long term activities suffered due to the continuous onslaught of problems that required immediate attention. Although continuous attention to daily problem solving hurts long term development efforts, attention to daily problem solving helped EA establish credibility so additional resources could be obtained to work on long term goals.

Transfer of Technology

Adequate training of personnel is important to establishing a competent staff in providing analytical support for the plant. This has been accomplished at RBS in several different ways. There are three general categories of training.

1. General orientation and employee training
2. Technical support training
3. Job specific training

The first two categories are typically left up to the Training Department, but the third category, which is very important in development of engineering analysis capabilities, comprises specific training that can develop engineers into technical

experts. This job specific training is listed below for each group in the EA section.

Core Analysis Job Specific Training

1. Training on use of CASMOS (lattice physics)
2. Training on use of MICBURN (Gad X-Sections)
3. Training on use of SIMULATE (3-D core simulations)
4. Training on use of FIBWR (SS-Core thermal/hydraulics)
5. Training on the critical power ratio (CPR) correlation
6. Training on reactor engineering support
7. Station nuclear engineering training
8. Training on preparing calculations
9. Training on preparing computer program compliance packages
10. Training on RETRAN-SIMULATE interface
11. Training on thermal/hydraulic and criticality analysis for spent fuel pool
12. Computer usage training
13. Fuel management training
14. Multi-cycle scoping and cost evaluation training
15. Fuel bundle design training
16. Training on developing thermal limits

Thermal/Hydraulics Analysis Job Specific Training

1. Training on use of RETRAN
2. Training on hot channel analysis
3. Training on RETRAN-SIMULATE interface
4. Training on developing thermal limits
5. Training on use of ESCORE/gap conductivity
6. Training on use of RELAP5
7. Training on thermal/hydraulics of the reactor vessel
8. Transient and LOCA training
9. Subcompartment and containment design training (use of GOTHIC and COMPARE)
10. Fluid flow dynamics training
11. Station nuclear engineering training
12. Training on using TRAC-BD1
13. Training on using RAMONA
14. Training on steady state flow analysis (KYPIPE)
15. Training on heat transfer analysis
16. Simulator training

Probabilistic Risk Assessment (PRA) and Radiological Analysis Job Specific Training

1. Training on performing PRA
2. Training on severe accident issues
3. Training on Emergency Operating Procedures (EOPs) technical basis
4. Training on the use of CAFTA and NUPRA (Level 1 PRA)

5. Training on the use of Level 2 programs
6. Training on the use of SCDAP/RELAP5
7. Maintenance evaluation training (NURISK)
8. Accident management training

Many of these training sessions can be provided by the originator of the work, i.e., NSSS vendor, A/E or consultant.

Develop Goals and Schedules

Goals and schedules are always important for any organization. Since it takes so long for an analysis group to mature into a viable organization, goals and schedules are essential. An example of goals for the PRA/Radiological Analysis group is presented in Table I.

Allocate Resources

This may be one of the most difficult areas for successful management. It is always important to have an adequate number of people to perform long term (1-2 year) tasks. Without adequate attention in this area, long term commitments will slip and you will not develop the necessary capability to provide good analytical support and a crisis environment will begin to exist. Providing engineering work through crisis management is demoralizing for the engineers and is usually expensive since much of the work is usually performed by consultants.

Develop Procedures and Verify Computer Programs

Developing procedures to provide the QA and format for performing safety related calculations and computer analysis is important for developing in-house analysis capabilities. At RBS the engineering procedure, EDP-AA-20, was developed for guidance to document all Engineering calculations. This provides for a systematic method of producing traceable and consistent calculations.

Besides the calculation procedure, guidance on performing verification and validation of computer programs must be developed. Engineering procedure EDP-AA-074 was developed to ensure the review and documentation of all computer programs so safety related calculations could be performed.

The Engineering Department uses many large computer programs to perform various calculations to support plant design modifications and operation. These programs are used by Engineering for plant support in areas such as probabilistic risk assessment (PRA), core physics analyses, stress

analyses and thermal/hydraulic analyses. These programs must be validated to ensure correct results and provide assurance that the program users are qualified to use the programs and understand the limitations of each program.

Computer Programs

Many computer programs are required to ensure that the groups are able to handle problems that come up. Table II provides a partial list of computer programs. It should be noted that several of these programs can be obtained in the public domain for a nominal charge.

Verify and Validate Computer Programs

Validation of a computer program consists of assuring that the program will adequately model the process of interest and that the individual using the program understands the use of the program and its limitations. Assurance that the program models a process correctly is accomplished by comparing cases with known conditions such as plant data, data from other plants, or industry standards. The known data is used as input for the program, along with the modeled process, and the output is compared with known results. The computer program results should agree reasonably well with the known results. This process is performed in Engineering with the guidance given in procedure EDP-AA-074.

Individuals are qualified through established training requirements or equivalent experience for each program. Established training plans specify training methods that are adequate to qualify users for productive use of the program. Methods for showing the applicability and limitations of the program are included in the training plans.

Computer program validation is documented according to Engineering Department procedures for calculations and computer program qualification. The computer program validation program at River Bend is an important part of assuring good and competent engineering support for RBS.

Other procedures and guidelines also must be developed so performance of tasks can be documented and a routine established through either a procedure or guideline.

Let Other People Know

Analysis is very abstract and esoteric to many plant management personnel. One must remember, most personnel have never worked at A/E or vendor firms where large analytical groups formed the design basis of the plant. Most people including many

engineers only see the product of these analyses, i.e., technical specifications, FSARs or design specifications. So it is up to the analytical group to ensure that plant management understands that analysis is a very important part of making proper modification changes, technical specification changes, safety evaluations, justification for continued operations (JCOs) and providing other regulation and operational input so that the plant is run safely and reliably.

This can be done through many vehicles. We do the following to help understanding and perception of analysis groups.

- a) At every opportunity discuss with Plant Staff and Design Engineering how the analysis groups have helped the plant and design organizations. Provide information sessions to operators and technical staff.
- b) Put out a newsletter discussing evaluations performed by the analysis groups to which plant staff and other engineering organizations can relate.
- c) Make sure top management knows what you are doing, that what you are doing is important, how much it can save and how much it can improve capacity factor. For example, make sure the PRA is used to help management and plant staff make good decisions. The CA group can contribute significantly to Reactor Engineering and the T/H group can help resolve many mysterious fluid flow problems.

Good communication is essential to ensure viable analytical groups.

Good Tracking

When the analysis groups become recognized as credible, many groups will request information and solutions. It is imperative that requests have prompt attention or your group will get a reputation of paralysis through analysis.

Track all required requests appropriately and establish a priority system to ensure that the most important items are performed first. A rule of thumb to use is that an urgent request that could impact plant safety or impact plant capacity factor will always be performed first.

Replace Outside Services

Remember your number one goal is to take care of the plant, but not too far behind is the need to reduce costs. One way to provide cost reduction is to reduce

contractor and consultant services. A schedule should be formulated to develop in-house capabilities to replace the need for outside services.

Improve Computer Capacity

No one can get their job completed in an adequate manner without tools. An analyst without a computer is like a laborer trying to dig a ditch without a shovel.

It is extremely important that all your analysts have at least a personal computer (PC). One must be patient in attaining this goal, but if you are persistent, it can be done.

Also, with the arrival of the high speed workstations, it is especially important to have your mainframe computer programs converted to workstation programs so computer work can be completed on site. This will increase computer program turnaround and reduce costs significantly. The EA Section uses IBM RISC 6000 machines at RBS.

The third area is to automate your work as much as practical. Develop a schedule to automate most of the analyst's work that is executed on PCs and workstations. This will ultimately improve productivity (up to 100%) and enable your group to perform more work and reduce outside services.

Primary emphasis should be placed on these activities to get the best results. Credibility and informing upper management are issues that are probably the most difficult to achieve, but are also two of the most essential areas to develop.

The EA Section at RBS is being developed based on these concepts. A description of each group in EA is provided in the following paragraphs.

DESCRIPTION OF ENGINEERING ANALYSIS ORGANIZATION

The EA Section is located in the Engineering Department on site at RBS in St. Francisville, Louisiana. EA is responsible for providing technical input to: (1) analyze various operational and abnormal transients as listed in the River Bend USAR; (2) perform reload safety and accident analysis in support of plant operations, licensing, and design engineering; (4) develop PRA capability for RBS; (5) perform containment, thermal/hydraulic and radiological analyses and (6) provide fuel management and licensing support.

At RBS, the EA Section is composed of three groups. These groups are the CA Group, the T/H Group, and the PRA/Radiological Group. The functional responsibilities of each of

these groups are given in Table III.

The CA Group is responsible for providing RBS and GSU plant specific assessment of the nuclear reactor core behavior. Detailed simulation of the reactor core burnup and refueling core management is required. Optimization of fuel reload and daily core follow are performed by this group.

The T/H Group is responsible for developing and maintaining the expertise to: (1) analyze various steady state and operational transients; (2) analyze loss-of-coolant accidents (LOCA); (3) operation, design engineering and licensing analysis, and (4) perform steady state and transient fluid flow calculations in piping systems and perform containment pressure and temperature calculations and heat exchanger analyses.

The PRA group provides an analytical model used for protecting the health and safety of the public. The primary application of PRA at RBS is to evaluate the impact on plant safety that might result from changes in plant design, methods of operation, or malfunctions of various components and systems.

Core Analysis Group

The CA group is responsible for performing in-core fuel management and other engineering activities relating to technical aspects of nuclear fuel. The mission is to minimize nuclear fuel costs and maximize plant availability while meeting regulatory, contractual and GSU system requirements.

CA uses large computer programs to develop and maintain steady-state physics models of the River Bend core. The core models are used to analyze, evaluate and make recommendations on core and fuel designs, reload batch size and enrichment, core loading patterns, cycle length, cycle operating alternatives, and multi-cycle fuel schedules. The core models are also used to support various aspects of plant operations, including estimated critical rod positions and other aspects of startups, control rod strategies, compliance with Technical Specification limits on local power peaking, fuel damage and heat flux, reactivity anomaly curves, cold shutdown margins, core isotopics, refuel planning, and plant process computer support.

Other areas of support include the following:

1. Providing information from the steady-state core models to the T/H group for input to transient analysis models.
2. Monitoring fuel performance and fuel integrity, developing and maintaining a failed fuel action plan.
3. Tracking and predicting control rod

exposures and recommending replacement/shuffle schemes to optimize control rod lifetime.

4. Providing target discharge fuel bundle burnups and monthly actual burnups for fuel amortization.
5. Providing technical support for QA audits of reload fuel design and manufacture, for fuel cost determination, fuel shipments, handling, storage and shuffling.

To date, CA has used the computerized core models for non-safety-related applications and for independent verifications of fuel vendor results. This has resulted in successfully optimizing fuel cycles and fuel burnups.

To become analytically independent of the fuel vendor in safety-related applications, CA has submitted a topical report to the NRC. When this report is approved by the NRC, CA can provide safety related physics calculations for fuel reload safety analysis and for safety related technical specification changes. Approval is expected in 1992.

Thermal/Hydraulic Analysis Group

The T/H Group is responsible for the following engineering areas:

1. Perform analyses of various operational and abnormal transients as listed in the River Bend Station (RBS) Updated Safety Analysis Report (USAR).
2. Perform safety and accident analyses (including loss-of-coolant accident (LOCA)) in support of Nuclear Licensing (i.e., Fuel Reload Analysis and Technical Specification Changes), plant staff and engineering.
3. Perform containment and subcompartment thermal/hydraulic analysis including steady-state and transient heat transfer analysis in support of the Equipment Qualification Group, Nuclear Licensing, Design Engineering and Plant Staff.
4. Perform fluid flow transient and steady-state analyses for equipment and piping evaluations.

The group is responsible for answering questions and performing various operational and abnormal transients as listed in the USAR. The computer program RETRAN is used for this simulation. The RETRAN model is a numerical model that can simulate the fluid and core physics behavior in the RBS reactor and core physics behavior in the RBS reactor vessel up to and including the turbine control valves (TCVs). All trip actuation devices and feedback controllers are simulated and have been verified and

validated to RBS start-up data and scram information. This model can simulate, with good accuracy, practically all transient situation that one can envision.

Other programs that are available to simulate transient and loss-of-coolant accidents are RELAP5 and TRAC-BF1. The TRAC-BF1 computer program can simulate two and three dimensional fluid flow behavior. To perform any of these analyses, the CA Group must provide the appropriate steady state physics for the RETRAN, RELAP5 and TRAC models. The RAMONA computer program is also being used for 3-D reactor kinetics simulation in determining the behavior of the reactor during instability events and other 3-D simulations.

Methods were developed to perform the fuel reload safety analyses for submittal to the NRC in 1991. This activity requires that the T/H Group have in-depth capability to determine the RBS operational core thermal limits. This work requires much computer usage and a thorough understanding of how the reactor and fuel behave during various transient events. Nuclear Licensing submittals are required to be given to the NRC for their review and approval prior to the reactor start-up for a refueling outage.

Other analyses performed by the T/H Group are containment and subcompartment analyses. Examples of this type of analysis would be to determine the heat-up of the RBS containment building including the drywell in the event of a loss of all alternate current (AC) power or the heat-up of the drywell and suppression pool due to leaking safety/relief valves (S/RVs). This requires a detailed understanding of how the containment is constructed and how the equipment works.

The group also performs steady-state, transient fluid flow and heat transfer analyses to determine piping and structural equipment capabilities during normal and abnormal events. When the system is not designed for high pressure and temperature transient water flow into a low pressure piping system and the event occurs. This situation must be analyzed. This work requires the analysis engineer to understand the system, the design basis of the system, numerical heat transfer analysis and two-phase fluid flow analysis, and the use of computers.

PRA/Radiological Analysis Group

The PRA/Radiological Analysis group is responsible for the following engineering areas:

- 1) Level 1 PRA
- 2) Level 2 PRA
- 3) Severe Accident Management
- 4) Radiological and Shielding Analysis

The Level 1 or "Front-End" PRA involves constructing a computer model of RBS consisting of complex fault trees for 23 critical systems, linked to nine event trees that define plant transients. The fault trees used component failure data to determine the probabilities for system failure. This information determines the plant's response to the transients in the event trees.

The Level 2 PRA provides event trees for the containment. Core damage information from the Level 1 PRA serves as an input to the Level 2. This "Back-End" phase of the PRA develops containment failure probabilities. This requires complex computer modeling of the thermal/hydraulics of the reactor core, the RPV, and the containment building. The Level 2 computer codes (e.g., MAAP2.0B, STCP, BWR SAR) also model dispersion of core radionuclides in the containment

Severe Accident Management is the use of PRA techniques and results to improve plant maintenance, operations, training, etc. This activity incorporates plant specific component data, emergency operating procedures, operator training and behavior, modifications, etc. into the PRA to increase the model's accuracy. The results from a more accurate PRA model improve the plant's ability to cope with severe transients. Examples of Severe Accident Management include:

- 1) Emergency Operating Procedure improvement
- 2) Station Blackout response
- 3) Review of External Events (fires, internal flooding, etc.)

Radiological analysis involves the modeling of plant process systems carrying radioactive materials to determine dose rates, shielding requirements, etc. These activities are performed to support plant modifications, operability determinations, equipment qualifications, and ALARA concerns. Operations and maintenance activities during both normal operations and outages can be directly affected by these analyses. Shielding analysis is performed using PC spreadsheets or codes such as QADMOD.

There is significant interchanging of information among the PRA and Radiological Analysis Group, T/H Group and the CA Group.

CONCLUSION

EA activities are very important to the safe and reliable operation of a power plant. With proper information about the analytical design basis of the plant, many timely decisions can be made to improve the safety of the plant and increase the availability of the plant.

TABLE I
1992 GOALS FOR
PRA/RADIOLOGICAL ANALYSIS

LEVEL 1 IPE

1. Complete Rev. 1 of Level 1 model (4/1/92)
2. Complete Rev. 1 of System Notebooks (8/1/92)
3. Incorporate RBS critical component data into model (4/1/92)
4. Submit Level 1 IPE Rev. 1 to NRC (10/1/92)

LEVEL 2 IPE

1. Qualify all Level 2 IPE computer codes (6/1/92)
2. Develop Level 2 IPE program controls and procedures (6/1/92)
3. Develop and quantify Level 2 IPE model (8/1/92)
4. Complete Rev. 0 of Level 2 model (8/1/92)
5. Submit Level 2 IPE Rev. 0 to NRC (10/1/92)

IPEEE

1. Develop IPEEE program controls and procedures (2Q92)
2. Perform seismic and fire risk walkdowns (2Q92)
3. Qualify IPEEE computer codes (3Q92)
4. Complete EPRI fire PRA analysis (12/31/92)

ACCIDENT MANAGEMENT

1. Upgrade EOP traceability (5/1/92)
2. Revise EOP's for Cycle 4 (5/1/92)
3. Review SBO Rule SER when issued by NRC (3/22/92)
4. Complete SBO Report (2/15/92)
5. Support SBO procedure changes and modifications (ongoing)
6. Develop RBS response to NRC hydrogen control SER (TBD)
7. Perform PSA's to support other departments (ongoing)
8. Perform RF-4 safety assessment (8/15/92)

SHIELDING/RADIOLOGICAL ANALYSIS

1. Perform calculations and studies to support other departments (ongoing)

TABLE II
COMPUTER PROGRAMS

<u>LOCATIONS *</u>	<u>GSU PROGRAMS</u>	<u>REPLACEMENT</u>	<u>APPLICATION</u>
MF, WS, PC	RETRAN	ODYN (GE) REDI (GE)	TRANSIENT AND PRESSURIZATION ANALYSIS
MF, WS	ESCORE	GEGAP (GE)	GAP CONDUCTION
WS, PC	FREY	GESTR(GE)	FUEL MECHANICAL
MF	TRAC-BF1/RELAP5	SAFE/REFLOOD AND SAFER (GE)	LOCA
MF, WS	HEATING-6	LION (SWEC) TRHEAT (SWEC)	HEAT TRANSFER HEAT TRANSFER
MF, WS	RELAP5/MOD3	STEHAM (SWEC)	DYNAMIC FLUID FLOW
WS	MCFIST	WATHAM (SWEC)	DYNAMIC FLUID FLOW
MF, WS, PC	COMPARE	THREED (SWEC)	SUBCOMPARTMENT
MF, WS, PC	RETRAN	CONSBA (SWEC)	REACTOR PRESSURIZATION
PC	CONTEMPT-LTMOD	LOTVS (SWEC)	CONTAINMENT ANALYSIS
WS	GOTHIC	LOTVS (SWEC)	CONTAINMENT ANALYSIS
MF, WS	QADMOD	QADMOD (SWEC)	SHIELDING
WS, PC	ORIGEN-2	RADIOISOTOPE (SWEC)	ACTIVATION ANALYSIS
PC	MORSE	COHORT (SWEC)	n&y STREAMING
PC	CAFTA	CAFTA (SAIC, EPRI)	PRA FAULT TREE
MF	FTAP	FTAP (SAIC)	PRA FAULT TREE
MF, WS	MAAP 3.0	MAAP (EPRI, IDCOR)	SEVERE ACCIDENT MANAGEMENT
	SCDAP/RELAP5	SCDAP/RELAP5 (EG&G)	ACCIDENT MANAGEMENT
PC	XOQDOQ	XQ (SWEC)	OFFSITE DOSE REPORT (REPORT 1.21)
WS	CASMOS-3	TGBLA (GE)	LATTICE PHYSICS
WS	SIMULATE-3	PANACEA (GE)	3-D CORE SIMULATOR
PC	KAREN	PROFCY (GE)	MULTI-CYCLE OPTIMIZATION
PC	ALGOR-FEA	MANY (GE AND SWEC)	DYNAMIC STRUCTURAL VIBRATION THERMAL

* MF implies mainframe, WS implies workstation (RISC 6000) and PC implies personal computer

TABLE III
ENGINEERING ANALYSIS RESPONSIBILITIES

Areas of Responsibilities

Thermal/Hydraulic Analysis Group
 Reload Verification
 Reactor Safety Analysis
 Support Tech Spec Changes
 Procedure Change Support
 Abnormal Operation Support
 Thermal Hydraulics for Piping Systems
 Heat Transfer Analysis
 Containment Analysis
 Special Analyses

Core Analysis Group
 Multi-Cycle Physics
 Fuel Loading Pattern Optimization
 Steady State Safety Analysis
 Shutdown Margin
 Target Control Rod Patterns
 Lattice Physics
 Reload Licensing and Design
 Tech Spec Change Support

Probabilistic Risk Assessment (PRA)/
 Radiological Analysis Group
 Level I and II PRA
 External Events for PRA
 Nuclear Safety Analysis
 Design Change Support
 Tech Spec Change Support
 Document Control of PRA
 Living System Notebook
 Station Blackout (SBO)
 Emergency Operating Procedures (EOPs)
 Accident Management
 Shielding Analysis
 Radiological Dose Assessment