TEXAS ENGINEERING EXPERIMENT STATION

TEXAS A&M UNIVERSITY
COLLEGE STATION, TEXAS 77843-3575

NUCLEAR SCIENCE CENTER
409/845-7551

April 23, 2001 2001-0062

U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555

Subject: 2000 Annual Report

Reference: NRC Facility License R-83, Docket 50-128

Dear Sir:

Attached you will find the 2000 Annual Report for the Texas A&M University System Nuclear Science Center. If you have any questions or comments, please contact me at (409) 845-7551.

Sincerely,

W. D. Reece, Director

WDR/eg

Attachment: 2000 Annual Report

xc: 211/Central File
7.122/NRC Correspondence File
1.41/NSC Annual Report 00/00

A020

Texas A&M University System
Texas Engineering Experiment Station

Nuclear Science Center

2000 Annual Report

Facility Operating License R-83

1095 Nuclear Science Road
College Station, Texas 77843-3575

April 2001

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1. Introduction

The Texas A&M University Nuclear Science Center (NSC) is a multi-disciplinary research and education center supporting basic and applied research in nuclear related fields of science and technology as well as providing educational opportunities for students in these fields as a service to the Texas A&M University System and the state of Texas. The NSC also provides services to commercial ventures requiring radiation or isotope production services.

The NSC reactor, a 1-MW, pool-type TRIGA reactor, is at the heart of the NSC facilities which includes a 2-MW micro-beam accelerator, a ^{60}Co gamma calibration range, a real-time neutron radiography facility, a large-object irradiation cell, hot cells and manipulators, three radiation measurement laboratories, radiochemical laboratories, five HPGe gamma spectroscopy systems, and a variety of instruments for radiation detection and measurement.

The NSC reactor is designed for easy load/unload of various types of samples and is being actively used to produce various kinds of radioisotopes for industry, hospitals, and academic users. The NSC is also nationally recognized for its neutron activation analysis (NAA) services to many research and academic institutions in the western part of the United States. The NSC reactor also actively supports the Nuclear Engineering Department on campus, one of the largest nuclear engineering programs in the United States. The NSC has become one of the major attractions on campus. Last year alone, the NSC had 2,910 visitors, which include elementary, middle, high school, and college students, faculty members, clients, and national laboratory and industrial scientists and engineers. Through these tours, the NSC is emphasizing the importance of nuclear energy in the United States.

With the strong support from the University, the NSC is continuously increasing the diversity of its facilities and services. Currently, the NSC is developing a second version of ^{125}Xe irradiation system to increase the production yield of ^{125}I, a new Fast Flux Irradiation Device (FFID), which will have a cooling system to remove the heat generated in the device, and a new topaz irradiation device for quality irradiation of gemstones.

This annual report has been prepared to satisfy the reporting requirements of Technical Specification 6.6.1 of the facility operating license R-83 and of the Department of Energy University Reactor Fuel Assistance Program subcontract No C87-101594 (DE-AC07-76ER02426). The facility license currently extends to March 2003.

1.1 Nuclear Science Center Staff

The staff at the Nuclear Science Center is divided into five groups: Reactor Operations, Reactor Maintenance, Health Physics, Technical Coordination, and Administrative Service (see Figure 1). Personnel directly involved with the operation and maintenance of the reactor are NRC-licensed operators. The NSC is committed to its educational responsibilities and many members of the staff are part or full-time students at Texas A&M University.

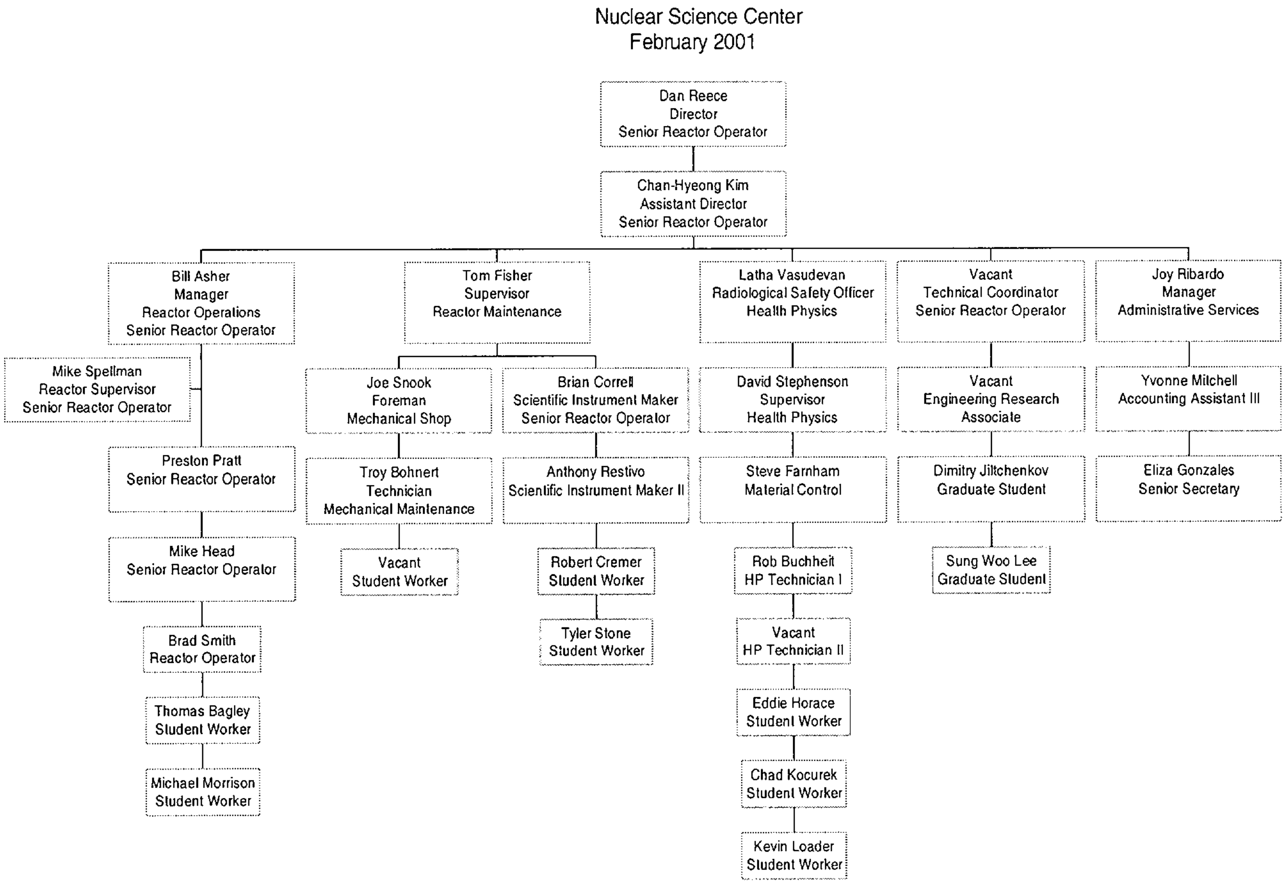


Figure 1-1. NSC Organization Chart

The Nuclear Science Center (NSC) is operated by the Texas Engineering Experiment Station (TEES) of the Texas A&M University System. The Director of the Nuclear Science Center (NSC) is responsible to the Deputy Director of the TEES for the administration and the proper and safe operation of the facility. In addition to the internal structure, the Reactor Safety Board (RSB) is established to advise the Deputy Director of the TEES and the Director of the NSC on issues or policy pertaining to reactor safety. The Texas A&M University Environmental Health and Safety Department (EHSD) provides assistance when it is required for emergencies and for special operations as agreed.

2. Reactor Utilization for 2000

The Nuclear Science Center (NSC) reactor has been in operation since 1962. The reactor is a 1-MW, MTR-converted type TRIGA reactor. The reactor uses highly enriched uranium fuel (70%), but will be converted to 20% enriched fuel core when DOE funds become available. Core VIII-A is the current core configuration and has been in use since March 1986. The NSC reactor is pulse operational and is pulsed up to powers of approximately 1,100 MW for nuclear engineering laboratories, staff training, and public tours.

The NSC reactor operated for 2209 hours in 2000 with a total integrated power of 89.1 MW-days. There were 638 irradiations and services performed at the NSC during the reporting period. The NSC provided services to TAMUS departments, other universities, research centers and secondary schools in and outside the state of Texas. Many departments at TAMU and other universities used the reactor regularly in the past year. The NSC reactor had about 90% of availability in 2000.

Table 2-1. Reactor Utilization Summary in 2000

Days of Reactor Operation	255
Integrated Power (MW-days)	89.1
Number of Hours at Steady-State	2209
Number of Pulses	62
Number of Reactor Irradiations (RFS)	638
Beam Port/Thermal Column Experiment Hours	1012
Hours Irradiation Cell Use	113
Number of Visitors	2910
Unscheduled Shutdowns	7

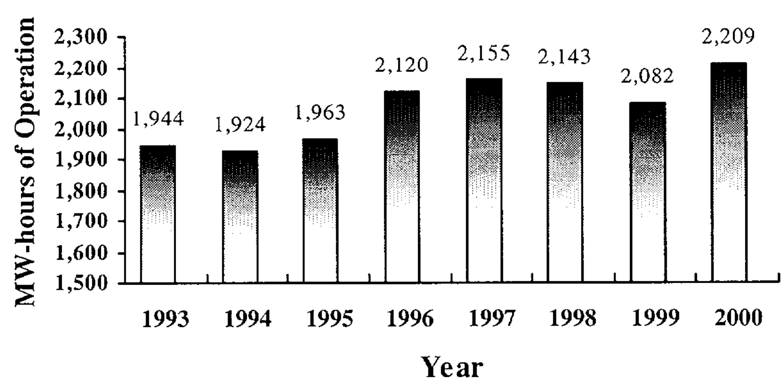


Figure 2-1. Annual Reactor Utilization

2.1 Research Enhancement Program (REP)

The Research Enhancement Program (REP) was established by the 70th Texas Legislature in 1987 to "encourage and provide for research conducted by faculty members." The REP replaced

the former "Organized Research" program. The TAMU Office of the Vice President for Research administers the REP funds. REP funds are generally allocated to the NSC early in the fiscal year. TAMUS faculty who desires to use the irradiation services at the NSC reactor must apply at the NSC to receive local funding for each individual project. This proposal method is flexible and does not hinder a project's start-up time.

2.2 TAMU Academic Support Program

Texas A&M University (TAMU) provides funding for the reactor for such academic activities as nuclear engineering laboratories, neutron activation analysis demonstrations and laboratories, graduate student thesis and dissertation research, and undergraduate research projects. The program has been very successful and is crucial for many graduate students whose chosen research uses the NSC reactor in some way but is not supported by any research grants. The NSC's reputation as a multi-disciplinary institution is reflected in the wide range of academic users from the university.

2.3 DOE University Reactor Sharing Program

The DOE University Reactor Sharing Program provides funds for reactor experimentation to those institutions that do not normally have access to a research reactor. The Nuclear Science Center (NSC) has participated in the program since 1980 with great success. During the 1999-2000 contract year, 9 research institutions utilized the NSC with the support of the Reactor Sharing Program. Additionally, the funding provided reactor tours and "hands-on" projects to many secondary schools. The research projects supported by the program range from geological dating to the production of high current superconducting magnets. The funding gave several small colleges and universities the opportunity to use the NSC facilities for teaching courses in nuclear processes, specifically neutron activation analysis and gamma spectroscopy. The Reactor Sharing Program supported the use of the Fast Flux Irradiation Device for multiple users at New Mexico Institute of Mining and Technology and the University of Nevada at Las Vegas. This device has been characterized and has been found to have near optimum neutron fluxes for $^{39}Ar/^{40}Ar$ dating.

2.4 Commercial Activity and External Research

The NSC provides services to a variety of users who have their own funding. The majority of commercial activities are related to isotope production of radioactive tracers for support of the Texas petroleum and chemical industries. Another commercial activity uses the converted Thermal Column area for the production of micropore filters that are used in ultra-pure water systems in the semiconductor industry. A significant amount of research at the reactor is funded by outside research grants. The NSC has many years of experience in the production of radioisotopes and has developed several customer-specific methods for radioactive sample production and handling. The production of radioisotopes generally involves handling of radioactive material with high activities. The NSC staff takes precautions to minimize their exposures during the transfer of radioactive materials to shipping shields.

3. Facility and Procedure Changes

3.1 Facility Modifications

The following items were authorized facility modifications and maintenance in accordance with 10 CFR 50.59. The approvals were documented in NSC staff meeting minutes or RSB meeting minutes as appropriate.

Replacement of the log and linear channel recorders with a PC (January 11, 2000)

The recorders of the log and linear channels were replaced by a personal computer. The personal computer had been recording and displaying the data supplied to the log and linear channel recorders for several months and there had not been any problems or degradation of the data. It had been the intention of the NSC management to eventually remove all recorders from the console and use the personal computer for data collection, display, and retention. The staff agreed that each week, the data should be burned onto a compact disk with a hard copy printed, reviewed and filed by the Reactor Supervisor.

Replacement of the fuel temperature recorder with a digital meter (February 2, 2000)

The fuel temperature recorder in the control room was replaced by a programmable digital indicator. In addition, a test switch was installed with the indicator to facilitate the daily scram test of the fuel temperature measuring circuitry. A separate switch was also installed on the input to the digital indicator for use in the performance of the annual scram time surveillance. The switch allows the rod drop timer to measure the elapsed time between the sensing of the limiting safety system setting (LSSS) signal and the actuation of the appropriate rod down switch. After two months of test period, the modification was approved by the NSC staff and RSB (NSC Modification Authorization #53).

Replacement of 12-V power supply to logic circuit of control rod drives (September 25, 2000)

The 12-V power supply to the logic circuit of the control rod drives (12V, 16 ADC) was replaced by a new system (12V, 20 ADC). The NSC reviewed the replacement and concluded that the replacement would not affect any function of the safety system.

3.2 Experiment Authorizations and Modifications

Temperature measurement using Xenon Irradiation Simulation Device (December 15, 2000)

The NSC was developing a second version of xenon-125 irradiation system to produce iodine-125 for medical usage. During the development, the temperature of the xenon gas in the irradiation chamber was necessary to assess the integrity of the irradiation chamber. To measure the temperature of the xenon gas, the NSC developed a Xenon Irradiation Simulation Device (XISD). The only difference of the XISD from other experiment devices is that it has a

thermocouple in the inner chamber, instead of sample material. The NSC staff reviewed the experiment (ERA #30) as per 50.59 and approved it without any comment or concern.

4. Reactor Maintenance and Surveillance

4.1 Scheduled Maintenance

Calibrations were performed on the Fuel Element Temperature Channel, Area Radiation Monitors and the Linear, Log, and Safety Power Channels as required by the Technical Specifications. All surveillances required by the reactor license were performed. Control rod worth and scram time measurements were performed in September 2000. The total rod worth was found to be $16.43. The most reactive control rod is Shim Safety #4 with a worth of $4.54. The shutdown margin was determined to be $4.40 and core excess was measured as $5.55. Scram times on all rods were less than 1.2 seconds. A calorimetric calibration was performed following each maintenance period. Fuel inspections were performed as required by the Technical Specification with no abnormalities noted. The cold critical reactivity worth for each reactor experiment was measured prior to full experiment approval. The most reactive fixed experiment has been found to be the Fast Flux Pneumatic Receiver (-$1.35) with the negative worth caused by high boron loading.

4.2 Unscheduled Maintenance

01-10-00	Seals and bearings on the primary pump were replaced.
01-10-00	New Auxiliary alarm panel is installed.
01-11-00	Flexible lines were installed on the diffuser pump to prevent stress breaks. And new bearings
01-27-00	Water meter is installed to determine the amount of secondary system water that is discharged.
01-27-00	The Log Power and Linear chart recorders were removed from the console, transferring the record keeping tasks to the Console Computer.
02-28-00	The motor contactor for the skimmer pump was cleaned so it would no longer stick in the "ON" position.
03-20-00	An ADC, to add the Thermal Column Cam to the FAM graph, and *Watchdog Timer*, to restart the computer in case it locks up was installed in the FAM computer along with updated software.
04-03-00	The Log Channel Scaler stopped counting and was replaced.
04-10-00	The common test point on the front of the Log Power drawer was replaced.
04-10-00	The wiring to the *Fill* water meter, at the cooling tower, was replaced following a loss of signal to the controller.

04-18-00	The Fuel Temperature Recorder was replaced with an alarming digital temperature meter. This completed the replacement of chart recorders with computers for recording reactor data.
04-24-00	The NOAA weather radio in the Control Room failed to receive weekly tests and it was replaced. An outside antenna was installed and connected for added reliability.
04-24-00	The over pressure safety valve on the Facility air compressor was replaced after it stuck open.
05-03-00	Rewired the Air Handing Shutdown Bypass so that the key override would work in all conditions of shutdown including a computer failure.
05-04-00	The electric fill valve for the cooling tower cracked and was replaced.
05-05-00	The chain on the front gate broke and was repaired.
05-06-00	The liquid waste level indicators were installed and connected to displays in the Control Room and Demineralizer Room.
05-22-00	The intercom in Lab-3 was repaired.
06-16-00	Wiring and a new relay were replaced on the gate controller after it failed, following a rainstorm.
06-16-00	The Cell exhaust fan was repaired, and a plug and receptacle were installed to make future maintenance easier.
06-19-00	A pin coupling the lead screw to the motor on Rod-3 was replaced after it was found sheared.
06-22-00	The magnet wiring was repaired following a dropped rod on Rod Drive 1.
06-22-00	The light sockets for the Secondary Pump's controller were remounted and rewired, after coming loose during a routine bulb replacement.
07-11-00	One the vacuum pumps for the Facility Air Monitors failed and was repaired.
07-27-00	The sample timers in the Control Room Auxiliary Panel were replaced with six new timers.
07-28-00	The magnet faces on Rod Drive -1 were cleaned after the rod dropped while it was being raised.

07-31-00	The mixing pump for the Secondary Water Treatment was repaired.
08-14-00	The Log Power detector was repaired after the instrument failed to respond.
09-01-00	Replaced collapsed vacuum lines on the Facility Air Monitoring system.
09-18-00	Cleaned and lubed the lead screw on Rod Drive – 1 after it failed to drive out.
09-25-00	The 12 VDC power supply that powers the rod drives was replaced with a new one, after it had failed.
09-27-00	The electric bleed valve for the Cooling Tower was repaired after it was found stuck open.
10-24-00	The 24 VDC power supply for the lower level access control was replaced after it failed.
11-02-00	The over pressure safety valve on the Facility Air Compressor was replaced after it stuck open.
11-06-01	Electrical outlets and computer connections were added to the bridge for the future Facility Air Monitoring system.
11-21-00	A *close* button for the front gate was replaced after it stuck.
12-04-00	The pitot tube, that was installed in the Stack, was moved to the Stack ductwork for use with the future Facility Air Monitoring system.

4.3 Emergency Planning and Review

The NSC Security Plan was reviewed by the NSC staff on April 20, 2000 and by the RSB on December 6, 2000. The Emergency Plan was reviewed by the NSC staff on April 20, 2000 and by the RSB on April 27, 2000. All required external audits were completed for the Emergency and Security plans during the reporting period.

4.4 Unscheduled Shutdowns

There were 7 unscheduled reactor shutdowns occurred during 2000. Four shutdowns resulted from a loss of facility electrical power. The remaining causes are detailed below:

2-01-00	The swagelok basket was being removed from D-7 when it became entangled with the neutron source rope. While attempting to untangle the rope, the neutron source was lifted approximately 2 inches causing Safety #1 to see high power and scram.

7-26-00 A dirty switch on the safety drawer caused an intermittent opening of the switch resulting in a scram.

9-25-00 The 12 volt power supply failed causing the reactor to scram

4.5 NSC Shipping Violation

On December 4, 2000, a package of radioactive material left the NSC without a securing device. On December 8, 2000, a Tru-Tec Services, Inc. (Tru-Tec) representative contacted the NRC Operations Center to report an event in which three unshielded liquid bromine-82 (Br-82) capsules arrived in St. Croix, the Virgin Islands. The shipping container of the capsules, which was similar in shape and size to a small propane tank, had a 3-inch by 5-inch cavity and a lid with a T-bar to hold it in place. The package left the NSC without the T-bar being secured and with no tamper indication device installed. Tru-Tec personnel discovered the problem when they received the package with the lid open. The three aluminum "Swagelok" cylinders with bromine-82 were resting on the top of the container between the lid and the collar of the container, instead of in the shielded position inside the container. The container's T bar was missing.

Conference calls regarding the event were held on December 8, 2000, and December 9, 2000. The calls included representatives from the NSC, NRC, Tru-Tec, Texas Bureau of Radiological Control, DOT, EPA, and U.S. Customs Services. On December 14-15, 2000, the NRC and DOT inspectors conduced a special inspection on the issue. Based on the results of this inspection, the NRC identified two violations. The first violation relates to NSC shipping the licensed material in a DOT Type 7A container without securing the container's restraining T bar. The second violation involved the failure to train all Hazmat workers involved in the shipment.

The NSC took immediate corrective actions after the incident. The NSC immediately stopped all shipments until further review could be done after the incident. The, NSC management initiated management review on all shipments until further notice. A new NSC policy which requires three independent reviews to be performed on all radioactive material shipments. In addition, NSC immediately had a general radioactive material training session for all persons involved in shipping. The NSC will also incorporate the Hazmat and general shipping training in the operator re-qualification program. The first training was already given as part of "Radiation Safety and Controls" training on March 22, 2001. The training will be followed by a written test. The NRC had a predecisional enforcement conference with the NSC Director in Washington, DC, on March 29, 2000 to discuss the NSC violations. Currently, the NSC is waiting for a decision from NRC regarding the violations and enforcement.

5. Health Physics Surveillance

The purpose of Health Physics surveillance is to ensure the safe use of radioactive materials in Nuclear Science Center's research and service activities and also to fulfill the regulatory requirements of U.S. Nuclear Regulatory Commission and State agencies. A dedicated Health Physics group is maintained at the NSC reactor facility as an integral part of the organization. They are responsible for chemical and physical safety concerns as well as radiological. The TAMU Environmental Health and Safety provides additional support to the NSC Health Physics group upon request.

5.1 Radioactive Shipments

The Health Physics monitoring and technical support that was provided in 2000 assured minimal exposure during sample handling, shipment of radioactive material, and normal reactor operation. The radiation exposures were maintained ALARA. During 2000, about 477 radioactive samples were handled of which 387 were sent to various research facilities including Texas A&M University campus and the rest retained at the Nuclear Science Center facility. A total of 321 curies was handled in 2000.

5.2 Personnel Monitoring

Personnel Monitoring was provided to approximately 44 personnel. All measured doses to personnel were below the limits set forth in 10CFR20. Four individuals received whole body doses greater than 10% of the annual limit in 10CFR20. Their doses were recorded as 500, 510, 590, and 880 mrem deep dose equivalent for the year. Airborne monitoring during sample handling continued to show no significant airborne activity. Therefore total effective dose equivalent will equal deep dose equivalent for 2000. A total of 2.9 man-rem was recorded for all of 2000. When total man-rem/curie was determined for 2000, the dose per curie equaled 0.00903. During 2000, 2910 visitors toured the Nuclear Science Center. Minimal exposures were measured with pocket ion chambers worn by these visitors when compared with the pocket ion chamber readings of their respective tour guides. NSC employees who were likely to exceed 10% of their total annual dose wore TLD/film badges and extremity dosimetry that were provided by Landauer, a NVLAP accredited supplier. Landauer also provided the analysis reports of the doses received.

5.3 Facility Monitoring

Surveys of the Nuclear Science Center facilities were performed to assess radiological hazards to NSC workers. Radiation levels and sources of radioactive contamination were routinely monitored. Approximately 350 smear samples were collected and evaluated each month. All accessible areas at the NSC are surveyed for radiation and contamination levels monthly. Areas where contamination is expected, access / egress controls are in place and are evaluated on shorter intervals. Area monitors were placed at strategic locations in the reactor facility which provides dose equivalent (mrem) on a monthly basis. The following table summarizes the annual accumulated dose equivalent (mrem) recorded on the area monitors for 2000.

Table 5-1. Annual Accumulated Dose Equivalent (mrem) Recorded on Area Monitors

Monitor ID	Location	Accumulated Dose Equivalent (mrem)
BLDG MNTR 1	Upper Research Level Mezzanine	840
BLDG MNTR 2	Lower Research Level Mezzanine	360
BLDG MNTR 3	Lower Research Level	20
AREA	Control Room	100
AREA	Upper Research Level	440
AREA	Hand and Foot Monitor Room	600

5.4 Particulate Effluent Monitoring

Radioactive particulates were monitored at the base of the central exhaust stack and summarized on a monthly basis. The annual average release concentration was 1.79 E-11μCi/cc. Total activity released for 2000 was 1.08E-3 Ci. The following table summarizes monthly particulate effluent releases during 2000.

Table 5-2. Particulate Effluent Releases

Quarter	Month	Average Release Conc. (μCi/cc)	Diluted Concentration (μCi/cc)	Exhaust Volume (cc)	Total Release (Ci)
I	January	5.39E-11	2.70^{E}-13	6.32 E+12	3.41E-04
	February	3.52E-11	1.76E-13	5.71E+12	2.01E-04
	March	1.66E-11	8.29^{E}-14	6.32 E+12	1.05E-04
	Average:	3.52E-11	1.76E-13	6.12E+12	2.16E-04
			total:	1.82E+13	6.47E-04
II	April	1.16E-12	5.81^{E}-15	6.12E+12	7.11E-06
	May	3.61E-11	1.81^{E}-13	6.32E+12	2.28E-04
	June	*<MDC	<MDC	6.12E+12	NIL
	Average:	1.24E-11	6.22E-14	6.19E+12	7.85E-05
			total:	1.86E+13	3.14E-04
III	July	3.34E-12	1.67E-14	6.32E+12	2.11E-05
	August	<MDC	<MDC	6.32E+12	NIL
	September	<MDC	<MDC	6.12E+12	NIL
	Average:	1.11E-12	5.56E-15	6.25E+12	7.03E-06
			total:	1.88E+13	2.11E-05
IV	October	1.48E-11	7.40E-14	6.32E+12	9.35E-05
	November	1.14E-11	5.68E-14	6.12E+12	6.95E-05
	December	4.22E-11	2.11E-13	6.32E+12	2.67E-04

	Average:	2.28E-11	1.14E-13	6.25E+12	1.43E-04
			total:	1.88E+13	9.35E-05
Annual Summary	**Average:**	1.79E-11	8.94E-14	6.20E+12	1.11E-04
			total:	7.43E+13	1.08E-03

* Minimum Detectable Concentration (MDC) 4.5 E-14 µCi/cc

5.5 Gaseous Effluent Monitoring

Argon-41 is the major gaseous effluent produced and released at the Nuclear Science Center. This effluent is monitored at the central exhaust stack. Total Argon-41 released during 2000 was 5.87 Ci with an annual average release concentration of 7.90 E-8 uCi/cc and with a diluted concentration of 3.95 E-10 uCi/cc. The following table summarizes monthly gaseous effluent releases during 2000.

Table 5-3. Monthly Gaseous Effluent Releases

Quarter	Month	Average Release Conc. (µCi/cc)	Diluted Concentration (µCi/cc)	Exhaust Volume (cc)	Total Release (Ci)
I	January	7.52E-08	3.76E-10	6.32E+12	4.75 E-01
	February	1.12E-07	5.58E-10	5.71E+12	6.37E-01
	March	8.84E-08	4.42E-10	6.32E+12	5.59E-01
	Average:	9.17E-08	4.59E-10	6.12E+12	5.57E-01
			total:	1.82E+13	16.7E-01
II	April	5.09E-08	2.55E-10	6.12E+12	3.12E-01
	May	1.23E-07	6.14E-10	6.32E+12	7.77E-01
	June	7.20E-08	3.60E-10	6.12E+12	4.41E-01
	Average:	8.19E-08	4.10E-10	6.19E+12	5.10E-01
			total:	1.86E+13	1.53E-01
III	July	9.48E-08	4.74E-10	6.32E+12	5.99E-01
	August	1.01E-07	5.03E-10	6.32E+12	6.36E-01
	September	1.23E-07	6.17E-10	6.12E+12	7.55E-01
	Average:	1.06E-07	5.31E-10	6.25E+12	6.64E-01
			total:	1.88E+13	19.9E-01
IV	October	3.95E-08	1.97E-10	6.32E+12	2.50E-01
	November	6.93E-08	3.47E-10	6.12E+12	4.24E-01
	December	<MDC	<MDC	6.32E+12	NIL
	Average:	3.63E-08	1.81E-10	6.32E+12	2.25E-01
			total:	1.88E+13	6.74E-01
Annual Summary	**Average:**	7.90E-08	3.95E-10	6.22E+12	4.89E-01
			total:	7.43E+13	58.7E-01

* Minimum Detectable Concentration (MDC) 6.2 E-10 µCi/cc

5.6 Liquid Effluents Monitoring

Radioactive Liquid effluents are maintained in collection tanks prior to release from the confines of the Nuclear Science Center. Sample activity concentrations and isotope identifications were determined prior to each release. There were 32 releases in 2000, totaling 2.73 E+05 gallons excluding dilution from the Nuclear Science Center. Including dilution, the total volume released was 9.41 E+05 gallons. The total radioactivity released was 2.05 E-03 Ci with an annual average concentration of 5.76 E-07 µCi/cc. Summaries of the release data are presented in the table below. Radioactivity concentrations for each isotope found were below the Effluent Concentration limits specified in 10CFR20, Appendix B. Some of the major radionuclides identified in the waste stream are Na^{24}, Sc^{46}, Sb^{124} and Co^{60}.

Table 5-4. Monthly Liquid Effluent Releases

Quarter	Month	Number of Releases	Volume Released (cc)	Total Radioactivity (Ci)	Average Concentration (µCi/cc)
I	January	2	5.26E+07	3.65E-05	6.94E-07
	February	3	7.99E+07	3.42E-04	4.28E-06
	March	2	4.91E+07	1.47E-04	2.99E-06
	Quarter Total:	7	6.18E+08	5.34E-04	8.64E-07
II	April	3	7.56E+07	1.63E-04	2.16E-06
	May	3	8.34E+07	1.82E-04	2.18E-06
	June	4	1.48E+08	2.30E-04	1.55E-06
	Quarter Total:	10	9.34E+08	6.93E-04	7.42E-07
III	July	3	1.31E+08	2.71E-04	2.07E-06
	August	4	1.51E+08	2.79E-04	1.85E-06
	September	3	9.19E+07	3.46E-05	3.77E-07
	Quarter Total:	10	1.22E+09	5.85E-04	4.80E-07
IV	October	2	7.74E+07	1.43E-05	1.85E-07
	November	2	7.71E+07	1.73E-04	2.24E-06
	December	1	1.44E+07	1.45E-05	1.01E-06
	Quarter Total:	5	7.90E+08	2.40E-04	3.04E-07
Annual Summary	**Total:**	32	3.56E+09	2.05E-03	5.76E-07

6. Environmental Monitoring

In conjunction with representatives from the Texas Department of Health, Bureau of Radiation Control, a quarterly environmental survey program is conducted to insure compliance with federal regulations. This program consists of TLD monitors located at various locations on the NSC site and two background monitors one located at 3.84 miles NW of facility and the other at 0.25 miles SE of facility. The collection, analysis, and evaluation of NSC creek sediment, and milk samples from the dairy downwind of the facility are also included in the program.

6.1 Environmental Survey Samples

The environmental samples were collected in accordance with the schedules of the cooperative surveillance program between the Texas Department of Health and the Texas A&M University. NSC creek sediment and milk samples from the dairy were analyzed using a high-purity germanium detection system for isotopic identification at the NSC. A second set of sediment and milk samples were analyzed by the Texas Department of Health for comparison. The concentrations of environmental samples determined for each quarter are listed below.

Table 6-1. Environmental Sample Analysis

MILK		
2000 Quarter	**Sample Location**	**Concentration (μCi/mL)-TDH**
1st	TAMU Dairy	< 4.4 E-09
2nd	TAMU Dairy	< 4.9 E-09
3rd	TAMU Dairy	< 6.9 E-09
4th	TAMU Dairy	< 3.8 E-06
	SEDIMENT	**(μCi/g)-NSC**
1st	NSC creek	6.41 E-06
2nd	NSC creek	1.34 E-06
3rd	NSC creek	1.81 E-06
4th	NSC creek	1.44 E-05

6.2 Site Boundary Dose Rate

The environmental survey program measures the integrated radiation exposures at the exclusion area boundaries. These measurements are made for periods of approximately 91 days, using TLDs. Monthly measurements of direct gamma exposure rate in μ rem/h are also made at each of the TLD locations. The dosimeters are provided and processed by Texas Department of Health (TDH), Bureau of Radiation Control, Division of Environmental Programs. Total doses are multiplied by our newly determined occupancy factor (1/16) to determine total deep dose to the general public. To determine internal exposure to individuals outside the site area the EPA's

approved code, *COMPLY*, was used. The exposure calculated via *COMPLY* was 0.093 mrem/yr. This exposure is added to the calculated total deep dose. This total is the dose received by the general public.

Table 6-2. Site Boundary Dose Rates

Site #	Location	Quarterly Exposure Rate (mrem/91 days)				TLD Dose	Deep Dose (mrem)	Internal Dose (mrem)	Total Dose (mrem)
2	300 ft. W of reactor building, near fence corner	5.0	0.0	4.4	4.2	14	0.875	0.093	0.968
3	250 ft W-SW of reactor building, on SW chain link fence	4.0	0.0	1.8	2.1	8	0.5	0.093	0.593
4	200 ft NW of reactor building, on chain link fence, near butane tank.	12.0	5.5	8.8	10.5	37	2.31	0.093	2.41
5	225 ft NE of reactor building, on fence N of driveway	6.0	0.0	3.5	1.0	11	0.688	0.093	0.781
10	190 ft SE of reactor building, near fence corner	4.0	0.0	3.5	2.1	10	0.625	0.093	0.718
11	300 ft NE of reactor building, near fence corner	1.0	0.0	1.8	1.0	4.0	0.25	0.093	0.343
18	375 ft NE of reactor building	4.0	0.0	4.4	1.0	10	0.625	0.093	0.718
19	320 ft NE of reactor building	4.0	0.0	3.5	2.1	10	0.625	0.093	0.718
14*	3.84 miles NW of facility	0.0	0.0	0.0	0.0	0.0	0.0	0.093	0.093
23*	0.25 miles SE of facility	0.0	0.0	0.0	0.0	0.0	0.0	0.093	0.093

* Background TLD station.

7. Radioactive Waste Shipments

During the year 2000 there was no solid waste released from the NSC for disposal offsite.

8. Reactor Safety Board

The Reactor Safety Board is responsible for providing an independent review and audit of the safety aspects of the NSCR. The RSB meets at least once a year to review audit reports, security and emergency plans, new experiments and modifications to the facility.

Chairman/Licensee:

Dr. Glen Williams/Dr. B. Don Russell
Texas Engineering Experiment Station

Members:

Dr. Marvin Adams, Associate Professor
Nuclear Engineering Department

Dr. Ted Parish, Professor
Nuclear Engineering Department

Dr. Rodger Koppa, Associate Professor,
Industrial Engineering Department

Dr. William Dennis James, Research Chemist
Chemistry Department

Dr. Robert Kenefick, Professor
Physics Department

Dr. Earl Morris, Professor
Veterinary Medicine-Large Animal Medicine

Ex-Officio Members:

Dr. Warren Reece, Director
Nuclear Science Center

Ms. Latha Vasudevan, Radiological Safety Officer
Nuclear Science Center

Mr. Chris Meyer, Director
Environmental Health and Safety Department

Dr. Alan Waltar, Professor and Head
Nuclear Engineering Department

Mr. Robert Berry, Reactor Supervisor
AGN201, Nuclear Engineering Department

Florida Power & Light Company, 6501 South Ocean Drive, Jensen Beach, FL 34957

April 24, 2001

L-2001-103
10 CFR 50.36

U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555

Re: St. Lucie Unit 1
Docket No. 50-335
Cycle 17 Core Operating Limits Report – Revision 0

Pursuant to St. Lucie Unit 1 Technical Specification (TS) 6.9.1.11.d, Florida Power & Light Company (FPL) is submitting the Core Operating Limits Report (COLR) Revision 0 for operating cycle 17.

Technical Specification 6.9.1.11.d requires that the COLR, including any mid-cycle revisions or supplements, be provided to the NRC upon issuance for each reload cycle. Accordingly, enclosed is a copy of the *St. Lucie Unit 1, Cycle 17 Core Operating Limits Report*, Revision 0.

Please contact us if there are any questions about this submittal.

Very truly yours,

Rajiv S. Kundalkar
Vice President
St. Lucie Plant

RSK/GRM

Enclosure

cc: Regional Administrator, Region II, USNRC
Senior Resident Inspector, USNRC, St. Lucie Plant

ST. LUCIE UNIT 1, CYCLE 17

CORE OPERATING LIMITS REPORT

Revision 0

Prepared By: J. Kabadi

Verified By: Kirk Nordmeyer

Approved By: Carl O'Farrill 12/19/2000

Table of Contents

List of Figures

1.0 INTRODUCTION

This CORE OPERATING LIMITS REPORT (COLR) describes the cycle-specific parameter limits for operation of St. Lucie Unit 1 Cycle 17. It contains the limits for the following as provided in Section 2.

Moderator Temperature Coefficient

Full Length CEA Position - Misalignment > 15 Inches

Regulating CEA Insertion Limits

Linear Heat Rate

TOTAL INTEGRATED RADIAL PEAKING FACTOR - F_r^T

DNB Parameter - AXIAL SHAPE INDEX

Refueling Operations - Boron Concentration

SHUTDOWN MARGIN – T_{avg} Greater Than 200 ^{0}F

SHUTDOWN MARGIN – T_{avg} Less Than or Equal To 200 ^{0}F

This report also contains the necessary figures which give the limits for the above listed parameters.

Terms appearing in capitalized type are DEFINED TERMS as defined in Section 1.0 of the Technical Specifications.

This report is prepared in accordance with the requirements of Technical Specification 6.9.1.11.

2.0 CORE OPERATING LIMITS

2.1 Moderator Temperature Coefficient (TS 3.1.1.4)

The moderator temperature coefficient (MTC) shall be less negative than -32 pcm/^{0}F at RATED THERMAL POWER.

2.2 Full Length CEA Position - Misalignment > 15 Inches (TS 3.1.3.1)

The time constraints for full power operation with the misalignment of one full length CEA by 15 or more inches from any other CEA in its group are shown in Figure 3.1-1a.

2.3 Regulating CEA Insertion Limits (TS 3.1.3.6)

The regulating CEA groups shall be limited to the withdrawal sequence and to the insertion limits shown on Figure 3.1-2, with CEA insertion between the Long Term Steady State Insertion Limits and the Power Dependent Insertion Limits restricted to:

a. ≤ 4 hours per 24 hour interval,

b. ≤ 5 Effective Full Power Days per 30 Effective Full Power Day interval, and

c. ≤ 14 Effective Full Power Days per calendar year.

2.4 Linear Heat Rate (TS 3.2.1)

The linear heat rate shall not exceed the limits shown on Figure 3.2-1.

The AXIAL SHAPE INDEX power dependent control limits are shown on Figure 3.2-2.

During operation, with the linear heat rate being monitored by the Excore Detector Monitoring System, the AXIAL SHAPE INDEX shall be maintained within the limits of Figure 3.2-2.

During operation, with the linear heat rate being monitored by the Incore Detector Monitoring System, the Local Power Density alarm setpoints shall be adjusted to less than or equal to the limits shown on Figure 3.2-1.

2.5 TOTAL INTEGRATED RADIAL PEAKING FACTOR - F_r^T (TS 3.2.3)

The calculated value of F_r^T shall be limited to ≤ 1.70.

The power dependent F_r^T limits are shown on Figure 3.2-3.

2.6 DNB Parameters - AXIAL SHAPE INDEX (TS 3.2.5)

The AXIAL SHAPE INDEX shall be maintained within the limits specified in Figure 3.2-4.

2.7 Refueling Operations - Boron Concentration (TS 3.9.1)

With the reactor vessel head unbolted or removed, the boron concentration of all filled portions of the Reactor Coolant System and the refueling cavity shall be maintained uniform and sufficient to ensure that the more restrictive of the following reactivity conditions is met:

a. Either a K_{eff} of 0.95 or less, which includes a 1000 pcm conservative allowance for uncertainties, or

b. A boron concentration of ≥ 1720 ppm, which includes a 50 ppm conservative allowance for uncertainties.

2.8 SHUTDOWN MARGIN – T_{avg} Greater Than 200 ^{0}F (TS 3.1.1.1)

The SHUTDOWN MARGIN shall be greater than or equal to 3600 pcm.

2.9 SHUTDOWN MARGIN – T_{avg} Less Than or Equal To 200 ^{0}F (TS 3.1.1.2)

The SHUTDOWN MARGIN shall be greater than or equal to 2000 pcm.

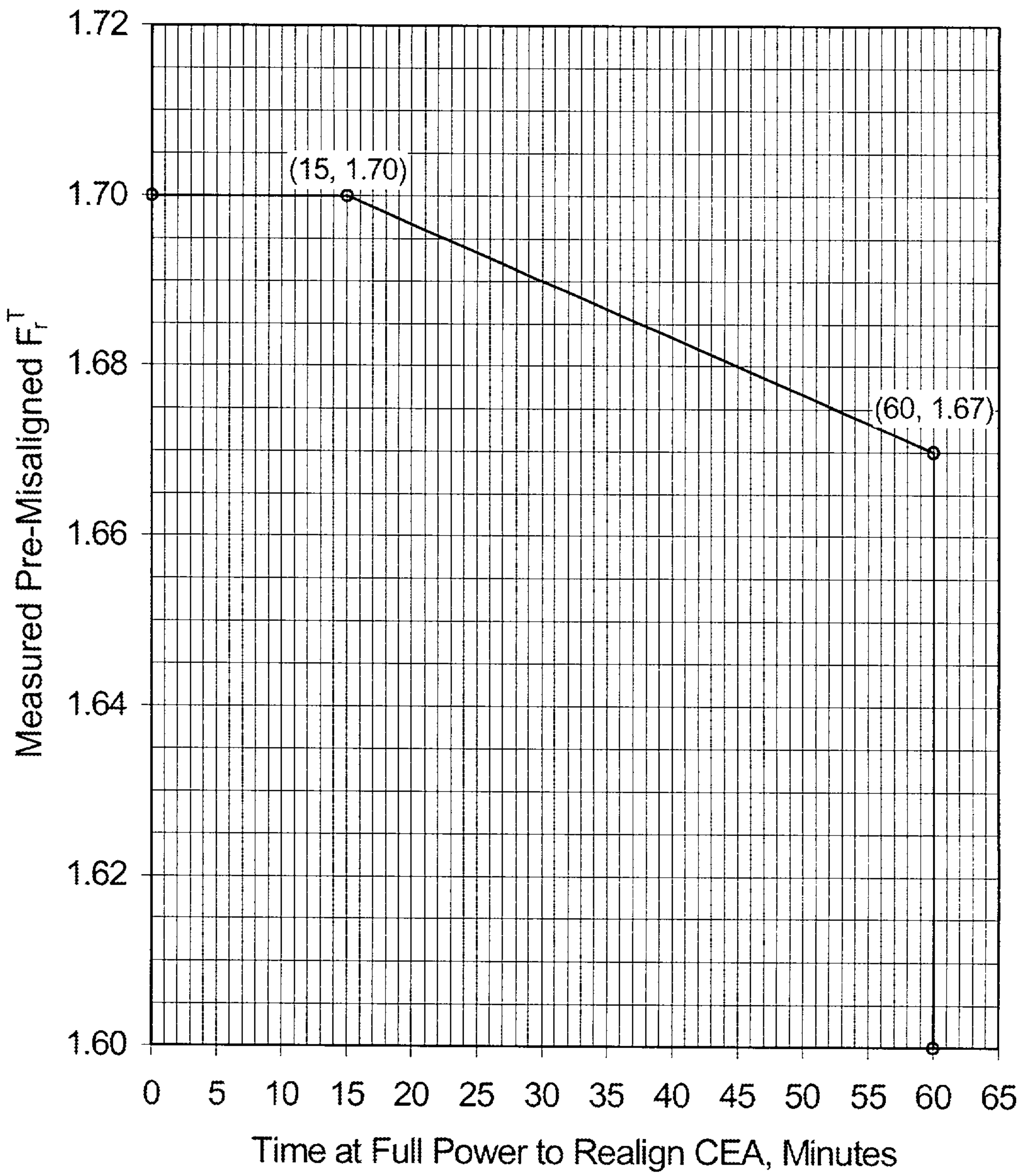


FIGURE 3.1-1a
Allowable Time to Realign CEA vs. Initial F_r^T

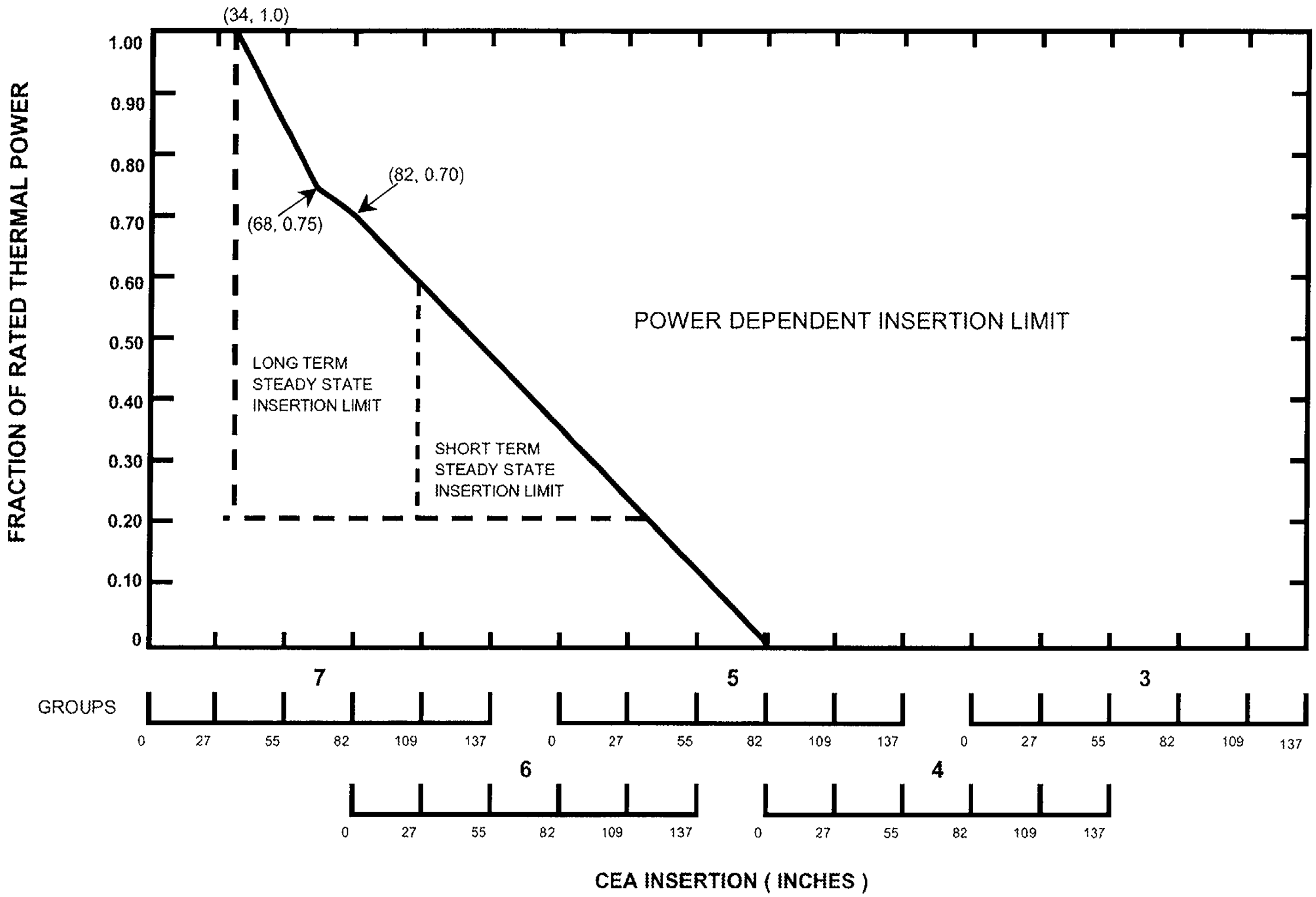
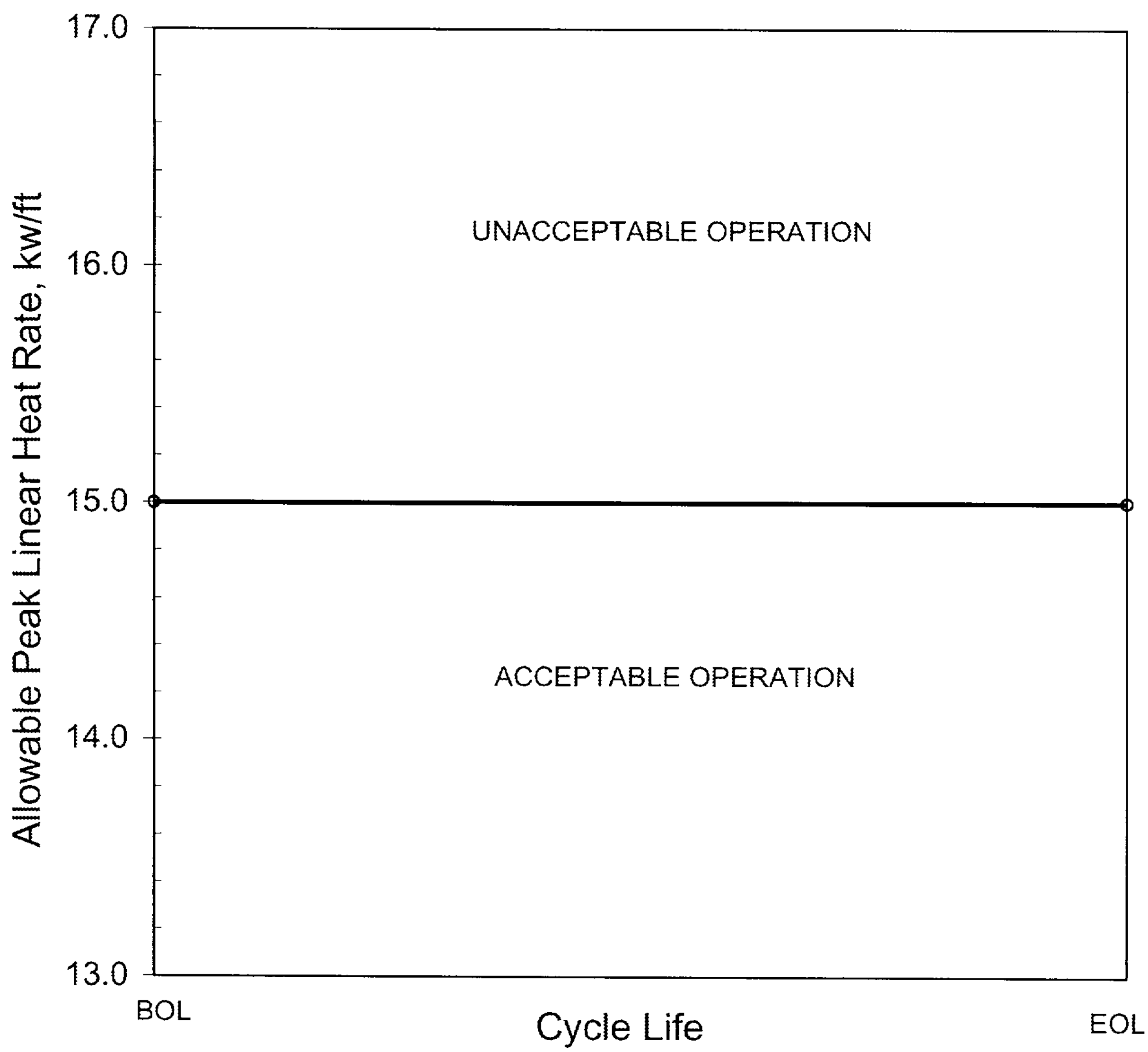
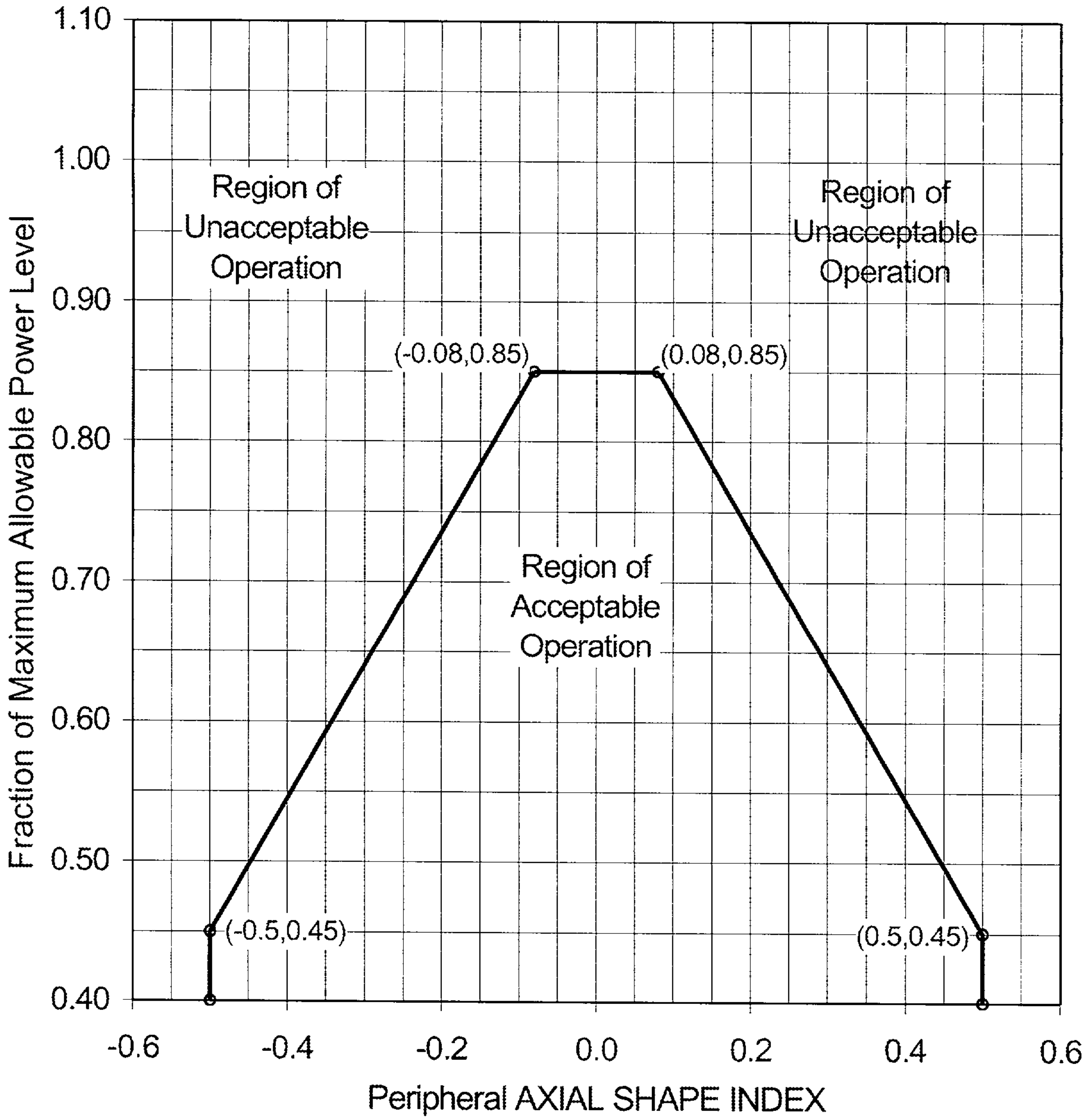


FIGURE 3.1-2
CEA Insertion Limits vs. THERMAL POWER
(4 Reactor Coolant Pumps Operating)



(Fuel + Clad + Moderator)

FIGURE 3.2-1
Allowable Peak Linear Heat Rate vs. Burnup



(Not Applicable Below 40% Power)

FIGURE 3.2-2
AXIAL SHAPE INDEX vs. Maximum Allowable Power Level

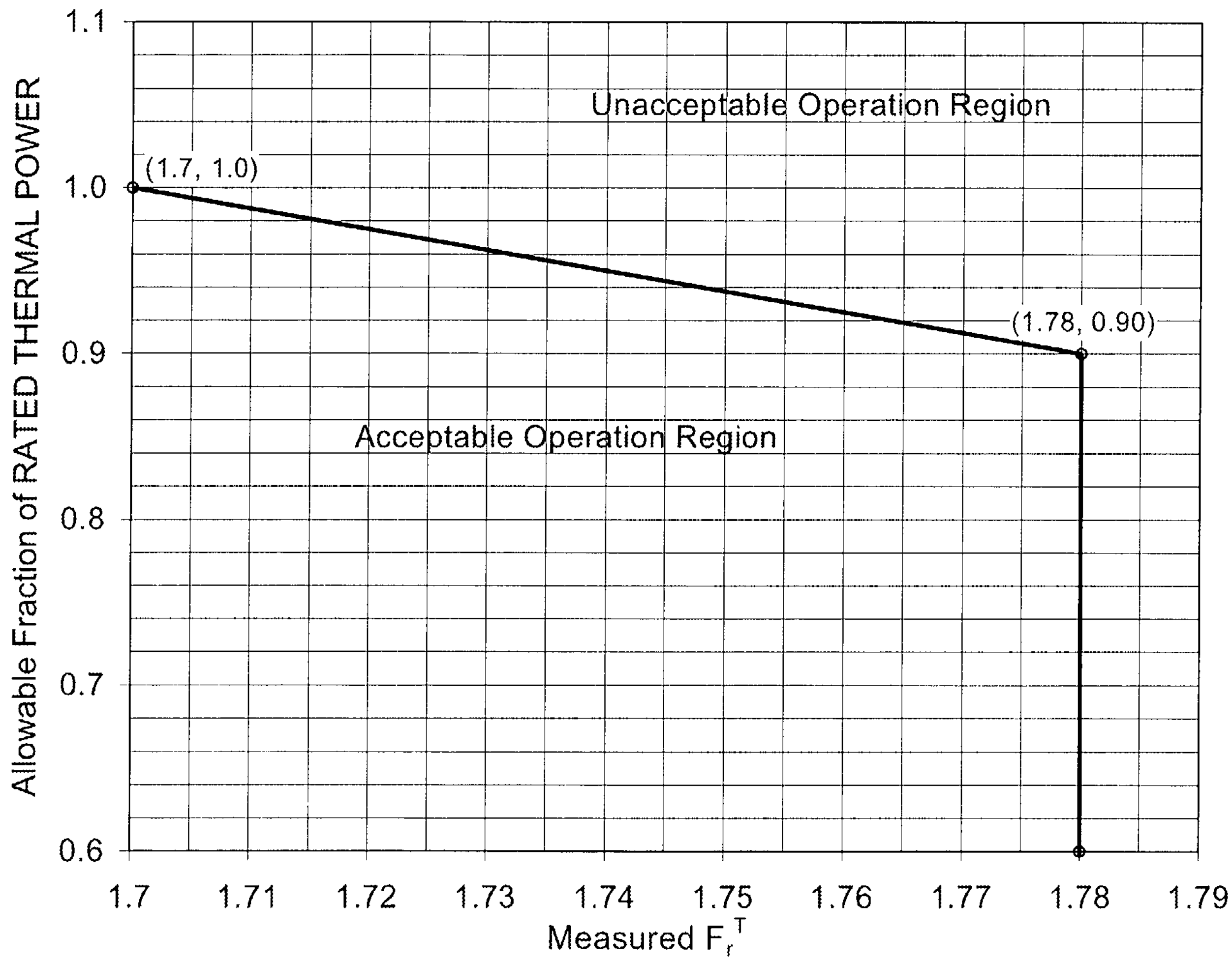
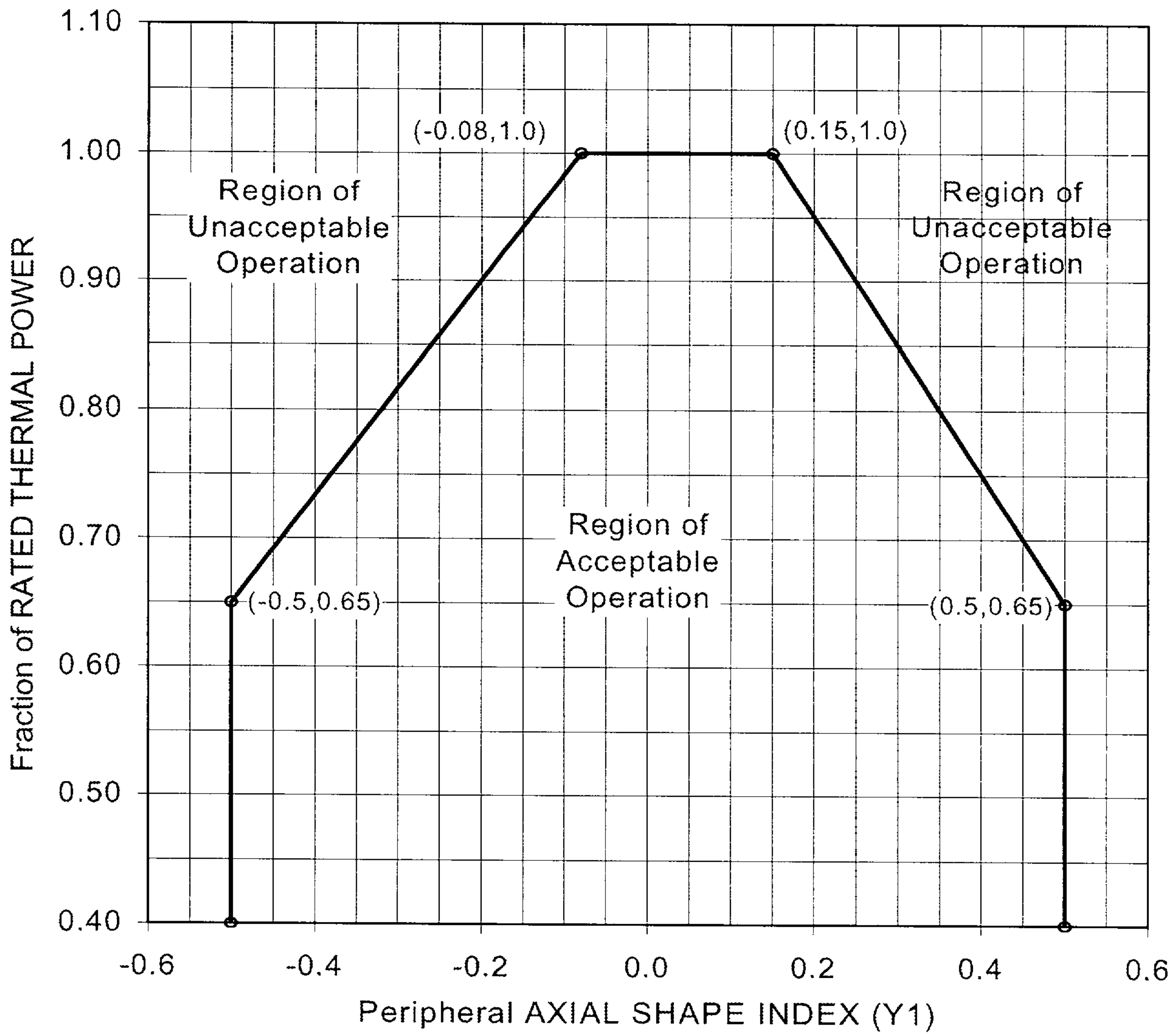


FIGURE 3.2-3
Allowable Combinations of THERMAL POWER and F_r^T



(Not Applicable Below 40% Power)

FIGURE 3.2-4
AXIAL SHAPE INDEX Operating Limits vs. THERMAL POWER
(Four Reactor Coolant Pumps Operating)

3.0 LIST OF APPROVED METHODS

The analytical methods used to determine the core operating limits are those previously approved by the NRC, and are listed below.

1. WCAP-11596-P-A, "Qualification of the PHOENIX-P/ANC Nuclear Design System for Pressurized Water Reactor Cores," June 1988 (Westinghouse Proprietary)

2. NF-TR-95-01, "Nuclear Physics Methodology for Reload Design of Turkey Point & St. Lucie Nuclear Plants," Florida Power & Light Company, January 1995

3. XN-75-27(A) and Supplements 1 through 5, [also issued as XN-NF-75-27(A)], "Exxon Nuclear Neutronic(s) Design Methods for Pressurized Water Reactors," Exxon Nuclear Company, Inc. / Advanced Nuclear Fuels Corporation, Report and Supplement 1 dated April 1977, Supplement 2 dated December 1980, Supplement 3 dated September 1981 (P), Supplement 4 dated December 1986 (P), and Supplement 5 dated February 1987 (P)

4. ANF-84-73(P)(A) Revision 5, Appendix B, & Supplements 1 and 2, "Advanced Nuclear Fuels Methodology for Pressurized Water Reactors: Analysis of Chapter 15 Events," Advanced Nuclear Fuels Corporation, October 1990

5. XN-NF-82-21(P)(A) Revision 1, "Application of Exxon Nuclear Company PWR Thermal Margin Methodology to Mixed Core Configurations," Exxon Nuclear Company, Inc., September 1983

6. a) ANF-84-93(P)(A) and Supplement 1, [also issued as XN-NF-84-93(P)(A)], "Steamline Break Methodology for PWRs," Advanced Nuclear Fuels Corporation, March 1989

   b) EMF-84-093(P)(A) Revision 1, "Steam Line Break Methodology for PWRs," Siemens Power Corporation, February 1999 (This document is a Revision to ANF-84-93)

7. XN-75-32(P)(A) Supplements 1 through 4, "Computational Procedure for Evaluating Fuel Rod Bowing," Exxon Nuclear Company, Inc., October 1983

8. Siemens Small Break LOCA methodology as defined by:

   a) XN-NF-82-49(P)(A) Revision 1, "Exxon Nuclear Company Evaluation Model EXEM PWR Small Break Model," Advanced Nuclear Fuels Corporation, April 1989

b) XN-NF-82-49(P)(A) Revision 1 Supplement 1, "Exxon Nuclear Company Evaluation Model Revised EXEM PWR Small Break Model," Siemens Power Corporation, December 1994

9. XN-NF-78-44(NP)(A), "A Generic Analysis of the Control Rod Ejection Transient for Pressurized Water Reactors," Exxon Nuclear Company, Inc., October 1983

10. XN-NF-621(P)(A) Revision 1, "Exxon Nuclear DNB Correlation for PWR Fuel Designs," Exxon Nuclear Company, Inc., September 1983

11. EXEM PWR Large Break LOCA Evaluation Model as defined by:

a) 1. XN-NF-82-20(P)(A) Revision 1 Supplement 2, "Exxon Nuclear Company Evaluation Model EXEM/PWR ECCS Model Updates," Exxon Nuclear Company, Inc., February 1985

2. XN-NF-82-20(P)(A) Revision 1 and Supplements 1, 3 and 4, "Exxon Nuclear Company Evaluation Model EXEM/PWR ECCS Model Updates," Advanced Nuclear Fuels Corporation, January 1990

3. XN-NF-82-20(P)(A) Revision 1 Supplement 6, "EXEM/PWR Large Break LOCA ECCS Model Updates," Siemens Power Corporation, June 1998

b) XN-NF-82-07(P)(A) Revision 1, "Exxon Nuclear Company ECCS Cladding Swelling and Rupture Model," Exxon Nuclear Company, Inc., November 1982

c) 1. XN-NF-81-58(P)(A) Revision 2, and Supplements 1 and 2, "RODEX2 Fuel Rod Thermal-Mechanical Response Evaluation Model," Exxon Nuclear Company, Inc., March 1984

2. ANF-81-58(P)(A) Revision 2 Supplement 3, and Supplement 4, "RODEX2 Fuel Rod Thermal Mechanical Response Evaluation Model," Advanced Nuclear Fuels Corporation, June 1990

d) XN-NF-85-16(P)(A) Volume 1, and Supplements 1, 2 and 3; Volume 2, Revision 1 and Supplement 1, "PWR 17x17 Fuel Cooling Test Program," Advanced Nuclear Fuels Corporation, February 1990

e) XN-NF-85-105(P)(A) and Supplement 1, "Scaling of FCTF Based Reflood Heat Transfer Correlation for Other Bundle Designs," Advanced Nuclear Fuels Corporation, January 1990

f) EMF-2087(P)(A) Revision 0, "SEM/PWR-98: ECCS Evaluation Model for PWR LBLOCA Applications," Siemens Power Corporation, June 1999

12. XN-NF-82-06(P)(A) Revision 1, and Supplements 2, 4 and 5, "Qualification of Exxon Nuclear Fuel for Extended Burnup," Exxon Nuclear Company, Inc., October 1986

13. ANF-88-133(P)(A) and Supplement 1, "Qualification of Advanced Nuclear Fuels' PWR Design Methodology for Rod Burnups of 62 GWd/MTU," Advanced Nuclear Fuels Corporation, December 1991

14. XN-NF-85-92(P)(A), "Exxon Nuclear Uranium Dioxide/Gadolinia Irradiation Examination and Thermal Conductivity Results," Exxon Nuclear Company, Inc., November 1986

15. ANF-89-151(P)(A), "ANF-RELAP Methodology for Pressurized Water Reactors: Analysis of Non-LOCA Chapter 15 Events," Advanced Nuclear Fuels Corporation, May 1992

16. XN-NF-507(P)(A), Supplements 1 and 2, "ENC Setpoint Methodology for C. E. Reactors: Statistical Setpoint Methodology," Exxon Nuclear Company, Inc., September 1986

17. EMF-92-116(P)(A), Revision 0, "Generic Mechanical Design Criteria for PWR Fuel Design," Siemens Power Corporation, February 1999

18. EMF-92-153(P)(A) and Supplement 1, "HTP: Departure from Nucleate Boiling Correlation for High Thermal Performance Fuel," Siemens Power Corporation, March 1994

19. EMF-96-029(P)(A) Volumes 1 and 2, "Reactor Analysis System for PWRs Volume 1 – Methodology Description, Volume 2 – Benchmarking Results," Siemens Power Corporation, January 1997

20. EMF-1961(P)(A), Revision 0, "Statistical Setpoint/Transient Methodology for Combustion Engineering Type Reactors," Siemens Power Corporation, July 2000