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Chapter 14

INITIAL TEST PROGRAM

14.1 SPECIFIC INFORMATION TO BE INCLUDED IN PRELIMINARY SAFETY ANALYSIS REPORTS

Not required in FSAR.

14.2 SPECIFIC INFORMATION TO BE INCLUDED IN FINAL SAFETY ANALYSIS REPORT

14.2.1 SUMMARY OF TEST PROGRAM AND OBJECTIVES

14.2.1.1 Introduction

Iowa Electric performed formal tests on all systems important to public safety or plant operation at the DAEC. These tests were divided into safety-related tests (termed preoperational tests), applicant acceptance tests, which were not safety related (termed acceptance tests), and startup and power tests. Acceptance tests were virtually equivalent to preoperational tests.

The preoperational test program and its objectives are discussed in Section 14.2.1.2. The preoperational test program was actually preceded by the so-called construction assurance tests. These tests resembled preoperational tests and for this reason they were considered to be part of the preoperational test program. A partial list of construction assurance tests is given in Section 14.2.1.2.1. The electrical systems, and the demineralized-water makeup and cooling water systems were tested first since they were required to provide auxiliary services for the testing and operation of other systems or for construction activities. These systems were given construction assurance tests as well as preoperational tests. The electrical system tests are discussed in Section 14.2.1.2.2. Preoperational test sequence and procedure considerations are discussed in Section 14.2.1.2.3. Some vibration testing of the DAEC was also provided as part of the preoperational testing. Detailed preoperational test descriptions are included in Section 14.2.12.

The startup and power test program followed the preoperational testing chronologically and included initial fuel loading and initial criticality, low-power testing at atmospheric pressure, heatup from ambient to rated temperature and pressure, and power escalation testing from rated temperature to 100% power. The startup and power test program is discussed in Section 14.2.1.3. The corresponding tests are enumerated in that section, and described in some detail in Tables 14.2-1 through 14.2-3.

Iowa Electric performed preoperational tests on all safety-related systems and components, and based its safety-related preoperational test program on the applicable portions of the "Guide for the Planning of Preoperational Testing Programs," December 7, 1970. In addition, Iowa Electric made use of the American Nuclear Society ANS-22 "Nuclear Safety Criteria for the Design of Stationary Boiling Water Reactor Plants," in determining which systems and components were safety related.

Similarly, Iowa Electric based its initial startup and power testing program on the "Guide for the Planning of Initial Startup Testing Programs." The two guides played a prominent baseline role in the initial test program for DAEC. Exceptions and additions to those two guides are summarized in Table 14.2-4.

14.2.1.2 Preoperational Test Program

The nuclear system was made operational by Iowa Electric under the technical direction of General Electric Nuclear Equipment Division (NED) as required by the contract. To implement technical direction, NED provided preoperational test specifications and instructions for NED supplied systems and equipment.

Preoperational test specifications identified the systems and equipment that had to be tested and stated the requirements of the tests necessary to ensure safe performance during testing. Test specifications were reviewed and approved by the responsible design engineering component person before release.

Preoperational test instructions provided the necessary information and traced the essential steps to be taken to fulfill the requirements of the preoperational test specifications.

The preoperational test program was basically a systems test program that began after significant construction was completed and extended through initial fuel loading. The purpose of the preoperational test program was threefold:

1. Confirm that construction was complete to the extent that equipment and systems could be put into use during construction.

2. Adjust and calibrate the equipment to the extent possible in the "cold" plant.

3. Ensure that all process and safety equipment was operational and in compliance with license requirements to the extent necessary to proceed with initial fuel loading and the startup test program.

Key systems were sequenced for completion and testing early enough to provide auxiliary services for the testing and operation of other systems or for construction activities (e.g., the use of the makeup water system for cleaning). This resulted in an early requirement for electrical systems, demineralized water makeup, and cooling-water systems.

The formal training program for the operators and some supervisors on the plant staff commenced on November 1, 1971, and was completed 6 months before fuel loading, at which time the operators were incorporated into the preoperational test program. The training program is described in Section 13.2. As some of the operating staff were not available for the initial phases of the preoperational test program,

contractors were used where necessary to supplement Iowa Electric's personnel in the performance and supervision of the preoperational test program. These people did not require training, as they were well qualified for their individual assignments. In addition to these people, General Electric (GE) and Bechtel personnel were available in an advisory capacity as required. Experience with and understanding of the plant systems and components were gained through accessibility to the plant personnel. Minimal restrictions were imposed on either the operators or the testing procedure, and thus there was ample opportunity to train and evaluate individual operators and to troubleshoot plant systems. In addition, plant equipment and systems were operated for a sufficient period of time to discover and correct any design, manufacturing, or installation errors, and to adjust and calibrate the equipment.

The preoperational test program sequence and procedure considerations are discussed in Section 14.2.1.2.3. Section 14.2.12 discusses the preoperational test prerequisites, defines test objectives, indicates in summary form the scope of preoperational testing, and provides examples of minimal restrictions needed to ensure subsequent safety. Preoperational tests were performed using written instructions and procedures issued before the test.

14.2.1.2.1 Construction Assurance Testing

Many testing requirements actually preceded the preoperational test program. These were categorized as construction assurance tests and were performed by subcontractors under the supervision of Iowa Electric's Engineering Department personnel. The tests resembled preoperational tests in that they were defined by formal procedures and data sheets and required formal reporting and acceptance.

Construction assurance testing included but was not limited to the following:

1. Containment leak rate tests.

2. System hydrostatic tests.

3. Chemical cleaning and flushing.

4. Wiring continuity checks.

5. Megger and high potential tests.

6. Electrical system tests, including energizing.

7. Initial adjustment and rotational checks.

8. Checks of the control and interlock functions of instruments, relays, and control devices.

9. The calibration of instruments and the checking or setting of initial trip setpoints.

10. The pneumatic testing of the instrument and service air systems and the cleaning of lines.

11. Equipment adjustments such as the alignment, greasing, and tightening of bolts.

12. The checking and adjusting of relief and safety valves.

13. Complete tests of motor-operated valves, including the adjustment of limits switches, checks of all interlocks and controls, the measurement of motor current and operating speed, and checks of the leak tightness of stem packings and valve seats during hydrotests.

14. Complete tests of air-operated valves, including checks of all interlocks and controls, the adjustment of limit switches, the measurement of operating speed, checks of the leaktightness of stem packings and valve seats during hydrotests, checks of the leaktightness of pneumatic operators, and checks for the proper operation of controllers, pilot solenoids, etc.

15. The nondestructive testing of field welds.

16. The verification of the correct installation of components.

14.2.1.2.2 Electrical System Tests

The dc system was placed into service, as required, to provide auxiliary power to the plant in a safe manner. Other portions of the dc system were completed as required.

Equipment in the reactor protection system and vital bus power supply required functional preoperational testing to verify adequacy of design and installation. Other testing performed by subcontractors under the surveillance of Iowa Electric's Engineering Department personnel was in the nature of construction assurance tests on wiring and individual components such as the following:

1. Continuity and phasing checks.

2. Megger tests on required control wiring.

3. Relay tests and adjustments.

4. Checks for the proper operation of transformer cooling and instrumentation.

5. Checks of circuit breaker operation controls.

6. High potential tests, where required.

7. Checks of the calibration of meters.

8. Checks for the proper operation of all controls.

14.2.1.2.3 Preoperational Test Program Sequence and Procedure Considerations

The following key points were considered in developing the sequence and procedures of the preoperational test program:

1. Supporting systems were sequenced for early checkouts and placed in routine operation to provide necessary auxiliary services for other systems. Examples are plant electrical, instrument air, makeup water supply, and service water systems.

2. Preoperational testing was coordinated with construction to permit fuel loading as early as possible, without compromising nuclear safety or impeding construction work. As a result, fuel loading was scheduled while construction work was still in progress on unrelated systems and areas.

3. Stricter controls of unit operation and maintenance work were required following fuel loading. To minimize possible contamination problems, acceptance testing was scheduled before fuel loading, to the extent possible, on all components and systems that could consequently be exposed to radioactive contamination except where full system testing could not be performed until after fuel loading.

4. Preoperational tests were important in plant operator training, and maximum participation by all operators was consistent with Iowa Electric offsite and onsite training requirements before licensing examinations.

5. Temporary construction power was sometimes required for initial tests at the beginning of the preoperational test program. However, the unnecessary use of temporary power and improvised setups were avoided because of the possibility of costly errors and inconsistency with the ultimate objective of proving the final installation.

6. Electric jumpers were used to facilitate preoperational testing in some instances, but their use was minimized and they were carefully controlled by means of identification tags on the equipment jumpered and by log book records.

7. When the plant was ready for fuel loading, construction workers were not permitted in the reactor building and drywell. Strict control was maintained

over access to the control room, electrical equipment rooms, reactor building, and the radioactive waste treatment area.

8. Specialized electronic equipment and nuclear instrumentation manufactured by GE was checked and preoperationally tested by subcontractors under the surveillance of Iowa Electric's Engineering Department personnel assisted by GE representatives.

9. Test procedures were specific regarding the intent, methods, and operating requirements for completing the test. The completion of detailed blank data sheets during the test was also required.

10. In general, tests were performed using permanently installed instrumentation to obtain the required data. Special instrumentation was specified in the preoperational test procedure. Any test requiring the artificial simulation of a plant parameter had the method detailed in the procedure as well as the means for ensuring that the system was returned to normal.

Plans were made to provide some vibration testing of the DAEC, starting in May 1973. By the time that startup of the DAEC was initiated, there had been vibration tests performed on at least eight BWR plants, including [redacted]. The nature of the tests and the selection of components to be tested on the DAEC were dictated largely by the results of the vibration testing conducted on these other plants. The DAEC vibration test plan, completed during the first quarter of 1972, addressed the results from other plants as they related to the scope of the testing that was performed at the DAEC. (Refer also to Sections 3.9.5 and 14.2.12.)

14.2.1.3 Startup and Power Test Program

Iowa Electric had control of the startup and power test program for the DAEC.

A summary of results obtained from a typical startup and power test program for a GE BWR was submitted to the AEC as a GE Topical Report.[1] A number of high power-density BWRs were in operation before the startup of the DAEC. Accordingly, fuel behavior of the higher power-density cores was confirmed.

Brief descriptions of the individual startup and power tests are presented in Tables 14.2-1 through 14.2-3. The startup and power test program was comprehensive, and as such, demonstrated that the plant was capable of operating safely and satisfactorily.

14.2.1.3.1 General Objectives

The startup and power test program extended from initial fuel loading through the completion of power demonstration and commencement of commercial operation. The startup and power test program was performed to demonstrate that the plant was capable

of operating safely and satisfactorily. Systems and components which could not be fully checked out in the preoperational tests were tested at power during this phase. The nuclear characteristics of the assembled core were compared with calculations throughout the startup program to confirm the design values. The detailed start-up test instructions were completed prior to startup. The schedule of tests was carefully supervised to achieve the planned objectives. During startup, operators who had been licensed for "cold" operations were further qualified for power operations.

14.2.1.3.2 Fuel Loading and Low Power Tests at Atmospheric Pressure

The initial fuel loading and criticality testing was performed at near zero power and at atmospheric pressure with the reactor pressure vessel open. Table 14.2-1 summarizes tests performed during this phase of the startup program.

14.2.1.3.3 Heatup from Ambient to Rated Temperature and Pressure

Following satisfactory completion of the core loading, the core components were visually inspected for proper installation. The additional in-vessel hardware, such as the steam separator and dryer assemblies, was installed. The reactor head was then installed, followed by a hydrostatic test to ensure the satisfactory sealing of the vessel head. The drywell head was then installed and the shield plugs were placed over it.

The recirculation pumps were started and operated at low speeds. After verification that the recirculation pumps were performing satisfactorily, the reactor was made critical and brought to low power for heatup. A sequence of tests were performed to confirm a number of the nuclear steam supply system characteristics as the temperature and pressure were increased with recirculation pump heating and nuclear heating. Table 14.2-2 lists the tests conducted during this phase of the startup.

14.2.1.3.4 From Rated Temperature to 100% Power (1593 MWt)

Following initial heating to rated temperature, reactor power was increased to 100% in 25% increments by withdrawing control rods in a predetermined sequence and/or by increasing recirculation flow. Major testing was performed at the 25%, 50%, 75%, and 100% power levels. Table 14.2-3 lists tests conducted at one or more power levels during this phase of the startup.

The following tests were performed at rated power and rated flow:

- Chemical and radiochemical.
- LPRM calibration.
- APRM calibration.
- Core power distribution.
- Core performance.
- Flux response to rods.

- Pressure regulator setpoint changes.
- Radiation measurements.
- Feedwater system setpoint change.
- Feedwater heater drop.
- Bypass valve trip.
- Flow control.
- Feedwater pump trip.
- Recirculation pump trip.
- Main steam isolation valve closure.

All these tests were performed at 1593 MWt, and they are described in Table 14.2-3. This amount of testing was sufficient to validate and support the operational safety of the plant at this power level.

14.2.1.3.5 Nuclear System Startup Test Restrictions

All operations and tests complied with the warranty limitations specified by GE, and with the safety limitations and limiting conditions for operation defined in the Technical Specifications. The prime objective of the startup program was to demonstrate that the plant was capable of operating safely and satisfactorily up to rated power. Accordingly, special restrictions applicable to the startup program were detailed in the written startup instructions and in supporting documents.

For example, during the initial fuel-loading operations, special neutron detectors and a test neutron source were installed near the first fuel-loading location to obtain a neutron flux sufficient to provide positive indications of neutron multiplication. The special neutron detectors were removed when the core was fully loaded. The test neutron source was removed during the second fuel loading. The normal operational neutron sources were then installed to provide ample neutron flux for the plant instrumentation.

14.2.1.3.6 Balance-of-Plant Startup Test Restrictions

Recommended procedures and limitations provided by the various equipment suppliers were incorporated into detailed operating procedures prepared by plant personnel. In particular, procedures were prepared and followed covering the normal startup and operation of the turbine-generator unit, with its accessories and auxiliaries.

“Restrictions” included limits on such items as the vibration of rotating equipment, turbine temperature increase rates and differentials, generator and transformer temperature, minimum condenser vacuum expansion rates and differentials, and feedwater purity.

14.2.2 ORGANIZATION AND STAFFING

Iowa Electric was responsible for all operations and for providing an adequate staff of qualified and licensed personnel for DAEC during the startup and power test program.

The initial fuel loading and nuclear system startup and operational testing were performed by Iowa Electric under the technical direction of GE and Bechtel. The procedures covering these activities were written in detail and included methods, data, and calculational aids. The startup procedures included test methods and described the steps for performing tests and judging results.

General Electric provided technical direction and assistance during initial fuel handling, storage; loading, startup, startup tests; and operation of the nuclear system prior to commercial operation. The objective of the technical direction was to ensure the inherent safety and reliability of the nuclear system, and to make sure that operating procedures reflected a course of action based on current engineering and operating practices for the nuclear steam supply system.

Technical direction was defined as engineering and technical guidance relating to the work to be performed. It included the specifications, instructions, and procedures for installation and preoperational testing of equipment and for initial fuel loading and startup testing. The implements of technical direction have the following meanings:

1. A specification is a minimum mandatory requirement.

2. An instruction or procedure provides the necessary information and steps to be taken to fulfill the requirements of a specification.

Figure 14.2-1 shows the working interrelationships and organizational interfaces of all augmenting groups of the DAEC startup organization. The functions, responsibilities, and authorities of the key Bechtel and GE jobsite personnel are described in the following subsections.

14.2.2.1 Bechtel Onsite Startup Personnel

Supervising Startup Engineer

Because of the interfaces and dependence of the various activities upon each other (such as construction activities, startup manpower, plant operations manpower, etc.) all activities were scheduled on the whole-plant basis. To achieve this in an orderly manner, the responsibility until the end of the preoperational test phase (commencement of fuel loading) rested with one individual: the Supervising Startup Engineer. At the time of fuel loading, his major responsibilities, listed below, were transferred to the plant operations organization (i.e., Chief Engineer and Operations Supervisor).

The Supervising Startup Engineer, under the supervision of the Home Office Project Startup Engineer, was responsible for the coordination of all startup, plant

operations, and, so far as they affect operations systems, construction activities. The major responsibilities were as follows:

1. Prepare and update Construction and Startup Coordination Master Schedule.

2. Issue and control Weekly Startup Work Schedules within the framework of the above.

3. Review progress and control of the project startup with Construction and Engineering and with Iowa Electric's management.

4. Ensure that all startup work was in compliance with the startup and other standards and codes.

5. Ensure that the necessary legal requirements affecting work in progress were complied with (permits, licenses, etc.).

6. Ensure that sufficient startup manpower was available to the Startup Group leaders.

7. Review and approve requests for vendor assistance as recommended by the Startup Group leaders.

8. Review and approve all requests for startup field design changes.

9. Ensure that all startup materials for instruments and consumable supplies were ordered in a timely manner.

10. Prepare and issue Weekly Startup Progress Reports.

11. Establish and exercise drawing and information filing control procedures.

12. Prepare and issue Weekly Startup Progress Reports.

13. Establish and exercise drawing and information filing control procedures.

14. Prepare special reports as deemed necessary.

15. Assign system responsibilities to startup groups.

16. Represent the startup organization on all first-level (operating) interdepartmental or interorganizational committees associated with the project.

<u>Startup Mechanical Group Leader</u>

A responsible group leader was required wherever more than three startup engineers were involved in the same types of activities. He was under the supervision of the Supervising Startup Engineer and was responsible for the supervision and technical direction of work of a mechanical nature during the preoperational test phase. At the time of fuel load, these responsibilities were turned over to Iowa Electric's Mechanical Maintenance and Operations Supervisors. The major responsibilities were as follows:

1. Check or prepare and review with the construction organization the mechanical equipment lists and piping system terminal points 12 to 15 weeks before the scheduled system turnover date to startup, as shown on the Construction and Startup Coordination Master Schedule.

2. Carry out final review of the equiment and system status and finalize terminal points 1 week before scheduled system turnover to startup.

3. Prepare and control the weekly work schedule of startup activities of a mechanical nature in cooperation with the plant operating staff and Electrical and Instrumentation Group leaders.

4. Prepare equipment data sheet forms and establish project procedures on the use of these forms to ensure uniformity, for the guidance of startup engineers. (Incorporate startup standards and customer requirements.)

5. Witness and/or supervise final inspection of all tanks and pressure vessels before the closure of manholes by construction.

6. Prepare or supervise the preparation of any and all flushing and other special procedures or instructions of a mechanical nature.

7. Assign mechanical system responsibilities to the individual startup engineers.

8. Review system design and/or startup or operating procedure changes with the responsible startup engineer.

9. Review and recommend the assistance of vendor's representatives as requested by the responsible startup engineers.

10. Review and discuss problems of a mechanical nature with the project engineering and construction personnel. Maintain system deficiency lists and expedite completion of deficiencies.

11. Accept formal system turnover from construction for those systems where system responsibility has been assigned to the mechanical group.

12. Ensure that all vendor instructions, P&IDS, preoperational test procedures, etc., were available and the copies were in the startus files well before the scheduled system turnover to startup.

13. Assume responsibility for water quality control during the preoperational test phase.

14. Review preoperational test work.

15. Direct mechanical trades and maintenance personnel assigned to startup.

16. Prepare a weekly summary of Mechanical Group activities.

17. Check that correct charges were entered in time cards for cost control purposes.

Startup Electrical Group Leader

A responsible group leader was required whenever more than three startup engineers were involved in the same types of activities. He was under the supervision of the Supervising Startup Engineer and was responsible for the supervision and technical direction of work of an electrical (power and logic control) nature during the preoperational test phase. At the time of fuel loading, these responsibilities were turned over to Iowa Electric's Electrical Maintenance and Operations Supervisors. The major responsibilities were as follows:

1. Check or prepare and review with the construction organization the Electrical Equipment Lists and electrical isolation terminal points 12 to 15 weeks before the scheduled system turnover date to startup as shown on the Construction and Startup Coordination Master Schedule.

2. Carry out the final review of the electrical equipment status and finalize terminal points 1 week before scheduled system turnover to startup. This must take place on all systems regardless of who has the total responsibility for the system.

3. Prepare and control the weekly work schedule of startup activities of an electrical nature in cooperation with the plant operations staff and Mechanical and Instrumentation Group leaders.

4. Prepare Equipment Data Sheet forms and establish project procedures on the use of these forms to ensure uniformity of checkout, for the guidance of the electrical startup engineers.

5. Witness and/or supervise the preparation of any and all electrical equipment before the energization of such equipment.

6. Prepare or supervise the preparation of any and all energization procedures and other special procedures of an electrical nature.

7. Assign system work responsibilities to the electrical startup engineers. Assign total system responsibilities for the system assigned to the Electrical Group.

8. Review system design and/or startup or operating procedure changes with the responsible startup engineer.

9. Review and recommend the assistance of vendor representatives as requested by the responsible startup engineer.

10. Review and discuss problems of an electrical nature with the project engineering and construction personnel. Maintain system deficiency lists and expedite the correction of such deficiencies of an electrical nature.

11. Accept formal system turnover from construction for those systems where system responsibility has been assigned to the Electrical Group.

12. Ensure that all vendor instructions, P&IDS, schematics, single lines, etc., were available and the copies were in the startup files well before the scheduled system turn-over to startup.

13. Ensure that all work of an electrical nature met all checkout and test standards.

14. Assume direct responsibility for all integrated logic and loss-of-power tests.

15. Review preoperational test work.

16. Direct electrical trades and maintenance personnel assigned to startup.

17. Control and schedule the use of test instruments assigned to the Electrical Group.

18. Prepare a weekly summary of Electrical Group activities.

19. Check the correctness of all charges entered on time cards for cost control purposes.

Startup Instrumentation and Control Group Leader

A responsible group leader was required whenever more than three start-up engineers were involved in the same types of activities. He was under the supervision of the Supervising Startup Engineer and was responsible for the supervision and technical

direction of work of an instrumentation and analog control nature during the preoperational test phase. At the time of fuel loading, these responsibilities were turned over to Iowas Electric's Electrical Maintenance Supervisor. The major responsibilities were as follows:

1. Check (or prepare) and review with the construction organization the Instrumentation Equipment Lists associated with a particular system 1 to 15 weeks before the scheduled system turnover date to startup, as shown on the Construction and Startup Coordination Master Schedule.

2. Carry out the final review of the instrumentation equipment associated with a system 1 week before the scheduled system turnover to startup. This took place on all systems regardless of which group had the responsibility for the system.

3. Prepare and control the weekly work schedule of startup activities of an instrumentation nature in cooperation with the plant operating staff and Electrical and Mechanical Group leaders.

4. Prepare Equipment Data Sheet forms and establish project procedures on the use of these forms to ensure uniformity of checkout, for the guidance of the instrumentation startup engineers.

5. Witness and/or supervise the checkout of computer analog and digital loops.

6. Prepare or supervise the preparation of any and all control loop transient tests and other special procedures during the preoperational test phase.

7. Assign system work responsibilities to the instrumentation startup engineers. Assign total system responsibilities for the systems assigned to the Instrumentation Group.

8. Review system design and/or startup or operating procedure changes with the responsible startup engineer.

9. Review and recommend the assistance of vendor representatives as requested by the responsible startup engineer.

10. Review and discuss problems of an instrumentation nature with the project engineering and construction personnel. Maintain system deficiency lists and expedite the correction of deficiencies of an instrumentation nature.

11. Accept formal system turnover from construction for those systems where system responsibility had been assigned to the Instrumentation Group.

12. Ensure that all vendor instructions, P&IDS, instrumentation schematics, etc., were available and the copies were in the startup files well before the scheduled system turnover to startup.

13. Ensure that all work of an instrumentation nature met checkout and test standards.

14. Assume direct responsibility for all integrated analog control loop tests.

15. Review preoperational test work.

16. Direct instrument technicians and maintenance personnel assigned to startup.

17. Control and schedule the use of test instruments assigned to the Instrumentation Group.

18. Ensure that all temporary instrumentation was available for preoperational test work and that installations were removed after the completion of tests.

19. Prepare a weekly summary of Instrumentation Group activities.

20. Check that correct charges had been entered on time cards for cost control purposes.

14.2.2.2 Qualifications of Bechtel Onsite Startup Personnel Appointees

[redacted] Supervising Startup Engineer

1952	Graduated from the New Mexico Institute of Mining & Technology with a B.S. degree in Mining Engineering.
June 1952-August 1960	Held various engineering and management positions with the Bunker Hill, American Smelting & Refining, and Union Carbide Nuclear Companies.

August 1960-October 1963	Shift Supervisor at various reactors at Richland, Washington, for the General Electric Company.
October 1963-December 1963	Shift Supervisor-in-Training at the VBWR at Vallecitos, California, for the General Electric Company.
December 1963-June 1966	Shift Supervisor at GETR at Vallecitos, California, for the General Electric Company. Obtained Senior Operator License.
June 1966-May 1967	Maintenance Manager at EVESR at Vallecitos, California, for the General Electric Company.
May 1967-August 1969	General Electric Shift Superintendent during startup of 400-MWe dual-unit [redacted]
August 1969-August 1970	General Day Shift Superintendent and Technical Advisor during startup and initial operation of 360-MWe plant in [redacted]
August 1970-October 1971	General Electric Shift Superintendent at dual-unit 1600-MWe [redacted]. Qualified and obtained "cold" Senior Reactor Operator License.
October 1971	Assigned as Supervising Startup Engineer, Bechtel Corporation, for the Duane Arnold Energy Center, Unit 1.

[redacted] Mechanical Startup Group Leader

1962	Graduated from Tunghai University, Taiwan, with a B.S. degree in Chemical Engineering.
September 1963-March 1966	Operating Engineer for Mobil China Allied Chemical Company in Taiwan. Participated in the startup of an ammonia plant, including the steam eneration system. Supervised production in the ammonia recovery and refrigeration areas.
June 1968	Graduated from Tennessee Technical University with an M.S. degree in Chemical Engineering.

August 1967-March 1970	Process Engineer for Chicago Bridge and Iron Company, doing evaporator design work.
March 1970-May 1970	Project Engineer for Jacobs Engineering Company, participating in engineering of the utilities section of an oil extraction plant.
May 1970-January 1972	Plant Engineer for the Koppers Company, responsible for the start-up, operation, and maintenance of the boilers, turbine, condenser and polishing equipment, cooling tower, and water treatment facilities for a phthalic anhydride plant.
February 1972	Assigned as Mechanical Group Leader, startup, for the Duane Arnold Energy Center, Unit 1.

[redacted] Electrical Startup Group Leader

June 1937	Graduated from University of Iowa with a B.S. degree in Electrical Engineering.
April 1937-October 1937	General Electric Company, Pittsfield, Massachusetts. Test Engineer, principally on transformers.
October 1937-April 1941	Engineer Electrical Service, for Chicago, Rock Island and Pacific Railway Company, Chicago, Illinois. Electrified (replaced steam engine equipment) terminal grain elevators, South Chicago, Illinois. Electrified engine terminals at Burr Oak, Illinois; Estherville, Iowa; Manly, Iowa; Ft. Worth, Texas; and Goodland, Kansas. Electrified draw-bridge over Mississippi River at Inner Grove, Minnesota. Erected fruit and produce terminal in Minneapolis, Minnesota. Installed fuel-oil facilities from Council Bluffs, Iowa, to Denver, Colorado (numerous projects)
April 1941-October 1944	Assistant Superintendent of Power Plants, Day and Zimmerman, Inc., Iowa Ordinance Plant, Burlington, Iowa. Operated steam electric power generating plant (four turbines) and five process steam plants.

October 1944-January 1969	Electrical Engineer, Electric Production Department, Iowa-Illinois Gas & Electric Company, Davenport, Iowa (1950-1965). In charge of all electric operation, design and construction of four steam-electric, two hydroelectric and one diesel-electric power generating stations. Project Engineer, Electric Engineering Department (1965-1969). Worked on transmission and substation projects and on study of computer-controlled gas and electric control center.
January 1969-December 1971	Electric Construction Supervisor and Startup Engineer, United Engineers and Constructors, Inc., at the Quad-Cities Nuclear Plant, Cordova, Illinois.
December 1971	Assigned as Electrical Group Leader, Startup, for the Duane Arnold Energy Center, Unit 1.

[redacted] Startup I&C Group Leader

1954	B.S. degree in Electrical Engineering from Oregon State College.
1964	Registered Professional Engineer, California.
1954-1955	Honeywell, Portland, Oregon. Responsible for sales and applications engineering in controls and instrumentation.
1955	Plant Engineer, Spreckels Sugar Company, Woodland, California. Installed and tested process system equipment.
1955-1968	Aerojet General Corporation, Sacramento, California. Served as Instrumentation Engineer for 2 years. Performed installation, checkout, and operation of instrumentation and control systems associated with the testing of large rocket engines and components.

	Served for 3 years as Design Engineer, Ground Support Equipment. Responsible for the design, testing, installation, and initial operation of preflight checker and launch control system for the Titan I weapon system.
	Worked for 3 years as Project Engineer, Titan II Activation Project. Involved in management of Aerojet participation in the activation of Titan II operational bases.
	Served for 3 years as Project Engineer, Gemini Pilot Safety. Performed detailed review of all propulsion system activity on the Gemini program.
	Worked for 3 years as Design Engineer, Nuclear Controls and Systems. Designed, installed, and tested the engine control system for the XE-1 nuclear rocket engine at NRDS.
1968-1969	Test Operations Supervisor, Lear Motors. Performed development testing on a prototype automotive steam engine and components.
1970-1971	Aerojet Nuclear Systems Company. Responsible for design and development testing of electric actuators and drive electronics for use in a high radiation, cryogenic environment.
1971	Bechtel Corporation. Assigned as Startup I&C Group Leader for the Duane Arnold Energy Center, Palo, Iowa.

14.2.2.3 General Electric Onsite Startup Personnel

Site Operations Manager

General Electric Atomic Power Equipment Department (APED) Project Management maintained total GE project responsibility. As such, the GE Site Operations Manager was responsible overall to Projects, San Jose, for the safe and expeditious conduct of preoperational tests under GE technical direction and of the fuel-loading and power-testing program. The GE Site Operations Manager reported directly to Startup Test Operations, San Jose, on all technical aspects of the startup program, and on administration of the GE startup crew. He was directly responsible to Startup Test Operations in all technical matters relating to the startup programs and to nuclear safety.

All formal internal GE communication and documentation with San Jose was through the GE Site Operations Manager to either San Jose Project Management or Startup Test Operations. In addition, close daily communication was maintained with Startup Test Operations and Projects by phone and TWX as required by the various GE startup people in order to facilitate needed technical support.

Coordination of GE site-San Jose relations was the responsibility of the GE Site Operations Manager. His other specific responsibilities, to the extent that they related to GE areas of responsibility, included:

1. Act as technical counsel on the coordination of preoperational tests with construction completion, construction testing, and the operation of completed systems.

2. Identify known deficiencies to Iowa Electric's personnel to guide and expedite the sequential completion of construction work.

3. Review and approve GE-prepared Preoperational Test Instructions as well as Startup Test Instructions.

4. Review and approve preoperational test results for GE-supplied systems and startup test results. Review the completed preoperational test program, cold functional test program, and the Initial Fuel Loading Checklist and indicate the acceptability of fuel loading.

5. Attend and advise Iowa Electric's personnel (and construction representatives as required) in their planning meetings for the preparation and execution of the preoperational and startup test programs.

6. Review and approve Preoperational Test Supplementary Instructions and revisions and Startup Test Instruction revisions as prepared and issued by Iowa Electric. Revisions were approved after appropriate consultation with cognizant GE engineering personnel and consultation with and approval by Iowa Electric.

7. Assume overall responsibility for GE site management before and during the startup test program.

Operations Superintendent

The Operations Superintendent was responsible for the technical direction of the day-to-day testing program of the plant and the performance of tests by Iowa Electric operating personnel as related to GE-supplied systems or other systems directly affecting GE systems. He was responsible for advising Iowa Electric in their planning to avoid interferences between scheduled tests and maintenance work. He reported on operating

problems and issued instructions to the GE Shift Supervisor to implement the preceding functions.

He checked that all prerequisites had been accomplished, special test equipment was on hand, and all preparations had been completed for starting a preoperational test under GE technical direction. He evaluated test results and data or coordinated an evaluation by design engineers or vendors' representatives where they were assigned to assist in testing. He provided on-shift support for GE Shift Supervisors during critical phases of the loading or testing program or substituted for an absent GE Shift Supervisor. In the absence of the Site Operations Manager, the Operations Superintendent was delegated the responsibilities of the Site Operations Manager.

Shift Supervisors

The GE Shift Supervisors worked very closely with and advised their Iowa Electric counterparts, who issued the action orders to Iowa Electric operating personnel. The GE Shift Supervisors and their Iowa Electric counterparts kept each other informed as to plant status at all times. The Shift Supervisor's responsibilities, to the extent that they related to GE areas of responsibility, were as follows:

1. Know all work in progress and the status of systems and keep Iowa Electric Shift Engineer informed.

2. Ensure that Iowa Electric was maintaining logs of testing and equipment operation.

3. Ensure that Iowa Electric access control procedures were followed by all GE personnel.

4. Advise Iowa Electric on safe removal and return of equipment to service.

5. Maintain cognizance of all shift activities.

6. Keep Iowa Electric and GE management informed of problems.

7. Provide technical direction for the conduct of all operations in accordance with approved procedures.

Test Design and Analysis Engineer

The Test Design and Analysis Engineer was responsible for the technical planning and detailing of the power test program starting with initial fuel loading.

The Test Design and Analysis Engineer supervised and directed the activities of GE technical support specialists and consultants during the startup test program. He coordinated the review and interpretations of his permanently assigned group and the

consultants, advised the GE Site Operations Manager on the acceptability of test results, and recommended approval to proceed to the next phase of the test program.

He was responsible to note any deviations from expected plant performance and make immediate recommendations for correction or additional diagnostic testing.

14.2.2.4 Qualifications of General Electric Onsite Startup Personnel

The qualifications of the GE site personnel referred to above were as follows:

1. Operations Site Manager: an AEC-licensable (Senior Operator) engineer who had been either an Operations Superintendent at a previous BWR startup or had had equivalent experience.

2. Operations Superintendent: an AEC-licensable (Senior Operator) engineer who had been either a Startup Test Operations Engineer at a previous BWR startup or had had equivalent experience.

3. Startup Shift Supervisor: an AEC-licensable (Senior Operator) engineer. His immediate supervisor was an Operations Superintendent with prior BWR startup experience.

The Startup Test Design and Analysis site team normally consisted of five people. This was made up of a lead engineer, three shift engineers and an Automatic Control Systems Specialist. Their minimum educational and experience requirements were as follows:

1. Lead Startup Test Design and Analysis Engineer

   Education: B.S. or M.S. in Nuclear, Mechanical, Chemical, or Electrical Engineering or Physics.

   Experience: Minimum of 3 years of experience in the nuclear energy field beyond the B.S. degree and at least two years in the power reactor area, including GE-BWR startup experience. Must have a demonstrated knowledge of BWR nuclear and thermal-hydraulic behavior and transient performance.

2. Shift Startup Test Design and Analysis Engineer

   Education: B.S. or M.S. in Nuclear, Mechanical, Chemical, or Electrical Engineering or Physics.

   Experience: Minimum of 2 years experience in nuclear energy field beyond the B.S. degree and at least one year in the power reactor area, including nuclear and thermal hydraulic analysis of BWR core performance and the

preparation of startup test procedures. (Of the three shift STD&A engineers, at least two would normally have had previous GE-BWR startup experience.)

3. Automatic Control Systems Specialist

Education: M.S. Electrical Engineer or B.S. Electrical Engineer with specialized courses in control systems and servo-mechanism theory.

Experience: Minimum of 5 years of experience in control system design and application plus demonstrated competence in field assignments.

14.2.3 TEST PROCEDURES

14.2.3.1 Preoperational Test Procedures

14.2.3.1.1 Preoperational Test Procedure Preparation, Review, and Approval

As illustrated in Figure 14.2-2, the system for preparing, reviewing, and approving the preoperational test procedures is described below.

1. Bechtel had the responsibility to prepare the initial copy of the balance-of-plant (BOP) and nuclear steam supply system (NSSS) preoperational test procedures.

2. The test procedures were sent to the DAEC's Chief Engineer to be distributed for review. The review process was performed by Iowa Electric's Quality Assurance Department and Operations Committee, Bechtel and GE site personnel, and consultants as required.

3. All comments were directed to the DAEC's Chief Engineer. The comments were then sent to Bechtel to be incorporated in the final copy of the test procedure. Bechtel and Iowa Electric's Operations Committee approved all preoperational test procedures; General Electric approved only NSSS preoperational test procedures.

4. Iowa Electric's Chief Engineer for DAEC gave final approval for each preoperational test procedure.

14.2.3.1.2 Preoperational Test Procedure Changes

If preoperational test procedure changes were required either before or after the associated preoperational test, the procedure for changing it was as follows (see Figure 14.2-3):

1. A change initiation and a document chan e notice were prepared and submitted to the DAEC Chief Engineer.

2. The DAEC Chief Engineer distributed the document change notice to the DAEC Operations Committee and to Bechtel and GE site personnel for review and either approval or rejection. General Electric was concerned only with NSSS preoperational test procedures.

3. The DAEC Operations Committee submitted the document change notice to Iowa Electric's Engineering Department and Quality Assurance Department for review as required.

4. Bechtel and GE, if required, submitted the change notice to their respective Engineering Departments for review.

5. Upon complete review of the document change notice, the DAEC Chief Engineer coordinated the processing of the approved or rejected document.

6. If the document change notice was rejected, the preoperational test procedure remained as originally written.

7. If the document change notice was approved, the preoperational test procedure was amended and distributed to all cognizant parties. The original preoperational test procedure was retained in Iowa Electric's preoperational test procedure file. If the preoperational test had already been conducted, then the portion affected by the change was repeated.

14.2.3.1.3 Deviation to Approved Preoperational Test Procedure During the Associated Preoperational Test

When deviations to approved preoperational test procedures were required during the associated test, the following procedures were used (Figure 14.2-4):

1. The test crew evaluated the required deviation to determine if it appeared to change the intent of the test.

2. When the deviation appeared to change the intent of the preoperational test, the affected portion of the test was stopped.

3. When the deviation did not appear to change the intent of the preoperational test, the test was continued.

4. In either case, a document deviation notice was prepared and submitted to the DAEC Chief Engineer.

5. The DAEC Chief Engineer distributed copies of the document deviation notice to the DAEC Operations Committee, Bechtel site personnel, and GE site personnel for review and either approval or rejection and to the Iowa Electric's Engineering Department and Quality Assurance Department for review as required. Bechtel and GE site personnel sent the document deviation notices to their respective Engineering Departments as required. General Electric was concerned only with NSSS preoperational test procedures.

6. Upon complete review of the document deviation notice, the DAEC Chief Engineer coordinated the processing of the approved or rejected document.

7. In those cases when the document deviation notice was rejected and the preoperational test had already been completed, the affected portion of the test was repeated. When the notice was rejected and the test had already been stopped before completion, the test was simply resumed and completed as originally planned.

8. In those cases when the deviation notice was approved and the preoperational test had already been completed, the test was signed off as "complete." When, conversely, the document deviation notice was approved and the test had already been stopped before completion, the test was simply continued from the point at which it was halted.

9. In either case, copies of the document deviation notice and the affected preoperational test procedure were sent to all cognizant parties and the original was retained in the preoperational test procedure file.

14.2.3.2 Startup and Power Test Procedures

14.2.3.2.1 General

Initial fuel loading, nuclear system startup, and operational testing were performed by Iowa Electric under the technical direction of GE NED personnel. To facilitate the technical direction of initial fuel loading and power testing, startup test specifications, calculations, and instructions were provided by NED.

14.2.3.2.2 Startup Test Specifications, Calculations and Instructions

Startup test specifications defined the minimum test program for safe and efficient startup and authorized and required the performance of the described tests. The specifications limited and defined the freedom for changes during the startup test activities and were reviewed and approved by the responsible design engineering component. Each required test was performed to the extent specified.

Startup test calculations contained the results of analyses made to facilitate startup testing activities required by the startup test specifications.

Startup test instructions presented the recommended test method and described the steps necessary to perform the test defined in the startup test specifications. When other test methods were employed, however, the resulting data had to be equivalent in quality and quantity to the data that would have resulted from the recommended test method. The startup test instructions also contained criteria for judging the test results, where applicable, and data and calculation sheets for site analysis of the data.

14.2.3.2.3 Test Instruction, Preparation, Review, and Approval

As illustrated in Figure 14.2-5, the system for preparing, reviewing, and approving the Startup Test Instructions is described below:

1. General Electric had the responsibility for preparing the initial copy of their Startup Test Instructions.

2. The Test Instructions were sent to Iowa Electric's Reactor and Plant Performance Engineer for revision as necessary and distribution for review. The review was performed by Iowa Electric's Engineering Department, Quality Assurance Department (as required), Production Department (Operations Committee), and Safety Committee; GE site personnel; Bechtel site personnel (as required); GE Engineering Departments (as required); and consultants (as required).

3. All comments were directed to Iowa Electric's Reactor and Plant Performance Engineer for the final preparation of the Test Instructions.

4. Iowa Electric's Operations Committee and Chief Engineer for DAEC gave final approval of each Test Instruction.

14.2.3.2.4 Test Instruction Changes

When test instruction changes were required, the procedure was as follows:

1. Changes to the test instruction were submitted to Iowa Electric's Reactor and Plant Performance Engineer.

2. Changes to the test instruction were submitted to the Iowa Electric's Operations Committee and to GE site personnel for review and approval.

3. All changes were documented in the master copy of the instructions that were retained in Iowa Electric's Test Instruction file.

14.2.4 CONDUCT OF TEST PROGRAM

The preoperational test program and the startup and power test program were conducted under the direction of Iowa Electric's Production Department using Engineering Department, Bechtel, GE, and contractor personnel as required.

NED supplied field engineers with extensive product knowledge and wide startup experience to provide technical direction of the preoperational tests.

NED supplied field engineers with extensive product knowledge and wide startup experience to provide technical direction for the startup test program. Results of the startup test program were analyzed at the reactor site as the data became available and periodic reports of the results of the program were issued during the course of testing activities.

Upon completion of preoperational tests, the NED technical specialist and an Iowa Electric representative formally verified that the tests had been completed and that the results were in accordance with applicable specifications and instructions.

14.2.5 REVIEW, EVALUATION, AND APPROVAL OF TEST RESULTS

14.2.5.1 General

The system used for evaluating, documenting, and approving the test results is described below and in Section 14.2.2. The personnel qualifications for those involved in the review and approval program are described in Sections 13.1.3 and 14.2.2.

Acceptance criteria for each system were documented in the preoperational test specifications and compliance with these acceptance criteria was documented in the preoperational test procedure or instruction.

The acceptance criteria were, in general, that the system perform as intended (e.g., the core spray system should respond in a specified time with a specified flow rate). Specific acceptance criteria for each system were obtained from the system preoperational test specifications.

14.2.5.2 Preoperational Tests

Upon the completion of each preoperational test, the results of the test were evaluated, approved, and documented by means of the following system (Figure 14.2-6):

1. Iowa Electric's DAEC site personnel prepared a test report for each preoperational test.

2. The test results and the test report were submitted to the DAEC Chief Engineer.

3. The DAEC Chief Engineer distributed the test results and report to the DAEC Operations Committee, Iowa Electric's Quality Assurance Department, and Bechtel and GE site personnel for review and either approval or rejection. General Electric was concerned only with NSSS preoperational test procedures.

4. The DAEC Operations Committee submitted the test results and report to the Safety Committee for review.

5. Bechtel and GE site personnel, when required, submitted the test results and report to their respective Engineering Departments for review.

6. Upon complete review of the test results and report, the DAEC Chief Engineer coordinated the processing of the approved or rejected test results and report.

7. When the test results and report were rejected, they were considered to be at variance and the procedure described below was followed.

8. When the test results and report were approved, copies were distributed to all cognizant parties. The original of the test results and report was retained in Iowa Electric's preoperational test file.

When test results were at variance with expected results, the procedures for ensuring that they were reflected in system modifications, operating procedures, or maintenance procedures were as follows (Figure 14.2-7):

1. The DAEC Chief Engineer coordinated the test results and reports that were at variance with those expected from the preoperational test. He had the option to do either or both of the following:

    a. Initiate a change to the preoperational procedure, requiring a portion or all of the preoperational test to be performed again.

b. Send the test results to Iowa Electric, GE, and Bechtel Engineering, as required, for system design review and possible system modifications.

2. When a system modification was required, this necessitated a preoperational procedure change and an operating and/or maintenance procedure change. In addition, the affected portion of the preoperational test was performed again.

3. When a system modification was not required, a change to the preoperational procedure was initiated as required to ensure that the test results were in accordance with expected results.

4. The DAEC Operations Committee reviewed and either approved or rejected the Operating/Maintenance Change Notice.

5. The DAEC Operations Committee sent the Operating/Maintenance Change Notice to the Safety Committee when it involved an unreviewed safety question.

6. The DAEC Operations Committee sent the Operating/Maintenance Change Notice to Iowa Electric's Quality Assurance Department for review and either approval or rejection.

7. Upon complete review of the Operating/Maintenance Change Notice, the DAEC Chief Engineer coordinated the processing of the approved or rejected document.

8. When the Operating/Maintenance Change Notice was approved, the operating and/or maintenance procedure was amended and distributed to all cognizant parties. The original Operating/Maintenance Change Notice was retained in Iowa Electric's procedure file.

9. When the Operating/Maintenance Change Notice was rejected, the operating and/or maintenance procedure remained as originally written.

14.2.5.3 Startup Tests

Upon completion of each startup test, the results of the test were evaluated, approved, and documented by means of the following system:

1. Iowa Electric's Reactor and Plant Performance Engineer and/or GE site personnel prepared a draft test report that included test results, evaluation results, and conclusions.

2. Iowa Electric's Engineering Department, Quality Assurance Department, and Operations Committee received a copy of the draft test report for review and approval. A copy of the draft test report was also forwarded to the Safety Committee for review and to Bechtel site personnel for review as required.

3. After all reviews of the draft test report had been completed, a final test report was issued for approval by Iowa Electric's Engineering Department, Quality Assurance Department, and Operations Committee.

4. The test report was filed with the master copy of the instruction that was retained in Iowa Electric's Test Instruction file.

14.2.5.4 System Modifications or Procedure Changes

General Electric and Bechtel administrative procedures for system modifications or procedure changes as a consequence of test results were as follows:

General Electric

1. Unacceptable performance or nonconformance with acceptance criteria was transmitted to San Jose by means of a Field Design Deviation Request (FDDR) for Design Engineering resolution.

2. Recommendations for changes to this and other projects were then made by Design Engineering via a Field Disposition Instruction (FDI) and implemented in the field, where necessary, by Startup Test Operation.

Bechtel

1. Unacceptable performance or nonconformance with acceptance criteria was transmitted to Bechtel San Francisco by means of an Interim Field Report for Engineering resolution.

2. Recommendations for changes to this and other projects were made by Engineering via an Interim Field Report Reply and/or a Field Change Notice (FCN) and implemented in the field, where necessary, by Bechtel Startup.

14.2.6 TEST RECORDS

All preoperational procedures, test data, and reports are kept on file at the plant site.

Complete records of the plant startup tests and initial operation are kept at the plant site in the test file. These records include the following:

1. A master copy of startup test procedures. This document, which is the final record of the "as run" test procedures, includes all approvals and original data sheets.

2. Pertinent recorder charts and log sheets.

3. The test log, a chronological report of all significant test occurrences and data. This log was prepared by the engineers in charge of the test.

4. Test reports, including any reports prepared by Iowa Electric, GE, or Bechtel.

14.2.7 CONFORMANCE OF TEST PROGRAMS WITH SAFETY GUIDES

The requirement of AEC Safety Guide 20 regarding the inspection of prototype reactors internals after preoperational flow testing were fully satisfied, as discussed in Section 1.8.

14.2.8 UTILIZATION OF REACTOR OPERATING AND TESTING EXPERIENCES IN DEVELOPMENT OF TEST PROGRAM

Experience obtained with vibration testing performed on several BWR plants, including [redacted] was used in the planning of vibration testing of the DAEC. (See Section 14.2.1.2.3)

The experience of both GE and Bechtel with other BWRs, was also used throughout the initial test program.

14.2.9 TRIAL USE OF PLANT OPERATING AND EMERGENCY PROCEDURES

Some plant operating and emergency procedures were developed and tested during the initial test program. More detailed discussion of the plant operating procedures is given in Section 13.5.2. Detailed emergency procedures are found in the "Emergency Plan" for the DAEC, which is separate from this UFSAR. (See Section 13.3.)

14.2.10 INITIAL FUEL LOADING AND INITIAL CRITICALITY

The initial fuel loading and initial criticality testing were activities conducted under the startup and power testing program. Table 14.2-1 summarizes the corresponding tests.

14.2.11 TEST PROGRAM SCHEDULE

The individual preoperational tests are described in detail in the following sections. The startup and power tests are briefly summarized in Tables 14.2-1 through 14.2-3. In addition, Section 14.2.12.9 discusses the RPV vibration test program and Section 14.2.12.10 discusses simulated emergency operating conditions.

14.2.12 INDIVIDUAL TEST DESCRIPTIONS

14.2.12.1 Reactivity Control Systems Tests

14.2.12.1.1 Control Rod Drive (CRD) Hydraulic System

Prerequisites

1. All piping and wiring was installed and connected.
2. The system was flushed and cleaned according to the applicable specification.
3. Demineralized water was available in a demineralized water reservoir.
4. The CRD hydraulic supply pumps were operational.
5. Instrument air was available.
6. Both ac and dc power were available.
7. Power was available through the reactor safety circuit to energized scram valves.

Test Objectives and Summary

1. The instruments were calibrated.
2. The alarms, controls, and interlocks were checked.
3. The flow control valves were adjusted.
4. The operation of the proper valves from the appropriate selector switches, interlocks, or trip signals was checked, including:

   a. Scram valves and scram solenoid pilot valves.
   b. Scram backup pilot valves.
   c. Scram volume dump and vent valves.
   d. Drive selection valves (withdraw and insert control).

5. After the drives were installed, the individual flow control valves for proper drive speeds were adjusted.

6. Total system performance with all drives installed was monitored and data were recorded, including:

   a. Cooling-water flow.
   b. Total system flow.
   c. Flow returned to the reactor.
   d. System pressures.
   e. Transient response of the system during insert and withdraw operations or following scrams.

14.2.12.1.2 Control Rod Drive Tests

Prerequisites

1. Control rod drive hydraulic system and control system tests were completed.

2. All reactor internals were installed, including guide tubes and thermal sleeves.

3. Blades and dummy fuel assemblies were installed.

Test Objectives and Summary

1. The insertion of each drive - continuous and by notch.

2. The withdrawal of each drive - continuous and by notch.

3. The stroke timing of each drive.

4. Friction measurements.

5. Proper position indication and in/out limit lights were checked.

6. Those tests in the hydraulic system and manual control system that were required to verify total system performance were repeated.

7. Rod control interlocks were rechecked.

8. The safety circuit in conjunction with the control rod system were tested to verify scram signals and rod withdrawal interlocks from all safety circuit sensors.

14.2.12.1.3 Standby Liquid Control System Test

All portions of this test, except for the measurement of the actual pumping rate into the reactor (Item 5 below) were performed, regardless of the status of the reactor vessel (full or empty, head on or off).

Test Objectives and Summary

1. The instruments were calibrated and the setpoints were checked.

2. The standby liquid control solution tank was filled with demineralized water and the injection pumps were operated to recirculate the water to the tank.

3. The setpoint of the pump discharge relief valves was checked.

4. The control circuits for the explosive injection valves were thoroughly checked before connecting them to the valves. A dummy resistance was used to simulate the valve during the circuit checkout.

5. The key-lock switch to each channel was turned to fire the explosive valve and to start the injection pump. Pumping rates into the reactor were measured.

6. The interlock with the reactor water cleanup system was checked to ensure isolation when the standby liquid control system is actuated.

7. The operation of the standby liquid control solution temperature controls and the air sparger was checked.

8. The test tank was filled with demineralized water and the injection pumps were operated recirculating the water to the test tank in a simulated test mode. All leakage from the pump packings was stopped.

9. After the system was demonstrated by the foregoing tests, the valve explosive cartridges were replaced. Just before fuel loading, the required boron chemical was added to the standby liquid control solution tank. This was followed by mixing and sampling. The pump packings were rechecked for leakage.

14.2.12.2 Reactor and Core Standby Cooling Systems Tests

14.2.12.2.1 Reactor Recirculation System

This test determined recirculation loop (recirculation pumps and jet pumps) characteristics to the degree possible under cold water conditions.

Prerequisites

1. 4160-V electric power was available.
2. 440-V electric power was available.
3. The reactor hydrotest and chemical cleaning were completed.
4. There was water in the vessel during the pump tests.

Test Objectives and Summary

1. All recirculation loop valves were operated.
2. The loop instrumentation was calibrated and the controls and interlocks were checked.
3. The recirculation pumps and motor-generator sets were operated at reduced speed.
4. The flow control transient operation within the range permitted by cold water and atmospheric pressure in the reactor was checked. The controller settings were optimized for system linearity and response time requirements.
5. A jet pump consistency test was performed.

14.2.12.2.2 Nuclear Boiler System

Test Objectives and Summary

1. Safety valves were installed as received from the factory, where setpoints were adjusted, verified, and indicated on the valve.
2. The proper operation of remote-controlled relief valve solenoids was verified from the main control room.
3. The automatic blowdown function of the relief valves was checked with a simulated pressure signal.

4. The vessel head leak detection system was checked.

5. The primary steam leak detection system was checked.

14.2.12.2.3 High-Pressure Coolant Injection (HPCI) System

Test Objectives and Summary

1. This test checked out the functional capability of all components needed to operate under simulated accident conditions and under various failure modes. The final operation and full capacity testing of the HPCI system was performed when an adequate steam supply was available during startup testing, using the auxiliary boiler.

2. All components of the system were checked during the test, including the turbine, pump, valves, and associated instrumentation.

3. The suction was aligned alternatively from the condensate storage tank and from the suppression pool to ensure the proper operation of these sources.

4. This preoperational test verified that the system logic satisfied its design objective and also furnished reference characteristics such as differential pressures and flow rates that could be used as base points for checking measurements in subsequent tests of the system.

14.2.12.2.4 Core Spray System

Prerequisites

1 The drywell pressure test was completed.

2. The reactor vessel was available to receive water, with the vessel head and dryer/separator removed for observation.

Test Objectives and Summary

1. The alarms, controls, and interlocks were checked, including complete verification of automatic system starting controls.

2. The pumps were operated by recirculating water to the torus in the test mode. The pump and system performances were verified from manufacturer's head flow curves and measured system pressures.

3. The operation of all motor-operated valves was checked.

4. With the valves closed and locked out of service, the system was automatically initiated and pump start was verified.

5. With the pumps locked out of service, the system was automatically initiated and it was verified that the valves opened. The process was repeated in a test configuration.

6. The pump suction was isolated from the torus and routed so as to receive the pump supply directly from the condensate storage tank. The spray was directed into the reactor vessel. The proper flow rate was verified and the spray pattern was observed.

7. Accident conditions were simulated simultaneously with a power failure and the proper sequential operation of the system pumps and valves was verified. This test was run concurrently with the containment cooling system automatic operation test and the diesel-generator automatic starting test.

8. Component failures were simulated by locking a selected pump out of service and initiating the system. Detection of the simulated failure condition and automatic start of the next pump were verified.

14.2.12.2.5 Residual Heat Removal (RHR) System - Low-Pressure Coolant Injection (LPCI) Mode, Containment Spray Mode, and Shutdown Cooling Mode

The LPCI, containment spray, and shutdown cooling modes of the RHR system were tested. The test was designed to verify all the logics, interlocks, automatic initiations, and automatic isolations of the modes individually. Then, where mode interfaces occur, the interlocks or blocks were tested under as near actual conditions as possible. However, at no time was flow permitted into the drywell.

Prerequisites

1. The drywell pressure test was completed.

2. There was water in the torus.

Test Objectives and Summary - Valve Test

1. LPCI: All valves in the system were cycled from the control room and the local control panels. Proper operation and indications were verified.

2. Containment Spray: During this test, all precautions were taken to ensure that no water was introduced into the drywell. The valves in the system were exercised as above, with the same verifications.

3. Shutdown Cooling (including reactor head spray): All valve action was verified as above. No special precautions were required for this test as long as torus water had not been allowed into the RHR system.

Test Objectives and Summary - Logic and Interlock Test

1. LPCI: This test verified the initiation logic, automatic isolation, valve, and pressure interlocks. Signals were simulated to cause an automatic initiation signal to the LPCI system.

2. Containment Spray: This manually initiated system has only a reactor pressure vessel level interlock associated with it. The suction valves to the pump interlocks had been checked in the preceding test; no reverification was necessary.

3. Shutdown Cooling (including the reactor head spray): This test verified the automatic isolation of the shutdown cooling system at a high drywell pressure or a low reactor-water level. No attempt was made to verify the heat removal capability of the RHR heat exchangers until sometime during the startup test program. The RHR service-water valves to the heat exchangers were checked at this time as part of the system. The system was used operationally before that time, however, to support other tests in which it was necessary to control the reactor water temperature.

Test Objectives and Summary - System Tests

1. LPCI: The LPCI pumps were operated to establish the system operating characteristics. Automatic initiation tests were performed to verify required flow rate versus time characteristics.

2. Containment Spray: No water flow was used to verify the flow through the containment spray drywell sparger. Compressed air was introduced into the sparger from an upstream test connection. (Note: The remainder of the system had to be isolated during this test.) Using flags, the flow through each nozzle was verified (the actual nozzle flow had been determined by bench testing at the nozzle manufacturer's facilities). To verify the flow through the remainder of the system, both isolation valves for each sparger were locked closed and the flow was diverted through a test line. At this time the containment spray torus sparger flow was verified.

3. Shutdown Cooling (including the reactor head spray): The RHR system was set up at t is time to take its suction from the reactor pressure vessel at the recirculation pump inlet. The system was placed into the normal configuration for shutdown cooling operations and was started according to unit operating procedures. Pumps were operated individually to ensure proper pump flow paths. Since all interlocks had been checked in previous tests,

only the system's flow characteristics had to be determined during the flow test. The flow path and operability of the reactor head spray was verified.

4. All sensors of the RHR system had their calibrations, alarms, or trip points verified during this test. Proper annunciations in the control room were also verified.

14.2.12.2.6 Reactor Core Isolation Cooling (RCIC) System

Test Objectives and Summary

1. This test involved the functional capability of all components needed to operate under simulated accident conditions and under various failure modes. Final operation and full-capacity testing of the RCIC system was performed when adequate steam supply was available during startup testing.

2. All components of the system were checked during the test, including the turbine, pump, valves, and associated instrumentation.

3. The suction was aligned alternatively from the condensate storage tank and from the suppression pool to ensure the proper operation of these sources.

4. This preoperational test verified that the system logic satisfied its design objective and also furnished reference characteristics such as differential pressures and flow rates that could be used as base points for checking measurements in subsequent tests of the system.

14.2.12.3 Primary Containment Tests

14.2.12.3.1 Primary Containment Leak Rate Measurement

Prerequisites

1. All piping and electrical penetrations were in place.

2. All isolation valves were fully operable.

3. The containment and core spray systems were complete and operable.

4. A complete survey was made to locate and remove any instrumentation, light blubs, etc., that could be damaged by external pressure.

Test Objectives and Summary

1. Testable penetrations were checked by applying air pressure.

2. All containment isolation valves were stroked and left in the closed position.

3. The containment was pressurized to 14 psig and a local leak survey was conducted.

4. The containment was pressurized to a reduced test pressure and leak rate measurements were conducted.

5. The testing described in this procedure was performed in the following sequence:

   a. Individual penetration leak rate measurements.
   b. Isolation valve operating tests.
   c. Valve seat leakage measurements.
   d. The reduced pressure test.
   e. The peak pressure test.

14.2.12.3.2 Isolation Valves Leak Rate Measurement

Prerequisites

1. All reactor coolant pressure boundary isolation valves and connected piping were installed, and they were hydrotested from the reactor vessel to the outside isolation valve.

2. All piping hangers, guides, and anchors that affect the isolation valves were installed and set properly.

Test Objective

Leakage across the set (inside the process line) of all isolation valves in the nuclear system was measured.

14.2.12.4 Secondary Containment Test

Standby Gas Treatment System and Reactor Building Negative Pressure

Instrumentation and controls were calibrated and interlocks were checked. Blowers were operated to check their flow capacity and their ability to maintain negative pressure in the reactor building. Automatic isolation of the reactor building and initiation of the standby gas treatment system were verified. The absolute and charcoal filter collection efficiencies were measured.

14.2.12.5 Instrumentation and Controls Tests

14.2.12.5.1 Instrumentation for Reactor Protection System

Prerequisites

1. All safety system sensors were installed and calibrated.

2. All wiring was installed and checked for continuity.

Test Objectives and Summary

1. The motor-generator sets were operated to check their capacity and regulation.

2. The buses were energized and the controls and the power source transfer were checked.

3. The operation and the pick-up and drop-out voltages of the protection system relays were checked.

4. Each safety sensor was checked for operation of the proper relay.

5. Using test signals, the scram setpoints were verified. Proper operation of level switches was checked by varying the water level against a suitable reference point such as the vessel flange.

6. All positions of the reactor mode switch were checked for proper interlocks and bypass functions.

7. The automatic closing of all isolation valves on the proper signal was checked.

8. The automatic initiation of relays and contacts for the core spray, HPCI, LPCI, automatic depressurization, and other plant protection systems on the proper signal was checked.

14.2.12.5.2 Neutron and Gamma Radiation Instrument Systems

This test included the following systems:

1. The source range monitoring (SRM) subsystem.
2. The intermediate range monitoring (IRM) subsystem.
3. The local power range monitoring (LPRM) subsystem.
4. The average power range monitoring (APRM) subsystem.
5. The traversing incore probe (TIP) subsystem.
6. The area radiation monitoring system.
7. The process liquid and gas monitors.

Test Objectives and Summary

The following types of preliminary testing were required (where applicable) before fuel loading:

1. The continuity and resistance to ground of all signal and power cables were checked.

2. The response and calibration of all channels with simulated input signals were checked.

3. The alarm and trip setpoints were checked.

4. The chamber response to bugging sources was checked.

5. All interlocks with the reactor manual control system were checked.

6. The operation and position indication of all SRM-IRM chamber drives were checked.

7. Using a dummy TIP chamber, the calibration probe was inserted into all incore calibration tubes. The capability to insert more than one calibration probe into the cross-calibration guide tube was verified.

8. All incore SRM and IRM chambers were installed and final system operability was verified.

14.2.12.5.3 Process Computer System (Rod Worth Minimizer Function)

After the control rod drive system was operational, the control rods were withdrawn in various sequences to expose the rod worth minimizer function of the process computer to simulated operational conditions and withdrawal patterns.

Test Objectives and Summary

1. All programmed normal rod withdrawal sequences were checked for satisfactory performance.

2. Different short-term sequences within the sequenced rod groups were checked for satisfactory performance.

3. An improper rod withdrawal was attempted at various points in the withdrawal sequence, and it was verified that the action was blocked.

4. The capability to insert drive mechanisms out of sequence to the extent permitted by the rod worth minimizer function was determined.

5. All alarms were checked under simulated or actual error conditions.

6. All controls were checked.

7. All displays and information printouts were checked.

14.2.12.6 Electrical System Tests

14.2.12.6.1 Standby AC Power System

After the instrumentation and controls were installed and calibrated and the wiring was checked, the capability of each diesel-generator to pick up core spray pumps, RHR cooling-water pumps, and associated emergency loads in sequence was demonstrated. Each diesel-generator was tested for load-carrying capability. All interlocks, automatic initiation schemes, and follow-up schemes on the auxiliary and shutdown transformers were tested as part of these tests.

14.2.12.6.2 DC Power System

Relays, instruments, breakers, interlocks, and other electrical components were checked and/or calibrated. Battery charging and discharging rates were verified.

14.2.12.6.3 AC Auxiliary Power System

All protective devices, interlocks, followup schemes, and other electrical components were checked and/or calibrated. Insulation quality and/or circuit continuity and functional operation were verified.

14.2.12.7 Gaseous Radwaste (Offgas) System Test

Prerequisites

Construction was completed and air and electric power was available for all control devices. The system was tested and operational before fuel loading.

Test Objectives and Summary

1. The automatic operation of isolation valves was checked.

2. The trip points of all instrumentation and alarms were calibrated and set.

14.2.12.8 Auxiliary Systems Tests

14.2.12.8.1 RHR Service Water System and Emergency Service Water System

Prerequisites

1. The systems were complete, cleaned, and leak tested.

2. RHR heat exchangers were complete and operable.

3. The RHR test piping was complete.

4. Raw cooling water was available.

Test Objectives and Summary

1. Proper operation of instruments and controls were checked.

2. The system was filled and the RHR service water pumps were operated.

3. The flows through the RHR heat exchanger and through the equipment supplied with emergency service water were verified.

4. The operation of the standby coolant flooding valve and the flow through the valve into the RHR system and through its test line were checked.

5. The proper operation of the emergency service water header isolation valves was verified.

6. The backup supplier of raw cooling water was checked.

7. The RHR effluent radiation monitors were calibrated and checked.

8. The proper operation of the equipment served by the RHR service-water and emergency service water systems as they were placed in service was checked.

14.2.12.8.2 Control Building Heating and Ventilation

Prerequisites

1. The buildings were complete or closed with temporary walls.

2. The ducts, fans, and plenums were clean and the filters were installed.

Test Summary

1. All fans were started and checked for proper operation.

2. All dampers and grilles were adjusted to specified air flows.

3. The proper operation of all controls and instrumentation was verified.

4. DOP tests were performed on the HEPA filters.

5. Differential pressure across all clean filter banks was obtained.

6. Proper operation of the system during an isolation condition was verified.

7. Proper operation of water chillers and associated air-conditioning units was verified.

14.2.12.8.3 Fuel-Handling Equipment

Equipment in this category was tested with a load equivalent to dummy fuel or blade guide assemblies through dry run simulations of the required operations. This was not one coordinated test of a system; there were many separate operations using different pieces of equipment. The equipment was tested on the operating floor, in the fuel storage pool, and both above and inside the reactor vessel.

Test Objectives and Summary (not necessarily in chronological order)

1. Tests in the storage pool.

   a. Fuel pool gates were installed and the pool was filled with water. The pool was inspected for leakage.

b. The fuel preparation machine was checked with a simulated dummy fuel assembly. This also checked auxiliary tools such as the channel-handling tool and the channel bolt wrench.

c. The fixed overhead lights and movable underwater lights were checked to ensure adequate visibility for fuel and blade handling and transfer operations.

d. The underwater vacuum cleaner was checked.

e. The refueling platform was operated above the storage pool. All equipment on the refueling platform was checked. The fuel assemblies and control blades were transferred between the storage racks with the grapple. All grapple controls and interlocks were checked.

f. The jib crane was used to transport simulated dummy fuel assemblies from the storage racks to the fuel preparation machine work areas.

2. Tests over the reactor vessel.

a. The service platform assembly was set on the vessel flange. The jib crane was mounted on the service platform and used for installing, removing, or shuffling dummy fuel assemblies.

b. The water level in the reactor well and the dryer-separator pool was raised and the leaktightness of the refueling bellows assembly and the drywell to the reactor well seal was checked. The water level was lowered and the ability of the fuel pool cooling system to drain these seals or associated low points was checked. The well and pool liner leakage rates were checked.

c. The following procedural methods and tools were verified:

(1) The removal and replacement of the steam dryer assembly.

(2) The removal and replacement of the shroud head steam separator assembly.

(3) The removal and replacement of the control rod blades, fuel support pieces, and control rod guide tubes.

All of the above tests recognized the shielding requirements of doing the job "hot" and attempted to simulate "normal operating" conditions.

d. Simulated dummy fuel assemblies and control blades were transferred between the storage pool and the reactor vessel, simulating a refueling operation.

e. The installation and removal of shield plugs in the designated peripheral positions were checked.

14.2.12.8.4 Process Radiation Monitoring System

Relays, sampling pumps, recorders, trips, interlocks, valve operations, and logics associated with the main steam, offgas, main stack, and reactor building ventilation systems were checked and/or calibrated.

14.2.12.9 Reactor Pressure Vessel Vibration Test Program

The GE vibration program included provisions for both prototype and confirmatory instrumented vibration tests as suggested in Safety Guide 20 (see Section 1.8). Since the DAEC has a prototype reactor size, a BWR prototype vibration testing program was conducted. (For the description of a typical BWR prototype vibration testing program, see Amendment 7 to the [redacted]) The extent of the measurements was determined, for each individual case, on the basis of the design and configuration of those structural elements of the reactor internals important to safety and reliability. The results of such tests are available.

The DAEC prototype vibration test program conformed in general to the provisions for testing suggested in Paragraph C (Specialized for Prototype Reactor) of Safety Guide 20. The details of the DAEC test program, corresponding to those items identified in Paragraphs C.1.a through C.1.g of Safety Guide 20, are discussed below.

14.2.12.9.1 Vibration Measurements

The vibration test program conducted at the DAEC included measurements of vibratory motions of the shroud, separator assembly, guide tubes, and the jet pump assembly (including the jet pump riser brace). Shroud motions were measured by means of displacement sensors situated on the shroud-to-shroud head flange at positions 180 degrees apart, and by means of strain gauges mounted on the shroud support legs near the juncture to the shroud at positions of 6, 108, and 168 degrees of azimuth. Separator assembly motions were measured by means of accelerometers mounted on the upper bolt-guide ring of the separator assembly at three positions 120 degrees apart. The major forcing parameter for motions of the shroud-separator assembly is considered to be mass flow through the steam separators. The guide tube motions were measured by means of strain gauges mounted in pairs (in a horizontal plane at ±45 degrees off radial) near the juncture of the guide tube to the vessel bottom head. The major forcing parameter for

motions of the guide tubes was considered to be the jet pump diffuser exit velocity that manifests itself as cross-flow in the lower plenum region.

Motions of the jet pump assembly, including the jet pump riser braces, were measured by means of displacement sensors mounted on top of the jet pump assembly (on the "ram's head") and on the diffusers of adjacent jet pumps at a position near the slip joint, and by means of strain gauges mounted on each face of a leg of the jet pump riser brace. The major forcing parameters for motions of the jet pump assembly were considered to be the jet pump nozzle velocity and the direction of mass flow caused by unbalanced recirculation pump speed. Only a simple description was needed to adequately define sensor locations.

14.2.12.9.2 Vibration Acceptance Criteria

The BWR vibration acceptance criteria included allowable sensor motions for continuous cyclic operation of the reactor for approximately 10 billion cycles. The durations of the vibration tests were sufficiently long to ensure that these acceptance criteria were not violated for normal steady-state or transient modes of plant operation. The acceptance criteria were based on the need to achieve 10 billion cycles of successful operation during the plant lifetime (material endurance limit).

14.2.12.9.3 Abnormal Operating Conditions

The abnormal operating conditions that were considered during the vibration test program were the transient recirculation pump trip conditions. While operating at power and at 100% core flow, the recirculation pumps were tripped, both individually and simultaneously (three separate trip conditions), and they were permitted to coast down to minimum speed. Power levels of 50%, 75%, and 100% power were tested in this manner (see Section 14.2.12.10.4). During each of these pump trip transients, the vibration motions were monitored and recorded to ensure that the vibration was well within acceptable levels.

14.2.12.9.4 Flow Modes and Transients

The following description is representative of the different flow modes of operation and transients to which the internals were subjected during vibration testing:

<u>50% Thermal Power Line (approximately 20% to 50% thermal power)</u>

1. Approximately equally spaced flow points from minimum flow to 100% flow.
2. With 100% core flow trip of Pump A.
3. With 100% core flow trip of Pump B.
4. With 100% core flow trip of both pumps simultaneously.

75% Thermal Power Line

1. Approximately equally spaced flow points from minimum flow to 100% flow.
2. With 100% core flow trip of Pump A.
3. With 100% core flow trip of Pump B.
4. With 100% core flow trip of both pumps simultaneously.

100% Thermal Power Line

1. Approximately equally spaced flow points from minimum flow to 100% flow.
2. With 100% core flow trip of Pump A.
3. With 100% core flow trip of Pump B.
4. With 100% core flow trip of both pumps simultaneously.

14.2.12.9.5 Availability of Vibration Test Data

The mode shapes and allowable sensor motions for the DAEC vibration test are available. Generally, these calculations are not performed earlier than 6 months before the vibration test is to be conducted.

14.2.12.9.6 Test Acceptance Criteria

The test acceptance criteria, permissible deviations from these criteria, and the bases upon which these criteria were established are discussed in Amendment 19 to the [redacted]

14.2.12.9.7 Inspection of DAEC Reactor Internals

An inspection of the DAEC reactor internals was conducted using Table IS-25 (Paragraph N) of the 1970 ASME B&PV Code, Section XI, as a guide. This approach to inspection was justified, since the BWR has no single major load-carrying component that is relied upon during normal operation to support a significant portion of the core.

The 89 individual control rod guide tubes independently support the 368 fuel assemblies in the DAEC BWR, with no more than four fuel assemblies supported by any single guide tube.

14.2.12.10 Simulated Emergency Operating Conditions

Iowa Electric simulated anticipated emergency operating conditions during the preoperational, cold functional, and hot functional testing programs. Signals were simulated by the use of electric and pneumatic signal generators for actuating sensors unless otherwise noted. The anticipated emergency conditions that were simulated are described below.

Standby Diesel Generators

Demonstrated the ability of each diesel-generator set to automatically come up to rated voltage and frequency within 10 sec of the start signal initiation and to accept loads to rated conditions.

Demonstrated the ability of each diesel generator to go through the prescribed automatic loading sequence with a simulated LOCA signal or a loss of offsite power (opening breaker).

Standby Heating and Ventilating System for the Control Building

Showed that either ventilation train automatically started on simulated high intake air radiation.

LPCI Mode of the RHR System

Verified that the RHR system initiated and properly responded to a simulated low reactor-water level signal and a high drywell pressure signal.

Demonstrated that the system could supply the required water to the reactor.

RCIC System

Verified that a simulated low reactor-water level signal sent an initiation signal to the RCIC system.

Demonstrated that the system could supply the required water to the reactor at various reactor pressures up to rated pressure.

HPCI System

Verified that a simulated low reactor-water level signal and a high drywell pressure signal sent an initiation signal to the HPCI system.

Demonstrated that the system could supply the required water to the reactor at various reactor pressures up to rated pressure.

Core Spray System

Verified that the system initiated and responded properly to a simulated low reactor-water level and high drywell pressure signal.

Demonstrated that the system could supply the required water to the reactor.

Standby Liquid Control System

Fired explosive valves and injected demineralized water into the reactor (at atmospheric pressure), and observed that rated pump head and flow were achieved.

Emergency Service Water System

Demonstrated that the emergency service water pumps automatically started and that the cooling water valves to the diesel automatically opened on a simulated diesel initiation signal.

Control Rod Drive Hydraulic System

Demonstrated the ability of the accumulators to scram the control rod drives within acceptable time limits with the reactor "cold" and at rated conditions.

Reactor Protection System

Demonstrated that scram sensors tripped at their prescribed settings and that a scram signal was received. Used the actual initiating parameter wherever practical.

Primary Containment

Performed an integrated leak rate test of the primary containment (including isolation valves) to demonstrate that the containment leak rate did not exceed the prescribed limit. Compressed air at the peak calculated LOCA pressure was used.

Nuclear Boiler System

Verified that the main steam line isolation valves tripped closed on a simulated high steam-line radiation and temperature, low reactor-water level, high reactor-water level, high steam-line flow, and low steam pressure. Verified that the closing time was within the Technical Specification closing time limits under low reactor pressure and rated pressure conditions.

Demonstrated that the ADS logic was functional. Using a manual initiation signal, each relief valve was lifted at low reactor pressure and rated pressure.

Verified that each of the water-level sensors tripped at their prescribed levels. A simulated signal was used at first; however, actual water-level manipulation was used to trip the sensors when practical.

Standby Gas Treatment System

Demonstrated that this system automatically started on high refueling-floor radiation, high reactor-exhaust-shaft radiation, and the LOCA signals; and that the reactor building isolation dampers shut. Simulated signals were used.

Showed that the reactor building (secondary containment) in-leakage did not exceed prescribed limits by performing a building leak rate test.

14.2.13 STRETCH POWER UPRATE TEST PROGRAM DESCRIPTION

14.2.13.1 Introduction

The stretch power uprate test program was conducted at the DAEC following the cycle 7-8 refueling. The test program included those tests which were performed while bringing reactor power from zero to 1593 MWt and those additional tests which were performed while increasing power level from 1593 to 1658 MWt. Using the data from the tests conducted at 1593 MWt, pretest predictions for those parameters which are directly power-level dependent were made for the expected results at 1658 MWt. These pretest predictions were compared with the actual results and the program was satisfactorily completed with the results comparing favorably to the values that were expected.

Table 14.2-5 is a listing of the startup tests performed at the beginning of cycle 8. Those tests in the list that were part of the stretch power uprate test program are so identified in Table 14.2-5 and are described in Sections 14.2.13.2 and 14.2.13.3. The results of the startup test program were reported to the NRC by Reference 2. Test data are available at the DAEC.

The tests, inspections, and verifications described in Sections 14.2.13.2 and 14.2.13.3 are standard surveillance tests performed after each refueling outage. Some of the procedures to be performed after core alterations are completed before criticality. Others are performed during startup at various power levels. A number of the tests are performed just prior to exceeding 1593 MWt and repeated at 1658 MWt.

The tests are generally presented in the order in which they are performed beginning with completion of core alterations.

When “prior to exceeding 1593 MWt” is referred to, the test is conducted between 1500 and 1593 MWt.

14.2.13.2 Zero to 1593 MWt Testing

Rod Sequence Control System and Rod Worth Minimizer Checks - 43B003*

The purpose of this test is to demonstrate operability of the rod sequence control system and rod worth minimizer system. This test is performed prior to rod withdrawal for the initial criticality of the cycle 8 core.

Source Range Monitor Trip Functional Test and Calibration - 42C005*

The purpose of this test is to demonstrate the operability of the source range monitor upscale rod block functions. This test is performed within 1 week prior to startup.

Intermediate Range Monitor Trip Functional Test and Calibration - 41A004*

The purpose of this test is to demonstrate the operability of the inoperative, downscale, upscale alarm, and upscale trip functions on the intermediate range monitoring system and the rod block logic system. This test is performed weekly while the mode switch is in startup or refuel mode and within 1 week before startup.

Average Power Range Monitor High Flux (15% Scram) Instrument Functional Test and Calibration - 41A017*

The purpose of this test is to demonstrate operability of the average power range monitoring system high flux, inoperative, and rod block functions when the mode switch is not in the run mode. This test is performed weekly during refueling or startup and before each startup.

Source Range Monitor/Intermediate Range Monitor Detector Not In Startup Position Functional Test - 42C004*

The purpose of this test is to demonstrate operability of the source and intermediate range detector not fully inserted rod block functions of the neutron monitoring system. This test is performed within 1 week of startup.

* These numbers refer to the Surveillance Test Procedure Number.

Reactor High Pressure Recirculation Pump Trip Instrument Functional Test and Calibration - 42G001*

The purpose of this test is to demonstrate operability of the reactor high pressure recirculation pump trip instrument channels of the reactor recirculation system. This test is performed once per operating cycle.

Shutdown Margin Test - 43A001*

The purpose of this test is to demonstrate that the reactor can be made subcritical at any time during the fuel cycle, with a margin of 0.38% $\Delta k/k$, with the highest worth operable control rod fully withdrawn. The test is performed during the first pull to critical following core alterations. The analytically determined highest worth rod is pulled out fully. The shutdown margin is verified. The reactor is then pulled to critical.

Heatup and Cooldown Rate - 46A003*

The purpose of this test is to permanently record vessel shell, bottom drain, recirculation loop, and bottom head temperatures during heatup and cooldown.

Scram Insertion Time Test - 43C001*

The purpose of this test is to demonstrate operability of the scram insertion function of the reactor protection system for all control rods. This test is performed prior to exceeding 40% power and at greater than or equal to 800 psig.

Main Steam Isolation Valve Trip and Closure Time Check - 47D004*

The purpose of this test is to demonstrate that closure time of the main steam isolation valves is between 3 and 5 sec for those valves that were manipulated during the refuel outage. This test is performed at reduced power (~75%) to accommodate the reduction in steam flow caused by valve closure.

14.2.13.3 1593 to 1658 MWt Testing

Average Power Range Monitor Gain Adjustment - 42F007*

The purpose of this calibration is to correlate the gain of the average power range monitor channels with the actual thermal power of the reactor core. This calibration is performed prior to reaching 20% power and daily thereafter. Just prior to exceeding 1593 MWt, the average power range monitor gain adjustment will be performed and will be

* These numbers refer to the Surveillance Test Procedure Number.

continued on a daily basis thereafter. Also, this adjustment will be made just prior to reaching 1658 MWt.

Local Power Range Monitor Instrument Calibration - 41A015*

The purpose of this test is to calibrate the local power range monitors by reference to the traversing incore probe system. This test is performed every 1000 effective full power hours (894 MWd/surveillance test). At approximately 40% power and prior to exceeding 1593 MWt, a local power range monitor instrument calibration is performed.

Axial Power Distribution (Predictor)

The purpose of this test is to compare the axial power distribution predicted by the General Electric 3D BWR core simulator code and the onsite predictor code to the actual Pl axial power distribution on the plant process computer. This test was performed at 1593 MWt and repeated at 1658 MWt. This test is not required by the Technical Specifications but is performed to verify the analytical tools available at the DAEC.

Reactivity Anomalies Check - 43D001*

The purpose of this test is to compare the critical rod configuration at specific power operating conditions with the configuration expected based upon appropriately corrected past data. This test is performed every full power month. This test was performed prior to exceeding 1593 MWt and after reaching 1658 MWt.

Reactor Coolant Chloride Ion and Conductivity Analysis - 46B003*

The purpose of this test is to sample the reactor coolant for

1. A chloride ion check at least every 4 hr during startup and at steaming rates below 100,000 lb/hr if the conductivity is above 0.5 μmho/cm or if it increases at a rate of 0.2 μmho/cm/hr or more.

2. A chloride ion check at least daily during startup and steaming below 100,000 lb/hr under normal conductivity levels.

3. A conductivity and chloride ion check at least every 4 days when fuel is in the reactor vessel.

This test is performed prior to exceeding 1593 MWt and at 1658 MWt. The test is performed according to the routine surveillance requirements in between these two power levels.

Reactor Coolant Gamma and Iodine Activity - 46B001*

* These numbers refer to the Surveillance Test Procedure Number.

The purpose of this test is to sample the reactor coolant system for gross gamma activity including

1. Taking a reactor sample at least every 96 hr and determining gross gamma activity of the filtrate. Iodine-131 and iodine-133 concentrations are determined weekly.

2. Taking a sample prior to startup and at 4-hr intervals during the startup when equilibrium iodine is equal to or greater than 0.012 μCi/g of dose equivalent iodine-131.

3. Taking a sample and analyzing for iodine-131 equivalent dose when the equilibrium iodine value is equal to or greater than 0.012 μCi/g of dose equivalent iodine-131 and the gaseous waste monitor prior to holdup indicates an increase of greater than 50% in the steady-state fission gas release.

4. Taking a sample and analyzing at 4-hr intervals for gross iodine when equilibrium iodine is equal to or greater than 0.012 μCi/g of dose equivalent iodine-131 and following a power change of greater than or equal to 15%.

5. Providing a means to determine if additional sampling is required.

Appropriate startup sections of this test are performed prior to exceeding 1593 MWt and after reaching 1658 MWt. At power levels in between, appropriate surveillances for startup are performed.

14.2.14 EXTENDED POWER UPRATE TEST PROGRAM DESCRIPTION

14.2.14.1 Extended Power Uprate – Phase I

In accordance with Section 1.8.16, a start-up testing program was conducted as part of the implementation of License Amendment 243 – Extended Power Uprate (EPU). Where Amendment 243 authorizes operation up to 1912 MWt, actual implementation of EPU is being conducted in phases that support the modification schedule. EPU Phase I had a target power level of 1790 MWt, an 8% increase in thermal power over the previous licensed limit of 1658 MWt.

All startup tests in the original testing program, described in Section 14.2.1.3 were evaluated for applicability to EPU. Table 14.2-6 is the summary of that review. In addition, four new tests were included:

• Steady – State Data Collection were	Key NSSS and BOP parameters recorded to ensure proper plant equipment performance.
• Power Conversion System Piping Vibration Monitoring	Main Steam and Feedwater piping was instrumented and monitored for unacceptable flow-induced vibrations.
• Turbine Combined – Intermediate Valve (CIV) and Turbine Control Valve (TCV) Surveillance Testing	Testing similar to Test No. 33 for the Turbine Stop Valves was conducted on the CIVs and TCVs. The purpose of the testing was to establish the proper level for conducting on-line surveillance testing of CIVs and TCVs.
• General Service Water (GSW) Heat Exchanger Performance Monitoring	GSW piping size was increased for EPU to provide additional cooling to key components. This monitoring program will confirm adequate cooling, as designed.

Special Test Provedures (SpTPs) were written to coordinate and control the EPU startup testing program. Where possible, the testing program took credit for existing Surveillance Test Procedure (STPs). Testing at a specified test condition (reactor power and core flow) was thoroughly, reviewed by an Expert Panel, a multi-disciplinary group, chaired by the Operations Manager, who made the recommendation that it was acceptable to proceed to the next test condition. Plant Manager approval was required to exceed the previous licensed power level of 1658 MWt.

As discussed in Reference 3, during performance of the test program, some Acceptance Criteria needed to be modified, as the original FSAR startup testing requirements were no longer applicable to the current plant configuration. A problem in the Feedwater Level Control System was discovered that required maintenance and reperformance of those tests at 1658 MWt. Also, based upon review of test data at lower power levels, the test matrix at high power was simplified and some tests were not performed, as they would not have provided useful data.

The completed testing at the Phase 1 target power level of 1790 MWt demonstrated stable plant operation. Changes in plant chemistry and radiological conditions were minor, vibration monitoring of main steam and feedwater piping was normal, and no plant equipment anomalies were noted.

14.2.14.2 Extended Power Uprate – Phase II

As noted above, EPU is being implemented in planned phases, as each set of plant modifications are installed. During Refuel Outage 19 (RFO19) conducted in Spring 2005, the second planned phase (Phase II) of EPU modifications were installed. These modifications were planned to permit the reactor thermal power level to be increased from Phase I steady state operation at 1790 MWt up to the Phase II target power level of 1840 MWt.

The Phase II testing program was conducted in the same manner as Phase I, in that SpTPs were used to control the in-plant testing and an Expert Panel reviewed the test results and made recommendations to the Plant Manager, who approved all power increases. Table 14.2-6 lists the Phase II test plan, which also included the Steady-State Data Collection, Power Conversion System Piping Vibration Monitoring and GSW Heat Exchanger Performance Monitoring tests added in Phase I. As discussed in more detail in Reference 4, not all the Phase I tests were required to be performed as part of Phase II (e.g., the CIV/TCV test was completed in Phase I and not required to be conducted in Phase II). In addition, per License Amendment No. 257 (Reference 5), Test No.25, Main Steam Isolation Valve (MSIV) Test, was not required to be performed as part of EPU testing.

Based upon industry operating experience, inspections of the Steam Dryer were conducted during RFO19, per General Electric Service Information Letter (SIL), 644, Rev. 1. Although minor cracking in the drain channels and in the cover plate upper supporting ring were observed, an engineering evaluation determined that these indications did not impair the structural integrity of the Steam Dryer. As part of startup testing for EPU Phase II, moisture carryover measurements were made, per the SIL recommendations, to establish a baseline for future comparison, should any increase in moisture carryover be observed.

The completed testing at the Phase II target power level of 1840 MWt demonstrated stable plant operation. Changes in plant chemistry and radiological conditions were minor, vibration monitoring of main steam and feedwater piping was acceptable, with one exception, and no other plant equipment anomalies were noted. A one-inch drainline off the FW pump discharge line from the regulating valve to FW heater 6B was observed to have a high amplitude vibration at 1790 MWt, right after plant startup from RFO19. A missing/broken U-bolt was replaced and the high vibration was eliminated. However, at Test Condition 3 (1840 MWt), the U-bolt was found broken again and the high amplitude vibration had returned. An evaluation determined that this condition was not acceptable for long-term operation at 1840 MWt and a permanent repair will be designed and installed at the first opportunity.

Steady state operation at 1840 MWt was approved by Plant Management.

14.2.14.3 Extended Power Uprate – Phase III

As noted above, EPU is being implemented in planned phases. Following Refuel Outage 19 (RFO19) when the second planned phase (Phase II) of EPU was implemented, a review of existing equipment performance was performed that indicated additional power generation was feasible without major modifications. This evaluation indicated power could be increased from the Phase II steady state operation at 1840 MWt up to the Phase III target power level of 1880 MWt.

The Phase III testing program was conducted in the same manner as Phases I and II, in that SpTPs were used to control the in-plant testing and an Expert Panel reviewed the test results and made recommendations to the Plant Manager, who approved all power increases. Table 14.2 – 6 lists the Phase III test plan, which also included the Steady-State Data Collection and Power Conversion System Piping Vibration Monitoring added in Phase I. As discussed in more detail in Reference 6, not all the Phase II tests were required to be repeated as part of Phase III (e.g., the GSW Heat Exchanger Performance Monitoring test was not conducted in Phase III).

As noted during Phase II, a one-inch drainline off the FW pump discharge line from the regulating valve to FW heater 6B was observed to have high amplitude vibrations and a permanent repair was to be designed and installed. Because this modification was not yet in place, a more-detailed vibration evaluation was conducted for Phase III, which determined that the previous analysis was conservative and that margin to the fatigue limit was available. However, particular emphasis was placed upon monitoring this drain line by the Expert Panel as a condition for further power ascension in Phase III. Initial in-situ vibration measurements of this drain line at Test Condition 2 (1860 MWt) were above the acceptance criteria and power was reduced back to 1840 MWt (CAP 43859). Further evaluation was conducted and it was decided to add more support to this drainline to reduce the vibration. This modification (Engineering Change Package (ECP) - 1795) was installed and revised and acceptance criteria were generated for this line. The post-modification measured vibration was well below the new acceptance limit. The measured vibration at Test Conditions 2 and 3 remained well below the new acceptance limit for this drainline.

Another focus area for this Phase of EPU testing was the main turbine control valves (TCVs), which operate in "partial arc" mode to control reactor dome pressure, approaching their final operating range. During this interim approach, TCVs 1, 2 or 3 can "float" on and off their mechanical open stops, which increases wear in the system and accelerates required maintenance, which is not desirable for long-term operation. At Test Condition 2 (1860 MWt), the TCVs displayed this behavior and the EHC System began to make a high pitched noise at this condition (CAP # 44070). The Expert Panel recommended power be reduced back to 1840 MWt and the turbine vendor (General Electric (GE)) was consulted prior to resuming power ascension. Initial review by GE technical personnel indicated that this condition was most likely attributable to flow noise in the EHC servo valves for TCVs 1, 2 and 3. GE personnel were on-site for

resumption of power ascension to both Test Conditions 2 and 3 (1860 MWt and 1880 MWt) and observed, firsthand, the phenomena. At Test Condition 3 (1880 MWt), the TCVs had achieved their desired final operating range and the high-pitched noise had greatly diminished in volume. GE's conclusion was that operation at both 1860 and 1880 MWt were acceptable.

The completed testing at the Phase III target power level of 1880 MWt demonstrated stable plant operation. Changes in plant chemistry and radiological conditions were minor, vibration monitoring of main steam and feedwater piping was acceptable, and no other plant equipment anomalies were noted.

Steady state operation at 1880 MWt was approved by Plant Management.

14.2.14.4 Extended Power Uprate – Phase IV

As noted above, EPU is being implemented in planned phases. Following Refuel Outage 21 (RFO21) the last of the major modifications needed to fully implement EPU were installed, allowing thermal power to be increased up to the licensed power level of 1912 MWt.

The Phase IV testing program was conducted in the same manner as Phases I - III, in that SpTPs were used to control the in-plant testing and an Expert Panel reviewed the test results and made recommendations to the Plant Manager, who approved all power increases. Table 14.2 – 6 lists the Phase IV test plan, which also included the Steady-State Data Collection and Power Conversion System Piping Vibration Monitoring added in Phase I. As discussed in more detail in Reference 7, not all the tests were required to be performed as part of Phase IV, specifically the Generator Load Reject Test.

See Section 8.2.2 for discussion of the revision to the grid stability analysis that was performed to support Phase IV generation targets for MWe.

As with previous Phases of EPU, inspections of the Steam Dryer were conducted during RFO21, per SIL 644, Rev. 1; in particular, re-inspection of the minor cracking in the drain channels and in the cover plate upper supporting ring previously observed. None of the previous indications were found to have propagated further. A new indication was noted in a tie bar to baffle plate weld.[1] An engineering evaluation determined that all these indications did not impair the structural integrity of the Steam Dryer. As part of startup testing for EPU Phase IV, moisture carryover measurements were made, per the SIL recommendations, to establish a baseline for future comparison, should any increase in moisture carryover be observed.

[1] During RFO22, a plant modification removed three central tie bars from the steam dryer (including the one with the indication) and installed replacement tie bars at approximately the same locations. The tie bar replacement repairs on the steam dryer were performed in accordance with the guidelines of Category A repairs of BWRVIP-181-A.

One plant modification was of special note. Changes were made to the Reactor Recirculation System (RRS) to allow operation above 100% rated core flow (Increase Core Flow (ICF)). Engineering evaluations had been performed to justify operation up to 105% of rated core flow (51.45 Mlb/hr). Prior to beginning EPU testing, post-modification testing at > 100% rated core flow was conducted to evaluate the plant response, in particular, various RRS equipment parameters and reactor process variables, such as pump speed, motor voltage/current, vibration, bearing temperatures, etc. (Note: reactor thermal power was not allowed to exceed the Phase III reactor power level (1880 MWt). ICF testing was completed and the limiting parameter was found to be recirculation pump speed (design value = 1710 rpm). No equipment anomalies were noted and plant procedures were revised to allow ICF.

EPU Phase IV testing then commenced, beginning with baseline data collection and testing at the previous power level of 1880 MWt. No problems were noted and power was raised to the next test condition of 1900 MWt. Unlike previous Phases of EPU, no abnormal piping vibrations were encountered at this power level and authorization was given to raise power and begin testing at 1912 MWt.

The completed EPU testing at the Phase IV target power level of 1912 MWt demonstrated stable plant operation. Changes in plant chemistry and radiological conditions were minor, vibration monitoring of main steam and feedwater piping was acceptable, and no other plant equipment anomalies were noted (Reference 8).

Steady state operation at 1912 MWt was approved by Plant Management.

REFERENCES FOR SECTION 14.2

1. General Electric Company, Summary of Results Obtained from a Typical Startup and Power Test Program for a GE-BWR, APED-5698, February 1969.

2. Letter from D. L. Mineck, Iowa Electric, to J. G. Keppler, NRC, Subject: DAEC Restart Testing at Beginning of Cycle 8, dated October 18, 1985 (DAEC-85-846).

3. Letter, K. Putnam (NMC) to USNRC, "Startup Test Report for Extended Power Uprate – Phase I," NG-02-0187, March 4, 2002.

4. Letter, G. Van Middlesworth (NMC) to USNRC, "Startup Test Report for Extended Power Uprate – Phase II," NG-05-0516, September 23, 2005.

5. D. Spaulding (USNRC) to M. Peifer (NMC), "Duane Arnold Energy Center – Issuance of Amendment Re: License Amendment Request TSCR-056, Modify License Condition 2.C.(2)(b) to Eliminate Main Steam Isolation Valve Closure Test for Extended Power Uprate (TAC No. MC2320)," March 17, 2005.

6. Letter, G. Van Middlesworth (FPL Energy) to USNRC, "Startup Test Report for Extended Power Uprate – Phase III," NG-06-0822, December 5, 2006.

7. K. Feintuch (USNRC) to G. Van Middlesworth (FPL Energy), "Duane Arnold Energy Center - Issuance of Amendment Regarding License Amendment Request TSCR-056 to Modify License Condition 2.C.(2)(B) to Eliminate the Requirement to Perform Generator Load Rejection Large Transient Testing (TAC NO. MD2835)," dated September 20, 2007.

8. Letter, R. Anderson (NextEra Energy) to USNRC, "Startup Test Report for Extended Power Uprate – Phase IV," NG-09-0442, June 10, 2009.

Table 14.2-1 Sheet 1 of 2

FUEL LOADING AND LOW POWER TESTS AT ATMOSPHERIC PRESSURE

1. Chemical and Radiochemical Tests

   Chemical and radiochemical tests were conducted to establish water conditions before initial operation and to maintain these throughout the test program. Chemical and radiochemical checks were made at sample primary coolant, offgas exhaust, waste, and auxiliary system locations. Base or background radioactivity levels were determined at this time for use in fuel assembly failure detection and long-range activity buildup studies.

2. Control Rod Drive System Tests

   CRD System tests were performed on all drives before fuel loading to ensure proper operability and to correctly adjust operating speeds. Functional testing of each drive was performed just before and just following the fuel loading in each cell. Drive friction and scram times were determined for all drives at zero reactor pressure with fuel loaded.

3. Fuel Loading

   Fuel loading was performed according to detailed, step-by-step written instructions.

4. Shutdown Margin

   It was demonstrated periodically during fuel loading that the reactor was subcritical by more than a specified amount with the single highest worth control rod withdrawn. The magnitude of the margin was chosen with consideration for expected reactivity changes during the first operating cycle, and for the accuracy of measurement. The test had three parts, (1) the analytical determination of the control rod having the greatest reactivity worth, (2) the analytical calibration of an adjacent control rod, and (3) the demonstration of subcriticality with the highest worth rod fully withdrawn and with the adjacent rod at the position needed to insert the required margin. This demonstration was made for the fully loaded core, and for selected smaller core loadings.

5. Initial Criticality

   Initial criticality was achieved by withdrawal of the control rods in a prescribed sequence. The rod sequence was preselected to stated criteria of safety, simplicity and operating convenience.

Table 14.2-1 Sheet 2 of 2

FUEL LOADING AND LOW POWER TESTS AT ATMOSPHERIC PRESSURE

6. Source Range Monitor (SRM) Performance

   Adequate performance of the source range monitors was established from data taken with the operational neutron sources in place. The system performance was compared to criteria on noise, signal-to-noise ratio, and response to changes in core reactivity.

7. Intermediate Range Monitor (IRM) Calibration

   The intermediate range monitors were initially calibrated to give useful readings and to supply protection for this phase of the test program. This initial calibration was made by comparing the IRM readings to the SRM readings in the overlap region.

8. Process Computer

   As plant process variable signals became available to the computer, verification was made that the input signals were being read correctly.

9. Radiation Measurements

   The purpose of this test was to determine the background radiation levels in the plant environs prior to operation for base data on activity buildup and to monitor radiation at selected power levels to assure the protection of personnel during plant operation.

Table 14.2-2 Sheet 1of 2

TESTS DURING HEATUP FROM AMBIENT TO RATED TEMPERATURE AND PRESSURE

1. IRM Calibration

   The IRM subsystem was recalibrated during heatup to make the IRM readings proportional to a known heat input to the reactor coolant. The proportionality was determined by measuring the reactor coolant temperature rise produced by pump heating and by nuclear heating.

2. SRM Performance

   SRM performance was determined by checking for the proper overlap with the IRM subsystem.

3. System Expansion

   Expansion checks were made during heatup to verify the freedom of motion of major equipment and piping.

4. Control Rod Drive System

   CRD system tests were made by measuring scram times on a selected number of drives at two intermediate pressures, the determination of scram times and drive line friction tests on a representative set of drives at rated reactor pressure, and tests of the in-out driving times of selected rods during heatup.

5. Control Rod Sequence

   The control rod sequence used during the heatup was checked periodically for satisfactory performance.

6. Radiation Measurements

   Radiation measurements were made periodically during nuclear heatup and at rated temperatures.

7. Chemical and Radiochemical Checks

   Chemical and radiochemical checks were made during heatup.

Table 14.2-2 Sheet 2 of 2

TESTS DURING HEATUP FROM AMBIENT TO RATED TEMPERATURE AND PRESSURE

8. Main Steam Line Isolation Valve

   Functional tests were made at rated pressure.

9. Core Performance Evaluations

   Core performance evaluations were made near or at rated temperature and pressure. This included a reactor heat balance at rated temperature.

10. Reactor Pressure Control

    Reactor pressure was controlled by the turbine pressure regulator.

11. HPCI System

    The HPCI system was tested to demonstrate proper performance of the system including the steam turbine drive.

Table 14.2-3 Sheet 1 of 3

TESTS FROM RATED TEMPERATURE AND PRESSURE TO 100% POWER

1. Chemical and Radiochemical Tests

   These tests have been continued during normal operation.

2. Radiation Measurements

   Limited measurements were made at 25% of rated power and thorough surveys will be made at 50% and 100% power.

3. Relief Valves

   Tests were performed to verify proper logic operation, valve function, and reclosure.

4. Main Steam Isolation Valve

   Functional and operational tests were made as reactor power was increased.

5. RCIC System

   With the reactor shut down and in a hot and pressurized condition, the RCIC system was actuated to demonstrate proper operation of the system including the steam turbine driven pump.

6. Recirculation Pump Trips

   Recirculation pump trips were tested periodically during power increase to demonstrate their effects on the jet pumps and on the reactor.

7. Flow Control

   Capabilities were determined at specified power levels.

8. Turbine Trip

   Tests were performed to determine speed and reactor response.

9. Pressure Regulator

   Tests were performed to determine the response of the reactor and the turbine governing system. Regulator settings were optimized using data from this test.

Table 14.2-3 Sheet 2 of 3

TESTS FROM RATED TEMPERATURE AND PRESSURE TO 100% POWER

10. Bypass Valve

    Measurements were performed by opening a turbine bypass valve and recording the reactor pressure transient. Final adjustments to the pressure regulators were made.

11. Feedwater System

    Reactor water level changes were made to determine reactor response and to optimize level controller settings. Tests were performed to demonstrate reactor water level and plant response to loss of part of the feedwater supply including the tripping of a feedwater pump.

12. Flux Response

    Flux response to control rod movements were determined in both equilibrium and transient conditions. Steady-state noise was measured. Power-void loop stability was verified from this data.

13. LPRM Calibrations

    Calibrati on of the LPRM was made at 50%, 75%, and 100% power by use of flux mapping techniques. Each local power range monitor was calibrated to read in terms of local fuel rod surface heat flux.

14. APRM Calibrations

    APRM calibrations were performed after making significant power level changes. Reactor heat balances form the bases of the calibrations of these average power range monitors.

15. Core Performance Evaluations

    These evaluations were made periodically to demonstrate that the core was operating within the allowable limits of maximum local surface heat flux and minimum critical heat flux ratio. This test included reactor heat balance determinations.

Table 14.2-3 Sheet 3 of 3

TESTS FROM RATED TEMPERATURE AND PRESSURE TO 100% POWER

16. Core Power Distribution

    Measurements were made with the traversing in-core probe system after significant changes in power, control rod pattern, or flow rate. The flux mapping technique was used for calibrating the LPRM and for evaluating the core performance.

17. Process Computer

    As reactor power level increases, additional plant process parameters become available as inputs to the process computer. Computer inputs and calculations were verified as the sensed parameters became available with increasing power level. Final verification of proper computer operation was made at or near rated power.

18. IRM Final Calibration

    The final calibration of the IRM subsystem was made in the APRM-IRM power overlap region subsequent to the calibration of the APRM subsystem.

19. Auxiliary Power Loss

    Tests were made to verify acceptable performance of the reactor, electrical equipment, and auxiliary systems during the resulting transients.

Table 14.2-4 Sheet 1 of 5

EXCEPTIONS AND ADDITIONS TO "GUIDE FOR THE PLANNING OF PREOPERATIONAL TESTING PROGRAMS" AND TO "GUIDE FOR THE PLANNING OF INITIAL STARTUP PROGRAMS"

1. Preoperational Testing

   a. Power Conversion System

      The main steam system and feedwater system are not required to safely shut down the reactor and maintain the reactor in a safe shutdown condition. Therefore, the portions of these systems outside their primary containment isolation valves are considered nonessential.

      Safety systems are employed to keep the reactor core adequately covered with water in the event the reactor requires water because of feedwater system failure.

      The main steam system outside the primary containment is not required to relieve the reactor pressure or convey steam to a heat sink (the condenser) during emergency or even upset conditions. The reactor safety/relief valves are installed to limit reactor pressure, and the primary containment suppression pool and the RHR heat exchangers are the heat sinks.

      The safety-related switches on the main steam lines (i.e., low steam-line pressure turbine fast closure, and stop-valve limit switches) were tested along with other safety-related systems.

      Although the above power conversion systems were not included along with the safety-related systems, they were given acceptance tests as well as hot and cold functional tests as part of the startup testing. Besides other tests, these tests included vibration frequency and amplitude of the tests as well as inspection of the piping suspension system during heatup.

   b. Auxiliary Systems

      (1) Fire Protection System Tests

         The design of the DAEC is such that the plant can be safely shut down and maintained in a safe shutdown condition in the event the fire protection system were unable to or failed to put out a fire. Essential shutdown systems have been designed to overlap (i.e., break size) each other, to be redundant, and to have physical separation between redundant systems. Fire-retardant materials are used extensively throughout the plant.

Table 14.2-4 Sheet 2 of 5

EXCEPTIONS AND ADDITIONS TO "GUIDE FOR THE PLANNING OF PREOPERATIONAL TESTING PROGRAMS" AND TO "GUIDE FOR THE PLANNING OF INITIAL STARTUP PROGRAMS"

The routing of the fire system piping is designed such that failure of the piping will not cause flooding or water damage to areas where safety-related equipment is located. Deluge systems are designed so that the fire-fighting pipes will not interfere with these systems during or following a seismic event. The HPCI and RCIC systems are protected by a dry-pipe water deluge system in order to protect equipment (see Section 3.1, Criterion 3, "Fire Protection").

As was the case for all other nonessential systems, Iowa Electric performed an acceptance test on the fire protection system.

(2) Reactor Building Ventilation

The design of DAEC is such that the reactor building ventilation system is not safety related. The standby gas treatment system is initiated automatically on a LOCA signal or a high refueling floor exhaust radiation signal. At the same time, the normal reactor building ventilation system shuts down and the reactor building isolation dampers shut (see Section 6.2.3).

The standby gas treatment system, the reactor building isolation damper system, and the engineered safeguards heating and ventilating systems are safety related and were given preoperational tests. The normal heating and ventilating system was given an acceptance test.

(3) Instrument Air System Tests

The organization of the system testing program at the DAEC was such that the safety-related components that are required to fail-safe on loss of air were tested along with their respective safety-related systems. In the case of safety-related components that depend on accumulators for the storage of their air supply, the accumulator air supplies were also tested, along with their safety-related systems. However, the air system itself is not required to safely shut the plant down, and it was given an acceptance test.

Table 14.2-4 Sheet 3 of 5

EXCEPTIONS AND ADDITIONS TO "GUIDE FOR THE PLANNING OF PREOPERATIONAL TESTING PROGRAMS" AND TO "GUIDE FOR THE PLANNING OF INITIAL STARTUP PROGRAMS"

c. Containment System: Hydrogen Removal System Tests

As a point of clarification, the DAEC originally had a containment atmosphere dilution (CAD) system rather than a hydrogen removal system which has been subsequently disabled.

The original CAD system was given a preoperational test.

d. Filtration Systems

The offgas system provides for the cleanup and "routine release of gaseous effluents." Physical failure of the offgas system results in releases well below the annual limits of 10 CFR 20 requirements (see Section 11.3.3). Hence, Iowa Electric does not consider the offgas system a safety-related system, and the system was given an acceptance test.

The "postaccident particulate and charcoal filter system," also known as the standby gas-treatment system, is a safety-related system and was given a preoperational test.

e. Fuel Storage and Handling Systems: Spent Fuel Pit Cooling System Tests

The fuel pool cooling and cleanup (FPCC) system is designed so that the spent-fuel pool cannot be inadvertently drained.

The spent-fuel pool and liner are designed to Seismic Category I requirements in order to prevent the loss of water over the spent fuel during an earthquake.

The spent-fuel pool liner and the concrete around the liner are designed to contain boiling water. This was done in the event the FPCC system physically failed and was unable to cool the fuel pool and the spent fuel in the pool caused the water to boil.

Table 14.2-4 Sheet 4 of 5

EXCEPTIONS AND ADDITIONS TO "GUIDE FOR THE PLANNING OF PREOPERATIONAL TESTING PROGRAMS" AND TO "GUIDE FOR THE PLANNING OF INITIAL STARTUP PROGRAMS"

Approximately 25 ft (20,000 ft^3) of water would have to evaporate before any spent fuel would be uncovered. This time interval would allow more than adequate time (over 3.5 days with an average spent-fuel batch), to provide a temporary supply of water to the fuel pool. Therefore, Iowa Electric does not consider the FPCC system safety related, and an acceptance test was performed on this system.

f. Radiation Protection Systems: Process, Criticality, and Area Monitor Tests

The criticallty alarm system and the safety-related process radiation system (the main steam line, reactor building ventilation shaft, and refueling floor exhaust ventilation radiation monitors) were given preoperational tests.

The area radiation monitoring system, as described in Section 7.7.1.3, has no automatic functions that are essential to safety. The area monitors only alarm. This system was given an acceptance test.

The standby control room ventilation system in the DAEC is safety related and automatically starts on a high outside radiation signal (see Section 9.4.1). These radiation monitors were tested during the standby control room ventilation system preoperational test.

g. Radioactive Waste Systems

Radioactive sampling was performed during hot functional tests.

The design of the DAEC is such that the failure of liquid and gaseous waste systems cannot cause undue risk to the health and safety of the public. The releases as a result of a physical failure within the waste systems are well within 10 CFR 20 annual limits (see Sections 11.2.3 and 11.3.3). Hence, the liquid, solid, and gaseous radwaste systems were given acceptance tests.

In addition to the applicable tests covered in the "Guide for the Planning of Preoperational Testing Programs," Iowa Electric considered the following additional systems safety related, and preoperational tests were performed on them:

Table 14.2-4 Sheet 5 of 5

EXCEPTIONS AND ADDITIONS TO "GUIDE FOR THE PLANNING OF PREOPERATIONAL TESTING PROGRAMS" AND TO "GUIDE FOR THE PLANNING OF INITIAL STARTUP PROGRAMS"

(1) River water supply system.
(2) Traveling screens (in the river intake structure).
(3) Containment atmospheric control system (hydrogen-oxygen analyzer system).
(4) H&V system for the pump house (RHR and emergency service water side).
(5) H&V system for the intake structure.
(6) Automatic depressurization system (ADS).

2. Startup and Power Testing

Iowa Electric complied with the "Guide for the Planning of Initial Startup Testing Programs" except for the shutdown of the plant from outside the control room at 100% power.

Section 7.4 contains an outline for a shutdown procedure by which to demonstrate that the DAEC can be safely shut down from outside the control room. However, Iowa Electric considers such a procedure only a contingency plan, since the plant operators should never have to abandon the control room. This is based on the fact that the DAEC's plant design incorporates two separate, redundant main control room H&V systems that are standby units and that will start automatically in the event of intake air high radiation. Either one could also be manually initiated from the control room. These two H&V strings each have a HEPA filter and charcoal filter. The strings are Seisimic Category I (see Section 9.4).

Moreover, Iowa Electric considered that such a test was by its nature potentially harmful to plant equipmnt. That is, during the hypothetical shutdown procedure, the operators would not be concerned with the effect on nonvital equipment while shutting the plant down.

Iowa Electric felt that a test of shutdown from outside the control room could be safely demonstrated at a lower power level. Iowa Electric performed such a test beginning at 10% power. Personnel were stationed in the main control room to observe the safe progress of the test.

Table 14.2-5 Sheet 1 of 4

SURVEILLANCE TEST PROCEDURES PERFORMED IN SUPPORT OF CYCLE 8 STARTUP

Number	Title
	Prior to Startup
1. 55A001	Fuel Storage Facilities K_∞ Limit check (prior to startup)
2. 41A001	MAPLHGR Curves Check (prior to startup)
3. 41A004[a]	Intermediate Range Monitor Trip Functional Test and Calibration (within 1 week prior to startup)
4. 41A017[a]	Average Power Range Monitor High Flux (15% Scram) Instrument Functional Test (within 1 week prior to startup)
5. 42C004[a]	Source Range Monitor/Intermediate Range Monitor Detector Not in Startup Position Functional Test (within 1 week prior to startup)
6. 42C005[a]	Source Range Monitor Trip Functional Test and Calibration (within 1 week prior to startup)
7. 42A004	Main Steam Lines High Flow Instrument Functional Test/Calibration (prior to startup)
8. 41A007	Turbine Control Valve Fast Closure Response Time Test and Initiate Logic (prior to startup)
9. 41A018	Average Power Range Monitor Flow Bias Instrument Functional Test (prior to initial rod withdrawal)
10. 47A002	Primary Containment Leak Rate Test (prior to startup)
11. 47A003	Containment Leak Tightness Test - Type B Penetrations (prior to startup)
12. 47A005	Containment Isolation Valve Leak Tightness Test - Type C Penetrations (prior to startup)
13. 42F00l	Reactor Water Level and Pressure Instruments Calibration (prior to startup)
14. 41A025	Reactor High Pressure Instrument Response Time Check (prior to startup)

[a] These tests were part of the Stretch Power Uprate Test Program.

Table 14.2-5 Sheet 2 of 4

SURVEILLANCE TEST PROCEDURES PERFORMED IN SUPPORT OF CYCLE 8 STARTUP

Number	Title
	Prior to Startup(Continued)
15. 42A001	Daily and Shift Instrument Checks (prior to and throughout startup)
16. 46B001	Reactor Coolant Gamma and Iodine Activity (prior to startup)
17. 41A001	Reactor High Pressure Instrument Functional Test and Calibration (prior to startup)
18. 46B003	Reactor Coolant Chloride Ion and Conductivity Analysis (prior to startup)
19. 41A021	First Stage Turbine Pressure Permissive Instrument Functional Test and Calibration (prior to startup)
20. 43B003[a]	Rod Worth Minimizer/Rod Sequence Control System Capability Test (immediately prior to initial rod withdrawal)
	Startup and Low Power Operation
21. 46A003[a]	Heatup and Cooldown Rate Log (during startup)
22. 43A001[a]	Shutdown Margin Test (during rod withdrawal to critical)
23. 47D004[a]	Main Steam Isolation Valves (immediately after placing mode switch in run and continuing power increase)
24. 45E001-Q	Reactor Core Isolation Cooling System Operability Tests (150 psi reactor pressure)
25. 45D001-Q	High Pressure Coolant Injection System Quarterly Operability Tests (150 psi reactor pressure)
26. 42C001	Average Power Range Monitor Instrument Functional Test and Calibration (after placing mode switch in run)
27. 41A016	Average Power Range Monitor High Flux and inoperative instrument Functional Test/Calibration (after placing mode switch in run)

[a] These tests were part of the Stretch Power Uprate Test Program.

Table 14.2-5 Sheet 3 of 4

SURVEILLANCE TEST PROCEDURES PERFORMED IN SUPPORT OF CYCLE 8 STARTUP

Number	Title
	Startup and Low Power Operation (Continued)
28. 42G001[a]	Reactor High Pressure Recirculation Pump Trip Instrument Functional Test and Calibration (within 24 hr after placing mode switch in run)
29. 41A013-Q	Steam Line High Radiation (during power operation)
3o. 41A013-W	Steam Line High Radiation (during power operation)
31. SpTP-123	Low Power Rod Block Monitor Functional Check (15% power)
32. 42F007[a]	Average Power Range Monitor Gain Adjustment Calibration (prior to 20% core thermal power)
33. 42C002	Rod Block Monitor Functional Test and Calibration (27-30% power)
34. N/A	Verification of Performance of Turbine Bypass Scram Interlocks and Rod Sequence Control System Interlock Pressure (30% power)
35. 43C001[a]	Scram Insertion Time Test (~38% power)
36. 41A015[a]	Local Power Range Monitor Instrument Calibration (~38% power)
	Medium and High Power operation
37. 43E00l	Average Power Range Monitor/Local Power Range Monitor Baseline Noise Data Collection for Two Loop Operation (45% core flow)
38. Appendix E of 42A00l[a]	Average Power Range Monitor Gain Adjustment Calibration (1500-1593 MWt)
39. 43D00l[a]	Reactivity Anomalies Check (1500-1593 MWt)
4o. 46B00l[a]	Reactor Coolant Gamma and Iodine Activity (1500-1593 MW)
41. 41A015[a]	Local PowerRangeMonitor Instrument Calibration (1500-1593 MWt)
42. 46B003[a]	Reactor Coolant Chloride Ion and Conductivity Analysis (1500-1593 MWt)

[a] These tests were part of the Stretch Power Uprate Test Program.

Table 14.2-5 Sheet 4 of 4

SURVEILLANCE TEST PROCEDURES PERFORMED IN SUPPORT OF CYCLE 8 STARTUP

Number	Title
	Medium and High Operation (Contiued)
43. Predictor[a]	Axial Power Shape Comparison: Check Reactor Parameters (axial and radial flux, load line, thermal limits, K_{eff}) Againist the Predicted Parameters Which Were Predicted at the Previous Power States Listed Below. 65% power (predicted from 38% power) 80% power 90% power 95% power 100% power
44. Appendix E of 42A001[a]	Average Power Range Monitor Gain Adjustment Calibration (1658 MWt)
45. 43D00l[a]	Reactivity Anomalies Check (1658 MWt)
46. 46B00l[a]	Reactor Coolant Gamma and Iodine Activity (1658 MWt)
47. 46B003[a]	Reactor Coolant Chloride Ion and Conductivity Analysis (1658 MWt)
48. 41AD13-Q	Steam Line High Radiation (1658 MWt)
49. 41A013-W	Steam Line High Radiation (1658 MWt)

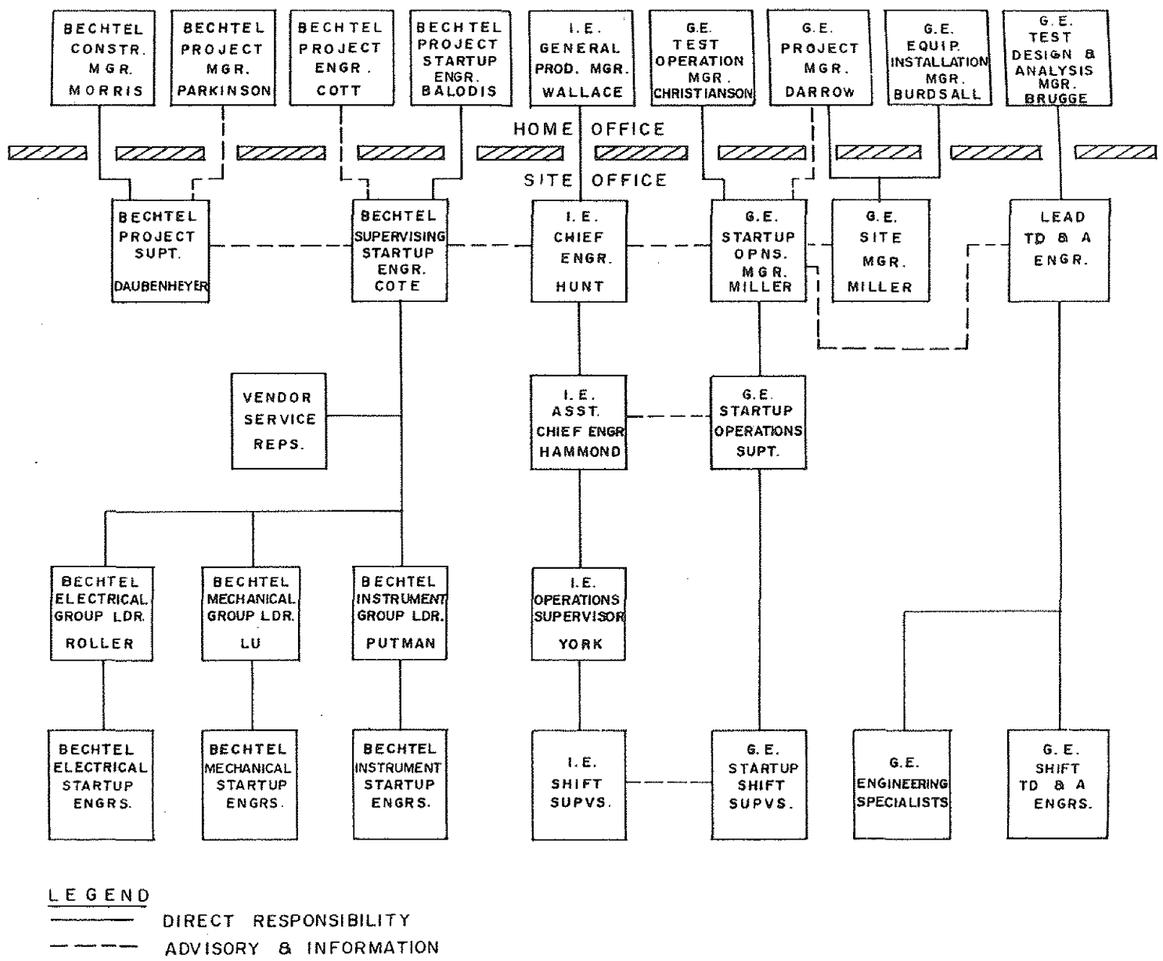
[a] These tests were part of the Stretch Power Uprate Test Program.

Table 14.2-6

EXTENDED POWER UPRATE TEST PROGRAM

Test No.	Test Title	Required for EPU-Phase I	Required for EPU-Phase II	Required for EPU-Phase III	Required for EPU-Phase IV
1	Chemical and Radiochemical Monitoring	Yes	Yes	Yes	Yes
2	Radiation Monitoring	Yes	Yes	Yes	Yes
3	Fuel Loading	No	No	No	No
4	Full Core Shutdown Margin	No (a)	No (a)	No (a)	No (a)
5	Control Rod Drive (CRD) System	No (a)	No (a)	No (a)	No (a)
6	Source Range Monitor (SRM) Response and Control Rod Sequence	No (a)	No (a)	No (a)	No (a)
9	Water Level Measurement	No	No	No	No
10	Intermediate Range Monitor (IRM) Performance	No (a)	No (a)	No (a)	No (a)
11	Local Power Range Monitor (LPRM) Calibration	No (a)	No (a)	No (a)	No (a)
12	Average Power Range Monitor (APRM) Calibration	No (a)	No (a)	No (a)	No (a)
13	Process Computer	No	No	No	No
14	Reactor Core Isolation Cooling (RCIC) System	No (a)	No (a)	No (a)	No (a)
15	High Pressure Coolant Injection (HPCI) System	No (a)	No (a)	No (a)	No (a)
16	Selected Process Temperatures	No (a)	No (a)	No (a)	No (a)
17	System Expansion	No	No	No	No
18	Core Power Distribution	No	No	No	No
19	Core Performance	Yes	Yes	Yes	Yes
20	Steam Production	No	No	No	No
21	Flux Response to Rods	No	No	No	No
22	Pressure Regulator	Yes (b)	Yes (b)	Yes (b)	Yes (b)
23	Feedwater System	Yes (b)	Yes (b)	Yes (b)	Yes (b)
24	Bypass Valves	Yes	No (d)	No (d)	No (d)
25	Main Steam Isolation Valves	Yes (b) (c)	Yes (b) (e)	Yes (b) (e)	Yes (b) (e)
26	Relief Valves	No (a)	No (a)	No (a)	No (a)
27	Turbine Stop and Control Valve Trips	Yes (c)	Yes (c)	Yes (c)	Yes (f)
28	Shutdown from Outside the Control Room	No	No	No	No
29	Flow Control	No	No	No	No
30	Recirculation System	No (a)	No (a)	No (a)	No (a)
31	Loss of Turbine-Generator and Offsite Power	No	No	No	No
32	Recirculation MG Set Speed Control	No	No	No	No
33	Main Turbine Stop Valve Surveillance Test	Yes	No (d)	No (d)	No (d)
34	Recirculation and Jet Pump Instrumentation Calibration	No	No	No	No
70	Reactor Water Cleanup System	No	No	No	No
71	Residual Heat Removal System	No	No	No	No
72	Drywell Atmosphere Cooling System	No	No	No	No
73	Cooling Water System	No	No	No	No
74	Offgas System	No	No	No	No
90	Vibration Monitoring	No	No	No	No

Notes (a) Credit was taken for existing Technical Specification Surveillances.
(b) The original test contains multiple sub-tests. Only those sub-tests affected by EPU were performed.
(c) While required for EPU, some tests were not performed during this Phase, as their required power levels are beyond those targeted for this Phase.
(d) Maximum power level required for this test was reached in Phase 1, so further testing is not required.
(e) Per License Amendment No. 257, this test is no longer required to be performed as part of EPU testing.
(f) Per License Amendment No. 266, this test is no longer required to be performed as part of EPU testing.



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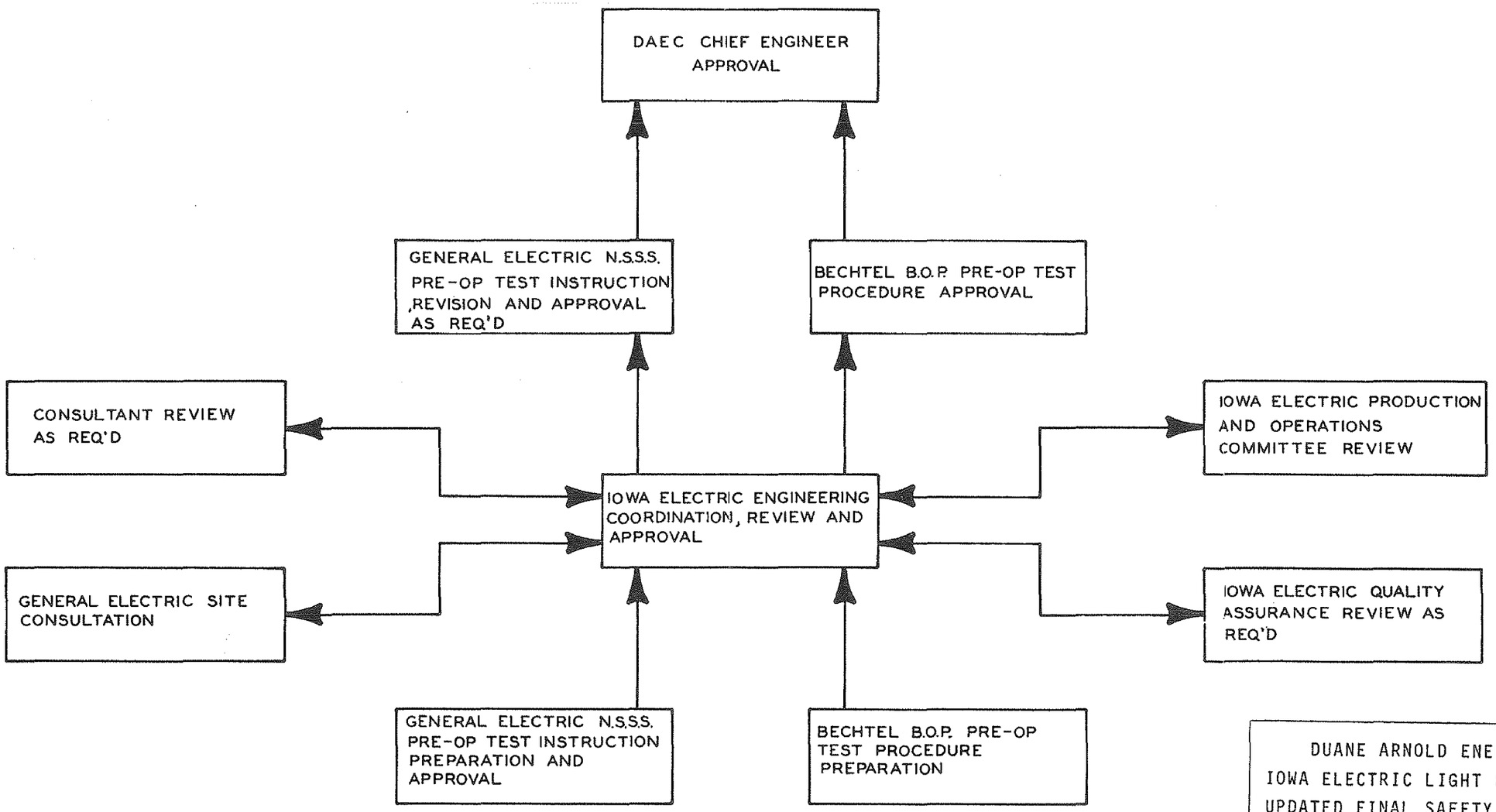
Interface Diagram for Preoperational and Startup Test Program

Figure 14.2-1

DUANE ARNOLD ENERGY CENTER UNIT NO. 1

N.S.S.S. PREOPERATIONAL TEST INSTRUCTION AND B.O.P. PREOPERATION TEST PROCEDURE PREPARATION, REVIEW AND APPROVAL



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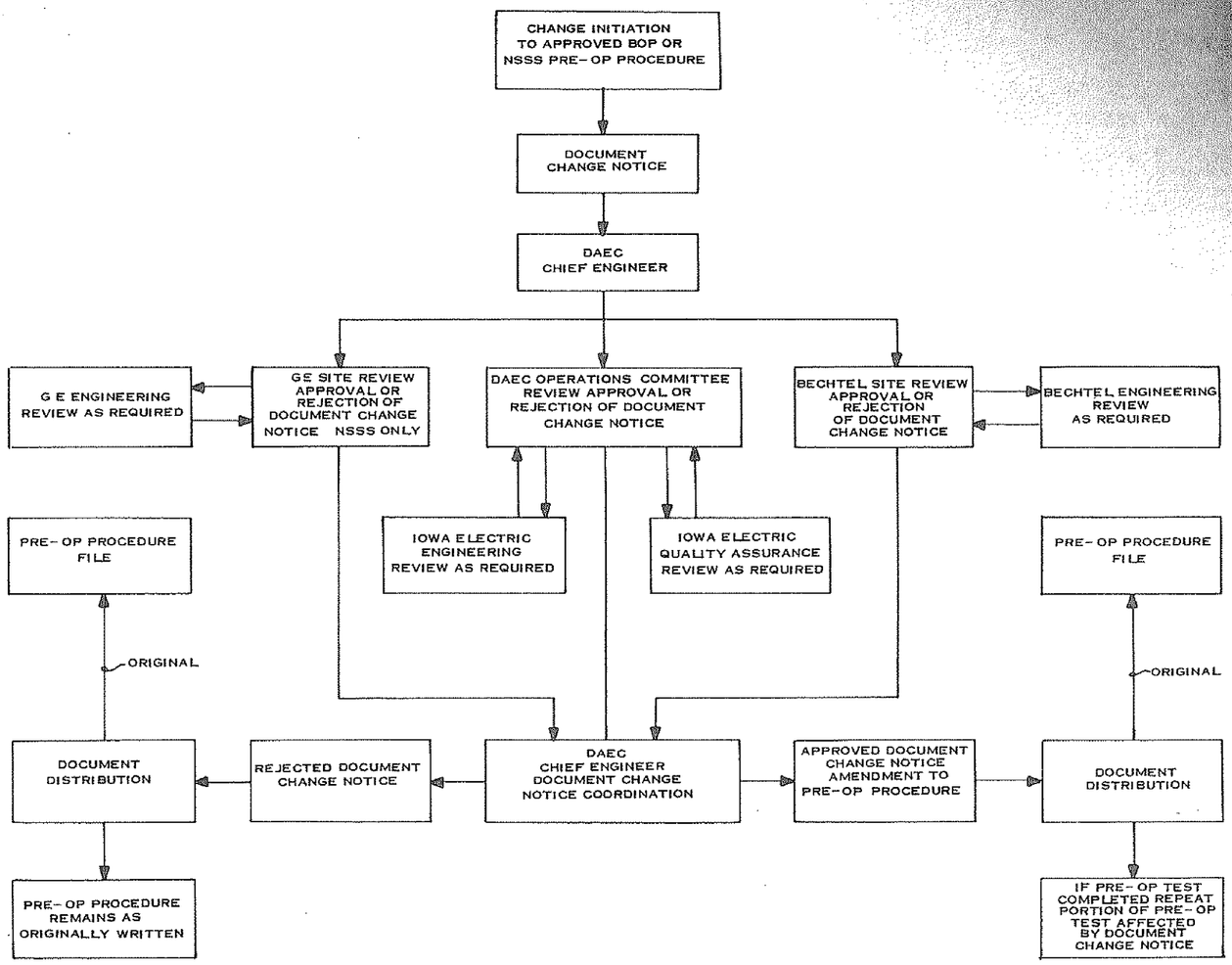
Preoperational Test Procedure, Preparation, Review and Approval

Figure 14.2-2



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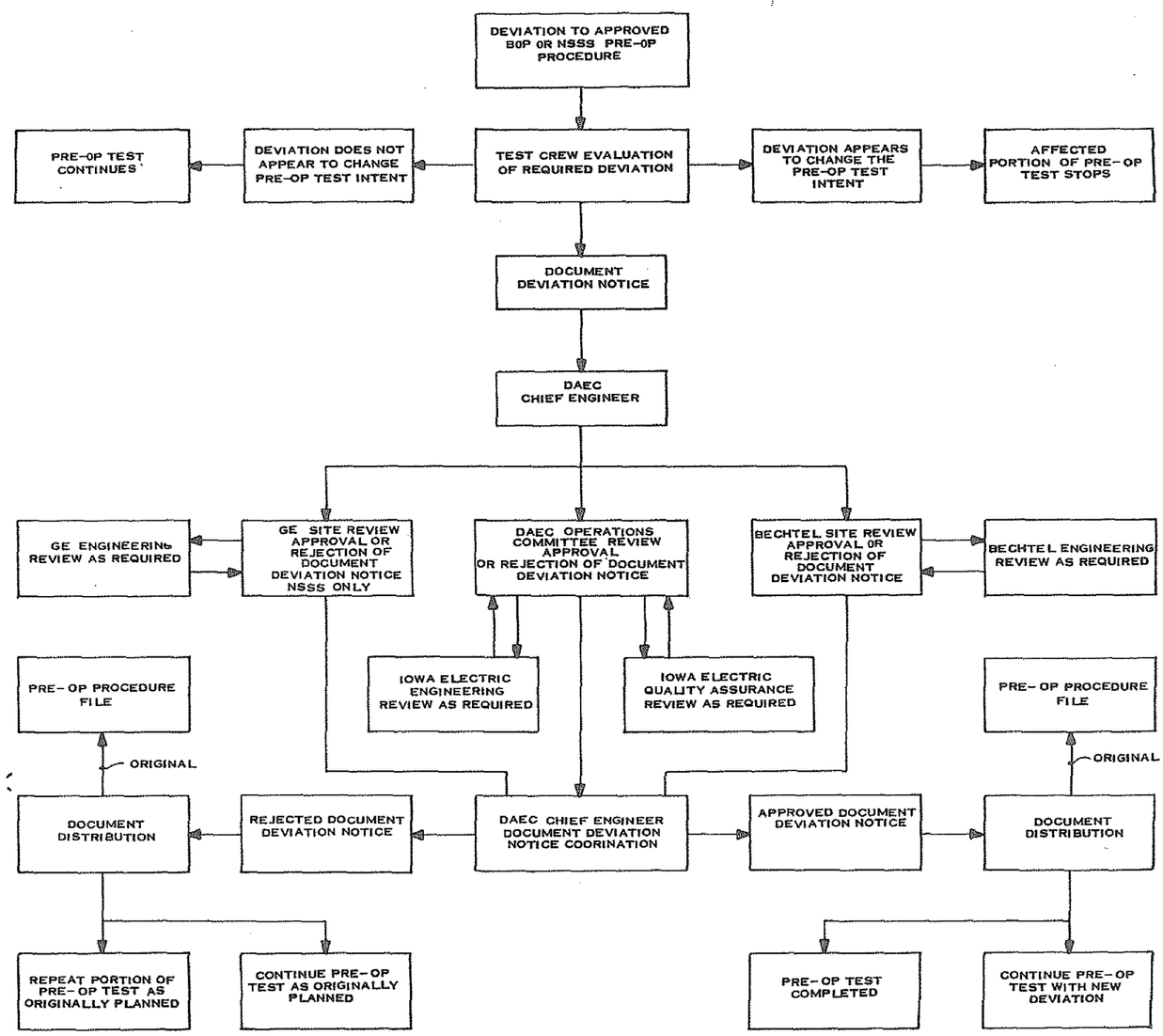
Change to Approved BOP or NSSS Preoperational Procedure Prior to or After the Associated Preop Test

Figure 14.2-3



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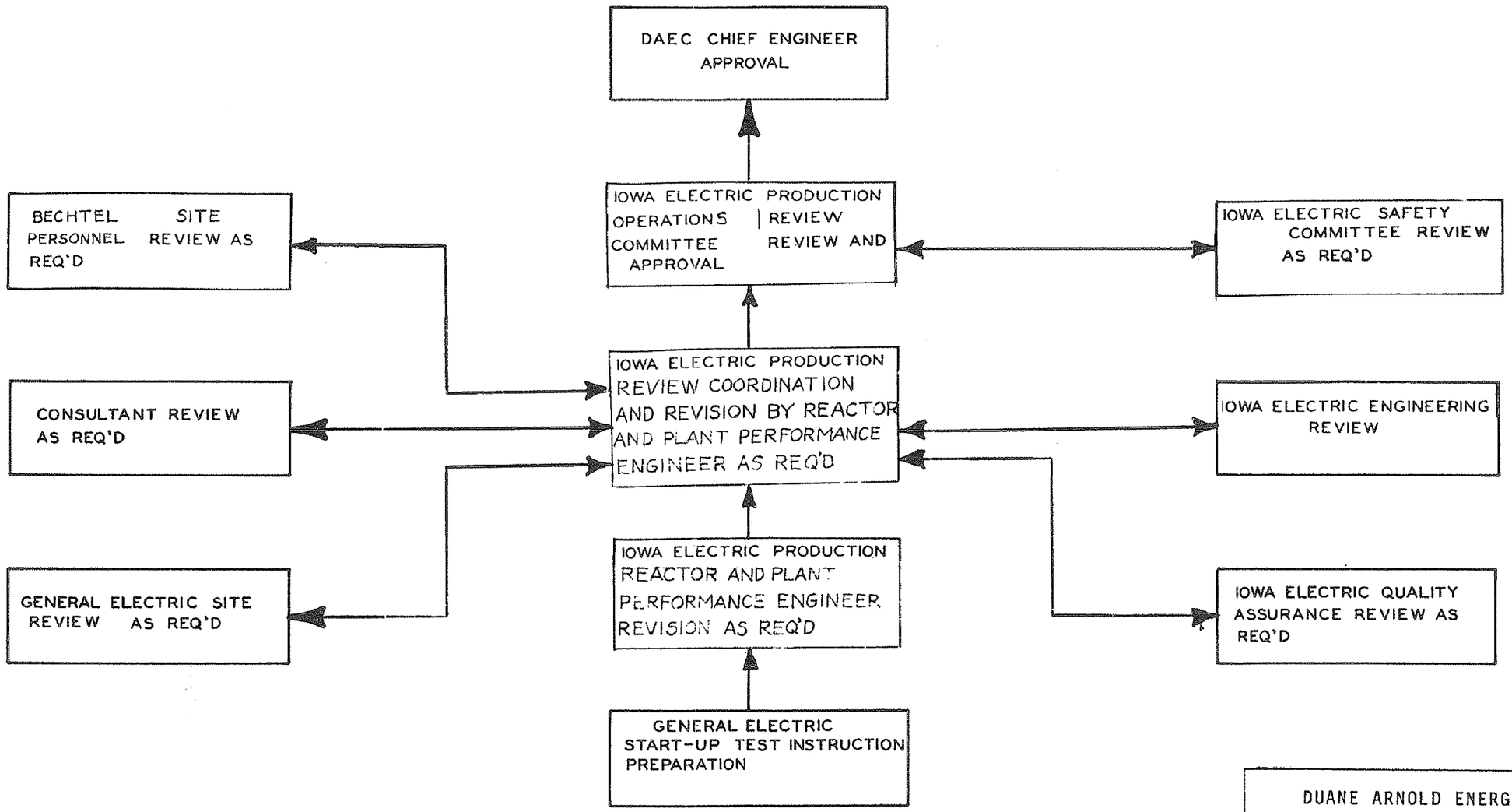
Deviation to Approved BOP or NSS Preoperational Procedure during the Associated Preop Test

Figure 14.2-4

DUANE ARNOLD ENERGY CENTER UNIT NO. 1

START-UP TEST INSTRUCTION, PREPARATION REVIEW AND APPROVAL



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Startup Test Instruction Preparation Review and Approval

Figure 14.2-5

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Evaluation of Test Results and Report after the Associated Preop Test

Figure 14.2-6

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Test Results at Variance with Expected Results

Figure 14.2-7