DOCKET NO. 50-29

Formal File Cy.

(Trans. w/ltr. of 9/15/59 - Amend. No. 14)

YANKEE NUCLEAR POWER STATION

YANKEE ATOMIC ELECTRIC COMPANY

PART B, LICENSE APPLICATION

AEC DOCKET NO. 50-29

TECHNICAL INFORMATION

AND

FINAL HAZARDS SUMMARY REPORT

VOLUME II

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500 GENERAL

The objective of normal operation of the Yankee plant is to generate base load electricity safely and at the lowest cost. To some extent, research information will be originated where nuclear plant safety is concerned; but extensive academic knowledge will not be produced. In order to generate electricity, maintain the equipment, and analyze for the safety of the fission process the full time plant organization includes 13 administrative people, 38 operating and maintenance people, and 14 scientists, engineers, and highly skilled technicians. The plant organization will be under the general direction of the Company management at Boston and will receive technical support from Boston. In addition, consulting services for special areas will be arranged as required. The technical consultants presently on call are as follows:

Dr. Theos J. Thompson, M.I.T. - Nuclear Physics

Professor James M. Austin, M.I.T. - Meteorology

Mr. Samuel Levin, M.I.T. - Industrial Hygiene

Combustion Engineering Co. - Radiation Monitoring

Nuclear Development Corp. of America - Nuclear Engineering

James I. Roberts, M.D., New England Electric System - Industrial Medicine

Shields Warren, M.D., New England Deaconess Hospital - Radiological Medicine

William C. Maloney, M.D. - Thorndike Laboratory - Hematology

David G. Cogan, M.D., Mass. Eye and Ear Infirmary - Ophthalmology

During startup and initial testing, the plant organization will be augmented by personnel of the major contractors, Westinghouse and Stone & Webster. Westinghouse Engineering and Services representatives will technically supervise the installation and startup of all nuclear steam generator equipment and other Westinghouse supplied steam plant equipment. Westinghouse Atomic Power Department physicists will plan, technically supervise, and analyze initial core loading and testing. Stone & Webster power plant engineering and construction personnel will technically supervise and, in some cases, perform other equipment, electrical and hydrostatic tests. Yankee plant personnel will operate the equipment and sign off for acceptance of the equipment.

Startup and normal operation of the plant with the nuclear core in place will be performed only after appropriate licensing of contractor personnel and plant personnel by the Atomic Energy Commission under Part 55 of AEC Regulations. The plant operating personnel are operating engineers, already appropriately licensed by the Massachusetts Department of Public Safety. Several of the plant operating personnel have had previous nuclear reactor operating experience.

Since the plant is primarily for base load generation of electricity, the operation of the plant can be detailed almost as soon as design is final. Therefore, this section of the report contains intermediate detail step-by-step instructions for startup, normal operation, shutdown, maintenance, and emergency operation of the plant. In all cases, operator action will be guided by these instructions, and these instructions cover all presently conceived conditions. If the instructions are found to be inappropriate in any respect, they will be reviewed and revised by the local Plant Operations Review Committee. The Committee is made up of the Plant Superintendent, the Chief Engineer, the Technical Manager, and the Reactor Engineer.

The broad principles of plant operation are as follows:

The plant is divided into two general areas, one to be considered potentially contaminated and the other clean. Access and operation in the potentially contaminated area are subject to restrictions as detailed in subsequent instructions.

Limited access is provided into the vapor container when the nuclear plant is at operating pressure and temperature and is subcritical. Access into the vapor container will not be allowed with the reactor critical, except for special test reasons.

Operation of the nuclear plant will be accomplished primarily from the centralized control room. The control room will be manned by two operators at all times, except during reactor refueling or during periods of cold shutdown.

Some nuclear plant operation will be performed at local panels under the direction of the centralized control room.

The waste disposal system is designed to be operated locally from the Waste Disposal Building panel.

All operations will be surveyed automatically and by patrol for hazard or release of radioactivity, and exposure records on all personnel will be maintained.

Maintenance work on the steam electric plant and on portions of nuclear plant outside the vapor container will be performed with the plant in operation if the work can be carried out in a safe manner.

Although all nuclear plant operation is by written procedure, the design of the plant recognizes that an operator error might be possible; therefore, nuclear plant design is such that no single operator or equipment failure can cause an accident of serious consequence.

The plant will be operated in compliance with the rules and regulations of the Commonwealth of Massachusetts and of the Federal Government and in a manner consistent with best industrial practices for large electric generating stations.

The plant will be open to properly authorized inspectors from insurance companies and the State and Federal Governments.

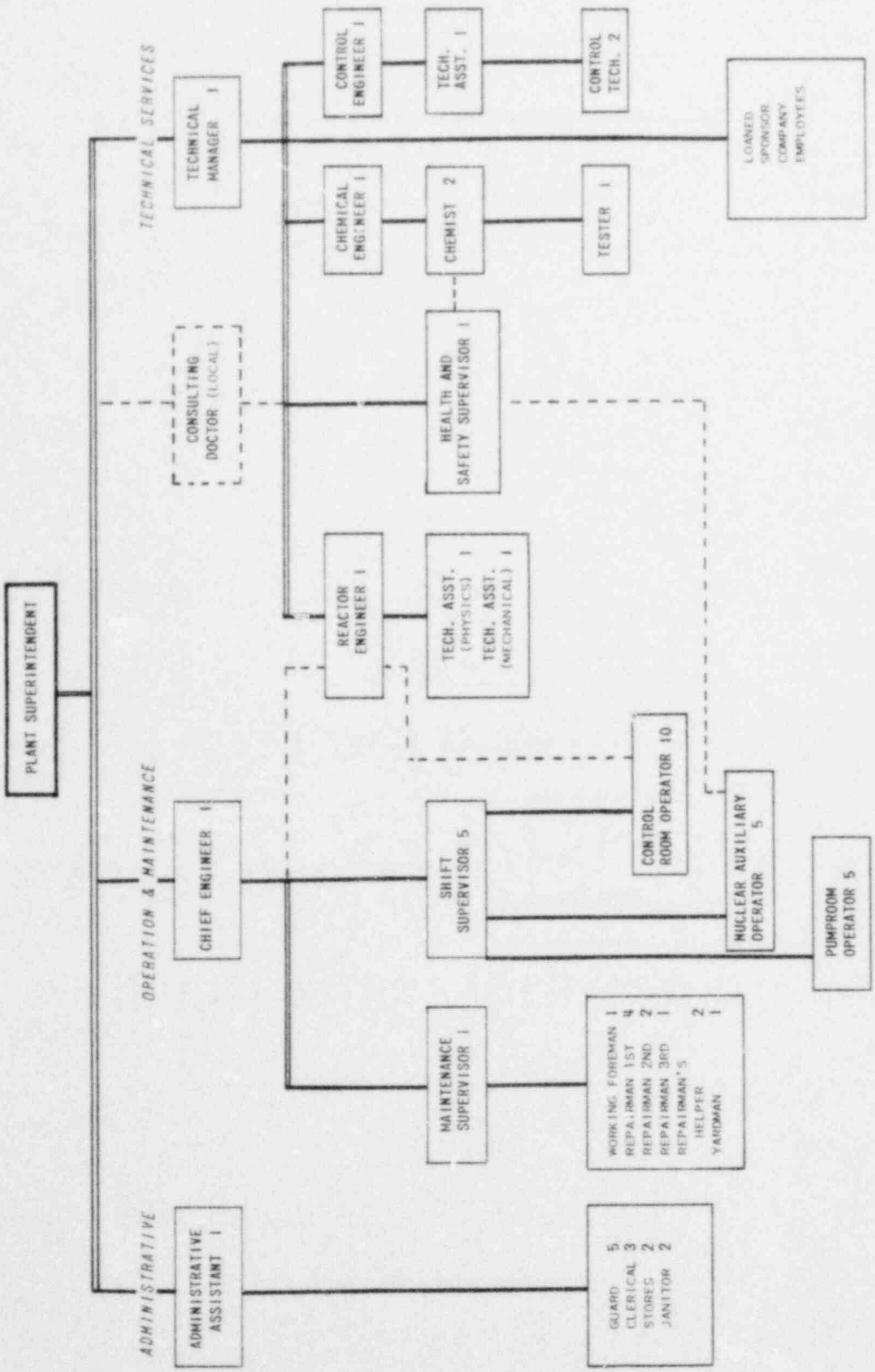
501 PLANT ORGANIZATION

The full time plant organization consists of 65 employees. In addition, the plant organization has available technical advice and services from consultants in medicine, meteorology, industrial hygiene, and nuclear engineering. The plant organization chart is shown on page 501:2. Operation of the entire plant is under the general supervision of the Plant Superintendent. Administrative functions, nuclear fuel control and accounting, and plant security are the responsibility of the Administrative Assistant. Operations and maintenance are under the supervision and control of the Chief Engineer. Technical services are under the supervision and control of the Technical Manager. Many jobs on the chart are explanatory by the job name alone; others require explanation to indicate responsibility and function.

The Shift Supervisors are operating engineers, appropriately licensed by the Department of Public Safety of the State of Massachusetts. They are in charge of operation of the plant on their respective shifts and report directly to the Chief Engineer. They will cause the plant to be operated at the direction of the Chief Engineer according to the normal and emergency instructions for operation. They must acquire an appropriate license as required by Part 55, AEC Regulations. During the preliminary nuclear plant operation, they will not make an approach to criticality nor a startup of the nuclear plant except at the direction of the Reactor Engineer, the Technical Manager, the Chief Engineer, or the Plant Superintendent. The Shift Supervisors may change reactor and plant power level above 10% power as required by demand. They must always be on the alert to analyze plant conditions and direct plant securement if an unsafe operating condition exists. For plant emergencies which do not involve the nuclear core or a radioactivity hazard, the Shift Supervisor must immediately contact the Chief Engineer. For emergencies which involve the nuclear core or a radioactivity hazard, the Shift Supervisor must immediately notify members of the Plant Operations Review Committee.

The Reactor Engineer is in charge of all nuclear physics and nuclear test programs associated with the core and the nuclear plant and reports directly to the Technical Manager. He will share responsibility with the Westinghouse physics complement for the supervision and performance of the initial core loading and the initial nuclear core tests. He will be responsible thereafter for safe thermal and nuclear flux operation of the core. He will be responsible for the continuing tests necessary to verify safety of the nuclear core with time. He can at any time take charge of the control room and direct nuclear plant operations, if he determines the situation warrants such action. The Reactor Engineer is assisted by two Technical Assistants. In his absence one of the Technical Assistants will assume his duties and responsibilities.

The Maintenance Supervisor is responsible for all mechanical and electrical maintenance associated with both the nuclear and the steam plant and reports directly to the Chief Engineer. Certain portions of the electrical maintenance work will be performed under his supervision by either New England Power Service Company or New England Power Company crews. This work includes the 115 kv switchyard maintenance, protective relaying, and certain electrical meter calibrations. Other electrical maintenance within the plant will be performed by the plant repairmen. Mechanical maintenance



YANKEE PLANT
ORGANIZATION CHART

throughout the nuclear and steam portions plant will be done with plant repairmen, except where a coincident heavy maintenance work load exists on nuclear and steam portions. If this occasion arises, plant repairmen will normally concentrate on the nuclear portion of the plant while the steam portion will be subcontracted. During the maintenance period, the plant operating crews will do reactor refueling under the direction of the Chief Engineer and the technical supervision of the Reactor Engineer, the Technical Manager, or the Plant Superintendent.

The Health and Safety Supervisor is responsible for the normal good safety practices of a large electric generating facility, for care of accident cases and health matters within the scope of a Registered Nurse, and for radiation exposure safety. He reports directly to the Technical Manager and indirectly to the local doctor and the New England Electric System Medical Director. As a part of radiation exposure safety, he will arrange for, and cause to be used, all such safety devices and special clothing as may be required for exposure control according to Section 507, RADIOLOGICAL HEALTH AND SAFETY. He will have charge of and be responsible for the processing of all monitoring devices attached to people. He will use and cause to be used all portable direct radiation monitoring equipment to establish and maintain a record for personnel safety from direct radiation. He will establish that personnel obey the rules for health and safety protection according to the instructions in Section 507 and the detailed Industrial Hygiene Manual. He will keep appropriate radiation exposure records as directed by the Technical Manager and the medical consultants and will assist in the required medical tests. He will receive direct radiation monitoring assistance from the Nuclear Auxiliary Operators and source strength information on contamination of solids, gases and liquids from the Chemical Engineer.

The Chemical Engineer is responsible for all plant water treatment and water conditioning and for all liquid, solid and gaseous waste processing. He reports directly to the Technical Manager. He will cause both the steam and nuclear portions of the plant to be operated with proper water conditioning. He will cause the necessary analytical work to be done to ascertain the radioactivity levels in liquids and gases in storage and direct their processing for plant control or disposal. He will be responsible for determining the source strengths of all radioactivity and contamination where indirect and precise techniques are required. He will be in charge of the counting room and make or request arrangements for radioisotopic identifications required for control and safety.

The Control Engineer is responsible for all instrumentation and control equipment of the nuclear and steam portions of the plant and reports directly to the Technical Manager. He will maintain and cause plant process instruments and control equipment to be in proper calibration and operating condition. He will be responsible for the maintenance and calibration of all plant and site direct radiation monitoring equipment. He will maintain and direct the repair of all control circuitry associated with the nuclear and steam plant, exclusive of electrical metering and relaying.

It is anticipated that the Plant Superintendent, the Chief Engineer, the Technical Manager, the Shift Supervisors, the Reactor Engineer, the Technical Assistant (Physics) and one half of the Control Room Operators will obtain AEC

Part 55 licenses before normal regular full time operation of the nuclear plant with core in place is allowed. Massachusetts Department of Public Safety licenses have been made a job requirement by Yankee Atomic Electric Company for the Chief Engineer, the Shift Supervisors, and one half of the Control Room Operators.

The hiring and transferring of technical, supervisory and top operating personnel for the plant have been completed in a most successful manner. Most of these people were acquired from sponsor companies of Yankee, and some have had years of experience in the nuclear field by way of loaned assignments. A brief resume of their qualifications is as follows:

Job Category	Training and Licenses
Plant Superintendent	BS in Mechanical Engineering 1947 Registered Professional Engineer Since June 1951 employed in research, design, operation or testing of several reactors, including STR, EBR-I and II, Borax I and III, EBWR, APDA-PRDC and YAEC. 2nd Class Massachusetts Operating Engineer's License
Chief Engineer	BS in Chemistry 1939 Since 1956 employed in research and design of APDA-PRDC and YAEC reactors. Shippingport School Feb. - July 1959 1st Class Massachusetts Operating Engineer's License
Technical Manager	BS in Mechanical Engineering 1942 Registered Professional Engineer Since 1953 employed in research and design of APDA-PRDC and YAEC reactors. Shippingport School Feb. - July 1959
Maintenance Supervisor	Graduate Lowell Institute 1939 Since 1925 employed as machinist and master mechanic in New England Electric System steam plants.
Shift Supervisors	All five have at least two years of formal technical schooling beyond high school. One has a degree in Marine Engineering. One has five years experience in operation and testing of Seawolf and Triton submarines and prototypes. Four have 1st Class Massachusetts Operating Engineer's Licenses.

Job Category	Training and Licenses
Reactor Engineer	BS in Engineering Physics 1955 Since 1955 employed at Savannah River on operation and since 1957 on performance of YAEC critical experiments. Shippingport school Feb. - July 1959
Health and Safety Supervisor	Registered Male Nurse 1941 R.A. Taft Sanitary Engineering Center School July 1959
Chemical Engineer	BS in Chemical Engineering 1955 Since 1955 employed at Savannah River, APPR and YAEC in design, operation and testing
Control Engineer	BS in Electrical Engineering 1951 Since June 1958 employed in instrumentation work for YAEC. WTR Training and Work Experience April - July 1959
Control Room Operators	All ten control room operators have academic high school course or equivalent diplomas. One has degree in Marine Engineering. One has 11 years of reactor operation at Hanford. Two have 1st Class Massachusetts Operating Engineer's Licenses. Four have 2nd Class Massachusetts Operating Engineer's Licenses. Two have 3rd Class Massachusetts Operating Engineer's Licenses.
Technical Assistant (Physics)	BS in Physics 1957 Since August 1959 employed in training program at YAEC plant
Technical Assistant (Mechanical)	BS in Mechanical Engineering 1958 Since June 1958 employed with construction forces on YAEC plant.
Chemists	Both chemists have BS - Chemistry degrees. One has several years experience in steam plant water chemistry and attended the R.A. Taft School in July 1959. The other took Master's degree credits in radio-chemistry plus Shippingport School July - October 1959.

Job Category	Training and Licenses
Loaned Sponsor Company Employees	At least six technical employees of the sponsor companies are scheduled for assignments at the plant during startup. One Sponsor Company Employee has seven years steam plant I and C plus one year on EBWR and two years on YAEC design. Other sponsor company employees will have served at least a two months indoctrination period on YAEC design before being given plant assignments during operation.

The remainder of the technical and operating persor·el for the plant will be hired in early 1960. They will be hired with appropriate technical training and Massachusetts Operating Engineer's Licenses.

502 PERSONNEL TRAINING

Personnel training has been divided into four phases depending upon the job requirements and the time required for preparation of the individuals participating. These training phases are as follows:

Phase I - Long Range Technical and Supervisory Training

Yankee sponsor company employees were placed on loan to AEC contractors and other reactor designers starting in 1951. A number of these men are included in the plant supervisory staff. By this method of loaning personnel and by additional hiring of a small number of experienced supervisory personnel, Section 501, PLANT ORGANIZATION, Yankee has in the Rowe plant organization a total of approximately 35 man years of nuclear reactor experience as of September 1, 1959. More than 12 man years of nuclear reactor experience are represented by the Boston Office supervisory technical group who generally direct and technically support plant operations.

Phase II - AEC and Designers Schools for Technical and Supervisory Training

Several Yankee plant technical and supervisory personnel have attended as students and have acted as instructors in various training schools which include the ARCO and the KAPL Navy Submarine Training Schools, the Argonne School of Nuclear Science and Engineering, and the Shippingport School. The total accumulated classroom hours for these personnel in AEC and designers schools is approximately 3,000 as of September 1, 1959.

Phase III - Rowe Plant Operations and Technical Training School

The plant operations and technical training school will begin on September 8, 1959, about one year before nuclear plant operation is planned. The instructors for the school will be Yankee supervisory personnel already trained by loan assignments or in outside training schools, Westinghouse engineers and scientists, Stone & Webster engineers, and Dr. Theos J. Thompson of M.I.T. Those attending the school will be the key operating and technical services personnel, about 30 people.

The specific personnel attending or acting as instructors in the school are the Plant Superintendent, the Chief Engineer, the Technical Manager, the Maintenance Supervisor, five Shift Supervisors, ten Control Room Operators, the Reactor Engineer, four Technical Assistants, the Health and Safety Supervisor, the Chemical Engineer, two Chemists, the Control Engineer, and one Control Technician. Approximately six sponsor company engineers will also participate in the school.

The objectives of the school are to prepare the key operating group for a complete understanding of plant operation and to prepare the technical services group for their functions necessary to the support and safety of plant operation. The training school will cover the following programs:

Theoretical Training Program - Basic theoretical science training will be given to the operators to prepare them for better understanding of the complexities of the nuclear plant. The approximate schedule of classroom hours to be devoted to each of these basic courses is as follows:

Subject	Hours
Mathematics	70
Chemistry	10
Nuclear Physics	30
Electricity and Magnetism	25

Engineering Training Program - Engineering associated with the Yankee plant will be taught concurrently with basic science subjects. The subjects and approximate hours are as follows:

Subject	Hours
Plant Cold Chemistry	15
Radiochemistry and Waste Disposal	25
Thermodynamics and Hydrodynamics	30
Reactor Theory	30
Reactor Operation	20
Plant Instrumentation and Control	25
Plant Systems, Flow Diagrams and Layouts	70
Plant Systems, Components	50
Integrated Plant Operation	50

On-The-Job Training Program - As the key operating personnel progress in the two classroom programs outlined above and as the construction contractors proceed with installation of certain equipment in the plant, assignments will be made for the operators to perform, witness, and check off the acceptance tests of equipment and systems being made under the technical direction of the contractors. The Chief Engineer will make these assignments in such a manner as to give the operators a working familiarity with the specific equipment which they will later be assigned to operate. Even though no hazard exists, other than the possibility of damaged equipment, no operator will be assigned to acceptance testing unless and before he has become satisfactorily oriented with respect to the equipment or system.

The key technical services personnel will in the same manner do on-the-job work after suitable classroom training. Their work will be carried out primarily in their respective laboratories such as the instrumentation and control laboratory, the radiochemistry laboratory, the plant chemistry laboratories, etc. Assignments for practice test work for this group will be made by the Technical Manager. They will perform acceptance testing on such systems as the water treatment system and the radiation monitoring system. The instrumentation and control group will do instrument calibration work at the request of the contractors throughout the extent of equipment installations.

Maintenance personnel will be trained primarily by on-the-job training. It is anticipated that some of the mechanics now engaged in plant construction work with the construction company will be hired for the plant maintenance force. Other skilled maintenance personnel will be acquired primarily from sponsor companies.

The final aspects of on-the-job training for operators, technical services personnel and maintenance personnel will be startup operational work in line with Section 503C PREOPERATIONAL PROCEDURES, SECONDARY PLANT; 503D, PREOPERATIONAL PROCEDURES, NUCLEAR PLANT; and 503E, INITIAL CORE LOADING AND NUCLEAR CORE TESTS. On-the-job training in these startup areas will be closely associated with manufacturer's startup representatives and experienced nuclear plant technical advisory personnel.

Training by Preparation of Detailed Instructions, Check-Off Lists and Technical Manuals - Even though the Final Hazards Summary Report contains extensive sections on normal operating, maintenance and emergency instructions, they may not be in adequate detail for operator action. The instructors will study the students' response to the Hazards Report instructions to ascertain whether or not further detail is necessary in order to assure correct operator action. Where it is found that the instructions are not adequate for operating requirements, they are to be rewritten by the student operators to include necessary added details as, for example, relating operations to specific valve numbers. Check-off lists for each instruction, Sections 503 and 504, will be prepared by the operators as a part of school training. Similarly, testing procedure write-ups and manuals will be prepared by the technical services personnel.

Phase IV - General Employee Training

The preceding phases of training are concerned primarily with preparing the key plant personnel. About 3 months before startup of the complete main coolant system for pre-core loading tests, the remainder of the plant staff will be hired. They will be prepared for their job assignments by the personnel already trained. Concurrently, two general classroom training programs for all plant personnel will be initiated. One program concerns Radiological Health and Safety, Section 507, and will be conducted under the general direction of Dr. James I. Roberts of the New England Electric System, consultant to Yankee. Classroom lecturers include the Health and Safety Supervisor, the Technical Manager, and Yankee consultants, Mr. Samuel Levin of M.I.T. and Dr. David Cogan of The Massachusetts Eye and Ear Infirmary. The subjects for Radiological Health and Safety Training and approximate classroom hours are listed below. Recurring lectures will take place as part of continuing safety education in those subjects marked below with an asterisk (*).

Subject	Hours
Industrial Medicine	2
Radiological Medicine	3
Dosimetry	3
Radiation Counters	2
*Radiological Safety Procedures	3
Protective Equipment and Clothing	2
Environmental Monitoring	1

The other general classroom training program concerns plant personnel safe working action and action during emergencies, and will cover the following subjects with the following approximate classroom hours:

Subject	Hours
*Fire Protection	2
*Industrial Safety	3
Sabotage and Security	1
*Nuclear Plant Accidents	5

The training of personnel for operation of the plant has been and will continue to be quite extensive. The ultimate goals are to develop complete competence at the plant to safeguard the plant and the public and to prepare the plant operators to qualify for licenses under AEC Regulations, Part 55. At the time the nuclear core is loaded, the plant personnel will have completed approximately 15,000 man-hours of classroom work, acquired about 75 man-years of nuclear plant experience and familiarity, and have more than a century of Massachusetts licensed steam plant operating experience.

503 INITIAL PLANT INSPECTION AND START-UP TEST PROGRAM

503A EQUIPMENT SPECIFICATIONS AND MANUFACTURES' TESTS

Specification

All equipment is procured from specifications. The specification is a formal document with necessary attachments in the case of important equipment or materials. In less important instances, a memorandum or a requisition for a catalog item of standard equipment suffices, but, in every instance, a definite requirement is specified, with sufficient identifying detail to be certain the item will perform its intended function.

The specification covers the conditions under which the item will operate, stressing those factors which must be understood by the supplier. Required performance characteristics, such as flow, pressure, temperature, and speed are stated. Where considered mandatory for the service, special materials are specified. Where there is a choice of available materials, the supplier is invited to recommend such, based on his experience. Where necessary, material specifications are included or reference is made to standard ASTM specifications. Requirements for all necessary auxiliary component parts are included.

Specifications require that the supplier include performance and quality guarantees.

Proposals are carefully reviewed for conformity to the specifications, and the quality of the offering and the prestige of the supplier are taken into account, as well as price, when procuring equipment.

After placing an order, the specification is revised to include any approved alterations, to record performance and material data, and to incorporate performance curve sheets.

A complete file of all specifications and orders is maintained in the offices of the operating company and of the design engineers, as well as at the job site, the latter of which is the Official File.

Manufacturers' drawings are reviewed for conformity with the specification. Manufacturers' shop procedures, such as welding, are reviewed and approved and, where necessary, specimens of their shop work are obtained and submitted to laboratory tests under the supervision of the design engineers.

Piping

Shop fabrication of piping is covered by "Specification for Piping (YS-497)" (not included) or accepted current issue. Shop fabrication of main coolant piping is covered by Westinghouse E-Specification 569006 (not included) or accepted current issue. Suppliers' shop welding specifications for secondary plant carbon steel pipe are reviewed and approved, but the design engineers' specifications for primary plant piping, as referenced in the above specifications, are followed.

Cleanliness

Specifications for components for the nuclear steam generator for the primary auxiliary systems and for primary plant piping contain special requirements for cleanliness. These specifications require the highest grade commercial cleanliness, but only such as is compatible with the necessary reopening of the equipment in the field for erection and making piping connections. The requirements for cleaning on manufacturers' premises specify reasonable cleanliness of the premises and the removal of all visible dirt, grit, scale, weld spatter, grease, and oil, with certain readily obtainable commercial cleaning fluids, prohibit certain fluids as damaging to stainless steel, require inspection of crevices and, after drying, specify that all openings in the item shall be covered and protected in a commercial manner. These requirements for cleaning of equipment, piping, and valves on manufacturers' premises are covered in "Requirements for Cleaning Material and Equipment for Main Coolant and Primary Auxiliary Systems" (not included).

Shop Inspection

The design engineers keep posted at all times as to the manufacturing status of each item by means of reports, periodic visits, and, where required, a prolonged time in residence at a manufacturer's shop, all in conformity with the importance of the equipment and previous experience with the qualifications of a supplier.

All major equipment and special materials are inspected by representatives of the design engineers. This includes the turbine generator unit, condenser, condenser tubes, pressure vessels, exchangers, pumps, fans, fabricated piping, high pressure valves, and special alloy material. The inspection procedure to be followed for each purchase order is outlined to an inspector.

This inspection includes the following, in varying degrees, as required:

All special material is checked to make certain it conforms to specification requirements.

Chemical analyses and physical tests are checked.

Hydrostatic and pressure tests are witnessed.

Running and performance tests of rotary equipment are witnessed.

A complete dimensional check is made to make certain that equipment conforms to drawing requirements.

Equipment is checked for flaws and imperfections.

Equipment and material are checked for cleanliness, readiness for shipment, and packaging.

503B DELIVERED EQUIPMENT INSPECTIONS AND INSTALLATION PROCEDURES

Receipt of Equipment at the Job Site

Equipment and material are delivered by truck or by railroad.

Equipment and material, as received, are checked for completeness or damage. If the latter is found, an immediate request is made for replacement.

Equipment and material after the receiving check are placed in storage, if erection can not immediately proceed. Small items susceptible to damage from exposure, such as motors and valves, are stored in a permanent warehouse. Large items are protected with a temporary shelter. The very largest items, such as the steam generators, are stored outside on wooden platforms and surrounded by a combination wooden and tarpaulin enclosure. All openings are left closed, as per Section 503A, EQUIPMENT SPECIFICATIONS AND MANUFACTURERS' TESTS.

Cleanliness

No "clean room" as such is employed in which near-surgical cleanliness is achieved. The requirements for the highest grade commercial cleanliness which can be obtained practically are observed. While a special effort over and above that used on a conventional plant is made to ensure cleanliness, it is recognized that components must be handled, opened, inspected, set in place, heated, and welded under field conditions. Cleanliness specifications have, therefore, been prepared with full awareness of the constraints imposed by field conditions and the necessity of eliminating all foreign material which may cause difficulties during operation.

Gross dirt and debris are continuously removed during the erection procedure, but final cleaning is reserved until the last, when a complete visual inspection is made and removal of all visible dirt and contaminants is undertaken, followed by a closed system flushing.

This manual cleaning prior to flushing is specified under "Requirements for Cleaning Material and Equipment for Main Coolant and Primary Auxiliary Systems" as follows:

> "Stringent service requirements for equipment and piping containing fluid that enters the main coolant loops make it imperative to maintain an unusual degree of cleanliness on all surfaces in contact with that fluid. Dirt is harmful in these circuits since it can become irradiated. Inspectors and foremen shall take all necessary precautions to insure the cleanliness of these circuits."

"The area in which the final assembly, connecting to and making up of pipe joints are undertaken shall be kept as clean as practicable. Floors and benches should be given the equivalent of a vacuum cleaning at least once a day and no dirt-producing operations shall be undertaken in the vicinity. If assembling or connecting up operations are interrupted, any exposed interior surfaces or openings shall be covered with plastic sheets taped in place, or the equivalent. Fabric covers shall not be used."

"Compressed air shall be used for cleaning to a minimum extent, and only if oil and moisture-free."

"All visible dirt, dust, chips and scale shall be removed by suction or lint-free wiping cloths. Finally, all accessible surfaces shall be washed with alcohol and dried, using lint-free cloths."

The cleaning requirements for primary plant piping during the process of erection, as specified in "Welding Procedure Specification No. W65-NPP, Part III Field Erection Welding," are as follows:

"All shop fabricated parts received at the job site for field erection welding shall have been previously cleaned in accordance with the shop fabrication procedure. The field erection forces shall thoroughly clean each end inside and outside. A circumferential band at least 3 in. wide at the end of the pipe shall be cleaned with a solution of warm water and Tide, or equivalent, and thoroughly rinsed with clean water and dried with a lint-free cloth. Immediately after cleaning, the ends of the piping shall be fitted together and the root bead welding performed."

Erection

Piping is erected in the field under the design engineers' "Specification for Piping Covering Field Erection" (YS-497A), which is a supplement to the general "Specification for Piping" (YS-497).

The referenced design engineers' specifications for welding (not included) are:

W40 - Procedure Specification for Manual Metallic Arc Welding for Carbon Steel Material

W65-NPP, Part III, Welding Procedure Specification for Nuclear Power Piping for Austenitic Stainless Steel Piping - Type 304

W65-NPP, Part IV, Welding Procedure Specification for Nuclear Power Piping for Austenitic Stainless Steel Piping - Types 304 and 316 for Speedline Fittings

No. 9699, Welding Procedure Specification for Main Coolant Loop - 20 In. and 24 In., 4 In. Pressurizer Surge Line and 5 In. Loop Equalizing Lines for Austenitic Stainless Steel Piping - Types 304 and 316

A step by step procedure for erecting the components of the nuclear steam generator is covered in "Procedure for Erecting Main Coolant System Components and Piping."

In summary, this procedure describes unloading, insulating and placing the reactor vessel in the lower part of the neutron shield tank. The vessel supports are levelled and pinned.

The steam generators are erected on their supports, the main coolant pumps are hung, and the main coolant piping and valves are erected, working radially either inward to or outward from the reactor, depending on the sequence of receipt of components, to the piping field pieces between the steam generator and main coolant pumps.

The pressurizer is piped up, and all small branch connections to the main coolant loops and instruments are made, at least to the first high pressure closure valve. Piping and equipment are insulated, leaving field welded joints exposed for the final hydrostatic test.

After installation of the preoperational filters in the steam generator outlet nozzles and the seal welding of the control rod drive mechanisms located on the reactor vessel head, a complete final hydrostatic test of the entire system is made, as per Section 503D2, PREOPERATIONAL PROCEDURES, NUCLEAR PLANT - MAIN COOLANT SYSTEM PRE-CORE LOADING TESTS.

The upper portion of the reactor body and those portions of the main coolant piping surrounded by the shield tank are insulated. The upper portion of the shield tank is completed, shield tank piping connections made up, and the whole tank assembly is then tested.

Pipe and vessel insulation is completed as far as possible. All closures in the main coolant system are opened, including valve bonnets wherever possible, and a complete visual check and cleaning of the entire main coolant system is made preparatory to the flushing operations.

All primary piping field welds are given visual, radiographic and dye check inspection by the construction organization, as required under the welding specifications. All welds in the main coolant lines, the pressurizer surge line, the main coolant by-pass lines, and all high pressure branch lines attached to the main coolant loops as far as the first shutoff valve are given a second inspection by an independent agency.

Construction procedures and practices which have been mutually agreed upon are listed in "Field Inspections and Procedures Requested by Westinghouse in Connection with Westinghouse Equipment."

All craftsmen are skilled in their respective trades. Welders are given the necessary qualification tests on the job, as required in the Boiler, Unfired Pressure Vessel, and Piping Codes.

503C PREOPERATIONAL PROCEDURES, SECONDARY PLANT

As construction work reaches a conclusion and before operation can be started, testing and tryouts of equipment proceed. All piping and equipment will be inspected, and that which requires cleaning will be blown out with steam, flushed with water or cleaned by some other acceptable method. The flushing and blowing procedure for secondary plant piping is described in the latest revision of "Cleaning Procedures for Piping Systems, Secondary Plant, January 26, 1959" or accepted current issue. This detailed procedure is not included in this document.

If rapid generation of steam is employed for blowing out the main steam lines, this will be obtained from the steam generator utilizing pump heat from the main coolant circuit, prior to the installation of the core, thereby eliminating any possible nuclear hazard.

All rotating equipment will be inspected to ascertain that it has been correctly assembled, properly installed, adequately lubricated and is ready for operation in all other respects. Included in this inspection are all essential instrumentation, controls, piping and wiring.

The initial trial of any equipment will be attended by personnel from the operating company who actually handle valves, switches, and other controls under the supervision of a Starting Engineer or Power Engineer specially detailed by the construction organization for this service. Craftsmen to make adjustments and a service representative of the equipment manufacturer to furnish supplementary supervision will be utilized, as required.

During these trials, the equipment will be operated to the fullest extent possible under the circumstances, safety devices will be tested, and special attention will be paid to conditions which might indicate incipient weakness or failure during subsequent operation.

At the conclusion of an adequate trial period, the equipment will be formally released in writing to the operating company. This release in effect establishes the responsibility for operational jurisdiction, as well as for its lubrication, maintenance and the requisite routine attention. The purpose of the formal release procedure is exactly as herein defined. It is conditional and should latent defects be found in either the equipment or in the manner of installation, the construction organization is obligated to assume responsibility for prompt correction of the defects.

The Power Engineer is a specialist in this start-up work. He is qualified by long experience in operation, maintenance, and testing. He is supported by the entire design and construction organization. An important aspect of his work is coordination of effort on the part of many individuals of diverse skills and viewpoints. He ascertains that the service representatives of equipment manufacturers are qualified for their particular assignments. He renders valuable service in instructing and guiding the operators so that they become conversant with the new equipment.

STARTUP PROCEDURE NO. 503D1

PREOPERATIONAL PROCEDURES, NUCLEAR PLANT
FILLING, CLEANING AND FUNCTIONAL TESTING OF AUXILIARY SYSTEMS

General

The methods listed for testing the various auxiliary systems in this procedure are not in a suggested sequence. The startup staff will determine the actual sequence according to convenience with the actual field schedule and revisions.

In all filling and cleaning procedures, the applicable portions of O.I. No. 504K2, PRIMARY PLANT SAMPLING SYSTEM - AUXILIARY SYSTEMS, should be employed to establish when required water purity has been obtained. As a nominal purity standard, specific resistance of any system water should be greater than 500,000 ohm-cm at 77 F, chloride content should not exceed 0.2 ppm, and total solids should not exceed 2 to 3 ppm. This standard applies to all systems which tie in to the main coolant system at the time when they are considered to be cleaned. Feed and bleed or complete drain followed by repeat fill and cleaning may be required of systems if the water is sub-standard.

All cleaning operations calling for the use of temporary strainers (not original equipment) will have these pieces installed before filling is initiated. In all cleaning operations, circulate at as high a rate as possible with all vents and drains open and continue until the drain water is about as pure as flush water being charged.

Hydrostatic tests will nominally be performed on each auxiliary system as soon as it is ready for testing, and are not described in this procedure. Details for these tests will be worked out by the field staff. In all tests, demineralized water should be used.

Since filling and cleaning operations are common to all systems, the purpose given for each system is to describe the design conditions which are to be satisfied and the method is intended to provide these data. This section may not logically follow the filling or cleaning steps, and should be performed when proper conditions exist to check the performance of the particular system. Use demineralized water for all filling and cleaning operations.

Charging and Volume Control System

Purpose - The purpose of this system is to determine that water can be charged at rated flow against normal system pressure; to check bleed flow against design rate for each pressure reduction station; to determine the response of the system to changes in pressurizer level and to check maximum and minimum flow of the variable speed charging pumps against design rated flows.

Filling - Perform filling operations as detailed in O.I. No. 504F, CHARGING AND VOLUME CONTROL SYSTEM, except that hydrogen overpressure need not be established.

Cleaning - With normal low pressure surge tank level controls by-passed and one make-up pump on manual control, raise the low pressure surge tank level until water reaches the pressurizer safety valve. Pump the level down to normal level via the drain pump to waste disposal. When the system is to be gas pressurized, use inert gas from the hydrogen manifold until waste disposal is ready to receive hydrogen.

Method

(1) With the main coolant system at 2,000 psi gage and temperature greater than 110 F (refer to S.P. No. 503D2, PREOPERATIONAL PROCEDURES, NUCLEAR PLANT - MAIN COOLANT SYSTEM PRE-CORE LOADING TESTS), put the two variable speed charging pumps on manual control. Individually start and observe each charging pump at full flow. Run all three pumps together and observe indicated flow. (Refer to Section 203, CHARGING AND VOLUME CONTROL SYSTEM).

CAUTION: If system pressure starts to rise, stop the charging pumps immediately and start bleed flow. Do not start any main coolant pump until pressurizer temperature is in the range of 385 F to 400 F.

(2) With the main coolant system at 2,000 psi gage and 514 F and the charging pumps on automatic control, open the stop valves in each pressure reduction station separately. Observe bleed flow, pressurizer level, feed flow, low pressure surge tank cooler performance, and feed and bleed heat exchanger performance.

(3) Determine minimum flow for each variable speed charging pump.

Pressure Control and Relief System

Purpose - The purpose of this system is to determine that the system will protect the main coolant system and control pressure.

Filling - With the pressurizer vent open, allow the pressurizer to fill at the same time the main coolant system is filled (Refer to S.P. No. 503D2, PREOPERATIONAL PROCEDURES, NUCLEAR PLANT - MAIN COOLANT SYSTEM PRE-CORE LOADING TESTS).

Cleaning - With the pressurizer vent open, operate the surge spray with one charging pump and concurrently drain the pressurizer. Flush until clean.

Method

(1) During initial heatup of the main coolant system (refer to S.P. No. 503D2, PREOPERATIONAL PROCEDURES, NUCLEAR PLANT - MAIN COOLANT SYSTEM PRE-CORE LOADING TESTS and O.I. No. 504E, PRESSURE CONTROL AND RELIEF SYSTEM), check regulation of main coolant system pressure against pressurizer steam pressure and temperature.

(2) With the main coolant system at 2,000 psi gage and 514 F, switch off the main coolant pumps and allow the pressurizer to maintain 2,000 psi gage. Determine pressurizer insulation heat loss by measuring heater cycles.

(3) With the main coolant system at 2,000 psi gage (all heaters in operation), and 514 F and all main coolant pumps operating, hold T_{avg} constant with steam by-pass and determine circulation spray flow by measuring heater cycles. Raise pressure to 2,300 psi gage with the charging and volume control system and check that the surge spray operates at 2,300 psi gage to reduce pressure to 2,250 psi gage.

(4) Turn off all sprays if the main coolant pumps are on, then place the pressurizer heaters on manual control and heat the pressurizer until the steam temperature reaches 661 F (2,400 psi gage). Check that the solenoid operated relief valve operates to reduce pressure to 2,350 psi gage and that the valve closes properly (pressure does not continue to drop). Note safety valve discharge pipe temperature.

(5) Close the gate valve in the solenoid relief line, heat the pressurizer up to 2,500 psi gage, and note the first safety valve blowdown pressure on the pressure indicator recorder. Gag the valve. Heat up to 2,575 psi gage, blow the second safety valve, and note the blowdown pressure. Lower the pressure and remove the gag from the first valve. Reseat the valve and prepare both valves for normal operation. In each case, note relief pipe temperatures as an indication of proper valve reseating.

(6) Using the charging and volume control system (with bleed greater than feed) reduce pressurizer level to 50 in. Check that the heaters automatically deenergize.

Vent and Drain System

Purpose - The purpose of this system is to demonstrate satisfactory operation of the system and check performance of individual components.

Method - Operate the system in conjunction with S.P. No. 503D2, PREOPERATIONAL PROCEDURES, NUCLEAR PLANT - MAIN COOLANT SYSTEM PRE-CORE LOADING TESTS, in order to determine the overall performance and satisfactory operation of the components, as described in Section 211, VENT AND DRAIN SYSTEM, PRIMARY PLANT. Verify:

(1) The discharge of hot and cold main coolant
(2) The venting of main coolant system gases

Sampling System

Purpose - The purpose of this system is to demonstrate satisfactorily that each main coolant sample point provides for the safe removal and collection of a specified quantity of representative fluid.

Cleaning - When design conditions are obtained at each sample point, blow down that sample line (with the appropriate coolers in service), to the primary drain collecting tank. Blow down each sample line until about 15 gal of fluid are discharged.

Method

(1) Perform sampling operations according to O.I. No. 504K1, PRIMARY PLANT SAMPLING SYSTEM - MAIN COOLANT SYSTEM. Check that the procedures are adequate for personnel safety and obtaining the desired sample.

(2) High pressure sampling for dissolved hydrogen has been provided as a check on the normal hydrogen sampling method. Procedures for the use of this high pressure connection will be developed in the field, if the check becomes desirable.

Shutdown Cooling System

Purpose - The purpose of this system is to evaluate the ability of the system to dissipate residual heat and fission product decay heat following main coolant system cooldown to 330 F and pressure reduction corresponding to 410 F pressurizer steam temperature.

Filling - Open the valves on both the shutdown cooling pump vent, the low pressure surge tank cooling pump vent, and the heat exchanger vents. Unlock and open the four key-locked motor-operated isolation valves in the inlet and outlet lines of the shutdown cooling system. Open all crossover valves between the shutdown cooling and low pressure surge tank cooling pumps and heat exchangers. Unlock and open the globe valve in the fuel pit emergency cooling line. Temporarily plug the suction bell in the fuel transfer pit pump and flood the pump with demineralized water from the priming line. Close the fuel transfer pit pump discharge valve and open the normally closed valve in the suction line tie to the emergency cooling line. Start one low pressure surge tank make-up pump on manual, and check that the shutdown cooling system is filling. As water discharges from each vent line, close the valve. When the system is filled to the key-locked isolation valves, isolate the system and stop the make-up pump.

Cleaning - Install a temporary strainer in the flanged connection at each pump suction. When the main coolant system has been filled, open the four key-locked valves and circulate main coolant through the shutdown cooling pump and heat exchanger. Repeat for the low pressure surge tank pump and cooler. Refer to O.I. No. 504M, SHUTDOWN COOLING SYSTEM, for instructions to operate the system.

Method - With the main coolant system at 330 F and 410 F pressurizer steam temperature, put all four main coolant pumps on line. If cooldown is in progress following performance of S.P. No. 503D2, PREOPERATIONAL PROCEDURES, NUCLEAR PLANT - MAIN COOLANT SYSTEM PRE-CORE LOADING TESTS, terminate steam by-pass. Put the shutdown cooling system in operation per O.I. No. 504M, SHUTDOWN COOLING SYSTEM, and determine that the system will lower main coolant temperature. Shutdown cooling flow may be slightly reduced, due to main coolant pump head and pressure drop across the reactor. Compare heat input calculated from the main coolant pump ammeter readings (corrected for heat removal by component cooling), with decay heat curves and determine minimum time at which shutdown cooling could be put in service.

Safety Injection System

Purpose - The purpose of this system is to determine the time required to bring the system up to full flow operation and to check that the motor-operated valves and the pumps are properly synchronized.

Filling - Hose down the safety injection and shield tank cavity water tank and drain through the 1 in. line to the sewer. Add about 100,000 gal of demineralized water to the tank, using the low pressure surge tank make-up pumps.

Cleaning - Install a temporary strainer in the 10 in. safety injection pump suction line. Open the motor-operated gate valve in the 3 in. recirculation line. Intermittently operate each safety injection pump manually during the filling time.

Method - As a part of the initial fill of the main coolant system (refer to S.P. No. 503D2, PREOPERATIONAL PROCEDURES, NUCLEAR PLANT - MAIN COOLANT SYSTEM PRE-CORE LOADING TESTS), automatically initiate E.I. No. 505B10, PRIMARY PLANT - TOTAL LOSS OF MAIN COOLANT. Check that the pumps do not run at shutoff, check that all valves and pumps are properly sequenced and timed, and record the time to obtain full flow, as indicated by pump ΔP and also by drop in tank volume. Stop the pumps as soon as full flow is obtained.

Purification System

Purpose - The purpose of this system is to establish that full design flow can be obtained and to vary flow between the design limits; to alternate flow paths so that each ion exchanger is shown to give satisfactory hydraulic performance.

Filling - Before the purification and chemical shutdown ion exchangers are installed, flood the purification, cooling and drain pumps with water from the low pressure surge tank (pump discharge valves closed, vent open). With the surge tank cooler by-pass valve closed and one ion exchanger inlet valve open, start one pump and open the pump discharge valve. When water discharges from the ion exchanger inlet line, close the inlet valve and open the inlet valve in the next ion exchanger. Repeat for all four ion exchangers, and stop the pump. Install the ion exchangers, close the globe valve in the purified make-up return to the charging pump suction header, open the crossover to the high surge tank level discharge line to waste disposal, and manually open the level control valve. Open one ion exchanger outlet valve, and pump demineralized water through the ion exchanger from the flush line until water discharges into the waste disposal tank. Isolate the ion exchanger and repeat for the other three ion exchangers.

Cleaning - Using the low pressure surge tank make-up pumps to maintain level in the surge tank, pump water through the purification system to waste disposal until the effluent sample meets purity standards.

Method - Start up the system per O.I. No. 504H, PURIFICATION SYSTEM. With both purification ion exchangers on line, vary the flow controller setting from 10 to 100 gpm, and observe indicated flow. Check that pump discharge pressure does not indicate unstable operation. Repeat the test, using the chemical shutdown ion exchangers. Operate and check all controls in the purification system.

Component Cooling System

Purpose - The purpose of this system is to determine that the component cooling system will circulate cooling water at the design rate and pressure; to determine that the various components are being adequately cooled.

Filling - With the component cooling pump, surge tank, and heat exchanger vents open, fill the system with demineralized water from the condensate supply line. With the exception of the surge tank vent, close each vent valve as water discharges from the vent line. Add potassium chromate solution from the corrosion control pot feeder to raise the level of chromate in the system to 500 ppm.

Cleaning - Install a temporary strainer in each component cooling pump suction line. Start up the system and circulate water to all components, as outlined in O.I. No. 504I, COMPONENT COOLING SYSTEM. Continue flushing until the drain taps run clean.

Method

(1) Circulate component cooling water with one pump. Place the various components on line, according to O.I. No. 504I, COMPONENT COOLING SYSTEM, and observe pump discharge pressure and system flow. Repeat for the other pump. Determine that design flow and pressure requirements are met by each pump.

(2) Using the temperature instrumentation for each component which can be tested under these conditions, determine that the component cooling system limits the temperature for each component to the design limit.

(3) Deenergize the operating pump and establish that the other pump automatically starts.

Chemical Shutdown System

Purpose - The purpose of this system is to check out the components, the batching procedure, and transfer features of the system.

Filling - Fill the 3,000 gal boric acid mixing and storage tank with about 1,000 gal of demineralized water from the low pressure surge tank make-up pumps.

Cleaning - With the boric acid fill and transfer lines isolated and recirculation loop open, start the boric acid solution transfer pump and agitator (high speed). After about one-half hour, during which the agitator and pump should be checked for performance, raise the water level in the mixing and storage tank. Stop the pump and agitator, and drain the tank via the drain-flush line.

Method

(1) Perform O.I. No. 504G1, CHEMICAL SHUTDOWN SYSTEM - BORIC ACID PREPARATION, to determine that boric acid batching procedures are correct.

(2) Pump the boric acid solution to the 125,000 gal safety injection and shield tank cavity water tank (refer to M.I. No. 506E3, REACTOR REFUELING, SHIELD TANK CAVITY - FILL AND DRAIN).

(3) When the main coolant system is to be initially borated, perform O.I. No. 504G2, CHEMICAL SHUTDOWN SYSTEM - BORIC ACID ADDITION.

NOTE: Rely on frequent sampling to establish the volume of boric acid solution required to attain shutdown boron concentration in the main coolant.

Corrosion Control System

Purpose - The purpose of this system is to obtain satisfactory evidence of the ability of the system to add the appropriate quantities of chemi als to the main coolant system.

Cleaning - Fill the hydrazine feed tank with demineralized water from the condensate supply line. Starting with any one of the three charging pump suction lines, take the cap off the strainer line and open the valve in the strainer line. Open the valves in the 1/2 in. feed line to charging pump suction and start the hydrazine feed pump. Collect about 8 gal of flush water in a receiver from each charging pump suction strainer.

Method

(1) Time the discharge of flush water and note volume change in feed tank and estimate the hydrazine injection rate at maximum flow adjustment.

(2) With the low pressure surge tank properly blanketed by nitrogen to 15 psi gage, open the remote operated isolation valve in the nitrogen gas header. Vent the low pressure surge tank to waste disposal, and determine maximum nitrogen flow to the surge tank by rate of change of cylinder pressure with time.

STARTUP PROCEDURE NO. 503D2

PREOPERATIONAL PROCEDURES, NUCLEAR PLANT
MAIN COOLANT SYSTEM PRE-CORE TESTS

I. Objective To fill, flush, hydrostatic test, and check heat-up and cooldown procedures for the main coolant system prior to installing the core.

II. Conditions

1. A minimum of 24,000 gal of primary grade demineralized water to fill the main coolant system is available.

2. The control rod mechanisms have been installed and seal welded or the control rod mechanism ports have been plugged. The eight remaining ports are also plugged.

   NOTE: To assure access to a leaky seal weld, the control rod drive mechanisms may be installed in three separate groups and leak tested after each installation. The control rod mechanisms would be installed as follows:

   a. Group I and II (center 4)
   b. Group III, IV, and V (intermediate 12)
   c. Group VI (outer 8)

3. All equipment in the main coolant system is in condition for filling and venting and for the flushing operation and is in condition to be hydrostatically tested.

   NOTE: The four preoperational filters and the steam generator manway covers, with gaskets, have been installed in each of the steam generator outlet nozzles.

   For visual inspection during the hydrostatic tests, welds and connections in the main coolant system are not insulated.

4. The secondary side of each steam generator is empty.

5. A hydrostatic test pump is connected to the charging pump discharge header and at least two hydrostatic pressure gages are installed.

6. All cleaning, exclusive of the recirculation flushing operation of pipes, valves and fittings, and associated equipment, is complete as well as certain installation and checkout tests.

7. Installation and checkout of the main coolant system instrumentation (pressure, temperature and flow indicators) is complete.

8. The thermal shield has been installed in the reactor vessel.

III. Precautions

1. While performing the operations covered in this document, the instruction manuals for the individual components in the main coolant system shall be followed. If there is a conflict between the instruction manuals and the instructions contained in this document, the instruction manual shall govern.

2. The pressure in the rotor-stator gap of the main coolant pumps must never be below atmospheric pressure.

3. Do not operate the main coolant pumps continuously until the system has been vented. Initially the pumps shall be jogged and the system shall be vented until the effluent from the vent is free of entrapped gas.

4. If a water solid isolated loop is above ambient temperature, precautions must be taken to prevent a vacuum from being formed by the contraction of the water as it cools.

5. Venting of the main coolant system should be performed when the coolant temperature is below 200 F.

6. The main coolant system pressure must not exceed 500 psi gage unless the reactor vessel metal temperature is above 90 F.

7. Before being hydrostatically tested, the main coolant system should be as free as possible of all gas pockets.

8. The main coolant system heating and cooling rate must not exceed 50 F per hr.

9. During plant heatup, the main coolant system must be held at 250 F for a sufficient length of time (approximately 2 hr) in order to obtain an isothermal condition in the reactor vessel.

IV. Check-off List

Prior to the initiation of this S.P., the check-off list must be completed by the operator(s) and signed off.

V. Instructions

1. Fill the main coolant system with demineralized water per O.I. No. 504D1, MAIN COOLANT SYSTEM - FILLING AND VENTING OF COMPLETE SYSTEM with the following exceptions:

   a. The filling of the main coolant system will be accomplished by use of the safety injection pump(s), pump suction being demineralized water taken from the safety injection shield cavity storage tank.

NOTE: The safety injection system, using demineralized water, should be tested in conjunction with the initial phase of the filling operation. Refer to S.P. No. 503D1, PREOPERATIONAL PROCEDURES, NUCLEAR PLANT - FILLING, CLEANING AND FUNCTIONAL TESTING OF AUXILIARY SYSTEMS.

b. Step No. 11a of O.I. No. 504D1, MAIN COOLANT SYSTEM - FILLING AND VENTING OF COMPLETE SYSTEM, the venting procedure is not done in conjunction with startup of the complete main coolant system but is done in conjunction with the flushing operation, Step No. 11-Note. During the initial filling operation stagnant water does not need to be removed from the control rod mechanisms but all mechanisms must be filled with water.

c. The main coolant system is maintained solid with demineralized water during the initial venting operation.

d. During the initial simultaneous operation of all four main coolant pumps, flow readings shall be taken on each loop. These flow readings shall be compared with the indicated flow during the subsequent flushing operation. In the event that a large reduction in the flow occurs (minimum pump flow is 2,500 gpm) the preoperational filter in the affected loop should be removed and cleaned.

e. If the pressure in the main coolant system approaches 500 psi gage before the coolant temperature is 90 F, the pressure may be reduced by venting, by opening the 25 gpm letdown valve in the bleed line, or by operation of the manually controlled flow valve in the drain header by-pass line to the low pressure surge tank.

2. After the main coolant system has been filled and vented, proceed with the initial hydrostatic test.

Initial hydrostatic test precautions and data are as follows:

a. Main coolant temperature - 100 to 110 F. (Obtained by pump heat)

NOTE: The reactor vessel metal temperature <u>must not</u> be below 90 F if the pressure is above 500 psi gage.

At the start of the test the main coolant temperature should be about 110 F.

b. Metal-water temperature equilibrium must be obtained in the main coolant system. The temperature of the outer wall of the reactor vessel and of the secondary side of the steam generator tube plates shall be determined and must meet the minimum values before the hydrostatic test is performed.

c. Pressurizer safety, loop relief valves, and relief valves on charging line at the feed and bleed heat exchanger - gagged.

d. Pressurizer solenoid relief valve is on manual control. Motor operated gate valve in inlet line to the pressurizer solenoid relief valve is open.

e. Hydrostatic test pressure - 3,435 psi gage (1 1/2 times the piping design pressure of 2,285 psi gage).

NOTE: Hydrostatic test pressure should be established in incremental steps as follows: (1) 500 psi gage (2) 1,000 psi gage (3) 1,500 psi gage (4) 2,000 psi gage (5) 2,500 psi gage (6) 3,000 psi gage (7) 3,435 psi gage

f. Test duration - two hours minimum.

g. With the main coolant system at 3,435 psi gage, observe the pressure stability. If drop in system pressure is excessive, the source of leakage should be determined and repairs should be made as required.

3. After maintaining hydrostatic test pressure of 3,435 psi gage for two hours, gradually reduce the system pressure to about 50 psi gage.

PRECAUTIONS: To prevent the main coolant pump stator can from collapsing, a positive pressure <u>must</u> <u>be</u> maintained on the main coolant system at all times. To meet this requirement, operation of the safety injection pumps, intermittent operation of the charging pumps (flow through the loop fill and chemical injection lines), or preferably a temporary head tank may be connected to the main coolant pump vent.

4. After the main coolant system has been hydrostatically tested and depressurized, remove gags from pressurizer safety, loop relief valves, relief valves on charging line at the feed and bleed heat exchanger and proceed with the main coolant system initial heat-up as follows:

a. Fill the secondary side of the steam generators to the startup level and close the main steam line nonreturn valves.

b. Start the pressure control and relief system. Refer to O.I. No. 504E, PRESSURE CONTROL AND RELIEF SYSTEM.

c. When the main coolant conditions are permissible, start the main coolant pumps. Refer to O.I. No. 504D4, MAIN COOLANT SYSTEM - STARTUP OF COMPLETE SYSTEM.

d. During the main coolant heat-up, maintain the normal pressurizer water level by intermittent operation of the bleed letdown valve(s).

e. Main coolant heat-up shall not exceed 50 F per hr. The system must be held at 250 F for a sufficient length of time (approximately 2 hr) in order to obtain an isothermal condition in the reactor vessel.

f. During plant heat-up, obtain information for determination of heating rate.

5. When the main coolant temperature has reached 514 F, terminate the initial plant heat-up by stopping the main coolant pumps.

NOTE: At this time the following tests should be performed:

a. Check set pressures for the pressurizer solenoid and self-actuated relief valves and for the pressurizer spray valve. Refer to S.P. No. 503D1, PREOPERATIONAL PROCEDURES, NUCLEAR PLANT - FILLING, CLEANING AND FUNCTIONAL TESTING OF AUXILIARY SYSTEMS.

NOTE: In order to prevent undue wear, subsequent tests performed on these valves should be kept to a minimum.

b. Hot leak test - Refer to O.I. No. 504D3, MAIN COOLANT SYSTEM, HOT LEAK TEST.

c. Feed and bleed performance tests. Refer to S.P. No. 503D1, PREOPERATIONAL PROCEDURES, NUCLEAR PLANT - FILLING, CLEANING AND FUNCTIONAL TESTING OF AUXILIARY SYSTEMS.

6. When required, the initial cooldown of the main coolant system shall be performed as follows:

a. Start one main coolant pump and alternate pump operation occasionally in order to keep main coolant temperature reasonably uniform.

NOTE: For safe operation of the main coolant pumps, the pressurizer steam conditions specified in O.I. No. 504E, PRESSURE CONTROL AND RELIEF SYSTEM, must be maintained.

b. Start steam flow through the secondary plant steam by-pass system. The rate of steam flow must be regulated so that the cooling rate of the main coolant system does not exceed 50 F per hr.

7. When main coolant conditions are permissible, start the shutdown cooling system. Refer to O.I. No. 504M, SHUTDOWN COOLING SYSTEM.

8. When the main coolant has been reduced in temperature to approximately 140 F and depressurized to about 50 psi gage, isolate and drain the loops. Refer to O.I. No. 504D2, MAIN COOLANT SYSTEM - FILLING, VENTING AND DRAINING AN ISOLATED LOOP.

9. After the loops have been drained, remove the preoperational filters from the steam generators, inspect the interior of the steam generator head for cleanliness, and replace manway covers. Refer to M.I. No. 506B1, PRIMARY PLANT - OPENING AND CLOSING ISOLATED MAIN COOLANT LOOP.

   NOTE: Strict cleanliness shall be observed during this operation.

10. For a complete visual inspection of the reactor vessel, remove reactor vessel head and remove water from reactor vessel with a portable sump pump. Refer to M.I. No. 506E2, REACTOR REFUELING - PREPARATION OF REACTOR SYSTEMS FOR REFUELING.

    NOTE: The recirculation flushing shall be repeated, if required, until the quality of the water drained from the system is satisfactory and inspection indicates that all surface contamination has been removed.

11. Fill and vent the complete main coolant system with borated (1,600 ppm) water. Refer to O.I. No. 504D1, MAIN COOLANT SYSTEM - FILLING AND VENTING OF COMPLETE SYSTEM.

    NOTE: Final venting shall be performed after the core is installed and after the main coolant gate valves are opened.

VI. Final Conditions

The reactor vessel head is removed, the vessel is filled with borated (1,600 ppm) water and is in condition for installation of the core. The isolated loops are filled and vented with borated water of the same concentration as the reactor vessel.

STARTUP PROCEDURE NO. 503E1

INITIAL CORE LOADING AND NUCLEAR CORE TESTS
INITIAL CORE LOADING

I. Objective To provide a safe and efficient method of initially installing the reactor vessel internals, the reactor core, the neutron sources, and the reactor vessel head preparatory to the initiation of the nuclear startup program and tests.

II. Conditions

1. The reactor vessel has been installed in its final position and the thermal shield segments bolted and welded together within it.

2. The following assemblies have been made up by welding or by the use of bolts and crimp type locking devices and are outside of the reactor vessel ready for use:

   Reactor vessel head assembly consisting of the reactor vessel head, control rod drive mechanisms, and thermal sleeves.

   Lower core support assembly consisting of the lower core support barrel, head alignment pins, internals alignment pins, core barrel, core baffle, lower core support plate, core plate guide blocks, control rod shrouds, and shroud tie plate.

   Upper core support assembly consisting of the upper core support barrel, lifting lugs, upper core support plate, core plate guide blocks, and shock absorber stops.

   Guide tube support assembly consisting of the guide tube support plate, lifting lugs, and guide buttons.

   Guide tube hold-down assembly consisting of the guide tube hold-down plate, lifting lugs, and core hold-down ring.

3. The primary plant component and systems test program has been completed.

4. The following preoperational startup procedures have been completed:

   S.P. No. 503D1, PREOPERATIONAL PROCEDURES, NUCLEAR PLANT - FILLING, CLEANING AND FUNCTIONAL TESTING OF AUXILIARY SYSTEMS

   S.P. No. 503D2, PREOPERATIONAL PROCEDURES, NUCLEAR PLANT - MAIN COOLANT SYSTEM PRE-CORE LOADING TESTS

5. The normal plant nuclear instrumentation has been checked out for operation (except for the source check with the reactor startup neutron sources).

6. Licensed personnel are present as well as personnel adequately trained in the following fuel handling operations:

   M.I. No. 506E1, REACTOR REFUELING - SITE HANDLING AND STORAGE OF NEW FUEL AND CONTROL RODS

   M.I. No. 506E2, REACTOR REFUELING - PREPARATION OF REACTOR SYSTEMS FOR REFUELING

7. The main coolant system is completely isolated. Refer to O.I. No. 504D7, MAIN COOLANT SYSTEM - SHUTDOWN OF COMPLETE SYSTEM.

8. The demineralized wat - storage tank is isolated.

9. The fuel handling equipment has been completely checked out with dummy fuel assembly and control rod.

10. Pertinent auxiliary systems are in the following status:

System	Status
Charging and Volume Control System (Refer to O.I. No. 504F)	Ready standby on manual control; lined up for suction from the 12% boric acid mixing and storage tank
Chemical Shutdown System (Refer to O.I. No. 504G)	Ready standby
Purification System (Refer to O.I. No. 504H)	System isolated
Component Cooling System (Refer to O.I. No. 504I)	In operation as required
Primary Plant Corrosion Control System (Refer to O.I. No. 504J)	Ready standby
Primary Plant Sampling System (Refer to O.I. No. 504K)	Ready standby
Shutdown Cooling System (Refer to O.I. No. 504M)	In operation

System	Status
Reactor Control System (Refer to O.I. No. 504N)	Rod position indication system disconnected; rod drive disconnected; T_{avg} control secured; rod breakers BK-1 & 2 are open and locked out; BK-3 are open
Nuclear Instrumentation System (Refer to O.I. No. 504O)	Normal operation
Radiation Monitoring System (Refer to O.I. No. 504P)	Normal operation
Vapor Container Atmosphere Control Systems (Refer to O.I. No. 504Q)	Normal operation at 15,000 cfm; personnel access hatch (both doors) open; radioactive filtration system secured
Safety Injection System (Refer to E.I. No. 505B10)	Isolated; charging pumps are lines up on 12% boric acid for this function; an amount of borated water of the chosen initial loading concentration sufficient to complete filling and venting of main coolant system should be in the safety injection shield tank cavity storage tank

III. Precautions

1. The reactor vessel interior must be thoroughly clean after the thermal shield segments are bolted and welded together within it.

2. All of the internals must be thoroughly clean and all of the locking devices must be crimped before insertion into the reactor vessel.

3. All of the fuel assemblies, control rods, shim rods, neutron sources, nuclear detectors, and handling tools must be thoroughly clean before insertion into the reactor vessel.

4. Foreign material must be prevented from falling into the reactor vessel during the loading operation.

5. The internals must be installed in strict accordance with the orientation marking on each part.

6. Once the addition of fuel to the core has begun, no operation can be performed which will reduce the boron concentration in the main coolant system.

7. No addition of fuel to the core can be made until the experimental results of the previous loading steps have been analyzed.

8. If during any loading step the count rate on any BF_3 channel goes up by a factor of as much as 2, the loading operation must be immediately stopped and the operation suspended until a satisfactory evaluation of the situation has been made.

9. If at any time the experimentally extrapolated value for the critical size of the reactor core is less than twice the number of fuel assemblies then in the core, the loading operation must be suspended until a satisfactory evaluation of the situation has been made.

10. No more than one nuclear detector should be relocated at any one time. In addition, at least three sets of data involving fuel additions must be taken with a given detector arrangement before that arrangement is changed.

    NOTE: This does not apply to Step No. 17 of Section V-D.

11. If one of the special BF_3 channels in the reactor vessel malfunctions, the loading operation must be suspended until the difficulty has been corrected. In addition, if more than one of these detector channels malfunctions, after the difficulties have been corrected, the three most previous fuel addition steps will be reversed and then repeated.

12. Should the loading operation be interrupted for a period of more than two hours, a new set of data must be taken before a new loading adjustment is made. If the new data deviates by more than 20% from the corresponding previous data, the last loading step involving the addition of fuel must be repeated and the extrapolation to criticality checked.

13. All of the fuel assemblies and internals must be properly seated before the reactor vessel head is installed.

IV. Check-off List

Prior to initiation of this S.P., the check-off list must be completed by the operator(s) and signed off.

V. Instructions

A. Procedural Method - The reactor vessel and pertinent portions of the primary coolant system will contain proper borated water from previous operations. The lower core support assembly will first be installed in the reactor vessel. Then the core components will be installed in a safe and systematic manner. One startup neutron source will be installed; and beginning in an area adjacent to that source, the control rods, shim rods, and fuel assemblies will be individually mounted on the lower core support plate. The loading will be accompanied by and regulated by inverse multiplication plots based on data obtained from special BF_3 detectors located inside the reactor vessel. The core will be maintained substantially subcritical throughout the loading operation. The last steps in the loading process will involve the installation of the remainder of the startup neutron sources and the checking of the corresponding response of the normal plant nuclear instrumentation. Upon the completion of the loading operation the remaining internals will be installed and the reactor vessel head will be bolted to the reactor vessel.

B. Data Required - The following data are required during the core loading operation and must be recorded as indicated:

1. Nuclear Instrumentation

   a. Count rate meter readings and scaler data from the special BF_3 channels as indicated below in Section V-D.

   b. When indicated below in Section V-D, normal plant BF_3 detector count rates and intermediate range ion chamber readings.

2. Immediately after it has been installed, the number and position of each core component in the core.

3. At least once every 8 hr during loading operations, the following:

   a. Temperature of the main coolant in the reactor vessel and in the remainder of the system.

   b. Boron concentration of the main coolant in the reactor vessel and in the remainder of the system.

4. Log of events.

C. Special Instrumentation Requirements - Not included as original equipment.

1. Three BF_3 detectors for installation within the reactor vessel, together with associated equipment including three preamplifiers, three amplifiers, three scalers, one count rate meter, and a system to provide an audible count rate indication at the charging floor in the vapor container.

2. At least two high sensitivity, (10^{-12} amp full scale or better) amplifiers for the intermediate range ion chambers.

D. Procedures

1. Check to be sure that the reactor vessel and the main coolant system is filled with borated (1,600 ppm), primary grade water to a level of approximately 2 ft below the top of the reactor vessel flange. Refer to M.I. No. 506E2, REACTOR REFUELING - PREPARATION OF REACTOR SYSTEMS FOR REFUELING.

2. Place the lower core support assembly into the reactor vessel by the use of a crane sling and removable lifting eyes.

3. Line up the charging pumps to take suction from the 12% boric acid storage tank, and place the pumps on "jury-rig" auto start. "Jury-rig" auto start can be provided by having a scram button at the operations area on the charging floor with temporary circuitry tied into the pressurizer low level charging pump start at the DP cell in the vapor container, or by direct circuitry to the charging pump breakers.

4. Establish and maintain circulation with the shutdown cooling pumps. Refer to the appropriate instructions in O.I. No. 504D7, MAIN COOLANT SYSTEM - SHUTDOWN OF COMPLETE SYSTEM.

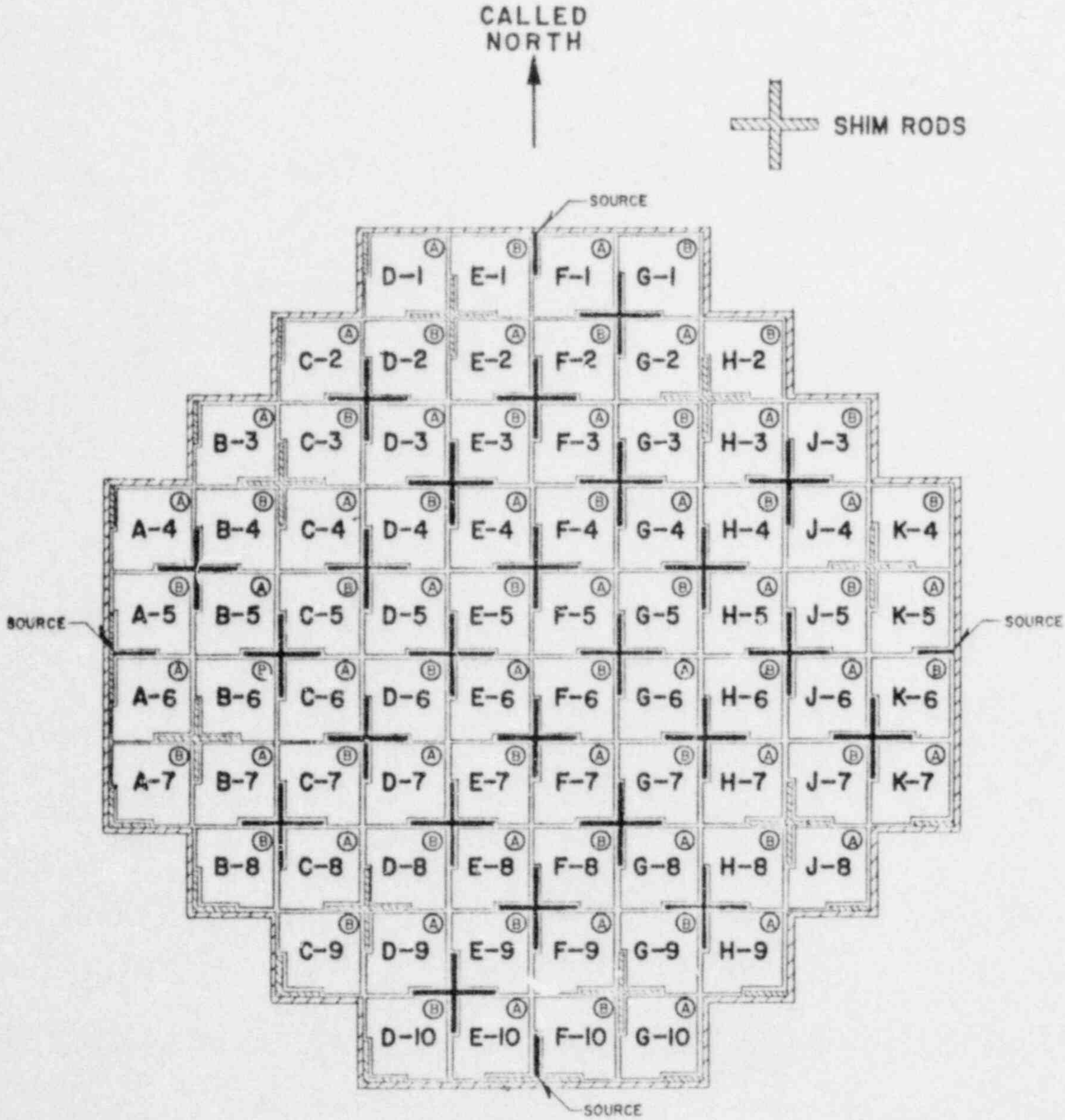
5. Obtain and record boron concentration in the main coolant. Refer to O.I. No. 504K, PRIMARY PLANT SAMPLING SYSTEM. Repeat this operation at least once every 8 hr.

6. Install the special BF_3 detectors within the reactor vessel at mid-fuel-assembly elevation as shown on page 503E1:7, that is,

   a. Channel B-1, (a fixed detector) in fuel assembly position H-2.

   b. Channel B-2, (a movable detector) in fuel assembly position C-2.

   c. Channel B-3, (a movable detector) in fuel assembly position D-1.



CORE LOADING PATTERN

7. Check out the special BF_3 channels with the detectors in place. After successful check out, record the nuclear instrumentation data indicated above in Section V-B; these data represent the background level.

8. Install one plant startup neutron source in position EF-1 by slipping the stainless steel vane to which it is attached into the appropriate slot in the core baffle.

9. Record nuclear instrumentation data indicated in Section V-B. These will be Baseline data. The special BF_3 channel count rates should show an increase of <u>10</u> counts per second over the corresponding data obtained in Step No. 7; if such is not the case, determine why not and, if necessary, make required adjustments before proceeding.

10. Establish at the charging floor in the vapor container a clearly audible signal which indicates the count rate of one of the special BF_3 channels.

11. Observing the appropriate instructions in the series M.I. No. 506E, REACTOR REFUELING, proceed to load the core in the sequence given in the attached Table I, Initial Core Loading Sequence for Yankee Reactor. Carefully observe the precautions listed in Section III, above. The loading conditions have been so chosen that there is no reasonable expectation but that the reactor will remain substantially subcritical throughout the loading. However, each time that a fuel assembly is added to the core the operation should be performed with the same care and attention as if the reactor were expected to go critical with the addition of that assembly.

12. After each loading increment and while preparations are being made for the next addition to the core, obtain and record the count rates from each of the special BF_3 channels.

13. Beginning after the addition of the first fuel assembly divide the observed count rate into the corresponding Baseline count rate (Step No. 9 above) and into the corresponding count rate from the most previous addition. Plot as ordinates both of these ratios as a function of the number of fuel assemblies installed in the core. Join the two most recent points of each set of data with a straight line which is extrapolated to intersect, if possible, the abscissa. This intersection will give the extrapolated value for the number of fuel assemblies required to make the core critical.

14. Repeat Steps Nos. 11, 12, and 13 above until the core is completely loaded except for fuel assemblies H-2, A-7, and J-8.

15. Record all the nuclear instrumentation data listed in Section V-B.

16. Install a plant startup neutron source in each of the positions A-56, K-56, and EF-10. Record all of the nuclear instrumentation data indicated above in Section V-B after each source is installed.

17. Complete the core loading (Steps Nos. 117 through 122 of Table I). After each detector is moved or a fuel assembly is added record data listed above in Section V-B. After each fuel assembly is added make an inverse multiplication plot (see Step No. 13 of Section V-D).

18. Remove the special BF_3 detectors from the reactor vessel. A suitable reading must be obtained on the normal plant nuclear instrumentation before this step.

19. Install the remaining internals and the reactor vessel head. Refer to M.I. No. 506E2, REACTOR REFUELING - PREPARATION OF REACTOR SYSTEMS FOR REFUELING.

20. Fill and vent the main coolant system, maintaining the boron concentration at (1,600 ppm). Refer to O.I. No. 504D1, MAIN COOLANT SYSTEM - FILLING AND VENTING OF COMPLETE SYSTEM.

    NOTE: Constant observation of the nuclear instrumentation is required during this operation. If the output of the nuclear instrumentation increases by a factor of 2, immediately stop the filling operation and initiate injection of the 12% boron solution. Refer to Step No. 3 of Section V-D and/or E.I. No. 505B10, PRIMARY PLANT - TOTAL LOSS OF MAIN COOLANT.

    Proceed with the filling and venting operation only after a satisfactory evaluation of the situation has been made.

21. Perform a cold leak test of the primary plant. Refer to M.I. No. 506B3, PRIMARY PLANT - COLD LEAK TEST.

VI. Final Conditions

The reactor vessel internals, the reactor core, the neutron sources, and the reactor vessel head have been assembled and the reactor is ready for the nuclear startup program and tests.

TABLE I

INITIAL CORE LOADING SEQUENCE FOR YANKEE REACTOR

Loading Sequence	Identification	Type of Assembly	Number of Fuel Elements Loaded
1	Source EF-1	Source in SS Vane	--
2	Shim DE-12	Shim Rod	--
3	Rod FG-12	Control Rod	--
4	Assembly E-1	B	1
5	Assembly F-1	A	2
6	Assembly G-1	B	3
7	Rod CD-23	Control Rod	--
8	Rod EF-23	Control Rod	--
9	Shim GH-23	Shim Rod	--
10	Assembly D-2	B	4
11	Assembly E-2	A	5
12	Assembly F-2	B	6
13	Assembly G-2	A	7
14	Shim BC-34	Shim Rod	--
15	Rod DE-34	Control Rod	--
16	Rod FG-34	Control Rod	--
17	Rod HJ-34	Control Rod	--
18	Assembly C-3	B	8
19	Assembly D-3	A	9
20	Assembly E-3	B	10
21	Assembly F-3	A	11
22	Assembly G-3	B	12
23	Assembly H-3	A	13
24	Rod AB-45	Control Rod	--
25	Rod CD-45	Control Rod	--
26	Rod EF-45	Control Rod	--
27	Rod GH-45	Control Rod	--
28	Shim JK-45	Shim Rod	--
29	Assembly B-4	B	14
30	Assembly C-4	A	15
31	Move detector B-2 from C-2 to position B-3		
32	Assembly C-2	A	16
33	Assembly D-4	B	17
34	Assembly E-4	A	18
35	Assembly F-4	B	19
36	Assembly G-4	A	20
37	Assembly H-4	B	21
38	Assembly J-4	A	22

Loading Sequence	Identification	Type of Assembly	Number of Fuel Elements Loaded
39	Move detector B-3 from D-1 to position J-3		
40	Assembly D-1	A	23
41	Rod BC-56	Control Rod	--
42	Rod DE-56	Control Rod	--
43	Rod FG-56	Control Rod	--
44	Rod HJ-56	Control Rod	--
45	Assembly A-5	B	24
46	Assembly B-5	A	25
47	Move detector B-2 from B-3 to position A-4		
48	Assembly B-3	A	26
49	Assembly C-5	B	27
50	Assembly D-5	A	28
51	Assembly E-5	B	29
52	Assembly F-5	A	30
53	Assembly G-5	B	31
54	Assembly H-5	A	32
55	Assembly J-5	B	33
56	Assembly K-5	A	34
57	Move detector B-3 from J-3 to position K-4		
58	Assembly J-3	B	35
59	Shim AB-67	Shim Rod	--
60	Rod CD-67	Control Rod	--
61	Rod EF-67	Control Rod	--
62	Rod GH-67	Control Rod	--
63	Rod JK-67	Control Rod	--
64	Assembly A-6	A	36
65	Assembly B-6	B	37
66	Assembly C-6	A	38
67	Assembly D-6	B	39
68	Assembly E-6	A	40
69	Assembly F-6	B	41
70	Assembly G-6	A	42
71	Assembly H-6	B	43
72	Assembly J-6	A	44
73	Assembly K-6	B	45
74	Rod BC-78	Control Rod	--
75	Rod DE-78	Control Rod	--
76	Rod FG-78	Control Rod	--
77	Shim HJ-78	Shim Rod	--
78	Assembly B-7	A	46

Loading Sequence	Identification	Type of Assembly	Number of Fuel Elements Loaded
79	Move detector B-2 from A-4 to position A-7		
80	Assembly A-4	A	47
81	Assembly C-7	B	48
82	Assembly D-7	A	49
83	Assembly E-7	B	50
84	Assembly F-7	A	51
85	Assembly G-7	B	52
86	Assembly H-7	A	53
87	Assembly J-7	B	54
88	Shim CD-89	Shim Rod	--
89	Rod EF-89	Control Rod	--
90	Rod GH-89	Control Rod	--
91	Move detector B-3 from K-4 to position K-7		
92	Assembly K-4	B	55
93	Assembly B-8	B	56
94	Assembly C-8	A	57
95	Assembly D-8	B	58
96	Assembly E-8	A	59
97	Assembly F-8	B	60
98	Assembly G-8	A	61
99	Assembly H-8	B	62
100	Move detector B-3 from K-7 to position J-8		
101	Assembly K-7	A	63
102	Rod DE-910	Control Rod	--
103	Shim FG-910	Shim Rod	--
104	Assembly C-9	B	64
105	Assembly D-9	A	65
106	Assembly E-9	B	66
107	Assembly F-9	A	67
108	Assembly G-9	B	68
109	Assembly H-9	A	69
110	Assembly D-10	B	70
111	Assembly E-10	A	71
112	Assembly F-10	B	72
113	Assembly G-10	A	73
114	Source A-56	Source in SS Vane	--
115	Source K-56	Source in SS Vane	--
116	Source EF-10	Source in SS Vane	--

Loading Sequence	Identification	Type of Assembly	Number of Fuel Elements Loaded
117	Remove detector B-3 from position J-8 and place it horizontally across the top of Assemblies H-8 and H-9		
118	Assembly J-8	A	74
119	Remove detector B-2 from position A-7 and place it horizontally across the top of Assemblies B-7 and B-8		
120	Assembly A-7	B	75
121	Remove detector B-1 from position H-2 and place it horizontally across the top of Assemblies H-3 and J-3		
122	Assembly H-2	B	76

STARTUP PROCEDURE NO. 503E2

INITIAL CORE LOADING AND NUCLEAR CORE TESTS
CONTROL ROD DRIVE AND PLANT SCRAM TESTS

I. Objective To establish the full operability of the control rod drive mechanisms, the integrity of the rod control and rod position indication circuits, and measure control rod scram and turbine throttle valves trip times.

II. Conditions

1. The main coolant system is in one of the following three conditions:

   a. Static and cold with a boron concentration of 1,600 ppm.

   b. At operating pressure and temperature with two adjacent main coolant pumps running and a boron concentration of 950 ppm.

   c. At operating pressure and temperature with four main coolant pumps running and a boron concentration of 950 ppm.

2. S.P. No. 503E1, INITIAL CORE LOADING AND NUCLEAR CORE TESTS - INITIAL CORE LOADING, has been completed.

3. The following checks have been made:

   a. Scram breakers closed
   b. Rod disconnect switches closed.
   c. Circuits feeding main control board are energized.
   d. All control rod operating switches are in nonactive positions.

4. Pertinent auxiliary systems are in the following status:

System	Status
Nuclear Instrumentation System (Refer to O.I. No. 5040)	Normal operation
Safety Injection System (Refer to E.I. No. 505B10)	Ready standby

III. Precautions

1. No rod group is to be withdrawn more than 9 in. unless the remaining groups are fully inserted.

2. Observe nuclear instrumentation during rod withdrawals. During control rod withdrawal, do not exceed a source count rate of two times the count rate observed with all control rods fully inserted.

IV. Tests and Data (not necessarily in this order) - Record data as required.

1. Circuit Checks

   a. Manual - Rods Out
   b. Manual - Rods In
   c. Manual - All Rods In
   d. Automatic - Rods Out
   e. Automatic - Rods In
   f. Manual Scrams
   g. Automatic Scrams

2. Mechanism Checks and Scram Time Measurements

   a. Individual Rod Position Indication
   b. Rod Group Position Indication
   c. Rod Group Withdrawal Rate
   d. Current Traces for the Operating Coils of Each Mechanism
   e. Control Rod Scram Time for Each Mechanism
   f. Turbine Throttle Valve Trip Time
   g. Circuit Scram Time for Automatic Trip Circuits

      1. High Flux Level
      2. Low Main Coolant Pressure
      3. High Start-up Rate
      4. Low Main Coolant Flow
      5. Generator Differential Relay
      6. Generator Ground Relay
      7. Unit Differential Relay
      8. Generator Overcurrent Relay
      9. Generator Loss of Field Relay
      10. No. 1 Station Service Transformer Overcurrent Relay
      11. No. 1 Station Service Transformer Differential Relay
      12. No. 4 Station Service Transformer Overcurrent Relay

V. Test Procedures

NOTE: All tests outlined below can be performed provided the conditions of Section II are observed.

1. Manual Group Motion

   a. Select group 6 rods

   b. Initiate manual "rods out" motion until rod group indicator reads 9 in. Note corresponding indications of the rod position indicators. Record the time required for the rod group to travel 9 in.

   c. Initiate manual "rods in" motion until rod group indicator reads 3 in. Note corresponding indications of the rod position indicators.

d. Repeat Steps a, b and c under Section IV-1 above for the remaining five rod groups in the following sequence - Groups 5, 4, 3, 2, 1.

e. Initiate manual "all rods in" motion until all rod group indicators read 0 in.

2. Automatic Group Motion

a. Select Group 5 rods.

b. Initiate automatic "rods out" motion until rod group indicator reads 6 in.

c. Initiate automatic "rods in" motion until rod group indicator reads 0 in.

3. Scram and Mechanism Tests

a. Manually withdraw four rods of Group 6 to a height of 90 in. Obtain current traces for the operating coils of each mechanism during withdrawal. Compare rod group position indication and individual rod position indication.

b. Manually scram the rods. Measure the total scram time for each individual rod and the total turbine throttle valve scram time for each valve. Also measure the time from initiation of the scram signal to the time the rod scram breakers trip and the time from initiation of scram to the time the turbine throttle valves trip.

c. Repeat steps a and b above, using the following rod groups:

1. The remaining four rods in Group 6.
2. Group 5 rods.
3. Group 4 rods.
4. Group 3 rods.
5. Group 2 rods.
6. Group 1 rods.

d. Manually withdraw all rods of Group 5 to a height of approximately 6 in.

e. Scram the rods using one of the remaining untested manual scram buttons. Measure the time from initiation of scram to the time both rod scram breakers trip and to the time both turbine throttle valves trip. Observe that the control rods drop.

f. Repeat Steps d and e using the remaining untested manual scram buttons.

g. Repeat Steps d and e, using each of the following automatic scram signals as the means of initiating scram:

High Flux Level
Low Main Coolant Pressure
High Start-up Rate
Low Main Coolant Flow
Generator Differential Relay
Generator Ground Relay
Unit Differential Relay
Generator Overcurrent Relay
Generator Loss of Field Relay
No. 1 Station Service Transformer Overcurrent Relay
No. 1 Station Service Transformer Differential Relay
No. 4 Station Service Transformer Overcurrent Relay

VI. <u>General Method for Determining Total Rod Scram Time</u>

1. When ful rod withdrawal is completed, apply the desired scram signal.

2. If necessary, the scram signal should simultaneously initiate the appropriate timing instrumentation which has been provided.

3. For determining when a rod is fully inserted, utilize the voltage across the lowest light of the rod positioner indicator.

STARTUP PROCEDURE NO. 503E3

INITIAL CORE LOADING AND NUCLEAR CORE TESTS
INITIAL CRITICALITY INSTRUCTION

I. Objective To establish initial criticality and minimum operational level.

II. Conditions

1. The following startup procedures have been completed:

   a. S.P. No. 503E1, INITIAL CORE LOADING AND NUCLEAR CORE TESTS - INITIAL CORE LOADING (including source check of instrumentation).

   b. S.P. No. 503E2, INITIAL CORE LOADING AND NUCLEAR CORE TESTS - CONTROL ROD DRIVE AND PLANT SCRAM TESTS (at ambient temperature).

2. Analytical prediction of control rod configuration for criticality has been completed and is available.

3. Special nuclear instrumentation, Section V-C, below, installed and checked out.

4. The main coolant system is filled with primary plant grade water containing 1,600 ppm boron. Venting of the system has been accomplished. Refer to O.I. No. 504D1, MAIN COOLANT SYSTEM - FILLING AND VENTING OF COMPLETE SYSTEM.

5. The boron concentration in the main coolant system has been checked using O.I. No. 504K1, PRIMARY PLANT SAMPLING SYSTEM - MAIN COOLANT SYSTEM.

6. Main coolant pressure and temperature are essentially at ambient.

7. The primary water storage tank is filled and isolated by temporarily locked valves and administrative control.

8. The main coolant system is ready for startup. Refer to O.I. No. 504D4, MAIN COOLANT SYSTEM - STARTUP OF COMPLETE SYSTEM.

9. Pertinent auxiliary systems are in the following status:

System	Status
Pressure Control and Relief System (Refer to O.I. No. 504E)	Ready for startup; filled with water to startup level
Charging and Volume Control System (Refer to O.I. No. 504F)	Ready for startup; system on manual control

System	Status
Chemical Shutdown System (Refer to O.I. No. 504G)	Normal standby; boric acid mixing and storage tank hot and filled
Purification System (Refer to O.I. No. 504H)	System isolated
Component Cooling System (Refer to O.I. No. 504I)	In operation as required
Primary Plant Corrosion Control System (Refer to O.I. No. 504J)	Ready standby
Primary Plant Sampling System (Refer to O.I. No. 504K)	Ready standby
Shutdown Cooling System (Refer to O.I. No. 504M)	Ready standby
Reactor Control System (Refer to O.I. No. 504N)	Ready standby on manual control
Nuclear Instrumentation System (Refer to O.I. No. 504O)	Normal operation
Radiation Monitoring System (Refer to O.I. No. 504P)	Normal operation
Vapor Container Atmosphere Control Systems (Refer to O.I. No. 504Q)	Normal operation
Safety Injection System (Refer to E.I. No. 505B10)	Ready standby

III. Precautions

1. Criticality should be anticipated at any time when control rods are being withdrawn.

2. Neutron sensitive detectors must be properly indicating at all times.

3. Any step resulting in a count rate increase by a factor of two or more must be followed by an inverse multiplication plot to redefine the control rod configuration for criticality. This will be done independently of the requirements stated in Section V-D, below.

4. After withdrawing control rod Group 6 to (40)* in., for use as the safety group, follow the sequence of Group 5 through Group 1, and restrict the withdrawal so that at no time is any one group more than 3 in. from the banked level of the remaining groups.

5. Startup rates greater than 1 decade per minute should be avoided.

IV. Check-off List

Prior to the initiation of the S.P., the check-off list must be completed by the operator(s) and signed off.

V. Instructions

A. Experimental Method - Initial criticality will be established using a prescribed withdrawal of control rods accompanied by and regulated by an inverse multiplication plot. After initial criticality is attained, a minimum operational level will be established and the linearity of the nuclear instrumentation checked.

B. Data Required - The following data are required and must be recorded as indicated in Section V-D, Experimental Procedure:

1. Nuclear Instrumentation

   a. Count rate meter readings and scaler data from the BF_3 channels

   and/or

   b. Outputs of the three intermediate range ion chamber channels.

   c. Stable startup rates.

2. Control rod positions.

3. Readings of temperature detectors in primary loops being used.

4. System pressure readings.

5. Boron concentration.

6. Time at which data are taken.

7. Log of events.

*To be confirmed.

C. Special Instrumentation Requirements - Not included as original equipment.

1. Scalers for BF_3 channels.

2. At least two extra-sensitive (better than 10^{-12} amp full scale) amplifiers for the compensated ion chamber channels. Strip recorders connected to the amplifier outputs.

D. Experimental Procedure

1. Notify all personnel that reactor startup is imminent and restrict all nonessential personnel to prescribed areas.

2. Record nuclear instrumentation data listed in Section V-B.

3. Check to see that the reactor shutdown amplifier has been reset.

4. Check that all control rods are at zero (fully inserted) position; then withdraw Group 6 control rods and put them in condition for ready insertion for safety protection. Refer to O.I. No. 504N, REACTOR CONTROL SYSTEM.

NOTE: Do not exceed a factor of 2 increase in count rate while withdrawing the safety rod group.

5. Start both of the shutdown cooling pumps, refer to O.I. No. 504M, SHUTDOWN COOLING SYSTEM. Adjust the shutdown cooling system to maintain the main coolant at ambient temperature ± 5 F.

6. Record data listed in Section V-B. These data will be used as base points for inverse multiplication plots.

7. Withdraw control rods 3 in. in the following sequence: Group 5, Group 4, Group 3, Group 2, Group 1. If during the withdrawal of Groups 5 through 1, the position of the safety rod Group 6 is attained, continue rod group withdrawal on a sequence of Group 6 through Group 1.

8. Record data listed in Section V-B. Plot ratio of data from Step No. 6 to data from this step versus banked control rod position for each BF_3 detector channel and extrapolate linearly to intersect the abscissa. The control rod position indicated by the intersection predicts the just critical rod bank configuration.

9. Repeat Steps Nos. 7 and 8 until the control rod positions are 12 in. below the extrapolated value for criticality.

10. Repeat Steps Nos. 7 and 8 using 2 in. increments of rod motion until criticality is achieved.

11. Using an incremental movement of the control rod bank, establish a startup rate of approximately 0.2 decades per minute. Record data listed in Section V-B.

12. Repeat Step No. 11 for startup rates of 0.4, 0.6, and 0.8 decades per minute. Limit the reactor flux level so that it does not exceed 6 decades above source level, Step No. 6 above. When a level of 6 decades above source level is reached, reduce the level by inserting control rods before continuing startup rate measurements.

13. During the measurements in Steps Nos. 11 and 12, record the nuclear channel instrument readings at decade intervals.

14. Leave the reactor, the auxiliary equipment, and the plant in the condition specified by person in charge of the experimental program.

E. <u>Data Analysis</u>

1. Using appropriate analytical curves, convert the startup rates observed in Steps Nos. 11 and 12 of Section V-D into reactivities.

2. Divide the reactivity increments by the appropriate banked control rod position increments to obtain the incremental banked control rod worth.

3. Extrapolate the banked control rod positions from Steps Nos. 11 and 12 of Section V-D back to the just critical position by obtaining the corresponding reactivity from Step No. 1 of Section V-E, dividing it by the incremental rod worth from Step No. 2 of Section V-E and then, subtracting the resultant distance from the appropriate banked control rod position.

STARTUP PROCEDURE NO. 503E4

INITIAL CORE LOADING AND NUCLEAR CORE TESTS
CONTROL ROD AND BORON WORTH DETERMINATIONS -
AT LOW TEMPERATURE

I. Objective To determine, at low temperature, the worth of banked control rods and the worth of boron in the reactor coolant.

II. Conditions

1. Satisfactory completion of S.P. No. 503E3, INITIAL CORE LOADING AND NUCLEAR CORE TESTS - INITIAL CRITICALITY INSTRUCTION.

2. Special nuclear instrumentation, Section V-C below, installed and checked out.

3. The main coolant system is filled with primary plant grade water containing 1,600 ppm boron. Venting of the system has been accomplished. Refer to O.I. No. 504D1, MAIN COOLANT SYSTEM - FILLING AND VENTING OF COMPLETE SYSTEM.

   The boron concentration in the main coolant system has been checked using O.I. No. 504K1, PRIMARY PLANT SAMPLING SYSTEM-MAIN COOLANT SYSTEM.

4. Main coolant pressure and temperature are essentially at ambient.

5. The primary water storage tank is filled (approximately 135,000 gal).

6. The main coolant system is ready for startup. Refer to O.I. No. 504D4, MAIN COOLANT SYSTEM - STARTUP OF COMPLETE SYSTEM.

7. Pertinent auxiliary systems are in the following status:

System	Status
Pressure Control and Relief System (Refer to O.I. No. 504E)	Ready for startup; filled with water to startup level
Charging and Volume Control System (Refer to O.I. No. 504F)	Ready for startup; system on manual control
Chemical Shutdown System (Refer to O.I. No. 504G2)	Normal standby; boric acid mixing and storage tank hot and filled
Purification System (Refer to O.I. No. 504H)	System isolated

System	Status
Component Cooling System (Refer to O.I. No. 504I)	Adequate coolant to equipment, as required
Primary Plant Corrosion Control System (Refer to O.I. No. 504J)	Ready standby
Primary Plant Sampling System (Refer to O.I. No. 504KI)	Ready standby
Shutdown Cooling System (Refer to O.I. No. 504M)	In operation, as required
Reactor Control System (Refer to O.I. No. 504N)	Ready standby on manual control with all rods inserted
Nuclear Instrumentation System (Refer to O.I. No. 504O)	Normal operation
Radiation Monitoring System (Refer to O.I. No. 504P)	Normal operation
Vapor Container Atmosphere Control Systems (Refer to O.I. No. 504Q)	Normal operation
Safety Injection System (Refer to E.I. No. 505B10)	Ready standby
Radioactive Waste Disposal System (Refer to O.I. No. 504L)	Capacity available to receive borated bleed

III. Precautions

1. Criticality should be anticipated at any time when control rods are being withdrawn.

2. Any plant changes which would produce a sudden lowering of the reactor coolant temperature (of the order of 10 F) must be avoided while the reactor is approaching criticality or is critical.

3. Startup rates greater than 1 decade per min should be avoided.

4. Available shutdown reactivity must not be reduced below 5% $\Delta k/k$ as determined by previous analysis and experiment. That is, the boron concentration in the system must not be reduced below the value required to give a k_{eff} of 0.95 for the core when all control rods are fully inserted.

5. Do not allow neutron flux levels to exceed 6 decades above source level.

IV. Check-off List

Prior to the initiation of this S.P., the check-off list must be completed by the operator(s) and signed off.

V. Instructions

A. Experimental Method - Control rod worths will be measured by removing boron and inserting control rods. Incremental control rod worths will be determined from startup rate changes caused by incremental control rod motions. Incremental boron worths will be determined by changes in startup rate corresponding to changes in boron concentration.

B. Data Required - The following data are required and must be recorded as indicated in Section D, Experimental Procedure, below:

1. Nuclear Instrumentation

a. Count rate meter readings and scaler data from the BF-3 channels

and/or

b. Outputs of the three intermediate range ion chamber channels.

c. Stable startup rates.

2. Control rod positions.

3. Readings of temperature detectors in primary loops being used.

4. System pressure readings.

5. Boron concentration.

6. Time at which data are taken.

7. Log of events.

C. Special Instrumentation Requirements - Not included as original equipment.

1. Scalers for BF_3 channels.

2. At least two extra-sensitive (better than 10^{-12} amp full scale) amplifiers for the compensated ion chamber channels. Strip recorders connected to the amplifier outputs.

3. Recording resistance bridge for at least one main coolant system temperature detector.

D. Experimental Procedure

1. Notify all personnel that reactor startup is imminent and restrict all nonessential personnel to prescribed areas.

2. Record nuclear instrumentation data as listed in Section V-E, above.

3. Check to see that the reactor shutdown amplifier has been reset.

4. Check that all control rods are at zero (fully inserted) position; then withdraw Group 6 control rods and put them in condition for ready insertion for safety protection. Refer to O.I. No. 504N - REACTOR CONTROL SYSTEM.

   NOTE: Do not exceed a factor of 2 increase in count rate in withdrawing the safety rod group.

5. Start two of the main coolant system pumps Nos. 2 and 4 (refer to O.I. No. 504D4, MAIN COOLANT SYSTEM - STARTUP OF COMPLETE SYSTEM). Open the other two loops stop valves, but do not start their pumps. Adjust systems pressure to (250 ± 50) psi gage. Use both heat exchangers of the shutdown cooling system, O.I. No. 504M, SHUTDOWN COOLING SYSTEM, to balance out pump heating and establish the lowest possible equilibrium temperature (about 110 ± 5 F).

6. Record data listed in Section V-B.

7. Perform reactor startup according to S.P. No. 503E6, INITIAL CORE LOADING AND NUCLEAR CORE TESTS - REACTOR STARTUP. Level reactor power after attaining criticality. Record data listed in Section V-B.

8. Reduce the boron concentration (see O.I. No. 504G3, CHEMICAL SHUTDOWN SYSTEM - BORIC ACID REMOVAL) until the startup rate approaches 0.8 decade per min.

9. Observe the startup rate, using stop-watch measurements of the level increase of the linear ion chamber channels, until it reaches steady value. Limit level increase to 6 decades above source level. If steady startup rate has not been achieved when the limiting level is reached, insert control rods, drop level 3 decades, and then, return the control rods to their previous position. Record data listed in Section V-B.

10. Insert control rods, maintaining them all at the same positions, until the startup rate drops to 0.7 decade per min. Record data listed in Section V-B.

11. Repeat Step No. 10 lowering the startup rate to 0.4 and 0.1 decade per min.

12. Repeat Steps Nos. 8 through 11 until the available shutdown reactivity approaches the minimum value, 5% $\Delta k/k$, as indicated by analytical calculations supported by the data obtained in this experiment.

13. Leave the reactor, the auxiliary equipment and the plant in the condition specified by the person in charge of the experimental program.

Data Analysis

1. Convert startup rate measurements in Steps Nos. 8 through 12 under Section V-D into reactivities.

2. Using banked rod position changes and corresponding reactivity changes from Step No. 1 under Section V-E, plot incremental rod worth as a function of banked rod position.

3. Using boron concentration changes and corresponding reactivity changes from Step No. 1 under Section V-E, determine the boron worth.

4. From the observed boron concentrations, calculate the banked control rod worths and plot as a function of banked control rod position. Compare the results with Step No. 2 under Section V-E.

STARTUP PROCEDURE NO. 503E5

INITIAL CORE LOADING AND NUCLEAR CORE TESTS
TEMPERATURE, PRESSURE AND FLOW COEFFICIENT DETERMINATIONS - WITH INCREASING TEMPERATURE

I. Objective To measure the temperature and pressure coefficients of reactivity under conditions of increasing moderator temperature, and to determine at near ambient temperature the reactivity effects of significant flow changes.

II. Conditions

1. The S.P. No. 503E4, INITIAL CORE LOADING AND NUCLEAR CORE TESTS - CONTROL ROD AND BORON WORTH DETERMINATIONS - AT LOW TEMPERATURE has been completed satisfactorily.

2. The main coolant system conditions are being maintained as follows:

   a. Temperature - about 110 ± 5 F

   b. Pressure - 250 ± 50 psi gage

   c. Boron concentration - same as at the conclusion of S.P. No. 503E4, INITIAL CORE LOADING AND NUCLEAR CORE TESTS - CONTROL ROD AND BORON WORTH DETERMINATIONS - AT LOW TEMPERATURE.

3. The special instrumentation, Section V-C below, has been installed and checked out.

4. The pertinent auxiliary systems are in the following status:

System	Status
Main Coolant System (Refer to O.I. No. 504D)	All four loops open, but only pumps Nos. 2 and 4 in operation
Pressure Control and Relief System (Refer to O.I. No. 504E)	Normal operation
Charging and Volume Control System (Refer to O.I. No. 504F)	Ready for startup; system on manual control
Chemical Shutdown System (Refer to O.I. No. 504G)	Normal standby; boric acid mixing and storage tank hot and filled
Purification System (Refer to O.I. No. 504H)	System isolated

System	Status
Component Cooling System (Refer to O.I. No. 504I)	Adequate coolant to equipment as required
Primary Plant Corrosion Control System (Refer to O.I. No. 504J)	Ready standby
Primary Plant Sampling System (Refer to O.I. No. 504K)	Ready standby
Radioactive Waste Disposal System (Refer to O.I. No. 504L)	Capacity available to receive borated bleed
Shutdown Cooling System (Refer to O.I. No. 504M)	In operation as required
Reactor Control System (Refer to O.I. No. 504N)	Ready standby on manual control
Nuclear Instrumentation System (Refer to O.I. No. 504O)	Normal operation
Radiation Monitoring System (Refer to O.I. No. 504P)	Normal operation
Vapor Container Atmosphere Control Systems (Refer to O.I. No. 504Q)	Normal operation
Safety Injection System (Refer to E.I. No. 505B10)	Ready standby

III. Precautions

1. Criticality should be anticipated at any time when control rods are being withdrawn.

2. Any plant changes which would produce a sudden lowering of the reactor coolant temperature (of the order of 10 F) must be avoided while the reactor is approaching criticality or is critical.

3. Startup rates greater than 1 decade per minute should be avoided.

4. Available shutdown reactivity must not be reduced below 3% $\Delta k/k$ as determined by analysis and experiment, including experimental data obtained during the performance of this procedure.

5. Use no more than three decades of power increase during startup rate measurements.

IV. Check-off List

Prior to the initiation of this S.P., the check-off list must be completed by the operator(s) and signed off.

V. Instructions

A. Experimental Method - The temperature coefficient and the pressure coefficient will be measured at various temperatures by changing the temperature or the pressure and observing the resultant changes in startup rates which can then be converted into changes in core reactivity. In addition, the reactivity effects of main coolant system flow changes will be measured by observing the effects of such changes on the startup rate.

B. Data Required - The following data are required and must be recorded as indicated in Section V-D, Experimental Procedure, below:

1. Nuclear Instrumentation

a. Count rate meter readings and scaler data from the BF_3 channels

and/or

b. Outputs of the three intermediate range ion chamber channels.

c. Stable startup rates.

2. Control rod positions.

3. Readings of temperature detectors in the main coolant system loops and at representative locations in the core.

4. System pressure readings.

5. Boron concentration (take samples at intervals of approximately 20 min).

6. Time at which data are taken.

7. Log of events.

C. Special Instrumentation Requirements - Not included as original equipment.

1. Scalers for BF_3 channels.

2. At least two extra sensitive (better than 10^{-12} amp full scale) amplifiers for the compensated ion chamber channels with strip chart recorders connected to the amplifier outputs.

3. Recording resistance bridge for at least one main coolant system temperature detector.

D. Experimental Procedure

1. Notify all personnel that reactor startup is imminent.

2. Verify that the conditions listed in Section II are satisfied.

3. Perform reactor startup with programed rod withdrawal. Level the reactor to approximately 3 decades above source level. Record the data listed in Section V-B.

4. Adjust control rod positions to obtain a startup rate of about 0.5 decade per minute. Record data listed in Section V-B.

5. Shut down the reactor by running in the controlling rod group.

6. Start up the main coolant system pumps Nos. 1 and 3.

NOTE: In the measurements through Step No. 10, minimize the time during which all four pumps are operating. This is required to avoid an excessive increase in main coolant temperature. Should the temperature reach 150 F, reduce it back to about 110 F by operating with only two pumps.

7. Return the controlling rod group to positions identical with those in Step No. 4; however, if in performing this operation, it should appear that the startup rate will exceed 1 decade per minute, proceed to Step No. 8c below. Record data listed in Section V-B.

8. a. If the startup rate observed in Step No. 7 is between 0.05 and 1 decade per minute, shut off the main coolant pumps Nos. 1 and 3. Record data listed in Section V-B.

   b. If the startup rate observed in Step No. 7 is less than 0.05 decade per minute, adjust the control rod positions to give a startup rate of 0.05 decade per minute; record data listed in Section V-B and then shut off the main coolant pumps Nos. 1 and 3. Record data listed in Section V-B.

c. If the startup rate observed in Step No. 7 is greater than 1 decade per minute, adjust the control rod positions to give a startup rate of 1 decade per minute; record data listed in Section V-B, and then shut off main coolant pumps Nos. 1 and 3. Record data listed in Section V-B.

9. a. If the final startup rate observed in Step No. 8 is between 0.05 and 1 decade per minute, again startup main coolant pumps Nos. 1 and 3. Record data listed in Section V-B. Compare the results with those obtained in Step No. 8. If they disagree by more than 10%, repeat Steps Nos. 8 and 9 until they do agree within 10%.

b. If it appears that the startup rates can not be maintained between 0.05 and 1 decade per minute for the four-pumps-on to two-pumps-on change, go to a banked control rod configuration and obtain the banked positions for a startup rate of about 0.5 decade per minute with the two pumps on. Record the data listed in Section V-B. Turn on pumps Nos. 1 and 3, obtain the banked rod positions for a startup rate of about 0.5 decade per minute. Record data listed in Section V-B. Adjust control rods back to the program configuration used in Step No. 3. Record the data listed in Section V-B.

10. Repeat Steps Nos. 4 through 9 with pumps Nos. 1 and 3 on and pumps Nos. 2 and 4 alternately on and off.

11. With all four main coolant pumps in operation, close down the shutdown cooling system and begin the warm-up of the main coolant system.

NOTE: During the remainder of this procedure, record the temperature measurements at least once every 5 min unless otherwise specified.

12. Adjust the control rod positions to give a startup rate of about 0.5 decade per minute. Record data listed in Section V-B.

13. When level approaches 6 decades above source level, drop back to approximately 3 decades above source level by running in control rods, and then return those control rods to positions identical with those in Step No. 12. Record data listed in Section V-B.

14. Repeat Steps Nos. 12 and 13 until the startup rate drops to 0.05 decade per minute. Then readjust the control rod positions to give a startup rate of 0.5 decade per minute. Record data listed in Section V-B.

15. Repeat Steps Nos. 12, 13, and 14 until the temperature reaches 250 F.

16. Lower the temperature to 200 F and repeat Steps Nos. 12, 13, and 14 in temperature range 200 - 250 F with a banked control rod configuration.

17. Change control rods to the program configuration used in Step No. 3. Record data listed in Section V-B.

18. Maintain the main coolant system temperatures at 250 ± 3 F with the aid of the steam by-pass to condenser system until the core vessel and components reach temperature equilibrium (approximately 2 hr). Then, maintaining the main coolant system temperature at 250 ± 3 F, increase the main coolant system pressure to 2,000 psi gage in 200 psi steps. Record data listed in Section V-B after each step. Then maintain the pressure at 2,000 ± 50 psi gage.

19. When the equilibrium temperature has been reached, shut off the steam by-pass system and repeat Steps Nos. 12, 13, and 14 until the main coolant system temperature reaches 539 F.

20. Start up the steam by-pass system and adjust it to stabilize the temperature at 539 ± 1 F.

21. Adjust the control rods to give a startup rate of about 0.1 decade per minute. Record data listed in Section V-B.

22. Increase steam by-pass flow to lower the temperature to 534 F and adjust it to hold at this temperature ± 1 F. Record data listed in Section V-B.

23. Repeat Step No. 22, successively dropping the temperature in 5 F steps to 489 F. If startup rate approaches 1 decade per minute during this sequence of measurements, hold temperature at the nearest of those listed and adjust the control rods to lower the startup rate to 0.1 decade per minute. Record the data listed in Section V-B and then proceed with the other measurements.

24. Change control rods to banked configuration and repeat Steps Nos. 12, 13, and 14 until temperature reaches 539 F.

25. Repeat Steps Nos. 21, 22, and 23.

26. Change to control rod configuration used in Step No. 3.

27. Decrease the steam by-pass flow and repeat Steps Nos. 12, 13, and 14 until the temperature reaches 514 F.

28. Adjust steam by-pass and hold the temperature at 514 ± 3 F during the remainder of the procedure.

29. Using analytical information together with the value of the temperature coefficient obtained from a preliminary analysis of the data obtained in Steps Nos. 20 through 25, determine the expected value for the pressure coefficient. If this value is such that it appears feasible to do so, select a startup rate such that when the pressure is lowered from 2,000 psi gage to 1,200 psi gage, the startup rate will remain positive. Otherwise, select a startup rate of about 1 decade per minute and, during the course of the pressure decrease, readjust the startup rate whenever it drops to 0.05 decade per minute.

30. Adjust control rods to obtain the startup rate selected in the previous step. Record data listed in Section V-B.

31. As rapidly as is practical, decrease the main coolant system pressure (refer to O.I. ... 504E, PRESSURE CONTROL AND RELIEF SYSTEM) from 2,000 psi gage to 1,200 psi gage. Record data listed in Section V-B at least once every 2 min.

32. Adjust control rod positions to obtain a startup rate of about 0.1 decade per minute. Then increase the main coolant system pressure to 2,400 psi gage in 200 psi steps. Record data listed in Section V-B after each step. Should the startup rate approach 1 decade per minute, hold the pressure at the nearest of the values in the sequence and adjust the control rods to reduce the startup rate of 0.1 decade per minute. Record the data listed in Section V-B and then proceed with the remaining measurements.

33. Holding the pressure at 2,400 ± 50 psi gage, adjust the control rods to obtain a startup rate of about 1 decade per minute. Record the data listed in Section V-B. Decrease main coolant system pressure as rapidly as practical to 2,000 psi gage. Record the data listed in Section V-B at least once every 2 min.

34. Leave the reactor, the auxiliary equipment, and the plant in the condition specified by the person in charge of the experimental program.

E. Data Analysis

1. Convert all startup rate measurements into reactivities.

2. From the temperature measurements, obtain the average temperature (θ) of the reactor core and plot it as a function of time for the entire period covered by this procedure.

3. For each set of measurements with a given control rod configuration during Steps Nos. 11 through 16, 19 through 24, and 27 of Section V-D and using the corresponding reactivities from Step No. 1 under Section V-E, obtain the change in reactivity ($\Delta\rho$) as a function of time.

4. Combining Steps Nos. 2 and 3 of Section V-E and using time as the common variable, obtain the temperature coefficient ($\Delta\rho/\Delta\theta$) as a function of temperature for each of the control rod configurations used.

5. From data obtained during Steps Nos. 21, 22, 23, and 25 under Section V-D, determine the change in reactivity ($\Delta\rho$) for each change in temperature ($\Delta\theta$) and plot the temperature coefficient ($\Delta\rho/\Delta\theta$) as a function of temperature. Compare the results obtained here with the appropriate portion of those obtained in Step No. 4 of Section V-E.

6. Select from the reactivities obtained in Step No. 1 of Section V-E, the reactivity changes ($\Delta\rho$) corresponding to the pressure changes (Δp) in Steps Nos. 18 and 30 through 33 of Section V-D.

7. From the temperature recorder charts and/or readings, obtain the temperatures and temperature changes during the pressure changes. Using these data together with the temperature coefficients obtained in Step No. 4 of Section V-E, correct the reactivity changes in Step No. 6 of Section V-E for any temperature variations during the measurement of those reactivity changes.

8. Combine these corrected values of $\Delta\rho$ with the corresponding pressure changes (Δp) to obtain the pressure coefficient ($\Delta\rho/\Delta p$) as a function of pressure at the two temperatures used.

9. From Step No. 1 of Section V-E select the reactivities and changes in reactivity corresponding to the data obtained during Steps Nos. 4 through 10 of Section V-D. These changes in reactivity give the reactivity effects of the corresponding changes in main coolant flow.

STARTUP PROCEDURE NO. 503E6

INITIAL CORE LOADING AND NUCLEAR CORE TESTS
REACTOR STARTUP

I. Objective To provide a safe and efficient method for starting up the reactor during the plant startup tests when the normal plant startup procedure, O.I. No. 504A1, PLANT STARTUP - REACTOR STARTUP FROM COLD CONDITION, is not applicable.

II. Conditions

1. The startup procedure, S.P. No. 503E3, INITIAL CORE LOADING AND NUCLEAR CORE TESTS - INITIAL CRITICALITY INSTRUCTION, has been completed and the results obtained are available.

2. If additional startup procedures have been completed or are in progress, the most recent applicable data are available on the following:

   a. Boron concentration in the main coolant system.

   b. Main coolant system temperature, pressure and number of loops in operation.

   c. Corresponding control rod positions for criticality.

3. A prediction of the control rod positions expected for criticality has been made using the best available experimental and analytical data.

4. Other conditions are the same as those specified in the startup procedure in connection with which this procedure is being performed.

   NOTE: If at the time criticality is to be achieved, the reactor conditions (i.e., temperature, pressure and/or boron concentration) are to differ from those for which previous criticality data are available and the differences are such as to cause an increase of 0.5% $\Delta k/k$ or more in core reactivity, then, the approach to criticality must be guided by a plot of inverse multiplication versus control rod position.

III. Precautions

1. Criticality should be anticipated at any time when the control rods are being withdrawn, or the boron concentration in the main coolant system is being reduced, or the temperature of the main coolant system is being lowered.

2. During each phase of the control rod withdrawal, the outermost control rods must be moved first and the innermost moved last.

3. Startup rates greater than one decade per minute should be avoided.

4. Observe the precautions listed in the startup procedure in connection with which this procedure is being performed.

IV. Check-off List

Prior to the initiation of this S.P., the check-off list must be completed by the operator(s) and signed off. If this S.P. is being performed in connection with another S.P., the two check-off lists may be combined.

V. Instructions

1. Notify all personnel that startup of the reactor is imminent.

2. Record the source and range count rates. Do not exceed a factor of two increase in the source range count rate during the withdrawal of the safety protection control rod group.

3. Check that all control rods are at zero (fully inserted) position; then withdraw the Group 6 control rods half way and put them in condition for ready insertion for safety reasons. Refer to O.I. No. 504N, REACTOR CONTROL SYSTEM. Record the source range count rates.

4. Check the main coolant system for the following:

   a. Temperature and pressure. Refer to appropriate console instruments.

   b. Boron concentration. Refer to O.I. No. 504K1, PRIMARY PLANT SAMPLING SYSTEM - MAIN COOLANT SYSTEM.

   c. Flow rates through each primary loop. Refer to the appropriate console instruments.

5. If necessary, adjust the main coolant system temperature, pressure and number of loops in operation and/or boron concentration until either they are the same as those for which previous criticality data are available (see Section II Step No. 1 or No. 2) or they agree with those required by the pertinent startup procedure.

   a. For adjustment of temperature, pressure or number of loops in operation refer to the startup procedure in connection with which this procedure is being performed.

b. For adjustment of the boron concentration, refer to the appropriate portion of O.I. No. 504G, CHEMICAL SHUTDOWN SYSTEM.

6. Continuously check and, if necessary, readjust the core conditions. Refer to Steps Nos. 4 and 5 of Section V.

7. If it is desired to go critical with all rods in banked position, proceed with Steps Nos. 8 through 13 below. If it is desired to go critical with rods in normal programmed sequence, omit Steps Nos. 8 through 13 and proceed to Step No. 14.

8. While observing nuclear instrumentation, withdraw each of the other control rod groups 3 in. at a time in the following order: Groups 5, 4, 3, 2 and 1 and repeat in same order. Do not allow any rods except Group 6 to deviate more than 3 in. from the position of the rod bank.

9. When the bank height reaches the position of the Group 6 rods, continue withdrawing rods as required in the following sequence: Groups 6, 5, 4, 3, 2 and 1 and repeat in the same order.

   NOTE: Maintain a plot of inverse multiplication versus banked rod position in Steps Nos. 8 and 9 if required by the note under Section II, Step No. 4.

10. Continue intermittent rod withdrawal and inverse multiplication plots, if required, until the reactor is critical.

11. Establish a startup rate of approximately 0.5 decade per minute and raise the power level to approximately 3 decades above initial source level.

12. Insert rods to maintain reactor power level constant. Adjust rods until all are at approximately the same level and record control rod positions, T_{avg} and system pressure for just critical conditions.

13. Proceed with the startup procedure for which this reactor startup was performed.

14. While observing nuclear instrumentation, withdraw each control rod group in normal program sequence.

   NOTE: Maintain a plot of inverse multiplication versus total rod withdrawal if required by the note under Section II, Step No. 4.

15. Continue intermittent rod withdraw and inverse multiplication plots, if required, until the reactor is critical.

16. Establish a startup rate of approximately 0.5 decade per minute and raise power level to approximately 3 decades above source level.

17. Insert rods to maintain reactor power level constant. Record control rod positions, T_{avg} and system pressure for just critical conditions.

18. Proceed with the startup procedure for which this reactor startup was performed.

VI. Final Condition

The reactor is critical at approximately 3 decades above source level and ready for the performance of the pertinent startup procedure.

STARTUP PROCEDURE NO. 503E7

INITIAL CORE LOADING AND NUCLEAR CORE TESTS
CONTROL ROD AND BORON WORTH DETERMINATIONS -
AT OPERATING TEMPERATURE

I. Objective To determine, at operating temperature, the worth of banked and programed control rods and the worth of boron in the reactor coolant

II. Conditions

1. S.P. No. 503E5, INITIAL CORE LOADING AND NUCLEAR CORE TESTS - TEMPERATURE, PRESSURE AND FLOW COEFFICIENT DETERMINATIONS - WITH INCREASING TEMPERATURE, has been satisfactorily completed.

2. Main coolant system conditions are being maintained as follows:

   a. Temperature - 514 ± 3 F maintained by steam by-pass to condenser.

   b. Pressure - 2,000 ± 50 psi gage.

   c. Boron concentration - Same as at the conclusion of S.P. No. 503E5, TEMPERATURE, PRESSURE AND FLOW COEFFICIENTS DETERMINATION - WITH INCREASING TEMPERATURE

3. Special instrumentation, Section V-C below, installed and checked out.

4. Pertinent auxiliary systems are in the following status:

System	Status
Main Coolant System (Refer to O.I. No. 504D)	Normal operation
Pressure Control and Relief System (Refer to O.I. No. 504E)	Normal operation
Charging and Volume Control System (Refer to O.I. No. 504F)	Ready for startup; system on manual control
Chemical Shutdown System (Refer to O.I. No. 504G)	Normal standby; boric acid mixing and storage tank hot and filled
Purification System (Refer to O.I. No. 504H)	System isolated

System	Status
Component Cooling System (Refer to O.I. No. 504I)	Adequate coolant to equipment as required
Primary Plant Corrosion Control System (Refer to O.I. No. 504J)	Ready standby
Primary Plant Sampling System (Refer to O.I. No. 504K)	Ready standby
Radioactive Waste Disposal System (Refer to O.I. No. 504L)	Capacity available to receive borated bleed
Shutdown Cooling System (Refer to O.I. No. 504M)	In operation as required
Reactor Control System (Refer to O.I. No. 504N)	Ready standby on manual control
Nuclear Instrumentation System (Refer to O.I. No. 504O)	Normal operation
Radiation Monitoring System (Refer to O.I. No. 504P)	Normal operation
Vapor Container Atmosphere Control Systems (Refer to O.I. No. 504Q)	Normal operation
Safety Injection System (Refer to E.I. No. 505B10)	Ready standby

III. Precautions

1. Criticality should be anticipated at any time when control rods are being withdrawn.

2. Any plant changes which would produce a sudden lowering of the reactor coolant temperature (of the order of 10 F) must be avoided while the reactor is approaching criticality or is critical.

3. Startup rates greater than 1 decade per minute should be avoided.

4. Available shutdown reactivity must not be reduced below 3% $\Delta k/k$ as determined by analysis and experiment, including experimental data obtained during the performance of this procedure.

5. Use no more than 3 decades of power increase during startup rate measurements.

IV. Check-off List

Prior to the initiation of the S.P., the check-off list must be completed by the operator(s) and signed off.

V. Instructions

A. Experimental Method - Control rod worths will be measured by removing boric acid and inserting control rods. Incremental control rod worths will be determined from startup rate changes caused by incremental control rod motions. Incremental boron worths will be determined by changes in startup rate corresponding to changes in boron concentration.

B. Data Required - The following data are required and must be recorded as indicated in Section V-D, Experimental Procedure, below:

1. Nuclear Instrumentation

   a. Count rate meter readings and scaler data from the BF_3 channels

   and/or

   b. Outputs of the three intermediate range ion chamber channels.

   c. Stable startup rates.

2. Control rod positions.

3. Readings of temperature detectors in main coolant loops being used.

4. System pressure readings.

5. Boron concentration (take sample after each change in boron concentration and/or about once every 20 min).

6. Time at which data are taken.

7. Log of events.

C. Special Instrumentation Requirements - Not included as original equipment.

1. Scalers for BF_3 channels

   or

   Two extra sensitive (better than 10^{-12} amp full scale) amplifiers for the compensated ion chamber channels with strip chart recorders connected to the amplifier outputs.

2. Recording resistance bridge for at least one main coolant system temperature detector.

D. Experimental Procedure

1. Notify all personnel that reactor startup is imminent.

2. Verify that the conditions listed in Section II have been satisfied.

3. Perform reactor startup according to S.P. No. 503E6, INITIAL CORE LOADING AND NUCLEAR CORE TESTS - REACTOR STARTUP. Level reactor power approximately 3 decades above source level. Record data as listed in Section V-B.

4. Adjust boric acid concentration until all control rods are removed and the reactor is on a measurable startup rate. Record data as listed in Section V-B.

   NOTE: In performing the startup rate measurements in this procedure, do not exceed a power level of approximately 6 decades above source level.

5. Following the procedures outlined below, reduce the boron concentration and observe the control rod positions and boron concentration required to maintain criticality for various rod configurations including all rods banked and rods in programed sequences. Rod configurations to be studied will be determined by the person in charge of the experimental program.

   NOTE: Experimental results must be checked frequently to determine that the reactor will be at least 3% $\Delta k/k$ shutdown with all control rods fully inserted. Do not reduce boron concentration below this limit.

6. Determine incremental control rod worths for various rod configurations including all rods banked and rods in programed sequences. Follow Steps Nos. 7 through 15, to measure incremental worths of all rods banked. Follow Steps Nos. 16 through 23, to measure incremental worths of programed rods.

All Rods Banked:

7. Adjust all control rods to banked position, i.e., all rods of the same vertical position in the core. Record data as listed in Section V-B.

8. Reduce boron concentration (refer to O.I. No. 504G3, CHEMICAL SHUTDOWN SYSTEM - BORIC ACID REMOVAL) until the startup rate approaches 0.8 decades per min. Record data as listed in Section V-B.

9. Repeat this startup rate measurement until boron concentrations are uniform in the main coolant as indicated by consistent startup rate measurements.

10. Insert Group 1 rods to establish 0.5 decade per min startup rate and record data as listed in Section V-B.

11. Insert Group 1 rods to establish 0.3 decade per min startup rate and record data as listed in Section V-B.

12. Insert Group 1 rods to establish approximately 0 startup rate and record data as listed in Section V-B.

13. Repeat Steps Nos. 8 through 12 using rod groups 2, 3, 4, 5, and 6 in that order. However, it is necessary that all rods end up banked at the same vertical position. Thus, in successive Steps 12, for each of the rod groups, it may be necessary to adjust the boron concentration if the rod group involved is still above the position of Group 1; or it may be necessary to proceed to the next group in the sequence before a 0 startup rate is reached if the reactor still has a positive startup rate when the rod group involved reaches the position of Group 1.

14. Remove Group 1 to the position it had during Step No. 7 and record the data listed in Section V-B. Then return the Group 1 rods to the position they had during Step No. 12.

15. Repeat Step No. 14 using rod groups 2, 3, 4, and 5 in that order.

<u>Rods in Programed Sequence:</u>

16. Adjust the control rods into a programed configuration. Maintain criticality by adjusting the position of the controlling group. Record data as listed in Section V-B.

17. Reduce boron concentration (refer to O.I. No. 504G3, CHEMICAL SHUTDOWN SYSTEM - BORIC ACID REMOVAL), until the startup rate approaches 0.8 decade per min. Record data as listed in Section V-B.

18. Repeat this startup rate measurement until the boron concentration is uniform in the main coolant as indicated by consistent startup rate measurements.

19. Insert the controlling rod group to establish a 0.5 decade per min startup rate. Record data as listed in Section V-B.

20. Insert the controlling rod group to establish a 0.3 decade per min startup rate. Record data as listed in Section V-B.

21. Insert the controlling rod group to establish approximately 0 startup rate. Record data as listed in Section V-B.

22. Repeat Steps Nos. 17 through 21 again.

23. Continue incremental rod worth determinations and rod position vs. boron concentration measurement until the boron concentration is reduced to the minimum practical value or until only 3% Δk/k shutdown is left in the control rods.

24. Leave the reactor, the auxiliary equipment and the plant in the condition specified by the person in charge of the experimental program.

E. Data Analysis

1. Convert the startup rate measurements into reactivities.

2. Using control rod position changes and corresponding reactivity changes from Step E-1, plot incremental rod worth as a function of control rod position.

3. Using boron concentration changes and corresponding reactivity changes from Step E-1, plot incremental boron worth as a function of boron concentration.

4. From the observed boron concentrations, calculate the banked control rod worths and plot them as a function of control rod position. Compare the corresponding results with Step E-2.

5. From the observed boron concentrations, calculate the worths of the various rod configurations studied.

STARTUP PROCEDURE NO. 503E8

INITIAL CORE LOADING AND NUCLEAR CORE TESTS
TEMPERATURE, PRESSURE AND FLOW COEFFICIENT DETERMINATIONS -
WITH DECREASING TEMPERATURE

I. Objective To measure the temperature and pressure coefficients of reactivity under conditions of decreasing moderator temperature, and to determine at operating temperature the reactivity effects of significant flow changes.

II. Conditions

1. The startup procedure, S.P. No. 503E7, INITIAL CORE LOADING AND NUCLEAR CORE TESTS - CONTROL ROD AND BORON WORTH DETERMINATIONS AT OPERATING TEMPERATURE, has been completed satisfactorily.

2. The main coolant system conditions are being maintained as follows:

   a. Temperature - 514 ± 3 F - Adjust turbine steam by-pass to condenser to hold this valve.

   b. Pressure - 2,000 ± 50 psi gage.

   c. Boron Concentration - At minimum practical value (to be determined in the field).

3. Special instrumentation, Section V-C, installed and checked out.

4. Pertinent auxiliary systems are in the following status:

System	Status
Main Coolant System (Refer to O.I. No. 504D)	Normal operation
Pressure Control and Relief System (Refer to O.I. No. 504E)	Normal operation
Charging and Volume Control System (Refer to O.I. No. 504F)	Ready for startup; system on manual control
Chemical Shutdown System (Refer to O.I. No. 504C)	Normal standby; boric acid mixing and storage tank hot and filled
Purification System (Refer to O.I. No. 504H)	System isolated

System	Status
Component Cooling System (Refer to O.I. No. 504I)	Adequate coolant to equipment as required
Primary Plant Corrosion Control System (Refer to O.I. No. 504J)	Ready standby
Primary Plant Sampling System (Refer to O.I. No. 504K)	Ready standby
Radioactive Waste Disposal System (Refer to O.I. No. 504L)	Ready standby
Shutdown Cooling System (Refer to O.I. No. 504M)	In operation, as required
Reactor Control System (Refer to O.I. No. 504N)	Ready standby on manual control
Nuclear Instrumentation System (Refer to O.I. No. 504O)	Normal operation
Radiation Monitoring System (Refer to O.I. No. 504P)	Normal operation
Vapor Container Atmosphere Control Systems (Refer to O.I. No. 504Q)	Normal operation
Safety Injection System (Refer to E.I. No. 505B10)	Ready standby

III. Precautions

1. Criticality should be anticipated at any time when control rods are being withdrawn.

2. Any plant changes which would produce a sudden lowering of the reactor coolant temperature (of the order of 10 F) must be avoided while the reactor is approaching criticality or is just critical.

3. Startup rates greater than 1 decade per minute should be avoided.

4. Available shutdown reactivity must not be reduced below 3% $\Delta k/k$ hot or 5% $\Delta k/k$ cold as determined by analysis and experiment, including experimental data obtained during the performance of this procedure.

5. Use no more than 3 decades of power increase during startup rate measurements.

IV. Check-off List

Prior to the initiation of this S.P., the check-off list must be completed by the operator(s) and signed off.

V. Instructions

A. Experimental Method - The temperature coefficient and the pressure coefficient will be measured at various temperatures by changing the temperature or the pressure and observing the resultant changes in startup rates which can then be converted into changes in core reactivity. In addition, the reactivity effects of main coolant system flow changes will be measured by observing the effects of such changes on the startup rate.

B. Data Required - The following data are required and must be recorded as indicated in Section V-D:

1. Nuclear Instrumentation

a. Count rate meter readings and scaler data from the BF_3 channels.

b. Outputs of the three intermediate-range ion chamber channels.

c. Stable startup rates.

2. Control rod positions.

3. Readings of temperature detectors in the main coolant system loops and at representative locations in the core.

4. System pressure readings.

5. Boron concentration (take samples at intervals of approximately 20 min).

6. Time at which data are taken.

7. Log of events.

C. Special Instrumentation Requirements - Not included as original equipment.

1. Scalers for BF_3 channels.

2. At least two extra sensitive (better than 10^{-12} amp full scale) amplifiers for the compensated ion chamber channels with strip chart recorders connected to the amplifier outputs.

3. Recording resistance bridge for at least one main coolant system temperature detector.

D. Experimental Procedure

1. Notify all personnel that reactor startup is imminent.

2. Verify that the conditions listed in Section II are satisfied.

3. Perform reactor startup using programmed rods according to S.P. No. 503E6, INITIAL CORE LOADING AND NUCLEAR CORE TESTS - REACTOR STARTUP. Level reactor at approximately 3 decades above source level. Record the data listed in Section V-B.

4. Adjust control rod positions to obtain a startup rate of about 0.5 decades per minute. Record data listed in Section V-B.

5. Shut down the reactor by inserting the controlling rod group.

6. Shut off main coolant pumps Nos. 1 and 3 and adjust the steam by-pass system to maintain the main coolant at 514 ± 3 F.

7. Return the controlling rod group to positions identical with those in Step No. 4; however, if in performing this operation, it should appear that the startup rate will exceed 1 decade per minute, proceed to Step No. 8c, below. Record data listed in Section V-B.

8. a. If the startup rate observed in Step No. 7 is between 0.05 and 1 decade per minute, start up the main coolant pumps Nos. 1 and 3. Record data listed in Section V-B.

   b. If the startup rate observed in Step No. 7 is less than 0.05 decades per minute, adjust the control rod positions to give a startup rate of 0.05 decades per minute; record data listed in Section V-B, and then start up the main coolant pumps Nos. 1 and 3. Record data listed in Section V-B.

   c. If the startup rate observed in Step No. 7 is greater than 1 decade per minute, adjust the control rod positions to give a startup rate of 1 decade per minute; record data listed in Section V-B, and then start up the main coolant pumps Nos. 1 and 3. Record data listed in Section V-B.

9. a. If the final startup rate observed in Step No. 8 is between 0.05 and 1 decade per minute, again shut off main coolant pumps Nos. 1 and 3. Record data listed in Section V-B. Compare the results with those obtained in Step No. 8, if they disagree by more than 10%, repeat Steps Nos. 8 and 9 until they do agree within 10%.

b. If it appears that the startup rates can not be maintained between 0.05 and 1 decade per minute for the four-pumps-on to two-pumps-on change, go to a banked control rod configuration and obtain the banked positions for a startup rate of about 0.05 decades per minute with two pumps on. Record the data listed in Section V-B. Turn on pumps Nos. 1 and 3, obtain the banked rod positions for a startup rate of about 0.5 decades per minute. Record data listed in Section V-B. Adjust control rods back to the program configuration used in Step No. 3. Record the data listed in Section V-B.

10. Repeat Steps Nos. 4 through 9 with pumps Nos. 1 and 3 on and pumps Nos. 2 and 4 alternately on and off.

11. With all four main coolant pumps in operation and the temperature at 514 ± 3 F, adjust the control rods to establish a startup rate of 0.5 decades per minute. Record data listed in Section V-B and then close down the steam by-pass system to allow the main coolant to heat up.

NOTE: During the remainder of this procedure, record the temperature measurements at least once every 5 min unless otherwise specified.

12. Adjust the control rod positions to give a startup rate of about 0.5 decades per minute. Record data listed in Section V-B.

13. When level approaches 6 decades above source level, drop back to 3 decades above source level by running in control rods and then return those control rods to positions identical with those in Step No. 12. Record data listed in Section V-B.

14. Repeat Steps Nos. 12 and 13 until the startup rate drops to 0.05 decades per minute. Then readjust the control rod positions to give a startup rate of 0.5 decades per minute. Record data listed in Section V-B.

15. Repeat Steps Nos. 12, 13, and 14 until main coolant temperature reaches 539 ± 1 F.

NOTE: In performing Steps Nos. 16, 17, and 18, below, stop if the available shutdown reactivity approaches 3% $\Delta k/k$ and proceed directly to Step No. 19.

16. Adjust the control rods to give a startup rate of about 0.1 decade per minute. Record data listed in Section V-B.

17. Increase steam by-pass flow to lower the temperature to 534 F and adjust it to hold at this temperature ± 1 F. Record data listed in Section V-B.

18. Repeat Step No. 17 successively dropping the temperature in 5 F steps to 489 F. If startup rate approaches 1 decade per minute during this sequence of measurements, hold temperature at the nearest of those listed and adjust control rods to lower the startup rate to 0.1 decade per minute. Record the data listed in Section V-B and then proceed with the other measurements.

19. Decrease the steam by-pass flow and repeat Steps Nos. 12, 13, and 14 until the temperature reaches 514 F.

20. Adjust the steam by-pass system to hold the main coolant temperature at 514 ± 3 F.

21. Adjust the control rods into a uniformly banked configuration and repeat Steps Nos. 11 through 20.

22. Return the control rods to the programmed configuration. Using analytical information together with the value of the temperature coefficient obtained from a preliminary analysis of the data obtained in Steps Nos. 12 through 19, determine the expected value for the pressure coefficient. If this value is such that it appears feasible to do so, select a startup rate such that when the pressure is lowered from 2,000 psi gage to 1,200 psi gage, the startup rate will remain positive. Otherwise, select a startup rate of about 1 decade per minute and during the course of the pressure decrease, readjust the startup rate whenever it drops to 0.05 decades per minute.

23. Adjust control rods to obtain the startup rate selected in the previous step. Record data listed in Section V-B.

24. As rapidly as is practical, decrease the main coolant system pressure (refer to O.I. No. 504E, PRESSURE CONTROL AND RELIEF SYSTEM) from 2,000 psi gage to 1,200 psi gage. Record data listed in Section V-B at least once every 2 min.

25. Adjust control rod positions to obtain a startup rate of about 0.1 decade per minute. Close pressurizer solenoid relief isolation valve. Then increase the main coolant system pressure to 2,400 psi gage in 200 psi steps. Record data listed in Section V-B after each step. Should the startup rate approach 1 decade per minute, hold the pressure at the nearest of the values in the sequence and adjust the control rods to reduce the startup rate of 0.1 decade per minute. Record the data listed in Section V-B and then proceed with the remaining measurements.

26. Holding the pressure at 2,400 ± 50 psi gage, adjust the control rods to obtain a startup rate of about 1 decade per minute. Record the data listed in Section V-B. Decrease main coolant system pressure as rapidly as practical to 2,000 psi gage. Open pressurizer solenoid relief isolation valve. Record the data listed in Section V-B at least once every 2 min.

27. Holding pressure at 2,000 ± 50 psi gage begin reactor cooldown according to O.I. No. 504C2, PLANT SHUTDOWN - REACTOR COOLDOWN, with the following deviations:

    a. Maintain reactor critical as specified in subsequent steps of the procedure.

    b. Delay the start of the boric acid injection until the available shutdown reactivity is reduced to 3% $\Delta k/k$ (refer to Section III, Step No. 4).

28. Adjust the control rods to establish a startup rate of about 0.05 decades per minute. Record the data listed in Section V-B.

29. When level approaches 6 decades above source level, drop back to 3 decades above source level by running in control rods and then return those control rods to positions identical with those in Step No. 28. Record data as listed in Section V-B.

30. Repeat Steps Nos. 28 and 29 until the startup rate approaches 0.5 decades per minute. Then readjust the control rods to establish a startup rate of about 0.05 decades per minute.

31. Repeat Steps Nos. 28, 29, and 30 until the main coolant temperature drops low enough so that there is only 3% shutdown available in control rods.

32. Hold main coolant temperature at the value reached in Step No. 31 and borate system to nominal shutdown boron concentration.

33. Allow boron to mix in the main coolant system. Sample to determine boron concentration.

34. Repeat Steps Nos. 12, 13, 14, 15, 16, 17, 18, 19, 20, 22, 23, 24, 25, and 26.

35. Repeat Steps Nos. 27 (with nominal boron concentration), 28, 29, and 30 until main coolant temperature reaches cold shutdown value.

36. Leave the reactor, the auxiliary equipment, and the plant in the condition specified by the person in charge of the experimental program.

E. Data Analysis

1. Convert all startup rate measurements into reactivities.

2. From the temperature measurements, obtain the average temperature (θ) of the reactor core and plot it as a function of time for the entire period covered by this procedure.

3. For each set of measurements with a given control rod configuration during Steps Nos. 11 through 15, 19, 21, 28 through 31, 34, and 35 under Section V-D, and using the corresponding reactivities from Step No. 1 under Section V-E, obtain the change in reactivity ($\Delta\rho$) as a function of time.

4. Combining Steps Nos. 2 and 3 of Section V-E and using time as the common variable, obtain the temperature coefficient ($\Delta\rho/\Delta\theta$) as a function of temperature for each control rod configuration used. The measurements made during the interval when boric acid was being added to the main coolant system must be corrected for the reactivity effects of the boron. This correction can be determined from the corresponding boron concentrations together with the data on boron worth obtained during the performance of S.P. No. 503E4, INITIAL CORE LOADING AND NUCLEAR CORE TESTS - CONTROL ROD AND BORON WORTH DETERMINATIONS - AT LOW TEMPERATURE and S.P. No. 503E7, INITIAL CORE LOADING AND NUCLEAR CORE TESTS - CONTROL ROD AND BORON WORTH DETERMINATIONS - AT OPERATING TEMPERATURE.

5. From data obtained during Steps Nos. 16, 17, 18, 21, and 34 under Section V-D, determine the change in reactivity ($\Delta\rho$) for each change in temperature ($\Delta\theta$) and plot the temperature coefficient ($\Delta\rho/\Delta\theta$) as a function of temperature. Compare the results obtained here with the appropriate portion of those obtained in Step No. 4 of Section V-E.

6. Select from the reactivities obtained in Step No. 1 of Section V-E, the reactivity changes ($\Delta\rho$) corresponding to the pressure changes (Δp) in Steps Nos. 23 through 26 and 34 of Section V-D.

7. From the temperature recorder charts and/or readings, obtain the temperatures and temperature changes during the pressure changes. Using these data together with the temperature coefficients obtained in Step No. 4 of Section V-E, correct the reactivity changes in Step No. 6 of Section V-E for any temperature variations during the measurement of those reactivity changes.

8. Combine these corrected valves of ($\Delta\rho$) with the corresponding pressure changes (Δp) to obtain the pressure coefficient ($\Delta\rho/\Delta p$) as a function of pressure.

9. From Step No. 1 of Section V-E, select the reactivities and changes in reactivity corresponding to the data obtained during Steps Nos. 4 through 10 under Section V-D. These changes in reactivities give the reactivity effects of the corresponding changes in main coolant flow.

STARTUP PROCEDURE NO. 503E9

INITIAL CORE LOADING AND NUCLEAR CORE TESTS
MAIN COOLANT SYSTEM HEATING RATE DETERMINATION

I. Objective To determine the main coolant system heating rate, heat losses at operating temperature and to check out nuclear instrumentation at a low power level. (This is a low priority test for useful information not connected with nuclear safety of the plant.)

II. Conditions

1. The following startup procedures have been completed:

   a. S.P. No. 503E1, INITIAL CORE LOADING AND NUCLEAR CORE TESTS - INITIAL CORE LOADING.

   b. S.P. No. 503E2, INITIAL CORE LOADING AND NUCLEAR CORE TESTS - CONTROL ROD DRIVE AND PLANT SCRAM TESTS.

   c. S.P. No. 503E3, INITIAL CORE LOADING AND NUCLEAR CORE TESTS - INITIAL CRITICALITY INSTRUCTION.

2. The secondary side of the steam generator is filled to approximately 280 in.

3. The main coolant temperature is at approximately 100 F.

4. The main coolant pressure is at 250 ± 50 psi gage and the pressurizer is at approximately 385 F.

5. Expansion water is being drained through the bleed line via the low pressure surge tank to waste disposal.

6. The main coolant system is borated to a concentration corresponding to a minus 5 per cent δ K shutdown throughout the performance of this procedure.

7. The pertinent auxiliary systems are in the following status:

System	Status
Main Coolant System (Refer to O.I. No. 504D)	All four loops open; four main coolant pumps ready for startup
Pressure Control and Relief System (Refer to O.I. No. 504E)	Operating

System	Status
Charging and Volume Control System (Refer to O.I. No. 504F)	Normal operation
Chemical Shutdown System (Refer to O.I. No. 504G)	Normal standby; boric acid mixing and storage tank hot and filled
Purification System (Refer to O.I. No. 504H)	Isolated
Component Cooling System (Refer to O.I. No. 504I)	Normal operation
Radioactive Waste Disposal System (Refer to O.I. No. 504L)	Ready standby
Shutdown Cooling System (Refer to O.I. No. 504M)	Isolated
Nuclear Instrumentation System (Refer to O.I. No. 504O)	Normal operation
Safety Injection System (Refer to E.I. No. 505B10)	Ready standby

III. Precautions

Same as O.I. No. 504A1, PLANT STARTUP - REACTOR STARTUP FROM COLD CONDITION.

IV. Check-off List

Prior to the initiation of this S.P., the check-off list must be completed by the operator(s) and signed off.

V. Instructions

A. Experimental Method - Four main coolant pumps will be used to heat up the main coolant system to operating temperature. Plant heat-up rate will be observed and heat losses near operating temperature will be calculated from pump electrical input and component cooling losses. Nuclear instrumentation will be calibrated against pump heat-up rates.

B. Data Required - The following data are required and should be recorded at the recommended frequency:

1. The main coolant system temperature and nuclear instrumentation from 100 to 480 F every 30 min.

2. The main coolant system temperature and nuclear instrumentation every 5 min while in the temperature range of 480 to 525 F.

3. Component cooling water inlet and outlet temperature of the main coolant pump every 30 min during main coolant increase from 100 to 525 F.

4. The main coolant pump current every 30 min from 100 to 525 F.

5. Main coolant system flow every 30 min from 100 to 525 F.

6. Log of events.

C. Special Instrumentation Requirements -- Not included as original equipment.

1. Two extra sensitive (better than 10^{-12} amp full scale) amplifiers for the compensated ion chamber channels with strip chart recorders connected to amplifier outputs.

D. Experimental Procedure

1. Using four main coolant pumps, raise the main coolant system temperature from 100 to 500 F. Refer to O.I. No. 504D4, MAIN COOLANT SYSTEM - STARTUP OF COMPLETE SYSTEM.

   NOTE: At 250 F, four pumps should be stopped for 2 hr to establish an isothermal condition between main coolant and reactor vessel.

2. Using two main coolant pumps, raise the main coolant system temperature from 500 to 514 F.

3. At 514 F and using two main coolant pumps, establish the rate of temperature increase or decrease (°F/hr) to determine the heat losses of the main coolant system.

   NOTE: It may be desirable to check the determined heat losses against heat removed by the vapor container ventilation system.

4. At an initiation temperature of 514 F and with one main coolant pump in operation, go critical at low power with rods in programmed sequence. Refer to S.P. No. 503E6, INITIAL CORE LOADING AND NUCLEAR CORE TESTS - REACTOR STARTUP. Adjust the reactor power to approximate the rate of increase or decrease (°F/hr) to Step No. 3 above. Continue heatup in this manner to 525 F.

5. Record all nuclear instrumentation readings, control rod positions, etc. The nuclear instrumentation readings are now recorded as being the neutron level indicative of a reactor power level of approximately 1,000 kw or less. The reactor will henceforth be considered at a zero power critical condition when nuclear instrumentation is at the above values.

NOTE: These values may change slightly with core life and instrumentation aging. Reasons for change should be evaluated.

E. Data Analysis

1. Plot main coolant system temperature from 100 to 525 F as a function of time.

2. Plot component cooling water Δ T from the main coolant pump while main coolant system increases from 100 to 525 F as a function of time.

3. Plot main coolant pump amperes from 100 to 525 F as a function of time.

4. Determine power sensitivity of nuclear instrumentation.

5. Calculate main coolant system heat losses at approximately operating temperature.

STARTUP PROCEDURE NO. 503E10

INITIAL CORE LOADING AND NUCLEAR CORE TESTS
NUCLEAR INSTRUMENTATION SYSTEM RESPONSE TO ASYMMETRIC CONTROL ROD POSITIONING

I. Objective To determine the ability of the nuclear instrumentation to detect flux tilts or flux asymmetry in the reactor core. And to determine the sensitivity of the nuclear detectors to rod motion in various sections of the core.

II. Conditions

1. The following startup procedures have been completed:

   a. S.P. No. 503E3, INITIAL CORE LOADING AND NUCLEAR CORE TESTS - INITIAL CRITICALITY INSTRUCTION.

   b. S.P. No. 503E7, INITIAL CORE LOADING AND NUCLEAR CORE TESTS - CONTROL ROD AND BORON WORTH DETERMINATIONS - AT OPERATING TEMPERATURE.

2. The conditions are satisfied for normal plant startup as given in O.I. No. 504A1, PLANT STARTUP - REACTOR STARTUP FROM COLD CONDITION, except Steps Nos 1 and 6 under Section II.

3. Special nuclear instrumentation, see Section V-C, has been installed and checked out.

4. Provision has been made for switching detector cables so that the outputs of all nuclear detectors can be measured.

III. Precautions

1. Observe the precautions listed in O.I. No. 504A1, PLANT STARTUP - REACTOR STARTUP FROM COLD CONDITION.

2. Limit operating power levels to below six decades above source level.

IV. Check-off List

Prior to the initiation of the S.P., the check-off list must be completed by the operator(s) and signed off.

V. Instructions

A. Experimental Method - Flux tilts and flux asymmetry will be deliberately introduced in the reactor core by nonuniform or asymmetric positioning of control rods. The interrelation between the nuclear instrument readings will be compared with in-core instrument readings and with analytically determined flux distributions in order to determine the capability of the nuclear instrumentation for detecting flux tilts and the sensitivity of the nuclear detectors to control rod motion in various sections of the core.

B. Data Required - The following data are required and must be recorded as indicated in Section V-D:

1. All startup, intermediate and power range nuclear detector readings.

2. All in-core instrumentation readings, if available.

3. Flow, cold-leg and hot-leg temperature measurements for each main coolant loop.

4. Readings of T_{avg} and pressure in main coolant system.

5. Control rod positions.

6. Neutron shield tank temperature.

7. Time at which data are taken.

8. Log of events.

C. Special Instrument Requirements - Not included as original equipment.

1. At least two extra sensitive (better than 10^{-12} ampere full scale) linear amplifiers for use with intermediate and/or power range detectors.

2. Strip recorders for the amplifiers described just above.

D. Experimental Procedure

1. Perform normal reactor startup according to O.I. No. 504A1, PLANT STARTUP - REACTOR STARTUP FROM COLD CONDITION. Use the rod program planned for initial normal operation. Level off reactor power at five decades above source level. Adjust T_{avg} and pressure of main coolant system to normal operational values ± 3 F and ± 50 psi gage. Maintain T_{avg} and pressure within these limits throughout the procedure.

2. Record data listed in Section V-B and initiate analysis (see Section V-E) so that the results can be used later in this procedure.

3. Maintain reactor power level constant; adjust control rod positions until they are all at the same elevation. This will introduce an axial flux asymmetry. Record the data listed in Section V-B.

4. Introduce various radial flux tilts by fully inserting various combinations of Group 6 (peripheral) control rods. Maintain reactor power level constant by withdrawing the control rods in the remaining groups in such a manner that those rods end up all at the same elevation. When reactor has reached an equilibrium condition, record the data listed in Section V-B.

5. Introduce radial flux tilts by fully inserting various combinations of Group 6 rods, while maintaining reactor power level constant by fully inserting Groups 1, 2, 3 and 4 rods and withdrawing Group 5 rods. Record and analyze data listed in Section V-B.

6. Steps Nos. 1 through 5 may be repeated with the reactor at power level up to 5% with the heat dissipated by the turbine steam by-pass connection. This may be done if it will provide improved data from the in-core instrumentation, if provided.

7. Leave the reactor, the auxiliary equipment, and the plant in the condition specified by the person in charge of the experimental program.

E. Data Analysis

1. Compare the flux distributions obtained with the following data:

   a. Analytically determined flux distributions, if available

   b. Interrelation of all nuclear detector outputs.

   c. Data from in-core instrumentation, if available.

2. Compare observed nuclear detector readings against control rod position changes obtained in Section V-D to determine detector sensitivity to rod motion in various sections of the core.

STARTUP PROCEDURE NO. 503F1

INITIAL NUCLEAR PLANT POWER OPERATIONAL TESTS
POWER COEFFICIENT AND LOSS OF LOAD TRANSIENT TESTS

I. Objective To determine the power coefficient of the reactor and also to determine the capability of the plant to handle a loss of load without accompanying reactor scram.

II. Conditions

1. Startup Procedure No. 503E, INITIAL CORE LOADING AND NUCLEAR CORE TESTS have been completed.

2. All normal plant operation conditions have been satisfied as required in O.I. No. 504B1, PLANT OPERATION - CHANGING REACTOR LOAD, Section II-B, Increasing Reactor Load (no boron present in main coolant system), with the turbine generator set in operation with no load.

3. The main turbine load limit has been set for 110% reactor power.

4. The network dispatcher has been notified of impending operation of the plant.

III. Precautions

1. The power levels used shall be limited to within the normal operating range of the reactor plant.

2. The experimental procedure will be performed in a sequence which involves increasingly higher power levels. Before proceeding from one power level to the next higher one, the performance data will be evaluated in order to ascertain that the succeeding phase will not cause damage to the reactor or the plant. The remainder of the procedure will be suspended for further operational evaluation if it appears that during the next phase any of the following limitations will be exceeded either in the performance of the experiment or in the event of a complete loss of load:

a. Pressurizer level in excess of (355)* in.

b. T_{avg} in excess of (573)* F.

c. T_{hot} in excess of (579)* F.

*To be confirmed.

3. The procedure will be suspended for further operational evaluation if the pressurizer spray or the solenoid relief valves fail to operate or if the following turbine generator set plant annunciators are activated:

    a. Condensate storage tank level, high or low.
    b. Condensate hotwell level, high or low.
    c. Any one of the four steam generator levels, high or low.

4. The reactor control rods shall be maintained on manual operation throughout the procedure.

5. The pressurizer pressure and level shall not be allowed to drop below the lower operational limits.

6. A proper plant water balance should be established in the water storage and waste collection tanks to ensure that adequate make-up water is available and to receive water rejected from the primary plant.

7. The network dispatcher should be notified before any scheduled load change.

IV. Check-off List

Prior to the initiation of this S.P., the check-off list must be completed by the operator(s) and signed off.

V. Instructions

A. Experimental Method - The reactivity effects of stepwise power level changes will be measured in terms of moderator temperature changes and control rod position changes which can be converted into reactivity changes to obtain the power coefficient. In addition, the response of the reactor and plant to loss of load transients will be determined by measuring the corresponding effects on the operational parameters.

B. Data Required - The following data will be recorded as indicated:

1. Data to be recorded at frequent intervals (as indicated in Section V-D below) or to be transcribed from strip recorder charts:

    a. Intermediate and/or power range nuclear instrument outputs.

    b. Cold-leg and hot-leg temperatures for each main coolant loop and T_{avg} readings.

    c. Main coolant system pressure, pressurizer pressure and temperature, and pressurizer level.

d. Gross electrical output of the turbine generator.

e. Steam flow and pressure in secondary system.

f. Feed water flow.

g. Hotwell level and condensate storage tank level.

h. Level in each steam generator.

2. Data to be recorded at less frequent intervals:

a. steam by-pass to condenser volume.

b. Neutron shield tank temperature.

c. Main coolant flow measurements for each of the main coolant loops.

d. In-core temperatures, if available.

3. Control rod positions each time they are changed.

4. Time at which any of the above data are taken.

5. Log of events.

C. <u>Special Instrumentation Requirements</u> - Not included as original equipment.

1. Strip chart recorders for recording the most significant data during transients including the following:

a. At least one set of cold-leg and hot-leg temperatures.

b. T_{avg}

c. Main coolant pressure.

d. Gross electrical output.

D. <u>Experimental Procedures</u>

1. Prior to the initiation of these procedures, the reactor will have been brought up to the minimum level required to operate the turbine generator set under no load conditions. Refer to O.I. No. 504B1, PLANT OPERATION - CHANGING REACTOR LOAD, Section B.

2. Record all data listed in Section V-B.

3. Start the required strip chart recorders (See Section V-C, Step No. 1 above) that are not already in operation. Index all recorder charts with a time marking to help correlate chart readings.

4. Determine initial xenon conditions at zero power level by observing reactivity changes as a function of time. Withdraw the controlling rod group to establish a startup rate of approximately 0.8 decades per minute. Record the actual startup rate and the control rod positions. Repeat this measurement and observe the change in startup rate as a function of time.

5. Record all data listed in Section V-B.

6. Increase the load on the turbine generator set (Refer to O.I. No. 504B1, PLANT OPERATION - CHANGING REACTOR LOAD, and O.I. No. 504B2, PLANT OPERATION - INCREASING TURBINE GENERATOR LOAD), to 30 mw gross electrical output at 4 mw per min. Maintain T_{avg} at nominal value ±2 F by control rod motion. Maintain pressure at 2,000 ±30 psi gage. During this load increase and until equilibrium conditions are reached, record once every 15 sec the data listed in Section V-B, Step No. 1 which is not being recorded on the strip chart recorders.

7. When the power level reaches a stable value, record all data listed in Section V-B.

8. Determine final xenon conditions by observing changes in T_{avg} and control rod positions as a function of time. Allow T_{avg} to deviate ± 2 F about the nominal value and observe the time of change of temperature. When the temperature reaches the limit of the control band, initiate appropriate control rod motion to return T_{avg} to the other end of the control band and record the amount of control rod motion required and the change in T_{avg} induced by the rod motion.

9. Record all data listed in Section V-B.

10. Notify all necessary personnel of the intended action and then remove the load from the turbine generator by manually tripping the two 115 kv oil circuit breakers. Do not initiate control rod motion unless it is required to correct an emergency condition. Once every 15 sec record the data listed in Section V-B, Step No. 1 that is not being recorded on strip chart recorders. Continue recording data until equilibrium conditions are reached.

11. After equilibrium conditions are reached, record all data in Section V-B.

12. Return T_{avg} to the nominal value by adjusting the positions of the controlling rod group. During this adjustment maintain the main coolant system pressure 2,000 ±30 psi gage. Once every 15 sec record the data listed in Section V-B, Step No. 1 that is not being recorded on strip chart recorders.

13. After equilibrium conditions are reached, record all data in Section V-B.

14. Repeat Step No. 8 under Section V-D.

15. Analyze data to determine if any hazard to plant equipment exists due to transient conditions associated with the ramp load increase or instantaneous load drop. Do not proceed with the following load changes unless careful evaluation of previous data indicates that a complete loss of load from any of the levels used can be safely handled by the reactor and the plant.

16. Repeat the above for the following power level changes which are given in gross electrical output:

    a. Ramp load increase from No load to 30 mw. Repeat Steps Nos. 4 through 9.

    b. Ramp load increase from 30 mw to 60 mw. Repeat Steps Nos. 6 through 9.

    c. Instantaneous loss of load from 60 mw to Low load. Repeat Steps Nos. 10 through 15.

    d. Ramp load increase from No load to 60 mw. Repeat Steps Nos. 4 through 9.

    e. Ramp load increase from 60 mw to 90 mw. Repeat Steps Nos. 6 through 9.

    f. Ramp load increase from 90 mw to Full load. Repeat Steps Nos. 6 through 9.

    g. Instantaneous loss of load from Full load to Low load. Repeat Steps Nos. 10 through 15.

17. Leave the reactor, the auxiliary equipment, and the plant in the conditions specified by the person in charge of the experimental program.

E. Data Analysis

1. The following data analysis will be performed concurrently with the experimental program:

   a. Obtain the moderator temperature coefficient values found during the zero power experiments. Obtain the total changes in T_{avg} between equilibrium conditions at the start and at the end of each power level change in Section V-D above, by summing the incremental changes made in Step No. 6 of Section V-D. Using the moderator temperature coefficient convert these ΔT_{avg} into reactivity changes. Divide these changes in reactivity by the corresponding changes in power level to obtain the power coefficient.

   b. Obtain the control rod worth values found during the zero power experiments. Obtain the total change in control rod position between equilibrium conditions of the start and at the end of each power level change in Section V-D, by summing the incremental control rod changes made in Step No. 6 of Section V-D. Convert the control rod position changes into reactivity changes and calculate the power coefficient.

   c. Obtain the total change in T_{avg} associated with the instantaneous loss of load and compare with Step a above.

   d. Obtain the total control rod position change associated with the instantaneous loss of load and compare with Step b above.

   e. Determine if the plant load can safely be increased to the next scheduled power level.

2. The following data analysis need not be performed concurrently with the experimental program:

   a. Plot control rod position, gross electrical output, T_{avg}, and main coolant pressure versus time for all load increases. Perform detailed analysis as outlined in Steps Nos. 1a and 1b of Section V-E, including corrections for fission product effects.

   b. Plot control rod position, gross electrical output, T_{avg}, pressure, and pressurizer level for all loss of load measurements. Perform detailed analysis as indicated in Steps Nos. 1c and 1d of Section V-E, including corrections for fission product effects.

c. Evaluate data from S.P. No. 503F6, INITIAL NUCLEAR PLANT POWER OPERATIONAL TESTS - VARIATION OF REACTIVITY DUE TO CHANGE IN FISSION PRODUCT LEVEL FOLLOWING REACTOR SHUTDOWN, to determine total changes in pressurizer level, T_{avg}, and control rod position and compare with Step 2b of Section V-E. Evaluate the data from S.P. No. 503F6 to determine the time after shutdown required for the control rods to return to the position they occupied at power.

d. Evaluate the data obtained above and select a method to be used at intervals throughout core life to determine the effects of the power coefficient on plant operation.

STARTUP PROCEDURE NO. 503F2

INITIAL NUCLEAR PLANT POWER OPERATIONAL TESTS
POWER CALIBRATION OF NUCLEAR INSTRUMENTATION
POW

I. Objective To calibrate the power range nuclear instrumentation against the heat output of the nuclear steam generator as measured by the station electrical load.

II. Conditions

1. The following startup procedure has been completed:

    a. S.P. No. 503F1, INITIAL NUCLEAR PLANT POWER OPERATIONAL TESTS - POWER COEFFICIENT AND LOSS OF LOAD TRANSIENT TESTS.

2. The turbine generator electrical load is being held constant at the normal full power rating.

3. All required instrumentation has been calibrated and adjusted.

4. Plant conditions are stable and can be so maintained for the duration of the test.

5. The steam generator blowdown valves are closed for the duration of the test.

6. The feed and bleed system is shutdown for the duration of the test.

III. Precautions

Observe the normal plant operation precautions as set forth in O.I. No. 504B1, PLANT OPERATION - CHANGING REACTOR LOAD.

IV. Check-off List

Prior to the initiation of this S.P., the check-off list must be completed by the operator(s) and signed off.

V. Instructions

A. Experimental Method - The heat output of the nuclear steam generator will be compared to the calculated heat output. The gross electrical output is related to the heat output as shown on drawings Nos. 9699-FM-45A through 9699-FM-45E which are included in Section 200. This relation, the gross electrical output to the corrected heat output, will remain the same as shown by turbine, condenser and feed-water heater testing done in accordance with standard procedures at regular intervals.

B. Data Required - Record the following readings at periodic intervals:

1. Per cent power on all channels
2. Gross electrical output
3. Steam pressure
4. Condenser pressure
5. Steam moisture
6. Plant heat balance (See drawings Nos. 9699-FM-45A through 9699-FM-45E which are included in Section 200)
7. Main coolant flow, T_C and T_H of all operating loops
8. Main coolant pressure
9. Final feed water temperature

C. Data Analysis

1. Determine the heat output of the nuclear steam generator using the theoretical relationship between heat output and gross electrical output. Correct this theoretical relationship using experimental data, to take into account actual field conditions.
2. Convert the calculated nuclear steam generator output to per cent reactor power and compare with observed nuclear channel readings.
3. If observed nuclear channel readings differ by more than 5% from the per cent reactor power calculated in Step No. 2 of Section V-C, adjust the nuclear instruments to read correctly.

STARTUP PROCEDURE NO. 503F3

INITIAL NUCLEAR PLANT POWER OPERATIONAL TESTS
VARIATION OF REACTIVITY DUE TO CHANGE IN FISSION PRODUCT
LEVEL FOLLOWING REACTOR POWER INCREASE

I. Objective To determine the variation of the core reactivity due to change in the fission product level following a reactor power increase to approximately the design full power.

II. Conditions

1. The startup procedure, S.P. No. 503F1, INITIAL NUCLEAR PLANT POWER OPERATIONAL TESTS - POWER COEFFICIENT AND LOSS OF LOAD TRANSIENT TESTS, has been completed and the resulting data have been analyzed sufficiently to determine the reactor characteristics for increasing and decreasing loads.

2. The reactor should be relatively free from fission product buildup; that is, the previous operation at high power should be minimized; or the reactor should have not been in operation for a period of approximately 48 hr prior to the start of this procedure in order to allow for adequate fission product decay.

3. All the normal plant operating conditions have been satisfied as required in O.I. No. 504B1, PLANT OPERATION - CHANGING REACTOR LOAD, Section II-B, Increasing Reactor Load (No Boron Present in Main Coolant System).

4. The main turbine load limit has been set at the maximum gross electrical output corresponding to the thermal rating of the installed core (see precaution, Section III, Step No. 1).

5. The interconnected electrical system is prepared to receive continuously for the next 36 hr, the maximum gross electrical output corresponding to the thermal rating of the installed core.

III. Precautions

1. The maximum power used during this procedure will be limited to an operationally safe level as determined from the results of S.P. No. 503F1, INITIAL NUCLEAR PLANT POWER OPERATIONAL TESTS - POWER COEFFICIENT AND LOSS OF LOAD TRANSIENT TESTS.

2. Observe the normal plant operation precautions as set forth in O.I. No. 504B1, PLANT OPERATION - CHANGING REACTOR LOAD, Section III.

IV. Check-off List

Prior to the initiation of this S.P., the check-off list must be completed by the operator(s) and signed off.

V. Instructions

A. Experimental Method - The reactivity effects of fission product level change after a reactor power increase will be measured in terms of moderator temperature changes and calibrated control rods. These measurements will be made as a function of time until equilibrium conditions have been established.

B. Data Required - The following data are required and must be recorded as indicated in Section V-D:

1. Intermediate and power range nuclear instrument readings.

2. In-core, cold-leg, hot-leg (for each main coolant loop) and T_{avg} temperature readings.

3. Flow measurements for each main coolant loop.

4. Pressure of the main coolant system; and level, temperature, and pressure of the pressurizer.

5. Gross electrical output of the turbine generator set.

6. Control rod positions.

7. Neutron shield tank temperature.

8. Time at which data are taken.

9. Log of events.

C. Special Instrumentation Requirements - Not included as original equipment.

1. One cold leg temperature recorded on recording temperature resistance bridge.

D. Experimental Procedure

1. Observing the normal plant operation procedures, start up the plant and raise the power to 90% (see Step No. 1 under Section III) of the design maximum output of the core. Refer to O.I. No. 504B1, PLANT OPERATION - CHANGING REACTOR LOAD, Section V-B. However, maintain reactor on manual control. Record the data listed in Section V-B.

2. Adjust the control rod positions, observing rod programming requirements until T_{avg} is 3 F above nominal; record data listed in Section V-B.

3. When T_{avg} has dropped to 3 F below nominal, record data listed in Section V-B.

4. Repeat Steps Nos. 2 and 3 until fission product equilibrium conditions have been reached (approximately 36 hr after the initial establishment of the power level).

5. Throughout the experiment, maintain the main coolant system pressure at nominal ±50 psi gage and maintain the plant power output constant to ±2%. If the interconnected electrical system load can not be held constant enough to meet the latter requirement, then provision must be made to handle reasonable load changes with the steam by-pass to condenser.

6. Leave the reactor, the auxiliary equipment, and the plant in the condition specified by the person in charge of the experimental program.

E. Data Analysis

1. From the temperature measurements obtained during Steps Nos. 2 and 3 for each control rod position, obtain the changes in T_{avg}.

2. Using the moderator temperature coefficient data obtained during the performance of S.P. No. 503E8, INITIAL CORE LOADING AND NUCLEAR CORE TESTS - TEMPERATURE, PRESSURE AND FLOW COEFFICIENT DETERMINATIONS - WITH DECREASING TEMPERATURE, convert the T_{avg} changes obtained in Step No. 1 under Section V-D into reactivity changes.

3. Sum up the reactivity changes from Step No. 2 under Section V-D and plot the sum as a function of time.

4. Using the control rod worth measurements obtained during the performance of S.P. No. 503E7, INITIAL CORE LOADING AND NUCLEAR CORE TESTS - CONTROL ROD AND BORON WORTH DETERMINATIONS - AT OPERATING TEMPERATURE, together with appropriate analytical corrections, convert into reactivity the control rod position data for each successive Step No. 2 of Section V-D. Plot reactivity as a function of time.

5. Compare the results of Steps Nos. 3 and 4 of Section V-D.

STARTUP PROCEDURE NO. 503F4

INITIAL NUCLEAR PLANT POWER OPERATIONAL TESTS
BIOLOGICAL SHIELD EFFECTIVENESS TEST

I. Objective To determine that radiation levels external to the vapor container during power operation are not hazardous to personnel.

II. Conditions

1. The plant is being readied for startup. S.P. 503F1, INITIAL NUCLEAR PLANT POWER OPERATION TESTS - POWER COEFFICIENT AND LOSS OF LOAD TRANSIENT TESTS.

2. Portable gamma and neutron sensitive detectors are available for use during the measurement of radiation levels.

3. A survey team is available to perform the necessary operation for carrying out this startup procedure.

III. Precautions

The vapor container must not be entered during the biological shield effectiveness test.

IV. Check-off List

Prior to the initiation of this S.P., the check-off list must be completed by the operator(s) and signed off.

V. Instructions

A. Data Required - Gamma and neutron radiation levels at the following locations:

1. Personnel hatch at equator of vapor container.
2. Below vapor container.
3. Access walkway to top of vapor container.
4. Control room and primary auxiliary building.
5. General area survey of the plant.

B. Special Instrumentation Requirements - Not included as original equipment.

1. Portable gamma detectors (0-50 mr per hr).
2. Portable thermal and fast neutron detector.

C. Procedure

1. When S.P. 503F1, INITIAL NUCLEAR PLANT POWER OPERATIONAL TESTS - POWER COEFFICIENT AND LOSS OF LOAD TRANSIENT TESTS, is initiated, the survey team equipped with portable survey instruments should be prepared to survey the following locations:

   a. Directly below the vapor container and in the vicinity of the equipment hatch.

   b. In the vicinity of the personnel hatch.

   c. At the top of the vapor container.

   d. In control room and Primary Auxiliary Building.

2. Gamma survey instrument readings should be recorded at power levels of one-half power and full power. (Reference S.P. 503F1, POWER COEFFICIENT AND LOSS OF LOAD TRANSIENT TESTS).

   NOTE: The survey team should be advised when the reactor power is at the prescribed power level.

3. If high radiation areas are found, take necessary steps to caution personnel against possible hazard and isolate high dosage areas as required by Section 507, RADIOLOGICAL HEALTH AND SAFETY.

D. Data Analysis

1. Tabulate radiation level data according to location, including gamma and neutron levels.

STARTUP PROCEDURE NO. 503F5

INITIAL NUCLEAR POWER PLANT POWER OPERATIONAL TESTS
INSTRUMENTATION AND CONTROL RESPONSE DETERMINATION

I. Objective To determine the actual operating characteristics of the primary plant instrumentation and control when integrated with secondary plant as the station is subjected to load changes and to determine the controlling ability of the T_{avg} control system when used to regulate the primary plant.

II. Conditions

1. The following startup procedures have been completed:

   a. S.P. No. 503F1, INITIAL NUCLEAR PLANT POWER OPERATIONAL TESTS - POWER COEFFICIENT AND LOSS OF LOAD TRANSIENT TESTS.

   b. S.P. No. 503F2, INITIAL NUCLEAR PLANT POWER OPERATIONAL TESTS - POWER CALIBRATION OF NUCLEAR INSTRUMENTATION.

2. All normal plant operating conditions have been satisfied as in Section II-B and C of O.I. No. 504B1, PLANT OPERATION - CHANGING REACTOR LOAD.

3. The turbine load limit shall be set for 120 mwe* gross with the 392 mwt core.

4. The network is prepared to accept 120 mwe.

5. The turbine generator is at 15 mwe gross output.

6. The rods operations selector switch on the nuclear section of the main control board should be in the manual position.

III. Precautions

If it appears that any of the following limitations will be exceeded in some test phase, then that test phase must be delayed for further operational evaluation.

1. Actuation of pressurizer solenoid operated relief valve at 2,400 psi gage.

2. Actuation of low pressure scram set at 1,800 psi gage.

*For the purposes of this test procedure, 120 mw gross is assumed to be the maximum continuous load for the reactor plant using Core I and will be subject to change prior to the execution of this test on the basis of the latest analytical data.

3. Pressurizer level in excess of 160 in.

4. Pressurizer level below 80 in.

5. Primary system average temperature in excess of 524 F.

6. Primary system average tamperature is less than 504 F.

7. Excessive rod motion.

8. All phases of the test should attempt to have the controlling rod group not closer than 12 in. of top or bottom of full travel.

9. Steam generator water level 5 in. below normal

IV. Check-off List

Prior to the initiation of this S.P., the check-off list must be completed by the operator(s) and signed off.

V. Instructions

A. Experimental Method

1. The turbine generator load will be increased and decreased at approximately 4 mwe per min at various power levels and primary system parameters will be "logged or recorded".

B. Data to be Logged or Recorded

1. Four main coolant cold leg and hot leg temperatures. (*)

2. Intermediate range and power range nuclear instruments.

3. Four main coolant flows.

4. Turbine generator gross generated mwe. (*)

5. Control rod positions on primary as well as secondary position indicating systems.

6. Main coolant pressure.

7. Pressurizer pressure. (*)

8. Pressurizer level (narrow and wide range).

9. Pressurizer temperature.

10. T_{avg} (*)

11. Steam pressure.

12. Steam temperature.

13. Steam flow.

14. Level in each of the four steam generators.

15. Feed water flow.

16. Level of condenser hot well.

17. Level in condensate storage tank.

C. Instrumentation Requirements

1. No additional instrumentation required.

D. Experimental Procedure

1. Manually adjust the plant to operate at 15 mw gross electric, four loops, 514 F, 2,000 psi gage.

2. Switch rods operation selector switch to automatic and increase the load to 30 mwe at the approximate rate of 4 mwe per min. Record items marked (*) in Section IV-B at 15 sec intervals and remaining items at 1 min intervals.

3. Manually adjust the plant to 30 mwe, four loops, 514 F, 2,000 psi gage.

4. Switch rods operation selector switch to automatic and increase the load to 60 mwe at the approximate rate of 4 mwe per min. Record items marked (*) in Section IV-B at 15 sec intervals and remaining items at 1 min intervals.

5. Manually adjust the plant to 60 mwe, four loops, 514 F, 2,000 psi gage.

6. Switch rods operation selector switch to automatic and increase the load to 120 mwe at the approximate rate of 4 mwe per min. Record items marked (*) in Section IV-B at 15 sec intervals and remaining items at 1 min intervals.

7. Manually adjust the plant to 120 mwe, four loops, 514 F, 2,000 psi gage.

8. Switch rods operation selector switch to automatic and decrease the load to 60 mwe at the approximate rate of 4 mwe per min. Record items marked (*) in Section IV-B at 15 sec intervals and remaining items at 1 min intervals.

9. Manually adjust the plant to 60 mwe, four loops, 514 F, 2,000 psi gage.

10. Switch rods operation selector switch to automatic and decrease the load to 30 mwe at the approximate rate of 4 mwe per min. Record items marked (*) in Section IV-B at 15 sec intervals and remaining items at 1 min intervals.

11. Manually adjust the plant to 30 mwe, four loops, 514 F, 2,000 psi gage.

12. Switch rods operation selector switch to automatic and decrease the load to 15 mwe at the approximate rate of 4 mwe per min. Record items marked (*) in Section IV-B at 15 sec intervals and remaining items at 1 min intervals.

13. Manually adjust the plant to 15 mwe, four loops, 514 F, 2,000 psi gage.

STARTUP PROCEDURE NO. 503F6

INITIAL NUCLEAR PLANT POWER OPERATIONAL TESTS
VARIATION OF REACTIVITY DUE TO CHANGE IN FISSION
PRODUCT LEVEL FOLLOWING REACTOR SHUTDOWN

I. Objective To determine the variation of the core reactivity due to change in the fission product level following a reactor shutdown from approximately the design full power.

II. Conditions

1. The startup procedure, S.P. No. 503F1, INITIAL NUCLEAR PLANT POWER OPERATIONAL TESTS - POWER COEFFICIENT AND LOSS OF LOAD TRANSIENT TESTS, has been completed and the resulting data have been analyzed sufficiently to determine the reactor characteristics for increasing and decreasing loads.

2. Prior to the initiation of this procedure, the reactor must have been operated 90 ± 10% of design full power of the core for a sufficient time, about 36 hr, to allow fission product build-up to have reached equilibrium conditions.

3. All the normal plant operating conditions for decreasing the reactor load have been satisfied as specified in O.I. No. 504B1, PLANT OPERATION - CHANGING REACTOR LOAD, Section II-C, Decreasing Reactor Load.

4. The interconnected electrical system is prepared to accept the conditions imposed by shutting down the reactor.

III. Precautions

Observe the normal plant operational precautions as given in O.I. No. 504B1, PLANT OPERATION - CHANGING REACTOR LOAD.

IV. Check-off List

Prior to the initiation of this S.P., the check-off list must be completed by the operator(s) and signed off.

V. Instructions

A. Experimental Method - After fission product build-up equilibrium has been established, the reactor will be rapidly shutdown to a low power level and maintained near criticality at that level, by adjusting control rod positions, until the fission products have decayed to a low level. The reactivity effects of changes in fission product level will be obtained from previous control rod calibrations and from incremental control rod worth measurements.

B. Data Required - The following data are required and must be recorded as indicated in Section V-D:

1. Intermediate range nuclear instrument readings and stable startup rates.

2. In-core temperatures, T_{avg} and, (for each main coolant loop) the cold-leg and hot-leg temperature readings.

3. Flow measurements for each main coolant loop.

4. Pressure of the main coolant system and level, temperature, and pressure of the pressurizer.

5. Control rod positions.

6. Time at which data are taken.

7. Log of events.

8. The time after the load decrease when the control rods return to the same position that they were in, prior to the load decrease.

C. Special Instrumentation Requirements - Not included as original equipment.

1. One cold leg loop temperature recorded on a recording resistance bridge.

D. Experimental Procedure

1. After the reactor has been operated at 90 ± 10% of core design full power for sufficient time, about 36 hr, to allow fission product equilibrium to be established, record data listed in Section V-B with the addition of power range nuclear instrument readings.

2. Decrease the reactor power output as rapidly as practical to below 0.01% of design full power. Refer to O.I. No. 504B1. PLANT OPERATION - CHANGING REACTOR LOAD, Section V-C, Decreasing Reactor Load. During this operation, maintain normal rod program sequence and maintain nominal temperature ± 3 F, nominal pressure ± 50 psi gage. Reactor will be on manual control throughout the performance of this S.P. Control rods will be moved in normal programming sequence.

3. Level reactor below 0.001% of design full power, but at a power level high enough that the intermediate range nuclear instrumentation still responds promptly to control rod motion. Record the data listed in Section V-B when the reactor goes subcritical as indicated by recorder flux traces reaching a peak and then decreasing.

4. Withdraw the controlling rod group to establish a startup rate of approximately 0.3 decade per minute. Record data listed in Section V-B.

5. When the reactor power level has increased approximately 1 decade, withdraw the controlling rod group to establish a startup rate of approximately 0.7 decade per minute. Record data listed in Section V-B.

6. When the reactor power level has increased approximately 1 decade, insert the controlling rod group and reduce reactor power level to the same level as was used in Step No. 3 above.

7. Maintain a constant power level by withdrawing the controlling rod group. When the rods reach the same position as used when measuring the 0.3 decade per minute startup rate above, stop rod motion and record the data listed in Section V-B when the reactor goes subcritical.

8. Withdraw the controlling rod group to the position used when measuring the 0.[illegible] decade per minute startup rate above. Record data listed in Section V-B. (This should now be approximately 0.[illegible] decade per minute startup rate.)

9. When the reactor power level has increased approximately 1 decade, withdraw the controlling rod group to establish a startup rate of approximately 0.7 decade per minute. Record data listed in Section V-B.

10. When the reactor power level has increased approximately 1 decade, insert the controlling rod group and reduce power to the same value used in Step No. 3 and Step No. 6 above.

11. Repeat Steps Nos. 7, 8, 9, and 10, each time withdrawing the rods one step further than used previously for measurements of similar startup rates. Continue these measurements until peak xenon is reached. Record the time when peak xenon poisoning is reached.

12. After peak xenon poisoning is reached and core excess reactivity begins to increase with time, continue the above startup rate measurements of 0, 0.3 and 0.7 decade per minute, only now the control rods will be inserted one step further into the core than was used previously for measurements of similar startup rates. For measurements of 0 startup rate, the time and position of rods for criticality will be noted rather than the position of rods and time of subcriticality as in Step No. 7.

13. Continue these measurements for approximately 48 hr after shutdown from power. Record the time when the control rods return to the same position that they were in just prior to the decrease in power level.

14. Leave the reactor, the auxiliary equipment, and the plant in the condition specified by the person in charge of the experimental program.

E. Data Analysis

1. Convert the measured startup rates to reactivity values.

2. Divide the changes in reactivity by the corresponding increments in control rod position to obtain incremental control rod worths.

3. Plot the measured reactivity values versus time after shutdown and draw a series of best fit straight lines through the points which correspond to reactivity values measured at constant rod positions. Extrapolate each straight line to intersect the time axis and draw a perpendicular to the time axis at this intersection. Note the reactivity value corresponding to the intersection of the perpendicular and the best fit straight line for the next rod position. Add up the reactivity increments obtained in this manner for each rod position and plot a curve of the change in core excess reactivity due to fission product poisoning versus time after shutdown.

STARTUP PROCEDURE NO. 503F7

INITIAL NUCLEAR PLANT POWER OPERATIONAL TESTS
EMERGENCY COOLING BY NATURAL CIRCULATION

I. Objective To demonstrate the ability of the main coolant system to provide adequate heat transfer from the reactor by natural circulation during a total loss-of-coolant-flow accident.

II. Conditions

1. S.P. No. 503F, INITIAL CORE LOADING AND NUCLEAR CORE TESTS, will have been completed before initiating this S.P.

2. At the time of initiation of this procedure, the reactor is stable and operating at one-half load. For purposes of obtaining adequate decay heat, the reactor core must have a history equivalent to 100 hr uninterrupted operation at half load. All system operating conditions are as listed in O.I. No. 504D6, MAIN COOLANT SYSTEM - RUNNING OPERATION, Section II-A, Operation During Power Generation.

3. The set point of the pressure controller for the turbine steam bypass valve is at 760 psi gage.

4. The boric acid mixing tank is filled and ready for boric acid addition to the main coolant system. Refer to O.I. No. 504G, CHEMICAL SHUTDOWN SYSTEM.

5. Waste holdup tank cavity for 1,000 gal is available in the radioactive waste disposal system.

6. Referring to O.I. No. 504G2, CHEMICAL SHUTDOWN SYSTEM - BORIC ACID ADDITION; the first two steps of Section V-A, Boric Acid Addition to the Main Coolant System, have been completed so that boric acid may be injected on short notice.

III. Precaution

1. Precautions for normal operation of the Pressure Control and Relief System, listed in O.I. No. 504E, apply to this startup procedure. There will be no spray in the pressurizer, however, after main coolant pumps are shut down.

2. The component cooling water flow to all main coolant pumps should be continued throughout the test.

3.* The average core coolant temperature must not be allowed to drop below 475 F during the test to assure that an unexpected condition of low temperature criticality will not occur.

4.* Throughout the test, personnel should be stationed so as to start boric acid injection to all main coolant loops immediately on a signal that cold leg temperature is below 475 F.

5. Since it will be necessary to stop all main coolant pumps during a period when there is decay heat generation in the core, it is important to exercise extreme care to assure that no core damage occurs. The following data are to be plotted versus time immediately after each reading is taken. Where possible, instrument alarm settings should be set to agree with the danger points listed below.

Measured Variable	Danger Point	Corrective Action
Core outlet temperature	636 F maximum limit (no alarm)	Start main coolant pumps
Pressurizer level	250 in. maximum limit above bottom of pressurizer vessel	Start main coolant pumps
Pressurizer pressure	2,300 psi gage maximum 2,000 psi gage minimum	Start main coolant pumps
Cold leg temperature	475 F minimum* (no alarm)	Inject boric acid into main coolant system as rapidly as possible according to O.I. No. 504G2. All control rods are to remain fully inserted during this procedure however.

IV. Check-off List

Prior to the initiation of this S.P., the check-off list will be completed by the operator(s) and signed off.

*The temperature indicated in this precaution is subject to verification by tests conducted under S.P. 503E, INITIAL CORE LOADING AND NUCLEAR CORE TESTS.

V. Instructions

A. Experimental Method

It is desired to demonstrate that natural circulation flow in the main coolant system can remove heat adequately from the reactor core during an emergency in which power is lost to all main coolant pumps.

Should such an unlikely emergency occur, the sequence of events in the plant would be as follows:

1. Both power lines outside the plant are lost. This results in a sudden loss of turbine generator load and immediate loss of power to two of the main coolant pumps.

2. Scram of the reactor will be initiated by a low flow signal as flow decays past approximately 80% of normal, and the turbine generator throttle will trip within 2 sec after start of scram.

3. The turbine generator will coast down supplying energy from its inertia to the two operating main coolant pumps. This power supply will continue until the generator field breaker is tripped manually one minute after throttle trip.

4. The remaining two main coolant pumps will then coast down rapidly, and natural circulation will be established in the main coolant system.

During the process of the accident described above, main coolant system temperatures are expected to change as follows:

1. Core outlet temperature is expected to rise sharply after loss of power to two main coolant pumps reach a maximum in a few seconds and begin to decline. Another increase may occur following shutdown of the remaining two pumps one minute after start of the process. Core outlet temperature should again decline and stabilize as natural circulation flow of coolant is established.

2. Reactor cold leg temperature is expected to drop and then rise to a value slightly greater than 514 F following start of the accident. The drop would be caused by the full power withdrawal of steam from the steam generator during the short interval of main coolant flow decay ($<$ 2 sec) before the turbine throttle is tripped.

3. Hot leg, cold leg, and reactor core outlet temperatures are expected to stabilize a few minutes after start of the process as steady natural circulation of coolant is established in the main coolant system.

After having operated at power for a length of time to provide adequate decay heat, the test will consist of a series of runs simulating the loss-of-coolant flow accident described above. To assure core safety, the first run will be initiated with the reactor operating at one-half of full power. Subsequent runs will be initiated from successively higher reactor power levels to establish that the accident can be performed safely with the reactor operating at full power. Instruments will be observed to indicate the magnitude of the coolant temperature rise at core outlet, the coolant temperature drop in the cold legs, and to determine whether a natural circulation flow will be maintained in the main coolant system.

The procedure of the half-power run will duplicate the sequence of events expected to occur in the total-loss-of-coolant flow accident. The run will be initiated only by trip of breakers interrupting power to the two main coolant pumps supplied by the outside system interconnections (Harriman & Cabot). Reactor scram will begin automatically within one second after pump shutdown on receipt of a low-flow signal. Turbine throttle trip will occur within 2 sec following reactor scram. Manual tripping of the two pumps taking power from the coasting down turbine generator will occur one minute after turbine throttle trip by removal of the generator exciter.

Subsequent runs will be made at successively higher reactor power levels. The test will be concluded with the performance of a run simulating the accident with the reactor initially operating at full power.

B. Data Required

1. Frequency of Recording Data

Data required must be recorded with sufficient frequency to provide information for analysis. Preparation should be made to record data* at 15 sec intervals after reactor scram. Time intervals between readings may be increased at the discretion of the operator(s) when changes in the measured variable occur at reduced rates. Rapid changes are anticipated for only a few minutes after main coolant pumps are shut down.

2. Data to be Taken

The following data are to be recorded:

a. *Selected core outlet temperatures (if available)

b. *Main coolant hot and cold leg temperatures

c. *Pressurizer pressure

*Only starred items need be recorded initially at 15 sec intervals. See Section III concerning precautions to be observed in the recording of these data.

d. *Pressurizer level

e. Main steam flow

f. Feed water inlet temperature

g. *Main steam pressure

h. Water level in steam generators

i. *Record time of pump shutdown and reactor scram. Time is also to be recorded with each reading of the above variables.

C. Special Instrument Requirements

1. Strip chart recorders, speed approximately 2 in. per min, are required for recording the following main coolant system temperatures during transients occurring following main coolant pump shut-off and reactor scram:

a. Coolant Temperature at Core Outlet

The outputs of two thermocouples, if available, shown to be located at the outlet of the core hot channels during the steady state run, are to be recorded for this test. Instrument range should be 500 F to 650 F.

b. Hot Leg Temperature

The outputs of the resistance elements for a minimum of two loops are to be recorded. Elements chosen are to be located in loops where main coolant pumps are to maintain flow for 1 min following reactor scram. Instrument range should be 500 F to 650 F.

D. Procedure

1. With the reactor operating steadily at one-half of full load, shut down the two main coolant pumps driven by power from the system interconnections. (Pumps driven from the turbine-generator output will remain in operation.) On decay of flow to approximately 80% of its normal operating value, the reactor is automatically scrammed. Within 2 sec following reactor scram the turbine throttle is automatically tripped. Refer to E.I. No. 505C, SECONDARY PLANT - EMERGENCY SHUTDOWN AND TURBINE THROTTLE TRIP, for subsequent action required in the secondary system.

*Only starred items need be recorded initially at 15 sec intervals. See Section III concerning precautions to be observed in the recording of these data.

2. Carefully observe the core outlet temperatures recorded by the special instrumentation immediately following the start of this procedure.

   Core outlet temperatures can be expected to rise after shutdown of the first main coolant pumps because of the short delay before reactor scram is started at 80% of normal flow. Core outlet temperatures will then decrease because of the decaying coolant flow and the continued steam demand during the short interval before the turbine throttle trips. During this test, if the main coolant cold leg temperature drops below 475 F, initiate boric acid injection.

3. One minute after the turbine throttle is tripped, open the breaker supplying generator field current. The two main coolant pumps driven by turbine generator output will coast down rapidly. With the resultant flow decay in the core, a rising temperature at core outlet can be expected until natural circulation of coolant is established. Should any one of the core outlet temperatures reach 636 F, the main coolant pumps are to be immediately restarted. Should any cold leg temperature drop below 475 F, boric acid injection should be started immediately. For this procedure, all control rods are to remain fully inserted.

4. Observe both the special recorders recording core outlet temperature and main coolant system hot leg temperatures. The indication that natural circulation has been established will be the achievement of stabilized temperatures at the core outlet and in the hot and cold legs of the main coolant system. Temperatures may continue to change for several minutes after all main coolant pumps are shut down. Continue to take data for 1 hr after main coolant temperatures are stabilized.

5. Start the main coolant pumps. When the system returns to equilibrium, the main coolant system is in the hot standby condition. Control rods are to be fully inserted when the main coolant pumps are started.

6. A minimum of one subsequent run is required to demonstrate that no core damage will result from the temperature transient occurring after total loss of main coolant pump power while the reactor is at full power.

   For safety, it may be desirable to provide a series of test runs initiated from successively higher reactor power levels between the 50% of full power and the full power condition required for fulfillment of the objective of this S.P. Responsible personnel will determine the reactor power level from which each succeeding run is to be initiated and the number of runs required for safety. Choice of power level will be made based upon the margin by which the maximum core outlet temperature in previous runs falls below the maximum safe limit of 636 F. Repeat Steps Nos. 1 through 5, under Section V-D, for all subsequent runs.

This startup procedure will be concluded with the demonstration of emergency cooling by natural circulation with the test initiated from the full power condition.

E. Data Analysis

1. From knowledge of the power-time history of the core, compute the relation between decay heat generation and time following reactor shutdown.

2. From steam flow, feed water temperature, and saturation temperature data for the steam generator, calculate the heat removal from the primary system after natural circulation has been established.*

3. Compare Steps Nos. 1 and 2 above and use the best information available for estimating decay heat removal rate. Use the decay heat removal rate so calculated in conjunction with the hot and cold leg temperatures of the main coolant system to calculate flow rate after natural circulation has reached equilibrium.

*It is possible that accurate steam flow data cannot be provided, since the steam generation rate due to decay heat is approximately 1% of the full power steam generation.

OPERATING INSTRUCTION NO. 504A1

PLANT STARTUP
PRIMARY PLANT STARTUP FROM COLD CONDITION

I. Objective To provide a safe and efficient method of bringing the primary plant from the cold shutdown condition to the hot standby condition.

II. Conditions

1. The main coolant system is filled with primary grade borated water and venting is being accomplished. Refer to O.I. No. 504D1, MAIN COOLANT SYSTEM - FILLING AND VENTING OF COMPLETE SYSTEM.

2. The low pressure surge tank is filled to the normal operating level with primary grade borated water and is covered with a hydrogen gas blanket to a pressure of 15 psig. The feed and bleed lines have been filled and vented.

3. The pressurizer is filled with primary grade borated water, and the pressurizer vent valve is open.

4. The shell side of the steam generators are filled to normal startup level. The steam line non-returns are open, the drain and traps are closed and the steam generator vents are open.

5. The pressurizer wide range and narrow range water level indicator is set for minimum pressure compensation.

6. Electrical power is available for all pressure control and relief system electrical equipment.

7. All pressurizer heaters are de-energized and the surge spray and relief system valves are closed.

8. The pressurizer circulation spray control valve had been positioned such that the required circulation spray flow rate will be established with occurrence of main coolant flow.

9. The following valves are open:

   a. Charging pump suction and discharge valves

   b. Meter operated valve between the charging pump suction header and the low pressure surge tank.

   c. Pressurizer low level control valve in the bleed line.

d. All valves in the feed line

10. A proper water balance is established to insure that adequate water for makeup and storage volume for waste water is available.

11. The critical control rod position has been determined, as firmly as possible, based on all available information and calculations.

12. Pertinent auxiliary systems are in the following status:

System	Status
Shutdown Cooling System (Refer to O.I. No. 504M)	In operation, if required
Component Cooling System (Refer to O.I. No. 504I)	In service, as required
Primary Plant Corrosion Control System (Refer to O.I. No. 504J)	15 psig hydrogen gas blanket maintained on low pressure surge tank
Chemical Shutdown (Refer to O.I. No. 504G)	Normal standby
Purification System (Refer to O.I. No. 504H)	Ion exchangers isolated and operating as required
Reactor Control System (Refer to O.I. No. 504N)	Ready standby on Manual
Nuclear Instrumentation System (Refer to O.I. No. 505O)	Normal operation
Radiation Monitoring System (Refer to O.I. No. 504P)	Normal operation
Safety Injection System (Refer to E.I. No. 505B10)	Ready standby
LPST Cooling System	Ready standby

III. Precautions

1. When there is a substantial amount of decay heat in the reactor fuel, maintain at least two main coolant loops tied into the reactor vessel (main coolant pumps may be off), or the shutdown cooling system in operation at all times. For purposes of cold leak testing only, however, isolation of the reactor vessel may be established per MAINTENANCE INSTRUCTION NO.506B3-PRIMARY PLANT-COLD LEAK TEST.

2. The shutdown cooling system must be valved off and locked, completely

isolating the system before the main coolant system pressure exceeds 300 psig.

3. The main coolant system pressure must not exceed 500 psig until the temperature of the main coolant is at least 90°F. Pressures in excess of this at low temperatures may be injurious to the reactor vessel.

4. The main coolant system heatup rate must not exceed 50°F/hr. As the normal operating temperature is approached in the system, the charging and bleed rate should be adjusted so as to normally maintain a temperature of the main coolant bleed downstream of the regenerative heat exchanger to less than an indicated temperature of 240°F.

5. In order to protect the main coolant pump stator cans from damage due to negative pressure loadings while shut down, the pressures acting on the pump must be controlled as follows:

   a. When the loops are isolated from the reactor vessel, the pressure in those loops must be maintained in the minimum range of 50 to 200 psi gage by periodic manual operation of the charging pumps.

      NOTE: This does not apply to loops which are vented or open to atmosphere.

   b. During startup of the plant, the pressure in the reactor vessel and non-isolated loops is initially maintained by the pressurizer water level and atmospheric pressure acting through the open pressurizer vent. When the water in the pressurizer attains a temperature of 220°F, the system pressure is maintained and controlled by the pressurizer steam conditions.

   c. The pressurizer temperature and pressure must be controlled so that proper overpressure is maintained on the main coolant pumps.

6. The pressurizer should not be heated at a rate exceeding 200°F/hr.

7. If the pressurizer NR low level alarm sounds, check to see that pressurizer heaters have been shut off automatically.

8. If main coolant pump lower bearing temperatures exceed 200°F, the affected pump should be shut down and the malfunction investigated.

9. No steam withdrawal from the secondary system is allowed until the main coolant system has attained a temperature level of 485°F.

10. The suction and discharge valves of the "ready standby" charging pumps be open during normal plant operation.

11. Criticality should be anticipated any time when control rods are being withdrawn or when boron is being removed from the main coolant system.

12. During a reactor startup in which core reactivity or control rod worths are not reasonably firm, a plot of inverse multiplication rate (or count rate) versus rod position should be made.

13. Any plant changes which might produce a sudden lowering of reactor water temperature (of the order of 10°F) must be avoided while the reactor is critical or approaching criticality.

14. During normal approach to criticality, a flux multiplication rate of 1 decade/minute or less is acceptable. Flux multiplication rates greater than 1 decade/minute should be avoided.

15. During normal approach to criticality, control rod withdrawal should be interrupted for approximately 1 minute whenever the count rate is doubled.

IV. Check Off Lists

Prior to initiation of this O.I. pre-startup check off lists P1, 504E-A and 504F-C must be completed.

V. Instructions

1. Start component cooling water flowing to the main coolant pumps, primary system sample cooler, and neutron shield tank. Refer to O.I. No. 504I, COMPONENT COOLING SYSTEM.

2. Place the low pressure surge tank high water level control, high pressure and high temperature alarms in service.

3. Check that the purification system is prepared to receive borated water from the low pressure surge tank. All ion exchangers are isolated.

4. Line up and operate the purification cooling and drain pumps as required for LPST cooling.

   NOTE: For abnormally high heat removal requirements, use the low pressure surge tank cooling pump.

5. Open the motor operated valve in the bleed line between the main coolant piping and the regenerative heat exchanger.

6. Turn on all pressurizer heater groups.

7. At a pressurizer temperature of 180°F, close the pressurizer vent

valve, open the hot leg main coolant loop 20" gate valve in loops which are to be placed in service. Open all of the loop bypass valves which are closed in loops which are to be placed in service.

8. Maintain main coolant pressure between 50 and 200 psig by intermittent bleed or feed as required.

9. When pressurizer temperature reaches 250°F, open the isolation and bleed orifice valves in the bleed line to the low pressure surge tank in order to drain the pressurizer, thereby flashing hot water to form a steam bubble. Close the bleed orifice valves when the water level drains to 120 inches above the bottom of the pressurizer.

   NOTE: Pressure control of the primary system is now accomplished by manually cycling of the pressurizer heaters after the steam bubble has been formed.

10. Check open the motor operated pressure relief isolation valve at a pressurizer temperature of 250°F. Switch the solenoid relief valve control to "Auto" position.

11. If the rod breakers are closed for the heatup, check that group 6 control rods are in the safety group position and that all other control rod groups are withdrawn 3 inches to provide for differential expansion.

12. Start main coolant pumps when the indicated pressurizer steam temperature is 390°F by closing the switches on the main control board. Run pumps for 2 minutes with cold leg valve closed and bypass valve open, then open cold leg and close bypass valve. Pump operation will result in heating up the main coolant system. Refer to curve P-MC-2 for anticipated heatup rate.

   NOTE: Observe the indicated main coolant flow in the individual loops. Vent the main coolant pumps. Refer to O.I. No. 504D1 - MAIN COOLANT - FILLING AND VENTING COMPLETE SYSTEM.

13. Maintain pressurizer water level between 100 and 120 inches above the bottom of the pressurizer by manual intermittent operation of the bleed valves or at 120 ± 5 inches by automatic level control.

14. Prior to attaining an indicated steam temperature of 410°F in the pressurizer (300 psig in the main coolant system), stop the shutdown cooling system if operating, and isolate it from the main coolant system.

15. After approximately 5 minutes of coolant circulation with all main coolant pumps operating, sample the coolant to determine O_2 and H_3BO.

16. Add Hydrazine to the main coolant system as required. Refer to O.I.

No. 504J2 - PR MARY PLANT CORROSION CONTROL SYSTEM.

17. Prior to obtaining a main coolant temperature of 200°F, perform final venting operation on the main coolant pumps, control rod mechanisms, instrumentation, etc. Refer to O.I. No. 504D1 - MAIN COOLANT SYSTEM - FILLING AND VENTING OF COMPLETE SYSTEM.

18. When the main coolant temperature reaches 250°F, shut down the main coolant pumps and maintain an essentially constant coolant temperature condition for a period of 2 hours. This will permit establishing water-metal equilibrium temperature conditions in main coolant system components. During isothermal wait, the reactor may be taken critical at low power level, to aid in plant heat up or for special physics tests. Operate main coolant pumps as required to maintain the essentially constant main coolant temperature. Refer to O.I. 504D8 - MAIN COOLANT SYSTEM - Shutdown of Individual Loop, Section V, for the main coolant pump shutdown procedure.

19. Observe that appropriate rod position lights go on as the control rods are being withdrawn.

20. During each control rod group withdrawal, observe neutron level instruments. Continue intermittent rod withdrawal until ciriticality is achieved.

21. Sample the pressurizer water and, as required, operate the pressurizer surge spray to increase water circulation and decrease the pressurizer water boron content.

22. Start one low pressure surge tank make up pump, after associated valves from the primary water storage tank or demineralized water storage tank have been opened.

23. Open associated valves from the low pressure surge tank make up pumps to the charging pump suction header.

NOTE: Since one LPST pump is a spare its discharge valve should be in the open position.

24. Immediately close the motor operated valve between the LPST and the charging pump suction header.

NOTE: The feed and bleed operation should continue as outlined above.

25. When O_2 concentration is less than .1 ppm, and system has been at 250°F for at least two hours, start up the main coolant pumps and continue with the system heat up to 514°F. Use reactor heat as well as pump heat if desired.

26. Operate the pressurizer heater groups as required to comply with the operating conditions indicated on curve P-MC-1 in the data reference book for safe operation of the main coolant pumps. Pressurizer temperature should not exceed main coolant system temperature by more than 200°F, unless necessary for main coolant pump operation when the surge spray is operating.

27. When the plant has reached the 500°F range and the integrity of the Primary Plant has been checked, initiate boric acid removal. Refer to O.I. No. 504G3 - CHEMICAL SHUTDOWN SYSTEM - BORIC ACID REMOVAL.

28. For completion of the borated water removal through the purification system, open the motor operated valve between the LPST and the charging pump suction header.

29. Close the valve in the individual loop demineralized water fill line at the charging pump suction header and stop LPST make up pump.

30. When the boron concentration reaches 80 ppm, start chemical shutdown system operation by putting the chemical shutdown ion exchangers in line. Refer to O.I. No. 504G3, CHEMICAL SHUTDOWN SYSTEM - BORIC ACID REMOVAL.

31. Place the purification ion exchangers into operation when boron concentration reaches 5 ppm or less. Refer to O.I. No. 504H, PURIFICATION SYSTEM.

    NOTE: Additional main coolant purification may be accomplished by increasing the flow to the ion exchangers and through the feed and bleed system.

32. When the main coolant pressure reaches 2000 psig, switch one pressurizer heater group to cycling control and the other groups to low pressure backup control.

33. Change the pressurizer wide range and NR water level channels pressure compensation to 2000 psig.

34. Operate surge spray intermittently until the pressurizer water boron concentration corresponds to that of the main coolant water.

35. Switch the solenoid operated surge spray valve controls from "off" to "Automatic".

VI. Final Condition

The main coolant system is at temperature of 514°F, and a pressure of 2000 psig.

The reactor is critical for low power tests, or is subcritical with the Primary Plant in the hot standby condition.

OPERATING INSTRUCTION NO. 504A2

PLANT STARTUP AND SHUTDOWN
STARTUP FROM HOT STANDBY CONDITION, SHUTDOWN TO THE HOT STANDBY CONDITION, AND CHANGING REACTOR LOAD.

I. Objective To provide a safe and efficient method of:

a. Starting up the reactor from the hot standby condition

b. Increasing reactor load

c. Decreasing reactor load and shutting down the plant to the hot standby condition

II. Conditions

1. The Main Coolant System is at 2000 psig and 514°F, and the reactor is in power generation or hot standby operation.

2. The normal feed and bleed rate has been established.

3. The charging pump suction is from the low pressure surge tank.

4. One group of pressurizer heaters is on cycling control, the remaining groups are on backup.

5. Pressurizer surge spray and relief valve controls are set for automatic operation.

6. A critical control rod position has been determined as firmly as possible based on all available information and calculations.

7. Boron conditions fulfill the requirements of the Technical Specifications.

8. The turbine generator is being prepared for operation according to O.I. No. 504A5 - TURBINE GENERATOR STARTUP FROM HOT CONDITION, or is operating at some reduced load.

9. Pertinent auxiliary systems are in the following condition:

System	Status
Chemical Shutdown System (Refer to O.I. No. 504G)	Normal Standby or Normal Operation
Purification System (Refer to O.I. No. 504N)	Normal Operation or Hot Standby
Component Cooling System (Refer to O.I. No. 504I)	Normal Operation
Primary Plant Corrosion Control System (Refer to O.I. No. 504J)	Normal Standby
Primary Plant Sampling System (Refer to O.I. No. 504K)	Normal Standby
Reactor Control System (Refer to O.I. No. 504N)	Normal Operation or Manual Control
Nuclear Instrumentation System (Refer to O.I. No. 504O)	Normal Operation
Radiation Monitoring System (Refer to O.I. No. 504P)	Normal Operation
Vapor Container Atmosphere Control Systems (Refer to O.I. No. 504Q)	Normal Operation
Electrical System (Refer to O.I. No. 504R)	Normal Operation
Safety Injection System (Refer to E.I. No. 505B10)	Ready Standby

III. Precautions

1. Criticality should be anticipated when control rods are being withdrawn or when boron is being removed from the main coolant system.

2. During a reactor startup in which core reactivity or control rod worths are not reasonably firm, a plot of inverse multiplication rate (or counting rate) versus rod position should be made.

3. Any plant changes which produce a sudden lowering of reactor water temperature (of the order of 10°F) must be avoided while the reactor is critical or approaching criticality.

4. During a normal approach to power level, a flux multiplication rate of 1 decade/minute or less is acceptable. Flux multiplication rates greater than 1 decade/minute should be avoided. Refer to O.I. No. 504N - REACTOR CONTROL SYSTEM.

5. During a normal approach to criticality, rod withdrawal should stop whenever the count rate is doubled.

6. A proper plant water balance should be established in the water storage and waste collection tanks to ensure that adequate make up water is available and to receive water rejected from the primary plant.

7. Power level changes in excess of 10% of full power per minute must be avoided.

8. Whenever there is a sustained outage of one of the 115 KV lines because of maintenance or fault condition, the three 2,400 V buses will be tied together through the normally open circuit breakers to provide electrical power supply to both safety injection pumps.

9. The pressurizer spray line shall not be isolated when the reactor power level is greater than 5 MW thermal.

IV. Instructions

A. Taking the Reactor Critical and Phasing the Turbine

1. Prestartup check off list P-2 Reactor and Turbine Startup from a Hot Condition has been completed.

2. Establish a firm critical rod position or start an inverse multiplication plot.

3. Commence an intermittent programmed rod withdrawal.

NOTE: Cease rod motion for at least one minute for successive count rate doubling increments.

4. Anticipate criticality whenever control rods are being withdrawn.

5. Continue programmed rod withdrawal following the steps outlined in the operational check off list P-2.

6. When reactor is critical, establish vacuum and prepare to roll and phase the turbine following the detailed steps outlined in the operational check off list P-2.

B. Increasing Reactor Load

1. As the load demand on the plant increased, increase the reactor power level using control rods if required. The reactor control

may be placed on "AUTO" if the plant power level is equal to or greater than 10% of full power. For power levels less than 10% "MANUAL" control must be used. Refer to O.I. No. 504N, REACTOR CONTROL SYSTEM.

2. Observe the neutron flux level instruments as the station load increases. Refer to Check off List No. 5040-A1, Section III, NUCLEAR INSTRUMENTATION SYSTEM.

3. After establishing the required reactor load, the reactor control may be placed on automatic T_{avg} control; continue to observe nuclear panel instrumentation.

NOTE: After attaining the required reactor power level, the reactor control system, when in "AUTO" control, will automatically compensate for reactivity changes due to fuel depletion and/or Xenon level changes, and station load will be automatically maintained.

C. Decreasing Reactor Load

1. As the load on the plant decreases, decrease the reactor power level using control rods as required. The reactor control may be placed on "AUTO" if the plant power level is equal to or greater than 10% of full power. For power levels less than 10%, "MANUAL" control must be used. Refer to O.I. No. 504N, REACTOR CONTROL SYSTEM.

2. Observe the neutron flux level instruments as the station load decreases. Refer to Check off List No. 5040-A1, Section III, NUCLEAR INSTRUMENTATION SYSTEM.

3. Check that the turbine permissive relay tripout interlock indicating light goes out when the turbine generator load is reduced to approximately 15,000 KW.

4. When it is required to reduce the reactor power level to a critical-zero power level or equivalent condition, shut down the turbine, refer to O.I. No. 504C3, SCHEDULED TURBINE GENERATOR SHUTDOWN. Maintain T_{avg} at 514°F with turbine steam bypass controller to bypass steam to condenser.

5. To place reactor in the hot standby condition, insert rods to the all in position, with the exception of the safety group which will be left in the safety position.

D. Charging and Volume Control Operation During Above Operating Conditions

1. During normal feed and bleed operation, the following operating

limits and conditions should be maintained and periodically checked:

a. Low pressure surge tank temperature and pressure - Between 120° and 130°F and 15 psi gage (pressure required to maintain desired hydrogen concentration in the main coolant) respectively.

b. Feed and bleed flows - 25 gpm.

2. If the flow from the purification cooling and drain pumps is insufficient to maintain the water temperature in the low pressure drain tank at 120°F, the low pressure surge tank cooling pump should be put into operation.

NOTE: This high temperature condition may be due to the following conditions:

Increased feed and bleed flow

Higher bleed than feed flow

Pressurizer relief or safety valve effluent into the low pressure surge tank.

E. Pressurizer and Relief System During Above Operating Conditions

1. When pressurizer automatic level control is shut down, maintain pressurizer water level between 115 and 125 in. (above the bottom of the vessel) by manual control of the charging and volume control system.

2. Maintain heater cycling duty on one specific heater bundle in order to fully expend all heaters in that heater bundle and to reduce the possibility of more than one bundle failing during any operating period. If one heater element burns out, switch the cycling duty to the other heater group in the same heater bundle.

3. Check pressurizer safety and relief valve discharge pipe temperatures periodically to determine if the valves are leaking. Refer to E.I. No. 505B14, PRIMARY PLANT - MALFUNCTION OF PRESSURE RELIEF AND SAFETY VALVES.

4. Check pressurizer heater cycling and compare the heat load with the measured insulation heat losses, or check pressurizer surge pipe temperature periodically to determine if the circulation spray is operating satisfactorily. If the surge pipe temperature drops below 530°F, operate the surge spray periodically as

required to induce a flow in the surge pipe and maintain the surge pipe temperature at or above 530°F. Clean or repair the circulation spray valve during the next shutdown period.

5. If automatic pressure control of pressurizer heaters is not operating, manually control one pressurizer heater group to maintain main coolant system pressure at 2,000 psi gage.

6. Sample the pressurizer water periodically to determine the degree of impurity buildup. If necessary, operate the pressurizer surge spray and heaters intermittently to increase the water flow through the pressurizer. Refer to O.I. No. 504K2, PRIMARY PLANT SAMPLING SYSTEM - AUXILIARY SYSTEMS.

V. Final Conditions

1. The reactor is critical at zero power.

2. The nuclear steam generators are in operation at the required power level.

3. The reactor is in the hot standby condition.

OPERATING INSTRUCTION NO. 504A4

PLANT STARTUP
TURBINE GENERATOR STARTUP FROM COLD CONDITION

I. Objective To provide a safe and efficient method of starting up the turbine generator from a cold condition.

II. Conditions

1. The nuclear reactor has been started up in accordance with O.I. No. 504A1, PLANT STARTUP - REACTOR STARTUP FROM COLD CONDITION and has achieved a condition of criticality.

2. The main condenser circulating water system is in operation, including circulating water pumps, circulating water air removal system, traveling water screens, and screen wash, if required.

3. During reactor startup, the steam line nonreturn valves are open and the steam traps and drains are closed.

4. The turbine generator manufacturer's recommendation for turning gear operation has been fulfilled.

5. The generator seal and bearing oil systems are in operation and the generator is filled with hydrogen.

6. The extraction steam lines to the feed-water heaters are open and the feed-water heater drain system is in operation.

NOTE: At very low turbine loads the second point extraction heater will be partially flooded.

7. The auxiliary systems of the secondary plant are in the following status:

System	Status
Condensate and Feed Water System (Refer to Section 220)	In operation as required
Service Water System (Refer to Section 222)	In normal operation
Compressed Air Systems (Refer to Section 224)	In normal operation
Lubricating Oil System (Refer to Section 225)	In operation as required

III. Precautions

The turbine generator manufacturer's startup instructions shall be carefully adhered to, particularly concerning mechanical clearances and eccentricity.

IV. Check-off List

Prior to initiation of this O.I., the check-off list must be completed by the operator(s) and signed off.

V. Instructions

1. Vent steam lines between steam generator and turbine stop valves and the auxiliary steam lines by opening the trap by-pass valves when the main coolant system temperature has reached a value at which control rods can hold the reactor 3% subcritical with no boron present. Refer to 504D4.

   CAUTION: Steam demand should not be of such a magnitude as to reduce main coolant system temperature.

2. Start one main condensate pump and establish minimum required flow of condensate through air ejector condensers and gland steam condenser back to the main condenser and maintain hot well level.

3. Admit steam to turbine steam seals.

   NOTE: Gland steam controller uses turbine control oil pressure but may be manually controlled.

4. Place condenser auxiliary priming jet in operation and open the connecting air off-take line from the condenser shell.

   NOTE: Steam flow from the steam generators is now estimated at 15,000 lb per hr.

   The priming jet is estimated to decrease condenser pressure to less than 14 in. Hg abs.

5. Start boiler feed pump auxiliary oil pumps.

   NOTE: During this and subsequent phases of starting procedure, one boiler feed pump only is operated intermittently as required to feed water to the steam generators under manual control to maintain proper water levels therein.

6. The main condenser steam jet air ejectors may be put in operation after steam pressure has increased to 300 psi gage or higher.

7. Open all turbine drains and ensure that all pockets are drained of water.

8. Check level in turbine oil tank and start turbine main auxiliary oil pump.

   NOTE: After control and bearing oil pressures are established, shut down turning gear oil pump.

9. Make all other prestart checks required by turbine generator manufacturer's starting procedure.

10. Admit cooling water to turbine oil coolers and hydrogen coolers, when required, as determined by temperature indications.

    NOTE: Water flow to the oil coolers should be controlled to maintain an oil temperature of 110 to 120 F leaving the oil coolers.

11. Start the turbine generator rolling with steam in accordance with the turbine generator manufacturer's instructions.

    NOTE: Turbine throttle valves should be opened slowly and alternately. After unit is rolling at a speed of about 100 rpm, the overspeed trip mechanism should be tripped by hand to close the throttle valves and then listen for rubs or unusual sounds. Reset the overspeed trip mechanism and see that governor valves open freely, then open throttle valves a small amount to keep the turbine rolling. Refer to turbine generator manufacturer's instructions for further information.

12. Stop turning gear motor.

13. Close the trap by-passes in the main and auxiliary steam lines leaving the trapped drains in service.

14. Gradually bring the turbine generator unit up to rated speed in accordance with turbine generator manufacturer's instructions.

15. Place one boiler feed pump in continuous operation.

16. When the unit reaches the governing speed range of about 1,700 rpm, the turbine control valves will automatically close, except the primary which will remain partially open. Speed control is now under the turbine speed governor and throttle valves can be opened wide.

17. Control of the turbine generator now passes from the operating floor to the control room.

18. Synchronize the turbine generator with the system and rapidly apply minimum load of 7,250 kw equivalent to about 150,000 lb per hr steam flow. Refer to O.I. No. 504R3, Station Power System.

19. Place the turbine main auxiliary oil pump on standby and check that it stops.

20. Change station service over. Refer to O.I. No. 504R3, Station Power System

21. Close turbine starting drains.

22. Place feed water control to steam generators on "automatic".

VI. Final Conditions

The plant is operating at minimum load condition and ready to increase load in accordance with O.I. No. 504B2, PLANT OPERATION - INCREASING TURBINE GENERATOR LOAD.

OPERATING INSTRUCTION NO. 504A5

PLANT STARTUP
TURBINE GENERATOR STARTUP FROM HOT CONDITION

I. Objective To provide a safe and efficient method of starting up the turbine generator from a nuclear plant hot standby condition.

II. Conditions

1. The reactor is at normal operating pressure and temperature, operating at critical zero power level. Excess heat is being dissipated by operation of the turbine steam by-pass line.

2. The turbine generator is on turning gear.

3. The turbine main auxiliary oil pump and turbine steam seals are in operation.

4. One condensate pump and one boiler feed pump are in operation.

5. Condenser vacuum is being maintained by the air ejector unit.

6. The steam line nonreturn valves are open and all the main steam line drains, the turbine inlet and shell drains and auxiliary steam line drains are open or partially open discharging to the main condenser.

7. The condensate is being recirculated through the air ejector and gland steam condensers back to the main condenser.

8. Extraction steam line valves are open.

9. The auxiliary systemscf the secondary plant are in the following status:

System	Status
Service water system	In normal operation
Instrument air system	In normal operation
Circulating water system	In normal operation
Feed water system	Under manual control

III. Precautions

The turbine generator manufacturer's startup instructions shall be carefully adhered to, particularly concerning mechanical clearances and eccentricity.

IV. Check-off List

Prior to initiation of this O.I., the check-off list must be completed by the operator(s) and signed off.

V. Instructions

1. Make all prestart checks required by turbine generator manufacturer's starting procedure.

2. If the turbine steam by-pass line has been operated in a manner to drop main steam pressure, gradually close the turbine steam by-pass valve from the central control panel until main steam pressure is 755 psi gage, normal pressure corresponding to zero power.

   NOTE: Under these conditions, the turbine steam by-pass line will be passing between 0 and 100,000 lb per hr, depending upon reactor heat developed.

3. Admit cooling water to turbine oil coolers and hydrogen coolers, when required, as determined by temperature indications in accordance with turbine generator manufacturer's instructions.

4. Start the turbine generator rolling with steam in accordance with turbine generator manufacturer's instructions.

5. Stop turning gear motor.

6. Gradually bring the turbine generator unit up to rated speed in accordance with turbine generator manufacturer's instructions.

7. As steam flow to the turbine increases and turbine steam flow exceeds turbine steam by-pass flow, the turbine steam by-pass valve can be closed.

8. When the unit reaches governing speed range of about 1,700 rpm, the turbine control valves will close automatically, except the primary which will remain partially open. Speed control is now under the turbine speed governor and throttle valves can be opened wide.

9. Control of the turbine generator unit now passes from the floor to the control room.

10. Synchronize the turbine generator with the system and rapidly apply minimum load of 7,250 kw equivalent to about 150,000 lb per hr steam flow. Refer to O.I. No. 504R3, STATION POWER SYSTEM.

11. Place the turbine main auxiliary oil pump on standby and check that it stops.

12. Change station service over. Refer to O.I. No. 504R3, STATION POWER SYSTEM.

13. Close turbine starting drains.

14. Place feed water control to steam generator on "automatic".

VI. Final Conditions

The turbine generator is operating at minimum load condition and ready to increase load in accordance with O.I. No. 504B2, PLANT OPERATION - INCREASING TURBINE GENERATOR LOAD.

OPERATING INSTRUCTION NO. 504B1

PLANT OPERATION
CHANGING REACTOR LOAD

I. Objective To provide safe and efficient means of changing the reactor load between critical-zero power level and the required power level.

II. Conditions

A. Increasing Reactor Load (with boron present in main coolant system)

This O.I. is initiated subsequent to O.I. No. 504A1, PLANT STARTUP - REACTOR STARTUP FROM COLD CONDITION.

1. The reactor is critical with main coolant system in operation. Refer to O.I. No. 504D4, MAIN COOLANT SYSTEM - STARTUP OF COMPLETE SYSTEM.

2. The turbine-generator set is being prepared for operation. Refer to O.I. No. 504A4, PLANT STARTUP - TURBINE GENERATOR STARTUP FROM COLD CONDITION.

3. Pertinent auxiliary systems are in the following status:

System	Status
Pressure Control and Relief System (Refer to O.I. No. 504E)	Normal operation
Charging and Volume Control System (Refer to O.I. No. 504F)	Normal operation
Chemical Shutdown System (Refer to O.I. No. 504G)	Normal standby
Purification System (Refer to O.I. No. 504H)	Both the chemical shutdown and purification iron exchangers are isolated
Component Cooling System (Refer to O.I. No. 504I)	Normal operation
Primary Plant Corrosion Control System (Refer to O.I. No. 504J)	Normal operation

System	Status
Primary Plant Sampling System (Refer to O.I. No. 504K)	Normal operation
Reactor Control System (Refer to O.I. No. 504N)	System on manual control
Nuclear Instrumentation System (Refer to O.I. No. 504O)	Normal operation
Vapor Container Atmosphere Control Systems (Refer to O.I. No. 504Q)	Normal operation
Safety Injection System (Refer to E.I. No. 505B10)	Ready standby

B. Increasing Reactor Load (no boron present in main coolant system)

1. The reactor is critical with the main coolant system in operation. Refer to O.I. No. 504D6, MAIN COOLANT SYSTEM - RUNNING OPERATION.

2. The turbine generator set is in operation at some reduced load taking steam from the main steam header as required. Refer to O.I. No. 504B2, PLANT OPERATION - INCREASING TURBINE GENERATOR LOAD.

3. With the exception of the following, all pertinent auxiliary system status is the same as that under Section II-A, Step No.3.

System	Status
Purification System (Refer to O.I. No. 504H)	Normal operation

C. Decreasing Reactor Load

1. The reactor is critical with the m in coolant system in operation. Refer to O.I. No. 504D6, M/IN COOLANT SYSTEM - RUNNING OPERATION.

2. The turbine generator set is in operation. Refer to O.I. No. 504B3, PLANT OPERATION - DECREASING TURBINE GENERATOR LOAD.

3. With the exception of the following, all pertinent auxiliary system status is the same as that under Section II-A, Step No. 3.

System	Status
Purification System (Refer to O.I. No. 504H)	Normal operation

III. Precautions

1. Power level changes in excess of 10% of full power per minute must be avoided.

2. Whenever there is a sustained outage of one of the 115 kv lines because of maintenance or fault conditions, the three 2,400 v buses will be tied together through the normally open circuit breakers to provide electrical power supply to both safety injection pumps.

3. A proper plant water balance should be established in the water storage and waste collection tanks to ensure that adequate make-up water is available and to receive water rejected from the primary plant.

IV. Check-off List

Prior to the initiation of this O.I., the check-off list must be completed by the operator(s) and signed off.

V. Instructions

A. Increasing Reactor Load (with boron present in the main coolant system)

1. Check that a critical-zero power level has been attained. Refer to O.I. No. 504A1, PLANT STARTUP - REACTOR STARTUP FROM COLD CONDITION.

2. Increase T_{avg} of main coolant system to normal operating temperature using pump and nuclear heat, if required.

CAUTION: Do not exceed the maximum main coolant heat up rate of (50 F)* per hour.

*Subject to confirmation

NOTE: By withdrawing steam from the steam generator, a normal main coolant system temperature is being maintained; a normal system pressure is being maintained by the use of pressurizer heaters. Refer to O.I. No. 504A4, PLANT STARTUP - TURBINE GENERATOR STARTUP FROM COLD CONDITION and O.I. No. 504E, PRESSURE CONTROL AND RELIEF SYSTEM. The reactor scram signal from the turbine tripout interlock will automatically reset when the turbine generator is loaded to approximately 15,000 kw. The turbine tripout interlock indicating light should be checked at this load to ensure that the interlock automatically resets.

3. Check the boron concentration of the main coolant system. Refer to O.I. No. 504K1, PRIMARY PLANT SAMPLING SYSTEM - MAIN COOLANT SYSTEM.

   NOTE: The boron concentration should be (200)* ppm.

4. While maintaining coolant temperature and reactor power level and adjusting control rods as necessary, initiate boric acid removal operation and reduce the boron concentration to 80 ppm. Refer to O.I. No. 504G3, CHEMICAL SHUTDOWN SYSTEM - BORIC ACID REMOVAL.

5. When the boron concentration reaches 80 ppm, place the chemical shutdown ion-exchanger in service. Refer to O.I. No. 504G3, CHEMICAL SHUTDOWN SYSTEM - BORIC ACID REMOVAL.

6. Allow the reactor power level to increase during boron removal, adjusting control rods as necessary. Refer to O.I. No. 504N, REACTOR CONTROL SYSTEM.

7. By sampling the main coolant, determine when the boron concentration has been reduced to 5 ppm or less in the main coolant system. Refer to O.I. No. 504K1, PRIMARY PLANT SAMPLING SYSTEM - MAIN COOLANT SYSTEM.

8. Isolate the chemical shutdown ion-exchanger. Refer to O.I. No. 504G3, CHEMICAL SHUTDOWN SYSTEM - BORIC ACID REMOVAL.

9. Place the purification ion-exchangers in service. Refer to O.I. No. 504H, PURIFICATION SYSTEM.

*Subject to confirmation

10. As the load demand on the plant increases as per O.I. No. 504B2, PLANT OPERATION - INCREASING TURBINE GENERATOR LOAD, increase the reactor power level using control rods if required. The reactor control may be placed on "AUTO" if the plant power level is equal to or greater than 10% of full power. For power levels less than 10%, "MANUAL" control must be used. Refer to O.I. No. 504N, REACTOR CONTROL SYSTEM.

11. Observe the neutron flux level instruments as the station load increases. Refer to O.I. No. 504O, NUCLEAR INSTRUMENTATION SYSTEM.

12. After establishing the required reactor load, the reactor control may be placed on automatic T_{avg} control; continue to observe nuclear panel instrumentation.

    NOTE: After attaining the required reactor power level, the reactor control system, when on "AUTO" control, will automatically compensate for reactivity changes due to fuel depletion and/or xenon level changes, and station load will be automatically maintained.

B. Increasing Reactor Load (no boron present in main coolant system)

1. Check that the reactor is at or above a critical-zero power level and that the main coolant system is at nominal normal operatir- temperature and pressure.

2. As the loa ~-and on the plant increases as per O.I. No. 504B2, PLANT OPERAT - INCREACING TURBINE GENERATOR LOAD, increase the reactor p level using control rods if required. The reactor contro. be placed on "AUTO" if the plant power level is equal to -eater than 10% of full power. For power levels less than ~%, "MANUAL" control must be used. Refer to O.I. No. 504N, R 'CTOR CONTROL SYSTEM.

3. Observe the neutron flux level -truments as the station load increases. Refer to O.I. [illegible], NUCLEAR INSTRUMENTATION SYSTEM.

4. After establishing the required reactor load, the reactor control may be placed on automatic T_{avg} control; continue to observe nuclear panel instrumentation.

NOTE: After attaining the required reactor power level, the reactor control system, when in "AUTO" control, will automatically compensate for reactivity changes due to fuel depletion and/or xenon level changes, and station load will be automatically maintained.

C. <u>Decreasing Reactor Load</u>

1. As the load on the plant decreases as per O.I. No. 504B3, PLANT OPERATION - DECREASING TURBINE GENERATOR LOAD, decrease the reactor power level using control rods as required. The reactor control may be placed on "AUTO" if the plant power level is equal to or greater than 10% of full power. For power levels less than 10%, "MANUAL" control must be used. Refer to O.I. No. 504N, REACTOR CONTROL SYSTEM.

2. Observe the neutron flux level instruments as the station load decreases. Refer to O.I. No. 504O, NUCLEAR INSTRUMENTATION SYSTEM.

3. Check the turbine tripout interlock indicating light to ensure it automatically by-passes when the turbine generator load is reduced to approximately 15,000 kw.

4. When it is required to reduce the reactor power level to a critical-zero power level or equivalent condition, manually regulate turbine steam by-pass controller to by-pass steam to condenser as per O.I. No. 504C3, PLANT SHUTDOWN - SCHEDULED TURBINE GENERATOR SHUTDOWN.

IV. <u>Final Conditions</u>

The nuclear steam generator is in operation at the required power level.

OPERATING INSTRUCTION NO. 504B2

PLANT OPERATION
INCREASING TURBINE GENERATOR LOAD

I. Objective To provide a safe method of increasing load on the turbine generator.

II. Conditions

1. The reactor is producing power and the turbine generator is on the line generating an electrical load. All pressures and temperatures are normal.

2. All main systems in the secondary plant are in normal operation.

III. Precautions

1. The limiting rate of load increase, based on the turbine generator, is about 4 mw per min. The length of time that a turbine should be held at minimum load and the rate at which load may be applied are both a function of the length of shutdown. Refer to turbine generator manufacturer's instructions.

2. Check that the load limit device is properly adjusted for the maximum approved output of the nuclear core.

3. If only one transmission line is in service, the load on the unit shall be limited to 50%.

IV. Check-off List

Prior to the initiation of this O.I., the check-off list must be completed by the operator(s) and signed off.

V. Instructions

1. Start second circulating water pump (if only one has been in operation) to ensure continuity of circulating water.

2. Start second main condensate and boiler feed pump, as required.

3. Load turbine generator to meet load requirements not to exceed 4 mw per min for ramp load changes and 15 mw per min for step load changes.

4. Close recirculation by-pass at the main condenser air ejectors and gland steam condenser.

NOTE: Condensate pump discharge flow should be above 1,000 gpm before by-pass is closed.

5. If it is desired to operate the turbine generator at partial load for an extended period, it may be desirable to readjust the load limit device.

VI. Final Conditions

The turbine generator load has been increased.

OPERATING INSTRUCTION NO. 504B3

PLANT OPERATION
DECREASING TURBINE GENERATOR LOAD

I. Objective To provide a safe method of decreasing load on the turbine generator.

II. Conditions

1. The reactor is at power with the main coolant system in operation.

2. Main steam pressure is between 450 psi gage (full load) and 755 psi gage (no load).

3. The turbine generator is in operation carrying the desired load.

4. The secondary plant auxiliary systems are in normal operation.

III. Precautions

1. The rate of ramp load change for the reactor is limited to about 4 mw per min. The rate of a step load change for the reactor is limited to 15 mw.

2. Refer to turbine generator manufacturer's instructions for recommended rate of load decrease.

IV. Check-off List

Prior to the initiation of this O.I., the check-off list must be completed by the operator(s) and signed off.

V. Instructions

1. Decrease turbine generator load as required.

2. When load is decreased to approximately 60% of rated capacity, only one boiler feed pump and one condensate pump may be required.

3. When decreasing main condensate flow approaches 1,000 gpm, open condensate recirculation control system to maintain this flow as a minimum through the gland steam condenser.

VI. Final Conditions

The turbine generator is in operation at the required load.

OPERATING INSTRUCTIONS 504C2

PLANT SHUTDOWN
REACTOR AND PRIMARY PLANT COOLDOWN

I. Objective To provide a safe and efficient method of cooling down and depressurizing the primary plant from the hot standby condition.

II. Conditions

1. The primary plant is in the hot standby condition.

2. Reactor decay heat is being dissipated by steam bypass to the condenser.

3. The pressurizer water level, pressure, and temperature are at normal operating conditions, and heater, spray and pressure relief controls set for automatic operation.

4. The pressurizer water level indicators are set for 2000 psig pressure compensation.

5. Pertinent auxiliary systems are in the following status:

System	Status
Chemical Shutdown System (Refer to O.I. No. 504G)	Boric acid mixing and storage tank is filled; boric acid solution is ready for addition to the main coolant system.
Purification System (Refer to O.I. No. 504N)	Normal Operation
Component Cooling System (Refer to O.I. No. 504I)	Normal Operation
Primary Plant Corrosion Control System (Refer to O.I. No. 504J)	Normal Operation
Primary Plant Sampling System (Refer to O.I. No. 504K)	Normal Operation
Shutdown Cooling System (Refer to O.I. No. 504M)	Normal Operation
V. C. Atmospheric Control Systems (Refer to O.I. No. 504Q)	Normal Operation
Safety Injection System (Refer to E.I. No. 505B10)	Ready Standby

III. Precautions

1. Pressurizer temperature and pressure must be controlled so that proper overpressure is maintained on the main coolant pumps and so that pressure commensurate with the change in reactor vessel NDT is not exceeded.

2. The shutdown cooling system must not be placed in operation until, the main coolant pressure has reached 300 psig.

3. The safety control rod group must be withdrawn to the safety position or the reactor held critical, until the main coolant system has reached essentially ambient temperature.

4. Since reactivity is being inserted as the reactor is cooled down, special attention should be directed to the neutron instrumentation during this period.

5. The primary plant cooldown rate must not exceed 50° per hour.

6. When there is a substantial amount of decay heat in the reactor fuel, maintain at least two main coolant loops tied into the reactor vessel (main coolant pumps may be off), or the shutdown cooling system in operation at all times. For purposes of cold leak testing only, however, isolation of the reactor vessel may be established per MAINTENANCE INSTRUCTION NO. 506B3 - PRIMARY PLANT-COLD LEAK TEST.

7. Do not shut off component cooling water to the main coolant pumps when the pumps are shut down until main coolant temperature reaches 200°F.

IV. Check Off Lists

Check off List Reactor Shutdown P3 and pre-cooldown check off list P4 have been completed. Operational check off list P4 is being completed as the Primary Plant cooldown progresses.

V. Instructions

CASE I. PRIMARY PLANT COOLDOWN FOR REACTOR REFUELING

1. Borate the main coolant system while at 514°F to the full shutdown boron concentration (1150 ppm).

   NOTE: The boron concentration may be varied to meet the requirements of special physics tests during the cooldown period.

2. Operate purification at full capacity on cation resin or bleed and feed until the main coolant crud level is reduced to less than 2 ppm and the rate of crud removal has slowed noticeably, and the main coolant specific activity is less than .58 μc/cc.

3. Follow the steps outlined in Case II, omitting steps 2 and 12.

CASE II PRIMARY PLANT COOLDOWN FOR MAINTENANCE OF PRIMARY PLANT PRESSURIZED EQUIPMENT

1. If a main coolant loop has been previously isolated, check to assure that it contains water equal to or greater than the proper shutdown boron concentration. If concentration is below the proper level, establish the proper concentration by addition of 12% boric acid solution to the isolated loop.

2. Initiate primary plant cooldown by shutting down the main coolant system. Borate to shutdown concentration (1150 ppm).

   NOTE: When main coolant pressure reaches 1300 psig place safety injection system on manual control.

3. Leaving one main coolant pump in operation, shut down all remaining coolant pumps.

4. By operation of the secondary plant auxiliary systems and bypassing steam to the condenser reduce main coolant temperature.

5. Maintain pressurizer level by use of charging pumps taking suction from the safety injection shield tank cavity water storage tank containing 1.0% boric acid solution, as main coolant water contracts due to temperature reduction.

6. Turn off all pressurizer heaters.

7. Switch solenoid operated spray and relief controls from automatic to OFF.

8. Decrease pressurizer temperature and pressure by manual control of the pressurizer surge spray valve during main coolant system cooling when one or more main coolant pumps are operating. Pressurizer water temperature must comply with the operating conditions indicated on curve P-MC-1 in the data reference book for safe operation of the main coolant pumps.

   CAUTION: The pressurizer must not be cooled at a rate exceeding 200°F per hour.

   NOTE: Cooling of the pressurizer from normal operating conditions to 385-410°F should be accomplished only by spray induced by main coolant pump operation, rather than by spray induced by charging pump flow through the auxiliary spray line, in order to reduce the thermal stresses imposed on the pressurizer spray line connection. Main coolant pumps Nos. 1 or 2 will provide the maximum spray flow during one pump operation. Running additional pumps will increase the spray flow if more flow is required.

9. Maintain normal pressurizer water level by manual or automatic control of a charging pump.

10. Shutdown remaining main coolant pump just prior to placing the shutdown cooling system in operation.

11. When main coolant system reaches 330°F and 300 psig, place shutdown cooling system in operation.

12. Sample main coolant system to determine boron concentration.

13. Insert all rods to the full in position with the exception of Group 6 which will be maintained at the safety position.

14. After all main coolant pumps are shutdown, further pressurizer temperature and pressure reduction is performed by charging pump flow through the auxiliary spray line to the pressurizer spray, or by raising and lowering the pressurizer level by using maximum feed and bleed. Pressurizer water temperature should be maintained 20°F greater than main coolant temperature measured by the shutdown cooling system inlet temperature detector until main coolant temperature reaches approximately 200°F.

    NOTE: When initiating auxiliary spray to the pressurizer, a variable speed charging pump, set for minimum flow, should be used to decrease the thermal shock on the pressurizer vessel spray connection. If possible, a bleed flow should be initiated to preheat the spray water. Do not use more than the capacity of one charging pump for the auxiliary spray flow.

15. Change the pressurizer wide range and narrow range water level pressure compensation to the minimum value.

16. When the main coolant system temperature reaches 200°F, increase charging rate to the main coolant system in order to fill the pressurizer, and vent the pressurizer steam and gas volume through the solenoid relief valve to the low pressure surge tank.

17. When the pressurizer water level reaches the upper limit of the wide range level detector operate one charging pump at full flow for 3 minutes to assure water has reached the motor operated relief isolation valve.

18. Remove the blind flanges from the pressurizer vent valve discharge line and the 3/4" vent line to the vent header.

19. Connect plastic hose to the uncovered flanges.

20. Check that the primary vent stack is discharging dilution air and that the stack monitors are on.

21. Line up the vent header to discharge to the primary vent stack instead of the primary drain collecting tank.

22. Line up the pressurizer vent line to discharge via the plastic hose to the vent header.

23. Close the motor operated relief isolation valve.

24. De-energize the solenoid operated relief valve.

25. When the main coolant temperature approaches 140°F, shut off the component cooling water to all main coolant pumps.

26. If maintenance is to be limited to loops only, then isolate only those loops required, by closing their motor operated stop valves after main coolant temperature has been reduced to approximately 140°F.

27. If maintenance requiring pressurizer draining is to be accomplished isolate all four loops prior to draining the pressurizer.

28. Maintain the isolated loops at a pressure of 50 psig by intermittent use of a charging pump through the loop fill lines.

29. The shutdown cooling system is continued in operation maintaining main coolant temperature below 140°F.

30. If vapor container gross air borne activity is greater than 3×10^{-9} µc/cc, start activity dilution operation.

31. Check meteorological conditions to ascertain whether or not purging of the vapor container is permissible.

32. Start the vapor container air purging operating at full capacity (15,000 cfm), when an air-borne radioactivity level of (3×10^{-9} µc/cc) or less is reached.

    NOTE: The vapor container air purging operation should be continued during reactor shutdown, giving one complete air change per hour.

33. If reactor vessel head removal is anticipated, sample the main coolant system for assurance that coolant activity level has not increased beyond allowable limit. Refer to O.I. No. 504K1, PRIMARY PLANT SAMPLING SYSTEM - MAIN COOLANT SYSTEM.

VI. <u>Final Condition</u>

The primary plant is cooled down and depressurized.

OPERATING INSTRUCTION NO. 504C3

PLANT SHUTDOWN
SCHEDULED TURBINE GENERATOR SHUTDOWN

I. Objective To provide a safe and efficient method of turbine generator shutdown when the reactor is in hot standby condition or in cold shutdown condition.

II. Conditions

1. A shutdown of the turbine generator has been planned.

2. Load on the turbine generator unit has been decreased to minimum load (about 7,250 kw) in accordance with O.I. No. 504B3, PLANT OPERATION - DECREASING TURBINE GENERATOR LOAD.

3. Load on the reactor has been decrease correspondingly in accordance with O.I. No. 504B1, PLANT OPERATION - CHANGING REACTOR LOAD.

4. All secondary plant auxiliary systems are in normal operation.

III. Precautions

1. Refer to turbine generator manufacturer's instructions for special shutdown instructions.

2. Steam withdrawal rate from steam generators must not cool main coolant system faster than (50) F per hr.

3. During plant cooldown all steam generators must be connected to the main steam header to maintain uniformity of cooldown.

IV. Check-off List

Prior to the initiation of this O.I., the check-off list must be completed by the operator(s) and signed off.

V. Instructions

A. Turbine Generator Shutdown With Reactor in Hot Standby Condition

1. Transfer 2,400 v No. 1 bus and 480 v No. 4-1 bus from No. 1 station service transformer to the appropriate station service transformer depending on station loading. Refer to O.I. No. 504R3, ELECTRICAL SYSTEM - STATION POWER SYSTEM.

2. Prepare turbine steam by-pass line for operation.

NOTE: The turbine steam by-pass line pressure controller can be set slightly above 760 psi gage, so that the by-pass line will operate when turbine throttle valves are tripped or can be set slightly below the main steam pressure to put the by-pass line in operation at this time.

3. Reduce load rapidly to zero load.

   NOTE: When the unit is operating at zero load, the steam flow to the turbine throttle at 760 psi gage and saturated temperature is 100,000 lb per hr.

4. Open generator circuit breaker.

5. rip the turbine throttle valves.

6. Remove generator excitation in accordance with O.I. No. 504R3, ELECTRICAL SYSTEM - STATION POWER SYSTEM.

7. Verify automatic start of the turbine main auxiliary oil pump.

   NOTE: This oil pump will start automatically on a decrease in bearing oil pressure to about 9 psi gage.

8. Manually reset the automatic pressure controller in the turbine steam by-pass line to dump steam to the condenser considering decay heat produced, number of main coolant pumps in operation, and secondary plant steam demands.

9. Increase water supply to turbine oil coolers to reduce temperature of oil leaving oil coolers in accordance with turbine generator manufacturer's instructions by the time the turbine stops rolling.

10. Start turning gear oil pump and turning gear motor and open oil feed to the turning gear.

    NOTE: The turning gear oil pump will start automatically on decrease of oil pressure. Engage turning gear as soon as rotor stops rolling.

11. Shutdown main turbine auxiliary oil pump.

    NOTE: The main auxiliary oil pump supplied control oil to the spindle gland steam controller. After shutdown of this pump, the turbine gland steam supply is manually controlled.

B. Turbine Generator Shutdown With Reactor in Cold Shutdown Condition

1. All instructions under Section V-A have been followed.

2. When main steam pressure decreases to about 325 psi gage, put the condenser auxiliary priming jet in operation, shift the condenser shell air off-take from the air ejector unit to the auxiliary priming jet, and shut down the air ejector unit.

3. After main steam pressure has decreased to a value between 90 psi gage (corresponding to 330 F main coolant temperature) and 50 psi gage and after the reactor shutdown cooling system is in operation, open the turbine vacuum breaker valve.

   NOTE: The shutdown cooling system can be put in operation after main coolant has decreased to 330 F and 300 psi gage. Refer to O.I. No. 504D7, MAIN COOLANT SYSTEM - SHUTDOWN OF COMPLETE SYSTEM and to O.I. No. 504M, SHUTDOWN COOLING SYSTEM.

   CAUTION: Loss of condenser vacuum will close the turbine steam by-pass line automatically.

4. Shut down the condenser auxiliary priming jet and turbine gland sealing system, including the gland steam condenser exhauster.

5. Open all turbine drains.

6. Shut down the condensate, feed water and circulating water systems.

VI. Final Conditions

A. Turbine Generator Shutdown With Reactor in Hot Standby Condition

1. The reactor is subcritical and is being maintained in the hot standby condition.

2. The turbine generator is on turning gear and condenser vacuum is being maintained.

B. Turbine Generator Shutdown With Reactor in Cold Shutdown Condition

1. The reactor main coolant system is below 330 F and 300 psi gage and the shutdown cooling system is in operation.

2. The turbine generator is on turning gear.

OPERATING INSTRUCTION NO. 504D1

MAIN COOLANT SYSTEM
FILLING AND VENTING OF COMPLETE SYSTEM

I. Objective To provide a safe and efficient method of filling and venting the main coolant system.

II. Conditions

1. Access to the vapor container is permissible.

2. All main coolant stop and by-pass valves are closed.

3. The height of borated water in the reactor vessel is just below the head flange joint; the hot and cold legs between the reactor vessel and the main coolant stop valves are filled with borated water.

4. A minimum of 13,000 gallons of primary grade 1% borated water to fill the main coolant system is available from the safety injection and shield tank cavity water tank.

5. Pertinent auxiliary systems are in the following status:

System	Status
Charging and Volume Control System (Refer to O.I. No. 504F)	Ready standby
Chemical Shutdown System - Boric Acid Addition (Refer to O.I. No. 504G2)	Ready standby
Component Cooling System (Refer to O.I. No. 504I)	In service as required
Primary Plant Sampling System - Main Coolant System (Refer to O.I. No. 504K1)	Ready standby

III. Precautions

1. The pressure in the rotor-stator-gap of the main coolant pump must never be below atmospheric pressure.

2. Do not operate the main coolant pumps continuously until the system has been vented. Initially the pumps shall be jogged and the system shall be vented until the effluent from the vent is free of entrapped gas.

3. Venting of the main coolant system should only be performed if the coolant temperature is below 200 F.

IV. Check-off List

Prior to the initiation of this O.I., the check-off list must be completed by the operator(s) and signed off.

V. Instructions

A. Filling and Venting Isolated Loops

Fill the isolated loops with borated water as per O.I. No. 504D2, MAIN COOLANT SYSTEM - FILLING, VENTING AND DRAINING AN ISOLATED LOOP, Step Nos. 1 through 9 under Section V-A.

B. Filling and Venting the Reactor Section of the Main Coolant System

NOTE: All main coolant loops are isolated.

1. Open the following valves:

   Pressurizer vent
   One control rod mechanism vent
   Manual control valve in pressurizer spray line

2. Open motor operated valve in the 2 inch charging line and establish pump suction from the safety injection shield cavity storage tank and start charging pumps. Refer to O.I. No. 504F, CHARGING AND VOLUME CONTROL SYSTEM.

3. Close vent on control rod mechanism opened in Step No. 1 when water discharges from the vent.

4. When water discharges from the pressurizer vent, close the vent and pressurize the main coolant reactor section to approximately 25 to 50 psi gage.

5. Bleed the following vents while maintaining pressure between 25 and 50 psi gage:

   All control rod mechanisms
   Differential pressure cells
   Pressurizer vent

C. Completion of Filling and Venting the Main Coolant System

NOTE: The reactor vessel, pressurizer, and all isolated main coolant loops have been partially vented and filled with borated water of the required concentration.

1. Open all main coolant stop valves.

2. By operation of the charging pumps, pressurize the complete main coolant system to approximately 250 psi gage.

3. Start cooling water flow to the main coolant pumps. Refer to O.I. No. 504I, COMPONENT COOLING SYSTEM.

4. Jog the rotor of the main coolant pump electrically; after the rotor has stopped, vent the pump. Repeat this operation for each pump until all evidence of escaping air has ceased.

   NOTE: A minimum pressure of 250 psi gage must be maintained on the system during pump jogging operation. During the venting operation, the pressure should not fall below 50 psi gage.

5. Vent the pressurizer, all control rod mechanisms, by-pass lines and instruments until effluent is free of air.

6. Maintain a minimum system pressure of 250 psi gage and operate the main coolant pump for about one minute; stop pump and wait for the rotor to coast to a stop. Requires about 30 seconds. Repeat operation for each pump.

7. Manually vent each main coolant pump.

8. Repeat Step Nos. 6 and 7 until water discharging from each pump vent is free of air.

9. Repeat Step No. 5.

10. Repeat Step Nos. 6, 7, 8, and 9 until all evidence of escaping air has ceased.

    NOTE: From this point on, primary system components may be vented while the main coolant pump is operating.

11. Vent the pressurizer, all control rod mechanisms, by-pass lines, instruments and pumps after approximately (a) ten minutes (b) one hour and (c) after two hours of pump operation.

NOTE: Venting procedure outlined in Step No. 11 may be done in conjunction with startup of complete main coolant system. System pressure must be increased during this venting operation in order to meet the minimum suction pressure requirements of the main coolant pumps. Refer to O.I. No. 504D4, MAIN COOLANT SYSTEM - STARTUP OF COMPLETE SYSTEM.

Experience will indicate the frequency of subsequent venting required in order to assure that no air pockets accumulate in the main coolant system.

If at the end of each period mentioned in Step No. 11, venting shows continued evidence of air, continue venting at that frequency until no air appears.

After the main coolant has been scavenged below 0.1 ppm oxygen, open vent on each control rod mechanism and remove approximately 1 1/2 gallons of water to assure that mechanism drives are filled with deaerated water.

VI. Final Conditions

The complete main coolant system has been filled and vented with primary grade borated water.

OPERATING INSTRUCTION NO. 504D2

MAIN COOLANT SYSTEM
FILLING, VENTING AND DRAINING AN ISOLATED LOOP

I. Objective To provide a safe and efficient method of filling, venting and draining an isolated main coolant loop.

II. Conditions

A. Filling and Venting an Isolated Loop

1. Access to vapor container is permissible.

2. A minimum of 2,000 gallons of primary grade 1% borated water is available from the safety injection and shield tank cavity water tank.

3. Loop to be filled is isolated and all loop drain valves are closed. Valve in by-pass line is closed.

4. Pertinent auxiliary systems are in the following status:

System	Status
Charging and Volume Control System (Refer to O.I. No. 504F)	Ready standby
Chemical Shutdown System - Boric Acid Addition (Refer to O.I. No. 504G2)	Ready standby
Component Cooling System (Refer to O.I. No. 504I)	In service as required
Primary Plant Sampling System - Main Coolant System (Refer to O.I. No. 504K1)	Ready standby

B. Draining an Isolated Loop

1. Loop to be drained has been isolated by closing main coolant stop valves.

2. Loop to be drained should have associated nonreturn valve, drains and traps closed.

3. Water to be drained has been reduced to approximately 140 F and is pressurized to a slight positive pressure less than 50 psi gage. Refer to O.I. No. 504D8, MAIN COOLANT SYSTEM - SHUTDOWN OF INDIVIDUAL LOOPS.

4. Pertinent auxiliary systems are in the following status:

System	Status
Radioactive Waste Disposal System - Liquid Waste Disposal (Refer to O.I. No. 504L1)	Primary drain collecting tank capacity is available

III. Precautions

The pressure in the rotor-stator gap of the main coolant pump must never be below atmospheric pressure. This requires manual venting, and access into the vapor container must be permissible.

A. Filling and Venting an Isolated Loop

1. Do not operate the main coolant pump continuously until the isolated loop has been vented. Initially the pumps shall be jogged and the system shall be vented until the effluent from the vent is free of entrapped gas.

2. Venting of an isolated loop should only be performed if the coolant temperature is below 200 F.

B. Draining an Isolated Loop

1. Do not drain an isolated loop until the temperature and pressure have been reduced to 140 F and 50 psi gage respectively.

IV. Check-off List

Prior to the initiation of the O.I., the check-off list must be completed by the operator(s) and signed off.

V. Instructions

A. Filling and Venting an Isolated Loop

1. Open the following vents:

   Steam generator hot leg vent
   By-pass line vent

2. Isolate the steam generator differential pressure cells.

3. Open the 3 in. motor operated valve in the loop fill and chemical injection line to the isolated loop to be filled.

4. Establish pump suction from the safety injection shield cavity water storage tank and start charging pumps. Refer to O.I. No. 504F, CHARGING AND VOLUME CONTROL SYSTEM.

5. When water discharges from by-pass line vent, close vent valve.

6. When water discharges from the main coolant pump vent, close valve.

7. Close valve when water discharges from the steam generator hot leg vent.

8. Continue operation of charging pumps until approximately 250 psi gage is obtained. Stop pumps.

9. If the complete main coolant system is being filled, close the 3 in. motor operated valve in the loop fill and chemical injection line. Maintain a positive pressure by intermittent use of the charging pumps on the filled isolation loop until start of system pressurization. Refer to O.I. No. 504D1, MAIN COOLANT SYSTEM - FILLING, VENTING AND DRAINING OF COMPLETE SYSTEM for the required jogging and venting procedure.

   If the complete main coolant system is not to be filled, continue to Step No. 10.

10. Open differential pressure cell isolation valves.

11. Open motor operated valve in the by-pass line.

12. Start cooling water flow to the main coolant pump. Refer to O.I. No. 504I, COMPONENT COOLING SYSTEM.

13. Jog the rotor of the main coolant pump electrically; after the rotor has stopped, vent the pump, by-pass line, and instruments. Repeat this operation until all evidence of escaping air has ceased.

    NOTE: A minimum pressure of 250 psi gage <u>must</u> be maintained on the loop during the jogging operation. During the venting operation the pressure should not fall below 50 psi gage.

14. Maintain a minimum loop pressure of 250 psi gage and operate the main coolant pump for about one minute; stop pump and wait for the rotor to coast to a stop (requires about 30 seconds).

15. Vent pump, by-pass line, and instruments until effluent is free of air.

16. Repeat Step Nos. 14 and 15 until all evidence of escaping air has ceased.

    NOTE: From this point on the isolated loop may be vented while the main coolant pump is operating.

17. Vent the pump, by-pass line, and instruments after approximately (a) ten minutes (b) one hour and (c) after two hours of pump operation.

    NOTE: System pressure must be increased during this operation in order to meet the minimum suction pressure requirements of the main coolant pumps. Refer to O.I. No. 504D5, MAIN COOLANT SYSTEM - STARTUP OF ISOLATED LOOP.

    If at the end of each period mentioned in Step No. 17, venting shows continued evidence of air, continue venting at that frequency until no air appears.

    Experience will indicate the frequency of subsequent venting required for an isolated loop in order to assure that the loop is free of air before it is opened to the reactor section of the main coolant system.

B. Draining an Isolated Loop

1. Isolate the steam generator differential pressure cell.

2. Open loop by-pass valve.

3. Open main coolant pump vent.

   NOTE: This valve must be open before drain valves are opened. Before opening the pump vent valve a hose will be connected from the vent valve leading to the vapor container sump.

4. Open valves in the drain lines from the main coolant stop valve, from the main coolant pump inlet and open associated valves in drain line going to the primary drain collecting tank.

5. Open the loop by-pass line vent.

6. After main coolant loop has been drained, close valves in drain lines opened in Step No. 4. Loop draining is completed when the water level in the primary drain collecting tank reaches a steady state condition.

   NOTE: The main coolant pump vent must remain open after loop has been drained .

7. Repeat Step Nos. 1 through 6 if additional main coolant loops are to be drained.

VI. Final Conditions

An isolated loop has been filled and vented with primary grade borated water and completely drained.

OPERATING INSTRUCTION NO. 504D3

MAIN COOLANT SYSTEM
HOT LEAK TEST

I. Objective The hot leak test is to prove leak tightness of the high pressure portions of the nuclear steam generator. This test is performed for periodic inspection.

II. Conditions

1. The reactor has been shut down and is being maintained in a hot standby condition. Refer to O.I. No. 504C1, PLANT SHUTDOWN - SCHEDULED REACTOR SHUTDOWN and O.I. No. 504C3, PLANT SHUTDOWN - SCHEDULED TURBINE GENERATOR SHUTDOWN.

2. Pertinent auxiliary systems are in the following status:

System	Status
Shutdown Cooling System (Refer to O.I. No. 504M)	Isolated
Charging and Volume Control System (Refer to O.I. No. 504F)	Initially on the line
Safety Injection System (Refer to E.I. No. 505B10)	Ready standby
Component Cooling System (Refer to O.I. No. 504I)	Normal operation
Pressure Control and Relief System (Refer to O.I. No. 504E)	Normal operation
Purification System (Refer to O.I. No. 504H)	Isolated
Primary Plant Sampling System (Refer to O.I. No. 504K)	Isolated
Primary Plant Corrosion Control System (Refer to O.I. No. 504J)	Isolated

III. Precautions

1. When nuclear core is in place, the maximum allowable leak test pressure is 2,485 psi gage.

2. The reactor plant pressure detection equipment must be in good working order.

3. Only authorized personnel are allowed in the vapor container during the leak test at selective times.

4. A proper water balance should be established in the water storage and waste collection tanks to ensure that adequate make-up is available and to receive water rejected from the primary plant.

IV. Check-off List

Prior to initiation of this O.I., the check-off list must be completed by the operator(s) and signed off.

V. Instructions

1. Obtain authorization to enter the vapor container after radiation survey has been completed. Refer to Section 507, RADIOLOGICAL HEALTH AND SAFETY.

2. Enter vapor container; comply with M.I. No. 506D, VAPOR CONTAINER.

3. Visually inspect plant for leakage of all joints, connections, and equipment. In the event of leakage in the system, depressurize, cool down, and make necessary repairs. Refer to O.I. No. 504C2, PLANT SHUTDOWN - REACTOR COOLDOWN. Upon completion of repairs, leak test the system according to M.I. No. 506B3, PRIMARY PLANT - COLD LEAK TEST.

4. Switch pressurizer solenoid operated spray and relief valve controls from "AUTOMATIC" to "OFF".

5. Upon completion of visual inspection, evacuate all non-essential personnel from vapor container.

6. Turn on all pressurizer heater groups to gradually increase system pressure from 2,000 psi gage to 2,200 psi gage. Shut off all heaters when pressure is approximately 35 psi gage below 2,200 psi gage. Then turn on one group of heaters and manually cycle until 2,200 psi gage is reached and stabilized. Refer to O.I. No. 504E, PRESSURE CONTROL AND RELIEF SYSTEM.

7. Check that all main coolant pumps except one are shut down. The single pump in operation is used to circulate the coolant which removes the decay heat in the system.

8. Shut down last group of pressurizer heaters. Refer to O.I. No. 504E, PRESSURE CONTROL AND RELIEF SYSTEM.

9. Shut down the remaining main coolant pump.

10. Observe system pressure and pressurizer temperature for 5 min after the pressurizer heater group and the main coolant pump have been shut down. Assure that the drop in the main coolant system pressure is less than 100 psi for a 5 min period. If the loss in the system pressure is less than 100 psi for the 5 min period, proceed to Step No. 12. If the system pressure loss is greater, determine the source of leakage by visual inspection; removal of thermal insulation may be required. Proceed to Step No. 11.

11. After establishing source of leakage, depressurize and cool down the system and make necessary repairs. Refer to O.I. No. 504C2, PLANT SHUTDOWN - REACTOR COOLDOWN. Upon completion of repairs, leak test the system according to M.I. No. 506B3, PRIMARY PLANT - COLD LEAK TEST.

12. Manually initiate pressurizer spray to return system to hot standby condition. Refer to O.I. No. 504E, PRESSURE CONTROL AND RELIEF SYSTEM.

13. Place one pressurizer heater group on "CYCLING" control; place the remaining heater groups on low pressure "BACKUP" control. Refer to O.I. No. 504E, PRESSURE CONTROL AND RELIEF SYSTEM.

14. Switch pressurizer solenoid operated spray and relief valve controls from "OFF" to "AUTOMATIC".

15. Evacuate personnel from vapor container.

16. Start all the main coolant pumps.

VI. Final Condition

The main coolant system has been hot leak tested satisfactorily and is ready for startup from the hot standby condition. Refer to O.I. No. 504A2, PLANT STARTUP - REACTOR STARTUP FROM HOT STANDBY.

OPERATING INSTRUCTION NO. 504D5

MAIN COOLANT SYSTEM
STARTUP OF ISOLATED LOOP

I. Objective To provide a safe and efficient procedure for adjusting the temperature, pressure and water composition in an isolated loop in preparation for returning the loop to service.

II. Conditions

1. One main coolant loop is isolated from the reactor vessel by the stop valves in its hot and cold legs. The valve in the loop bypass line is open.

2. The isolated main coolant loop is filled with borated primary grade water. The venting operations have been completed. Refer to O.I. No. 504D2, MAIN COOLANT SYSTEM - FILLING, VENTING AND DRAINING AN ISOLATED LOOP.

3. Repair and leak testing of the isolated loop, if required, have been completed.

4. The remainder of the main coolant system is at either of the following conditions:

   a. Cold shutdown
   b. Hot standby

5. A pressure of 50 to 200 psi gage is being maintained in the isolated loop by intermittent operation of a charging pump and via the loop fill header.

6. The shell side of the steam generator in the isolated loop is filled with water to the normal startup level. The nonreturn valve in the main steam line may be closed depending upon the extent of loop isolation required for maintenance.

7. The pertinent auxiliary systems are in the following conditions:

System	Status
Charging and Volume Control System (Refer to O.I. No. 504F)	In operation or ready standby, as required
Chemical Shutdown System (Refer to O.I. No. 504G)	Normal standby
Primary Plant Corrosion Control System (Refer to O.I. No. 504J)	In operation or ready standby, as required

System	Status
Component Cooling System (Refer to O.I. No. 504I)	Partial operation, as required
Primary Plant Sampling System (Refer to O.I. No. 504K)	Ready standby
Radioactive Waste Disposal System (Refer to O.I. No. 504L)	Ready standby
Safety Injection System (Refer to E.I. No. 505B10)	Ready standby

III. Precautions

1. The temperature of the coolant in the isolated loop should not be more than 30 F colder than the highest cold leg temperature of the operating loops when the isolated loop 20 in. gate valves are opened.

   NOTE: The valve-temperature interlock system is designed to prevent such an occurrence.

2. The main coolant pump in the isolated loop must not be operated against a shutoff discharge or a shutoff suction for periods longer than those given in the pump technical manual. The valve in the by-pass line should be opened when the loop isolation valves are closed.

   NOTE: The valve-pump interlock system is designed to prevent such an occurrence.

3. The main coolant pump in the isolated loop must not be started until after the required minimum system pressure, as presented in the pump technical manual, is established.

4. Refer to the various component's technical manual for recommended operating instructions and limitations.

5. Prior to opening the main coolant 20 in. gate valves in the isolated loop, the water compositions of the reactor vessel and the isolated loop must be matched.

IV. Check-off List

Prior to the initiation of this Operating Instruction, the check-off list must be completed by the operator and signed off.

V. Instructions

A. Cut In Of An Isolated Loop To The Cold Shutdown Reactor

NOTE: This should be the most frequent operation on an isolated loop.

1. Sample the coolant in the isolated loop to determine the boron concentrations. Refer to O.I. No. 504K1, PRIMARY PLANT SAMPLING SYSTEM - MAIN COOLANT SYSTEM.

2. The boron concentration in the isolated loop coolant must not be less than the required shutdown concentration. If the concentration is below this value, add boron. Refer to O.I. No. 504G2, CHEMICAL SHUTDOWN SYSTEM - BORIC ACID ADDITION.

3. In order to pressure balance the isolated loop with the remainder of the main coolant system, open the motor operated valve in the loop fill header to the isolated loop and also to a loop connected to the reactor vessel.

4. Open the valves in the loop's hot and cold legs.

5. Close the motor operated valve in the isolated loop by-pass line.

6. The main coolant loop has now been returned to service and the complete main coolant system is being maintained in a cold shutdown condition.

B. Cut In And Startup Of An Isolated Loop To The Main Coolant System At Hot Standby Condition

NOTE: This situation should occur infrequently and may be due to instrument problem or misinterpretation, or due to scheduled operation at reduced load.

1. If not in operation, start component cooling water flowing to the main coolant pump in the isolated loop.

2. Close the necessary valves in the charging pump suction and discharge headers in order to isolate charging pump No. 3 from the operating portion of the headers.

3. Open the motor operated stop valves in the fill line to the isolated loop, thus establishing a flow path between charging pump No. 3 and the isolated loop.

4. After pressurizing the isolated loop to a pressure of 300 to 400 psi gage with charging pump No. 3, shut down the charging pump.

5. With the exception of the hand controlled flow valve, open all necessary valves in the drain line and drain header to establish a flow path between the isolated loop and the low pressure surge tank.

6. Start up the main coolant pump in the isolated loop.

NOTES: Operation of the pump in the isolated loop will result in the heating up of the loop at a rate of approximately 27 F per hr.

If excessive main coolant pump lower bearing temperature is experienced, as indicated by an annunciator, the pump should be shut down and the indicated malfunction investigated and corrected. Refer to the pump technical manual.

When excessive bearing temperature is indicated, the component cooling water should also be checked.

7. Open and continually adjust the manually controlled flow valve in the drain header to relieve the expansion of the coolant in the isolated loop while maintaining the loop pressure between 300 to 400 psi gage. If the pressure in the isolated loop falls below this range of pressures, shut down the main coolant pump until the pressure is restored.

8. Sample the coolant in the isolated loop to determine the oxygen and boron concentrations. Refer to O.I. No. 504K1, PRIMARY PLANT SAMPLING SYSTEM - MAIN COOLANT SYSTEM.

9. The boron concentration in the isolated loop coolant must not be less than the required shutdown concentration. If the concentration is below this value, add boron Refer to O.I. No. 504G2, CHEMICAL SHUTDOWN SYSTEM - BORIC ACID ADDITION.

10. If necessary, and as required, add hydrazine to the isolated loop. Refer to O.I. No. 504J2, PRIMARY PLANT CORROSION CONTROL SYSTEM - HYDRAZINE ADDITION.

NOTES: Hourly checks and adjustments should be made until the desired results are obtained.

Bleed flow will have to be increased to compensate for the hydrazine charging operation.

11. After the temperature of the coolant in the isolated loop attains a temperature of 100 F, reduce the bleed flow from the loop with the hand controlled flow valve and gradually increase the pressure in the isolated loop to 900 to 1,000 psi gage. Maintain the loop pressure within this range.

    NOTE: If the pressure in the loop falls below this range, shut down the pump until the pressure is restored.

12. Continue to heat up the isolated loop until its indicated temperature is within ± 5 F of the cold leg temperatures of the loops connected to the reactor vessel.

13. Sample the coolant in the isolated loop to determine the boron concentration. Refer to O.I. No. 504K1, PRIMARY PLANT SAMPLING SYSTEM - MAIN COOLANT SYSTEM. Repeat instruction No. 9, if required.

14. Shut down the main coolant pump in the isolated loop.

15. If the plant is operating at a power level consistent with three loop operation, reduce the load and establish a hot standby condition in the main coolant system. At this time, the reactor is approximately 3% subcritical. Refer to O.I. No. 504B1, PLANT OPERATION - CHANGING REACTOR LOAD AND O.I. No. 504C1, PLANT SHUTDOWN - SCHEDULED REACTOR SHUTDOWN.

    NOTE: A loop may be temporarily isolated if temperature and boron concentration does not change while searching for a main coolant system leak. Loop may be returned to service without establishing a hot standby condition. Refer to E.I. No. 505B11, PRIMARY PLANT - LARGE OR PARTIAL LOSS OF MAIN COOLANT, paragraph III-A, Case I.

16. Close the motor operated valve in the isolated loop drain line.

17. Raise the pressure in the isolated loop to within ± 50 psi of the reactor vessel by operating charging pump No. 3.

18. Open the stop valves in the isolated loop's hot and cold legs.

19. Close the motor operated valve in the isolated loop bypass line.

20. Operate all of the main coolant pumps, one at a time, for a period of approximately 15 min. This will distribute the borated coolant, from the loop just returned to service, throughout the main coolant system.

NOTE: It may be necessary to extract steam from the shell side of the steam generators in order to maintain normal hot standby temperatures in the main coolant system.

21. If closed, open the nonreturn valve in the steam line from the steam generator in the isolated loop.

22. Initiate normal boric acid dilution operations. Refer to O.I. No. 504G3, CHEMICAL SHUTDOWN SYSTEM - BORIC ACID REMOVAL.

23. The main coolant loop has now been returned to service and the complete main coolant system is being maintained in a hot standby condition. Refer to O.I. No. 504D6, MAIN COOLANT SYSTEM - RUNNING OPERATION.

VI. Final Conditions

The boron concentration in the isolated loop, as well as the coolant temperature and pressure, has been adjusted to match those of the coolant in the reactor vessel, and the loop has been connected to the reactor vessel. The complete main coolant system is ready for startup from either a cold shutdown or hot standby condition.

OPERATING INSTRUCTION NO. 504D6

MAIN COOLANT SYSTEM
RUNNING OPERATION

I. Objective To indicate the procedures necessary to maintain normal operating conditions in the main coolant system during the period after startup of the main coolant system and prior to shutdown, including the hot standby condition.

II. Conditions

A. Operation During Power Generation

1. The reactor is critical and the main coolant system has been brought from a cold shutdown condition to normal operating conditions by main coolant pump heating and reactor core heat generation. Refer to O.I. No. 504A1, Plant Startup - REACTOR STARTUP FROM COLD CONDITION and O.I. No. 504D4, MAIN COOLANT SYSTEM - STARTUP OF COMPLETE SYSTEM.

2. Electrical power is available for all main coolant and primary auxiliary system electrical equipment.

3. The secondary plant is receiving steam from the main coolant system steam generators.

4. Pertinent auxiliary systems are in the following status:

System	Status
Pressure Control and Relief System (Refer to O.I. No. 504E)	Normal operation
Charging and Volume Control System (Refer to O.I. No. 504F)	Normal operation or ready standby
Chemical Shutdown System - Boric Acid Addition (Refer to O.I. No. 504G2)	Ready standby
Purification System (Refer to O.I. No. 504H)	Normal operation or ready standby
Component Cooling System (Refer to O.I. No. 504I)	Normal operation
Primary Plant Corrosion Control System (Refer to O.I. No. 504J)	Normal operation

System	Status
Primary Plant Sampling System (Refer to O.I. No. 504K)	Ready standby
Radioactive Waste Disposal System (Refer to O.I. No. 504L)	Normal operation or ready standby
Reactor Control System (Refer to O.I. No. 504N)	Normal operation
Nuclear Instrumentation System (Refer to O.I. No. 504O)	Normal operation
Radiation Monitoring System (Refer to O.I. No. 504P)	Normal operation
Vapor Container Atmosphere Control Systems (Refer to O.I. No. 504Q)	Normal operation

B. Operation During Hot Standby Condition

1. The reactor is subcritical and the main coolant system is at normal operating conditions. Refer to O.I. No. 504C1, PLANT SHUTDOWN - SCHEDULED REACTOR SHUTDOWN.

2. Electrical power is available for all main coolant and primary auxiliary system electrical equipment.

3. The secondary plant is prepared to receive steam to the extent available from the nuclear plant considering core decay heat produced and number of main coolant pumps in operation.

4. Except for the following exception, pertinent auxiliary systems are in the status outlined in Section II-A, Step No. 4:

System	Status
Reactor Control System (Refer to O.I. No. 504N)	Manual operation

III. Precautions

1. The reactor should not generate more than 80% of full power if only three main coolant pumps are operating. Power level must be reduced to 80% of full power or less prior to flow reduction from four to three main coolant pumps. Reactor scram will be initiated automatically if less than three main coolant pumps are operating. Refer to O.I. No. 504B1, PLANT OPERATION - CHANGING REACTOR LOAD.

2. Failure of component cooling water flow to the main coolant pumps will require pump shutdown in 8 min to prevent damage to the pump. Attempts to restore cooling water flow should be begun as soon as possible after the failure, so that sufficient time remains to shut down the reactor if flow cannot be restored.

3. If the main coolant pump lower bearing water temperature exceeds 225 F, shut down the pump to prevent bearing damage.

4. In order to maintain a main coolant loop that is out of service in a hot condition, the loop isolation valves should not be closed except for a suspected or actual leak in the loop.

IV. Check-off List

Prior to the initiation of this O.I., the check-off list must be completed by the operator(s) and signed off.

V. Instructions

A. Operation During Power Generation

1. Maintain three or four main coolant pumps in operation as required by reactor load. Refer to O.I. No. 504B1, PLANT OPERATION - CHANGING REACTOR LOAD.

2. During reactor power generation, it is recommended that the following checks be performed periodically in order to determine main coolant system equipment performance:

Check main coolant T_{av} temperature. Refer to O.I. No. 504B1, PLANT OPERATION - CHANGING REACTOR LOAD.

Check main coolant pressure, and compare main coolant and pressurizer pressure readings for agreement.

Check pressurizer level. Adjust with charging pumps if necessary. Refer to O.I. No. 504F, CHARGING AND VOLUME CONTROL SYSTEM.

Check steam generator main coolant inlet and outlet temperatures, main coolant pump and boiler feed pump flows, and steam generator level and steam flows for agreement as an indication of main coolant equipment and instrumentation performance.

Check main coolant pump bearing water and cooling water outlet temperatures and motor current readings.

Sample main coolant system and as required:

Start the purification system if not in operation, or if in operation increase the purification flow.

Decrease purification flow or shut down purification system.

Refer to O.I. No. 504H, PURIFICATION SYSTEM AND O.I. No. 504K1, PRIMARY PLANT SAMPLING SYSTEM - MAIN COOLANT SYSTEM.

B. Operation During Hot Standby Condition

1. During hot standby operation when activity dilution or boric acid addition or removal operations are not being performed, shut down all but one main coolant pump.

   NOTE: One main coolant pump will provide more than enough heat to overcome main coolant system and secondary plant steam piping insulation heat losses.

2. Adjust secondary plant steam flow to maintain main coolant average temperature if main coolant system heat losses are less than main coolant pump heat addition.

VI. Final Condition

1. The reactor is critical and the main coolant system is being maintained at normal operating pressure and temperature. Main coolant pumps are transferring reactor heat to the steam generators.

2. The reactor is subcritical and the main coolant system is being maintained in the hot standby condition.

OPERATING INSTRUCTION NO. 504D8

MAIN COOLANT SYSTEM
SHUTDOWN OF INDIVIDUAL LOOPS

I. Objective To provide a safe and efficient method of removing one loop of the main coolant system from service during:

A. Plant power operation or hot standby;
B. Shutdown or startup of the main coolant system.

II. Conditions

1. Removal of one loop may be required for one of the following or other general reasons:

a. Reduced load operation is required.

b. Main coolant leakage beyond a desirable limit from an individual loop.

c. Malfunction of secondary plant equipment affecting only one main coolant loop.

d. Malfunction of a main coolant component in an individual loop.

e. Malfunction of main coolant instrumentation in an individual loop.

2. Primary Plant condition can be one of the following:

A. Plant Power Operation or Hot Standby

Pertinent auxiliary systems are in the following status:

System	Status
Charging and Volume Control System (Refer to O.I. No. 504F)	Automatic control
Pressure Control and Relief System (Refer to O.I. No. 504E)	Automatic control
Reactor Control System (Refer to O.I. No. 504N)	Automatic or manual control

B. Shutdown or Startup of the Main Coolant System

System	Status
Charging and Volume Control System (Refer to O.I. No. 504F)	Manual control

System	Status
Pressure Control and Relief System (Refer to O.I. No. 504E)	Manual control
Reactor Control System (Refer to O.I. No. 504N)	Manual control

III. Precautions

1. If shutdown of an individual loop is required during power operation, power level will be reduced to less than 80%* compatible with three loop power operation as the first step of this O.I.

2. After a loop has been isolated and cooled, make periodic checks to assure that it is maintained at approximately 50 psi gage pressure.

IV. Check-off List

Prior to initiation of this O.I., the check-off list must be completed by the operator(s) and signed off.

V. Instructions

A. Plant Power Operation or Hot Standby

1. If the plant is on power operation, decrease power to a selected reduced load compatible with three loop operation using O.I. No. 504B1, PLANT OPERATION - CHANGING REACTOR LOAD. If the plant is on hot standby, omit this step and proceed to Step No. 2.

NOTE: The selected power level will be determined by station operation but shall not exceed 80%* full load.

2. Open the main coolant by-pass valve and close the steam generator blowdown valve of the loop to be idled or isolated.

3. Close the main coolant motor operated stop valve in the cold (pump discharge) leg of the loop to be idled or isolated.

4. Stop the main coolant pump in the loop to be idled or isolated.

NOTE: Continue component cooling to this pump until temperature of the isolated loop has dropped to less than 200 F.

*Based on first core

5. If it is desired to float this loop idle in a hot standby condition, open the main coolant motor operated stop valve in the cold (pump discharge) leg previously closed in Step No. 3, and close the by-pass valve.

NOTE: Depending on plant conditions, it may be desirable to float this idle loop in a hot standby condition for a considerable period while certain observations and/or corrections are made, or an increased load is required. Under such conditions when the loop is not isolated, return the loop to service by starting the main coolant pump.

6. If complete isolation of the loop is desired, close the main coolant motor operated stop valve in the hot (pump suction) leg.

7. The steam nonreturn valve and feed valve on the secondary side of the steam generator in the loop that has been isolated may have to be closed depending upont the extent of loop isolation desired.

8. To obtain pressure indication for the isolated loop, open the loop fill valve and read pressure from the loop fill header pressure indicator.

9. If it is anticipated that the isolated loop is not to be returned to service in the near future, borate the loop. In any event, borate the isolated loop if the temperature has dropped more than 30 F. Refer to O.I. No. 504G2, CHEMICAL SHUTDOWN SYSTEM - BORIC ACID ADDITION.

10. If it is desired to increase the cooldown rate of the isolated loop, use secondary plant feed and blowdown of the isolated steam generator. Blowdown rate shall be controlled so as not to exceed a cooldown rate of 100 F per hr.

CAUTION: Keep shell side water level above steam generator tubes at all times.

11. When the isolated loop temperature has dropped below 300 F, establish and maintain a minimum pressure of 50 psi gage in the loop by the use of one charging pump with 950 ppm boron solution.

NOTE: If excessive leakage was the reason for isolation of the loop, Step No. 11 is not required.

12. After an isolated loop has cooled to vapor container ambient temperature (50-120 F), shut down the charging pump, leaving the loop at 50 psi gage pressure.

B. Shutdown or Startup of the Main Coolant System

1. If only one loop is in operation and it is a loop to b isolated, place another loop in operation. Refer to O.I. No. 504D5, MAIN COOLANT SYSTEM - STARTUP OF ISOLATED LOOP.

2. Open the main coolant by-pass valve and close the blowdown valve of the loop to be idled or isolated.

3. Close the main coolant motor operated stop valve in the cold (pump discharge) leg of the loop to be idled or isolated.

4. Stop the main coolant pump in the loop to be idled or isolated.

   NOTE: Continue component cooling to this pump until temperature of the isolated loop has dropped to less than 200 F.

5. If it is desired to float this loop idle at reactor temperature and boron conditions, open the main coolant motor operated stop valve in the cold (pump discharge) leg previously closed in Step No. 3, and close the by-pass valve.

   NOTE: Depending on plant conditions, it may be desirable to float this idle loop at the same temperature and boron conditions as the reactor, by backflow, for a considerable period while certain observations or corrections are made. Under such conditions the loop is to be returned to service by starting the main coolant pump.

6. If complete isolation of the loop is desired, close the main coolant motor operated stop valve in the hot (pump suction) leg.

7. The steam nonreturn valve and feed valve on the secondary side of the steam generator in the loop that has been isolated may have to be closed, depending upon extent of the loop isolation desired.

8. To obtain pressure indication for the isolated loop, open the loop fill valve and read pressure from the loop fill header pressure indicator.

9. Sample the isolated loop water to determine its boron concentration. Refer to O.I. No. 504K1, PRIMARY PLANT SAMPLING SYSTEM - MAIN COOLANT SYSTEM.

10. If the boron concentration is below 950 ppm, establish this required concentration by addition of 12 wt % boric acid solution. Refer to O.I. No. 504G2, CHEMICAL SHUTDOWN SYSTEM - BORIC ACID ADDITION.

11. If it is desired to increase the cooldown rate of the isolated loop, use secondary plant feed and blowdown of the isolated steam generator. Blowdown rate shall be controlled so as not to exceed a cooldown rate of 100 F per hr.

    CAUTION: Keep shell side water level above steam generator tubes at all times.

12. For isolated loop temperatures below 300 F, establish and maintain a minimum pressure of 50 psi gage in the loop by the use of one charging pump with 950 ppm boron solution.

    NOTE: If excessive leakage was the reason for isolation of the loop, Step No. 12 is not required.

13. When the isolated loop has cooled to vapor container ambient temperature (50-120 F), establish a 50 psi gage pressure in the loop and shut down the charging pump.

VI. Final Condition

One loop is isolated and cooled to vapor container ambient temperature (50-120 F) at a pressure of 50 psi gage. It contains the required boron concentration and may be left until repairs can be made or until it is desired to return it to service.

OPERATING INSTRUCTION NO. 504G1

CHEMICAL SHUTDOWN SYSTEM
BORIC ACID PREPARATION

I. Objective To prepare a boric acid solution for use as a neutron absorbing material.

II. Conditions

1. Preparation of the boric acid solution can be accomplished at any convenient time, except when the boric acid solution is being added to the main coolant system or to the safety injection and shield tank cavity water tank. However, it is preferable to prepare the solution when the reactor is subcritical.

2. Analytical services are available to determine the concentration of boric acid solution in the boric acid mixing and storage tank.

III. Precautions

1. Do not add boric acid to the boric acid mixing and storage tank until the water temperature reaches 125 F.

2. Check that the boric acid mixing and storage tank is isolated from the charging pump suction header and the 125,000 gal shield tank cavity water storage tank before preparing a batch of boric acid solution.

IV. Check-off List

Prior to the initiation of this O.I., the check-off list must be completed by the operator(s) and signed off.

V. Instructions

A. General

1. Determine the level of boric acid solution remaining in the boric acid mixing and storage tank.

2. If the level has dropped:

Because solution has been pumped out - proceed with Section V-B

Because of evaporation - proceed with Section V-C

B. <u>If The Tank Has Been Pumped Out</u>

1. Check that the stop valves in the following lines are <u>closed</u>:

   Charging pump suction demineralized water feed line

   Demineralized water flush to the boric acid solution feed line and the transfer pump suction line

   Demineralized water supply to the safety injection and shield tank cavity water tank and shield tank cavity fill pump suction

   Gate valve in the boric acid solution transfer pump suction

2. Take one low pressure surge tank make-up pump off standby and put it in manual position.

3. Line up the boric acid recirculating line.

4. Open the demineralized water supply line from the primary water storage tank to the boric acid mixing and storage tank, via the low pressure surge tank make-up pumps.

5. Start the low pressure surge tank make-up pump that has been put on manual position.

6. When the steam coils are submerged, check that the steam supply is on.

   a. Check that the steam supply line to the boric acid mixing and storage tank is open and under automatic temperature control.

   b. Check that the condensate line is open to steam trap.

7. Stop the pump when the tank minimum level (about 70% full) point is passed. Start the agitator at slow speed.

8. Close the stop valve in the demineralized water supply line to the boric acid mixing and storage tank.

9. Return the low pressure surge tank make-up pump to standby position.

10. Start the boric acid solution transfer pump.

11. Sample the solution per O.I. No. 504K2, PRIMARY PLANT SAMPLING SYSTEM - AUXILIARY SYSTEMS.

12. Compute the weight of boric acid to add from the sample analysis and the tank liquid level.

13. Add boric acid when the solution reaches 125 F.

    a. Increase agitator to full speed.

    b. Slowly* add the calculated amount of technical grade granular boric acid.

14. After all the boric acid has been added, continue circulation of the hot solution and sample as per O.I. No. 504K2, PRIMARY PLANT SAMPLING SYSTEM - AUXILIARY SYSTEMS, for boric acid concentration.

    NOTE: A nominal 12% by weight H_3BO_3 solution is required. The minimum allowable concentration of boric acid is 11 1/2% by weight. The maximum allowable is 12 1/2%. Add additional boric acid or dilute with water, if required.

15. Stop the mixer and the boric acid solution transfer pump.

C. <u>If Evaporation Has Occurred</u>

1. Open the boric acid recirculating line.

2. Start the boric acid solution transfer pump.

3. Wait 20 min, then sample per O.I. No. 504K2, PRIMARY PLANT SAMPLING SYSTEM - AUXILIARY SYSTEMS.

4. Required concentration - 12%; maximum = 12 1/2%; minimum = 11 1/2% by weight H_3BO_3. If the sample analysis does not fall within the required concentration limits, determine the weight of water or boric acid to add.

    a. Add the calculated weight of water per Section V-B, Steps Nos. 1 through 7 or

    b. Add the calculated weight of boric acid per Section V-B, Steps Nos. 10 through B 14.

*Addition rate to be determined in the field.

5. Stop the boric acid solution transfer pump.

6. Close the boric acid recirculating line and flush to storm sewer.

VI. Final Conditions

1. Hot boric acid solution has been prepared for use in O.I. No. 504G2, CHEMICAL SHUTDOWN SYSTEM - BORIC ACID ADDITION or in the shield tank cavity storage tank.

OPERATING INSTRUCTION NO. 504G2

CHEMICAL SHUTDOWN SYSTEM
BORIC ACID ADDITION

I. Objective To provide a means of adding boric acid to the main coolant system or to an isolated main coolant loop.

II. Conditions

A. Boric Acid Addition to the Main Coolant System

1. Boric acid addition to the main coolant is to be made to maintain the desired main coolant boron concentration for operation.

2. Boric acid addition to the main coolant is to be made prior to a reactor cooldown, or if required to maintain the required cold shutdown concentration. See O.I. 504C2, PLANT SHUTDOWN -- REACTOR COOLDOWN.

3. At least (1,500)* gal. of 12% by weight boric acid aqueous solution is available in the boric acid mixing and storage tank, hot and ready for injection whenever the reactor is critical.

4. Addition of boric acid to the safety injection and shield tank cavity water tank (refer to M.I. No. 406E3, REACTOR REFUELING -- SHIELD TANK CAVITY -- FILL AND DRAIN) can be made at any time, within the following limitations:

a. In available amounts which are in excess of the 1,500 gal. required in Section II-A, Step No. 3 above, when the reactor is critical.

b. In any amount, when the reactor is subcritical and shutdown boron concentration has been established in the main coolant.

5. Pertinent auxiliary systems are in the following status:

System	Status
Purification System (Refer to O.I. No. 504H)	Operating as Required

* To be detailed later.

System	Status
Main Coolant System (Refer to O.I. No. 504D)	Normal operation
Charging and Volume Control System (Refer to O.I. No. 504F)	Normal operation
Sampling System (Refer to O.I. No. 504K1)	Normal operation
Radioactive Waste Disposal System (Refer to O.I. No. 504L1)	Waste holdup tank capacity for 2,000 gal. is available

B. Boric Acid Addition to an Isolated Main Coolant Loop

1. The individual loop fill line to the isolated loop is open back to the fill header. Refer to O.I. No. 504D8, MAIN COOLANT SYSTEM -- SHUTDOWN OF INDIVIDUAL LOOPS.

2. Cold leg temperature recorded at the time the loop was isolated.

3. Boron concentration recorded at time loop was isolated. Refer to O.I. No. 504D8, MAIN COOLANT SYSTEM -- SHUTDOWN OF INDIVIDUAL LOOPS.

III. Precautions

1. A group of control rods must be in the safety position ready for insertion into the reactor as required for safety reasons when adding boric acid to the main coolant system.

2. The boric acid mixing and storage tank instrumentation and associated valves, lines, pumps, etc., are to be kept in operating condition at all times when fuel is in place or the main coolant is not borated to shutdown concentration.

3. When boric acid addition is complete, flush the boric acid feed lines and the boric acid solution transfer pump.

IV. Check-Off List

Prior to the initiation of this O.I., the check-off list must be completed by the operator(s) and signed off.

V. Instructions

A. Boric Acid Addition to the Main Coolant System

1. Check that all charging pumps are available and valved for operation (see O.I. No. 504F, CHARGING AND VOLUME CONTROL SYSTEM). Check that the charging pump suction header isolation valve is open.

2. Check that manual valves are lined up to discharge borated waste from the low pressure surge tank to the waste holdup tank, and that the purification, cooling, and drain pumps will provide adequate cooling for the low pressure surge tank. For bleed flows in excess of 75 gpm, put the 1,000 gpm low pressure surge tank cooler in service. See O.I. No. 504F, CHARGING AND VOLUME CONTROL SYSTEM.

3. Switch charging pump suction from the low pressure surge tank to the boric acid mixing and storage tank by closing the valve in the line to the suction header from the low pressure surge tank and opening the motor operated gate valve in the feed line from the boric acid mixing and storage tank to the charging pump suction header.

4. Establish maximum bleed from the main coolant system, consistent with holding normal pressurizer level. See O.I. No. 504F, CHARGING AND VOLUME CONTROL SYSTEM).

5. Add (1,500)* gal of 12% by weight boric acid to the main coolant system.

   NOTE: If all three pumps are used, approximately (15)* min will be required to charge the amount of boric acid necessary for nuclear safety.

6. Close the valves in the bleed line and stop the charging pumps.

7. Sample the main coolant per O.I. No. 504K1, PRIMARY PLANT SAMPLING SYSTEM - MAIN COOLANT SYSTEM. If the boron concentration is less than shutdown concentration, repeat Steps Nos. 5, 6 and 7.

   WARNING: Before repeating Step No. 5, determine that sufficient boric acid solution is available. Operation with one charging pump and the 25 gpm leg of the bleed line may be desirable to add sufficient boric acid to achieve shutdown boron concentration.

B. Boric Acid Addition to an Isolated Main Coolant Loop

1. Compute the weight of water in the loop from the loop volume and temperature at the time of isolation.

2. Based on the weight of water and boron concentration in the loop, determine the volume of 12% boric acid solution to add to obtain shutdown concentration in the loop.

3. Shut down charging pump No. 3, and put the pump on manual control. Check that charging pump No. 1 is automatically maintaining make-up to the main coolant system, if required, from the low pressure surge tank.

*To be detailed later

4. Isolate charging pump No. 3 on both the suction and discharge headers.

5. Open the motor operated gate valve in the feed line from the boric acid mixing and storage tank to the charging pump suction header.

6. Open the motor operated gate valves in the individual fill line for the loop to be borated and in the loop fill header.

7. Open the motor operated gate valve in the loop by-pass line.

8. Just unseat the throttle valve in the loop drain line to the low pressure surge tank.

9. Start charging pump No. 3 at minimum speed, and adjust the drain line throttle valve setting to maintain loop pressure greater than saturation pressure, by observation of the loop fill header pressure indicator.

10. Add the required volume of boric acid solution, as calculated in Step No. 2. Check that the low pressure surge tank level controller is operating to discharge excess water to the waste holdup tank.

11. If low pressure surge tank temperature exceeds 140 F, increase cooling before putting purification on line (refer to O.I. No. 504F, CHARGING AND VOLUME CONTROL SYSTEM).

VI. Final Conditions

A. Boric Acid Addition to the Main Coolant System

1. The shutdown boron concentration has been established in the main coolant system.

2. All boric acid lines and the boric acid transfer pump have been flushed.

B. Boric Acid Addition to an Isolated Main Coolant Loop

1. The shutdown boron concentration has been established in an isolated loop.

2. All boric acid lines and the boric acid transfer pump have been flushed.

OPERATING INSTRUCTION NO. 504G3

CHEMICAL SHUTDOWN SYSTEM
BORIC ACID REMOVAL

I. Objective To provide a safe and efficient method for removal of boron from the main coolant system.

II. Conditions

1. A proper water balance should be established in the primary plant make-up and storage tanks, so that adequate make-up water is available and water rejected from the primary plant can be received.

2. Boron concentration in the Main Coolant System has been determined to be in excess of that required for minimum shutdown requirements.

3. Pertinent auxiliary systems are in the following status:

System	Status
Main Coolant System (Refer to O.I. No. 504D4)	Normal operation
Pressure Control and Relief System (Refer to O.I. No. 504E)	Surge spray operable, if required, on wide bank level
Charging and Volume Control System (Refer to O.I. No. 504F)	On automatic control
Chemical Shutdown System (Refer to O.I. No. 504G2)	Mixing and storage tank full of 12% boric acid solution
Purification System (Refer to O.I. No. 504H)	In operation as required
Primary Plant Sampling System (Refer to O.I. No. 504K1)	Normal operation
Radioactive Waste Disposal System (Refer to O.I. No. 504L1)	Prepared to receive dilution water

III. Precautions

1. Do not initiate removal of boron until main coolant system temperature reaches 250 F*.

2. Criticality should be anticipated any time that boron is being removed.

3. Because the dilution rate will not be constant throughout the performance of this O.I., determination of boron concentration in the main coolant system should be accomplished according to the schedule outlined herein.

4. Boron removal should be stopped during the final approach to, and the checks at, criticality. Refer to O.I. No. 504A1, PLANT STARTUP - REACTOR STARTUP FROM COLD CONDITION.

IV. Check-off List

Prior to the initiation of this O.I., the check-off list must be completed by the operator(s) and signed off.

V. Instructions

1. Verify that main coolant expansion is being rejected to radioactive waste disposal via the bleed line to the low pressure surge tank, and that the low pressure surge tank level is being maintained by the operation of the purification cooling and drain pumps. Refer to O.I. No. 504F, CHARGING AND VOLUME CONTROL SYSTEM.

2. Check that primary water supply line valves to and from the low pressure surge tank make-up pumps are open.

3. Place the standby make-up pump on manual control and start the pump.

   NOTE: The other pump should remain on automatic control, even though high level exists in the low pressure surge tank.

4. Open the isolation valve in the line from the low pressure surge tank make-up pumps to the charging pump suction header.

5. Close the isolation valve between the low pressure surge tank and the charging pump suction header.

6. Continue increasing main coolant system pressure. When bleed flow exceeds 66 gpm, start the constant speed charging pump. Refer to O.I. No. 504F, CHARGING AND VOLUME CONTROL SYSTEM.

*Subject to confirmation

7. Sample the main coolant system for boron concentration at least every 15 min, and sample the pressurizer at least every 4 hr. Refer to O.I. No. 504K1, PRIMARY PLANT SAMPLING SYSTEM - MAIN COOLANT SYSTEM.

   NOTE: Unless corrective action is taken, dilution of boron in the pressurizer will lag far behind the main coolant. It may be desirable to operate the surge spray on an intermittent basis to prevent excess consumption of purification resin, undesirable pH, and undesirable nuclear operation.

8. Continue main coolant dilution until boron concentration reaches 200 ± 20 ppm. Transfer charging pump suction from the individual loop demineralized water fill line to the low pressure surge tank.

9. Simultaneously close the motor operated valves in the bleed lines for the 75 gpm and one 25 gpm orifice and shut down the constant speed charging pump.

10. After establishing and maintaining a critical-zero power condition, (refer to O.I. No. 504A1, PLANT STARTUP - REACTOR STARTUP FROM COLD CONDITION) verify that boron concentration in the main coolant system is 200 ± 20 ppm.

11. Resume dilution of boron in the main coolant.

    NOTE: Steps Nos. 1 through 4 under Section V-A of O.I. No. 504B1, PLANT OPERATION - CHANGING REACTOR LOAD, must be satisfied before resuming dilution.

12. Start the standby low pressure surge tank make-up pump, transfer charging pump suction back to the individual loop demineralized water fill line, and open the motor-operated valves in the bleed lines for the 75 gpm and 25 gpm orifices.

13. Start the constant speed charging pump.

14. Continue dilution of the main coolant system until boron concentration reaches 80 ± 10 ppm.

    NOTE: Sample the main coolant for boron concentration at least every 30 min, and sample the pressurizer at least once near the end of dilution to 80 ± 10 ppm.

15. Check that both chemical shutdown ion exchanger inlet and outlet isolation valves are open, and that all purification ion exchanger isolation valves are closed.

16. Open the isolation valve between the low pressure surge tank and the charging pump suction header.

17. Open the purification flow control valve adjusting the flow controller.

18. Check the purification flow indicator to determine that the purification, cooling and drain pump is delivering borated main coolant to the chemical shutdown ion exchangers.

19. Return the standby low pressure surge tank make-up pump to the standby condition.

20. Sample the main coolant system for boron concentration every 2 hr, and sample the pressurizer according to the frequency of manual operation of the surge spray. Refer to O.I. No. 504K1, PRIMARY PLANT SAMPLING SYSTEM - MAIN COOLANT SYSTEM.

21. When boron concentration in the main coolant reaches 5 (+ 0-2) ppm, start up the purification system. Refer to O.I. No. 504H, PURIFICATION SYSTEM.

VI. Final Conditions

Boron concentration in the main coolant system is less than 5 ppm.

OPERATING INSTRUCTION NO. 504H

PURIFICATION SYSTEM

I. Objective To provide a safe and efficient method of operating the purification system for the purpose of removing impurities from the main coolant. This instruction provides a procedure to perform the following:

A. Startup of the Purification System

B. Normal Operation of the Purification System

C. Shutdown of the Purification System (when it is unnecessary or undesirable to continue purification of the main coolant)

II. Conditions

A. Startup

1. Two ion exchangers are available for service.

2. Boron concentration in the main coolant is acceptable for the ion exchangers to be put in service.

3. Pertinent auxiliary systems are in the following status:

System	Status
Charging and Volume Control System (Refer to O.I. No. 504F)	Normal operation
Chemical Shutdown System (Refer to O.I. No. 504G3)	Chemical shutdown ion exchangers in operation as required

B. Normal Operation

1. At least one purification ion exchanger is available to process main coolant.

2. Liquid from the primary drain collecting tank may not be processed in the purification system if it:

a. Contains an unacceptable boron concentration for the ion exchanger in service.

b. Contains decontamination solution.

3. Any liquid processed through the resin must be less than 140°F.

4. At least one spare purification ion exchanger should be on the plant site if the alternate ion exchanger is used to process primary drain liquid.

5. Pertinent auxiliary systems are in the following status:

System	Status
Charging and Volume Control System (Refer to O.I. No. 504F)	Normal operation - taking suction from both purification and low pressure surge tank
Primary Plant Sampling System (Refer to O.I. No. 504K2)	Normal operation

C. Shutdown

NOTE: Shutdown should be initiated by any of the following conditions:

1. Prior to initiation of O.I. No. 504C2, PLANT SHUTDOWN - REACTOR COOLDOWN.

2. As soon as possible after initiation of E.I. No. 505B10, PRIMARY PLANT - TOTAL LOSS OF MAIN COOLANT.

3. Pertinent auxiliary systems are in the following status:

System	Status
Pressure Control and Relief System (Refer to O.I. No. 504E)	Normal operation
Charging and Volume Control System (Refer to O.I. No. 504F)	Normal operation
Primary Plant Corrosion Control System - Hydrogen Addition (Refer to O.I. No. 504J1)	Normal operation
Primary Plant Sampling System (Refer to O.I. No. 504K2)	Normal operation

III. Precautions

A. Startup

When starting up purification, high temperatures may result from a change in flow rate through the cooler. Increase cooling water flow, if required.

B. Normal Operation

1. Stop the purification pump(s) if the motor operated valve in the pump suction is closed.

2. The low pressure surge tank temperature should be maintained at less than 140 F. Refer to O.I. No. 504F, CHARGING AND VOLUME CONTROL SYSTEM, when purification flow is to be increased.

3. For purification flows above 50 gpm, two ion exchangers are required to purify main coolant.

C. Shutdown

None

IV. Check-off List

Prior to initiation of this O.I., the check-off list must be completed by the operator(s) and signed off.

V. Instructions

A. Startup

1. Check that the charging and volume control system is lined up for normal filling operations from the low pressure surge tank to the main coolant system as per O.I. No. 504F, CHARGING AND VOLUME CONTROL SYSTEM.

2. If startup is during normal plant operation, open the purified make-up return line to the charging pump suction header.

3. If startup is at completion of O.I. No. 504G3, CHEMICAL SHUTDOWN SYSTEM - BORIC ACID REMOVAL, put both purification ion exchangers on line by opening their inlet and outlet header isolation valves and isolate both chemical shutdown ion exchangers, by closing their inlet and outlet header isolation valves.

4. Set the purification flow controller to the desired flow and adjust the bleed rate accordingly.

5. Check that the line from the low pressure surge tank to the purification-cooling-drain pumps is open.

6. Check that the purification-cooling-drain pump isolation valves are open and start one pump.

   NOTE: The charging pump(s) are on automatic control from the pressurizer and are now taking suction from both purification system and the low pressure surge tank.

7. Check the purification system flow indicator for flow. If there is no flow, check the valve lineup. Repeat Steps Nos. 6 and 7.

B. Normal Operation

1. Sampling and Corrective Action

   a. To determine whether established operating limits are being met, sample the fluid before and after the ion exchanger. Refer to O.I. No. 504K2, PRIMARY PLANT SAMPLING SYSTEM - AUXILIARY SYSTEMS.

      (1) Samples should be taken once per shift for two weeks following startup and approximately once per day thereafter.

   b. If the degassed, 15 min decay gross decontamination factor

$$\frac{\text{(ion exchanger inlet c/m/ml)}}{\text{(ion exchanger outlet c/m/ml)}}$$

   is 100 or less, corrective action should be taken as follows:

      (1) If the alternate ion exchanger is not in service, open its isolation valves to the purification inlet header and the purified make-up return header. Close the isolation valves on the expended ion exchanger.

   c. The gross decontamination factor will be under surveillance during ion exchange purification system operation. Plant chemistry will determine when replacement is necessary. Perform Step No. 1b under Section V-B.

2. Increasing or Decreasing Flow

a. For planned reactor shutdown

(1) Prior to reactor shutdown, reset the purification system flow controller to reduce coolant activity level according to scheduled shutdown maintenance operations.

NOTE: Two ion exchangers are required to be on line for purification flows above 50 gpm.

(2) Adjust bleed rate as required per O.I. No. 504F, CHARGING AND VOLUME CONTROL SYSTEM.

(3) Adjust the low pressure surge tank cooling rate, if required. Refer to O.I. No. 504F, CHARGING AND VOLUME CONTROL SYSTEM.

b. For an increase in main coolant activity

(1) Check that Step No. 1b(1) under Section V-B is satisfied.

(2) Adjust the purification flow controller and bleed flow to maintain plant operation within the chemical and radiochemical specifications. Refer to Section 106, REACTOR COOLANT CHEMISTRY and O.I. No. 504F, CHARGING AND VOLUME CONTROL SYSTEM.

(3) Adjust the low pressure surge tank cooling rate, if required. Refer to O.I. No. 504F, CHARGING AND VOLUME CONTROL SYSTEM.

C. Shutdown

1. Close the purification flow control valve.

2. Close the valve in the purified make-up return to the charging pump suction header. Refer to O.I. No. 504F, CHARGING AND VOLUME CONTROL SYSTEM.

VI. Final Conditions

1. The purification system has been placed in operation.

2. The purification system is maintaining main coolant purity within the prescribed limits.

3. The purification system has been shut down.

OPERATING INSTRUCTION NO. 504I

COMPONENT COOLING SYSTEM

I. Objective To provide a safe and efficient method for removal of heat from various primary plant components in order to maintain them at required operating temperature.

II. Conditions

1. The component cooling system (heat exchangers, pumps, water surge tank, piping, and instruments) has been filled and vented with secondary plant condensate. Secondary plant condensate is available for subsequent make-up.

2. The component cooling water should be treated with chromate and be conditioned, ready for service.

3. Pertinent auxiliary systems are in the following status:

System	Status
Main Coolant System - Startup of Complete System (Refer to O.I. No. 504D4)	Ready for startup
Charging and Volume Control System (Refer to O.I. No. 504F)	Ready for startup
Purification System (Refer to O.I. No. 504H)	Ready for startup
Shutdown Cooling System (Refer to O.I. No. 504M)	Ready for startup
Primary Plant Sampling System (Refer to O.I. No. 504K)	Ready for startup
Service Water System	Normal operation

III. Precautions

1. If the cooling water flow to a component(s) is regulated to the desired value and cooling water flow is initiated to another component, the cooling water flow to the former component(s) should be checked for possible readjustment.

IV. Check-off List

Prior to the initiation of this O.I., the check-off list must be completed by the operator(s) and signed off.

V. Instructions

A. General Operation

1. Place component cooling water surge tank level control valve on automatic control.

2. Place motor operated, surge tank vent on radiation monitor control.

3. Start service water flow to one of the component cooling exchangers.

NOTE: One exchanger will be a spare.

4. Open the component cooling water inlet and outlet valves to cooling exchanger.

5. Open the component cooling water pump suction valve.

NOTE: One pump is a spare and has an independent power supply and is interlocked to the operative pump, so that a power failure to one pump will not affect the operation of the component cooling system. The spare pump discharge and suction valves are in the open position when system is in operation.

6. Place the temperature, pressure, flow indicators, and alarms from the inlet and outlet lines of the component cooling pump and exchanger into service.

7. Start component cooling pump. See Manufacturer's Instruction Book.

8. Open component cooling pump discharge valve slowly.

NOTE: Establish flow before pump heating and flashing take place.

9. The service water supply, component cooling pump and cooling exchanger are in operation and in condition to supply cooling water to the different primary plant components.

NOTE: Subsequent sections (B through E) apply to applying cooling water to the different components as required.

During the following operations the temperature of the service water leaving the component cooling water heat exchangers should be approximately 75 F and the component cooling water leaving the heat exchangers should be maintained at approximately 90 F.

As cooling water flow is initiated to the various components, periodic sampling of the cooling water should be done. Refer to O.I. No. 504K2, PRIMARY PLANT SAMPLING SYSTEM - AUXILIARY SYSTEMS. If the addition of chromate to the cooling water is required, the corrosion control pot feeder should be put into operation until the desired concentration of chromate is established.

B. Main Coolant Pump (applies for each pump)

1. If not open, actuate the closure trip valve in cooling water effluent header.

2. Place the temperature alarm and indicator on the cooling water discharge line from the main coolant pump, or preferably from the main coolant pump lower thrust bearing, into operation.

3. Open manual gate valves in the inlet and outlet cooling lines from the main coolant pump to the full open position.

4. Open hand control valve in the outlet cooling line from the main coolant pump to the full open position.

5. After establishment of cooling water flow to the main coolant pumps, startup of the main coolant pump may be initiated. Refer to O.I. No. 504D4, MAIN COOLANT SYSTEM - STARTUP OF COMPLETE SYSTEM.

6. Continue maximum cooling water flow to the main coolant pump until the temperature of the main coolant system is at normal operating levels. Refer to O.I. No. 504D6, MAIN COOLANT SYSTEM - RUNNING OPERATION.

7. After the main coolant system is at normal operating conditions, by gradual regulation of the hand control valve in the cooling discharge line from the main coolant pump, maintain a cooling water flow so that the component cooling effluent from the main coolant pump is at approximately 100 F. The lower, main coolant thrust bearing temperature should be between 140 and 185 F.

The main coolant thrust bearing alarm should be set slightly above the normal operating temperature of the bearing.

The cooling water effluent from the main coolant pump should never exceed 125 F and the thrust bearing temperature must not exceed 225 F.

NOTE: Normally after stopping cooling water flow to the main coolant pumps, the hand control valve will remain in the desired position.

8. When the main coolant pump is stopped, cooling water flow to the pump must be continued until the main coolant temperature is reduced to 200 F.

9. To stop cooling water flow to the main coolant pumps, close the gate valves in the pump cooling water inlet and outlet lines. The hand control valve in the cooling water discharge line should remain in the normal operating position.

C. Low Pressure Surge Tank (LPST) Cooler

NOTE: The LPST cooler may also be used for shutdown cooling if the LPST temperature control valve is by-passed.

1. Place the LPST temperature control valve in operation. Open control valve isolation valves.

2. Open stop valves in the LPST cooling water inlet and outlet lines.

3. After establishing cooling water flow to the LPST cooler, the purification cooling and drain pumps and the LPST pump can be put into operation. Refer to O.I. No. 504F, CHARGING AND VOLUME CONTROL SYSTEM and O.I. No. 504H, PURIFICATION SYSTEM.

4. By adjustment of the cooling water temperature control valve, regulate the cooling water flow in order to maintain the desired water temperature in the LPST. Normally this temperature should be approximately 120 F.

5. If cooling water is not required for heat removal from the LPST cooler, place the cooler in standby condition.

D. Shutdown Cooler

1. Open the cooling water inlet valve to the shutdown cooler.

2. Open stop valve in the LPST temperature control by-pass line.

3. Open stop valve in the shutdown cooler water discharge line. By regulation of this valve, control the cooling water flow to the shutdown cooler to maintain the desired main coolant temperature. Refer to O.I. No. 504M, SHUTDOWN COOLING SYSTEM.

4. To stop cooling water flow to the shutdown cooler, close valves opened in Step Nos. 1, 2, and 3.

E. Fuel Transfer Pit (FTP) Cooler

1. Open stop valve in FTP cooler inlet cooling line.

2. Open hand control valve in FTP cooler discharge cooling line.

3. With cooling water flow to the FTP cooler being established, water flow through the tube side of the exchanger can be started by operation of the FTP pump and by opening the associated valves. Refer to M.I. No. 506B5, FUEL TRANSFER PIT COOLING SYSTEM OPERATION.

4. By regulation of cooling water flow by the hand control valve, maintain water in fuel pit at 130 F or less.

5. To stop cooling water flow to FTP cooler, close valves opened in Step Nos. 1 and 2.

F. Sample Cooler

NOTE: Start cooling water flow to sample cooler before sample water flow is started.

1. Open stop valves in sample cooler, cooling discharge and inlet lines.

2. Open hand control valve in sample cooler, cooling discharge line to full open position.

3. After sample water flow is obtained with hand control valve in sample cooler, cooling water discharge line, regulate the cooling water flow to maintain desired temperature of sample. Refer to O.I. No. 504K, PRIMARY PLANT SAMPLING SYSTEM.

   NOTE: Normally after stopping cooling water flow to the sample cooler, the hand control valve will remain at the desired position.

4. To stop cooling water flow to the sample cooler, close valves opened in Step Nos. 1 and 2.

G. Neutron Shield Tank

1. Open stop valves in neutron shield tank cooling water inlet and outlet lines.

2. Open hand control valve in neutron shield tank cooling water outlet line. By regulation of this flow control valve, maintain water temperature in neutron shield tank at or below 120 F.

3. To stop cooling water flow to neutron shield tank, close valves opened in Step No. 1.

VI. Final Conditions

Cooling water flow as required to the various primary plant components has been established.

OPERATING INSTRUCTION NO. 504J1

PRIMARY PLANT CORROSION CONTROL SYSTEM
HYDROGEN ADDITION

I. Objective To provide a safe means of injecting into and maintaining hydrogen gas in the main coolant in order to minimize corrosion in the primary plant systems.

II. Conditions

A. Startup

1. A minimum of three filled cylinders (2,000 psi gage minimum) of hydrogen are available for service.

2. The main coolant system is in cold shutdown condition.

3. The pertinent auxiliary systems are in the following status:

System	Status
Charging and Volume Control System (Refer to O.I. No. 504F)	Filling and venting of system in progress
Radioactive Waste Disposal System - Liquid Waste Disposal (Refer to O.I. No. 504L1)	Prepared to receive bleed off liquid from main coolant

B. Normal Operation

1. All plant startup feed and bleed operations have been completed.

2. The main coolant system is on line and is at normal operating temperature and pressure.

3. Pertinent auxiliary systems are in the following status:

System	Status
Charging and Volume Control System (Refer to O.I. No. 504F)	On line - auto control
Primary Plant Sampling System - Main Coolant System (Refer to O.I. No. 504K1)	Normal operation

C. Shutdown

1. Reactor shutdown has been completed and reactor cooldown is in progress. Refer to O.I. No. 504C1, SCHEDULED REACTOR SHUTDOWN and O.I. No. 504C2, REACTOR COOLDOWN.

2. The pertinent auxiliary systems are in the following status:

System	Status
Charging and Volume Control System (Refer to O.I. No. 504F)	On line - operating on auto control
Primary Plant Sampling System - Main Coolant System (Refer to O.I. No. 504K1)	Normal operation

III. Precautions

Hydrogen-air mixtures are potentially explosive.

1. Do not strike sparks, ignite matches, etc. around hydrogen gas cylinders and lines.

2. Do not add hydrogen to any equipment (especially low pressure surge tank) before adequately venting all air. Refer to O.I. No. 504F, CHARGING AND VOLUME CONTROL SYSTEM.

3. Refer to regulations published by National Board of Fire Underwriters and other regulatory bodies for additional precautions in handling hydrogen gas.

IV. Check-off List

Prior to the initiation of this O.I., the check-off list must be completed by the operator(s) and signed off.

V. Instructions

A. Startup

1. Check that all valves in hydrogen injection line are closed.

2. Open the isolation valve on the injection line. This valve is between the regulator valve and the hydrogen cylinder manifold.

3. Place one hydrogen cylinder in service.

4. Check the pressure reading on high pressure gage located on regulator valve. The high pressure gage should read approximately 2,000 psi.

5. Open pressure regulator valve until an indication of 15 psi gage is obtained on the regulator valve low pressure gage.

6. Open globe valve on the hydrogen injection line between the check valve and the low pressure surge tank, then drain the surge tank to normal operating level. Refer to O.I. No. 504F, CHARGING AND VOLUME CONTROL SYSTEM.

7. When normal operating level is established in the surge tank, adjust pressure regulator valve until a reading of 15 psi gage is indicated on the regulator valve low pressure gage.

   NOTE: The low pressure surge tank is now in a stand-by status, ready to receive bleed-off fluid during primary plant startup

8. Maintain a periodic check on the surge tank pressure while all coolant bleed-off operations are in progress during startup.

9. Upon initiation of the chemical shutdown system (refer to O.I. No. 504G3, CHEMICAL SHUTDOWN SYSTEM - BORIC ACID REMOVAL), adjust the pressure regulator valve until an indication of 10-15 psi gage is obtained on the low pressure gage.

10. Sequence the hydrogen supply cylinder(s) to assure adequate hydrogen supply to manifold. Replace cylinder(s) when the pressure drops to the established minimum (100 psi gage).

11. After completion of Step No. 10, maintain a periodic check on the following:

    Surge tank pressure (10-15 psi gage).

    Outlet pressure reading on regulator valve (10-15 psi gage).

    Gas cylinder manifold pressure.

    NOTE: If these conditions are exceeded, check that the isolation valve on injection line is closed.

12. Periodically determine hydrogen concentration in main coolant system. Refer to O.I. No. 504K1, PRIMARY PLANT SAMPLING SYSTEM - MAIN COOLANT SYSTEM. Hydrogen concentration should be between 25 and 50 cc H_2 (STP)/kg H_2O.

    NOTE: If this concentration is exceeded, close isolation valve on injection line until normal operating conditions are established.

B. Normal Operation

For normal operation, this system is self-operating and requires only a periodic check of the components listed under Section V-A, **Step Nos. 11 and 12.**

C. Shutdown

NOTE: Normally when the reactor is shut down, a positive pressure on the hydrogen addition equipment should be maintained by adjusting the regulator valve.

1. Close hydrogen cylinder valve(s).
2. Close cylinder stop valves leading to manifold, isolation valve and regulator valve on injection line.
3. When required, surge tank can be isolated from injection line by closing globe valve between check valve and the low pressure surge tank.
4. During the draining of the charging and volume control system, vent the hydrogen blanket in the low pressure surge tank as per O.I. 504F, CHARGING AND VOLUME CONTROL SYSTEM.

VI. Final Conditions

1. Hydrogen injection system has been started and hydrogen concentration in main coolant is being maintained between 25-50 cc H_2 (STP)/kg H_2O (normal concentration will be between 25-30 cc H_2 (STP)/kg H_2O).
2. The system has been shut down and isolated.

OPERATING INSTRUCTION NO. 504J2

PRIMARY PLANT CORROSION CONTROL SYSTEM
HYDRAZINE ADDITION

I. Objective To provide a safe means of injecting hydrazine solution into the main coolant system when the reactor is subcritical to reduce the dissolved oxygen concentration.

II. Conditions

1. The main coolant system is being operated with the reactor in a subcritical condition. Refer to O.I. No. 504D4, MAIN COOLANT SYSTEM - STARTUP OF COMPLETE SYSTEM.

2. All the main coolant pumps have been operated for approximately 5 min. Refer to O.I. No. 504D4, MAIN COOLANT SYSTEM - STARTUP OF COMPLETE SYSTEM.

3. A minimum 8 gal of a commercial hydrazine-water solution containing 35% hydrazine by weight is available.

4. The main coolant has been sampled and analysis reveals an oxygen concentration in excess of 0.1 ppm. Refer to O.I. No. 504K1, PRIMARY PLANT SAMPLING SYSTEM - MAIN COOLANT SYSTEM.

5. Pertinent auxiliary systems are in the following status:

System	Status
Pressure Control and Relief System (Refer to O.I. No. 504E)	In service, as required
Charging and Volume Control System (Refer to O.I. No. 504F)	Normal operation
Primary Plant Sampling System - Main Coolant System (Refer to O.I. No. 504K1)	Normal operation
Radioactive Waste Disposal System (Refer to O.I. No. 504L)	Normal operation

III. Precautions

Comply with manufacturer's recommended safety practices for handling of hydrazine solutions.

IV. Check-off List

Prior to the initiation of this O.I., the check-off list must be completed by the operator(s) and signed off.

V. Instructions

1. Determine the amount of hydrazine solution to be injected based upon the laboratory report of dissolved oxygen concentration in the main coolant. Refer to curve on page 504J2:3.

   NOTE: A concentration of hydrazine should be selected to enable close control of the amount of hydrazine solution added to the main coolant system.

2. Prepare a hydrazine solution of the selected concentration in the hydrazine feed tank.

3. Check that the valve on the hydrazine feed pump suction line is open.

4. Close the valve on the hydrazine injection line to the condensate pump discharge in the secondary plant.

5. Open the isolation valve on the hydrazine injection line to the primary plant charging pumps.

6. Check that the globe valves on the injection line at the discharge points to the charging pumps suction lines are open.

7. Start the hydrazine feed pump; inject the required amount of hydrazine.

   NOTE: The required amount of solution injected is determined by change in level of the hydrazine feed tank.

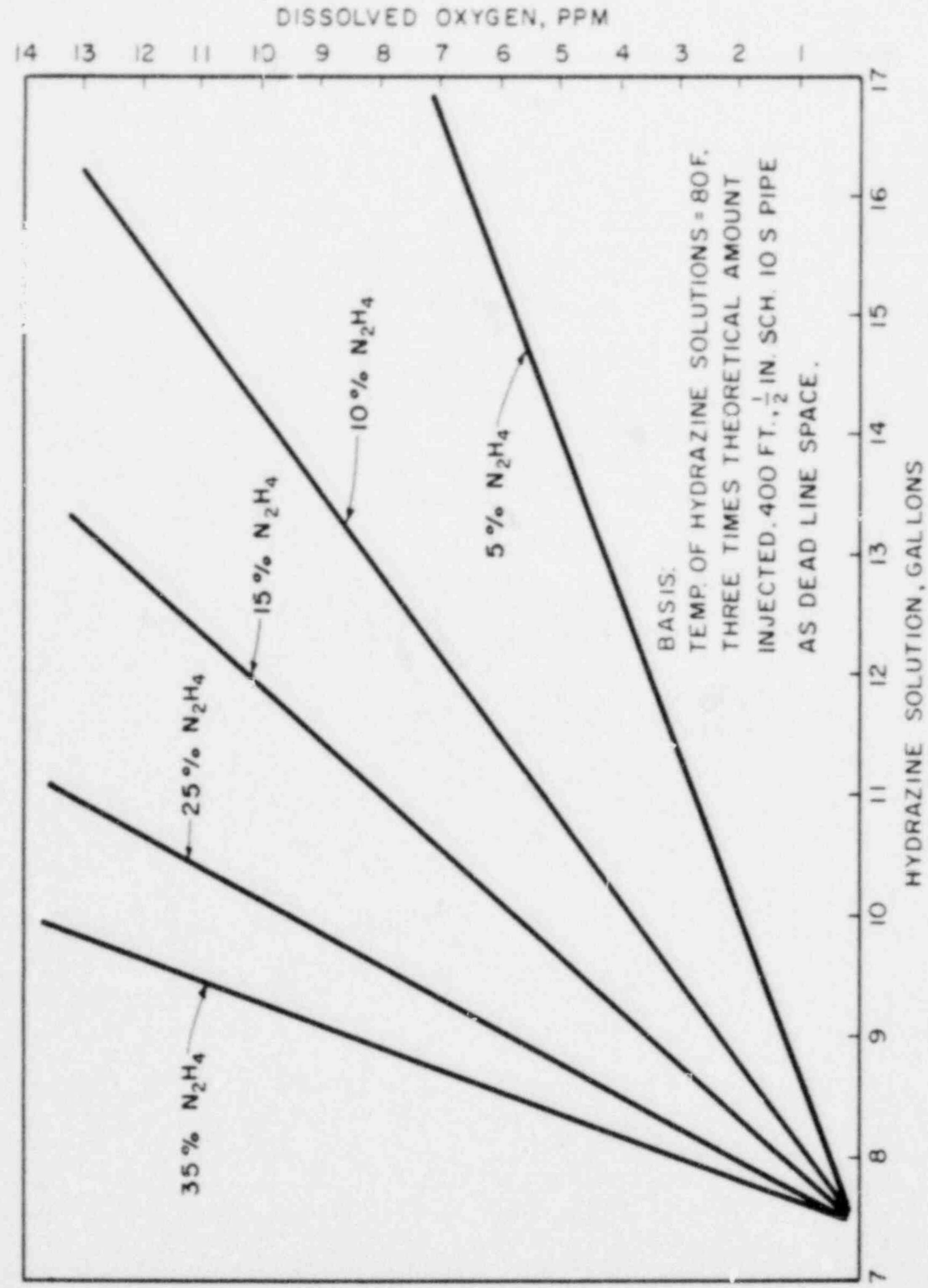
8. If additional hydrazine is required as per O.I. No. 504K1, PRIMARY PLANT SAMPLING SYSTEM - MAIN COOLANT SYSTEM, repeat Step No. 1 through 7.

9. If no further hydrazine addition is necessary, close the isolation valve on primary plant hydrazine injection line and the globe valves at the discharge points to the charging pumps suction lines.

10. Open the isolation valve on the hydrazine injection line to the condensate pump discharge in the secondary plant.

VI. Final Condition

The required amount of hydrazine has been injected into the main coolant while the reactor has been operating in a subcritical condition. The oxygen concentration in the main coolant has been reduced to less than 0.1 ppm, and the system has been isolated from the primary plant.



HYDRAZINE SOLUTION REQUIRED TO REDUCE DISSOLVED OXYGEN IN MAIN COOLANT TO LESS THAN 0.1 PPM

OPERATING INSTRUCTION NO. 504J3

PRIMARY PLANT CORROSION CONTROL SYSTEM
LITHIUM HYDROXIDE ADDITION

NOTE: This operating instruction is to be put into practice only if and when the use of LiOH in the primary plant is decided upon by Yankee and approved by the AEC. See Section 106, REACTOR COOLANT CHEMISTRY.

I. Objective To present a safe and efficient method of adjusting pH of the main coolant system by the addition of lithium hydroxide.

II. Conditions

1. Boric acid concentration in the main coolant system has been reduced to less than 6 ppm. Refer to O.I. No. 504D4, MAIN COOLANT SYSTEM - STARTUP OF COMPLETE SYSTEM.

2. A minimum of 20 gal of lithium hydroxide solution containing 5 wt % lithium hydroxide monohydrate is available.

3. Pertinent auxiliary systems are in the following status:

System	Status
Charging and Volume Control System (Refer to O.I. No. 504F)	Normal operation
Primary Plant Sampling System (Refer to O.I. No. 504K)	Normal operation

III. Precautions

1. To avoid adding escessive lithium hydroxide solution to the main coolant, do not add solution until boric acid content is less than 6 ppm.

2. One or more main coolant pumps must be in operation.

IV. Check-off List

Prior to the initiation of this O.I., the check-off list must be completed by the operator(s) and signed off.

V. Instructions

1. Determine the main coolant pH and boric acid concentration. Refer to O.I. No. 504K1, PRIMARY PLANT SAMPLING SYSTEM - MAIN COOLANT SYSTEM.

2. Check that the valve in the feed line from the lithium hydroxide feed tank (hydrazine feed tank) to the feed pump suction is open.

3. Close the isolation valve in the feed pump injection line to the condensate pump discharge.

4. Open the isolation valves in the feed pump injection line to each of the three charging pump suction lines.

5. Determine the amount of lithium hydroxide solution to add using the sample analysis results obtained in Step No. 1 and page 504J3:3.

6. Purge the feed line by pumping lithium hydroxide through the drain connection at the charging pump suction.

7. Start the feed pump and add the required volume of lithium hydroxide by observing the feed tank level change.

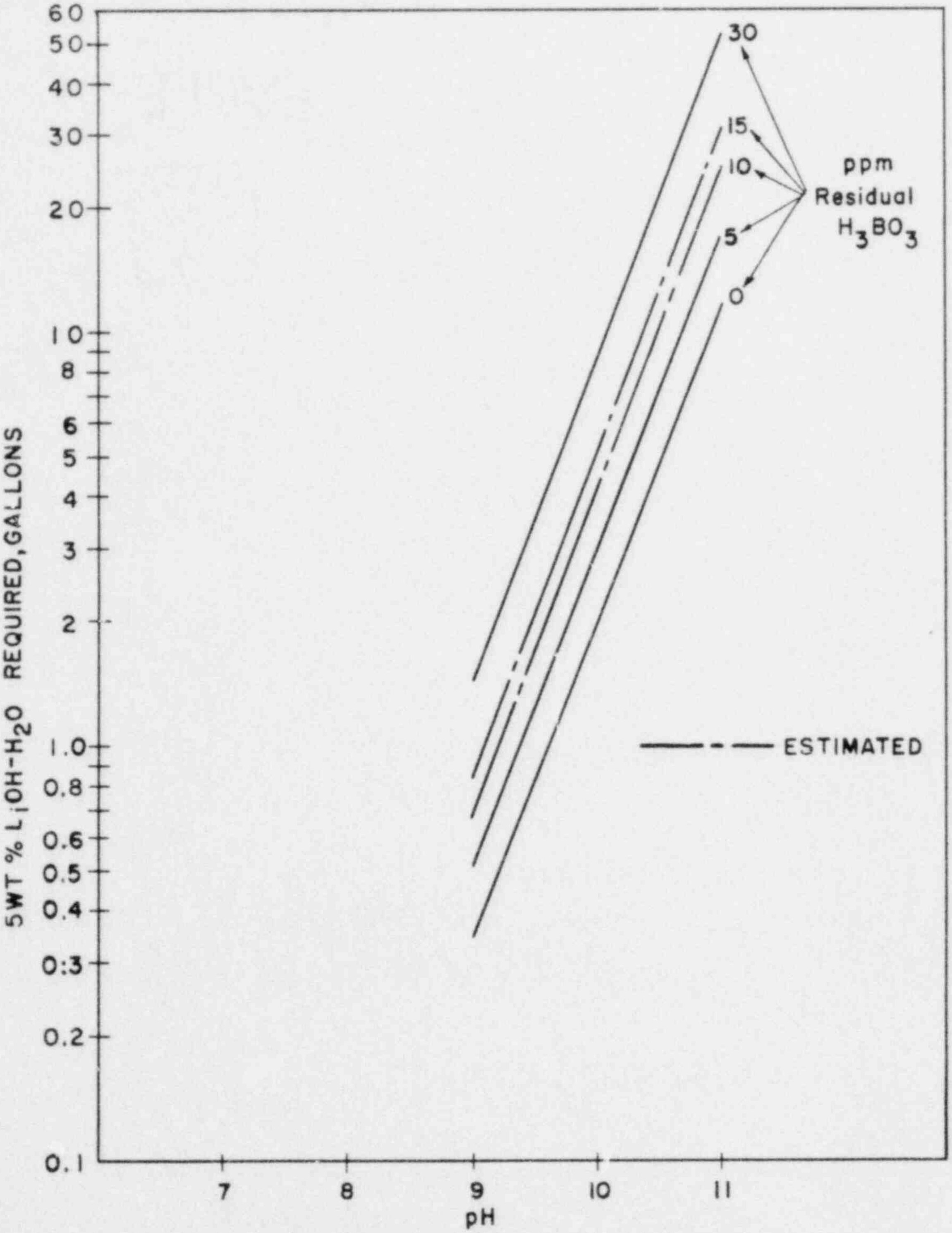
8. Verify pH. Add additional lithium hydroxide solution, if required.

9. When addition is complete, drain the lithium hydroxide tank of any left-over lithium hydroxide solution and flush the tank and drain line through the charging pump suction drain connection.

10. Close the drain line valve and return the valves in Steps Nos. 3 and 4 to their original positions.

VI. Final Conditions

The main coolant pH has been adjusted to the desired value.



VOLUME OF LITHIUM HYDROXIDE SOLUTION REQUIRED TO ADJUST MAIN COOLANT pH

OPERATING INSTRUCTION NO. 504K1

PRIMARY PLANT SAMPLING SYSTEM
MAIN COOLANT SYSTEM

I. Objective To provide a safe means of sampling the primary coolant in the main coolant and pressure control and relief systems.

II. Conditions

1. Positive pressure exists in any loop that is to be sampled.

2. An adequate water supply for flushing and rinsing is available in the sampling room.

3. Proper ventilation of the sampling room has been established.

4. A proper water balance should be established in the primary plant make-up and storage tanks to ensure that adequate make-up water is available and to receive water rejected from the primary plant.

5. The pertinent auxiliary systems are in the following conditions:

System	Status
Component Cooling System (Refer to O.I. No. 504I)	In normal operation - cooling water flow has been established to both sampling coolers.

III. Precuations

1. Before entering the sampling room, check radiation level inside room (see Section 507, RADIOLOGICAL HEALTH AND SAFETY).

2. All personnel entering the room should wear "Special Work Procedure" clothing and adequate respiratory protection (see Section 507, RADIOLOGICAL HEALTH AND SAFETY). In addition, face shield should be worn throughout all sampling operations.

3. During all sampling operations, the sampling header must at all times have an open access to the drain line leading to the primary drain collecting tank.

4. All sample receivers should be properly labeled as to source of sample it contains and the time when it was taken.

5. Sample recievers should be immediately capped or stoppered after the sample has been collected.

6. Avoid spillage of bleed or sample fluid onto floors, clothing, etc., during sampling operation. In the event of such an accident during sampling of a radioactive source, further sampling operations should be suspended until the affected area is decontaminated.

7. All personnel who are involved in sampling primary plant fluids must be thoroughly familiar with Section 507 and must abide by the principles and procedures regarding established radiation standards and the handling of radioactive fluids as detailed in this section.

IV. <u>Instructions</u>

1. Check that the auxiliary sample lines are isolated from the sample header.

2. Check that all valves in the main coolant sampling line between the hand control valve and the main coolant drain header are open.

3. Check that the drain line from the sampling header in the room to the primary drain collecting tank is open.

4. Check that the line from the sampling header to the drain line via the low pressure sample cooler is open.

   NOTE: During any sampling operation of the main coolant system or pressurizer, the drain line to the primary drain collecting tank must be open to the sampling header, either directly or by way of the low pressure sample cooler. This is consistent with Step No. 3, Section III above.

5. Slowly open the hand control valve on the main coolant sample line.

6. Open the appropriate motor operated drain valve(s) from the main loop(s) to be sampled or the motor operated valve on the pressurizer drain line. This step established a bleed flow to the sample header.

7. Check temperature of bleed fluid at the sampling header. It should be around 200 F. If not, adjust high pressure sample cooler cooling water flow.

8. Check pressure on sample header. If pressure is above 30 psi gage, throttle down hand control (Step No. 5) until pressure reduces to approximately 15 psi gage.

9. Close valve on drain line between sampling header and the primary drain collecting tank. This assures an adequate sample flow through the low pressure cooler.

   NOTE: If pressure at sample header rises above 30 psi gage when this step is completed, throttle back the hand control valve (Step No. 5) until a pressure of 15 psi gage is obtained.

10. Open the sample sink drain valve.

11. After bleeding the sampling line for about 2 min, slowly open sampling tap line to establish flow to the sample sink.

CAUTION: Avoid splashing of fluid out of sink basin.

12. After bleed flow to sink has been allowed for about 30 sec, close sampling tap valve, place receiver under tap and carefully open valve withdrawing adequate fluid for analysis, then reclose valve. Stopper sample receiver.

13. Immediately close the hand control valve in the sample line from the main loops.

14. Close the drain valve(s) from the main loop(s) or the pressurizer.

NOTE: All valves in the main coolant sample line between the hand control valve and the main coolant drain header may be left open upon termination of sampling.

15. Open valve in drain line between sampling header and primary drain tank.

16. Flush sink; clean up any spilled fluids. All fluid collected other than the sample(s) must be washed down the sink drain.

NOTE: Refer to Section 507 for proper decontamination procedures.

17. Close the sample sink drain valve.

18. Shut off cooling water supply to both sample coolers. Refer to O.I. No. 504I, COMPONENT COOLING SYSTEM.

V. Final Conditions

The required samples have been taken and the system has been isolated from the main coolant loops and the pressurizer.

OPERATING INSTRUCTION NO. 504K2

PRIMARY PLANT SAMPLING SYSTEM
AUXILIARY SYSTEMS

I. Objective To provide a safe means of sampling:

Primary coolant from the low pressure primary plant auxiliary systems.
Primary plant component cooling water.
Chemical additive solutions for the primary coolant.
Decontamination solutions.
Fuel transfer pit water.

II. Conditions

A. For the Purification System

(Refer to O.I. No. 504H, PURIFICATION SYSTEM)

1. Proper ventilation of the sampling room has been established.

2. Cooling water has been established to the low pressure sampling coolers. Refer to O.I. No. 504I, COMPONENT COOLING SYSTEM.

3. Capacity is available in the primary drain collecting tank for receiving bleed fluid.

B. For the Chemical Shutdown System

1. During Boric Acid Preparation

(Refer to O.I. No. 504G1, CHEMICAL SHUTDOWN SYSTEM - BORIC ACID PREPARATION)

a. The boric acid solution transfer pump is in operation.

2. During Boric Acid Addition

a. The chemical shutdown system is not sampled during boric acid addition to the main coolant system.

3. During Boric Acid Removal

(Refer to O.I. No. 504G3, CHEMICAL SHUTDOWN SYSTEM - BORIC ACID REMOVAL)

a. Startup feed and bleed for boric acid removal by dilution of the primary coolant has terminated.

NOTE: Sampling here is to determine the boron removal by ion exchange. To determine boron concentration during startup while feed and bleed is in progress, see sampling instructions for the charging and volume control system.

b. The chemical shutdown ion exchangers have been put into operation.

c. All conditions for the purification system outlined under Section II-A must be satisfied to sample this system during boric acid removal.

C. For the Charging and Volume Control System

(Refer to O.I. No. 504F, CHARGING AND VOLUME CONTROL SYSTEM)

1. During Startup

a. No sampling of this system during filling and venting.

2. During Normal Operation

a. All conditions for the purification system outlined under Section II-A must be satisfied to sample the charging and volume control system during normal operation. When sampling for dissolved gas, bleed fluid temperature at sample header should not exceed 200 F.

3. During Shutdown

a. No sampling of this system during shutdown.

D. For the Shutdown Cooling System

(Refer to O.I. No. 504M, SHUTDOWN COOLING SYSTEM)

1. The reactor has been shut down and the shutdown cooling system is in operation with the temperature of the primary coolant below 200 F.

2. All conditions for the purification system outlined under Section II-A must be satisfied to sample the shutdown cooling system.

E. For the Component Cooling System

(Refer to O.I. No. 504I, COMPONENT COOLING SYSTEM)

1. To sample the neutron shield tank, the neutron shield surge tank should be full to assure adequate sampling flow.

F. For the Waste Disposal System

(Refer to O.I. No. 504L1, RADIOACTIVE WASTE DISPOSAL SYSTEM - LIQUID WASTE DISPOSAL, O.I. No. 504L2, RADIOACTIVE WASTE DISPOSAL SYSTEM - GASEOUS WASTE DISPOSAL, and O.I. No. 504L3, RADIOACTIVE WASTE DISPOSAL SYSTEM - SOLID WASTE DISPOSAL)

1. No general conditions specified; see instructions for waste disposal system under Section V-F for any particular conditions.

G. For the Safety Injection System

(Refer to E.I. No. 505B10, SAFETY INJECTION SYSTEM OPERATION)

1. Boric acid solution is not being charged to the primary loop(s) or to the shield tank.

H. For the Corrosion Control System (If adjusted pH is employed)

1. The lithium hydroxide tank has been stirred prior to sampling.

I. For the Decontamination System

1. Either solution in the mixing tank must be stirred prior to sampling.

J. For the Fuel Transfer Pit

1. An approved receiver must be available for the sample bottle, which may have surface contamination.

III. Precautions

1. In sampling any auxiliary system from a location other than the sampling room (i.e. localized sampling), an adequate size container for receiving the bleed fluid is required. If the fluid being sampled is radioactive, the container must be of a designated type for use in transporting or containing radioactive fluids.

2. Before entering the sampling room, check radiation level inside the room. Also check radiation level at local sampling taps where radioactive fluid is to be sampled. Refer to Section 507, RADIOLOGICAL HEALTH AND SAFETY.

3. All personnel involved with sampling radioactive fluid should wear "Special Work Procedure" clothing and adequate respiratory protection (see Section 507). In addition, face shields should be worn throughout all sampling operations.

4. During all operations within the sampling room, the sampling header must have an open access to the primary drain collecting tank.

5. All sample receivers should be properly labeled as to source of sample it contains and the time when it was taken.

6. Sample receivers should be immediately capped or stoppered after the sample has been collected.

7. Avoid spillage of bleed or sample fluid onto floors, clothing, etc., during sampling operation. In the event of such an accident during sampling of a radioactive fluid, further sampling operations should be suspended until the affected area is decontaminated.

8. All personnel involved in sampling primary plant fluids must be thoroughly familiar with Section 507 and must abide by the principles and procedures regarding established radiation standards and the handling of radioactive fluids as detailed in this section.

IV. Check-off List

Prior to the initiation of this O.I., the check-off list must be completed by the operator(s) and signed off.

V. Instructions

General

Many of the sampling operations for the primary plant auxiliary systems are performed in the sampling room; therefore, many of the steps necessary to obtain a sample from the auxiliary systems are common to each system. To avoid confusion and unnecessary repetition, the steps outlined below apply to all sampling operations of the auxiliary systems that take place in the sampling room. Prior to actually establishing sample flow from an auxiliary system to the sample room:

1. Check that the line from the sample header through the low pressure sample cooler to the primary drain collecting tank drain line is open.

2. Check that the sample sink drain line is open.

3. Check that the valve is open that connects the sample header to the primary drain collecting tank drain line.

4. Check that all sampling valves at the sample sink are closed.

5. Isolate the hydrogen sampling line from the sampling header.

At the termination of sampling, or when the sample flow from an auxiliary system to the sample room has been shut off, the following instructions apply in common:

1. Flush the sample sink; clean up any spilled fluids. Refer to Section 507, RADIOLOGICAL HEALTH AND SAFETY, for proper decontamination procedures, etc.

2. Shut off cooling water supply to the low pressure sample cooler. Refer to O.I. No. 504i, COMPONENT COOLING SYSTEM.

A. <u>For the Purification System</u>

   1. Refer to the general instructions above for preparing sampling room prior to sampling.

   2. To sample main coolant before it has passed through ion exchangers:

      a. Check that the isolation valve is open on the sample line from the ion exchanger inlet line.

      b. Open the appropriate hand control valves and establish bleed flow through sample cooler and sample header to the primary drain collecting tank.

      c. Close the valve between the sample header and the drain line to the primary drain collecting tank after bleed flow has been established for 30 sec.

      d. Continue the bleed flow through the low pressure sample cooler for 2 min.

      e. Establish bleed flow from the low pressure sample cooler to the sample sink by opening the appropriate sampling valve. Bleed the sample line of dead fluid, then close sampling valve.

      f. Observe the sample fluid temperature from the low pressure cooler. It should not exceed 100 F.

      g. Place the sample receiver under the sampling valve; open this valve and withdraw adequate fluid for analysis; then close valve.

      h. Immediately close the hand control valve on the sample line to stop flow through the low pressure sample cooler.

      i. Stopper the sample container and remove to a safe location.

      j. Open valve between sample header and primary drain collecting tank drain line.

3. To sample main coolant after it has passed through ion exchangers:

   a. Check that the isolation valve is open on the sample line from the ion exchanger effluent line.

   b. Follow Steps Nos. 2b through 2j under Section V-A.

4. Refer to the general instructions outlined under Section V for clean-up of sampling cubicle.

B. For the Chemical Shutdown System

NOTE: As specified in Section II-B, the chemical shutdown system is not sampled during boric acid addition to the primary coolant.

1. During Boric Acid Preparation

   a. Place receiver for the collection of bleed fluid under the sample valve located on the discharge line of the boric acid solution transfer pump.

   b. Carefully open sampling valve and clear the line of dead fluid.

   c. Close sampling valve to stop bleed flow.

   d. Place sample receiver under sampling valve; open valve and withdraw adequate fluid for analysis; then close valve.

   e. Stopper the sample receiver.

2. During Boric Acid Removal

   NOTE: The instructions below permit an operator to obtain fluid samples of the primary coolant while boric acid is being removed by ion exchanger in the chemical shutdown ion exchangers. For determining the boric acid content of the main coolant during feed and bleed, refer to sampling instructions for the charging and volume control system during normal operation under Section V-C.

   a. Refer to instructions for sampling the purification system during normal operation as outlined under Section V-A.

C. For the Charging and Volume Control System

NOTE: As specified in Section II-C, the charging and volume control system is sampled only during its normal operation.

1. Refer to the general instructions under Section V for preparing sampling room prior to sampling.

2. Check that the isolation valve on the sample line from the main coolant low pressure bleed line is open.

3. Follow procedure for liquid sampling as outlined in Steps Nos. 2b and 2j, Section V-A.

4. To sample the low pressure bleed line for dissolved gases:

   a. Check that the hand control valves in all sample lines to the sample header are closed.

   b. Close the drain line from the sampling header to the primary drain collecting tank and close the drain line from the low pressure sample cooler to the primary drain collecting tank.

   c. Check that hydrogen sampling bomb is secured correctly in place in the hydrogen sample line.

   d. Check that the low pressure sample cooler cooling water supply is on.

   e. Close sample sink drain valve.

   f. Open all valves on the hydrogen sampling line including the needle valves on the bomb.

   g. Open the hand control valve on the main coolant low pressure bleed sample line.

   h. Check pressure on the sample header. It should not read above 30 psi gage.

   i. Check temperature of the bleed fluid at sample header. It should not go above 200 F.

   NOTE: Refer to O.I. No. 504F, CHARGING AND VOLUME CONTROL SYSTEM, to accomplish lower main coolant feed water temperature.

   j. Throttle (reduce) flow through the hydrogen sample line by slowly closing the valve on the outlet side sample bomb drain line to the primary drain collecting tank. Observe pressure increase in sample header and hydrogen sample line as flow is reduced.

k. When pressure has been established in the sample bomb as outlined in Step No. 4j, close the downstream needle valve on the sample bomb.

l. Close the upstream valve on the sample bomb.

m. Set the drain valves (Steps Nos. 4b and 4e) to full open position.

n. Close the hand control valve on the main coolant low pressure bleed line.

o. Open the valve between the sample bomb and the drain line to the primary drain collecting tank.

p. Open the valve between the low pressure sample cooler and the sample sink.

q. Carefully loosen the unions on the hydrogen sample bomb, and remove bomb from the sample line.

NOTE: A small receiver should be placed under the disconnect points as they are loosened and the sample bomb is removed.

r. Flush the ends of the sample bomb with water at the sample sink. Flush out with water any fluid trapped in receivers placed under bomb disconnects in Step No. 4q.

5. Refer to the general instructions outlined in Section V for clean up of the sampling room.

D. For the Shutdown Cooling System

1. Refer to the general instructions under Section V for preparing sampling room prior to sampling this system.

2. Check that the isolation valve on the sample line from the shutdown cooling system is open. This sample line comes from the shutdown cooling line between the outlet of the shutdown cooling heat exchanger and the main coolant system.

3. Refer to and follow Steps Nos. 2b through 2j as outlined in the instructions for sampling and purification system under Section V-A.

E. For the Component Cooling System

1. Component Cooling Heat Exchangers

   a. Place container under drain and sample valve on the heat exchanger to receive bleed fluid.

   b. Carefully open the sample valve and bleed fluid for several seconds, until the drain line has been flushed.

   c. Close the sample valve; place the sample receiver under valve.

   d. Open the sample valve and withdraw adequate fluid for analysis. Close the sample valve.

   e. Stopper the sample receiver.

2. Neutron Shield Tank

   a. Check that the sample sink drain valve is open.

   b. Check that trip valve in neutron shield tank sample line is open.

   c. To sample the fluid in the top portion of the neutron shield tank, check that the sample line extension to the top of the neutron shield tank is open and close the sample line extension to the bottom of the shield tank.

   d. To sample the fluid at the bottom portion of the neutron shield tank, check that the sample line extension to the bottom of the shield tank is open, and close sample line extension to the top of the shield tank.

   e. Check the temperature of the fluid in the neutron shield tank. Do not sample if the temperature is above 150 F.

   f. Open sampling valve at the sample sink and bleed line for 2 min.

   g. Close the sampling valve; place the sample receiver under the valve and withdraw enough neutron shield tank fluid for analyzing; then close sample valve.

   h. Stopper the sample receiver.

   i. Flush the sample sink; clean up any spilled fluids. Refer to Section 507, RADIOLOGICAL HEALTH AND SAFETY for proper decontamination procedures, etc.

F. For the Waste Disposal System

NOTE: Before sampling any of the components in this system, check radiation level around the sampling location and accordingly abide by established principles and procedures as detailed in Section 507.

1. Primary Drain Collecting Tank

a. Isolate the pumps on the primary drain collecting tank from the transfer line between the drain collecting tank and the waste holdup tank by closing the appropriate stop valves.

b. Establish a flow path between one of the primary drain collecting tank pumps and the sample connection line.

c. Check that the valve is open in the return line from the sample connection line to the drain collecting tank.

d. Start the appropriate pump, establishing a flow from the drain collecting tank up to the sample connection valve and back via the return line to the drain collecting tank. This operation constitutes a bleed flow.

e. After bleed flow has been established to clear the line of dead fluid, place the sample receiver on the sample connection, open sampling valve, and withdraw adequate fluid for analysis; then close the sampling valve.

f. Stopper the sample receiver.

g. Stop the transfer pump; isolate the pump discharge line from the sample connection line.

h. Establish a flow path from the discharge of transfer pumps to the transfer line between waste holdup tank and the primary drain collecting tank.

2. Gravity Drain Tank

a. Isolate the gravity tank transfer pumps discharge from the gas stripper.

b. Establish the flow path from one of the gravity tank transfer pumps to the sampling connection valve.

c. Check that the line from sampling connection line back to the gravity drain tank is open.

d. Start the appropriate transfer pump, establishing a bleed flow to the sample connection.

e. Place the receiver on the sample connection; open the sampling valve and withdraw fluid for analysis.

f. Close the sampling valve and remove the sampling receiver from the sample connection.

g. Stopper the sample receiver.

h. Stop transfer pump; establish the flow path from both transfer pumps to the gas stripper.

3. Waste Holdup Tank

a. Isolate the waste holdup tank from the primary drain collecting tank, by closing the valve on the transfer line between these tanks.

b. Check that the activity dilution decay tank is isolated from the waste liquid transfer pumps.

c. To prevent liquid from being discharged to either the monitored waste tanks or to the orifice mixer, isolate the appropriate transfer lines to these locations from the waste liquid transfer pump(s) discharge.

d. Close the valve on the suction line of one waste liquid transfer pump.

e. Establish the flow path from the waste holdup tank to the suction of the other waste liquid transfer pump.

f. Establish the flow path from the discharge of the waste liquid transfer pump back to the waste holdup tank.

g. Check that the valve on the line between the activity dilution decay tank and the discharge line of the waste liquid transfer pump is closed.

h. Start the waste liquid transfer pump. This establishes a bleed flow of fluid from the waste holdup tank through the waste liquid transfer pumps, past the sample connection.

i. After establishing bleed flow for enough time to clear dead fluid, place a sample receiver under the sample connection; carefully open the sampling valve and withdraw sufficient fluid for analysis; then close the sampling valve.

j. Stopper the sample receiver and stop the pump.

k. Return all lines to and from the waste holdup tank, the activity dilution decay tank and the waste liquid transfer pumps to their original position. Refer to Steps Nos. a through g above.

4. Activity Dilution Decay Tank

a. Check that the drain line of the waste holdup tank is isolated from the waste liquid transfer pump(s) suction line.

b. Check that the waste holdup tank is isolated from the discharge line of the waste liquid transfer pumps.

c. Close the valves located on the suction and discharge line of one waste liquid transfer pump.

d. Isolate the lines that lead from the discharge of the waste liquid transfer pumps to the orifice mixer and test tank effluent pump discharge.

e. Establish the flow path from the drain of the activity dilution decay tank to the suction of the other waste liquid transfer pump.

f. Establish the flow path from discharge of this pump back to the activity dilution decay tank.

g. Start the waste liquid transfer pump, establishing a bleed flow past sample connection located on the line between the discharge of waste liquid transfer pumps and the activity dilution decay tank.

h. Continue bleed for enough time to clear dead fluid; then place the sample receiver under the sampling connection; open the sampling valve and withdraw sufficient fluid for analysis. Close the sampling valve.

i. Stopper the sample receiver and stop the transfer pump.

j. Return all lines to and from the activity dilution decay tank and the waste liquid transfer pumps to their original position. Refer to Steps Nos. a through f above.

5. Evaporator Feed

a. To sample feed going to the evaporator, place the sample receiver under the sample connection on the discharge line from the stripper bottoms pump to the evaporator feed inlet.

b. Carefully open the sampling valve and withdraw fluid for analysis; then close the valve.

c. Stopper the sample receiver.

6. Test Tanks

a. Fluid to test tanks.

(1) To sample fluid going to the test tanks from the stripper feed-distillate exchanger, place the sample receiver under the sample connection on the line between the test tank and the stripper feed-distillate exchanger.

(2) Open the sampling valve and carefully withdraw adequate fluid for analysis; then close the valve.

(3) Stopper the sample receiver.

b. Fluid in test tanks.

(1) To sample fluid in the test tank(s), isolate the tank from the stripper feed-distillate exchanger by closing the valve in the overhead condenser inlet line.

(2) Place the bleed receiver under the drain valve on the test tank to be sampled.

(3) Open the drain valve and carefully bleed the tank for enough time to clear dead fluid; then close the valve and remove receiver.

(4) Place the sample receiver under the drain valve; open the valve and withdraw adequate fluid for analysis; then close the valve.

(5) Stopper the sample receiver.

(6) Place the tank on line by opening the valve closed in Step No. 6b (1) above.

7. Monitored Waste Tanks

a. Start the tank agitator(s).

b. Place bleed fluid receiver(s) under the sample connection(s) on tank(s).

c. Open the sample valve and bleed the tank(s) to clear dead fluid in the sample line; then close the valve.

d. Remove the bleed fluid receiver(s) from the sample connection, and place the sample receiver under the sample connection.

e. Open the sample valve and withdraw enough fluid for analysis; then close the sample valve.

f. Remove the sample receiver from the sample connection and stopper the receiver.

g. Stop the tank agitator(s).

8. Gas Decay Drums

a. Connect an evacuated gas sample receiver to the gas decay drum sample connection.

b. Open the sample line valve. If no gas leakage occurs, open the inlet valve on the gas sample receiver.

c. Close both sample valves; remove the gas sample container.

9. Roto-Clone Exhaust Filter

a. To sample gases either before or after they pass through the Roto-Clone exhaust filter, connect an evacuated gas sample receiver to the sample connection at either the Roto-Clone inlet or outlet.

b. Open the sampling valves; collect gas in the receiver; then close the sampling valves.

c. Remove the gas sample receiver from the sampling connection.

G. For the Safety Injection System

1. Open the line between the safety injection and shield tank cavity water tank and the safety injection line.

2. Unlock the sample valve.

3. Place a receiver under the sample valve to collect bleed fluid.

4. Open the sampling valve, and bleed the line to clear dead fluid; then close the valve.

5. Place the sample receiver under the valve; open the valve and withdraw enough fluid for analysis; then close the valve. Stopper the receiver.

6. Lock the sampling valve.

7. Close the valve on the line between the safety injection and shield tank cavity water tank and the safety injection line.

H. For the Corrosion Control System (If adjusted pH is employed)

1. Lithium hydroxide feed tank.

a. Sample directly from the tank by putting a sample receiver into the solution. Stopper the receiver.

I. For the Decontamination System

1. Caustic-permanganate or ammonium citrate solutions.

a. Sample directly from the tank for either solution by putting a sample receiver into the solution. Stopper the receiver.

CAUTION: Use extreme care in handling the caustic-permanganate solution.

J. For the Fuel Transfer Pit

1. Sample directly from the pit by putting a sample receiver into the pit water. Stopper the receiver.

2. Place the sample receiver into an approved (polyethylene-type) bag to avoid transfer of surface contamination.

VI. Final Conditions

The required sample(s) have been taken from the auxiliary system(s).

OPERATING INSTRUCTION NO. 504L1

RADIOACTIVE WASTE DISPOSAL SYSTEM
LIQUID WASTE DISPOSAL

I. Objective Class 1 liquids, those which are radioactive and contain hydrogen and fission product gases, and Class 2 liquids, those which are radioactive and contain dissolved air with low volatile activity, are processed to remove radioactivity, boron, and other impurities.

The following operations are described herein:

Part 1 - Class 1 Liquids

A. Liquid transfer from low pressure surge tank during normal plant operation.

B. Liquid transfer from low pressure surge tank during the activity dilution operation.

C. Liquid transfer from low pressure surge tank during boric acid removal.

D. Lineup of primary drain collecting tank without ion exchange.

E. Lineup of primary drain collecting tank with ion exchange.

F. Direct liquid transfer from holdup tanks to primary water storage tank.

G. Startup of gas stripper and evaporator on nonradioactive water.

H. Normal processing of Class 1 liquids.

I. Shutdown of gas stripper and evaporator and cooling of evaporator bottoms.

J. 1. Recycle of liquid from test tank to waste holdup tank when evaporator is in operation.

2. Recycle of liquid from test tank to holdup tanks when evaporator is not in operation.

3. Transfer of liquid from test tank to primary water storage tank.

K. Evaporator bottoms removal and drumming.

Part 2 - Class 2 Liquids

A. Filling and emptying Primary Building sump tank.

B. 1. Emptying of monitored waste tank to river after dilution of liquid.

2. Transfer of monitored waste tank liquid to the gravity drain tank.

C. Normal processing of Class 2 liquids.

II. Conditions

A. Processing by Purification System

Refer to O.I. No. 504H, PURIFICATION SYSTEM.

B. Class 1 Liquids

1. Waste holdup tank and activity dilution decay tank must be empty at suitable times to receive the proper liquid.

2. 55-gal closed top sheet steel drums and cement must be available for evaporator bottoms disposal.

3. Evaporator is in operation before liquid leaves the waste holdup or activity dilution decay tank.

4. Steam supply is required to waste holdup and activity dilution decay tanks when the temperature of the liquid in the tanks falls below 40 F.

5. One test tank is empty.

6. A plant water balance should be maintained to assure capacity in the primary water storage tank to receive treated Class 1 liquid effluent.

C. Class 2 Liquids

1. Capacity must be available in a monitored waste tank to receive liquid from the Primary Building sump tank.

2. 55-gal closed top sheet steel drums and cement must be available for evaporator bottoms disposal.

3. Evaporator is in operation before liquid leaves the gravity drain tank.

4. A plant water balance should be maintained to assure capacity in the primary water storage tank to receive processed gravity drain tank liquid.

D. Pertinent auxiliary systems are in the following status:

System	Status
Component Cooling System (Refer to O.I. No. 504I)	Cooling water available for heat exchangers
Primary Plant Sampling System (Refer to O.I. No. 504K2)	Normal operation

III. Precautions

1. Do not process any liquid without taking a sample to check for radioactivity. Refer to Section 507, RADIOLOGICAL HEALTH AND SAFETY.

2. Any person entering the waste disposal area must wear adequate special work procedure (SWP) clothing. Refer to Section 507, RADIOLOGICAL HEALTH AND SAFETY.

3. The system must be properly purged and gas blanketed. Care must be exercised to prevent mixing Class 1 and Class 2 liquids either during discharge of these liquids into the waste disposal system or during processing of these in equipment ahead of the evaporator.

4. Care must be taken to line up the gas discharged from the gas stripper to the proper gas header while processing Class 1 or Class 2 liquids.

5. All water must be drained from the evaporator jacket and the vent on the jacket open before the power supply is switched on to the evaporator electrodes.

6. For processing by purification system, refer to O.I. No. 504H, PURIFICATION SYSTEM, Section III - Precautions.

IV. Check-off List

Prior to startup of this O.I., the pre-operational check-off list must be completed and signed.

V. Instructions

Part 1 - Class 1 Liquids

The normal operation of the waste holdup tank, activity dilution decay tank, gas stripper and auxiliaries, evaporator and auxiliaries, test tanks, and primary water storage tank is as follows:

A. Liquid Transfer from Low Pressure Surge Tank During Normal Plant Operation

NOTE: This transfer occurs automatically by actuation of the low pressure surge tank level controller on high level. Liquid discharged to waste disposal by-passes the purification ion exchangers.

1. Line up from the discharge of the purification, cooling and drain pumps through the low pressure surge tank cooler to the waste holdup tank.

2. When the liquid in the low pressure surge tank reaches a high level, the level controller on this tank opens the level control valve in the discharge line to waste disposal.

3. When the low pressure surge tank is at normal operating level, the level controller closes the valve in the discharge line to waste disposal.

4. Steps Nos. 2 and 3 repeat automatically to remove excess liquid from the low pressure surge tank during normal operation.

B. Liquid Transfer from Low Pressure Surge Tank During the Activity Dilution Operation

NOTE: This transfer occurs only after the reactor is subcritical but with the main coolant at 500 F and 2,000 psi gage. Activity dilution liquid discharged to waste disposal is processed at a maximum rate of 100 gpm through both purification ion exchangers.

1. Line up from the discharge of the purification, cooling and drain pumps through the low pressure surge tank cooler and the two purification ion exchangers in parallel to the activity dilution decay tank.

2. Check that the normal purification return line to the charging pump suction header and the return spray line to the low pressure surge tank are closed and the by-pass line around the purification flow control valve is open.

3. When the liquid in the low pressure surge tank reaches a high level due to high bleed flow from the bleed and feed heat exchanger, the level controller on this tank opens the level control valve in the discharge line to waste disposal. This control valve will remain open for the duration of the activity dilution operation.

4. Take a sample of the activity dilution liquid from the main coolant low pressure bleed line (refer to O.I. No. 504K2, PRIMARY PLANT SAMPLING SYSTEM - AUXILIARY SYSTEMS) every 30 min and determine the activity of the sample.

5. Continue activity dilution until the gross volatile and nonvolatile activity of the sample decreases to 0.4 μc/ml when dilution only is used to reduce the main coolant activity or to 0.5 μc/ml when a 100 gpm purification rate is used for one week before reactor shutdown followed by dilution.

6. When the activity dilution operation is completed and the charging pumps shutdown, the low pressure surge tank liquid drops to normal and the level controller closes the valve in the discharge line to waste disposal.

C. Liquid Transfer from Low Pressure Surge Tank During Boric Acid Removal

NOTE: This transfer occurs during reactor startup. Liquid discharged to waste disposal by-passes the purification ion exchangers.

1. Line up from the discharge of the purification, cooling and drain pumps through the low pressure surge tank cooler to the waste holdup tank.

2. Excess liquid in low pressure surge tank is removed by operation of the level controller on this tank which opens the level control valve in the discharge line to waste disposal (refer to O.I. No. 504G3, CHEMICAL SHUTDOWN SYSTEM - BORIC ACID REMOVAL, and O.I. No. 504F, CHARGING AND VOLUME CONTROL SYSTEM).

3. When boric acid removal is completed, piping is already lined up for normal operation as given in Part A.

D. Lineup of Primary Drain Collecting Tank Without Ion Exchange

1. Check that all appropriate influent lines are open to the primary drain collecting tank.

2. Line up from discharge of collecting tank transfer pumps to waste holdup tank. (All liquid in the primary drain collecting tank is discharged to waste holdup tank. Only activity dilution is discharged to the activity dilution decay tank.)

3. When the liquid in the primary drain collecting tank reaches a high level, the level indicator controller located on the tank will activate a collecting tank transfer pump.

4. When the primary drain collecting tank is at a minimum low level, the level indicator controller will shut down the collecting tank transfer pump.

5. Liquid in primary drain collecting tank will continue to be transferred batchwise to the waste holdup tank by automatic operation of the level controller as given in Steps Nos. 3 and 4.

E. Lineup of Primary Drain Collecting Tank with Ion Exchange

NOTE: Only one purification ion exchanger should be used to process waste liquid in this tank when the reactor is in operation.

1. If the boron concentration in primary drain collecting tank liquid is below 5 ppm and the temperature of this liquid does not exceed 140 F, a portion of the radioactivity in this liquid may be removed on ion exchange resin by processing through one of the purification ion exchangers.

2. Check that the ion exchanger isolation valves at the purification inlet and outlet headers are closed.

3. Line up from discharge of collecting tank transfer pumps through the one purification ion exchanger to the waste holdup tank.

4. When the liquid in the primary drain collecting tank reaches a high level, the level indicator controller located on the tank will activate a collecting tank transfer pump.

5. When the primary drain collecting tank is at a minimum low level, the level indicator controller will shut down the collecting tank transfer pump.

6. Liquid in primary drain collecting tank will continue to be transferred batchwise to the waste holdup tank by automatic operation of the level controller as given in Steps Nos. 4 and 5.

F. Direct Liquid Transfer from Holdup Tanks to Primary Water Storage Tank

NOTE: This operation is prior to nuclear operation or nuclear plant operation.

1. If the activity level in the waste holdup tank or the activity dilution decay tank is below maximum permissable concentration (MPC) and free of boron and other impurities (see O.I. No. 504K2, PRIMARY PLANT SAMPLING SYSTEM - AUXILIARY SYSTEMS), a direct transfer of liquid may be made to the primary water storage tank.

2. Line up from the tank to be emptied to the discharge of the test tank effluent pump via the waste liquid transfer pumps.

3. Line up from the isolation valve on the test tank effluent pump to the primary water storage tank.

4. Start up the waste liquid transfer pumps.

5. When the holdup tank being drained is at the low level, shut off the waste liquid transfer pumps.

6. Close the lines opened in Steps Nos. 2 and 3.

7. If there is insufficient capacity in the primary water storage tank, the excess liquid can be discharged into the component cooling water exchanger service water discharge line by operating one of the monitored tank transfer pumps.

G. Startup of Gas Stripper and Evaporator on Nonradioactive Water

1. Line up from the orifice mixer via the pH meter to the stripper feed distillate exchanger.

2. Line up from the stripper feed distillate exchanger to the gas stripper.

3. Open gas discharge line from stripper overhead condenser to primary vent stack via the vent gas header.

4. Line up from the bottom of the gas stripper to the evaporator and open level gage and level recorder controller on gas stripper and evaporator.

5. All other lines associated with the gas stripper, evaporator and their auxiliaries should be closed except drain and vent on evaporator jacket and vent on distillate accumulator.

6. Line up from a filled test tank to the orifice mixer via one of the waste liquid transfer pumps and start that pump.

7. Put the flow recorder controller in the gas stripper feed line in service and adjust to control at 5 gpm.

   NOTE: The level recorder controller on the evaporator will override the flow recorder controller in the gas stripper feed line on high liquid level in the evaporator.

8. When the bottom of the gas stripper is about one half full of liquid, put the bottoms liquid level controller in service to maintain the liquid level at the midpoint.

9. Start one of the stripper bottoms pumps.

10. When the electrode tips in the upper two nests of electrodes in the evaporator are one half submerged, as shown by the level gage on this vessel, switch on the power supply to all electrodes.

11. If the liquid in the evaporator is not sufficiently conductive, add a suitable spiking chemical.

    NOTE: Addition of spiking chemical to the evaporator is accomplished by passing service water through the spiking chemical addition drum which dissolves the solid chemical and injects it into the evaporator feed line.

12. Put the evaporator bottoms level recorder controller in service and set to override and close the stripper feed flow control valve when the evaporator liquid level is approximately 4 in. above the top of the electrode tips in the upper electrode nests.

13. When the feed to the stripper drops to less than 0.5 gpm, close stripper feed line upstream of orifice mixer and shut down the waste liquid transfer and stripper bottoms pumps.

14. When pressure in distillate accumulator increases to 10 psi gage, put pressure recorder controller in operation to start and control cooling water flow to evaporator overhead condenser and set controller to maintain this pressure.

15. Open distillate accumulator vent valve at frequent intervals to vent air out of system.

16. Reestablish flow of feed to stripper when evaporator bottoms level drops to top of upper electrode tips by opening feed line and starting waste liquid transfer and stripper bottoms pumps.

17. When distillate accumulator is about one-half full put accumulator level controller in operation and set to hold liquid level at midpoint.

18. Line up from distillate accumulator through distillate pump, through stripper feed distillate exchanger and back to stripper feed line using the distillate by-pass recycle line provided, so that the distillate can be recycled to the stripper under control of both the distillate accumulator level controller and the stripper feed flow controller. Start distillate pump.

19. Establish proper reflux flow to the evaporator by observing reading of flow indicator in reflux line.

20. Start flow of cooling water to stripper overhead condenser.

21. Start flow of steam to stripper from top of evaporator and adjust to proper flow by observing flow recorder in stripper overhead line.

22. Close stripper feed line upstream of orifice mixer and shut down the waste liquid transfer pump.

23. Continue operation of stripper and evaporator with distillate recycle used for stripper feed until all operating conditions and liquid levels are stabilized and all air is vented from the system.

24. If necessary, additional liquid from the test tank is added to the system to increase the evaporator level until the feed rate to the stripper reaches 5 gpm.

NOTE: The stripper and evaporator system can be maintained in operation indefinitely under this condition of complete distillate recycle to the stripper feed line. The feed rate to the stripper can be reduced within the range of 3 to 5 gpm by discharging some of the distillate to a test tank to adjust the level in the evaporator and simultaneously reducing the setting on the stripper feed flow controller.

H. <u>Normal Processing of Contaminated Class 1 Liquids</u>

NOTE: The activity dilution liquid is held in the activity dilution decay tank for a total of 30 days to permit suitable decay.

With the stripper and evaporator system operating under complete distillate recycle, either waste holdup tank or acitivity dilution decay tank liquid can be processed in this equipment.

1. Shut off the cooling water flow to the stripper overhead condenser and allow gradual increase in temperature of gas leaving this condenser as shown by temperature indicator in gas discharge line.

2. When stripper overhead condenser gas discharge temperature reaches 212 F, indicating that steam has purged all air from condenser, close line to vent gas header and open line to waste gas header.

3. Reestablish flow of cooling water to stripper overhead condenser.

4. Open the caustic solution charging line. Put pH recorder controller in service and set t control at about 8. Start caustic pump.

NOTE: The pH recorder controller will automatically control the addition of dilute caustic to maintain the preset pH.

5. Line up from either holdup tank to one waste liquid transfer pump and from this pump back to the same tank and start that pump to establish pump flow.

6. Close waste liquid transfer pump discharge line back to holdup tank, close the by-pass recycle line between stripper feed-distillate exchanger distillate outlet and stripper feed line, and immediately open waste liquid pump discharge line to stripper feed line.

7. Line up from stripper feed distillate exchanger distillate outlet to one of the test tanks and open this line.

NOTE: System is now in operation processing radioactive water. Recheck all liquid levels, temperatures, pressures, and flows and readjust controllers and manual valves until design conditions are obtained.

Operation of the stripper and evaporator under complete distillate recycle can be established when only a partial batch has been reprocessed and the system maintained hot for any desired interval. Net flow can be reestablished quickly from this condition.

8. Processing of radioactive waste liquids is contineud until the evaporator bottom activity of solids contents reaches a predetermined level.

I. Shutdown of Gas Stripper and Evaporator and Cooling of Evaporator Bottoms

1. Close line between holdup tank and waste liquid transfer pump.

2. Open line from operating test tank to the operating waste liquid transfer pump. Continue feeding water from test tank until all the radioactive water in the waste liquid transfer pump, stripper feed-distillate exchanger and pipelines has been flushed into the stripper.

3. Close caustic solution line and stop the caustic pump.

4. Close stripper feed line upstream of orifice mixer, shut down waste liquid transfer pump and close line from test tank to suction of this pump.

5. Close line from stripper feed-distillate exchanger distillate outlet to test tank and immediately open by-pass recycle line from this exchanger to the stripper feed line.

NOTE: System is again in operation under complete distillate recycle and prepared for final shutdown.

6. Shut off the cooling water flow to the stripper overhead condenser allowing gas discharge temperature to increase.

7. When exit gas temperature from this condenser reaches 212 F, indicating that all radioactive gases have been purged out of the condenser with steam, close line to waste gas header and open line to vent gas header.

8. Reestablish flow of cooling water to stripper overhead condenser.

   NOTE: System is now vented to the atmosphere via the primary vent stack and radioactive gases and hydrogen can not be drawn back into the equipment as it cools down.

9. Close by-pass recycle line from stripper feed-distillate exchanger distillate outlet to stripper feed line and open line from this exchanger to test tank which was in use during this evaporator batch.

10. Shut off steam flow to stripper.

11. Continue operation of stripper bottoms pump until level gage on stripper bottoms indicates all liquid has been pumped from this vessel.

12. Close line between stripper bottoms pump and evaporator and shut down this pump.

13. Take pressure recorder controller on distillate accumulator out of service and manually adjust by-pass valve in cooling water outlet line from evaporator overhead condenser so that evaporator pressure gradually decreases.

14. Switch power off of one or more nests of evaporator electrodes in order to maintain normal operating evaporator bottom level while pressure is dropping.

15. When evaporator pressure decreases to atmospheric and evaporator bottoms temperature is about 212 F, recheck evaporator bottoms level and adjust to normal.

16. Close evaporator reflux line.

17. Switch off power supply to all evaporator electrodes.

18. Continue operation of distillate pump until gage on distillate accumulator indicates all liquid has been pumped from this vessel.

19. Close line from distillate pump to test tank and stop this pump.

20. Open distillate accumulator vent.

21. Close evaporator jacket drain and open cooling water supply to jacket and slowly fill with water until all air is exhausted from jacket vent, after which close vent.

22. Open cooling water return from evaporator jacket and continue cooling evaporator bottoms until temperature is reduced to 140 F.

23. Close evaporator jacket cooling water supply and return lines.

24. Open evaporator jacket vent and drain allowing cooling water in jacket to drain out.

J. Emptying Test Tanks

1. If either test tank is filled during processing, as seen on the level indicator, line up to the other test tank.

2. Close the line to the filled test tank.

3. Sample the filled test tank (see O.I. No. 504K2, PRIMARY PLANT SAMPLING SYSTEM - AUXILIARY SYSTEMS). If the activity is above 1×10^{-7} μc/cc and/or the liquid contains boron and other impurities, the following steps are required:

   a. If the evaporator is in operation the following procedure is to be performed:

      (1) Line up from the filled test tank to the test tank effluent pump.

      (2) Line up from the test tank effluent pump to the waste holdup tank.

      (3) Start up test tank effluent pump.

      (4) When the test tank is empty, as indicated by the level indicator on the vessel, shut off the test tank effluent pump and close the lines opened in Steps Nos. 1 and 2.

   b. If the evaporator is not in operation perform the following steps:

      (1) Line up from the filled test tank to the waste liquid transfer pump.

      (2) Line up from the waste liquid transfer pump to either the waste holdup tank or the activity dilution decay tank depending on which one has the lower liquid level.

(3) Startup a waste liquid transfer pump.

(4) When the test tank is empty, as indicated by the level indicator on the vessel, shut off the waste liquid transfer pump and close the lines opened in Steps Nos. 1 and 2.

4. If the sample taken in Step No. 3 has an activity below the limits referred in Section 507, RADIOLOGICAL HEALTH AND SAFETY and is free of boron and other impurities, the following steps are required:

a. Line up from the filled test tank to the primary water storage tank via the test tank effluent pump.

b. Startup the test tank effluent pump.

c. When the test tank is empty, as seen by its level indicator, stop the test tank effluent pump and close the lines opened in Step No. 1.

d. At infrequent intervals the primary water storage tank will not have sufficient capacity to contain the water from the test tank. Since water in the test tank is at an activity below the tolerance concentration, a discharge line is provided with a flow recording controller to permit discharge of this excess water to the river via the component cooling water exchanger service water discharge line.

K. <u>Evaporator Removal and Drumming</u>

1. Line up from evaporator to drum fill line at drumming station via stripper bottoms pump.

2. Tare empty closed top drum and pallet on scale.

3. Feed approximately 27 gal of evaporator bottoms, about 230 lb by weight, and 400 lb of cement into drum.

4. Use mechanical lift truck to transfer loaded drum and pallet from scales and monorail hoist to lift drum off pallet and place it in horizontal position on drum roller.

5. Roll drum about 30 min on drum roller.

6. Remove drum from drum roller and place it in a vertical position on floor in front of door through which drums are removed from building.

7. Allow mixture in drum to solidify and decant any excess liquid by means of a portable aspirator into an empty drum standing down in the pit on a pallet.

8. Securely tighten all bungs in preparation for transfer of drum to outside storage area as described in O.I. No. 504L3, RADIOACTIVE WASTE DISPOSAL SYSTEM - SOLID WASTE DISPOSAL.

9. Repeat Steps Nos. 2 through 7 until all evaporator bottoms have been transferred into drums and mixed with cement. This requires approximately 11 drums.

10. Use service water to flush radioactive liquid out of evaporator bottoms discharge line and stripper bottoms pump into last drum.

Part 2 - Class 2 Liquids

The normal operation of the Primary Building sump tank, monitored waste tanks, and gravity drain tank are as follows:

A. Filling and Emptying Primary Building Sump Tank

1. Check that all appropriate influent lines are open to the Primary Building sump tank and that vent line to primary vent stack is locked open.

2. Line up from the Primary Building sump tank to an empty monitored waste tank.

3. When the liquid in the Primary Building sump tank reaches a high level, the level controller will start a Primary Building sump tank pump.

4. When the Primary Building sump tank liquid is at a minimum low level, the level controller will shut down the Primary Building sump tank pump.

5. a. If activity of liquid in vapor container drain tank, as determined by sampling and testing (see O.I. No. 504K2, PRIMARY PLANT SAMPLING SYSTEM - AUXILIARY SYSTEMS), is greater than 1×10^{-7} $\mu c/ml$, line up from Primary Building sump tank pump through waste liquid strainers to gravity drain tank so that this liquid will be transferred direct to the gravity drain tank.

   b. If activity of vapor container drain tank liquid is less than 1×10^{-7} $\mu c/ml$, transfer to a monitored waste tank in accordance with Steps Nos. 2, 3, and 4.

B. Emptying of Monitored Waste Tanks

1. When the level indicator indicates that a monitored waste tank is full, any liquid being sent to it is diverted to the other monitored tank by opening the inlet line to the empty tank and closing the inlet line to the filled tank.

2. Turn on the agitator in the filled monitored waste tank for 30 min.

3. Just before completion of 30 min period of agitation, take sample of liquid in monitored waste tank and test sample for radioactivity. See O.I.No. 504K2, PRIMARY PLANT SAMPLING SYSTEM - AUXILIARY SYSTEMS.

4. a. If the activity, together with any activity from steam generator blowdown, is below the limits as referred to in Section 209, RADIOACTIVE WASTE DISPOSAL SYSTEM, start the agitator in the filled monitored waste tank, start monitored tank transfer pump, and discharge liquid from this tank through the effluent flow recorder controller to the component cooling water service water discharge line. Continue operation of agitator until monitored waste tank is empty, so that all solids will be discharged with the liquid.

   b. If activity is above 1×10^{-7} μc/ml, line up from monitored waste tank through monitored tank transfer pump and waste liquid strainers to gravity drain tank. Start this pump and transfer liquid to gravity drain tank.

5. When level indicator indicates that monitored waste tank is empty, stop the monitored tank transfer pump.

6. Close the lines opened in Step No. 4.

C. Normal Processing of Class 2 Gravity Drain Tank Liquids

1. Check that the appropriate influent lines are open to the gravity drain tank and that the vent line to primary vent stack is locked open.

2. When the gravity drain tank contains approximately 4,000 gal, as determined from the level indicator on the tank, start up the gas stripper and evaporator on nonradioactive water as outlined in Section V, Part 1, G.

3. Perform Step No. 4 given in Section V, Part 1, H.

4. Line up from gravity drain tank through gravity tank transfer pump and back to the same tank via the sample purge line, and start that pump to establish pump flow.

5. Close the sample purge line; close the by-pass recycle line between stripper feed-distillate exchanger distillate outlet and stripper feed line; and immediately open gravity tank transfer pump discharge line to stripper feed line.

6. Perform Step No. 7 given in Section V, Part 1, H.

7. Processing of gravity drain tank liq[illegible]ntinued until the evaporator bottoms activity or solids content reaches a predetermined level or until level indicator on gravity tank indicates minimum liquid level.

8. a. If evaporator bottoms activity or solids content is at predetermined level, proceed as follows:

   (1) Close line between gravity tank transfer pump and stripper feed line. Stop this pump.

   (2) Open line from operating test tank through waste liquid transfer pump to stripper feed line. Start this pump and continue feeding water from test tank until all the radioactive water in the stripper feed-distillate exchanger and pipe lines has been flushed to the stripper.

   (3) Perform Steps Nos. 3 through 24 given in Section V, Part 1, I, to complete shutdown of gas stripper and evaporator and cooling of evaporator bottoms.

   (4) Follow procedure given in Section V, Part 1, K, for evaporator bottoms removal and drumming.

   b. If gravity drain tank level indicator shows minimum liquid level without evaporator bottoms reaching a predetermined level of activity or solids content, proceed as follows:

   (1) Close line between gravity tank transfer pump and stripper feed line, close line from stripper feed-distillate exchanger distillate outlet to test tank, and immediately open by-pass recycle line between this exchanger distillate outlet and the stripper feed line. Stop gravity tank transfer pump.

   (2) Close caustic solution line and stop caustic pump.

   NOTE: The stripper and evaporator system is in operation under complete distillate recycle with radioactive liquid in bottom of evaporator as a result of processing only part of the total volume of gravity drain tank liquid required for a complete evaporator batch.

   The evaporator batch should be completed by charging additional radioactive liquid from either the waste holdup tank or the activity dilution decay tank. This can be accomplished by following procedure given in Section V, Part 1, H, for normal processing of Class 1 liquids; Section V, Part 1, I, for shutdown of gas stripper and evaporator and cooling of evaporator bottoms; and Section V, Part 1, K, for evaporator bottoms removal and drumming.

VI. Final Conditions

1. Radioactive materials, boron, and other impurities have been removed from Class 1 and Class 2 liquids so that the recovered water can be re-used as primary plant make-up water.

2. The radioactive constituents and other nonvolatile materials have been solidified with cement in 55-gal drums.

3. Low activity level liquids after monitoring have been discharged to the river at a carefully controlled rate after dilution with service water followed by dilution with main condenser effluent water.

OPERATING INSTRUCTION NO. 504L2

RADIOACTIVE WASTE DISPOSAL SYSTEM
GASEOUS WASTE DISPOSAL

I. Objective To dispose of hydrogen and fission product gases.

II. Conditions

1. One empty gas decay drum is available.

2. Pertinent auxiliary systems are in the following condition:

System	Status
Component Cooling System (Refer to O.I. No. 504I)	Cooling water available for heat exchangers

III. Precautions

1. Do not discharge any gas to the stack without checking the activity level of the gas and the activity of air ejector effluent.

2. Any person entering the waste disposal area must wear adequate protective clothing. See Section 507, RADIOLOGICAL HEALTH AND SAFETY.

3. If Class 2 liquids are being processed in the gas stripper, be sure the line from the stripper overhead condenser is open to the primary vent stack via the vent gas header. See O.I. No. 504L1, RADIOACTIVE WASTE DISPOSAL SYSTEM - LIQUID WASTE DISPOSAL.

IV. Check-off List

Prior to startup of this O.I., the check-off list must be completed by the operator(s) and signed off.

V. Instructions

A. Purging

NOTE: Purging of all equipment and piping in the waste gas system, including all liquid storage tanks interconnected with this system, with nitrogen from cylinders is required before any waste liquid or gas containing hydrogen is discharged to waste disposal from the primary plant. This is necessary to prevent the formation of explosive hydrogen-air mixtures. The purging operation will be greatly simplified if water is used to displace the air in the large liquid and gas storage tanks. However, care must be taken not to exceed the 1 psi gage design pressure of the liquid storage tanks when full of water.

1. Fill the primary drain collecting tank, waste holdup tank, activity dilution decay tank, waste gas surge drum and the three gas decay drums, including instrument connections, completely full of water and discharge the displaced air to atmosphere.

2. Fill all interconnecting lines to the primary plant, all liquid lines handling Class 1 liquids up to the gas stripper feed inlet nozzle and all waste gas lines, including safety valve discharge lines and decay gas header, with water that will not put too high a hydrostatic pressure on associated tanks and discharge the displaced air to atmosphere.

3. Pipe lines and small pieces of equipment which cannot be filled with water must be purged with nitrogen. Lines or groups of lines should be purged in sequence with samples of gas taken at intervals from the downstream end of the section being purged. The oxygen of the gas sample can be determined by Orsat analysis. Purging should be continued until the oxygen content of the gas sample is 5% or less.

4. Drain water out of waste gas surge drum and simultaneously feed in sufficient nitrogen to maintain at least 4 psi gage pressure.

5. Open line from waste gas surge drum through waste gas by-pass pressure controller and pressure recorder controller to compressor K.O. drum. adjust setting on by-pass pressure recorder controller to maintain minimum of 2 in. H_2O gage pressure in waste gas header. Drain water out of all tanks, drums, and pipelines using nitrogen from the waste gas header to replace this water so that entrance of atmospheric air is avoided. Continue feeding nitrogen into waste gas surge drum to maintain 2 psi gage pressure in drum.

   NOTE: The waste gas system is completely purged, and water in all tanks connected to this system is at minimum level.

B. Initial Startup and Operation

1. Start flow of component cooling water to compressor suction cooler, compressor discharge cooler and heads of both waste gas compressors.

2. Line up from waste gas header through both waste gas compressors to waste gas surge drum and open loop seal drain line on compressor K.O. drum.

   NOTE: Care should be taken to drain all water out of the compressor discharge cooler before either of the waste gas compressors are started. This cooler should be drained periodically during operation.

3. Switch one of the waste gas compressors on manual control which will automatically open unloader by-pass valve, start compressor, close by-pass valve, and open suction valve in proper sequence.

4. Adjust setting of compressor backpressure recorder controller to hold 70 psi gage backpressure on compressor discharge.

5. Operation of compressor will reduce waste gas header pressure and by-pass pressure recorder controller in by-pass line from waste gas surge drum to compressor K.O. drum should be adjusted to start opening at 4 in. of water gage pressure in this header and be completely open at 2 in. of water gage pressure in header.

6. Switch off compressor and observe that suction valve closes automatically.

7. Repeat Steps Nos. 3 and 6 on second waste gas compressor.

8. Fill waste holdup tank about one half full of water while operating one waste gas compressor intermittently to maintain waste gas header pressure at about 6 in. water gage. This will increase gas pressure in waste gas surge drum.

9. Switch one of the waste gas compressors on automatic and manually by-pass the waste gas by-pass pressure controller and pressure recorder controller so that waste gas header pressure increases. Adjust waste gas header pressure switch HPS-301 to start compressor at 13 in. water gage pressure and low pressure switch LPS-302 to stop compressor at 6 in. water gage pressure. Switch off this compressor.

10. Continue by-passing gas from waste gas surge drum to waste gas header so header pressure will increase. Switch one waste gas compressor on automatic with selector switch positioned for operation of other compressor so that normal range pressure switch HPS-301 is not in circuit being used.

11. Adjust high pressure switch HPS-303 to close pressure control valve in by-pass line from waste gas surge drum at 14 in. water gage pressure.

12. Adjust waste gas header pressure switch HPS-302 to start the other compressor, not selected, and sound gas header high pressure alarm when header pressure reaches 18 in. water gage. LPS-302 should stop compressor at 6 in. water gage pressure.

13. Continue to increase gas header pressure. High level switch HLS-310 on low pressure side of loop water seal should actuate alarm when pressure in waste gas header reaches 21 in. water gage.

14. Close by-pass line from waste gas surge drum to compressor K.O. drum and switch one waste gas compressor on manual control. Adjust gas header low pressure switch LPS-301 to sound alarm at 2 in. water gage pressure.

15. Continue to reduce gas header pressure by operating compressor. Adjust high level alarm on waste gas header side of loop water seal so that high level switch HLS-313 actuates alarm when vacuum in gas header reaches 12 in. water gage.

    NOTE: Extreme care must be taken not to reduce the pressure in the waste gas header below about 27 in. water gage vacuum, since primary drain collecting tank is designed for only 1 psi gage vacuum.

16. Switch off compressor and open by-pass line from waste gas surge drum to compressor K.O. drum. Waste gas header pressure should automatically increase to 4 in. water gage.

17. Line up from waste holdup tank through waste liquid transfer pump, monitored tank transfer pump and effluent flow recorder controller to component cooling water exchanger service water discharge line. Start these pumps.

18. Adjust setting on effluent flow recorder controller at 50 gpm and start pumping water out of waste holdup tank.

19. Close outlet line from waste holdup tank to waste liquid transfer pump when minimum level readable on level indicator is obtained in this tank. Stop waste liquid transfer and monitored tank transfer pumps.

20. Switch both compressors on automatic and switch selector switch to put desired compressor on automatic control.

    NOTE: The waste gas system is in operation with all controls and alarms set to control automatically the waste gas header pressure within the normal operating range of 2 in. to 13 in. water gage and to prevent exceeding the range of 24 in. water gage vacuum to 24 in. water gage pressure.

C. <u>Decay and Discharge of Waste Gas</u>

NOTE: The net inflow of gases to the waste disposal system in both waste gases and liquids will collect as net gas make gradually in the waste gas surge drum. Using the previously prepared curve showing the total volume of liquid above minimum level in the primary drain collecting tank, waste holdup tank and activity dilution decay tank vs waste gas surge drum pressure, exclusive of that caused by net gas make, it is possible to determine the volume of net gas collected.

1. When the volume of net gas make in the waste gas surge drum corrected to 70 psi gage pressure is about 45 cu ft, switch one waste gas compressor on manual.

   NOTE: During normal operation of the primary plant, it is expected this net gas make volume will collect once a month.

2. Open line between compressor discharge cooler gas outlet line and an empty gas decay drum.

3. When the pressure in the gas decay drum reaches 70 psi gage, this drum is full. Close line opened in Step No. 2 and switch operating compressor to automatic.

4. When the activity, together with any activity from air ejector effluent, is below the limits referred to in Section 209, RADIOACTIVE WASTE DISPOSAL SYSTEM, and Section 507, RADIOLOGICAL HEALTH AND SAFETY, which normally requires approximately 60 days decay, the gas can be safely discharged at a carefully controlled rate to the primary vent stack after dilution with air. Line up from the filled and checked gas decay drum through the decay gas header, the decay gas filter and the flow recorder controller to the suction side of the primary auxiliary building exhaust fan or the vapor container purge fan.

5. Check and, if necessary, adjust temperature controller to provide a 120 F constant temperature water bath in which both the flow recorder-controller measuring element and the control valve are immersed. This temperature controller will automatically maintain the 120 F temperature by admitting steam to the heating coils in the water bath.

6. The primary auxiliary building exhaust fan will normally be operating. Therefore, the discharge damper and the decay gas inlet line will normally be open.

   NOTE: Interlocks are provided to stop automatically the flow of decay gas and close the discharge damper if the fan stops.

   If the primary auxiliary building exhaust fan is inoperative, the vapor container purge fan can be used by transferring the blanks in the suction and discharge ducts from one fan to the other.

7. Set the flow recorder-controller so that, after mixing and dilution of the decay gas and air ejector effluent with air in the fan, the activity of the air leaving the primary vent stack will not exceed the limits as referred to in Section 507, RADIOLOGICAL HEALTH AND SAFETY. It will be necessary to

correct the flowmeter reading for the gas density since the decay gas will consist of varying mixtures of nitrogen and hydrogen until all of the nitrogen has been removed by dilution.

NOTE: The primary vent stack gas monitor should be set to sound an alarm when the activity of gases passing through the stack exceeds its maximum sensitivity.

8. When the decay gas drum is empty as indicated by a reading of about 0 psi gage pressure on the pressure gage upstream of the flow recorder-controller, close the lines opened in Step No. 4.

D. Drainage of Drums and Coolers

1. After emptying decayed gas from a gas decay drum, all water should be drained from this drum by opening the drain line to the fission gas drain header. Water drainage from the drum can be observed in the sight glass in the drain line.

2. Any water which collects in the waste gas surge drum should be drained out periodically. Care should be taken when the drain line on this drum is opened to prevent a flow rate of high pressure gas through the fission gas drain header, the primary drain collecting tank and into the waste gas header in excess of that which can be handled by the waste gas compressors. When bubbles of gas appear in the sight glass, this line should be closed immediately.

3. The compressor suction and discharge coolers should also be drained periodically.

VI. Final Conditions

1. The pressure in the waste gas header and tanks discharging into it is being maintained within prescribed limits.

2. Fission product gases are decaying in the gas decay drum.

3. Hydrogen and fission product gases have been safely discharged to the atmosphere.

4. At least one gas decay drum is empty.

OPERATING INSTRUCTION NO. 504L3

RADIOACTIVE WASTE DISPOSAL SYSTEM
SOLID WASTE DISPOSAL

I. Objective To burn contaminated combustible solid waste and to dispose of the radioactive incinerator ashes and evaporator bottoms solidified with cement in 55 gal steel drums. To effectively dispose of contaminated noncombustible solid waste material.

II. Conditions

1. A supply of bottled gas is available.

2. 55 gal open top sheet steel drums and cement must be available for incinerator ash disposal.

3. Service water is available for use as make-up to the Roto-Clone.

III. Precautions

1. The Roto-Clone inlet gas temperature should not exceed 700 F.

2. To prevent the escape of radioactive ash into the room area near the incinerator, the incinerator charging door should never be opened unless all ashes have been discharged.

3. Care should be taken to insure airtight closure of the joint between the special drum head below the incinerator and the open top drum.

4. Combustible waste should be roughly classified to prevent charging relatively large metal objects and an excessive quantity of small metal objects or plastic materials per incinerator batch. Large plastic drop cloths should be divided among several batches to facilitate complete combustion.

IV. Check-off List

Prior to startup of the system, the check-off list must be completed by the operator(s) and signed off.

V. Instructions

A. Burning of Combustible Waste

NOTE: Combustible solid wastes, such as removal floor coverings, cloths used for decontamination, shoe coverings, and contaminated paper are collected from various locations in the plant and transported to the waste disposal buildings in combustible fiber drums. These drums are re-used until they become contaminated and then they are burned.

1. Fill the Roto-Clone with service water to normal operating level.

2. Place open top 55 gal sheet steel drum on pallet and pallet on mechanical lift truck. Position drum under special drum head and jack truck up until drum lifts special head making a tight joint. Connect drum securely to special drum head by means of drum closure clamp. Install pipe fitting in 2 in. bung hole in side of drum. Make up flexible pipe connection to complete piping back to ash dewatering sump and close this line.

3. Fill open top drum one half full of water by operating ash dewatering sump pump and pumping water from ash dewatering sump through spray by-pass line.

4. Close incinerator bottom blast gate valve, place and pin grates in horizontal position and charge 80 lb of combustible waste into incinerator through charging door.

5. Start Roto-Clone and check incinerator draft as shown on manometer. A vacuum of 5 in. to 6 in. water should be maintained in the incinerator body before and during combustion.

6. Start incinerator burner and continue operation until combustible waste is well ignited. Shut off burner.

   NOTE: Automatic flame failure instrumentation is provided on the incinerator to prevent a build-up of fuel gas in case of prolonged flame failure.

7. Adjust damper in outside air inlet duct to control gas inlet temperature to Roto-Clone so that it never exceeds 700 F.

8. Allow self-combustion of waste to continue until burning slows down, as observed through top view port of incinerator, and then restart burner to complete the combustion. Shut off burner.

9. Open bottom blast gate valve. Shake and tip grates to vertical position to dump ash into drum.

10. Repeat Steps Nos. 4 through 10 under Section V-A, until about six incinerator batches have been burned and the ashes dumped into the drum.

11. After every three incinerator batches, drain water containing fine particles of ash from the Roto-Clone into the ash dewatering sump and refill Roto-Clone with service water to normal operating level.

12. Pump water drained from the Roto-Clone in excess of that remaining with the settled ash in the drum, through the ash slurry filter into the gravity drain tank.

13. When reduced flow through the ash slurry filter indicates the filter is plugged with collected particles of incinerator ash, operate handle to clean solids from the filter leaves. Flush solids out bottom of filter into open top drum using liquid from ash dewatering sump.

B. Drumming of Incinerator Ash

1. Start ash dewatering sump pump and pump water into drum through the sprays inside the special drum head. Continue spraying water into the drum until any ashes floating on the water have been thoroughly wet. When drum is full, excess water will overflow back to the ash dewatering sump through the sight glass in the higher line. Stop ash dewatering sump pump.

2. Allow ashes in drum to settle at least 1 hr, preferably overnight. Open line connected to large bung and decant water from settled ashes into the ash dewatering sump.

3. When all water down to midpoint of the drum has been drained out as indicated by flow through sight glass, disconnect this line and replace large bung.

4. Remove drum closure clamp, jack mechanical lift truck down until drum will clear special drum head when truck is pulled out from below incinerator.

5. Place cover on drum and attach securely to drum with drum closure clamp.

6. Tare drum and pallet on scales and place end of cement hose in large bung hole in drum cover.

7. Perform Steps Nos. 3 through 7 in Section V-L of O.I. No. 504L1, RADIOACTIVE WASTE DISPOSAL SYSTEM - LIQUID WASTE DISPOSAL, except in Step No. 5, weigh about 350 lb of cement into drum.

   NOTE: It is expected that the actual number of incinerator batches of ash and the weight of cement added to a drum in order to obtain solidification of the material in the drum will be determined by experiment after the plant is started.

8. Securely tighten all bungs in preparation for transfer of drum to outside storage area.

C. Disposal of Drums Containing Solidified Radioactive Material

1. Drums of solidified evaporator bottoms and solidified incinerator ashes are transferred from the Waste Disposal Building to the outside storage area by means of a fork lift truck or a pick-up truck.

   NOTE: Drums of solidified material must be held in the outside storage area for a sufficient decay period before shipment, so that the radioactive dose from each drum as determined by a portable radiation monitor is in accord with all AEC and ICC Regulations.

2. When a sufficient number of drums containing adequately decayed radioactive material have collected in the storage area, they are transferred from this area, loaded on a common carrier, and shipped away without additional shielding for ultimate disposal in an approved manner.

   NOTE: Before the common carrier leaves the plant, the external radioactive dose must be determined by means of a portable radiation monitor to insure that all AEC and ICC Regulations are complied with for common carrier shipments of radioactive materials.

D. Noncombustible Solid Waste Material Disposal

1. Place all small, noncombustible contaminated solid wastes such as filter cartridges, glass wool, and various small items of plant equipment in 55 gal drums and mix with concrete such that the dose rate from the drum will meet AEC and ICC Regulations for common carrier shipment.

2. Large items of contaminated noncombustible solid waste material which can not be decontaminated will be suitably shielded for temporary storage until arrangements for permanent storage can be made for burial at an AEC approved disposal area.

VI. Final Conditions

1. Contaminated combustible solid waste has been burned, the ashes solidified with cement in drums, and the drums have been shipped to ultimate disposal.

2. Drums of solidified evaporator bottoms are either in storage in the outside storage area or have been shipped to ultimate disposal.

3. Contaminated noncombustible solid waste material is properly shielded and is either temporarily located in the outside storage area or has been shipped to ultimate disposal point.

OPERATING INSTRUCTION NO. 504M

SHUTDOWN COOLING SYSTEM

I. Objective To provide a safe and efficient method of removing decay heat from the reactor and reduce main coolant temperature.

II. Conditions

A. Startup

1. Decay heat and main coolant pumping heat are being removed from the main coolant system by use of the steam dump line to the condenser. Refer to O.I. No. 504C3, PLANT SHUTDOWN - SCHEDULED TURBINE GENERATOR SHUTDOWN.

2. Pertinent auxiliary systems are in the following status:

System	Status
Main Coolant System - Shutdown of Complete System (Refer to O.I. No. 504D7)	One pump in operation
Pressure Control and Relief System (Refer to O.I. No. 504E)	In operation manual control
Component Cooling System (Refer to O.I. No. 504I)	In operation
Electrical System (Refer to O.I. No. 504R)	In operation

B. Operation

1. Pertinent systems are in the same status as indicated in Section II-A, Step No. 2 with the following exception:

System	Status
Main Coolant System - Shutdown of Complete System (Refer to O.I. No. 504D7)	All pumps shut down

C. Removal from Operation

The shutdown cooling system shall be removed from operation for one of the following reasons:

Sufficient decay heat has been removed and cooling is no longer required.

Decay heat removal is no longer desired during plant startup.

III. Precautions

1. Maintain the required main coolant system pressure for the main coolant pump until it is shut down.

2. Shutdown cooling system must be put into operation slowly to avoid thermal shock.

3. Main coolant pressure must be below 300 psi gage and temperature below 330 F before the shutdown cooling system is put in operation.

IV. Check-off List

Prior to initiation of this O.I., the check-off list must be completed by the operator(s) and signed off.

V. Instructions

A. Startup

1. Provide component cooling water to the shutdown cooler. Refer to O.I. No. 504I, COMPONENT COOLING SYSTEM.

2. Start the shutdown cooling pump gland sealing system so that the sealing system pressure is greater than the pump suction pressure.

3. Close the shutdown cooling pump discharge valve.

4. Unlock and open the four, key locked motor operated isolation valves in sequence from the inlet to the outlet of the shutdown cooling system.

5. Start the shutdown cooling pump and adjust its discharge valve to obtain approximately 50 gpm on the flow indicator.

6. After approximately five minutes, open the discharge valve of the shutdown cooling pump to full open and check the flow indicator for approximately 1,000 gpm full flow.

B. Operation

1. Make periodic checks of inlet and outlet temperatures, pump discharge pressure and flow to assure proper operation of the shutdown cooling system.

NOTE: Based on the decay heat of a 10,000 hr reactor core, the shutdown cooling system will remove decay heat and reduce the main coolant temperature to approximately 140 F in less than 60 hours.

2. Adjust main coolant system cooldown rate as desired by controlling the component cooling water flow rate to the shutdown cooler. Refer to O.I. No. 504I, COMPONENT COOLING SYSTEM.

C. Removal from Operation

1. De-energize the shutdown cooling pump.

2. Close and lock the four key-locked motor operated isolation valves in sequence from the outlet to the inlet of the shutdown cooling system.

3. Shut off the component cooling water to the shutdown cooler. Refer to O.I. No. 504I, COMPONENT COOLING SYSTEM.

4. Check to assure that all valves to cross connecting systems are closed.

VI. Final Conditions

1. Shutdown Cooling System has been put in operation.

2. Shutdown Cooling System is being maintained in operation.

3. Shutdown Cooling System has been removed from operation.

OPERATING INSTRUCTION NO. 504N

REACTOR CONTROL SYSTEM

I. Objective To provide a safe and efficient standardized method of taking the reactor critical, operating at various power levels, and shutting down the reactor.

II. Conditions

A. Start Up and Increasing Reactor Load (with boron present in the Main Coolant System)

1. Preoperational checks have been completed.

2. Main coolant pressure and temperature are essentially at ambient.

3. Main coolant system is in operation per O.I. No. 504D4, MAIN COOLANT SYSTEM -- STARTUP OF COMPLETE SYSTEM.

4. Boron is present in the main coolant system and concentration has been determined by O.I. No. 504K1, PRIMARY PLANT SAMPLING SYSTEM -- MAIN COOLANT SYSTEM.

5. The turbine generator is being prepared for operation as indicated in O.I. No. 504A4, PLANT STARTUP -- TURBINE GENERATOR STARTUP FROM COLD CONDITION.

6. The primary water storage tank is filled.

7. Pertinent auxiliary systems are in the following status: Systems status are the same as for O.I. No. 504B1, PLANT OPERATION -- CHANGING REACTOR LOAD.

B. Increasing Reactor Load

1. The reactor is critical with the main coolant system in operation. Refer to O.I. No. 504D6, MAIN COOLANT SYSTEM -- RUNNING OPERATION.

2. The turbine generator is in operation at some reduced load and steam discharge to main steam header is being used as required. Refer to O.I. No. 504B2, PLANT OPERATION -- INCREASING TURBINE GENERATOR LOAD.

3. With the exception of the following, all pertinent auxiliary systems are as indicated under Section II-A7:

System	Status
Purification System (Refer to O.I. No. 504H)	Normal operation

C. Decreasing Reactor Load

1. The reactor is critical with the main coolant system in operation. Refer to O.I. No. 504D6, MAIN COOLANT SYSTEM - RUNNING OPERATION.

2. The turbine generator is in operation. Refer to O.I. No. 504B3, PLANT OPERATION - DECREASING TURBINE GENERATOR LOAD.

3. With the exception of the following, all pertinent auxiliary systems are as indicated under Section II-A7:

System	Status
Purification System (Refer to O.I. No. 504H)	Normal operation

D. Scheduled Reactor Shutdown

Conditions are the same as for O.I. No. 504C1, PLANT SHUTDOWN - SCHEDULED REACTOR SHUTDOWN.

E. Reactor Cooldown

Conditions are the same as for O.I. No. 504C2, PLANT SHUTDOWN - REACTOR COOLDOWN.

III. Precautions

It should be noted that the safety rod group must be withdrawn for safety protection when:

Main Coolant System Temperature is being reduced.
Main Coolant System Boron Concentration is being reduced.
Reactor is in Hot Standby Condition.

A. Start Up and Increasing Reactor Load (with boron present in the main coolant system)

1. Qualified personnel must be stationed at the control board at all times when the scram breakers are closed, when boron removal procedures are in progress, or when boron concentration does not meet full cold shutdown requirements.

2. A minimum control rod position for criticality has been calculated.

3. Criticality should be anticipated at any time when control rods are being withdrawn, when boron is being removed from the main coolant system, or when system temperature is decreasing.

4. Continuously monitor the flux level and startup rate. Be prepared to initiate a manual scram for any unplanned or uncontrolled increase in flux level.

5. Any plant changes which produce a sudden lowering of reactor water temperature (of the order of 10°F) must be avoided while the reactor is approaching criticality or is critical at low power levels.

6. If, while increasing turbine generator load, the pressurizer level falls below 60 in. or if the pressure falls below 1,900 psi gage, the loading operation must be halted until manual or automatic control can re-establish level to 120 in. plus or minus 10 in. and pressure to 2,000 psi gage plus or minus 30. Refer to O.I. No. 504E, PRESSURE CONTROL AND RELIEF SYSTEM and O.I. No. 504F, CHARGING AND VOLUME CONTROL SYSTEM.

7. In the process of heating the main coolant system, pressurizer level and temperature must be maintained in accordance with O.I. No. 504E, PRESSURE CONTROL AND RELIEF SYSTEM.

8. Auto rod control may be used whenever the plant is at a base load above 15 MWe and should be used as follows:

   a. Controlling Rod Group Above 12"

      Select auto rod control.
      Select the controlling rod group.

   b. Controlling Rod Group Below 12"

      Select auto rod control.
      Select the rod group which has the previous group withdrawn in the program sequence.

   c. There are no restrictions on the use of auto rod control at the upper end of group travel now that auto rod withdrawal has been removed.

All scheduled rod motion should be made using manual rod control. The auto rod insertion control is intended only to provide immediate rod insertion in the event that an unexpected plant transient resulted in a sudden increase in T_{ave}.

11. On completion of Step No. 10 and establishment of 10% power level, reset power level scram settings from 25% to 120% power.

12. Check that scram circuits for turbine trip, low pressure, and loss of flow are energized and permissive relay light is off.

13. Turbine can proceed to power. T_{avg} is to be maintained by operation of the controlling rod group. Power level will be determined by steam load. Refer to O.I. No. 504B2, PLANT OPERATION - INCREASING TURBINE GENERATOR LOAD.

14. Continuously monitor main coolant T_{avg}, pressure, and power level.

B. Increasing Reactor Load (no boron present in main coolant system)

1. During reactor load increase, monitor neutron level continuously.

2. As reactor load is increased, T_{avg} is to be maintained by operation of the controlling rod group. Power level will be determined by turbine steam load. Refer to O.I. No. 504B2, PLANT OPERATION - INCREASING TURBINE GENERATOR LOAD.

3. Continuously monitor main coolant T_{avg}, pressure, and power level.

C. Decreasing Reactor Load

1. During reactor load decrease, monitor neutron level continuously.

2. When decreasing load below 15 mw, check that turbine trip, low pressure and low flow scrams are by-passed and that permissive relay light is on.

3. As reactor load is decreased, T_{avg} is to be maintained by operation of the controlling rod group. Power level will be determined by the turbine steam load. Refer to O.I. No. 504B3, PLANT OPERATION - DECREASING TURBINE GENERATOR LOAD.

4. Continuously monitor main coolant T_{avg}, pressure, and power level.

D. Scheduled Reactor Shutdown

1. Check that the reactor is on manual control.

2. Check that, at a loading of below 15 mw, the turbine trip, low pressure and low flow scrams are by-passed and that the permissive relay light is on.

3. Reset power level scrams from 120% to 25% of nominal full power.

B. Increasing Reactor Load

1. Same as A1
2. Same as A4
3. Same as A5
4. Same as A6
5. Same as A8

C. Decreasing Reactor Load

1. Same as A1
2. Same as A4
3. Same as A5
4. If, in the process of decreasing turbine generator load, the pressurizer level rises above 150 in., or if the primary plant pressure exceeds 2,280 psi gage, the unloading operation must be halted until manual or automatic control can re-establish level at 120 in. plus or minus 10 in. and pressure to 2,000 psi gage plus or minus 30. Refer to O.I. No. 504E, PRESSURE CONTROL AND RELIEF SYSTEM and O.I. No. 504F, CHARGING AND VOLUME CONTROL SYSTEM.
5. Same as A8

D. Scheduled Reactor Shutdown

1. Same as A1
2. Same as A4
3. Same as A5
4. Same as C4
5. Same as A8

E. Reactor Cooldown

1. Same as A1
2. Same as A3
3. Same as A4
4. Same as A5
5. In the process of cooling the main coolant system, pressurizer level and temperature must be maintained in accordance with O.I. No. 504E, PRESSURE CONTROL AND RELIEF SYSTEM.

IV. Check-Off List

Prior to initiation of this O.I., the check-off list must be completed by the operator(s) and signed off. The check-off list must indicate that the reactor control equipment and plant systems are in proper condition.

V. Instructions

NOTE: Refer to O.I. No. 504A1, PLANT STARTUP - REACTOR STARTUP FROM COLD CONDITION, O.I. No. 504A2, PLANT STARTUP - REACTOR STARTUP FROM HOT STANDBY, O.I. No. 504A3, PLANT STARTUP - REACTOR STARTUP FOLLOWING SCRAM CONDITION, or O.I. No. 504B1, PLANT OPERATION - CHANGING REACTOR LOAD, as applicable.

A. Startup and Increasing Reactor Load (with boron present in the main coolant system)

1. Commence programmed rod motion as per rod program schedule.

   NOTE: In commencing a programmed rod withdrawal, the safety control group will be withdrawn to the safety position. This safety group position is such that rod worths are at a maximum value, as well as making possible more accurate nuclear instrumentation monitoring.

2. During rod withdrawal, monitor startup rate and neutron level continuously. Do not exceed 1 decade per minute startup rate. Make frequent checks between secondary rod position indicators for correlation and to assure that all rods in the group are moving.

3. Continue intermittent programmed rod withdrawal until a startup rate of approximately 0.5 decade per minute can be maintained with no rod motion. At this point suspend rod motion and report reactor critical.

4. When neutron level indicates 10,000 counts per second on source range instruments, switch the start up rate selector switch of the highest reading channel to intermediate range.

5. When both source range instruments indicate 10,000 counts per second, switch second startup switch to intermediate range.

6. As intermediate range power level passes 10^{-9} amp, note that the BF_3 high voltage is automatically deenergized.

7. When intermediate range power level reaches 10^{-7} amp, insert controlling rod group until zero startup rate is achieved and can be maintained.

8. Advise plant personnel that the reactor is critical at a power level of 10^{-7} amp and ready to proceed range.

9. Proceed to power range and maintain a power level consistent with permissible plant heat up rate. Refer to O.I. No. 504D4, MAIN COOLANT SYSTEM - STARTUP OF COMPLETE SYSTEM. If the reactor is at nominal temperature and pressure proceed to Step No. 10.

10. Maintain T_{avg} of 514 F at the required power level by operation of the controlling rod group while turbine is being warmed up and/or a minimum power level is established. Refer to O.I. No. 504A4, PLANT STARTUP - TURBINE GENERATOR STARTUP FROM COLD CONDITION or O.I. No. 504A5, PLANT STARTUP - TURBINE GENERATOR STARTUP FROM HOT CONDITION.

OPERATING INSTRUCTION NO. 5040

NUCLEAR INSTRUMENTATION SYSTEM

I. Objective To provide a method of energizing and operating the nuclear instrumentation system to detect the reactor neutron flux in the neutron shield tank and provide the necessary indicating, alarm and control signals for the operation and protection of the reactor.

II. Conditions

1. The instrument A-C vital bus is energized.
2. The nuclear instrumentation system has been calibrated and tested according to manufacturer's instructions.

III. Precautions

1. The BF_3 high voltage must be de-energized at flux levels greater than 2.5×10^4 nv at the BF_3 detectors corresponding to 10^5 counts per second.
2. At all times when the flux level is less than 10^5 counts per second, the source-range signal of one BF_3 channel must be recording on the nuclear recorder.
3. The temperature of the neutron shield tank should not exceed a temperature to cause the BF_3 detector to reach 175 F.
4. The following minimum startup instrument requirements must be met:

   a. Two source range channels) Startup Rate Protection
   b. Two intermediate range channels)
   c. Three power range channels (Automatic high level scram).

5. The following minimum operating instrument requirements must be met:

   a. Four detectors which provide automatic high level scram protection.

      NOTE: There must be one detector in each of the three radial positions and these must provide automatic high level scram protection.

   b. (1) In a condition where one upper or one lower power range channel is inoperative, the reactor can continue to be operated at the existing power level provided no major rod program change is carried out and provided the power range high level scram protection is set for single channel operation for the group containing the failed channel.

      (2) In a condition where two power range channels are inoperative, the reactor can continue to be operated at the existing power level provided no major rod program change is carried out and provided the power range high level scram protection is set for single channel operation on both the upper and lower groups.

4. Advise turbine operator to proceed to turbine shutdown. Once turbine is tripped, place reactor control switch to "All Rods In" position. Refer to O.I. No. 504C3, PLANT SHUTDOWN - SCHEDULED TURBINE GENERATOR SHUTDOWN and O.I. No. 504C1, PLANT SHUTDOWN - SCHEDULED REACTOR SHUTDOWN.

5. When power level has decayed to 10^{-9} amp, note that source range high voltage is reenergized.

6. Continue rod insertion until all rods are fully inserted, except safety control group which are in the safety position.

7. Note source range reading after decay has leveled out and ascertain that the two point recorder is recording this indication.

8. Reactor is in hot standby condition. Continue to monitor neutron level, T_{avg}, and system pressure.

E. Reactor Cooldown

1. Withdraw the safety control rod group to safety position.

2. During a scheduled reactor cooldown and boron addition, from hot standby condition, continuously monitor neutron level and be prepared to manually scram the reactor. Refer to O.I. No. 504C2, PLANT SHUTDOWN - SCHEDULE REACTOR COOLDOWN.

3. Insert the safety control rod group to full in position (0") when the temperature and pressure of the system reach final lower values.

4. Actuate manual Scram Button.

5. Take adequate precautions to prevent closing of scram breakers by racking them out and locking them in test position.

VI. Final Conditions

1. For A, B and C, the reactor is critical at the required power level.

2. For D, the reactor is subcritical and is being maintained in a hot standby condition.

3. For E, the reactor is subcritical with all control rods fully inserted.

IV. Check-off List

1. Prior to the initiation of this O.I., the check-off list must be completed by the operator(s) and signed off.

2. Ensure that the nuclear instrumentation is energized by use of appropriate switches at the A-C vital bus control cubicle and in the nuclear instrumentation cabinets.

   NOTE: The source-range BF_3 channels should normally be energized at all times when a core is in the reactor vessel and the intermediate level meters read less than 2×10^{-9} amp.

3. Check that the equipment is in the following condition:

   a. All eight channels are operating and functioning properly.

   b. Startup Rate Alarm set at 1.0 decade per minute.

   c. Rods Stop Signal set at 1.3 decades per minute.

   d. Startup Rate Scram set at 5.2 decades per minute.

   e. Power Level Scram set at 25% of full power by means of the Low Level Scram Set Switch.

   f. Both Startup Rate selector switches are in the Source-Range position.

   g. The Nuclear recorder is monitoring one of the two Source-Range channels (counts per second) and one of the two Intermediate-Range channels (log level).

V. Instructions

1. Allow equipment to warm up at least four hours before attempting calibration.

2. Monitor the source level, intermediate level and startup rate meters continuously during the startup operation. Refer to O.I. No. 504N, REACTOR CONTROL SYSTEM.

3. When the neutron level indicates between 10^4 and 10^5 counts per second on the source level meters, switch the startup rate selector switch of the highest reading channel to its corresponding intermediate-range position.

4. When both intermediate level meters show an indication of flux, switch the second startup rate switch to its corresponding intermediate-range position.

5. As the intermediate level meters pass the 2×10^{-9} amp reading, note that the BF_3 high voltage is disconnected automatically by observing that the Hi-Voltage red lights are off and the source level meters go to a minimum indication.

6. After the turbine has reached 15 mw, the low level scram set switch on the nuclear instrumentation panel should be placed in the off position.

7. After a power run, if turbine is being shut down, the power level scram should be reset to 25% of full power (low level trip set) as the turbine power goes below 15 mw load. Refer to O.I. No. 504N, REACTOR CONTROL SYSTEM.

8. During a reactor shutdown or scram, note that the BF_3 high voltage is turned on automatically when the intermediate level meters read below 2×10^{-9} amp.

9. During a reactor shutdown or scram, turn the two startup rate selector switches to source-range position when the source level meters read between 10^4 and 10^5 counts per second.

VI. Final Conditions

The nuclear instrumentation system is energized and operating. The appropriate signals are continuously indicated on the nuclear section of the main control board.

OPERATING INSTRUCTION NO. 504P

RADIATION MONITORING SYSTEM

I. Objective To provide a means of placing the radiation monitoring system in service and establishing normal operating limits in order to detect, compute, and indicate the radiation level at various plant locations.

II. Conditions

1. Suitable power supply is available to the radiation monitoring system.

2. All channels of the radiation monitoring system have been calibrated and tested.

III. Precautions

In order to maintain detector sensitivity:

The temperature at the primary vent stack detector should not exceed 200 F.

The temperature at the component cooling water detector should not exceed 300 F.

The temperature at the steam generator leak detectors should not exceed 250 F.

IV. Check-off List

Prior to the initiation of this O.I., the check-off list must be completed by the operator(s) and signed off.

V. Instructions

A. Vapor Container Air Particle Detector

1. Turn on the power switch and the pump switch.

2. Establish and maintain the following conditions:

An air flow rate of 1 cfm

A filter paper speed of 1 inch per hour

The alarm set point at 1,500 counts per second

A computer-indicator reading of 500 counts per second when the calibration source is moved in front of the detector head

B. Primary Vent Stack Detector

1. Turn on the power switch.

2. Establish and maintain the following conditions:

The alarm set point at 3 counts per second

A computer-indicator reading of 1,000 counts per second when the calibrating signal is fed into the calibration signal input jack

CAUTION: Check vapor container temperature before any release of gases through the primary vent stack.

C. Component Cooling Water Detector

1. Turn on the power switch.

2. Establish and maintain the following conditions:

The alarm set point at 100 counts per second

A computer-indicator reading of 1,000 counts per second when the calibrating signal is fed into the calibration signal input jack

D. Steam Generator Leak Detectors

1. Turn on the power switches.

2. Establish and maintain the following conditions for each detector channel:

The alarm set point at 100 counts per second

A computer-indicator reading of 1,000 counts per second when the calibrating signal is fed into the calibration input jack

A minimum flow of 0.5 gpm through a hold-up tank

E. Air Ejector Effluent Detector

1. Turn on the power switch.

2. Establish and maintain the following conditions for each detector channel:

The alarm set point at 3 counts per second

A computer-indicator reading of 1,000 counts per second when the calibrating signal is fed into the calibration signal input jack

F. Recorder

1. Connect the following computer-indicator output signals to the 10 point multi-channel recorder:

   The air particle detector

   The primary plant stack detector

   The component cooling water detector

   The steam generator leak detectors

G. Alarms

1. During normal operation, if any of the alarms are actuated refer to E.I. No. 505B13, PRIMARY PLANT - EXCESSIVE RADIOACTIVITY LEVEL.

VI. Final Condition

The radiation monitoring system is under normal operating conditions.

OPERATING INSTRUCTION NO. 504Q

VAPOR CONTAINER ATMOSPHERE CONTROL SYSTEMS

A. LEAKAGE RATE DETECTION

I. Objective To provide an efficient method of determining the vapor container leakage tightness immediately after closure of all openings and subsequent leakage testing during operation.

II. Conditions

1. The vapor container has been subjected to field acceptance tests and has passed these tests as called for in Section 231.

2. The personnel hatches, equipment hatch, auxiliary manholes, piping, electrical and ventilating penetrations have been closed.

3. The service air system is in operation and 80 psi gage air is available from the service air header.

III. Precautions

1. All personnel must be out of the vapor container.

2. When adding air into the vapor container, care must be taken not to inject more air than allowed per curve A on page 504Q:2 for the average temperature conditions within the vapor container.

IV. Check-off List

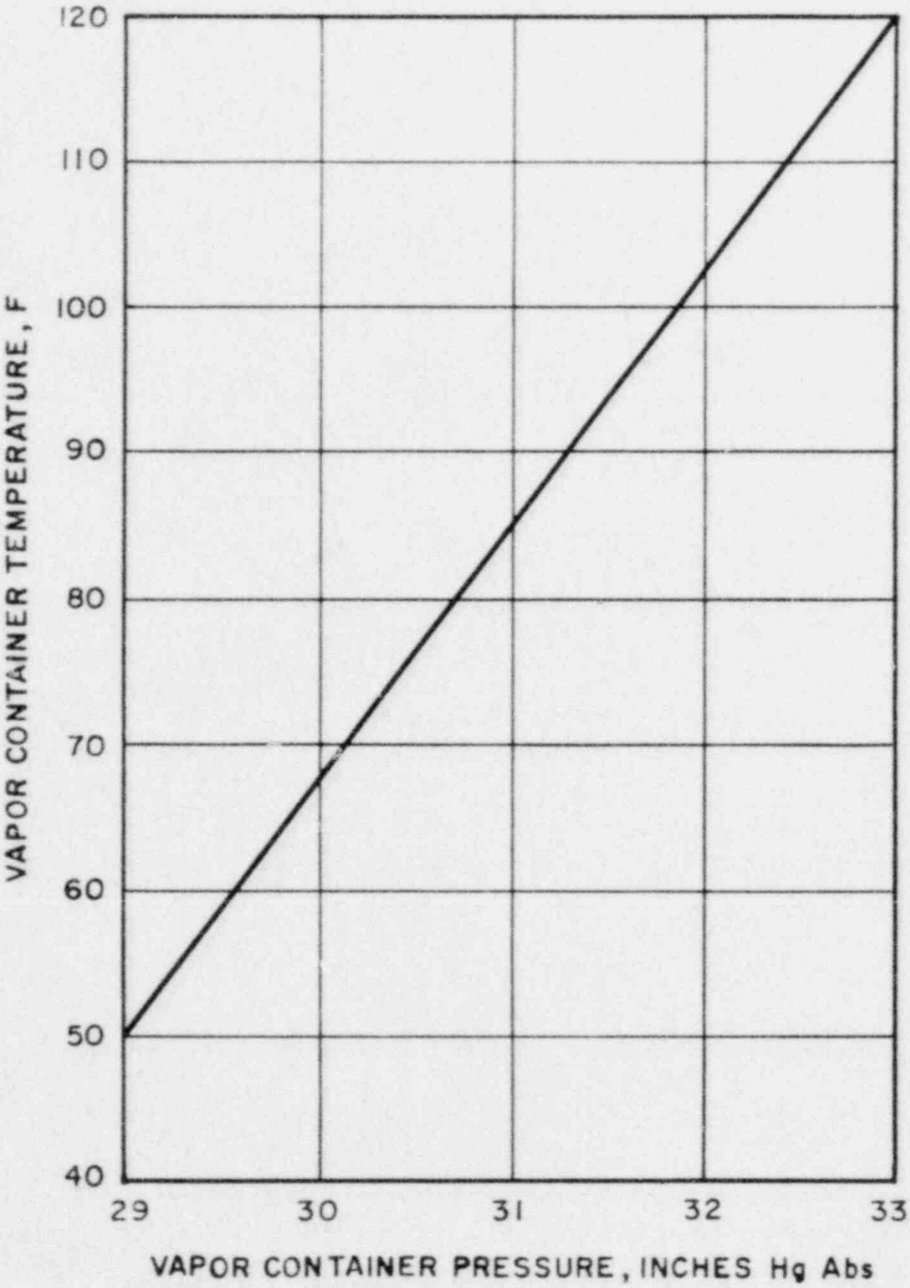
Prior to initiation of this O.I. all equipment within the vapor container requiring manual adjustment or checking must be lined up for power operation. See system diagram on page 504Q:3. These are:

1. Open block and by-pass valves around the differential pressure recorder and the U-tube manometer. The instruments should read zero.

2. Close both the block valve on the outlet of pressure trip valve and the by-pass valve around air meter.

3. Open the appropriate trip valves and adjust the pressure reducing valve, so that pressure indicator reads 2.5 psi gage.

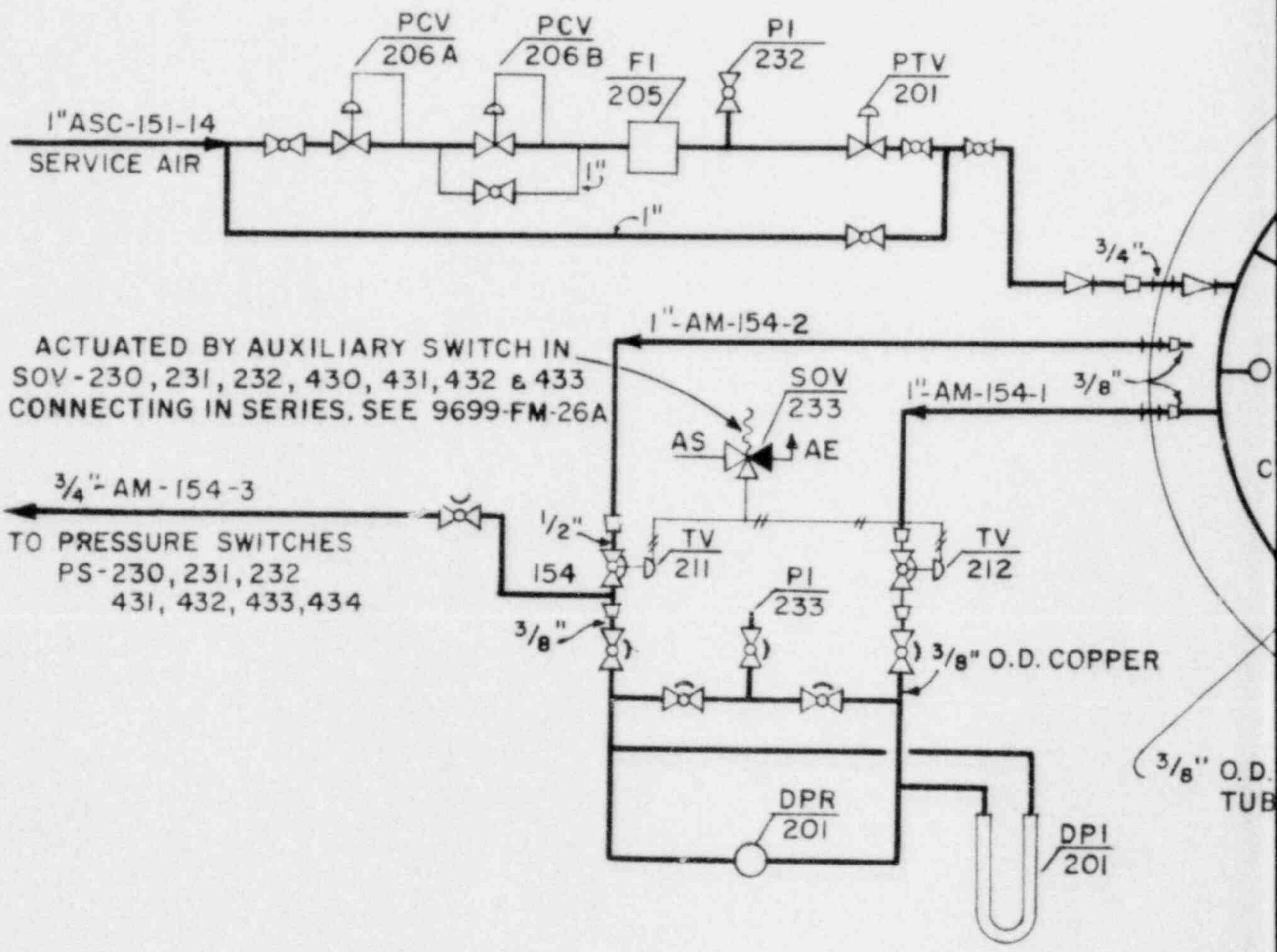
4. Record the register reading on the air meter.

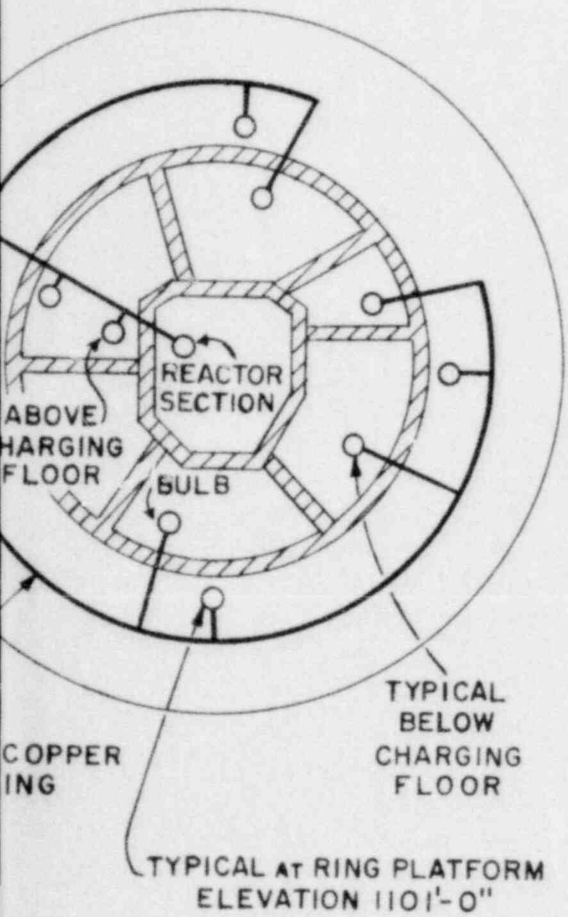


GIVEN VAPOR CONTAINER TEMPERATURE, PRESSURE SHALL BE MAINTAINED WITHIN ±0.5 INCHES Hg OF NORMAL BY ADDING AIR.

AFTER CONTAINER HAS BEEN OPENED, PRESSURE SHALL BE RAISED TO NORMAL VALUE BY ADDING AIR

NORMAL VAPOR CONTAINER
PRESSURE vs TEMPERATURE


PCV 206A
PCV 206B
FI 205
PI 232
PTV 201
1"ASC-151-14
SERVICE AIR
1"
1"
3/4"
1"-AM-154-2
ACTUATED BY AUXILIARY SWITCH IN SOV-230, 231, 232, 430, 431, 432 & 433 CONNECTING IN SERIES. SEE 9699-FM-26A
SOV 233
1"-AM-154-1
3/8"
AS
AE
3/4"-AM-154-3
TO PRESSURE SWITCHES PS-230, 231, 232 431, 432, 433, 434
1/2"
TV 211
TV 212
154
PI 233
3/8"
3/8" O.D. COPPER
DPR 201
DPI 201
3/8" O.D.
TUB
C



LEGEND

ITEM	DESCRIPTION
FI-205	DISPLACEMENT TYPE GAS METER DIRECT READING - CUBIC FEET AND TENTHS
DPR-201	DIFFERENTIAL PRESSURE RECORDER 0-20" RANGE
DPI-201	U TUBE MANOMETER
PCV-206 A	PRESSURE REDUCING VALVE OUTLET PRESSURE 10-15 PSIG
PTV-206 B	PRESSURE REDUCING VALVE OUTLET PRESSURE 70" H_2O GAGE
PTV-201	PRESSURE TRIP VALVE TO CLOSE ABOVE 100" H_2O GAGE

VAPOR CONTAINER LEAKAGE RATE DETECTION SYSTEM DIAGRAM

V. Instructions

1. Determine average air temperature inside the vapor container by the temperature indicator.

2. Determine vapor container pressure at average temperature from curve 504Q:2.

3. Add air to vapor container until value for step V.2. is reached. Air added in this step is equivalent to a vapor container internal pressure of 33 in. Hg abs when temperature is at 120 F.

4. Record the indicated vapor container pressure. Add 3 in. H_2O air pressure to the closed system.

   NOTE: Leakage out of the vapor container will be indicated by an increase in differential pressure above 3 in. H_2O on the U-tube manometer.

   CAUTION: Meteorological conditions will cause a reading deviation in the differential pressure and must be disregarded. A continuous rise in the differential pressure at the more stable predawn hours will indicate more accurately leakage conditions.

5. Check the differential pressure reading every 2 hr for the first 24 hr. Estimate the per cent air loss for the 24 hr period using the formula for per cent air loss.

6. If necessary, add air through the gas meter until the differential pressure reading reaches 3 in. H_2O. Record the registered reading on the air meter before and after the addition of air.

   CAUTION: Leak rate must not exceed 860 ft^3 in any 24 hr period. Air must be added only in predawn hours.

7. After initial 24 hr check, record differential readings every 8 hr.

8. More frequent checks of the differential air needed if a sharp rise in the differential reading on the manometer is not accompanied by a rapid fall in the ambient air temperature.

9. Likely sources of leakage should be checked if excessive leakage (more than 0.5 in. per 24 hr) from the vapor container is apparent. These are: 1) personnel hatch seals, 2) air purge valve open, 3) air particle monitor, 4) vapor container drain lines to drain tank. These leaks need to be eliminated or plant shutdown conditions initiated.

VI. Final Conditions

Continuing test and pressure conditions are maintained inside the vapor container in relationship to the internal temperature according to curve 504Q:2. If necessary, air, corrected for temperature and pressure conditions, is added through the air meter to retain the same reading on the differential pressure recorder as indicated at the start of the test.

B. RECIRCULATION AND COOLING

I. Objective To provide a safe and efficient method to startup, operate to remove heat from the vapor container atmosphere, and shut down the system.

II. Conditions

1. Operation is normally required if the outdoor air temperature is above 50 F.
2. Vapor container cooler booster pumps are ready for startup.
3. Valves on supply and discharge side of coolers are closed.
4. Trip valve in cooling water discharge header is open.
5. Service water system in normal operation.

III. Precautions

1. Check that no personnel are working on vapor container air recirculation fans if vapor container is open for maintenance purposes.
2. Do not run vapor container cooler booster pumps unless supply and discharge valves on at least one of the coolers are open.
3. Valves in lines supplying steam to heating coils are closed.

IV. Instructions

1. Start at least two air recirculation fans.
2. Open gate valves in cooling water supply lines to vapor container air coolers.
3. Open globe valve in cooling water discharge line of one of vapor container air coolers.
4. Start vapor container cooler booster pump.
5. Permit water to flow through open vapor container cooler water circuit until air is purged from circuit.
6. Open globe valve on second air cooler, close globe valve on first air cooler and repeat purging operation.
7. Repeat purging operation for all coolers. Close discharge globe valves on coolers of fans not in service.

8. Open all globe valves in discharge lines of all coolers to be placed in service.

9. Observe bulk air temperatures in various areas of container on remote reading temperature indicator in control room.

10. Throttle cooling water flow uniformly for each air cooler circuit to maintain bulk air temperature in any area of the container below 120 F. Uniformity of adjustment of water flow is indicated by thermometers on cooling water discharge lines.

11. To shut down recirculation and cooling cycle:

    a. Stop vapor container cooler booster pump.

    b. Permit water to drain through globe valves on cooling water discharge.

    c. Close gate and globe valves on cooler circuits.

    d. Close gate valve at pump discharge.

    e. Stop recirculation fans.

    NOTE: Alternate operation of vapor container cooler booster pumps periodically to equalize wear.

V. <u>Final Conditions</u>

Bulk air temperatures inside vapor container are such that no further heat removal is required.

C. <u>RECIRCULATION AND HEATING</u>

I. <u>Objective</u> To provide a safe and effective means of starting up, heating the interior of the vapor container, and shutting down the system.

II. <u>Conditions</u>

1. Normally the outdoor temperature is 50 F or lower.
2. Gate valve supplying steam to manifold header is closed.
3. Trip valve in return header is open.
4. Condensate pumps are ready for startup.
5. Recirculation fans are ready for startup.

III. <u>Precautions</u>

1. If personnel are inside vapor container, make certain no one is working on vapor container air recirculation fans.

2. Maintain steam pressure downstream from pressure reducing valve at 15 psi gage.

3. Do not supply cooling water to air coolers.

IV. Instructions

1. Close hand control valves in steam lines to heating coils.

2. Close valves in drain lines on steam supply lines to heating coils.

3. Slowly open gate valve supplying steam to steam header.

4. Open gate valves in lines supplying steam to heating coils.

5. Slowly open hand control valve supplying steam to one bank of heating coils.

6. Crack trap by-pass valve to purge air from piping and to dispose of heavy condensate load on startup.

7. Close trap by-pass valve.

8. Repeat steps 5, 6 and 7 for each bank of heating coils.

9. Start at least two recirculation fans, in sequence.

10. Observe bulk air temperature in space between internal shielding and vapor container shell on temperature indicator in control room.

11. Uniformly throttle those hand control valves of the fans in service, in the steam supply lines to heating coils, to maintain bulk air temperature in space between internal shielding and vapor container shell above 50 F and below 100 F. Uniformity of valve adjustment may be observed on pressure indicators downstream from hand control valves.

12. To shut down heating cycle:

    a. Stop recirculation fans.

    b. Close gate valves in steam supply lines to heating coils.

    c. Close gate valves in line supplying steam to manifold.

    d. Open valves in drain lines on steam pipes to heating coils.

V. Final Conditions

Bulk air temperatures inside vapor container are such that no further heat addition is required.

D. INTERNAL AIR FILTRATION

I. Objective To provide a safe and efficient method of starting up, operating, and shutting down the internal air filtration system to control primarily the vapor container air borne particulate activity of iodine-131 and strontium-90, and also other fission products.

II. Conditions

1. Vapor container access openings and purge system butterfly valves are closed.

2. At least two vapor container air recirculation fans are in operation.

3. Radiation monitor for vapor container air borne particulate matter is in normal operation.

4. Vapor container atmosphere air borne particulate activity is above tolerance.

5. Internal air filtration fans are ready for startup.

III. Precautions

1. Do not run internal air filtration fans during dusty construction or maintenance operations.

2. Radiation monitor for vapor container air borne particulate matter must be capable of accurately indicating radiation levels.

3. During scheduled plant shutdowns, observe resistance across pre- and after-filters of each assembly. Replace filters on which activity has decayed to safe levels if the resistance exceeds the following values:

Prefilter	1.5 in. water gage
Afterfilter	2.5 in. water gage

IV. Instructions

1. Start one or two internal air filtration fans, depending upon vapor container activity level.

2. Alternate operation of internal air filtration fans so that the unit with the most running time can be stopped for a period of decay time before scheduled filter change.

3. Observe particulate activity of vapor container atmosphere on radiation monitor. Consult Technical Services representative for verification.

4. Stop internal air filtration fans when particulate activity of vapor container atmosphere is reduced to a suitable value below the selected tolerable level.

V. Final Conditions

The vapor container air borne particulate activity is below the maximum allowable level and allows initiation of purging system operation, if required.

E. PURGING

I. Objective To provide a safe and efficient method of purging the vapor container atmosphere to allowable air borne activity levels before permitting personnel to enter the vapor container.

II. Conditions

1. Main coolant system is depressurized.

2. Air borne iodine and strontium activity within the vapor container have been reduced to tolerance levels by operation of the internal air filtration system as described in Paragraph D.

3. Radiation monitor at stack discharge is in normal operation.

4. At least two vapor container air recirculation fans are in operation.

5. Purge exhaust fan; butterfly valves and by-pass valve are ready for operation.

III. Precautions

1. The equipment hatch and one door of the vapor container personnel hatch must be closed until purging operation has reduced the internal air borne activity to allowable levels. Refer to Section 507, RADIOLOGICAL HEALTH AND SAFETY.

   Personnel entering the vapor container during the purging operation must wear protective clothing and face masks.

2. Cross connection between purge exhaust fan and exhaust fan for contaminated area of the Primary Auxiliary Building shall be closed.

3. Radiation monitor at stack discharge must be capable of accurately indicating radiation levels.

4. When the outdoor temperature is below 50 F, the purge supply air shall be heated to 50 F by adjusting the valve in the steam supply piping to the purge air heating coils.

5. When the outdoor air temperature is below 32 F, the heating cables on the butterfly valves at the vapor container are in operation to prevent ice formation at the valve seats.

IV. Instructions

1. Open butterfly damper in dilution air duct.

2. Start purge air exhaust fan.

3. Open 8 in. by-pass valve at vapor container slightly.

4. Open butterfly valve in supply duct to vapor container slightly.

5. Observe activity of stack effluent which must be below the maximum permissible concentration. Refer to Sections 209, RADIOACTIVE WASTE DISPOSAL SYSTEM and 507, RADIOLOGICAL HEALTH AND SAFETY.

6. Continue opening butterfly valve in supply duct to vapor container until wide open.

7. Continue opening by-pass valve, maintaining activity of stack effluent below maximum permissible concentration.

8. Close by-pass valve completely after wide open position has been attained and then open butterfly valve in purge air exhaust duct slightly, keeping activity level of stack effluent below tolerance.

9. After butterfly valve in purge air exhaust duct has attained wide open position, open by-pass valve, keeping activity of stack effluent below tolerance.

10. When both valves in the purge air exhaust ducts are wide open, close butterfly valve in dilution air duct, keeping activity of stack effluent below tolerance.

V. Final Conditions

Air borne activity of vapor container atmosphere has reached allowable levels for human occupancy without the use of gas or fresh air masks.

OPERATING INSTRUCTION NO. 504R1

ELECTRICAL SYSTEM
120 VOLT A-C VITAL BUS SYSTEM

I. Objective To provide a firm single phase alternating current supply for radiation monitors, FN nuclear instruments, pressurizer instruments, main coolant instruments and various process instruments.

NOTE: The 120 v a-c vital bus is energized from the battery source through an inverter.

II. Conditions

A. Normal Operation

1. The vital bus is normally fed from the inverter which is operated off of the battery.

B. Maintenance

1. During maintenance of inverter equipment, the vital bus will be fed from the plant alternating current bus.

III. Precautions

Manual transfer from inverter to reserve supply causes amplifiers to drop out unless the reserve supply is paralleled with the inverter before the inverter is taken out of service.

IV. Check-off List

Prior to the initiation of this O.I., the check-off list must be completed by the operator(s) and signed off.

V. Instructions

A. Normal Operation

1. With load removed, close direct current motor contactor.

2. Adjust generator voltage at 120 v and frequency at 60 cycles.

3. Close inverter air circuit breaker to vital bus and air circuit breakers to various instrumentation feeders.

4. Adjust voltage and frequency, if required.

B. Maintenance

1. Check voltage and frequency of inverter.
2. Check voltage of reserve supply.
3. Adjust inverter frequency, if required.
4. Synchronize inverter with reserve supply.
5. Close reserve air circuit breaker.
6. Open inverter air circuit breaker.
7. Trip direct current motor contactor of inverter.

VI. Final Conditions

Operation of instrumentation is secure from either supply.

OPERATING INSTRUCTION NO. 504R2

ELECTRICAL SYSTEM
125 VOLT D-C SYSTEM

I. Objective To furnish reliable direct current power to control boards, switchgear for breaker operation, emergency lighting, rod drives, nuclear instrumentation, generator emergency seal oil pump, and emergency turning gear oil pump.

II. Conditions

1. Each battery operates independently with its own charger.

2. A bus tie manually operated switch is provided in order to continue operation of the battery system during maintenance of a battery charger.

III. Precautions

1. The battery chargers should not be paralleled.

2. Batteries should be kept in a fully charged condition at all times due to the emergency services that may be imposed on them without warning.

IV. Check-off List

Prior to the initiation of this O.I., the check-off list must be completed by the operator(s) and signed off.

V. Instructions

1. Check battery voltage and specific gravity.

2. Check charging rate.

VI. Final Conditions

Batteries will be kept fully charged with the battery chargers carrying station load plus charging load and the battery discharge on peak loads will be kept to a minimum.

OPERATING INSTRUCTION NO. 504R3

ELECTRICAL SYSTEM
STATION POWER SYSTEM

I. Objective To provide a safe and proper method of operation of station power system to insure a reliable alternating current supply for station auxiliaries during start-up, normal operation, and shutdown.

NOTE: Where equipment is indicated by number in the following, refer to drawing No. 9699-FE-1B, Schematic Diagram - Meters, Relays & Synchronizing, included in Section 226.

II. Condition

A. Startup

1. 115 kv line energized and 115 kv oil circuit breakers open.

2. 2,400 v bus sections Nos. 2 and 3 energized via respective station service transformer Nos. 2 and 3.

3. 480 v bus sections Nos. 5-2 and 6-3 energized via respective station service transformer Nos. 5 and 6.

4. 2,400 v bus section No. 1 energized from either section No. 2 or No. 3.

5. 480 v bus section No. 4-1 energized from either section No. 5-2 or No. 6-3.

B. Normal Operation

1. Same as Step No. 1 under Section II-A except 115 kv oil circuit breakers closed.

2. Same as Step No. 2 under Section II-A.

3. Same as Step No. 3 under Section II-A.

4. 2,400 v bus section No. 1 energized via station service transformer No. 1.

5. 480 v bus section No. 4-3 energized via station service transformer No. 4.

C. Shutdown

All items the same as Section II-A except 115 kv oil circuit breakers may be closed under dispatcher's orders after unit is cleared from 115 kv bus in order to make tie between lines.

III. Precautions

1. Under conditions of Section II-A and C, select station auxiliaries so that load will be distributed between transformers Nos. 2 and 3 as permitted by the particular operating condition.

2. Under no conditions shall the 115 kv system be connected through the 2,400 v or 480 v bus by means of their bus tie breakers, when either or both of the 115 kv oil circuit breakers are open.

3. Plant operator should utilize all visual indication provided such as ammeter, voltmeter, operating lights, and control switch target so as to be aware at all times of the physical condition of the electrical system.

IV. Check-off List

Prior to the initiation of this O.I., the check-off list must be completed by the operator(s) and signed off.

V. Instructions

Accepted switching procedure will be employed while performing any manual switching operation associated with the 115 kv lines or bus, transformers, 2,400 v and 480 v buses, and phasing of the generator to the system. The plant operator will work in conjunction with Dispatching Department of the New England Electric System for proper switching procedure on its equipment and for coordinating its operation into the interconnected electrical system. The daily load schedule, however, will be determined by Yankee, and all auxiliary equipment using electrical power from either the 2,400 v or 480 v bus will be placed in operation by plant personnel in accordance with its particular plant operating instructions without notifying the dispatcher.

The dispatcher will be involved on any operation affecting the condition of the 115 kv system and the procedure that will be followed is outlined as follows:

1. The plant operator notifies dispatcher of required operation.

2. The dispatcher will issue a verbal switching instruction to be recorded in the log book by the plant operator.

3. The plant operator will carry out instructions and report back to dispatcher that the operation has been completed.

It is not necessary to cover all the various switching procedures that are required for plant operation but only those specific instructions which apply for the conditions listed in Section II.

A. Startup

The electrical system has been energized fulfilling the preceding Step Nos. 1, 2, and 3 in accordance with basic switching procedures.

1. Operator's instructions to energize 2,400 v bus section No. 1 from bus section No. 2 would be as follows:

   a. Check open airbreak 1S18 and air circuit breakers 124, 1224 and 1324 and bus dead.

   b. Check all load disconnected.

   c. Close air circuit breaker 1224 synchronizing switch and check scope voltmeters for bus 2 alive and bus 1 dead.

   d. Close air circuit breaker 1224 energizing bus 1 and check alive.

   e. Open synchronizing switch.

   NOTE: Air circuit breaker 1324 may be substituted for air circuit breaker 1224 in c. and d. if bus 1 is to be energized from bus 3.

   Auxiliary equipment fed from bus 1 can now be placed in operation in accordance with plant instructions.

2. A similar set of operator's instructions as per Section V-A, Step No. 1 would cover energizing the 480 v bus 4-1 from bus 6-3 or 5-2.

B. Normal Operation

The turbine generator has been brought up to speed in accordance with O.I. No. 504A4, PLANT STARTUP - TURBINE GENERATOR STARTUP FROM COLD CONDITION or O.I. No. 504A5, PLANT STARTUP - TURBINE GENERATOR START-UP FROM HOT CONDITION, and the generator is ready to assume field.

1. Plant operator will notify dispatcher that generator is being readied for phasing to system and will initiate the following in conjunction with the dispatcher's instructions listed in Step No. 2 under Section V-B:

   a. With automatic regulator in manual position and minimum field on main exciter, close field air circuit breaker.

   b. Manually adjust field to develop rated terminal voltage on generator.

   c. Place automatic regulator in operation by first setting in test position to establish balance against generator voltage before switching to auto position.

2. Dispatcher's instructions would be as follows for phasing generator to system:

   * a. Check oil circuit breakers Z-126 and Y-177 open and 115 kv bus dead.

   * b. Close airbreak T1.

   c. Close oil circuit breaker Z-126 synchronizing switch and observe scope voltmeter and balance generator voltage to line voltage.

   d. Observe scope and close oil circuit breaker Z-126 coincident with zero phase displacement on scope. Open synchronizing switch.

   e. Close oil circuit breaker Y-177 synchronizing switch and observe scope voltmeter and scope. Voltage variation should not be greater than 5 v on scale.

   *NOTE: a and b will be performed prior to applying field on generator.

   f. With scope steady and displacement not greater than 10 min close oil circuit breaker Y-177. Open synchronizing switch.

   NOTE: Oil circuit breaker Y-177 may be substituted for Z-126 in a. and b., and oil circuit breaker Z-126 for Y-177 in e. and f. if generator is to be phased to Y-177 line.

3. Generator can now assume minimum load in accordance with O.I. No. 504A4 or No. 504A5, and at this point the 2,400 v bus 1 and 480 v bus 4-1 will be transferred to its normal source.

4. Operator's instructions for transfer of bus 1 to normal source would be as follows:

   a. Close airbreak 1S18 and check station service transformer No. 1 alive.

   b. Close air circuit breaker 124 synchronizing switch and observe scope voltmeter and scope.

   c. With scope steady and no displacement, close air circuit breaker 124 and check for load on all three phases.

   d. Open synchronizing switch.

   e. Open air circuit breaker 1224.

5. Operator's instruction for transfer of bus 4-1 to normal source would be similar to and include only Step Nos. 4b. through 4d. since Step No. 4a. energizes station service transformer No. 4.

6. With this completed, the turbine generator can now be loaded in accordance with O.I. No. 504B2, PLANT OPERATION - INCREASING TURBINE GENERATOR LOAD. As the unit is loaded, the plant operator shall adjust main exciter field rheostat to hold proper field voltage by balancing regulator indicator at zero. When full load is reached, main rheostat shall be adjusted to give reactive component required within established limits and regulator indicator set to slight boost by voltage adjustment switch.

C. Shutdown

Load will be decreased to minimum in accordance with O.I. No. 504B3, PLANT OPERATION - DECREASING TURBINE GENERATOR LOAD, and transfer of 2,400 v bus 1 and 480 v bus 4-1 will be made. This instruction is applicable to E.I. No. 505C1, SECONDARY PLANT - EMERGENCY SHUTDOWN for conditions stated therein except when entire load on unit is dumped.

1. Operator's instructions would be as follows for transferring 480 v bus 4-1 to bus 6-3.

    a. Check open air circuit breakers 4548 and 4648 and load on station service transformer No. 6.

    b. Close air circuit breaker 4648 synchronizing switch.

    c. With scope steady and no displacement, close air circuit breaker 4648 and check for increase in load on all three phases of station service transformer No. 6.

    d. Open synchronizing switch.

    e. Open air circuit breaker 448 and check for increase of load on all three phases of station service transformer No. 6.

2. A similar set of operator's instructions as per Step No. 1 would cover transfer of 2,400 v bus 1 to bus 2 and would include deenergizing station service transformer No. 1 by opening airbreak 1S18 when all load is removed.

3. Unit may now be brought to zero load per O.I. No. 504C3, PLANT SHUTDOWN - SCHEDULED TURBINE GENERATOR SHUTDOWN and 115 kv oil circuit breakers may be tripped by hand. The generator field breaker shall be hand tripped one minute after the throttle valves are tripped.

4. In the event that system conditions require that the 115 kv oil circuit breakers be closed during a plant shutdown, the procedure indicated below will be followed:

    a. Check Z-126 and Y-177 oil circuit breakers open and 115 kv bus dead.

    b. Open airbreak T1.

    c. Turn key in interlock on airbreak T1 to lock open releasing key.

    d. Insert key in interlock at main control board and turn to by-pass position.

    e. Synchronize and close oil circuit breakers Z-126 and Y-177.

VI. Final Conditions

Plant is in a condition of either startup, normal operation or shutdown as indicated in Section II.

505 EMERGENCY INSTRUCTIONS

505A GENERAL

This section consists of emergency instructions which delineate operator action to be taken to minimize damage and limit exposure of plant personnel and the public under accident conditions. Fundamentally, the design of the plant is conservative and equipment is not likely to fail, nor is it possible for any single equipment failure or operator error to result in an accident of consequence. However, this section describes the action to be taken in accidents which involve both equipment failures and operator errors. These instructions are detailed primarily for control room operators, since they are stationed at the centralized control room where telemetered knowledge about plant conditions is received and where appropriate action to control and limit accidents can be taken. Credible accidents, covered in Section 4, ACCIDENTS AND HAZARDS, of this report, are analyzed for symptoms and control room action to be taken is then described for each case.

Even though the hypothetical accident, also described in Section 4, is not considered credible, emergency instructions are included for this accident. The measures to be taken for protection of property, plant personnel and the public are set forth in detail.

Emergency instructions included herein deal primarily with action for accidents that might occur in the nuclear portion of the plant. However, if a secondary plant accident affects the nuclear plant in such a way as to raise questions of safety, the steps to be taken are described. Detailed instructions for operator action in accidents resulting from fire, earthquake, flood, or hurricane are not included but are discussed briefly here.

Fire at the plant will be handled according to well tried methods already established for large steam generating facilities. Actually the high pressure nuclear reactor plant, fabricated of metals, operated at comparatively low temperatures, and housed in massive concrete and steel, seems almost incapable of burning. However, a fire protection system is installed, Section 229, and personnel will be trained to use it in an effective manner. Emphasis in fire protection training will center on the turbo-generator unit. Here again, however, steam temperatures at the turbine throttle are low and the likelihood of fire is reduced. Fires within the plant chain link fence will be handled by plant personnel. The Fire Department of the Town of Rowe will be notified if a fire is in progress so that areas outside the chain link fence can be put on standby observation.

Earthquakes in the region of the plant are considered most unlikely. (See Section 3.) Since plant effects in the event of an earthquake would be unpredictable, no detailed procedure has been written. Operator action would follow emergency shutdown instructions, using whatever additional measures seem advisable in the judgment of the trained operator personnel.

Possible floods in the area have been studied for many years in conjunction with the highly developed hydroelectric capability of the Deerfield River. At the Sherman hydroelectric plant, adjacent to the plant site, the crest of the spillway is at El. 998', the top of removable flashboards at El. 1,002', and the top of the earth dam at El. 1,014'. Maximum recorded pond elevation over a period of 32 yr occurred during the 1938 flood when the water reached El. 1,009.5'. The plant grade is El. 1,022', 8 ft above the top of the dam and 12.5 ft above the highest recorded flood elevation. All nuclear portions of the plant, the spent fuel storage pit and the new fuel storage vault are at or above El. 1,022'. In addition, both new and spent fuel storage facilities are arranged for subcriticality even in the completely flooded condition. Accordingly, no detailed procedure has been written for a situation involving flooding of the plant.

Hurricanes and violent windstorms do occur in the area with a frequency of about one in every 10 yr. A hurricane might cause the collapse of high line towers and result in the Yankee plant being separated from the transmission system and without auxiliary power supply. This was considered in the plant design and emergency instructions are included in this section which set up the operator action. (See Section 505B2, PRIMARY PLANT - LOSS OF LOAD ACCIDENT and Section 505D2, ELECTRICAL SYSTEM - LOSS OF A-C SUPPLY.) In one very unlikely case a hurricane might cause an interruption of long duration to the electrical supply to all four coolant pumps. Even in this case there would be no thermal damage to the core during the initial transient. Natural circulation will prevent damage to the core and an emergency power supply is provided to charge water to the primary and secondary systems if the loss of auxiliary power continues for more than an hour.

EMERGENCY INSTRUCTION NO. 505B1

PRIMARY PLANT
EMERGENCY SHUTDOWN

Any unscheduled shutdown is considered an emergency shutdown. The reactor may be shut down under emergency conditions by manually running in control rods, as necessary, to coordinate with rapid load reduction on the turbine by manual scram or by automatic scram.

I. Symptoms

Any of the following symptoms may be an indication of the emergency condition:

Low pressure in the pressurizer and/or alarm.
High neutron flux level in the reactor and/or alarm.
Short reactor period and/or alarm.
Low main coolant flow and/or alarm.
A secondary plant main turbine throttle valve trip.

See E.I. Nos. 505B3 through 505B19 for specific symptoms relating to particular primary plant emergency conditions that may lead to automatic reactor scram or manual reactor scram.

II. Immediate Action

A. Automatic Action

1. Whenever the reactor is scrammed, the turbine throttle valves trip automatically within 2 sec.

2. When the turbine throttle is tripped at loads above 15 mw, the reactor is automatically scrammed.

3. When the turbine throttle valves are tripped, the pressure in the main steam line will increase. The turbine steam by-pass line controls, sensitive to such an increase, will automatically put this system in operation.

4. Refer to E.I. Nos. 505B3 through 505B19 for specific automatic action expected under particular emergency conditions.

B. Instrument Check

Check all instruments relative to symptoms observed.

C. Manual Action

1. Emergency reactor shutdown without reactor scram.

For secondary plant failures where reactor scram and turbine trip are not used or desired the following actions are taken:

Insert reactor control rods, as necessary, to coordinate reactor shutdown with rapid load reduction on the turbine generator.

Maintain the main coolant system in a hot standby condition by turbine steam by-pass to the main condenser.

2. Reactor scram and turbine trip.

Refer to E.I. Nos. 505B3 through 505B19 for specific manual action in the case of reactor scram and turbine trip due to particular primary plant failures.

III. Subsequent Action

A. Procedure

1. Determine the cause of the emergency. If the cause can be corrected without requiring primary plant cooldown, maintain the primary plant in a hot standby condition while repairs are accomplished.

2. If the cause of the emergency cannot be corrected without primary plant cooldown, commence primary plant cooldown.

B. Action Summary

Complete the survey of the plant equipment and note action(s) taken and status of the system after completion of this procedure.

EMERGENCY INSTRUCTION NO. 505B2

PRIMARY PLANT
LOSS OF LOAD ACCIDENT

A primary plant emergency condition exists only when loss of load occurs above 15 mw. This results in the following:

Case A - loss of load causing an automatic reactor scram.
Case B - loss of load not causing an automatic reactor scram.

Case A - Loss of Load Causing an Automatic Reactor Scram

Loss of load and automatic reactor scram will occur infrequently. Automatic control of equipment during such operation insures complete safety and control of the shutdown.

Failure of the electrical transmission lines connecting the plant to the interconnected system or secondary plant equipment may cause an almost instantaneous loss of load to zero or to plant auxiliary load level. An interlock arrangement functions when certain turbine generator faults occur (with load above 15 mw), causing an automatic reactor scram. This action prevents pressurizer safety valve operation.

Case B - Loss of Load Not Causing an Automatic Reactor Scram

Although extremely improbable, two loss of load conditions exist which can cause loss of plant load but which will not cause an automatic reactor scram. These two are as follows:

(1) If, through some operating error, both main circuit breakers are opened, load will drop to auxiliary load level.

(2) If, by some fault on the interconnected system, certain circuit breakers are caused to open, separating the plant from the interconnected system, load will drop to auxiliary load level.

The turbine generator manufacturer states that these load drops will not cause turbine overspeed tripping and, therefore, automatic reactor scram on turbine tripout would not occur. In some cases, automatic reactor scram may be initiated by a loss of main coolant flow condition resulting from condition (2) above.

Operator judgment of plant and system conditions will dictate whether or not a manual reactor scram should be initiated.

I. Symptoms

Any of the following symptoms may be an indication of the emergency condition:

Reactor scram alarm indication.
Control rod indicators show all control rods inserted.
Turbine generator tripout alarms indication.
High primary coolant temperature alarm indication.
High pressurizer water level alarm indication.
Charging pump flow has decreased.
High primary coolant pressure alarm indication.
Pressurizer spray is operating.
Pressurizer solenoid operated relief valve is operating.
Reactor power output is substantially greater than the secondary plant output.

II. Immediate Action

The following actions should be initiated immediately after the indication of an emergency condition:

A. Automatic Action

Case A - Loss of Load Causing an Automatic Reactor Scram

1. Reactor is shut down by automatic scram caused by turbine generator tripout if load is 15 mw or above.

2. Control valve in the steam dump line to the secondary plant condenser opens when the steam pressure reaches 760 psi gage if the control valve is set for automatic operation.

3. Pressurizer spray is initiated at a pressurizer pressure of 2,300 psi gage.

4. Steam relief is initiated through the solenoid relief valve at a pressurizer pressure of 2,400 psi gage.

5. Pressurizer self-actuated relief valves open at pressurizer pressures of 2,485 psi gage and 2,560 psi gage.

NOTE: Pressurizer solenoid relief and safety valves should not normally operate with an automatic scram following a large loss of load and turbine tripout.

Case B - Loss of Load Not Causing an Automatic Reactor Scram

1. Control valve in the steam by-pass to the secondary plant condenser opens when the steam pressure reaches 760 psi gage if the control valve is set for automatic operation.

2. Pressurizer spray is initiated at a pressurizer pressure of 2,300 psi gage.

3. Steam relief is initiated through the solenoid relief valve at a pressurizer pressure of 2,400 psi gage.

4. Pressurizer self-actuated relief valves open at pressurizer pressures of 2,485 psi gage and 2,560 psi gage.

NOTE: Pressurizer solenoid relief and safety valves may operate if a loss of load does not trip the turbine and the reactor does not scram automatically.

B. Instrument Check

Case A - Loss of Load Causing an Automatic Reactor Scram

1. Check the secondary plant steam flow instruments for verification of stoppage or large decrease in steam flow.

2. Check the secondary plant steam temperature and pressure instruments for indication of rapidly increasing or abnormally high conditions.

3. Check the reactor power level instruments for indication of a scram condition.

Case B - Loss of Load Not Causing an Automatic Reactor Scram

Perform the instrument checks as detailed in Case A.

C. Manual Action

Case A - Loss of Load Causing an Automatic Reactor Scram

1. Check manual reactor scram control to assure that scram action has taken place.

2. Open control valve in steam by-pass to the secondary plant condenser, if not opened automatically, in time to prevent secondary plant safety valves from opening.

Case B - Loss of Load Not Causing an Automatic Reactor Scram

1. Depending on plant and system conditions, manual scram of the reactor may be initiated.

2. Open control valve in steam by-pass to the secondary plant condenser, if not opened automatically, in time to prevent secondary plant safety valves from opening.

III. Subsequent Action

A. Procedure

Case A - Loss of Load Causing an Automatic Reactor Scram

1. Check the reactor alarm and shutdown panel to verify the cause of reactor scram.

2. Determine the cause of the loss of load condition. If the cause can be corrected without requiring a plant cooldown, maintain the primary plant in a hot standby condition. Refer to O.I. No. 504D6, MAIN COOLANT SYSTEM-RUNNING OPERATION.

3. If the cause of the loss of load condition cannot be corrected without requiring a plant cooldown, initiate primary plant shutdown procedures. Refer to O.I. No. 504C2, PLANT SHUTDOWN - REACTOR COOLDOWN, E.I. No. 505C, SECONDARY PLANT - EMERGENCY SHUTDOWN AND TURBINE THROTTLE TRIP, and O.I. No. 504D7, MAIN COOLANT SYSTEM - SHUTDOWN OF COMPLETE SYSTEM.

Case B - Loss of Load Not Causing an Automatic Reactor Scram

1. Determine the cause of the loss of load condition. If the cause can be corrected without requiring a plant cooldown, maintain the primary plant in a hot standby condition. Refer to O.I. No. 504D6, MAIN COOLANT SYSTEM - RUNNING OPERATION.

2. If the cause of the loss of load condition cannot be corrected without requiring a plant cooldown, initiate primary plant shutdown procedures. Refer to O.I. No. 504C2, PLANT SHUTDOWN - REACTOR COOLDOWN, E.I. No. 505C, SECONDARY PLANT - EMERGENCY SHUTDOWN AND TURBINE THROTTLE TRIP, and O.I. No. 504D7, MAIN COOLANT SYSTEM-SHUTDOWN OF COMPLETE SYSTEM.

B. Action Summary

Case A - Loss of Load Causing an Automatic Reactor Scram

Complete the survey of the plant equipment and note action(s) taken and status of the system after completion of this procedure.

Case B - Loss of Load Not Causing an Automatic Reactor Scram

Complete the survey of the plant equipment and note action(s) taken and status of the system after completion of this procedure.

EMERGENCY INSTRUCTION NO. 505B3

PRIMARY PLANT
FUEL CLADDING FAILURE

This emergency condition is defined as a major fuel cladding failure resulting from a local cladding burnout. The plant design is such that, during normal operation, a fuel cladding failure in approximately 1% of the fuel rods can be handled by the purification system in order to maintain safe radioactivity levels in the main coolant system.

I. Symptoms

Any of the following symptoms may be an indication of the emergency condition:

1. Main coolant water impurity radioactivity, measured by sampling, is above 40 μc* per cc.

2. Operational radiation monitoring alarm may be actuated.

II. Immediate Action

Action must be taken immediately after the emergency condition is noticed in order to reduce plant contamination.

A. Automatic Action

Not required.

B. Instrument Check

None.

C. Manual Action

1. Attempt to reduce main coolant water radioactivity by operating the purification system at such a flow so as to maintain water radioactivity below 40 μc* per cc. Refer to O.I. No. 504H, PURIFICATION SYSTEM.

2. If the main coolant water radioactivity remains above 40 μc* per cc for more than 2 hr, initiate plant shutdown; refer to O.I. No. 504C1, PLANT SHUTDOWN - SCHEDULED REACTOR SHUTDOWN.

3. Initiate reactor cooldown; refer to O.I. No. 504C2, PLANT SHUTDOWN - REACTOR COOLDOWN.

*Subject to confirmation.

III. Subsequent Action

Action must be taken as soon as the main coolant water radioactivity is reduced below 0.156 μc per cc.

A. Procedure

1. Sample main coolant water for radioactivity level.

2. If radioactivity level is above 0.156 μc per cc, secure main coolant system and calculate decay time necessary to reach tolerable radioactivity level to allow discharge to the waste disposal system.

3. Replace the core. Refer to M.I, No. 506E, REACTOR REFUELING.

B. Action Summary

Complete the survey of the plant equipment and note action(s) taken and status of the system after completion of this procedure.

EMERGENCY INSTRUCTION NO. 505B4

PRIMARY PLANT
COLD WATER ACCIDENT

Since the Yankee reactor has a relatively large negative moderator temperature coefficient of reactivity, a lowering of temperature represents an addition of reactivity. Such a downward temperature change might come about through opening valves which previously had isolated a coolant loop containing water at a temperature below that of the water in the reactor core. A credible combination of interlock failure with failure to borate or failure to match temperatures leads to the maximum accident when combined in the following manner:

(a) Mechanical failure - 30 F interlock

(b) Operator error - Failure to match loop temperatures before cutting in an isolated loop

This results in the cutting in of a cold (70 F) borated (950 ppm) loop into a hot (514 F) critical system.

I. Symptoms

Any one of the following may be an indication of the emergency condition:

1. Cold leg low temperature alarm.

2. Nuclear instrument startup rate meter indicates a high startup rate.

   NOTE: Nuclear startup rate meter is in operation only at power levels less than 10%.

3. Alarm: Nuclear startup rate higher than one decade per minute.

4. Neutron flux level indicator indicates an increasing neutron flux level.

5. Sudden increase in the temperatures of the main coolant in the cut-in loop.

6. Temperature fluctuations of the main coolant in the operating loops.

7. Fluctuations in the pressurizer water level and in the main coolant pressure.

II. Immediate Action

A. Automatic Action

Depending upon the magnitude of the accident, the following may occur:

1. Reactor may scram due to a high neutron flux level or a high startup rate.

2. Pressurizer solenoid relief and self-actuated relief valves may discharge. Pressurizer spray valve may operate.

3. The feed flow is reduced to the minimum rate.

B. Instrument Check

Check all instruments relative to the symptoms observed.

C. Manual Action

Manually scram the reactor.

III. Subsequent Action

A. Procedure

1. Determine if the core has had cladding failure and if fission products have been released into the main coolant. Refer to E.I. No. 505B3, PRIMARY PLANT - FUEL CLADDING FAILURE.

2. By remote indications at the control board determine if any apparent damage occurred to the control rods. Refer to E.I. No. 505B5, PRIMARY PLANT - MALFUNCTIONING CONTROL ROD DRIVE(S).

3. If the cladding or control rods have been damaged, initiate reactor cooldown. Refer to O.I. No. 504C2, PLANT SHUTDOWN - REACTOR COOLDOWN. If not, return to normal operation. Refer to O.I. No. 504B1, PLANT OPERATION - CHANGING REACTOR LOAD.

B. Action Summary

Complete the survey of the plant equipment and note action(s) taken and status of the system after completion of this procedure.

EMERGENCY INSTRUCTION NO. 505B5

PRIMARY PLANT
MALFUNCTIONING CONTROL ROD DRIVE(S)

This emergency is defined as a stuck control rod or rods. The degree of the emergency is dependent on which rod or rods are stuck since their relative reactivity worths and their consequent effects upon the redistribution of flux and control are the criteria. A stuck rod or rods in some group other than that which is used for automatic control will not be evidenced until operational requirements necessitate movement of that group.

I. Symptoms

Any of the following symptoms may be an indication of the emergency condition:

NOTE: During steady state operation and for the condition where the number of stuck rods is less than the number of rods in the automatic control group, the only symptom of this condition will be the rod position indicators. If there is a substantial redistribution in flux, it may be evidenced by a disagreement in power level between the three flux power level channels.

For Increasing Load

1. Primary rod position indications for all rods in a group do not agree.

2. Decreasing T_{avg} of main coolant system beyond normal control range.

For Decreasing Load

1. Primary rod position indications for all rods in a group do not agree.

2. Increasing T_{avg} of main coolant system beyond normal control range.

II. Immediate Action

NOTE: Since the reactor is under administrative control, only the following automatic action should occur. As generator load is changed and performance of overall plant is surveyed at this time, the appearance of the preceding symptoms will alert the operator to the condition of malfunctioning control rods. If this condition is not recognized and proper manual action is not taken, additional automatic action will occur in that the reactor will scram, the pressurizer spray will be initiated, and the turbine will trip.

A. Automatic Action

1. For increasing load, increase of charging pump flow.

2. For decreasing load, decrease of charging pump flow.

B. Instrument Check

Check that all rods in a group are at the same level or that the relation between rods within a group is as programmed.

C. Manual Action

1. Immediately cease all turbine load changes and revert to previous fixed load.

2. If necessary, transfer reactor to manual control.

3. Further action will be determined by the amount of loss of rod effectiveness.

III. Subsequent Action

A. Procedure

1. Continue to operate under normal conditions at previous fixed power level until further action is deemed advisable.

B. Action Summary

1. Complete the survey of plant equipment and note action(s) taken and status of the system after completion of this procedure.

EMERGENCY INSTRUCTION NO. 505B6

PRIMARY PLANT
FAILURE IN REACTOR CONTROL CIRCUIT

NOTE: In taking corrective action, the control rod motion should always be in program sequence, if possible. Any other control rod motion should be used only as a last resort.

CASE A - Control Rods Fail to Move

Since the reactor is under administrative control when turbine load is being changed, the condition should be observed before there is a low pressure scram.

I. Symptoms

Any of the following symptons may be an indication of this emergency condition:

For increasing turbine generator load:

1. Reactor power level is less than turbine power level.
2. Low cold leg temperature indication.
3. Low pressurizer level indication.
4. Low pressure indication on Alarm and Shutdown Panel.
5. Low pressurizer pressure indication.
6. Primary and secondary rod position indicators indicate different rod positions.
7. No rod motion when on automatic control above 10% power level with T_{avg} outside of dead band.
8. Indication of scram on nuclear section of control board.
9. Permissive relay light is on.

For decreasing turbine generator load:

1. Reactor power level is higher than turbine power level.
2. High hot leg temperature indication.
3. High pressurizer level indication.
4. High pressurizer pressure indication.

5. Indication that spray valve on pressurizer is open.

6. Indication that solenoid operated relief valve on pressurizer is open.

7. No rod motion when on automatic control above 10% power level with T_{avg} outside of dead band.

8. Permissive relay light is ON.

II. Immediate Action

If the load on the turbine is being increased, action must be taken in approximately 2 to 3 min. Additional automatic action is not a necessity since the reactor is under administrative control during a change of load.

A. Automatic Action

Any of the following automatic actions may occur as a consequence of this emergency condition:

For increasing turbine generator load:

1. The reactor scrams.

2. Turbine trip.

3. Throttle pressure regulator reduces turbine power.

4. Charging pump goes to maximum flow.

5. Pressurizer heaters turned ON.

For decreasing turbine generator load:

1. Sp ay is initiated in pressurizer.

2. Solenoid operated relief valve opens on pressurizer.

3. Safety valves open on pressurizer.

4. Charging pump goes to minimum flow.

B. Instrument Check

1. Permissive relay light.

2. Rod selector switch position.

3. Rods operations selector position.

4. "Rods Out" and "Rods In" indicating lights.

5. "Rods Out" and "Rods In" signal lights.

C. Manual Action

1. Transfer reactor control to manual, if not already on manual control.

2. Stop load change until the trouble is corrected.

3. If necessary, transfer to another controlling rod group.

III. Subsequent Action

A. Procedure

The plant may be operated indefinitely with manual control.

B. Action Summary

Complete the survey of plant equipment and note action(s) taken and status of the system after completion of this procedure.

CASE B - Continuous Control Rod Withdrawal Initiated by Circuit Failure

If remedial action is not taken there may be center of fuel melting and the pressurizer may be filled and commence water relief from safety valves. If the reactivity withdrawal rate is fast enough to cause center of fuel melting, reactor high power level scram will be initiated.

I. Symptoms

Any of the following symptoms may be an indication of this emergency condition:

1. Reactor power level is higher than turbine power level.

2. High hot leg temperature indication.

3. High pressurizer level indication.

4. Indication that spray valve on pressurizer is open.

5. High pressurizer pressure indication.

6. Indication that solenoid operated relief valve on pressurizer is open.

7. Fail safe light and alarm from reactor servo control.

8. High power level scram.

II. Immediate Action

Approximately 10 min is available before the pressurizer begins water relief. Sufficient automatic signals are available to permit the operator to take manual control.

A. Automatic Action

Any of the following automatic actions may occur as a consequence of this emergency condition:

1. Spray is initiated in pressurizer.

2. Solenoid operated relief valve opens on pressurizer.

3. Safety valves open on pressurizer.

4. Control rods continue to move out with high T_{avg}.

5. Charging pump goes to minimum flow.

6. High power level scram.

B. Instrument Check

Check T_{ref} indicator on temperature summing unit.

C. Manual Action

1. Transfer reactor control to manual.

2. If necessary, transfer to another controlling rod group.

3. If necessary, actuate the "All Rods In" control.

III. Subsequent Action

A. Procedure

The plant may be operated indefinitely with manual control.

B. Action Summary

Complete the survey of plant equipment and note action(s) taken and status of the system after completion of this procedure.

CASE C - Continuous Control Rod Insertion Initiated by Circuit Failure

If remedial action is not taken, this condition will lead to a low pressure scram.

I. Symptoms

Any of the following symptoms may be an indication of this emergency condition:

1. Reactor power level is less than turbine power level.
2. Low cold leg temperature indication.
3. Low Pressurizer level indication.
4. Low pressure indication on Alarm and Shutdown Panel.
5. Low pressurizer pressure indication.
6. Fail safe light and alarm from reactor servo control.
7. Primary and secondary rod position indicators indicate different rod positions.
8. Primary rod position lights indicate that one or more rods are out of programing sequence.
9. Indication of scram on nuclear section of control board.

II. Immediate Action

Approximately 3 to 4 min are available prior to a low pressure scram. Prompt operator response is required to avoid this.

A. Automatic Action

Any of the following automatic actions may occur as a consequence of this emergency condition:

1. The reactor scrams.
2. Turbine trip.
3. Throttle pressure regulator reduces turbine power.
4. Control rods continue to move in with low T_{avg}.
5. Charging pump goes to maximum flow.
6. Pressurizer heaters turned on.

B. Instrument Check

1. Check T_{avg} indicator on control board.

2. Check T_{ref} indicator on temperature summing unit.

C. Manual Action

1. Transfer reactor control to manual.

2. If necessary, transfer to another controlling rod group.

III. Subsequent Action

A. Procedure

The plant may be operated indefinitely with manual control.

B. Action Summary

Complete the survey of plant equipment and note action(s) taken and status of the system after completion of this procedure.

CASE D - Partial Scram (drop one group of rods)

This will probably cause a low pressure scram, depending on the worth of the dropped group.

I. Symptoms

Any of the following symptoms may be an indication of this emergency condition:

1. Reactor power level is less than turbine power level.

2. Low cold leg temperature indication.

3. Low pressurizer level indication.

4. Low pressure indication on Alarm and Shutdown Panel.

5. Low pressurizer pressure indication.

6. Primary and secondary rod position indicators indicate different rod positions.

7. Primary rod position lights indicate that one or more rods are fully inserted.

8. Indication of scram on nuclear section of control board.

II. Immediate Action

This case will probably lead to a low pressure scram.

A. Automatic Action

Any of the following automatic actions may occur as a consequence of this emergency condition:

1. The reactor scrams.

2. Turbine trip.

3. Throttle pressure regulator reduces turbine power.

4. Charging pump goes to maximum flow.

5. Partial scram (1 group drops).

6. Pressurizer heaters turned on.

B. Instrument Check

Primary position indicating system lights.

C. Manual Action

Press the scram button.

III. Subsequent Action

A. Procedure

Determine cause of partial scram and make necessary repairs.

B. Action Summary

Complete the survey of plant equipment and note action(s) taken and status of the system after completion of this procedure.

CASE E - Turbine Is Tripped and Reactor Does not Scram Due to Faulty Control Circuitry

Pressurizer will be almost filled with water and pressurizer and steam generator safety valves will relieve steam. If feed water is lost, there will be water relief and eventually boiling in the reactor.

I. Symptoms

Any of the following symptoms may be an indication of this emergency condition:

1. Reactor power level is higher than turbine power level.

2. High hot leg temperature indication.

3. High pressurizer level indication.

4. High pressurizer pressure indication.

5. Indication that spray valve on pressurizer is open.

6. Indication that solenoid operated relief valve on pressurizer is open.

7. Turbine trip scram indication on Alarm and Shutdown Panel.

8. Indication of scram on nuclear section of control board.

II. Immediate Action

Action should be taken within 1 or 2 min if filling of pressurizer with water is to be avoided. This is based on an initial power level of 100% (482 mw core).

A. Automatic Action

Any of the following automatic actions may occur as a consequence of this emergency condition:

1. Spray is initiated in pressurizer.

2. Solenoid operated relief valve opens on pressurizer.

3. Safety valves open on pressurizer.

4. Charging pump goes to minimum flow.

B. Instrument Check

Turbine steam flow and generator load.

C. Manual Action

Press the scram button, and if necessary, manually trip both scram breakers.

III. Subsequent Action

A. Procedure

The reactor should be placed on hot standby or cooled down depending on expected time of outage.

B. Action Summary

Complete the survey of plant equipment and note action(s) taken and status of the system after completion of this procedure.

CASE F - Partial Scram (dropping of one rod)

Dropping of one rod may cause a re-distribution in power density. This may lead to a burn-out condition.

I. Symptoms

Any of the following may be an indication of the emergency condition:

1. Reactor power level is less than turbine power level.

2. Instantaneous and short term neutron flux reduction indicated on flux recorders and meters.

3. Low Pressurizer level indication with level control on "Manual".

4. Primary rod position lights indicate that one or more rods are out of programming sequence.

5. Indication of power unbalance between nuclear instrumentation channels.

II. Immediate Action

If the worth of the dropped rod is of the order of 1/2%, an undesirable re-distribution in power density will occur in 5 to 10 seconds. (Values in the preceding statement were predicted prior to operation. Experimental data indicates that, if the worth of the dropped rod is of the order of 1/4%, an undesirable re-distribution in power density will occur within approximately 30 seconds.)

A. Automatic Action

Any of the following automatic actions may occur as a consequence of this emergency conditions:

1. Load is reduced automatically to 90 MW_e.

2. Charging pump goes to maximum flow if on "Auto" control.

3. A sudden re-positioning of controlling rod group to restore T_{avg} to normal, with the control in "Auto" position.

4. A low pressure scram may occur.

B. Instrument Check

Primary position indicating system lights.

C. Manual Action

Determine that load has automatically cut back to 90 MW_e.

III. Subsequent Action

A. Procedure

1. Determine the cause of rod drop and if possible make necessary repairs.

2. If repair is not possible within 8 hours, shutdown the plant according to normal procedures.

B. Action Summary

Complete the survey of plant equipment and note action (s) taken and status of the system after completion of this procedure.

EMERGENCY INSTRUCTION NO. 505B7

PRIMARY PLANT
TOTAL LOSS OF MAIN COOLANT FLOW

The basic design of the plant provides that an emergency condition of total loss of main coolant flow will occur only with a total loss of alternating current supply. The detailed description of the total loss of main coolant flow emergency and the necessary mechanical and electrical procedures to maintain the plant in a safe condition are presented in E.I. No. 505D2, ELECTRICAL SYSTEM - LOSS OF A-C SUPPLY, Section II.

EMERGENCY INSTRUCTION NO. 505B8

PRIMARY PLANT
PARTIAL LOSS OF MAIN COOLANT FLOW

The primary plant has experienced a partial loss of main coolant flow. A signal is provided that will automatically scram the reactor and tripout the turbine generator when the flow per loop decreases by approximately 80% in any two of the four loops in operation, provided the turbine generator is at a power level above 15 mw.

I. Symptoms

Any of the following symptoms may be an indication of the emergency condition:

Complete Loss of Flow in One of Four Loops in Operation

1. Main coolant steam generator low flow alarm is actuated.

2. A main coolant pump automatic trip and trip alarm.

3. A main coolant pump overload alarm.

4. A main coolant cold leg or hot leg valve is in the closed or intermediate position.

Complete Loss of One of Three Loops in Operation

1. Reactor scram alarm is actuated.

2. Main coolant steam generator low flow alarm is actuated.

3. A main coolant pump automatic trip and trip alarm.

4. A main coolant pump overload alarm.

5. A main coolant cold leg or hot leg valve is in the closed or intermediate position.

II. Immediate Action (Approximately 3 minutes)

A. Automatic Action

Complete Loss of Flow in One of Four Loops in Operation

1. Decrease of turbine generator load to a level that can be properly sustained by remaining three loops in operation.

Complete Loss of Flow in One of Three Loops in Operation

1. Reactor scram, turbine tripout, and opening of turbine steam by-pass.

B. Instrument Check

Survey the nuclear section of the main control board to determine cause of partial loss of main coolant flow.

C. Manual Action

Complete Loss of Flow in One of Four Loops in Operation

1. Insure that turbine generator load has automatically decreased to a level that can be properly sustained by the remaining three loops in operation; if it has not decreased, take manual action to reduce load to appropriate level.

Complete Loss of Flow in One of Three Loops in Operation

1. Verify that reactor scram has occurred; if it has not occurred, perform manual scram.

2. Verify that turbine steam by-pass has opened; if it has not opened, perform manual opening. Adjust turbine steam by-pass controller as required.

III. Subsequent Action

A. Procedure

Complete Loss of Flow in One of Four Loops in Operation

1. Continue survey of the nuclear section of the main control board to locate cause of partial loss of flow.

2. If cause of partial loss of flow can not be located, shut down main coolant pump in affected loop. Do not isolate this loop.

3. Observe closely and record at regular short intervals the main coolant hot and cold leg temperatures in affected loop.

4. Continue to operate plant at a reduced power level commensurate with number of loops remaining in operation.

Complete Loss of Flow in One of Three Loops in Operation

1. Continue survey of nuclear section of the main control board to locate cause of partial loss of flow.

2. If cause can not be determined, isolate the affected loop and initiate plant cooldown. Refer to O. I. No. 504D8, MAIN COOLANT SYSTEM-SHUTDOWN OF INDIVIDUAL LOOPS and O. I. No. 504C2, PLANT SHUTDOWN-REACTOR COOLDOWN.

B. Action Summary

Complete the survey of the plant equipment and note action(s) taken and status of the system after completion of this procedure.

EMERGENCY INSTRUCTION NO. 505B9

PRIMARY PLANT
CHEMICAL NEUTRON ABSORBER ACCIDENTS

In this type of accident, uncontrolled criticality is of concern but is not a major problem. This instruction has been divided into two cases as follows:

Case A - Reactor Cooldown Is Initiated Before Boric Acid Is Added To The Main Coolant

Case B - Boric Acid Concentration In The Main Coolant Is Continuously Diluted While The Reactor Is In Cold Shutdown Condition With The Head On

In both of these cases the addition of reactivity is at a slow rate and even if allowed to proceed to completion, would not be likely to result in any plant damage.

Case A - Reactor Cooldown Is Initiated Before Boric Acid Is Added To The Main Coolant

The physical mechanism of the credible accident is a combination of (a), (b) and (c) below:

(a) Operator error - Failure to borate before cooldown from 514 F of the subcritical system.

(b) Operator error - Failure to position safety group before cooldown.

(c) Operator error - Failure to observe low pressure and temperature alarms.

The accident would result from a combination of (a) + (c) or (a) + (b).

I. Symptoms

Any of the following symptoms may be an indication of the emergency condition:

1. Startup rate meter showing a positive increase.

2. Source and intermediate range flux indicators in service show that reactivity is being added to the core.

3. Low pressurizer pressure and loop temperature alarms.

4. Startup rate annunciator light and horn actuated (greater than 1 decade per min).

5. Startup rate or level scram.

II. Immediate Action

If the accident results from (a) + (c), a startup rate alarm and scram or high pressure alarm and level scram will follow. If the accident results from (a) + (b), low pressure and temperature alarms are actuated and boration is required. Therefore, strictly observe the boration procedure requiring boration at 485 F.

A. Auto Action

If (a) + (c), safety scram.

B. Instrument Check

1. Cold leg temperature - Main coolant temperature must not go below 485 F without boration (see Section III-A, Step No. 1).

2. Main coolant pressure - Pressure should be normal if scram has occurred.

3. Neutron level recorder - Fluxes in source or intermediate range are being recorded.

4. Startup rate meter - Decreasing from a peak of 5.2 decades per minute, or less.

C. Manual Action

1. Close the turbine steam by-pass valve.

2. Check that the steam generator automatic level control has closed the flow control valve.

III. Subsequent Action (Steps Nos. 1 and 2, under Section III-A should immediately follow Section II-C)

A. Procedure

1. Start all main coolant pumps as fast as they can be put on line.

2. Add boric acid to the main coolant. Refer to O.I. No. 504G2, CHEMICAL SHUTDOWN SYSTEM - BORIC ACID ADDITION.

3. Either level temperature off when boric acid addition is complete, (Refer to O.I. No. 504K1, PRIMARY PLANT SAMPLING SYSTEM - MAIN COOLANT SYSTEM), or start turbine steam by-pass operation again when main coolant temperature reaches 515 F.

4. Proceed with cooldown. Refer to O.I. No. 504C2, PLANT SHUTDOWN - REACTOR COOLDOWN.

5. Sample the main coolant system to comply with the action summary. Refer to O.I. No. 504K1, PRIMARY PLANT SAMPLING SYSTEM - MAIN COOLANT SYSTEM.

B. Action Summary

Complete the survey of the plant equipment and note action(s) taken and status of the system after completion of this procedure.

Case B - Boric Acid Concentration In The Main Coolant Is Continuously Diluted While The Reactor Is In Cold Shutdown Condition With The Head On

(a) Operator error - Positive reactivity is added to the cold, -5% Δ K shutdown core with all rods in, by concurrent bleed of borated main coolant and feed of unborated make-up water at a rate of 100 gpm.

(b) Operator error - Operator fails to observe the increasing count rate.

I. Symptoms

Any of the following symptoms may be an indication of the emergency condition:

1. Decrease in main coolant boron concentration, as determined by analysis.
2. Scaler or source range flux recorder increase.
3. Purification flow greater than zero.
4. Temperature and pressure increase.

II. Immediate Action

A. Auto Action

Safety scram.

B. Instrument Check

1. Purification flow - should be zero.
2. Charging flow - if other than zero, suction should be from borated solutions in the boric acid mixing and storage tank or the safety injection and shield tank cavity water tank only. If it is not zero and not from above, line up to boric acid mixing and storage tank.
3. Neutron level recorder - fluxes in source or intermediate range are being recorded.
4. Startup rate meter - decreasing following injection.
5. Audible scaler - count decreasing following injection.

C. Manual Action

1. If the purification flow is not zero, close the purification flow control valve.

2. If the charging pumps are taking suction from the low pressure surge tank make-up pumps, stop the charging pumps and close the gate valve in the demineralized water supply to the charging pump suction.

3. Line up the charging and volume control system to take suction from the boric acid mixing and storage tank and to allow for discharge through the bleed line to the low pressure surge tank.

III. Subsequent Action (no time limit)

A. Procedure

1. Sample the main coolant. Refer to O.I. No. 504K2, PRIMARY PLANT SAMPLING SYSTEM - AUXILIARY SYSTEMS (Shutdown Cooling System). Prepare additional boric acid solution, if required. Refer to O.I. No. 504G1, CHEMICAL SHUTDOWN SYSTEM - BORIC ACID PREPARATION.

B. Action Summary

Complete the survey of the plant equipment and note action(s) taken and status of the system after completion of this procedure.

EMERGENCY INSTRUCTION NO. 505B10

PRIMARY PLANT
TOTAL LOSS OF MAIN COOLANT

General

In Section 4 are discussed the accidents and hazards which could arise from equipment and human failure, using credible compounding of failures. It is noted in Section 4 that credible accidents, including the maximum credible accident, will not cause radiation hazards for the public. However, a hypothetical accident has been postulated and analyzed in order to evaluate the effectiveness of containment and other safety features which are incorporated in the plant design. Calculations for this accident show that, under certain unfavorable meteorological conditions, measures might have to be taken for the protection of the public in nearby communities. Both the maximum credible accident and the hypothetical accident involve rupture of the primary system and total loss of main coolant. Accordingly, a two-step emergency plan has been formulated to be carried out if total loss of main coolant occurs.

The Massachusetts Commissioner of Public Safety has agreed that the State Police are the proper organization to handle a physical emergency involving the public in the general area of the plant. By agreement with the New York Operations Office of The Atomic Energy Commission an emergency technical group will be dispatched to the site in the event of an accident at the plant which might involve potential hazards to the public. This group will provide complete facilities for evaluating any radiological hazard to the public in the general area. The Manager of the New York Operations Office and the Massachusetts Commissioner of Public Safety each have authorized their respective organizations to work out jointly with Yankee, a detailed plan of action to be followed in dealing with any emergency situation arising from a plant accident.

The action to be taken by the control room and the shift operating personnel is outlined in detail below. The action to be taken by other plant personnel is outlined in more general terms. Two courses of action are available to these personnel, depending on whether or not plant direct radiation levels at the chain link fence exceed 1.0 r per hr. This level has been set on the basis that with direct radiation of 1.0 r per hr or less at the gatehouse, 360 ft distant from the vapor container, no significant hazard exists to the public even at the nearest public highway, 1,300 ft from the plant.

Action by Control Room

The Control Room Operators will be alerted to a total loss of main coolant accident by the following symptoms and will take the following actions:

I. Symptoms

1. Low pressure indication and alarm in main coolant system.

2. Low water level indication and alarm from pressurizer vessel.

3. High pressure indication and/or alarm from vapor container.

4. Charging pumps at maximum flow.

5. Low flow alarm - main coolant system. (Main coolant pumps are operating and main gate valves are open.)

6. Increase in vapor container temperature.

7. Operation of safety injection system (valves and pumps) as shown by indicating lights.

II. Immediate Action

A. Automatic Action

1. Reactor scrams due to main coolant low pressure and low flow.

2. Turbine trips following reactor scram.

3. Trip valves in lines going from vapor container close due to high pressure in the vapor container.

4. Safety injection system (valves and pumps) actuates due to high vapor container pressure and low main coolant system pressure.

5. Low level control valve in bleed line closes due to low level in the pressurizer.

6. Pressurizer heaters shut off due to low level in the pressurizer.

7. Standby charging pump actuates due to low level in the pressurizer.

B. Instrument Check

Check all instrument indications relative to the symptoms observed.

C. Manual Action

1. Actuate manual reactor scram.

2. Actuate the safety injection manual master control switch as a backup to "auto." Check indicating lights for correct system alignment.

3. Sound plant evacuation sirens.

III. Subsequent Action

A. Procedure

1. Stop all main coolant and charging pumps.

2. Shut down all unnecessary systems and auxiliaries.

3. Start system isolation by the following steps:

   a. Close motor operated valves in bleed line and charging line between the main coolant piping and feed and bleed heat exchanger.

   b. Close motor operated gate valve in line to pressurizer solenoid operated relief valve.

   c. Check that motor operated gate valves in main coolant system by-pass lines and shutdown cooling line are closed, as well as valves in pressurizer drain and spray lines.

4. After injecting approximately 12,000 gal of safety injection solution, reduce from full flow rate to by-pass rate by performing the following operations:

   a. Stop one safety injection pump at the safety injection panel.

   b. Check that valve in by-pass line in pump discharge header is open.

   c. Close motor operated valve in pump discharge header.

   d. Open valve in safety injection tank recirculation line.

   e. By regulation of the valve in the recirculation line and in the by-pass line, throttle the flow in the by-pass line to approximately 50 gpm.

   NOTE: Rigid conservation of water in the safety injection-shield tank cavity water tank is mandatory.

5. If the main coolant stop valves are operable, attempt to isolate rupture. Isolate two loops at a time. Flow from the safety injection system should be continued. When choosing two loops to isolate, first consider plant maintenance record and any unusual instrumentation record which may have preceded accident. After closing off two loops, watch pressure indicators closely. Wait 4 hr and if no pressure rise or water level rise into the pressurizer has been observed, open two loops; isolate and close off other two loops.

6. If isolation is successful, initiate the shutdown cooling system when pressure and temperature allow.

7. Follow water level in safety injection-shield tank cavity water tank. Take measures, as necessary, to replenish this tank with borated water or, if necessary, with unborated water.

B. Action Summary

Complete the survey of the plant equipment and note actions taken and status of plant systems after completion of this procedure.

Action by Other Shift Operating Personnel

Upon hearing the plant evacuation siren, shift operating personnel are to assemble immediately in the control room. The Shift Supervisor will direct the overall securement of the primary plant equipment, in addition to the control room action detailed above. This would include pumps and systems operable from the control room. Nonessential equipment will be shut down. The secondary plant will be shut down in a manner similar to the procedure detailed in E.I. No. 505C, SECONDARY PLANT - EMERGENCY SH[illegible]DOWN AND TURBINE THROTTLE TRIP, except that operating personnel will remai[illegible] behind the control room shield wall until radiation levels in the general plant area are determined to be within safe limits.

If the accident occurs on a backshift, holiday or weekend, the Shift Supervisor will telephone one or more members of the Plant Operations Review Committee. Upon receipt of information by telephone from the gatehouse relative to the direct radiation level emanating from the vapor container and corroboration of this level by comparison with other plant monitoring instruments, the Shift Supervisor will determine further action as follows:

1. Direct Radiation Level Greater Than 1.0 r per hr

If the Shif[illegible] [illegible]rd reports a reading of greater than 1.0 r per [illegible] [illegible]he Shift Supervisor will proceed to initiate me[illegible] [illegible] for the protection of the public by notifying [illegible] [illegible]adiological Health and Safety Officer, AEC N[illegible] [illegible]rk Operations Office, and the Massachusetts S[illegible]ate Police at the Shelburne Falls barracks.

2. Direct Radiation Level of 1.0 r per hr or Less

If the Shift Guard reports a reading of 1.0 r per hr or less, the Shift Supervisor will await the arrival of one or more members of the Plant Operations Review Committee. Neither the AEC New York Operations Office nor the State Police will be notified at this time.

Action by the Shift Guard and/or Health and Safety Supervisor

The following action is written for the Shift Guard. However, if the accident occurs while the Health and Safety Supervisor is on duty, the Shift Guard and the Health and Safety Supervisor will work as a team.

Upon hearing the plant evacuation siren, the Shift Guard will remove the plastic wrapping from one of the hand counters located in the gatehouse, put on a gas mask, and proceed outside the gatehouse. The hand counter will be placed in service and the direct radiation emanating from the vapor container will be measured for a period of 5 min. If, during this period, a value of 1.0 r per hr or less is noted, the Shift Guard will so notify the Shift Supervisor in the control room. Thereafter, the Shift Guard will not leave the gatehouse except at 15 min intervals to recheck the direct radiation level for a 5 min period.

At the first indication during a 5 min measuring period of a reading greater than 1.0 r per hr, the Shift Guard will terminate measurements and inform the Shift Supervisor. The Shift Guard will then proceed (taking certain prescribed, protective devices) to the assembly point - the Laboratory Building on the Rowe Hill Road, 2,500 ft distant from the plant. The Shift Guard will await the arrival of the State Police and the Off-Duty Shift Supervisors. He will inform Non-Shift Personnel, except technical services personnel, at the assembly point to go to their homes.

Action by Non-Shift Personnel

Administration, Maintenance and Technical Services personnel, if at the plant at the time of the accident, will proceed through the gatehouse to the parking lot. Each person will retain his individual exposure meter. Each person will then drive his automobile to the assembly point and await further orders. If sent home, no report of the accident will be made, but employees should inform questioners that official announcements will be made in due course.

Action by the Plant Operations Review Committee

If the accident occurs while the members of the Plant Operations Reveiw Committee are at the plant, they will assemble in the control room upon hearing the plant evacuation siren. If the accident occurs while the members of the Committee are off-site, they will be summoned to the plant by the Shift Supervisor and they, in turn, will summon the Off-Duty Shift Supervisors and the Health and Safety Supervisor. The Plant Operations Review Committee will evaluate the plant situation by a review of control room action and by reference to plant radiation monitoring and meteorological equipment.

If the "greater than 1.0 r per hr" plan has been initiated by the Shift Supervisor, the Plant Operations Review Committee will direct any nonessential shift operating personnel at the plant to go to their homes. They will see that the personnel remaining are supplied with gas masks. They will evaluate the exposure of operating personnel and determine a schedule of relief by other shifts. They will periodically check the direct radiation level emanating from the vapor container and review the meteorological situation based on plant instrumentation. After it has been ascertained that core cooling is under control, that the facility is secured as far as possible, and that direct radiation levels are decreasing, the Committee will leave the plant for the assembly point. They will, at the assembly point, confer with the State Police and New York Operations Office Personnel on the plant status, area contamination, and need for any further measures to protect the public.

If the "1.0 r per hr or less" plan is in operation, the Committee will re-evaluate core condition and radiation levels. If no serious direct radiation problem exists, they will dispatch one member of the operating shift to the Non-Shift Personnel assembly point to request the return of the Chemistry Personnel. Other Non-Shift Personnel will be told to go to their homes. The Committee will direct the returned Chemistry Personnel to proceed with contamination testing to determine vapor container leakage and radioisotopic hazards in the plant area. The Committee will then notify the New York Operations Office that an accident has occurred, that the situation is under control, and that no significant radiation hazard exists for the public.

Action by Off-Duty Shift Supervisors

Upon being notified of a total loss of main coolant accident, the Off-Duty Shift Supervisors will report to the assembly point. They will obtain hand counters and protective devices from the Shift Guard or the Health and Safety Supervisor. If the greater than 1.0 r per hr plan has been put into operation, they will accompany and assist State Police in carrying out any measures necessary for the protection of the public. They will also confer with and assist New York Operations Office Personnel in any way possible.

Action by State Police and AEC New York Operations Office Personnel

If called to the plant for a "greater than 1.0 r per hr" accident, the State Police will report to the assembly point and pick up protective devices from the Shift Guard. After consultation with the Plant Operations Review Committee and New York Operations Office Personnel, they will institute such measures as are required for the protection of the public, including the placing of road blocks on public highways at a safe distance from the plant and, if necessary, proceed with evacuation of the public from nearby areas. They will be assisted by two Off-Duty Shift Supervisors.

New York Operations Office Personnel will report to the assembly point where they will confer with Shift Supervisors and members of the Plant Operations Review Committee. A review of site background monitoring instrumentation records, plant monitoring records, and meteorological conditions will be made. Further radiation monitoring will be accomplished and the extent of health hazards evaluated.

EMERGENCY INSTRUCTION NO. 505B11

PRIMARY PLANT
LARGE OR PARTIAL LOSS OF MAIN COOLANT

This emergency, depending upon the size of the leak, is divided into the following categories:

Case I - Large Loss of Main Coolant

A large loss of main coolant will be the result of coolant water escaping from a ruptured main coolant system vessel or pipe at a leakage rate greater than 100 gpm, resulting in a rate of depressurization, such that some time will pass before a pressure of 300 psi gage will be reached in the main coolant system.

Case II - Partial Loss of Main Coolant

A partial loss of main coolant will be the result of coolant water escaping from a small break or hole in the main coolant system at a leakage rate of less than 100 gpm. The main coolant system pressure is maintained during this emergency condition by operation of the charging pumps.

I. Symptoms

Any of the following symptoms may be an indication of the emergency condition:

Case I - Large Loss of Main Coolant

1. Low pressure indication and alarm in main coolant system.

2. Low water level indication and alarm from pressurizer vessel.

3. High pressure indication and/or alarm from vapor container.

4. Charging pump at maximum flow.

5. Low flow alarm - main coolant system. (Main coolant pumps are operating and main gate valves are open).

6. Increase in vapor container temperature.

7. Rapid increase of water level in the component cooling surge tank followed by prolonged discharge from the tank relief valve. (Indicates a ruptured cooling coil in a main coolant pump).

8. High radiation level in the steam generator blowdown line. (Indicates a ruptured steam generator tube).

9. Operation of safety injection system (valves and pumps) may occur as shown by indicating lights.

Case II - Partial Loss of Main Coolant

1. Alarms

   a. Maximum flow - charging pump
   b. Low water level - pressurizer

2. Flow totalizer in the low pressure surge tank make-up line shows that make-up water to tank is exceeding the normal amount.

3. The bleed line flow indicator shows a lower reading than the charging line flow indicator.

4. A change in the indicated temperature of the return bleed to the low pressure surge tank.

5. An abnormal quantity of drains from the vapor container to the gravity drain tank.

II. Immediate Action

A. Automatic Action

Case I - Large Loss of Main Coolant

1. Reactor scram due to main coolant low pressure and flow.

2. Turbine trip following reactor scram.

3. Trip valves, in lines going from vapor container, close due to high pressure in the vapor container.

4. Low level control valve in bleed line closes due to low level in the pressurizer.

5. Pressurizer heaters automatically shut off due to low level in the pressurizer.

6. Stand-by charging pump actuated due to low level in the pressurizer.

7. Safety injection system (valves and pumps) may be actuated due to high vapor container pressure and low main coolant system pressure.

Case II - Partial Loss of Main Coolant (Time available is function of leakage rate)

1. Assuming a normal feed and bleed flow of 25 gpm, if main coolant loss is above 8 gpm, the charging pump flow will increase to maximum value.

2. Stand-by charging pump will be actuated, if leakage rate exceeds the make-up rate of one charging pump.

3. By automatic operation of the low pressure surge tank make-up pump and low level control valve, make-up water will be provided to the low pressure surge tank.

4. Pressurizer water level will be automatically controlled by action of the variable speed control of the charging pumps.

B. Instrument Check

Case I - Large Loss of Main Coolant

1. Check all instrument indications relative to the symptoms observed and determine from indications the approximate magnitude and rate of the main coolant loss such that this accident can be classified as a Case I or Case II condition.

Case II - Partial Loss of Main Coolant

1. Check all instruments relative to the symptoms observed.

C. Manual Action

Case I - Large Loss of Main Coolant

1. Actuate manual reactor scram.

2. Place the charging pump system into operation at full capacity.

   a. Initially charging pump suction shall be concentrated boric acid from the boric acid storage tank.

   b. When the concentrated boric acid supply is depleted, transfer the charging pump suction to the safety injection and shield tank cavity water tank.

      NOTE: After depleted, the concentrated boric acid supply must be restored as soon as possible inthe boric acid storage tank.

3. Actuate the pressurizer low level trip valve in the bleed line.

NOTE: As the system pressure decreases slowly, with 100 gpm charging rate and with a decreasing water level in the pressurizer, it may be desirable to open the solenoid operated relief valve in the pressure control system. By relieving steam from the pressurizer, the main coolant system pressure will be reduced which means a reduction in the leakage rate. With a reduced leakage rate, the pressurizer water level may possibly be restored to its normal level by operation of the charging system.

If any main coolant pumps are operating and if the system temperature is at the normal operating level, the system pressure must not be reduced below 1,200 psi gage.

4. Except when isolating one loop at a time, if possible, keep all main coolant gate valves open and maintain operation of one main coolant pump if conditions permit.

5. Shutdown all unnecessary systems and auxiliaries.

6. Actuate the safety injection master control switch and check indicating lights for correct system alignment. Take manual corrective action if necessary.

Case II - Partial Loss of Main Coolant

1. Based on the seriousness of coolant loss, close the bleed valve(s).

III. Subsequent Action

A. Procedure

Case I - Large Loss of Main Coolant

1. Proceed to locate and isolate the leak as follows:

a. Review the following instrumentation for possible indication of location of failure.

(1) Radiation monitor in the steam generator blowdown lines.
(2) Radiation monitor in the component cooling system.
(3) Check water level in component cooling surge tank.

NOTE: If it is determined that the main coolant is leaking into the component cooling system, check the component cooling effluent temperature from each main coolant pump in order to find the location of the failure. Isolate the involved loop if possible.

b. Open valves in the loop fill and chemical injection line between the charging pump discharges and the main coolant system. Close motor operated valves in the charging line between the main coolant pipe and the regenerative heat exchanger and at the charging pump discharge. If leakage reduction is not accomplished, restore the pump flow through the charging line.

c. Attempt to isolate one loop at a time by closing the main coolant stop valves. Restore the valves to the open position unless the leakage from the system is stopped.

2. If leak can not be isolated, maintain pressurizer water level near normal by proportionately decreasing the charging flow as leakage rate decreases with decreasing pressure in the main coolant system.

3. Establish reactor cooldown. Refer to O.I. No. 504C2, PLANT SHUTDOWN - REACTOR COOLDOWN.

4. When conditions are permissible enter the vapor container. Refer to M.I. No. 506D, VAPOR CONTAINER ACCESS. Locate and repair the leak as soon as possible.

<u>Case II - Partial Loss of Main Coolant</u> (Make every effort to determine cause of leakage before system is depressurized)

1. Check the following items and attempt to determine cause of partial loss of main coolant:

   a. Radiation monitors on the component cooling system and the blowdown from the secondary side of the steam generators.

   b. Temperature indicator in pressurizer safety valve discharge line (located outside vapor container, will give indication of leakage through the main coolant water relief valves and the pressurizer safety valves).

   c. Check leakage rate by loop isolation.

   d. Valve stem leak-off lines for leakage.

   e. All drain lines, including vapor container drain lines.

   f. Level of water in component cooling surge tank.

2. If break can not be isolated and the leakage rate is undesirable, but less than 100 gpm, shutdown the reactor and start cooldown of main coolant system. Refer to O.I. No. 504D7, MAIN COOLANT SYSTEM - SHUTDOWN OF COMPLETE SYSTEM.

B. <u>Action Summary</u>

For Cases I and II, complete the survey of the plant equipment and note action(s) taken and status of the system after completion of this procedure.

EMERGENCY INSTRUCTION NO. 505B12

PRIMARY PLANT
NEUTRON SHIELD TANK LEAK

Loss of water from the neutron shield tank can occur by leakage through an unwanted opening or crack in the neutron shield tank during otherwise normal reactor operation. A very low leakage rate that can be handled by the outer concrete shield drain and allows the water level in the neutron shield tank to be maintained by the addition of water through the fill line may permit continuing operation of the primary plant. Leakage of water into the inner shield annuli or any other leakage rate to the outer shield annuli, too large to maintain neutron shield tank water level, will require immediate shutdown of the primary plant.

I. Symptoms

Checking of telltale drains (by uncapping) will be performed on a regular schedule in order to detect any small neutron shield tank leakage.

Any of the following symptoms may be an indication of the emergency condition:

1. Low water level alarm indication for the neutron shield surge tank.

2. Low temperature indication for the neutron shield tank.

3. Low temperature indication for component coolant water from neutron shield tank cooling coils.

4. Low reading indication from neutron detectors.

II. Immediate Action

A. Automatic Action

No automatic action is required since the neutron shield tank system is static, separated from other plant systems, and requires no automatic control during normal operation.

B. Instrument Check

1. Check the low level indicator light for the neutron shield surge tank for verification of the decreasing water level.

2. Check the exit temperature indication of the neutron shield tank component cooling water for a decreasing temperature reading which indicates a decreasing water level in the neutron shield tank.

C. Manual Action

1. Immediately upon receiving the low water level alarm indication from the neutron shield surge tank, uncap the inner shield telltale drain and the concrete telltale drain and open the two diaphragm valves located under the vapor container in order to verify the actual leakage water flow.

2. If the exit temperature indication of the neutron shield tank component cooling water remains unchanged, indicating a stable water level in the neutron shield tank, observe the action of the two telltale drains.

   a. Absence of water flow from the two telltale drains indicates that the neutron shield tank proper is not leaking and that the leak is in the neutron shield surge tank or connecting lines. The two telltale drains may be recapped, the two diaphragm valves closed, and plant operation continued without the use of the neutron shield surge tank until the next scheduled reactor shutdown. Close the valve in the fill line, drain the water lost by leakage into the vapor container drain tank, and close the drain tank valve. Caution must be exercised that the water level in the neutron shield tank does not decrease during the period of operation without the use of the neutron shield surge tank.

   A very small amount of water flow from the outer concrete shield telltale drain, after the initial accumulation of water has passed, indicates that the neutron shield tank has a small leak. This drain may be recapped, the diaphragm valves closed, and the plant operation continued at the discretion of the operator(s) until the next scheduled reactor shutdown. Periodically open the telltale drain to remove the water lost by leakage and replenish through the fill line from the component cooling water header.

   c. If there is a water flow of any magnitude from the inner annuli telltale drain, prepare to decrease reactor power and shut down the primary plant. Refer to O.I. No. 504B1, PLANT OPERATION - CHANGING REACTOR LOAD, O.I. No. 504C1, PLANT SHUTDOWN - SCHEDULED REACTOR SHUTDOWN, and O.I. No. 504D7, MAIN COOLANT SYSTEM - SHUTDOWN OF COMPLETE SYSTEM.

3. If the exit temperature indication of the neutron shield tank component cooling water decreases, indicating a decreasing water level in the neutron shield tank, prepare to decrease reactor power and shut down the primary plant. Refer to O.I. No. 504B1, PLANT OPERATION - CHANGING REACTOR LOAD, O.I. No. 504C1, PLANT SHUTDOWN - SCHEDULED REACTOR SHUTDOWN, and O.I. No. 504D7, MAIN COOLANT SYSTEM - SHUTDOWN OF COMPLETE SYSTEM.

NOTE: This high leakage rate from the neutron shield tank will result in a large amount of water flow from one or both of the telltale drains. The two diaphragm valves should then be closed.

4. Close the valve in the fill line, if it is not already closed.

5. Decrease the flow of component coolant water to the neutron shield tank cooling coils.

NOTE: In case of a gross leak in the neutron shield tank, the lower portion of the reactor vessel will become submerged in leakage water. The severity of the thermal shock to the reactor vessel will be lessened, if the temperature of the reactor vessel wall and the temperature of the neutron shield tank water can be made to approach each other before contact. Steps Nos. 4 and 5 will tend to achieve this.

CAUTION: The temperature of the neutron detectors should not exceed 176 F.

III. Subsequent Action

A. Procedure

Prepare to repair the neutron shield tank when primary plant shutdown is complete. Refer to M.I. No. 506B8, PRIMARY PLANT - NEUTRON SHIELD TANK MAINTENANCE.

B. Action Summary

Complete the survey of the plant and equipment and note action(s) taken and status of the system.

EMERGENCY INSTRUCTION NO. 505B13

PRIMARY PLANT
EXCESSIVE RADIOACTIVITY LEVEL

This emergency instruction is an instruction primarily for operational radiation monitoring which may be observed in the control room. Any other excess radioactivity at the plant site will be detected by portable detection equipment through routine plant survey, which is explained in Section 507, RADIOLOGICAL HEALTH AND SAFETY. The emergency condition, if ignored, may lead to serious health hazard or plant contamination.

I. Symptoms

Any of the following symptoms may be an indication of the emergency condition:

1. The vapor container air particle detector alarm is actuated.
2. The component cooling water detector alarm is actuated.
3. Any of the steam generator leak detector alarms is actuated.
4. The primary vent stack discharge detector alarm is actuated.
5. The air ejector effluent detector alarm is actuated.

II. Immediate Action

To prevent any health hazard or plant contamination, action must be taken immediately after the emergency condition has occurred.

A. Automatic Action

Not required.

B. Instrument Check

Request laboratory to verify reading of instruments in question.

C. Manual Action

1. If the vapor container air particle detector alarm is actuated:

a. Reduce air-borne activity in the vapor container; refer to O.I. No. 504Q, VAPOR CONTAINER ATMOSPHERE CONTROL SYSTEMS.

b. If the normal radioactivity level cannot be restored, initiate reactor shutdown; refer to O.I. No. 504C1, PLANT SHUTDOWN - SCHEDULED REACTOR SHUTDOWN.

c. Continue ventilation operation; if normal radioactivity level cannot be restored, initiate reactor cooldown; refer to O.I. No. 504C2, PLANT SHUTDOWN - REACTOR COOLDOWN.

2. If the component cooling water detector alarm is actuated:

   a. By the use of a portable radiation detector, check the radioactivity level of each of the four component cooling pipes downstream of the main coolant pumps (outside vapor container).

   b. If the increase in radioactivity of the component cooling water is mainly caused by leakage through one main coolant pump, initiate shutdown of the corresponding loop; refer to O.I. No. 504D8, MAIN COOLANT SYSTEM - SHUTDOWN OF INDIVIDUAL LOOPS.

   c. If the increase in radioactivity of the component cooling water is caused by leakage through more than one main coolant pump or by an undetermined reason, initiate reactor shutdown and reactor cooldown; refer to O.I. No. 504C1, PLANT SHUTDOWN - SCHEDULED REACTOR SHUTDOWN and O.I. No. 504C2, PLANT SHUTDOWN - REACTOR COOLDOWN.

3. If any of the steam generator leak detector alarms are actuated:

   a. Immediately discontinue blowdown.

   b. Arrange blowdown system valves manually to direct blowdown to the primary building sump tank.

   c. Initiate blowdown as operating conditions require.

   d. Check radiation detector locally to verify monitor indication.

   e. If monitor indication is substantiated, determine whether the loop is to be:

      1. Isolated according to O.I. No. 504D8, MAIN COOLANT SYSTEM - SHUTDOWN OF INDIVIDUAL LOOPS,

      2. Operated with blowdown discharged to waste disposal, or

      3. Operated with blowdown discharged to the environment using characterized MPC.

      This decision will be based on waste disposal system capacity, magnitude of leak between primary and secondary systems, and the isotopic analysis of the blowdown.

4. If the primary vent stack discharge detector alarm is actuated:

   a. Stop waste disposal plant gas discharge to the primary auxiliary building exhaust fan suction. Reset alarm.

   b. Check radioactivity level in the filled gas decay drum. Refer to O.I. No. 504L2, RADIOACTIVE WASTE DISPOSAL SYSTEM - GASEOUS WASTE DISPOSAL.

   c. Check air ejector effluent monitor. If alarm continues, sample air ejector effluent. If discharged activity is higher than allowable, shut down plant if corrective action cannot be taken.

5. If the air ejector effluent detector alarm is actuated:

   a. Check radiation detector locally to verify monitor indication.

   b. If monitor indication is substantiated, check steam generator leak detectors to locate leaking steam generator and determine whether the loop is to be:

      1. Isolated according to O.I. No. 504D8, MAIN COOLANT SYSTEM - SHUTDOWN OF INDIVIDUAL LOOPS,

      2. Operated with blowdown discharged to the waste disposal, or

      3. Operated with blowdown discharged to the environment using characterized MPC.

   This decision will be based on the need to discharge waste disposal system gaseous wastes, the magnitude of the leak between the primary and secondary systems, and the isotopic analysis of the air ejector effluent.

III. <u>Subsequent Action</u>

Action must be taken as soon as the radioactivity level is below tolerance.

A. <u>Procedure</u>

1. Investigate the cause of excessive radioactivity level.

2. Make necessary repairs and decontaminate, as required.

3. Refer to Section 507, RADIOLOGICAL HEALTH AND SAFETY for any operation involving radiation hazard.

B. Action Summary

Complete the survey of the plant equipment and note action(s) taken and status of the system after completion of this procedure.

EMERGENCY INSTRUCTION NO. 505B14

PRIMARY PLANT
MALFUNCTION OF PRESSURE RELIEF AND SAFETY VALVES

One or more of the primary plant relief or safety valves, consisting of the pressurizer safety valves, solenoid relief valve and loop safety valves, is leaking due to a worn seat or disc or due to a failure to reseat properly after opening to relieve pressure or vent gases (solenoid valve operation). A high leakage rate may cause a reactor scram or may require immediate shutdown of the primary plant. Small leakage rates may not depressurize the primary plant, but would damage the valves if permitted to continue.

I. Symptoms

Any of the following symptoms may be an indication of the emergency condition:

High relief valve discharge piping temperature.

Increased charging pump flow.

Standby charging pump operation and alarm indication.

Decreasing pressurizer water level.

Low pressurizer water level alarm indication.

Low primary plant pressure alarm indication.

High temperature and/or pressure alarm indication for the low pressure surge tank.

Reactor low pressure scram alarm indication.

II. Immediate Action

The degree of leakage, or the rate of pressure decrease due to the leakage, will dictate whether the following actions must be initiated immediately or at the discretion of the operator(s).

A. Automatic Action

1. Pressurizer heaters energized due to low primary plant pressure.

2. Charging pump flow increased by pressurizer water level control.

3. Reactor is shut down by automatic scram due to very high leakage rates causing a low primary plant pressure.

B. Instrument Check

Check all relief valve discharge piping temperatures. A temperature above normal, or ambient, temperature indicates that the associated valve is leaking.

C. Manual Action

1. Start one or more charging pumps as required to stop or reduce the primary plant pressure decrease. Refer to O.I. No. 504F, CHARGING AND VOLUME CONTROL SYSTEM.

2. If the apparent leakage rate or rate of pressure decrease is high but has not resulted in a reactor scram, prepare to decrease reactor power and shut down the primary plant. Refer to O.I. No. 504B1, PLANT OPERATION - CHANGING REACTOR LOAD, O.I. No. 504C1, PLANT SHUTDOWN - SCHEDULED REACTOR SHUTDOWN, and O.I. No. 504D7, MAIN COOLANT SYSTEM - SHUTDOWN OF COMPLETE SYSTEM.

3. If a check of the relief pipe temperature detectors indicates that the solenoid operated relief valve is leaking, close the motor operated pressure relief isolation valve and turn the solenoid relief valve control board switch from "Automatic" to "OFF" position. If leakage has stopped, establish normal operating conditions that existed before the emergency and continue power generation.

4. If any of the pressure relief or safety valves are leaking and the leakage rate is excessive, continue with plant shutdown operations.

III. Subsequent Action

A. Procedure

1. If the solenoid valve was the cause of leakage, open motor operated relief isolation valve, and open and close solenoid valve in an attempt to improve the valve reseating and stop leakage. Care should be exercised to prevent excessive depressurization of the main coolant system, since the reactor is still producing power.

2. If solenoid valve leakge stops, return to normal operating condtions with motor operated relief isolation valve open.

3. If solenoid valve leakage continues, return to normal operating conditions with motor operated relief isolation valve closed.

4. If any of the pressure relief or safety valves are leaking, prepare to repair the valve(s) when primary plant shutdown is complete.

NOTE: An attempt may be made to reseat the pressurizer safety valve(s) using the manual lifting lever on the valve while the plant is pressurized and the reactor is subcritical so that plant cooldown is avoided. If this attempt fails, continue with plant shutdown and cooldown.

B. Action Summary

Complete the survey of the plant and equipment and note action(s) taken and status of the system.

EMERGENCY INSTRUCTION NO. 505B15

PRIMARY PLANT
MALFUNCTION OF PRESSURIZER PRESSURE AND LEVEL CONTROL

Case A - Malfunction of Pressurizer Narrow Range Pressure Detector

Since the pressure signal is used to control the heaters, surge spray, relief, and scram functions, the malfunctioning condition should be corrected before a low or high pressure occurs.

Case B - Malfunction of Pressurizer Narrow Range Level Detector

Since the level signal is used to control the feed flow, the malfunctioning condition should be corrected before either a high or a low pressurizer level occurs (low pressurizer level will cause pressurizer heaters burnout).

I. Symptoms

Any of the following symptoms may be an indication of the emergency condition:

Case A - Malfunction of Pressurizer Narrow Range Pressure Detector

1. Pressurizer pressure detector fail safe alarm is actuated.
2. Low or high pressure alarm is actuated.
3. Pressurizer pressure indication is different from main coolant pressure indication.
4. Pressurizer pressure indication is not consistent with pressurizer water temperature indication.
5. Heaters are automatically energized and main coolant pressure indication is above 2,030 psi gage.
6. Surge spray valve is energized and main coolant pressure indication is below 2,250 psi gage.
7. Solenoid relief valve is energized and main coolant pressure is below 2,350 psi gage.

Case B - Malfunction of Pressurizer Narrow Range Level Detector

1. Pressurizer narrow range level detector fail safe alarm is actuated.
2. Low or high level alarm is actuated.
3. Pressurizer narrow range level indication is different from pressurizer wide range level indication.

4. The following conditions are simultaneously present:

   a. Pressurizer narrow range level indication is lower than normal.

   b. Pressurizer wide range level indication is higher than normal.

   c. Pressure indication is higher than normal.

   d. Charging pump auto-start alarm is actuated.

5. The following conditions are simultaneously present:

   a. Pressurizer narrow range level indication is higher than normal.

   b. Pressurizer wide range level indication is lower than normal.

   c. Pressure indication is lower than normal.

   d. Charging pump auto-trip alarm is actuated.

II. Immediate Action

For Case A, to avoid scram or steam relief from the pressurizer, action must be taken immediately after the emergency condition is noted.

For Case B, to avoid scram or steam and water relief from the pressurizer, action must be taken less than 2 min after either the low or the high level alarm is actuated.

A. Automatic Action

Case A

1. Reactor scram if pressure drops below 1,800 psi gage.

2. Safety valves open if pressure is higher than 2,485 psi gage.

Case B

Not required.

B. Instrument Check

Case A

1. Check pressurizer water and steam temperature indication.

2. Check main coolant pressure indication.

3. Check fill line pressure indiation.

Case B

1. Check pressurizer wide range level indication.

2. Check pressurizer pressure and temperature indications.

C. Manual Action

Case A

1. If scram has not occurred:

   a. Switch the heaters, surge spray valve, and solenoid relief valve from automatic control to manual control.

   b. Adjust and maintain the pressure in the normal operating range by manual control of heaters and surge spray.

   c. Transfer the pressure control system for the pressurizer narrow range pressure detector to the main coolant wide range pressure detector.

   d. Readjust heaters, surge spray valve, and solenoid relief valve set points to operate from the wide range pressure signal.

   e. Switch the heaters, surge spray valve, and solenoid relief valve from manual control to automatic control.

2. If scram has occurred, refer to O.I. No. 504A3, PLANT STARTUP - REACTOR STARTUP FOLLOWING SCRAM CONDITION.

Case B

1. Switch the operating variable speed charging pump from automatic control to manual control.

2. Adjust feed flow to restore the normal operating level of the pressurizer.

3. Transfer the level control system from the pressurizer narrow range level detector to the pressurizer wide range level detector.

4. Readjust the variable speed charging pump range to operate from the wide range level signal.

5. Switch the operating variable speed charging pump from manual control to automatic control.

III. Subsequent Action

A. Procedure

Case A

1. Investigate the cause of narrow range pressure detector malfunction and make directed repairs.

2. Switch the heaters, surge spray valve, and solenoid relief valve from automatic control to manual control.

3. Transfer the pressure control system from the main coolant wide range pressure detector to the pressurizer narrow range pressure detector.

4. Readjust heaters, surge spray valve, and solenoid relief valve set points to operate from the narrow range pressure signal.

5. Switch the heaters, surge spray valve, and solenoid relief valve from manual control to automatic control.

Case B

1. Investigate the cause of narrow range level detector malfunction and make directed repairs.

2. Switch the operating variable speed charging pump from automatic control to manual control.

3. Transfer the level control system from the pressurizer wide range level detector to the pressurizer narrow range level detector.

4. Readjust the variable speed charging pump range to operate from the narrow range level signal.

5. Switch the operating variable speed charging pump from manual control to automatic control.

B. Action Summary

Case A

Complete the survey of the plant equipment and note action(s) taken and status of the system after completion of this procedure.

Case B

Complete the survey of the plant equipment and note action(s) taken and status of the system after completion of this procedure.

EMERGENCY INSTRUCTION NO. 505B16

PRIMARY PLANT
FAILURE OF REGENERATIVE HEAT EXCHANGER

Case A - Bleed (Tube) Side Failure and
Case B - Feed (Shell) Side Failure

Although very improbable, failure of a 2 in. nozzle in the regenerative heat exchanger would be a serious emergency. The heat exchanger is designed to withstand maximum possible induced stress but is operated on a limited load change schedule, therefore reducing to an absolute minimum the possibility of inducing repeated high thermal and pressure stresses that could endanger the unit.

Case C - Failure Between Bleed (Tube) and Feed (Shell) Side

A tube to shell side failure in the regenerative heat exchanger would be a minor emergency.

I. Symptoms

Any of the following symptoms may be an indication of the emergency condition:

Case A - Bleed (Tube) Side Failure

1. Sharp drop in main coolant and pressurizer pressure, low pressure alarm actuated, reactor scram, and turbine trip.

2. Sharp drop in pressurizer water level and charging pump automatic start alarm.

3. Increase in regenerative heat exchanger compartment temperature.

4. Sharp increase or decrease on feed temperature indicator.

5. Sharp drop in bleed flow.

Case B - Feed (Shell) Side Failure

1. Sharp drop in main coolant and pressurizer pressure, low pressure alarm actuated, reactor scram, and turbine trip.

2. Sharp drop in pressurizer water level and charging pump automatic start alarm.

3. Increase in regenerative heat exchanger compartment temperature.

4. Sharp increase in feed temperature approaching 530 F.

5. Sharp increase in bleed temperature.

6. Increase in low pressure surge tank temperature.

Case C - Failure Between Bleed (Tube) and Feed (Shell) Sides

1. Decrease in feed temperature.

2. Decrease in bleed temperature.

3. Increase in water purity of bleed line samples.

4. Concentration of impurities in the main coolant system and lack of response to water conditioning, as noted by drain line samples.

II. Immediate Action

For Case A and Case B, any combination of symptoms including loss of main coolant pressure requires immediate action by the operator.

For Case C, no immediate danger is indicated although eventual scheduled shutdown of the plant for repairs of the regenerative heat exchanger is in order.

A. Automatic Action

Case A and Case B

1. All pressurizer heaters energized when main coolant pressure drops below 1,950 psi gage.

2. Reactor scrams and turbine trips when main coolant pressure drops to 1,850 psi gage.

3. When pressurizer water level drops below its normal control level, the second variable speed charging pump is automatically placed in service from the standby condition.

4. Bleed shutoff valve to the low pressure surge tank will close when pressurizer low water level is reached.

Case C

No automatic action required.

B. Instrument Check

Case A and Case B

Proceed immediately to "Manual" action.

Case C

Check the feed and bleed temperature instrumentation to be sure that the indication is not caused by instrument failure.

C. Manual Action

Case A and Case B

Approximately 30 sec are available in the worst possible case (complete severance of a 2 in. nozzle) before main coolant pressure reaches saturation or the pressurizer reaches low water level.

Approximately 5 min are available in the case of a complete severance of a 3/4 in. drain or vent line in the regenerative heat exchanger, before main coolant pressure reaches saturation or the pressurizer reaches low water level.

1. Actuate manual scram.

2. Simultaneously close both the motor operated bleed and feed root valves and the charging valve to the regenerative heat exchanger.

3. Switch charging pump discharge to enter the main coolant system through the fill header by simultaneous operation of the following motor operated valves:

   Open charging valve to fill header.
   Open full header root valve to one main coolant loop.

4. Put all remaining charging pumps in service to restore water level in the pressurizer.

5. If main coolant pressure drops below 950 psi gage, shut off all main coolant pumps. Steam dump to the main condenser will automatically occur, dissipating reactor decay heat by natural thermal circulation and steam flow.

Case C

No immediate manual action is necessary.

III. Subsequent Action

A. Procedure

Case A and Case B

It is estimated that up to 4 min would be required to restore pressurizer safe water level and approximately 6 min to restore system pressure to 2,000 psi gage for the worst case conditions.

1. Close all motor operated bleed flow control valves.

2. When a safe water level is established in the pressurizer, stop the charging pumps and actuate all heaters to raise main coolant pressure to a point where main coolant pumps may be operated.

3. When a minimum of 950 psi gage pressure is restored to the main coolant system, start one main coolant pump.

4. Maintain the system in hot standby condition at a pressure in excess of 950 psi gage and temperature of 514 F by turbine steam by-pass operation.

5. Determine extent of damage and prepare to commence reactor cooldown and main coolant shutdown for repairs, if required.

   NOTE: A return to power operation can only be considered if the extent of damage is definitely established as minor in nature.

Case C

As long as reasonable feed and bleed level control can be maintained, several hours are available for performance of subsequent action.

When it is decided to commence shutdown for repairs, proceed as follows:

1. Establish alternate charging pump feed to the main coolant system through the fill header by simultaneous operation of the following motor operated valves:

   Open charging valve to fill header.
   Open fill header root valve to one main coolant loop.
   Close charging valve to regenerative heat exchanger.
   Close feed root valve to the main coolant loop.
   Close all bleed valves to the low pressure surge tank.

B. Action Summary

Complete the survey of the plant equipment and note action(s) taken and status of the system after completion of this procedure. Schedule a shutdown for repairs.

EMERGENCY INSTRUCTION NO. 505B17

PRIMARY PLANT
LOSS OF SHUTDOWN COOLING

A loss of shutdown cooling presents only a limited degree of emergency for the following reasons:

Probability of equipment malfunction is low since the system is available for maintenance during plant power operation.

The low pressure surge tank cooling system is ready and available as a complete back-up, if necessary.

The associated component cooling and circulating water systems have duplicate pumps and heat exchangers available, if required.

I. Symptoms

Any of the following symptoms may be an indication of the emergency condition:

Drastically reduced or zero flow indication on the shutdown cooling flowmeter.

Abnormally low pressure indication on shutdown cooling pump discharge pressure gage.

Excessive vibration or overheating of the shutdown cooling pump.

Indication on main control board that the shutdown cooling pump circuit breaker has tripped.

Increasing main coolant temperature.

Excessive visible leakage.

Lack of temperature change across the shutdown cooler.

II. Immediate Action

Depending upon the temperature and rate of production of decay heat, a period of time (up to 2 hours) is available before an alternate method of cooling becomes mandatory.

A. Automatic Action

Since an alternate method of cooling can be initiated in a short time, automatic action as such is not required.

B. Instrument Check

Check all instruments relative to the symptoms observed.

C. Manual Action

1. Attempt to correct any minor cause of failure and restore shutdown cooling.

   NOTE: There are many reasons for which shutdown cooling might fail that would allow it to be restored almost at once.

2. If the shutdown cooling system is leaking or it is determined it can not be put back in service, isolate the pump and cooler and restore cooling by operation of the low pressure surge tank cooling pump and heat exchanger in the shutdown cooling circuit.

3. If the fault is in the component cooling system, shift to the standby component cooling pump and heat exchanger or make temporary emergency repairs,as necessary,to restore component cooling to the shutdown cooler. Resume normal shutdown cooling system operation.

   NOTE: If component cooling water pumps or heat exchangers are not available, it is possible to cross-connect the service water supply to the component cooling water header using the 4 in. blind flanged connections.

III. Subsequent Action To be used as backup action only if necessary in the event that shutdown cooling is not readily restored to operation.

A. Procedure

1. If the emergency condition occurs while the main coolant system is in its cooldown cycle from 330 F to 140 F, re-pressurize to 300 psi gage with pressurizer heaters and restore circulation with one main coolant pump to facilitate heat removal through a steam generator utilizing blowdown. Refer to O.I. No. 504C3, PLANT SHUTDOWN - SCHEDULED TURBINE GENERATOR SHUTDOWN.

2. If the emergency condition occurs during the latter phases of reactor head removal operations, commence flooding the shield tank cavity to the refueling water level by using one safety injection and shield tank cavity fill pump and discharging through one safety injection line to one main coolant loop to the inlet of the reactor vessel. Suction for the safety injection pump will be the normally lined up safety injection and shield tank cavity water tank borated water. The normal shield tank cavity fill line valve would remain closed.

B. Action Summary

Complete the survey of the plant equipment and note action taken and status of the system after completion of this procedure.

EMERGENCY INSTRUCTION NO. 505B18

PRIMARY PLANT
FAILURE OF CHARGING AND VOLUME CONTROL SYSTEM

Case A - Complete or Partial Loss of Bleed Flow

If feed flow is not reduced, pressurizer will be filled with water and commence water relief from safety valves.

Case B - High Bleed Flow or High Leakage Rate

If feed is not increased, a low pressure scram will occur.

Case C - Loss of the Normally Operating Variable Speed Charging Pump

If feed flow is not restored, a low pressure scram will occur.

Case D - Failure of Charging and Volume Control System Response to AUTOMATIC LEVEL CONTROL

Failure in response to automatic pressurizer level control will lead either to low pressure scram or to water relief from the safety valves.

I. Symptoms

Any of the following symptoms may be an indication of the emergency conditions:

Case A - Complete or Partial Loss of Bleed Flow

1. Charging pump auto-trip alarm is actuated.

2. Pressurizer narrow and wide range high level indication and alarm.

Case B - High Bleed Flow or High Leakage Rate

1. Charging pump auto-start alarm is actuated.

2. Pressurizer narrow and wide range low level indication and alarm.

Case C - Loss of the Normally Operating Variable Speed Charging Pump

1. Charging pump auto-start alarm is actuated.

2. Pressurizer narrow and wide range low level indication and alarm.

3. The normally operating variable speed charging pump has tripped.

Case D - Failure of Charging and Volume Control System Response to Automatic Level Control

1. Pressurizer narrow and wide range high level indication and alarm when feed flow is higher or equal to bleed flow.

2. Pressurizer narrow and wide range low level indication and alarm when feed flow is lower or equal to bleed flow.

II. Immediate Action

For Case A, approximately 5 min are available.

For Case B, approximately 3 min are available.

For Case C, approximately 10 min are available.

For Case D, a minimum of 5 min is available before the system will reach a low pressure scram point or a water relief point.

A. Automatic Action

Case A

Operating variable speed charging pump tripout.

Case B

Standby variable speed charging pump is started.

Case C

Standby variable speed charging pump is started.

Case D

Not required.

B. Instrument Check

Case A

1. Check bleed flow meter.

2. Check position of the valves in the bleed line.

Case B

1. Check bleed flow meter and feed flow meter.

Case C

1. Check feed flow meter.

Case D

1. None

C. Manual Action

Case A

1. Restore normal bleed flow. Refer to O.I. No. 504F, CHARGING AND VOLUME CONTROL SYSTEM.

2. If normal bleed flow cannot be restored, switch the normally operating variable speed charging pump to the OFF position.

Case B

1. Adjust the standby variable speed charging pump flow to restore normal pressurizer level.

2. If bleed flow has increased, restore normal bleed flow. Refer to O.I. No. 504F, CHARGING AND VOLUME CONTROL SYSTEM.

3. If the pressurizer level decreases below 90 in., start the constant speed charging pump.

Case C

1. Switch the normally operating variable speed charging pump to OFF.

2. Switch the standby variable speed charging pump on automatic control.

3. Reset the charging pump auto-start alarm.

4. If the pressurizer level continues to drop, start the constant speed charging pump.

5. When the pressurizer level reaches the normal operating point, stop the constant speed charging pump and reset the charging pump auto-start alarm.

Case D

1. Switch the normally operating variable speed charging pump from automatic to manual control.

2. Adjust the feed flow to restore the normal operating level of the pressurizer.

3. If needed, start the constant speed charging pump until normal operating level of the pressurizer is restored.

III. Subsequent Action (No time limit)

A. Procedure

Case A

1. Investigate the cause of decrease in bleed flow.

2. Restore normal bleed flow rate.

3. When pressurizer level reaches the normal operating point, switch the normally operating variable speed charging pump to automatic control.

Case B

1. Observe the feed and bleed flow indicators for unequal flow rates. If feed flow is greater than bleed flow, investigate cause of leakage. If bleed flow is greater than feed flow, investigate cause of increase in bleed flow.

2. When pressurizer level reaches the normal operating point, stop the constant speed charging pump.

Case C

1. Investigate the cause of charging pump failure and make necessary repairs.

2. Switch the normally operating variable speed charging pump on automatic control.

3. Transfer the standby variable speed charging pump to the standby position.

Case D

1. Investigate the cause of automatic level control failure and make necessary repairs.

2. When normal operating pressurizer level is restored, return the normally operating variable speed charging pump to automatic control.

B. Action Summary

For Cases A, B, C, and D, complete the survey of the plant equipment and note action(s) taken and status of the system after completion of this procedure.

EMERGENCY INSTRUCTION NO. 505B19

PRIMARY PLANT
LOSS OF COMPONENT COOLING

Case A - Rupture of a Component Cooling Main Header Pipe
Case B - Rupture of a Component Cooling Lead Pipe to or from a Main Coolant Pump

These two types of failure could result in a serious emergency; therefore, the system is provided with numerous alarms such as low pressure, high temperature, and low flow. A component cooling surge tank is also provided with reserve cooling water volume to extend the time allowed for corrective action.

Case C - Rupture of Main Coolant Pump Cooling Coil

This type of failure could, depending on size of leak, also result in a serious emergency, since component cooling system pressure and temperature would rise rapidly. If not corrected immediately, this could result in loss of cooling for other essential primary plant equipment.

Case D - Loss of Component Cooling Flow

This mode of failure is of small consequence as a standby pump is automatically put into operation. Both low flow and low pump discharge pressure alarms are provided to alert the operator.

Case E - Rupture of Component Cooling Piping at the Low Pressure Surge Tank Cooler, Shutdown Cooler or Fuel Pit Cooler

This type of failure is an emergency of a minor nature as the substitute heat exchanger can be put in operation in a short time.

Case F - Rupture of Component Cooling Pipe to or in the Neutron Shield Tank Cooler(s) or the Sample Cooler

This would be an emergency of least consequence as the plant can continue power operation for a reasonable time without these units.

I. Symptoms

Any of the following symptoms may be an indication of the emergency condition:

Case A - Rupture of a Component Cooling Main Header Pipe

1. Low water level indication and/or alarm from the component cooling surge tank.

2. Component cooling surge tank level control valve indicating lights will show valve open for prolonged periods.

3. High temperature indication and/or alarms from all main coolant pump bearings.

4. Rapid decrease of component cooling pump discharge pressure.

5. Rapid increase of component cooling water flow.

6. Observation of high level in vapor container drain tank.

Case B - Rupture of a Component Cooling Lead Pipe to or from a Main Coolant Pump

1. Low water level indication and/or alarm from the component cooling surge tank.

2. Component cooling surge tank level control valve indicating lights will show valve open for prolonged periods.

3. High temperature indication and/or alarm from one main coolant pump bearing.

4. Rapid decrease of component cooling pump discharge pressure.

5. Rapid increase of component cooling water flow.

6. Observation of high level in vapor container drain tank or visible leakage from component cooling piping outside vapor container.

Case C - Rupture of Main Coolant Pump Cooling Coil

1. High temperature indication and/or alarm from main coolant pump component cooling water discharge.

2. High temperature indication and/or alarm from main coolant pump bearings.

3. High temperature indication and/or alarm from discharge of component cooling system exchangers.

4. Rapid increase in component cooling pump discharge pressure.

5. Sudden increase above normal of the component cooling water pump suction radiation monitor reading.

6. High level indication and/or alarm on the component cooling water surge tank.

7. Observation of high level in the vapor container drain tank resulting from component cooling water surge tank safety valve operation.

Case D - Loss of Component Cooling Flow

1. Low component cooling pump discharge pressure indication and/or alarm.

2. Low component cooling flow indication and/or alarm.

3. High temperature indication and/or alarm from all main coolant pump bearings.

Case E - Rupture of Component Cooling Piping at the Low Pressure Surge Tank Cooler, Shutdown Cooler or Fuel Pit Cooler

1. Sudden rise in low pressure surge tank cooler outlet temperature and low pressure surge tank water temperature.

2. Sudden rise in shutdown cooler outlet temperature.

3. Rise in main coolant temperature during shutdown cooling operations.

4. Abnormal rise in fuel pit water temperature and/or high temperature alarm.

5. Low water level indication and/or alarm from the component cooling surge tank.

6. Component cooling surge tank level control valve indicating lights will show valve open for prolonged periods.

7. Rapid decrease of component cooling pump discharge pressure.

8. Rapid increase of component cooling water flow.

Case F - Rupture of Component Cooling Pipe to or in the Neutron Shield Tank Cooler(s) or the Sample Cooler

1. Drop in component cooling water temperature returning from the neutron shield tank coolers.

2. High water level indication and/or alarm from the neutron shield surge tank.

3. Rise in neutron shield tank water temperature and/or alarm.

4. Low water level indication and/or alarm from the component cooling surge tank.

5. Component cooling surge tank level control valve indicating lights will show valve open for prolonged periods.

6. Rapid decrease of component cooling pump discharge pressure.

7. Rapid increase of component cooling water flow.

8. Observation of high level in vapor container drain tank.

9. Abnormal rise in main coolant sample water temperature.

II. Immediate Action

For Case A, Case B, and Case C, approximately four minutes are available to take manual action before main coolant pumps must be shut down due to complete loss of component cooling water from the pump jacket.

For Case D and Case E, approximately eight minutes are available to take manual action before the main coolant pumps must be shut down due to loss of component cooling flow.

For Case F, approximately eleven minutes are available to take manual action before main coolant pumps must be shut down due to loss of component cooling in the case of a pipe failure to the neutron shield tank. Better than a half hour is available for manual action in the case of a pipe failure to the sample cooler.

A. Automatic Action

Case A, Case B, Case E, and Case F

When the component cooling surge tank water level drops to low level, a switch automatically opens the level control valve admitting make-up water to the tank from the secondary plant condensate supply.

Case C

As leakage progresses from the main coolant system into the component cooling system and activity level of the component cooling system increases, the component cooling system tank vent opens automatically as set radiation level point is reached.

Pressure increase in a particular main coolant, pump cooling circuit will cause component cooling safety valve operation, relief going to the component cooling water surge tank. As pressure increases in the surge tank, this will in turn cause surge tank safety valve operation, relief going to the vapor container drain tank.

Case D

Standby component cooling pump is put into operation automatically.

B. Instrument Check

Check all instruments pertinent to the symptoms observed and attempt to classify the condition under one of these cases.

C. Manual Action

Case A

1. Initiate reactor scram and trip the turbine generator.

2. Shut down all main coolant pumps.

3. Use turbine steam by-pass line to the main condenser as necessary to maintain the system in hot standby condition until repairs can be made.

Case B

1. Shut down the one affected main coolant pump.

2. Reduce the turbine generator load to a value compatible with three-loop operation.

3. Isolate the ruptured pipe by closing the inlet header and outlet header root valves to the affected pump.

Case C

1. Stop the affected main coolant pump.

2. Isolate the affected main coolant loop. Refer to O. I. No. 504D8, Main Coolant System - Shutdown of Individual Loops.

3. Check to see that the component cooling system is operable.

4. Continue operation of component cooling system.

5. Verify that the turbine initial pressure regulator has reduced turbine generator load to a value compatible with three-loop operation.

Case D

1. Isolate the faulty component cooling pump.

Case E

1. Isolate the failure by closing the inlet and outlet component cooling water valves to the affected heat exchanger.

2. Put the below indicated standby heat exchanger in service by opening the cross connecting valves as required and providing component cooling water to the standby exchanger.

   a. The shutdown cooler is standby for the low pressure surge tank cooler.

b. The low pressure surge tank cooler is standby for the shutdown cooler.

c. Either the shutdown cooler or the low pressure surge tank cooler is standby for the fuel pit cooler.

Case F

1. Isolate the failure in the pipe by closing the inlet and outlet component cooling root valves to and from the neutron shield tank or sample cooler, whichever is involved.

III. Subsequent Action

A. Procedure

Case A

1. Determine the location of the failure, estimate time required for repairs, and commence repairs.

Case B

1. Isolate the affected main coolant loop.

2. Continue three-loop reduced power operation until it is desired to shut down the reactor and enter the vapor container to repair the affected component cooling line to the pump in the isolated loop.

Case C

1. Continue three-loop reduced power operation until it is desired to shut down the reactor, enter the vapor container and make repairs.

Case D

1. Make repairs, as necessary, to restore the faulty component cooling pump to reliable operating condition.

Case E

1. Isolate the tube (cooled medium) side of the affected heat exchanger and commence repairs.

Case F

1. Plan a scheduled reactor shutdown to allow locating the failure of neutron shield tank cooling and a scheduled plant shutdown for repairs; or

2. Isolate the main coolant side of the sample cooler and continue power operation as desired.

B. Action Summary

Complete the survey of the plant equipment and note action(s) taken and status of the system after completion of this procedure.

EMERGENCY INSTRUCTION NO. 505C

SECONDARY PLANT
EMERGENCY SHUTDOWN AND TURBINE THROTTLE TRIP

The operator may cause an emergency shutdown of the turbine generator either by rapidly reducing as much of the load as possible and dumping the remainder or by dumping the entire load.

The emergency conditions listed below will automatically trip the turbine throttle valves. Refe to Section II-C for generator field trip.

I. Symptoms

A. Primary Plant Conditions

Whenever the nuclear reactor is scrammed for one of the following conditions in the primary plant, the turbine throttle valves trip automatically within 2 sec:

*1. Low pressure in the pressurizer.
*2. High neutron flux level in the reactor.
*3. Short reactor period.
*4. Low main coolant flow.
5. Manual scram.

B. Secondary Plant Conditions (Mechanical)

Any of the following conditions in the secondary plant will automatically trip the turbine throttle valves without delay:

*1. Loss of condenser vacuum.
*2. Low turbine bearing oil header pressure.
*3. Abnormal action of the turbine thrust bearing.
*4. High water level in turbine moisture separators.
5. Hand trip.
*6. Overspeed of unit.
*7. High pressure in vapor container.

C. Secondary Plant Conditions (Electrical)

Any of the following electrical conditions in the secondary plant will automatically trip the turbine throttle valves without delay:

*1. Unit differential.

*2. Generator differential and ground.

*3. Generator loss of field and overcurrent.

*4. No. 1 station service transformer differential and overcurrent.

*Indicated by annunciator on main control board.

*5. No. 4 station service transformer overcurrent.

*6. A stuck 115 kv oil circuit breaker.

II. Immediate Action

A. Automatic Action

When the turbine throttle valves are tripped, the pressure in the main steam line will increase. The turbine steam by-pass line controls, sensitive to such an increase, will automatically put this system in operation provided condenser vacuum is maintained.

A turbine throttle valve trip will automatically open the 115 kv oil circuit breakers and will scram the reactor when turbine load is above 15 mw but will not automatically scram the reactor when turbine load is below 15 mw as in startup or when load is reduced to below 15 mw and continues below 15 mw for a preset time (adjustable 0-10 sec) as in a scheduled or emergency load reduction.

NOTE: The preset time of 0-10 sec is required to allow a time delay relay to isolate the reactor scram from the throttle trip circuit.

When the turbine throttle valves are tripped by any one of the electrical faults listed in Section I-C, the generator field is automatically tripped.

Loss of power on the No. 1, 2,400 v bus shuts down two of the four reactor main coolant pumps. When turbine load is above 15 mw (indicative of above 10% reactor power level), a minimum of three main coolant pumps are required and automatic scram will occur if this is not satisfied. When turbine load is between 7.25 and 15 mw (indicative of below 10% reactor power level), a minimum of one main coolant pump is required for heat removal but no automatic scram is provided.

E. Instrument Check

Check all instruments relative to the symptoms observed. If the fault is in the primary plant, the nuclear auxiliary operator should check the pertinent system.

C. Manual Action

When turbine throttle valves are tripped by reactor or turbine (mechanical) conditions or by hand, the generator field breaker shall be hand tripped 1 min after throttle valve trip. Refer to O.I. No. 504R3, ELECTRICAL SYSTEM - STATION POWER SYSTEM.

*Indicated by annunciator on main control board.

1. <u>Emergency reduction in load to less than 15 mw to be followed by throttle valve hand trip without reactor scram.</u>

   a. Transfer 2,400 v, No. 1 bus and 480 v, No. 4-1 bus from No. 1 station service transformer to the appropriate station service transformer, depending on station loading. Refer to O.I. No. 504R3, ELECTRICAL SYSTEM - STATION POWER SYSTEM.

   b. Maintain load below 15 mw for a minimum preset time (adjustable 0-10 sec).

   NOTE: If load is not maintained below 15 mw for minimum preset time (adjustable 0-10 sec), the reactor is scrammed. Refer to Section II-C, Step No. 3 for instructions.

   c. Trip throttle valves.

   d. Verify automatic start of turbine main auxiliary oil pump.

2. <u>Load is less than 15 mw and throttle valves tripped automatically or by hand.</u>

   a. Verify automatic start of turbine main auxiliary oil pump.

   b. Locate cause of throttle trip.

3. <u>Emergency reduction in load to more than 15 mw followed by hand trip.</u>

   <u>Load is more than 15 mw and throttle valves tripped automatically.</u>

   a. Verify automatic start of turbine main auxiliary oil pump.

   b. Transfer 2,400 v, No. 1 bus and 480 v, No. 4-1 bus from No. 1 station service transformer to the appropriate station service transformer depending on station loading. Refer to O.I. No. 504R3, ELECTRICAL SYSTEM - STATION POWER SYSTEM.

   c. Locate cause of throttle trip.

III. Subsequent Action

A. Procedure

1. Emergency reduction in load to less than 15 mw to be followed by throttle valve hand trip without reactor scram.

a. If the condition causing the throttle valves to be tripped can be corrected within about 20-30 min or before the turbine has slowed to turning gear speed and if the unit is desired back on the line as soon as possible, the following instructions apply:

(1) Proceed with Steps Nos. 6 through 12 under Section V of O.I. No. 504A5, PLANT STARTUP - TURBINE GENERATOR STARTUP FROM HOT CONDITION.

b. If the condition causing the throttle valves to be hand tripped can not be corrected within 20-30 min, the following instructions apply:

(1) Proceed with Steps Nos. 8 through 11 under Section V-A of O.I. No. 504C3, PLANT SHUTDOWN - SCHEDULED TURBINE GENERATOR SHUTDOWN.

2. Load is less than 15 mw and throttle valves tripped automatically or by hand trip.

a. If the condition causing the throttle valves to be tripped either by hand or automatically can be corrected within about 20-30 min or before the turbine has slowed to turning gear speed, and if the unit is desired back on the line as soon as possible, refer to instructions under Section III-A, Step No. 1a.

b. If the condition causing the throttle valves to be tripped either by hand or automatically can not be corrected within 20-30 min, refer to instructions under Section III-A, Step No. 1b.

3. Emergency reduction in load to more than 15 mw followed by hand trip.

Load is more than 15 mw and throttle valves tripped automatically.

NOTE: Under these conditions the reactor has been scrammed. It is assumed that the condition causing the throttle valve trip can not be corrected and the reactor will not again be made critical before the turbine slows down to turning gear speed.

a. Proceed with Steps Nos. 8 through 11 under Section V-A of O.I. No. 504C3, PLANT SHUTDOWN - SCHEDULED TURBINE GENERATOR SHUTDOWN.

B. Action Summary

Complete the survey of the plant equipment and note action(s) taken and status of the system after completion of this procedure.

EMERGENCY INSTRUCTION 505D1

ELECTRICAL SYSTEM
LOSS OF 120 VOLT A-C VITAL BUS

I. Symptoms

Any of the following symptoms may be an indication of the emergency condition:

1. Loss of all nuclear instrumentation and chart drives, which would cause:

   Dropout of amplifiers causing reactor scram.
   Turbine generator trip.

2. Loss of vital bus voltage.

   NOTE: This is not indicated at main control board but is indicated at the inverter control cabinet.

II. Immediate Action

A. Automatic Action

1. All nuclear instrumentation and chart drives stop.
2. Reactor scram.
3. Turbine generator trip.

B. Instrument Check

1. Check vital bus voltage.

C. Manual Action

1. Transfer vital bus to reserve supply in accordance with O.I. No. 504R1, ELECTRICAL SYSTEM - 120 VOLT A-C VITAL BUS SYSTEM.
2. Reset nuclear instrumentation.
3. Proceed with reactor startup, if directed, in accordance with O.I. No. 504A3, PLANT STARTUP - REACTOR STARTUP FOLLOWING SCRAM CONDITION.

III. Subsequent Action

A. Procedure

1. Check inverter equipment to determine cause of trouble.

   NOTE: When trouble is corrected, refer to O.I. No. 504R1, ELECTRICAL SYSTEM - 120 VOLT A-C VITAL BUS SYSTEM before returning vital bus power supply to normal.

B. Action Summary

1. Nuclear instrumentation is now in service from the reserve supply and, if directed, the plant may be placed back in operation.

2. Vital bus power supply to be transferred to its normal source, the inverter, when available.

EMERGENCY INSTRUCTION NO. 505D2

ELECTRICAL SYSTEM
LOSS OF A-C SUPPLY

This emergency instruction covers conditions of Partial and Total Loss of A-C Supply to the plant.

I. Partial Loss of A-C Supply

Partial loss of A-C supply is that condition caused by an electrical fault on a portion of the plant auxiliary electric system or connecting transmission lines. The basic design incorporates relaying and electrical equipment standard to conventional steam power plant design which provides automatic control action to isolate immediately the faulted area from the rest of the system. In this manner, regardless of location or severity of the fault, power is maintained to operate vital station auxiliaries and to maintain the reactor in a safe condition. A summary of operations, which will occur for various electrical faults, and their effect upon plant operation is given below. Refer to the Main Electrical One Line Operating Diagram on page 505D2:10.

A. Fault on Line Z-126 S.S. Trans. No. 2, or 115 Kv and 2,400 V Connections to S.S. Trans. No. 2

I. Symptoms

In all cases, A through L, plant operators will be alerted of the loss of A-C supply by an alarm and appropriate annunciator drops.

II. Action

A. Automatic Action

1. No. Z-126, 224, and 548 breakers open automatically.

2. Power output is reduced to 78%.

B. Subsequent Action

1. Operator will restore plant to scheduled power output by energizing the 2,400 v bus No. 2 from normal source if available, or from 2,400 v bus No. 1.

III. Action Summary

Complete the survey of the plant equipment and note action(s) taken and status of the system after completion of this procedure.

B. <u>Failure of Breaker No. Z-126 to Operate</u> (In Case A, above)

I. <u>Symptoms</u>

Same as Case A.

The following sequence will occur in order to maintain adequate main coolant flow.

II. <u>Action</u>

A. <u>Automatic Action</u>

1. Breakers Nos. Y-177, 124, and 448 open automatically with throttle-stop valve trip and reactor scram.

2. Breaker No. 1324 closes automatically.

B. <u>Subsequent Action</u>

1. Plant is placed on hot standby. Refer to E.I. No. 505B2, PRIMARY PLANT - LOSS OF LOAD ACCIDENT.

III. <u>Action Summary</u>

Same as Case A.

C. <u>Fault on Line Y-177 or 115 Kv Connections to S.S. Trans. No. 3</u>

I. <u>Symptoms</u>

Same as Case A.

II. <u>Action</u>

A. <u>Automatic Action</u>

1. Breakers Nos. Y-177, 324, and 648 open automatically.

2. Power output is reduced to 78%.

B. <u>Subsequent Action</u>

1. Plant will be restored to scheduled power output by energizing the 2,400 v bus No. 3 from the normal source, if available, or from 2,400 v bus No. 1.

III. <u>Action Summary</u>

Same as Case A.

D. Fault on S.S. Trans. No. 3 or Its 2,400 V Connections

I. Symptoms

Same as Case A.

II. Action

A. Automatic Action

1. Breakers Nos. Y-177, 324, 648, and airbreak switch 3S115 open automatically.

2. Power is reduced to 78%.

B. Subsequent Action

1. Same as Case C - II B.

III. Action Summary

Same as Case A.

E. Failure of Breaker No. Y-177 to Operate (In Cases C and D above)

I. Symptoms

Same as Case A.

The following sequence will occur in order to maintain adequate main coolant flow.

II. Action

A. Automatic Action

1. Breakers Nos. Z-126, 124, and 448 open automatically with throttle-stop valve trip and reactor scram.

2. Breaker No. 1224 closes automatically.

B. Subsequent Action

1. Plant is placed on hot standby. Refer to E.I. No. 505B2, PRIMARY PLANT - LOSS OF LOAD ACCIDENT.

III. Action Summary

Same as Case A.

F. An Overload or Loss of Field on the Generator; a Fault on the 115 Kv Station Bus, Trans. No. 1, 18 Kv Bus, Generator, S.S. Trans. No. 1, or the 2,400 V Connections to S.S. Trans. No. 1

I. Symptoms

Same as Case A.

II. Action

A. Automatic Action

1. Breakers Nos. Y-177, Z-126, 124, 448, and exciter breaker opens automatically with throttle-stop valve trip and reactor scram.

B. Subsequent Action

1. Plant is placed on hot standby. Refer to E.I. No. 505B2, PRIMARY PLANT - LOSS OF LOAD ACCIDENT.

III. Action Summary

Same as Case A.

G. Failure of Breakers Nos. Y-177 or Z-126 to Operate (In Case F, above)

I. Symptoms

Same as Case A.

The following sequence will occur in order to maintain adequate main coolant flow.

II. Action

A. Automatic Action

1. Breaker No. 1224 closes automatically for breaker No. Y-177 failure, or breaker No. 1324 closes automatically for breaker No. Z-126 failure.

B. Subsequent Action

None.

III. Action Summary

Same as Case A.

H. Generator Ground Fault

I. Symptoms

Same as Case A.

II. Action

A. Automatic Action

1. No immediate action.

B. Subsequent Action

1. Shutdown turbine generator in accordance with O.I. No. 504C3 - PLANT SHUTDOWN, SCHEDULED TURBINE GENERATOR SHUTDOWN.

2. If Item 1 is not completed within 2 hr from initiation of fault, the following automatic action will occur:

Breakers Nos. Y-177, Z-126, 124, 448 and exciter breaker opens automatically with Throttle-Stop Valve Trip and Reactor Scram.

3. Plant is placed on hot standby following the occurrence of Item 2. Refer to E.I. No. 505B2 - PRIMARY PLANT - LOSS OF LOAD ACCIDENT.

III. Action Summary

Same as Case A.

I. Fault on 2,400 V Bus No. 1

I. Symptoms

Same as Case A.

II. Action

A. Automatic Action

1. Breaker No. 124 opens automatically.

2. Reactor scram with throttle-stop valve trip and breakers Nos. Y-177 and Z-126 trip.

B. Subsequent Action

1. Plant is based on hot standby. Refer to E.I. No. 505B2, PRIMARY PLANT - LOSS OF LOAD ACCIDENT.

III. Action Summary

Same as Case A.

J. Fault on 2,400 V Bus No. 2

I. Symptoms

Same as Case A.

II. Action

A. Automatic Action

1. Breaker No. 224 opens automatically.

2. Power is reduced to 78%.

B. Subsequent Action

1. Plant is placed on hot standby. Refer to E.I. No. 505B2, PRIMARY PLANT - LOSS OF LOAD ACCIDENT.

III. Action Summary

Same as Case A.

K. Fault on 2,400 V Bus No. 3

I. Symptoms

Same as Case A.

II. Action

A. Automatic Action

1. Breaker No. 324 opens automatically.

2. Power output is reduced to 78%.

B. Subsequent Action

1. Plant is placed on hot standby. Refer to E.I. No. 505B2, PRIMARY PLANT - LOSS OF LOAD ACCIDENT.

III. Action Summary

Same as Case A.

L. Fault on 480 V Bus Nos. 4-1, 5-2 or 6-3

I. Symptoms

Same as Case A.

II. Action

A. Automatic Action

1. Breakers Nos. 448, 548, and 648 open automatically respectively.

B. Subsequent Action

1. Operator will check that all vital duplicate equipment is in service.

III. Action Summary

Same as Case A.

II. Total Loss of A-C Supply

A total loss of A-C supply results from a complete separation of the plant from the interconnected system. Although it is highly improbable that such a condition will be experienced, an automatic turbine throttle-stop valve trip and reactor scram accompany the total loss of power. The return of A-C supply is subject to transmission line conditions and system operation. The total loss of A-C supply emergency procedure will be initiated if transmission lines are dead for a period of 15 min with no communication, or if the system dispatcher can not advise an exact time at which A-C supply will be restored. In any event, emergency power will be available within three hours after loss of all A-C supply to maintain the plant in a safe condition.

The only credible way in which a total loss of main coolant flow can occur is by a total loss of A-C supply. If total A-C supply is lost, with four loops in operation, the resulting low main coolant flow causes a reactor scram at approximately 60% flow. During the short term transient, the pump coastdown flow will prevent core damage. Heat transferred by natural circulation from the core to the steam generators will provide for removal of decay heat and will maintain the plant in a safe condition.

Referring to one line diagrams, drawings Nos. 9699-FE-1D and 9699-RE-1F included in Section 226, the combined emergency electrical and mechanical instruction for total loss of A-C supply and total loss of main coolant flow follows:

I. Symptoms

Any of the following symptoms may be an indication of the emergency condition:

1. Total loss of A-C supply.

2. Low flow scram and alarm.

II. Immediate Action

A. Automatic Action

Reactor scram and turbine trip out.

B. Instrumentation Check

Survey nuclear, turbine and electrical sections of the main control board to determine the cause of total loss of flow.

C. Manual Action

Check that automatic scram has occurred. Initiate same, if necessary.

III. Subsequent Action

Initiation of the following action is dependent upon the anticipated length of time the plant will be separated from the interconnected system. It is to be recognized that a number of the steps may be performed concurrently and in variance to the sequence listed.

A. Procedure

1. Check turbine generator lubricating oil conditions, making certain that the D-C emergency bearing oil pump and D-C emergency seal oil pump are operating and maintain the required pressure.

   Note: The D-C emergency bearing oil pump may be removed from service after the turbine generator stops rotating. This is accomplished by operation of the control switch located on the turbine startup panel.

2. Contact the system dispatcher for information relative to the expected time that restoration of A-C supply will occur.

3. Considerable noise may occur by steam generator safety valve operation relieving heat and pressure from the primary system.

4. Start engine driven A-C generator.

5. Check open, breaker No. 17 to 480 v bus No. 4-1.

6. At rated speed, apply field and adjust for rated terminal voltage.

7. Check open all breakers on the 480 v bus No. 4-1 No. 5-2.

8. Close breaker No. 17, energizing the 480 v bus No. 4-1.

9. Close breaker No. 11, energizing the 480 v bus No. 5-2.

10. Check open all breakers on MCC1 bus No. 1

11. Close breaker No. 10, energizing MCC1 bus No. 1.

12. Close 480 v breaker and contactor to motor generator set No. 1.

13. Adjust field for 129 v and close the D-C contactor to the battery bus No. 1.

14. Close the 480 v breaker to the 7 1/2 kva transformer for process instrumentation.

15. Close the 480 v breaker and contactor to the pressurizer heaters. Manually cycle heaters to maintain nominal main coolant system pressure.

16. Check open all breakers on MCC4 bus No. 2.

17. Close breaker No. 15 energizing MCC4 bus No. 2. (No. 2 charging pump supply)

18. Manually initiate feed water flow to the secondary side of the steam generators by:

    a. Line up the emergency feed water supply line connecting the charging pump discharge header to the secondary feed water system.

    b. Line up No. 2 charging pump with its discharge isolated from the remaining charging pumps.

    c. Line up the demineralized water storage tank and/or the primary storage water tank to supply water to the charging pump suction header only.

    d. Close 480 v breaker and operate contactor to No. 2 charging pump as required, to maintain proper water level in the steam generators.

    <u>Note</u>: When starting No. 2 charging pump with the engine-driven A-C generator as power source, it is required to relieve the discharge pressure.

19. Continue surveys of the nuclear, turbine and electrical sections of the main control board.

20. After the turbine generator unit has stopped turning, partially rotate the unit by barring, as detailed in the Manufacturer's Instruction Book.

21. When restoration of the normal A-C power supply is accomplished, start the circulating water pump(s), one or more main coolant pumps, component cooling water pump and initiate steam by-pass to the main condenser.

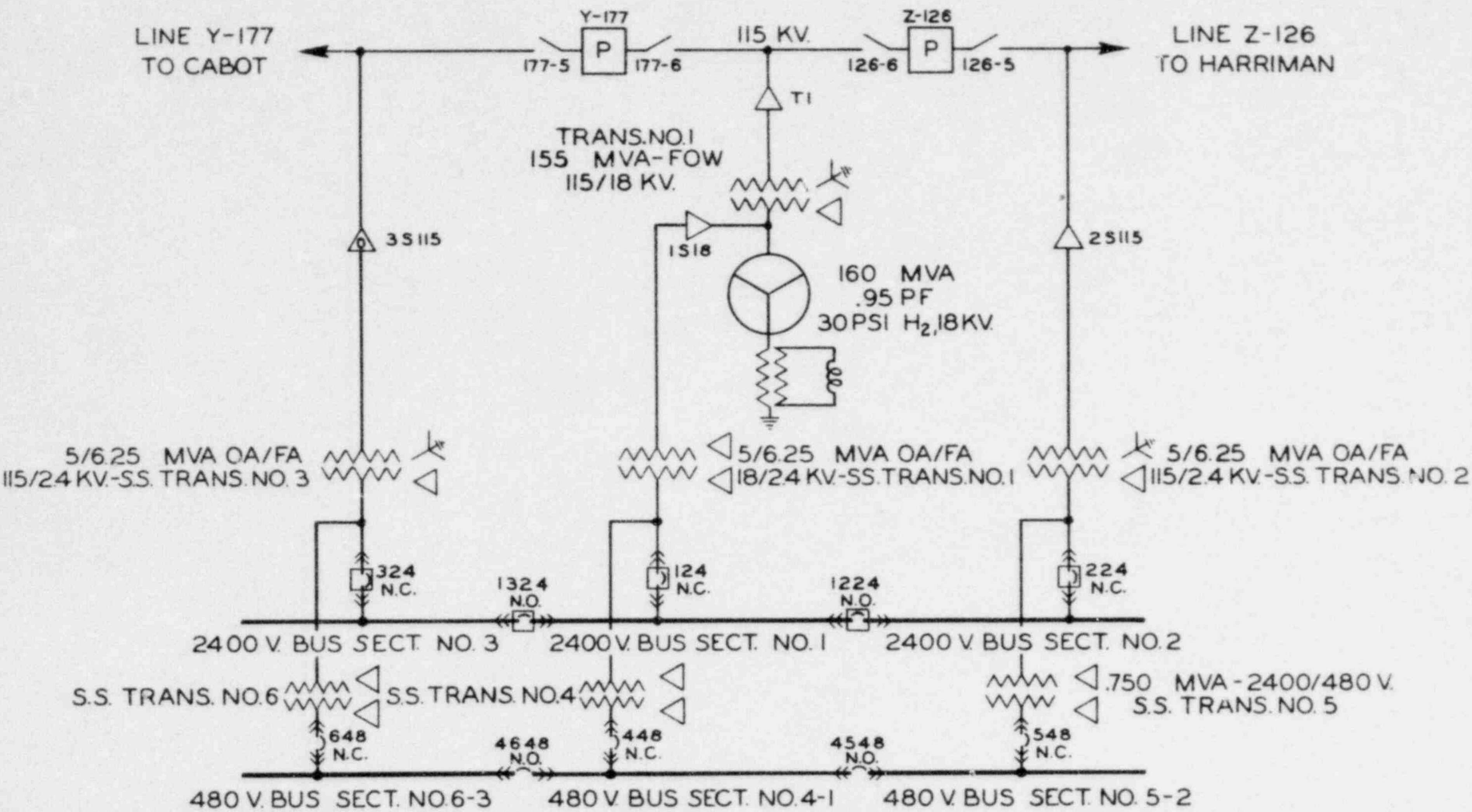
22. Trip the engine-driven A-C generator from service and energize 480 v buses from the normal supply.

23. Return the secondary system feed water supply to normal by performing Step 18 in reverse order.

24. Establish hot standby conditions in the main coolant system.

B. <u>Action Summary</u>

Complete the survey of the plant and note action(s) taken and status of the system(s) after completion of this procedure.



MAIN ELECTRICAL ONE LINE
OPERATING DIAGRAM

505D2:10
9/15/59

506 PLANT MAINTENANCE INSTRUCTIONS

506A GENERAL

The primary plant maintenance program is designed to safely and efficiently provide for the repair and adjustment of equipment in order to maintain the plant in good operating order.

During normal operation, the plant vapor container is closed, and the temperature and radioactivity buildup within the container are monitored. The reinforced concrete shielding design does not allow access to the vapor container with the reactor at high power levels and, in like manner, with the vapor container closed, the vapor container atmosphere control systems limit access. Due to these restrictions, the maintenance operations on the primary plant are grouped into two general situations.

Minor adjustments or maintenance required on portions of the nuclear plant equipment outside of the vapor container will be performed with the plant in operation, if the work can be carried out in a safe manner. Minor maintenance on equipment in the vapor container for which depressurization is not required and for which entrance is possible without hazard from the high pressure plant will also be performed without complete plant shutdown.

Major maintenance on the nuclear plant equipment within the vapor container will be performed on a deferred basis at a time of complete plant shutdown and depressurization. All of the maintenance operations on contaminated equipment or in contaminated areas will be supervised by technical services to see that proper decontamination procedures and radioactivity safeguards are observed.

In the performance of the primary plant maintenance, special maintenance methods will be required. Specific instructions have been prepared for a number of these maintenance operations: these appearing in Sections 506B, 506D, and 506E. Maintenance of equipment beyond that covered in these special written procedures will be carried out in about the same manner as in a conventional power plant.

Maintenance of primary plant equipment also presents special problems in equipment isolation, working methods, and personnel safety. (Personnel protection is discussed in Section 507, RADIOLOGICAL HEALTH AND SAFETY). The plant layout and the items of equipment have all been designed to meet these special problems. Careful study was given to plant layout with respect to equipment inspection, shielding, and extra cleaning connections. Special tools will also be provided where required.

Safety procedures and rules have also been prepared, based on the usual conventional power plant practices. Incorporated in these procedures is a nuclear clearance procedure. Plant maintenance requests will be initiated by authorized personnel as a result of equipment malfunction, preventive maintenance, and the equipment testing programs. The authorized personnel are allowed to request, grant, and release such clearances by first demonstrating knowledge of the plant as well as company safety rules by passing an examination.

The work will be performed by trained personnel under technical supervision. The personnel training program will be carried out as described in Section 502. Only men who are thoroughly grounded in basic skills will be engaged in this maintenance work. Manufacturers' representatives will be employed for special items of equipment. A preventive maintenance schedule based on manufacturers' recommendations will be followed for routine inspections and adjustments. A suitable maintenance record and appropriate spare parts inventory will also be maintained at the plant.

MAINTENANCE INSTRUCTION NO. 506B1

PRIMARY PLANT
OPENING AND CLOSING ISOLATED MAIN COOLANT LOOP

I. Objective To provide a procedure for opening and closing an isolated main coolant loop prior to and subsequent to planned maintenance and/or inspection.

II. Conditions

1. The main coolant system has been shut down, is below 140 F, and is essentially at atmospheric pressure. Refer to O.I. No. 504C2, PLANT SHUTDOWN - REACTOR COOLDOWN and O.I. No. 504D7, MAIN COOLANT SYSTEM - SHUTDOWN OF COMPLETE SYSTEM.

2. The main coolant loop isolation valves are closed and the bypass isolation valve is opened.

3. The vapor container has been ventilated and prepared for personnel and equipment access. Refer to O.I. No. 504Q, VAPOR CONTAINER ATMOSPHERE CONTROL SYSTEMS and M.I. No. 506D, VAPOR CONTAINER.

4. Pertinent auxiliary systems are in the following status:

System	Status
Charging and Volume Control System (Refer to O.I. No. 504F)	Isolated
Component Cooling System (Refer to O.I. No. 504I)	Partial operation - as required
Shutdown Cooling System (Refer to O.I. No. 504M)	Normal operation
Vapor Container Atmosphere Control Systems (Refer to O.I. No. 504Q)	Normal operation

III. Precautions

1. When entering the vapor container, comply with all pertinent requirements of Section 507, RADIOLOGICAL HEALTH AND SAFETY.

2. The secondary side of the steam generator should be completely drained only when it is desired to inspect the secondary face of the tube plate and when a tube leak test is required.

3. All instrument isolation valves must be closed.

IV. Check-off List

Prior to initiation of this M.I., the check-off list must be completed by the operator(s) and signed off.

V. Instructions

A. Opening An Isolated Main Coolant Loop

1. Check that the main coolant isolation valves are closed and the bypass isolation valve is open.

2. Check that the charging and volume control system is isolated.

3. Check cold leg temperature to assure that the system temperature is below 140 F.

4. Drain the isolated loop. Refer to O.I. No. 504D2, MAIN COOLANT SYSTEM - FILLING, VENTING AND DRAINING AN ISOLATED LOOP.

5. After complete draining of the isolated loop, determine by radiation survey if decontamination of the loop is required. If decontamination is required, refer to M.I. No. 506B2, PRIMARY PLANT - DECONTAMINATION SYSTEM OPERATION.

6. Upon completion of decontamination of the isolated loop, check that the loop has been properly rinsed and drained.

7. Depending upon the maintenance operation required, open the appropriate section of the isolated loop. Refer to Manufacturer's Instructions.

B. Closing An Isolated Main Coolant Loop

1. Depending upon the maintenance operation that was required, close the appropriate section of the isolated loop. Refer to Manufacturer's Instructions.

2. Fill the isolated loop. Refer to O.I. No. 504D2, MAIN COOLANT SYSTEM - FILLING, VENTING AND DRAINING AN ISOLATED LOOP.

3. Check cold leg temperature.

VI. Final Condition

A. Opening An Isolated Main Coolant Loop

The isolated main coolant loop has been drained, decontaminated if necessary and has been opened for planned maintenance and/or inspection.

B. Closing An Isolated Main Coolant Loop

The isolated main coolant loop has been closed and filled with borated primary grade water and is ready for cold leak test. Refer to M.I. No. 506B3, PRIMARY PLANT - COLD LEAK TEST.

MAINTENANCE INSTRUCTION NO. 506B2

PRIMARY PLANT
DECONTAMINATION SYSTEM OPERATION

I. Objective To provide a safe and efficient method of decontaminating primary plant equipment for the purpose of removing radioactive fission and corrosion products.

II. Conditions

A. Decontamination of a Loop

1. Decontamination of a loop is required and a water flush or other mild decontamination procedure is insufficient. (See Section 507, Radiological Health and Safety.)

2. The reactor is shut down and cold.

3. The 3,000 gal boric acid mixing and storage tank is empty. The loop that must be decontaminated is isolated by the main stop valves. The valve in the by-pass line is closed.

4. Auxiliary steam is available for heating the decontamination solutions.

5. At least 15,000 gal of demineralized water is available in the demineralized water storage tank.

6. The shell side of the steam generator is filled with water to the normal operating level. Refer to O.I. No. 504A4, PLANT STARTUP - TURBINE GENERATOR STARTUP FROM COLD CONDITION.

7. Pertinent auxiliary systems are in the following status:

System	Status
Charging and Volume Control System (Refer to O. I. No. 504F)	Ready standby
Component Cooling System (Refer to O. I. No. 504I)	Cooling supply to the canned motor pump is on
Primary Plant Sampling System (Refer to O.I. No. 504K1)	Ready standby
Radioactive Waste Disposal System (Refer to O. I. No. 504L1)	The primary drain collecting tank and one holdup tank have been purged and have capacity for receiving decontamination solutions. Piping is lined up to allow gas stripper discharge to the primary vent stack.

B. Decontamination of the Pressurizer

1. Decontamination of the pressurizer is required and a bora. d water flush is insufficient. (See Section 507, Radiological Health and Safety.)

2. The reactor is shut down and cold.

3. The 3,000 gal boric acid mixing and storage tank is empty.

4. Auxiliary steam is available for heating the decontamination solutions.

5. At least 5,500 gal of demineralized water is available in the demineralized water storage tank.

6. Approximately 2,000 gal of 0.55% boric acid solution is available from the safety injection and shield tank cavity water storage tank.

7. Pertinent systems are in the following status:

System	Status
Charging and Volume Control System (Refer to O. I. No. 504F)	Ready standby
Chemical Shutdown System (Refer to O. I. No. 504G1)	Ready standby
Primary Plant Sampling System (Refer to O.I. No. 504K1)	Ready standby
Radioactive Waste Disposal System (Refer to O. I. No. 504L1)	The primary drain collecting tank and one holdup tank have been purged and have capacity for receiving decontamination solutions. Piping is lined up to allow gas stripper discharge to the primary vent stack.

III. Precautions

A. Decontamination of a Loop

1. Decontamination will be ineffective unless it is possible to pressurize and circulate the main coolant in the loop.

2. The water purge into the main coolant pump must be maintained at a rate of 4.5 gpm.

3. Adequate precaution should be taken to prevent an inadvertent opening of the main stop valves.

4. Personnel entering the loop cubicle and preparing decontamination solutions must wear adequate special work procedure (SWP) clothing. (See Section 507, Radiological Health and Safety.)

B. Decontamination of the Pressurizer

Personnel entering the pressurizer cubicle and preparing decontamination solutions must wear adequate special work procedure (SWP) clothing. (See Section 507, Radiological Health and Safety.)

IV. Check-off List

Prior to the initiation of this Maintenance Instruction, the check-off list must be completed by the operator(s) and signed off.

V. Instructions

A. Decontamination of a Loop

1. Drain the main coolant loop that is to be decontaminated. Refer to O.I. No. 504D2, MAIN COOLANT SYSTEM - FILLING, VENTING AND DRAINING AN ISOLATED LOOP.

2. Prepare approximately 2,300 gal of the first decontamination solution using the boric acid mixing and storage tank.

a. Measure out 2,150 lb of sodium hydroxide and 650 lb of potassium permanganate.

b. Close the valves in the boric acid feed line to the charging pump suction header.

c. Check that the stop valves in the following lines are closed:

Charging pump suction demineralized water feed line.

Demineralized water flush to the boric acid solution feed line and the transfer pump suction line.

Demineralized water supply to the safety injection and shield tank cavity water tank and shield tank cavity fill pump suction.

Gate valve in the boric acid solution transfer pump suction.

d. Line up the boric acid recirculating line.

e. Open the demineralized water supply line from the primary water storage tank to the boric acid mixing and storage tank, via the low pressure surge tank makeup pumps.

f. Start the low pressure surge tank make-up pump that has been put on manual position.

g. When the steam coils are submerged, check that the steam supply is on by:

Checking that the steam supply line to the boric acid mixing and storage tank is open and under automatic temperature control.

Checking that the condensate line is open to steam trap.

h. Stop the pump when 2,200 gal of water have been added to the tank. Start the mechanical mixer.

i. Close the valve in the water supply line to the boric acid mixing and storage tank.

j. Slowly add, into the tank, the weighed amounts of sodium hydroxide and then potassium permanganate.

CAUTION: Caution must be exercised when handling and mixing both the sodium hydroxide and permanganate solutions.

k. Sample the solution.

l. When the temperature of the solution reaches 150 F, stop the mechanical mixer.

3. Connect the main coolant pump temporary purge line with the main coolant pump integral vent.

4. Open the valve from the demineralized water storage tank to the purge pump and close the valve to the low pressure surge tank make-up pumps.

5. Start the purge pump.

6. Open the influent line from the boric acid mixing and storage tank to the charging pump suction.

7. Fill the isolated loop via the chemical injection line. Refer to O. I. No. 504D2, MAIN COOLANT SYSTEM - FILLING, VENTING AND DRAINING AN ISOLATED LOOP.

8. Start up the isolated main coolant loop. Refer to O. I. No. 504D5, MAIN COOLANT SYSTEM - STARTUP OF ISOLATED LOOP.

9. Vent the steam produced in the steam generator through the double valved vent line, by removing the trap and venting through the drain line; by removing and venting through the safety valve in the main steam line; or by blowing down water from the steam generator.

10. After approximately 90 min circulation, stop the main coolant pump and close the by-pass valve. Refer to O. I. No. 504D8, MAIN COOLANT SYSTEM - SHUTDOWN OF INDIVIDUAL LOOPS.

11. Drain the solution into the waste disposal system. Fill the loop with demineralized water. Refer to O. I. No. 504D2, MAIN COOLANT SYSTEM - FILLING, VENTING AND DRAINING AN ISOLATED LOOP.

    NOTE: Refer to O. I. No. 504L1, RADIOACTIVE WASTE DISPOSAL SYSTEM, page 504L1:15, paragraph C, and process the primary drain collecting tank liquids in accordance with this procedure. The primary drain collecting tank and one holdup tank will be purged of hydrogen and fission product gases and a nitrogen blanket established over them.

12. Circulate, for 15 min, demineralized water into the isolated loop. Refer to O. I. No. 504D5, MAIN COOLANT SYSTEM - STARTUP OF ISOLATED LOOP.

13. Drain the loop. Refer to O. I. No. 504D2, MAIN COOLANT SYSTEM - FILLING, VENTING AND DRAINING AN ISOLATED LOOP.

14. Drain the boric acid mixing and storage tank of the residual first solution by opening the appropriate drain valve.

15. Prepare, in the boric acid mixing and storage tank, approximately 2,300 gal of the second decontamination solution.

    a. Measure out 2,000 lb of ammonium citrate.

    b. Repeat Steps b through g, paragraph A-2.

    c. Stop the pump when 2,160 gal of water have been added to the tank.

    d. Close the valve in the water supply line to the boric acid mixing and storage tank.

    e. Slowly add the specified amount of ammonium citrate into the tank.

    f. Sample the solution.

    g. When the temperature of the solution reaches 150 F, stop the mechanical mixer.

16. Repeat Steps 6, 7 and 8.

17. After circulating the solution for approximately 150 min, stop the main coolant pump and close the bypass valve. Refer to O. I. No. 504D8, MAIN COOLANT SYSTEM - SHUTDOWN OF INDIVIDUAL LOOPS.

18. Close the valve downstream of the purge line pump, shut off the pump and close the valve from the demineralized water storage tank to the purge line.

19. Disconnect the purge line from the integral vent of the main coolant pump.

20. Drain the boric acid mixing and storage tank of the residual second decontamination solution by opening the appropriate drain valve and then flush the tank with water.

21. Drain the solution into the waste disposal system and fill the loop with demineralized water. Refer to O. I. No. 504D2, MAIN COOLANT SYSTEM - FILLING, VENTING AND DRAINING AN ISOLATED LOOP.

22. Circulate, for 15 min, demineralized water into the isolated loop. Refer to O. I. No. 504D5, MAIN COOLANT SYSTEM - STARTUP OF ISOLATED LOOP.

23. Drain the demineralized water and fill the loop with borated water. Refer to O. I. No. 504D2, MAIN COOLANT SYSTEM - FILLING, VENTING AND DRAINING AN ISOLATED LOOP.

24. Repeat Steps 1 through 23 for any isolated loop, if required.

NOTE: Process the decontamination solutions in the waste disposal system as soon as possible.

B. Decontamination of the Pressurizer

1. Drain the pressurizer. Refer to O. I. No. 504E, PRESSURE CONTROL AND RELIEF SYSTEM.

2. Prepare approximately 3,000 gal of the first decontamination solution in the boric acid mixing and storage tank.

   a. Measure out 2,800 lb of sodium hydroxide and 840 lb of potassium permanganate.

   b. Repeat Steps b through g, paragraph A-2.

   c. Stop the pump when 2,900 gal of water have been added to the tank.

   d. Repeat Steps h through l, paragraph A-2.

3. Close the isolation valve in the charging pump suction header, between charging pumps Nos. 2 and 3.

4. Check that the motor operated valves in the fill and chemical injection line located in the vapor container are closed.

5. Open the manual operated valve located in the vapor container in the temporary line connecting the fill and chemical injection line to the pressurizer spray line.

CAUTION: See Section 507, Radiological Health and Safety, for entering the vapor container.

6. Open associated valves in the line connecting the safety injection water tank and the low pressure surge tank.

7. Check that the motor operated valve between the low pressure surge tank and the charging pump suction header is open, and the valves in the charging line are open.

8. To keep solution from entering into the reactor via the surge line, start the variable speed charging pump at its minimum flow in order to have a purge flow from the reactor to the pressurizer.

9. Open the feed line from the boric acid mixing and storage tank to the charging pump suction header.

10. Start the isolated charging pump at its maximum capacity, adding the first decontamination solution into the pressurizer via the spray nozzle.

11. When the pressurizer level is between 90 and 100 in., turn on the available pressurizer heater group.

12. Open the drain valves in the pressurizer drain line, setting the drain valve to maintain pressurizer level between 90 and 100 in.

NOTE: Refer to O.I. No. 504L1, RADIOACTIVE WASTE DISPOSAL SYSTEM, page 504L1:15, paragraph C, and process the primary drain collecting tank liquids in accordance with this procedure. The primary drain collecting tank and one holdup tank will be purged of hydrogen and fission product gases and a nitrogen blanket established over them.

13. Maintain the solution in the pressurizer at a temperature of approximately 230 F.

14. After approximately 90 min, shut off the isolated charging pump and close the valves in the feed line from the boric acid mixing and storage tank to the charging pump suction header opened in Step 9.

15. Turn off the pressurizer heaters.

16. Allow the pressurizer to be filled with borated water by readjusting the pressurizer drain valve.

17. Drain the boric acid tank of the residual first solution by opening the appropriate drain valve.

18. Prepare approximately 3,000 gal of the second decontamination solution in the boric acid mixing and storage tank.

    a. Measure out 2,600 lb of ammonium citrate.

    b. Repeat Steps b through g, paragraph A-2.

    c. Stop the pump when 2,800 gal of water have been added to the tank.

    d. Close the valve in the water supply line to the boric acid mixing and storage tank.

    e. Slowly add into the tank the specified amount of ammonium citrate.

    f. Sample the solution.

    g. When the temperature of the solution reaches 150 F, stop the mechanical mixer.

19. Open the valve in the charging line for operation of an isolated charging pump.

20. Repeat Steps 9 through 12, paragraph B.

21. Maintain the solution in the pressurizer at a temperature of approximately 200 F.

22. Repeat Steps 14 and 15, paragraph B.

23. Allow the pressurizer to be filled with borated water by readjusting the pressurizer drain valve.

24. Shut off the charging pump feeding borated water and close the valves in the line connecting the safety injection and shield tank cavity water tank and the low pressure surge tank.

25. Open the isolation valve in the charging pump suction header.

26. Close the manually operated valve located in the vapor container in the line connecting the chemical injection line to the pressurizer spray line.

27. Close the valves in the pressurizer drain line.

NOTE: Process the drained decontamination solutions as soon as possible.

VI. Final Conditions

1. A loop has been decontaminated and is ready for inspection and/or maintenance operation.

2. The pressurizer has been decontaminated and is ready for maintenance operation.

MAINTENANCE INSTRUCTION NO. 506B3

PRIMARY PLANT
COLD LEAK TEST

I. Objective The cold leak test is to prove leak tightness of the reactor vessel closure, vessel connections and connecting pressurizer system after having been opened and subsequently closed for purposes of maintenance and/or periodic refueling.

II. Conditions

1. All maintenance work and/or refueling has been completed and the high pressure portions of the nuclear steam generator are "buttoned up."

2. The main coolant system is filled solid with borated water and is adequately vented. Refer to O.I. 504D1, MAIN COOLANT SYSTEM FILLING, VENTING AND DRAINING OF COMPLETE SYSTEM.

   NOTE: If only maintenance work is required in an isolated loop and is completed, the isolated loop is filled with borated water and is adequately vented by referring to O.I. No. 504D2, MAIN COOLANT SYSTEM-FILLING, VENTING AND DRAINING AN ISOLATED LOOP.

3. The main coolant system is at a pressure of 250 psi gage and at approximately 70°F. Refer to O.I. No. 504D1 and O.I. No. 504D2.

4. Isolation of the reactor vessel and connecting pressurizer system from the heat removal system may be established for the cold leak test period provided the coolant temperature in the vessel does not increase at a rate exceeding 50°F per hour and that the maximum temperature increase during the test period does not exceed 100°F. Temperature monitoring shall be accomplished by means of the in-core thermocouples.

5. Pertinent auxiliary systems are in the following status:

System	Status
Component Cooling System (Refer to O.I. No. 504I)	Partial operation - as required
Primary Plant Corrosion Control System (Refer to O.I. No. 504J)	Isolated
Purification System (Refer to O.I. No. 504H)	Isolated
Shutdown Cooling System (Refer to O.I. No. 504M)	Operating, if required

System	Status
Nuclear Instrumentation System (Refer to O.I. No. 5040)	Operating
Safety Injection System (Refer to E.I. No. 505B10)	Ready Standby

III. Precautions

1. When the nuclear core is in place, the maximum allowable leak test pressure is 2,485 psi gage at a temperature 60°F in excess of the estimated vessel nil ductility temperature.

2. The reactor plant pressure detection equipment must be in good working order.

3. Full pressurization shall not be effected until the coolant and metal temperatures have reached the test temperature.

4. The main coolant system pressure must not exceed 500 psi gage until the temperature of the coolant is at the test temperature.

5. Only authorized personnel are allowed in the vapor container during the leak test at selected times.

6. A proper water balance should be established in the water storage and waste collection tanks to ensure that adequate make-up is available and to receive water rejected from the primary plant.

IV. Check-Off List

Prior to initiation of this M.I., the check-off list must be completed by the operator(s) and signed off.

V. Instructions

A. Cold Leak Test of Complete Main Coolant System

1. Evacuate all non-essential personnel from the vapor container.

2. Prepare for plant cold leak test by gagging the pressurizer safety valve and other relief valves which are likely to leak during the test.

CAUTION: Leave at least one safety valve in operation if decay heat is being added to the main coolant system. Establish which valves, other than the safety valve, can be used to bleed off liquid to prevent any rapid pressure rise resulting from expansion of the coolant.

3. Shut off and isolate the shutdown coolant system when the complete system is to be cold leak tested. Refer to O.I. No. 504M, SHUTDOWN COOLING SYSTEM.

4. Start all the main coolant pumps and gradually heat up the main coolant system to a minimum temperature of 90 F.

   NOTE: The main coolant system must be maintained at a minimum pressure of 250 psi gage in order to meet the minimum operating suction requirement of 100 psi gage for the main coolant pumps.

5. Relieve the main coolant system expansion during heating up operation by using the manually controlled flow valve in the drain header bypass line to low pressure surge tank.

6. When the main coolant system reaches a minimum temperature of 90 F, shut off the main coolant pumps.

7. Maintain a minimum main coolant system temperature of 90 F for approximately 30 min to establish a main coolant system metal-water temperature equilibrium. Operate one main coolant pump, if necessary.

8. When the main coolant system metal-water temperature equilibrium is obtained, operate the designated variable speed charging pump to gradually raise the system pressure from 250 psi gage to 500 psi gage.

   NOTE: The charging pump suction should be maintained with primary grade borated water.

9. Observe the system pressure for 5 min after the charging pump has been shut off. Assure that the drop in the main coolant system pressure is less than 100 psi for this 5 min period. If the loss in the system pressure is less than 100 psi for this 5 min period proceed to Step No. 14. If the system pressure loss is greater, determine the source of leakage by visual inspection; removal of thermal insulation may be required. Proceed to Step No. 10.

   NOTE: If the core is producing decay heat during the leak test, the heat added will tend to raise the main coolant system pressure. If system pressure remains constant or decreases, leakage exists. If system pressure increases, leakage may or may not exist.

10. After establishing source of leakage, depressurize the main coolant system by using the manually controlled flow valve in the drain header bypass line to the low pressure surge tank.

11. Adjust the level in the low pressure surge tank, if necessary Refer to O.I. No. 504F, CHARGING AND VOLUME CONTROL SYSTEM.

12. Cool down the main coolant system by employing the shutdown cooling system and make the necessary repairs. Refer to O.I. No. 504M, SHUTDOWN COOLING SYSTEM.

13. Start the available charging pump and gradually raise the main coolant system pressure to a minimum of 250 psi gage and repeat cold leak test from Step No. 3 under Section V-A.

14. Start the charging pump and gradually increase the system pressure from approximately 500 to 2,485 psi gage.

15. Observe the main coolant system pressure for 5 min after the charging pump has been shut off. Assure that the drop in the system pressure is less than 100 psi for the 5 min period. If the loss in the system pressure is less than 100 psi for the 5 min period proceed to Step No. 20. If the system pressure loss is greater, determine the source of leakage by visual inspection; removal of thermal insulation may be required. Proceed to Step No. 16.

16. After establishing source of leakage, depressurize the main coolant system by using the manually controlled flow valve in the drain header bypass line to the low pressure surge tank.

17. Repeat Step No. 11, if necessary.

18. Cool down the main coolant system by employing the shutdown cooling system and make necessary repairs. Refer to O.I. No. 504M, SHUTDOWN COOLING SYSTEM.

19. Repeat Step No. 13.

20. Depressurize the system to 250 psi gage by using the manually controlled flow valve in the drain header bypass line to the low pressure surge tank.

21. Repeat Step No. 11, if necessary.

22. When the system is depressurized start the shutdown cooling system. Refer to O.I. No. 504M, SHUTDOWN COOLING SYSTEM.

23. Remove gag from appropriate pressurizer safety valve and other valves gagged in Step No. 2 under Section V-A.

NOTE: Upon completion of the cold leak test, the main coolant system is maintained at a minimum temperature and pressure of 90 F and 250 psi gage, respectively.

B. Cold Leak Test of an Isolated Loop

1. After the isolated loop has been filled and vented, maintain system for approximately 30 min at a temperature of approximately 70 F to permit a water-metal temperature equilibrium to be established in the isolated loop.

2. Maintain shutdown cooling system in operation when a cold leak test is performed in an isolated loop. Refer to O.I. No. 504M, SHUTDOWN COOLING SYSTEM.

3. Start the available charging pump and gradually increase the isolated loop pressure from 250 to 500 psi gage through the designated isolated loop fill line.

4. Observe the isolated loop pressure for 5 min after the charging pump has been shut off. Assure that the drop in the isolated loop pressure is less than 100 psi for this 5 min period. If the loss in the isolated loop pressure is less than 100 psi for this 5 min period, proceed to Step No. 6. If the system pressure loss is greater, determine the source of leakage by visual inspection; removal of thermal insulation may be required. Proceed to Step No. 5.

5. After establishing a source of leakage, depressurize the isolated loop by using the manually controlled flow valve in the drain header bypass line to the low pressure surge tank and make necessary repairs. Adjust level in the low pressure surge tank, if necessary. When the system has been repaired, repeat this cold leak test from Section V-B, Step No. 2.

6. Start the charging pump and gradually increase the system pressure from approximately 500 to 2,485 psi gage.

7. Observe the isolated loop pressure for 5 min after the charging pump has been shut off. Assure that the drop in the pressure is less than 100 psi for this 5 min period. If loss in the isolated loop pressure is less than 100 psi for the 5 min period, proceed to Step No. 9. If the system pressure loss is greater, determine the source of leakage by visual inspection; removal of thermal insulation may be required. Proceed to Step No. 8.

8. Repeat Step No. 5 under Section V-B.

9. Depressurize the system by using the manually controlled flow valve in the drain header bypass line to the low pressure surge tank. Adjust level in the low pressure surge tank, if necessary.

   NOTE: Upon completion of the cold leak test, the isolated loop is maintained at a temperature of approximately 70 F and a minimum pressure of 250 psi gage.

VI. Final Conditions

A satisfactory cold leak test has been performed on the complete main coolant system or an isolated loop, either of which is ready for normal startup from the cold condition. Refer to O.I. No. 504D4, MAIN COOLANT SYSTEM - STARTUP OF COMPLETE SYSTEM

MAINTENANCE INSTRUCTION NO. 506B4

PRIMARY PLANT
FUEL TRANSFER PIT PURIFICATION SYSTEM OPERATION

I. Objective To provide a means for removal of impurities from the fuel transfer pit water when the fuel transfer pit cooler is in operation and when the fuel transfer pit cooler is not in operation.

II. Conditions

1. The activity in the fuel transfer pit water is above the maximum permissible value given in the Radiation Protection Manual and/or the quantity of undissolved impurities in the fuel transfer pit water is above normal.

2. The fuel transfer pit ion exchanger is available for service.

3. Pertinent auxiliary systems are in the following status:

System	Status
Fuel Transfer Pit Cooling System Operation (Refer to M.I. No. 506B5)	Cooling fuel pit water, if required

III. Precautions

The fuel transfer pit ion exchanger must not be exposed to temperatures exceeding 140 F.

IV. Check-off List

Prior to the initiation of this M.I., the check-off list must be completed by the operator(s) and signed off.

V. Instructions

A. Fuel Transfer Pit (FTP) Cooler in Operation

1. Open the bypass globe valve from the cooler outlet header to the FTP ion exchanger inlet line.

2. Open the upstream and downstream valves to and from the ion exchanger.

3. Open the globe valve from the FTP ion exchanger return line to the discharge header returning to the fuel transfer pit.

4. Close the gate valve in the FTP cooler discharge header that normally allows flow to return directly to the FTP.

5. Close the valves in the bypass line of the FTP ion exchanger.

6. Sample the FTP water. Refer to O.I. No. 504K2, PRIMARY PLANT SAMPLING SYSTEM - AUXILIARY SYSTEMS.

7. When the activity has been reduced to the value given in the Radiation Protection Manual, open the valves closed in preceding Step Nos. 4 and 5 and close valves opened in preceding Step Nos. 1, 2 and 3.

B. Fuel Transfer Pit (FTP) Cooler Not in Operation

1. Open the globe valve to the FTP ion exchanger inlet line.

2. Open the upstream and downstream valves to and from the ion exchanger.

3. Open the globe valve from the FTP ion exchanger return line to the discharge header returning to the FTP.

4. Close the gate valve in the FTP cooler inlet header.

5. Close the valves in the bypass line of the FTP ion exchanger.

6. Close the gate valve in the FTP cooler discharge header.

7. Prime the FTP pump suction by flooding it with primary grade water.

8. Start the FTP pump.

9. Sample the FTP water. Refer to O.I. No. 504K2, PRIMARY PLANT SAMPLING SYSTEM - AUXILIARY SYSTEMS.

10. When the activity has been reduced to the value given in the Radiation Protection Manual, shut off the FTP pump and open the valves closed in Step Nos. 4, 5 and 6 and close the valves opened in Step Nos. 1, 2 and 3.

VI. Final Condition

The fuel transfer pit purification system has been put into operation or has been shut down when operation is no longer required.

MAINTENANCE INSTRUCTION NO. 506B5

PRIMARY PLANT
FUEL TRANSFER PIT COOLING SYSTEM OPERATION

I. Objective To provide a safe and efficient method of removing decay heat from spent fuel assemblies that are transferred to the fuel pit during refueling operations and the subsequent storage period, until they are loaded into coffins and removed from the fuel pit.

II. Conditions

1. Reactor refueling operations have progressed to the stage where the spent fuel is to be removed from the reactor. Refer to M.I. No. 506E4, REACTOR REFUELING - FUEL AND CONTROL ROD REPLACEMENT.

2. The fuel pit is filled with primary grade water to the proper water level (approximately 36 feet) and is at ambient temperature.

3. The component cooling system is in operation. Refer to O.I. No. 504I, COMPONENT COOLING SYSTEM.

III. Precautions

Fuel pit water temperature should be maintained below 130 F at all times.

IV. Check-off List

Prior to initiation of this M.I., the check-off list must be completed by the operator(s) and signed off.

V. Instructions

1. Provide component cooling water flow to the fuel pit cooler by opening the inlet gate valve and the outlet by-pass hand control valve of the component cooling system.

2. Open the primary grade water to the priming line for the fuel pit cooling pump and start the pump.

3. As the decay heat load varies during refueling operations and the subsequent storage period, maintain the fuel pit water temperature below 130 F by adjusting the component cooling water flow rate through the fuel pit cooler.

4. After all the spent fuel assemblies have been loaded into coffins and removed from the fuel pit, stop the fuel pit cooling pump and shut off the component cooling water flow to the fuel pit cooler.

IV. Final Conditions

1. The fuel pit cooling system has been put into operation to maintain fuel pit water temperature below 130 F during refueling and the subsequent storage period.

2. The fuel pit cooling system has been shutdown following removal of all spent fuel assemblies from the pit.

MAINTENANCE INSTRUCTION NO. 506B6

PRIMARY PLANT
REPLACEMENT OF ION EXCHANGE CONTAINERS

I. Objective To provide a safe and efficient method of flushing and moving spent ion exchangers and replacing them with containers of fresh resin and of loading spent exchangers into the shipping coffin.

II. Conditions

1. The work area crane is available for moving ion exchanger and removing concrete shield slabs.

NOTE: The pad area south of the pipe tunnel and stairs can be used for temporary storage of vessels filled with fresh resin, slabs, tools, etc.

2. Before work begins on moving an ion exchanger containing spent resin, tools for unbolting the pipe flanges, plugging the vessel nipples, unscrewing the standpipes, and inserting the cored sealing plugs should be available. If a vessel is to be loaded into the shipping container, tools for assembly of that unit should be available.

3. Ion exchanger shells have been filled with fresh resin prior to starting Step A under Section V.

4. Pertinent auxiliary systems are in the following status:

System	Status
Radioactive Waste Disposal System - Liquid Waste Disposal (Refer to O. I. No. 504L1)	Prepared to receive radioactive rinse water

III. Precautions

1. Any time that work is carried on with any shielding out of place, the applicable portions of the Section 507, RADIOLOGICAL HEALTH AND SAFETY must be followed.

2. Flush the spent resin with fresh water if the contamination and gaseous release in the ion exchanger is sufficient to require it. Then shut off all valves to and from ion exchanger and proceed to disconnect flexible connection pipe flanges for removal of spent ion exchanger.

3. Extra caution should be exercised in removing a spent fuel transfer pit ion exchanger, since it cannot be flushed with uncontaminated water, as per the following Step Nos. 2 and 9 under Section V-A.

4. Before a vessel containing spent resin is loaded into the shipping container, it should be monitored to assure that radiation will not exceed specified limits.

IV. Check-off List

Prior to the initiation of this M. I., the check-off list must be completed by the operator(s) and signed off.

V. Instructions

A. Flushing and Moving a Spent Ion Exchanger and Installing a Fresh Ion Exchanger

1. If it is necessary to continue purification or boric acid removal, transfer flow to the alternate ion exchanger by opening its inlet and outlet header isolation valves. Close the inlet and outlet valves from the headers to the vessel to be replaced.

NOTE: Replacement of the fuel pit ion exchanger should be made at a time when purification of the fuel pit water is not required.

2. Check that the primary water supply isolation valves to the following are closed:

The boric acid mixing and storage tank
The pump sealing system
The safety injection and shield tank cavity water tank
The fuel pit
The charging pump suction line

3. Open the primary water supply isolation valve to the ion exchanger flush line.

4. Open the shutoff valve in the inlet line to the spent ion exchanger from the primary water supply header.

5. Open the shutoff valve in the outlet line from the ion exchanger to the discharge line to either of the 75,000 gal holdup tanks in the waste disposal system.

6. Take one low pressure surge tank make-up pump off standby and put it in manual position.

7. Start the low pressure surge tank make-up pump which has been put on "Manual". Stop the pump when about 200 gal have been flushed through the ion exchanger.

8. Close the valves which were opened in Step Nos. 5, 4 and 3 under Section V-A.

9. Open the valves which were closed in Step No. 2 of Section V-A.

10. If a purification ion exchanger is being replaced, check that the shutoff valve in the inlet to the ion exchanger from the primary drain collecting tank is closed.

11. Remove the hand rail at the south end of the ion exchanger storage pit.

12. Move the work area crane over the south end of the ion exchanger storage pit, and remove the horizontal concrete slab from the top of the ion exchanger pit to a convenient temporary storage spot.

13. Disconnect the pipe flanges at the tops of the inlet and outlet risers.

14. Insert an ion exchanger sealing plug through either the inlet or the outlet riser until the plug seats in the nipple.

15. Back the manipulating wrench out of the sealing plug and remove the wrench from the riser.

16. Repeat Step Nos. 14 and 15 for the other riser.

17. Unscrew both risers and remove them from the pit.

    NOTE: Survey the risers for external contamination. Cleaning may be required before they are assembled on another vessel.

18. Insert cored pipe plugs in the inlet and outlet nipples, above the sealing plugs.

19. Using the work area crane, remove the vertical concrete shield and put the shield in a convenient temporary storage location.

20. Move the crane over the pit and remove the section of the pit cover which is necessary to uncover the alleyway for moving the spent resin vessel.

21. Move the crane over the ion exchanger which is to be moved, and lift the vessel enough to clear the rails.

22. Move the ion exchanger vessel, as far as possible, toward the north end of the alleyway. Set the vessel down and move the crane to pick up the vertical concrete shield. Put the shield back in place.

23. Replace the section of ion exchanger storage pit cover which was removed in Step No. 20.

24. Assemble both risers on the fresh ion exchanger nozzles.

NOTE: If the risers have been removed from an ion exchanger which was in service, inspect the threads on the riser for damage. Inadequate sealing where the riser makes up with the nozzle may result if the threads are damaged.

25. Pick up the assembled unit with the crane and move the crane into position to lower the ion exchanger into the south end of the pit.

26. Lower the fresh ion exchanger onto the supporting rails and position it so that the riser flange faces can be made up to the flexible connector flange faces.

27. Bolt the ion exchanger inlet flange.

28. Perform Step Nos. 2 and 3 under Section V-A.

29. Open the shutoff valve to the ion exchanger from the primary water supply header about half of the valve travel.

30. Start the low pressure surge tank make-up pump which is on "Manual". Stop the pump when water flows out of the ion exchanger outlet riser.

31. Open the valve which was throttled in Step No. 29.

32. Make up the flange at the top of the outlet riser.

33. Start the manual low pressure surge tank make-up pump and observe the flanges for leaks. Return the pump to standby position.

34. Open the valves which were closed in Step No. 28 and close the valves which were opened in Step No. 28.

35. Using the work area crane, replace the horizontal concrete sheild slab.

B. Loading a Decayed Ion Exchanger Into the Shipping Coffin

1. If detailed instructions for loading a spent exchanger into the shipping coffin are deemed necessary, they will be added to this instruction at a later date since several years of storage capacity appear to be available.

VI. Final Conditions

1. A spent ion exchanger has been flushed and moved to storage, and a fresh ion exchanger has been installed.

2. A sufficiently decayed ion exchanger has been loaded for disposal.

MAINTENANCE INSTRUCTION NO. 506B7

PRIMARY PLANT
REPLACEMENT OF PRESSURIZER HEATERS

I. Objective To provide a procedure for replacing a pressurizer heater bundle.

II. Conditions

1. The pressure control and relief system is shut down and the pressurizer vent is open to the atmosphere. Refer to O.I. No. 504E, PRESSURE CONTROL AND RELIEF SYSTEM.

2. The main coolant system is shut down. Refer to O.I. No. 504D7, MAIN COOLANT SYSTEM - SHUTDOWN OF COMPLETE SYSTEM.

3. The low pressure surge tank is prepared to receive one pressurizer water volume (less than 300 cu ft).

4. The reactor vessel head is in place and will not be removed for refueling operations during the period when pressurizer heaters are being replaced.

5. The vapor container has been ventilated and prepared for personnel and equipment access. Refer to O.I. No. 504Q, VAPOR CONTAINER ATMOSPHERE CONTROL SYSTEMS and M.I. No. 506D, VAPOR CONTAINER ACCESS.

6. A heater removal coffin and a replacement heater bundle are available and have been transported to the refueling floor in the vapor container.

7. Pertinent auxiliary systems are in the following status:

System	Status
Component Cooling System (Refer to O.I. No. 504I)	Normal operation
Shutdown Cooling System (Refer to O.I. No. 504M)	Normal operation

III. Precautions

1. Do not open a control rod vent while the pressurizer heater maintenance is being performed. Breaking the vacuum in the reactor head could flood the pressurizer.

2. Do not permit the pressurizer surge pipe water level to decrease during heater bundle replacement operations, in order to prevent air from entering the main coolant system.

3. Refer to Section 507, RADIOLOGICAL HEALTH AND SAFETY for the required personnel protection procedures.

4. Take necessary precautions to prevent energizing any pressurizer heaters during maintenance operations.

5. Take necessary precautions to prevent closing the pressurizer drain valve while the pressurizer heaters are being replaced.

6. Check hydrogen concentration in the working area inside the pressurizer cubicle for indications of an explosive mixture.

IV. Check-off List

Both the premaintenance and the maintenance check-off lists have been prepared. The premaintenance check-off list must be completed and signed off by the operator(s) prior to initiation of this instruction.

V. Instructions

1. Using the polar crane, remove the lower pressurizer cubicle access slab located in the refueling floor (El. 1112'-0").

2. Check the radiation level in the pressurizer cubicle and at the pressurizer heater cover plates. If radiation level is high, use of a decontamination solution in the pressurizer may be necessary or advisable. Refer to M.I. No. 506B2, PRIMARY PLANT - DECONTAMINATION SYSTEM OPERATION.

3. Open the valves in the charging and volume control system bleed line so that the water in the pressurizer will drain into the low pressure surge tank.

4. When the pressurizer water level has decreased to the lower limit of the wide range level detector, close the bleed valves and open the pressurizer drain valve and valves in the drain header to the primary drain collecting tank.

5. Prevent main coolant volume contraction during the maintenance operation by either maintaining main coolant temperature or adding water to the pressurizer surge pipe from an external source.

6. Lower the heater removal coffin, the new heater bundle, and all other necessary equipment to the heater maintenance platform (El. 1083'-3 1/2"), using the vapor container polar crane.

7. Prepare the heater removal coffin for placement over the heater nozzle.

8. Rig a two-ton chain hoist to the trolley rail above the heater bundle to be removed.

9. Attach the chain hoist to the lug on the heater cover plate.

10. Disconnect the 12 heater cable plugs from the heater terminal seals.

11. Remove the two nuts on the long studs and remove the heater support plate.

12. Remove the 12 nuts holding the cover plate in place.

13. Pull the cover plate clear of the long studs and lower the cover plate to the heater maintenance platform.

14. Check radiation level at the heater diaphragm.

15. Remove the studs, if necessary, for heater coffin clearance.

16. Clamp a cable to the heater bundle and run the cable through the heater coffin and through the eyebolt installed in the wall opposite the heater nozzle.

17. Attach the chain hoist to the heater coffin, raise the coffin to a position in line with the heater nozzle, and move the coffin to within about 6 in. of the nozzle face.

18. Remove the three bolts holding the heater diaphragm against the gasket. Check for any indication that the gasket is sticking and pry loose if stuck.

    NOTE: If the diaphragm has been seal welded to the vessel, grind through the weld until the diaphragm is loose.

19. Place the coffin against the vessel, pull the heater bundle into the coffin, and unclamp and remove the cable.

20. Pull the coffin away from the vessel, bolt end caps in place, and lower the coffin to the heater maintenance platform.

    CAUTION: During all steps performed while the heater nozzle is uncovered, necessary precautions for radiation monitoring and shielding should be observed. The nozzle opening should be plugged so that foreign matter can not enter the pressurizer.

21. Install the replacement heater in accordance with the Manufacturer's Instruction Book.

22. Raise heater coffin and other equipment to the refueling floor using the vapor container polar crane. Transport the heater coffin to the waste disposal area.

23. Close the pressurizer drain valve.

24. Perform a cold leak test. Refer to M.I. No. 506B3, PRIMARY PLANT - COLD LEAK TEST AND O.I. No. 504D1, MAIN COOLANT SYSTEM - FILLING, VENTING AND DRAINING OF COMPLETE SYSTEM.

25. Replace the access slab in the refueling floor.

VI. Final Condition

1. A pressurizer heater bundle has been replaced.

2. The pressurizer has been tested for leakage and is prepared for plant startup operations.

MAINTENANCE INSTRUCTION NO. 506B8

PRIMARY PLANT
NEUTRON SHIELD TANK MAINTENANCE

I. Objective To provide safe and efficient methods for accomplishing the following actions relative to the neutron shield tank:

A. Filling
B. Draining
C. Sampling
D. Operating
E. Minor Repairing
F. Major Repairing

II. Conditions

A. Filling

1. The reactor plant is not operating.

2. Personnel are available within the vapor container.

3. Sufficient treated water, including rust inhibitor, is available from the component cooling water header.

B. Draining

1. The reactor plant is not operating.

2. Personnel are available within the vapor container.

3. The vapor container drain tank and/or the gravity drain tank is available to receive the neutron shield tank water.

C. Sampling

1. The reactor plant may or may not be operating.

2. Suitable containers are available for collecting the samples.

D. Operating

1. The reactor plant is operating.

2. The water level in the surge tank is at the proper level.

3. The temperature of the water in the neutron shield tank is at the proper value.

E. Minor Repairing

1. The reactor has been made subcritical and is in hot standby condition as per O.I. No. 504C1, PLANT SHUTDOWN - SCHEDULED REACTOR SHUTDOWN, that is, plant temperature and pressure are being maintained.

2. Internal air filtration system is in operation. Refer to O.I. No. 504Q, VAPOR CONTAINER ATMOSPHERE CONTROL SYSTEMS.

3 Lights in the vapor container have been switch on.

4. The vapor container has been approved for personnel access by a Health and Safety representative.

5. Pertinent auxiliary systems are in the following status:

System	Status
Vapor Container Atmosphere Control Systems (Refer to O.I. No. 504Q)	
Internal Filtration	Normal operation
Heating or Cooling	Normal operation
Purging	Shutdown

F. Major Repairing

1. The reactor plant has been cooled down and depressurized as per O.I. No. 504C2, PLANT SHUTDOWN - REACTOR COOLDOWN.

2. Airborne activity has been reduced to tolerance by internal filtration and external purging as per O.I. No. 504Q, VAPOR CONTAINER ATMOSPHERE CONTROL SYSTEMS.

3. Lights in the vapor container have been switched on.

4. The vapor container has been approved for personnel access by a Health and Safety representative.

5. Pertinent auxiliary systems are in the following status:

System	Status
Vapor Container Atmosphere Control Systems (Refer to O.I. No. 504Q)	
Internal Filtration	Shutdown
Heating or Cooling	Normal operation
Purging	Normal operation

III. Precautions

A. Filling

The neutron shield tank hand hole flanges and other flanges must be secured before the water level reaches the top of the neutron shield tank.

B. Draining

1. The valve in the fill line must be closed.

2. The neutron shield tank water must be monitored for radioactivity after being drained into the vapor container drain tank. If the radioactivity level is below the allowable level, the water may be discharged to the river through the circulating water system. If radioactivity is above allowable level the water must be transferred to the primary drain collecting tank for processing via the waste disposal system.

C. Sampling

The valves in the sampling lines must be completely closed after the sampling operation.

D. Operating

1. The water level in the surge tank must not be permitted to fall below the low level alarm position.

2. The temperature of the neutron shield tank water must not rise above 130 F.

E. Minor Repairing

1. Personnel entry into the vapor container is directed by a Health and Safety representative.

2. Maintenance operations on contaminated equipment or in contaminated areas must be performed in accordance with instructions given in Section 507, Radiological Health and Safety.

3. Plant startup should not proceed until all hatches and vapor container openings have been secured. Refer to M.I. No. 506D, Vapor Container Access.

F. Major Repairing

1. The same precautions apply as for minor repairing.

2. The shipping hatch must not be opened unless the main coolant system is depressurized.

IV. Check-off List

Prior to the initiation of the M.I. the check-off list must be completed by the operator(s) and signed off.

V. Instructions

A. Filling

1. Open the valve in the fill line

2. Close the valve in the fill line when the water level in the surge tank reaches the second indicator position from the bottom of the surge tank.

B. Draining

1. Attach a temporary level detection instrument to the level detection line.

2. Attach a hose to the ejection line hose connection and allow the hose to drain into the vapor container drain tank.

3. Attach a water line to the ejection line eductor.

4. Turn on the water and empty the neutron shield tank through the ejection line.

C. Sampling

Open the appropriate sampling line, depending on whether a sample is desired from the bottom or the top of the neutron shield tank, and collect the sample in a proper container.

D. Operating

1. Maintain the water level in the surge tank at the third indicating position from the bottom of the surge tank by observing the action of the level indicator lights. Operate the valve in the fill line as necessary to maintain the water level.

2. It is recommended that water temperature in the neutron shield tank be maintained between 120 F and 130 F (max) by controlling the amount of cooling water flowing through the coolers.

3. Uncap the two telltale drains and inspect for leakage at least once a month.

E. Minor Repairing

1. Enter the vapor container. Refer to M.I. No. 506D, VAPOR CONTAINER ACCESS.

2. Accomplish the minor repairs. Minor repairs are repairs to instrumentation or to other equipment outside of the neutron shield tank which do not jeopardize the integrity of the main coolant system.

F. Major Repairing

1. Enter the vapor container. Refer to M.I. No. 506D, VAPOR CONTAINER ACCESS.

2. Make a radiation survey in the vicinity of the neutron shield tank repair area. Flush and decontaminate the tank if required.

   NOTE: Remove old core if the radiation levels are too high. Major repairs are repairs to the inside of the neutron shield tank.

3. Open the manhole in the top of the neutron shield tank.

4. Provide lead shielding, if required, in the neutron shield tank repair area.

5. Make the major repairs and test the neutron shield tank by local techniques and by observation of the two telltale drains.

VI. Final Condition

A. The neutron shield tank is filled.

B. The neutron shield tank is drained.

C. Water samples have been taken from the neutron shield tank.

D. The neutron shield tank is operating.

E. Minor repairs of the neutron shield tank have been accomplished.

F. Major repairs of the neutron shield tank have been accomplished.

506C SECONDARY PLANT

The secondary plant maintenance program is designed to keep the secondary plant in good operating order through the use of conventional power plant methods. The spread of radioactivity into the secondary plant is prevented by layout and design of equipment, administrative control of personnel and of operations, and is further guarded against by a continuous monitoring and testing program.

Maintenance of secondary plant equipment will be carried out subject to traditional company safety rules and procedures with which many of the plant personnel are already familiar. These safety rules provide for various types of electrical and mechanical clearances necessary before individual items of equipment may be taken out of service and maintenance performed. The safety rules also provide for proper working methods, tool inspections, and the safety instruction of plant personnel. A list will be compiled showing the individuals authorized to isolate, tag, or work on equipment. Each of these individuals will have demonstrated and been tested in his knowledge of the plant and the safety procedures.

The personnel engaged in the maintenance of the secondary plant will be trained as described in Section 502, PERSONNEL TRAINING, and will have acquired basic mechanical skills prior to their employment.

A preventive maintenance program and lubrication schedule will be adopted based on equipment manufacturers' instructions and recommendations. A record will be kept at the plant of all maintenance operations. Spare parts and materials will be in stock in the usual power plant quantities and in accordance with manufacturers' recommendations.

The service of manufacturers' representatives will be employed on certain items of equipment and Yankee will also have available the special services and experience of its sponsoring companies acquired over many years of steam-electric station operation.

MAINTENANCE INSTRUCTION NO. 506D

VAPOR CONTAINER ACCESS

I. Objective To provide a safe means of personnel and equipment access to the interior of the vapor container.

II. Conditions

A. For Minor Repairs or Maintenance (requiring only a short interval of time)

1. The reactor has been made subcritical and is in the hot standby condition as per O.I. No. 504C1, PLANT SHUTDOWN - SCHEDULED REACTOR SHUTDOWN, that is plant temperature and pressure are maintained.

2. Internal air filtration system is in operation. Refer to O.I. No. 504Q, VAPOR CONTAINER ATMOSPHERE CONTROL SYSTEMS.

3. Lights in the vapor container have been switched on.

4. The vapor container has been approved for personnel access by the health and safety supervisor.

6. Pertinent auxiliary systems are in the following status:

System	Status
Vapor Container Atmosphere Control Systems (Refer to O.I. No. 504Q)	
Internal Filtration	Normal operation
Heating or Cooling	Normal operation
Purging	Shutdown

B. For a Scheduled Reactor Shutdown

1. The reactor plant has been cooled down and depressurized as per O.I. No. 504C2, PLANT SHUTDOWN - REACTOR COOLDOWN.

2. Airborne activity has been reduced to tolerance by internal filtration and external purging as per O.I. No. 504Q, VAPOR CONTAINER ATMOSPHERE CONTROL SYSTEMS.

3. Lights in the vapor container have been switched on.

4. The vapor container has been approved for personnel access by the health and safety supervisor.

5. Pertinent auxiliary systems are in the following status:

System	Status
Vapor Container Atmosphere Control Systems (Refer to O.I. No. 504Q)	
Internal Filtration	Shutdown
Heating or Cooling	Normal operation
Purging	Normal operation

III. Precautions

General

1. Personnel entry is directed by a health and safety representative.

2. Maintenance operation on contaminated equipment or in contaminated areas must be performed in accordance with instructions given in Section 507, RADIOLOGICAL HEALTH AND SAFETY.

3. Plant startup should not proceed until all hatches and vapor container openings have been secured.

4. Before opening the inner personnel hatch door, the personnel entering the vapor container will check that the pressures are equalized between the vapor container and inside of the personnel hatch.

A. For Minor Repairs or Maintenance

1. Personnel entering the vapor container must wear proper apparel as prescribed in Section 507, RADIOLOGICAL HEALTH AND SAFETY.

2. Exposure records of personnel entering the vapor container are available.

3. The shipping hatch must not be opened during hot standby condition.

B. For a Scheduled Reactor Shutdown

The airborne activity in the vapor container must be at or below tolerance as prescribed in Section 507, RADIOLOGICAL HEALTH AND SAFETY.

IV. Check-off List

Prior to the initiation of this M.I., the check-off list must be completed by the operator(s) and signed off.

V. Instructions

A. For Minor Repairs or Maintenance

1. Operate outer hatch until it is in the open position.

2. The health and safety representative will enter the hatch with at least one other man as prescribed in Section 507, RADIOLOGICAL HEALTH AND SAFETY.

3. Close the outer hatch before opening the inner hatch. Open the inner hatch to admit personnel into the vapor container.

B. For a Scheduled Reactor Shutdown

Same as V-A except that both hatches may remain open upon approval or technical services.

NOTE: Hatch operating switches are located on both sides of the outer hatch and the outer side of the inner hatch. If personnel access hatch operating mechanism fails, entrance to the vapor container may be gained by use of the auxiliary manhole located adjacent to the access hatch. Use of the manhole is permitted only when main coolant system is depressurized.

VI. Final Conditions

The vapor container has been entered. For A, the outer hatch is closed. For B, both hatches are open.

MAINTENANCE INSTRUCTION NO. 506E1

REACTOR REFUELING
SITE HANDLING AND STORAGE OF NEW FUEL AND CONTROL RODS

I. Objective To provide a safe and efficient method for site handling and storage of new fuel assemblies and control rods. Shim rods will be handled in the same manner as control rods.

II. Conditions

1. The vehicle transporting the new fuel assemblies and control rods is at the plant site loading platform of the new fuel storage vault.

2. The yard work area crane above the spent fuel storage pit is available for service.

3. The short handled new fuel assembly lifting fixture has been checked and is available for service.

4. The required number of storage racks are available for receiving new fuel assemblies, control rods and shim rods in the new fuel storage vault.

III. Precautions

1. The fuel assembly shipping container must be depressurized prior to opening.

2. Adequate precautions must be taken to prevent a fuel assembly from being ruptured when being removed from the shipping containers to the storage racks inside the new fuel storage vault. If a new fuel assembly is ruptured radiation levels, as well as airborne contamination, must be checked continuously as specified in Section 507, Radiological Health and Safety.

   All instructions labeled on shipping container must be adhered to.

3. Positive identification should be maintained on all components stored in the new fuel storage vault.

IV. Check-off List

Prior to initiation of this M.I. the maintenance check-off list must be completed by the operator(s) and signed off.

V. Instructions

A. New Fuel Assemblies

1. Using the yard work area crane, move the new fuel assembly shipping container from the transporting vehicle, to the unloading platform and place vertically in the new fuel storage vault.

2. Attach sling to top cover of shipping container and monorail crane.

3. Depressurize the shipping container and remove all bolts.

4. Remove the shipping container top cover by use of the monorail crane.

5 Remove the bolts which clamp the new fuel assembly in the shipping container.

CAUTION: Polyethylene cover must not be damaged when unclamping new fuel assembly from within shipping container.

6. Take a smear sample from the outer surface of the polyethylene cover and have it counted by the chemical laboratory.

7. When unclamping of the fuel assembly is completed, slide down a portion of the polyethylene cover exposing upper grappling connection of the fuel assembly sufficient to allow the short handle new fuel assembly lifting fixture to be attached.

8. Using the short handled new fuel assembly lifting fixture and the monorail crane, lift the fuel assembly vertically and place in designated storage rack.

CAUTION: Do not remove the polyethylene cover.

9. When the assembly is placed in the rack, remove the short handle new fuel assembly lifting fixture with the monorail craneto the disassembly platform. Reclose the polyethylene cover on top of fuel assembly.

10. Replace all bolts, nuts and clamps on shipping container.

11. Using the yard work area crane, raise the shipping container from the new fuel assembly platform and place it on the transporting vehicle.

12. Repeat steps 1 through 11 until all new fuel assemblies are stored.

B. Control Rods and Shim Rods

1. Remove the control rod or shim rod shipping container from the transporting vehicle and place in the fuel storage vault.

2. Open control rod or shim rod shipping container and slide down a portion of the polyethylene cover exposing upper grappling connection of the rod, sufficient to allow the short handled new fuel assembly lifting fixture to be attached (see Caution, Step 5, V-A).

3. By using the monorail crane and short handled new fuel assembly lifting fixture raise the control rod or shim rod vertically and place in designated storage rack.

CAUTION: Do not remove the polyethylene cover.

4. Remove short handled new fuel assembly lifting fixture and return to entrance of new fuel storage vault. Reclose the polyethylene cover on top of rod.

5. Repeat steps 1 through 4 until all control rods and shim rods are stored.

VI. Final Conditions

1. The new fuel assemblies, control rods and shim rods have been stored in racks in the new fuel storage vault and are ready when refueling of the reactor vessel is initiated.

MAINTENANCE INSTRUCTION NO. 506E2

REACTOR REFUELING
PREPARATION OF REACTOR SYSTEMS FOR REFUELING

I. Objective: To provide a safe and efficient method of preparing the reactor systems for refueling and subsequently assembling the reactor vessel after refueling.

II. Conditions Prior to Head Removal

1. The reactor is shut down and depressurized; all main coolant stop valves are closed.

2. The reactor has been borated to shutdown concentration and cooled down in accordance with O.I. No. 504C2, PLANT SHUTDOWN - REACTOR AND PRIMARY PLANT COOLDOWN.

3. The pressurizer is filled with borated water and is prepared for draining.

4. The main coolant system temperature is below 140°F.

5. Storage is available in the fuel transfer pit for spent fuel assemblies and for fresh fuel as required. The neutron count rate in the pit will be monitored whenever fresh fuel is being loaded into a storage rack. The count rate will also be monitored whenever spent fuel is being loaded into a rack unless fresh fuel of the same initial enrichment has been previously stored in the rack and an adequate subcritical margin has been verified.

6. A mixed bed resin is in place for fuel transfer pit demineralization.

7. Pertinent auxiliary systems are in the following status:

System	Status
Component Cooling System (Refer to O.I. No. 504I)	In operation as required
Shutdown Cooling System (Refer to O.I. No. 504M)	In operation
Nuclear Instrumentation System (Refer to O.I. No. 504O)	In operation
Vapor Container Atmosphere Control Systems (Refer to O.I. No. 504Q)	In operation
Radiation Monitoring System (Refer to O.I. No. 504P)	In operation

III. Precautions

1. The radiation level above the surface of the refueling water will be continuously monitored by a gamma guard mounted on the fuel handling crane.

2. Minimum depths of water over the various reactor internals should be maintained to limit radiation level above the refueling water.

3. The tools and equipment used should be kept free of dirt, grease, and foreign matter.

4. Personnel must wear special work clothing in all radiation and contamination areas. Refer to Section 507, RADIOLOGICAL HEALTH AND SAFETY.

5. A positive pressure must be maintained in the isolated loops, or loops must be open to atmospheric pressure, so as to prevent main coolant pump stator can damage.

6. For action to be taken in the event of refueling accident, refer to Emergency Instruction 505B21, REFUELING ACCIDENTS.

7. Foreign material must be prevented from falling into the reactor vessel while the reactor head is off, and no unauthorized or unnecessary personnel are to be allowed on the manipulator cranes or in refueling areas.

8. Equipment such as MC valves which might cause inadvertent changes in reactivity shall be tagged out of service.

IV. Instructions

Instructions	Date Complete	Initials
1. Enter the vapor container. Comply with M. I. No. 506D, VAPOR CONTAINER ACCESS.	______	______
2. Remove missile shield. Store between cubicles 4 and 1.	______	______
3. Remove items from cavity: lead, doghouse, etc.	______	______
4. Remove equipment hatch. Store on #3 steam generator cubicle.	______	______
5. Remove rod drive air ducts. Store outside VC.	______	______
6. Remove flux wire tubes between reactor head and cavity edge, thermocouple connections, and intercom.	______	______
7. Remove rod drive cables. Store on broadway.	______	______
8. Remove cable trays. Store outside V.C.	______	______
9. Remove coil stacks. Store in racks.	______	______
10. Remove shield blocks from cavity. Store on pressurizer compartment.	______	______

		Date Completed	Initials
3.	Ready manipulator crane.	________	________
	a. Install control cabinets	________	________
	b. Install trolley resistors	________	________
	c. Check guide rods	________	________
	d. Install pointer and stops and provide targets for drive rod and guide tube storage racks	________	________
	e. Change lubrication in gear boxes	________	________
	f. Replace SS boom guide bearings with C.S. bearings	________	________
	g. Install warning bell	________	________
	h. Add lights	________	________
	i. Install bracket for in-core instrumentation locking rod	________	________
	j. Install universal handling tool	________	________
	k. Install T.V.	________	________
	l. Get elevations for guide tube plugs in rack	________	________
4.	Remove grating and beams over equipment hatch and store on #4 steam generator cubicle.	________	________
5.	Remove equipment hatch cover and store on #3 steam generator cubicle.	________	________
6.	Remove rod drive air supply ducts and store on flat car.	________	________
7.	Remove flux wire tubes between reactor head and cavity edge, thermocouple connections, and intercom.	________	________
8.	Remove rod drive cables.	________	________
9.	Remove rod drive cable trays and store on flat car.	________	________
10.	Remove rod drive coil stacks and store in racks.	________	________
11.	Remove shield tank shielding blocks and store on #1 steam generator cubicle.	________	________
12.	Remove reactor head thermal insulation and store on flat car.	________	________

Item	Date Completed	Initials
13. Remove top hat air duct and baffles.		
a. Baffl bolted to top hat should be marked for reassembly		
b. Southeast segment of upper top hat must be removed first		
c. Lower section of top hat must be modified to facilitate removal		
d. Baffles bundled and stored on charging floor		
e. Top hat sections stored on flat car		
14. Install control rod and follower disengaging mechanism.		
15. Install track for bolt stretcher.		
16. Install parts of guide tube rack.		
17. Install jacking mechanism. Rig level in order or set into dowel pins.		
18. Complete jacking pump changes.		
a. Install prefabricated gage and accumulator board		
b. Install suction and discharge piping to cavity		
19. Remove fuel chute blank. (Cable car now rests against blank)		
20. Complete winch changes and check out:		
a. Wire DC motor		
b. Check rotation of motor		
c. Check proper operation of following:		
1. Stop and wait positions		
2. Slow down point		
3. Carriage speeds (loaded and light)		
4. Lower lock valve		
5. Proper operation of dewatering system so far as possible in dry condition of shield tank cavity and fuel pit about storage rack		

	Date Completed	Initials
6. Check upper lock valve for water tightness	________	________
d. Install stand pipe float and remove jumpers	________	________
21. Add fuel assembly support block to carriage.	________	________
22. Operate fuel handling system with new fuel element through 5 complete cycles with shield tank cavity dry and only bottom of fuel transfer pit wet.	________	________
23. Complete filling of fuel transfer pit and place demineralization in service as required by water quality.	________	________
24. Tighten neutron shield tank expansion joint rings.	________	________
a. Check condition of gasket	________	________
b. Replace missing washers removed placing shielding block racks	________	________
c. Install hooks on shield tank rim	________	________
25. Check that 4 BF_3 counters are operable and are indicating counts in the control room.	________	________
26. Install kidney covers with new gaskets.	________	________
27. Place caps with O rings on valves on reactor head.	________	________
28. Install extension on reactor head tell tale valve to bring to operating position above insulation.	________	________
29. Paint the following carbon steel parts:		
a. Welds and clips added to head lifting rig since original painting	________	________
b. Nuts and washers of expansion joint ring	________	________
c. Moat between expansion joints	________	________
d. Bracket of temperature indicator	________	________
30. Set up internals stacking plate to scribe marks on cavity floor and add guide tubes.	________	________

	Date Completed	Initials
31. Start to lower reactor vessel water level to desired height.		
a. Check that hydrogen pressure has been reduced to approximately 2 psig of H_2 on LPST		
b. Open pressurizer vent valve		
c. Check solenoid relief valve and motor operated isolation valve closed		
d. Open pressurizer drain valve and associated valves in line to LPST		
e. When the water level in the pressurizer falls below 150", open the vent connections on all the control rod drive mechanisms		
f. Close the pressurizer drain valve 30 minutes after the water level in the pressurizer has reached 20" on the wide range water level indicator		
32. Remove reactor head studs (see B&W Instruction Book, Pages 4-9).		
a. Place numbered sets of stud, washer, and nut in stud carrier		
b. Store carrier on charging floor		
c. Remove unground studs to shop for completion of machining		
d. Install 48 stud hole seal plugs and "O" rings		
e. Install 4 guide studs at hole numbers 9, 21, 33,45		
33. Install head lifting fixture.		
a. Observe point markings on legs		
b. Weld bails on lifting rig and on polar crane hook		
c. Clean and paint turnbuckle threads (after Step 39)		
34. Install platform on side of cavity manipulator crane.		
35. Cut instrumentation port welds, remove thimbles and Conoseals.		
a. Smaller weld cut first by Yankee cutter		

	Date Completed	Initials
b. Larger weld cut by AMF cutter	________	________
c. See Instruction Book, IN-CORE INSTRUMENTATION Section IV. P.2		
36. Place bullet nose covers on in-core instrumentation thimbles.	________	________
37. Clean cavity, head, moat, etc.	________	________
38. Open 3/4" vent valve on the reactor head.	________	________
39. Lift reactor head 1/2 to 1 inch to check levelness of head. Fasten line to bail of lifting rig.	________	________
40. Fill shield tank cavity to level of two feet of borated refueling water. Refer to M.I. No. 506E3, REACTOR REFUELING, SHIELD TANK CAVITY-FILL DRAIN.	________	________
41. Check shield tank cavity for leaks via the tell tales, compartments, and fuel chute.	________	________
42. Continue to fill the shield tank cavity to a level of ten feet while running a capacity test on both SI pumps.	________	________
43. Open the equalizer valve in the fuel transfer chute equalizer line in order to fill completely the upper portion of the fuel transfer chute with borated water from the shield tank cavity.	________	________
44. Make several trial runs with a new fuel element for final check of operability of fuel handling system in wet conditon.	________	________
45. Check TV for underwater operation.	________	________
46. Position and turn on underwater lights. Lights must not be turned on until submerged in water.	________	________
47. Remove head and store in allotted position.	________	________
a. Manipulator crane must be in extreme south position	________	________
b. Reactor centerline position for polar crane is marked with balck paint on primary shielding, bridge and trolley	________	________

	Date Completed	Initials
48. Remove guide tube hold down plate and hold down ring using plate and barrel lifting fixture.		
a. Install 2 levels on plate and barrel lifting fixture		
b. Install air hose and control valve on lifting fixture		
c. Use lifting fixture in proper orientation as marked on guide holes		
d. Store plate and ring on internals stacking plate		
49. Remove 4 guide tube support plate plugs and store in rack.		
a. Three section boom is required to be on manipulator crane. For details of installing third boom section, see Instruction Book, FUEL HANDLING SYSTEM USMC, Page 61		
b. See rack elevations taken previously		
50. Remove one guide tube.		
a. Two section boom is required on manipulator crane. For details of removing third section, see Instruction Book, FUEL HANDLING SYSTEM, USMC Page 61		
b. For operation of Universal Tool, see Instruction Books, Fuel Handling System, USMC, Page 62, UNIVERSAL HANDLING TOOL, West. Page 34		
c. See elevation data taken on installation of first core		
d. Maintain positive identification of guide tubes i.e., record core positions and rack positions		
51. Remove one unsupported drive shaft.		
a. Two section boom is required on manipulator crane		
b. See Instruction Books, FUEL HANDLING SYSTEM, USMC, Page 63, UNIVERSAL HANDLING TOOL, West. Page 26, 27, 36		
c. See elevation data taken on installation of first core		

	Date Completed	Initials
d. Maintain positive identification of drive rods, i.e. record core positions and rack positions		
52. Repeat above two steps until all 24 guide tubes and drive shafts have been removed.		
53. Remove guide tube support plate and store on top of guide tube hold down plate, with plate and barrel lifting fixture observing levelness and proper orientations (during removal).		
54. Retract in-core instrumentation thimbles from fuel elements. See Instruction Book, IN-CORE INSTRUMENTATION, west. Page 29. Welding called for on locking tool See Instruction Book, IN-CORE INSTRUMENTATION, West. Page 19.		
55. Ready the upper core support barrel with attached core support plate and contained in-core instrumentation structure for removal.		
NOTE: Use plate and barrel lifting fixture observing levelness and proper orientation, longer slings may be required for this operation.		
56. Fill the shield tank cavity to the upper level limit.		
57. Remove charging pumps from main coolant loop pressure maintenance service and establish water level equilibrium between shield tank cavity, pressurizer and steam generator through pressurizer and loop drain lines.		
58. Momentarily shut down flow in the shutdown cooling system while doing Step 59 below to avoid cocking of upper core support barrel by hydraulic pressure.		
59. Remove upper core support barrel with attached core support plate and contained in-core instrumentation structure.		

		Date Completed	Initials
60.	Disengage polar crane hook leaving lifting fixture attached to core barrel.	______	______
61.	Remove control rods, fuel assemblies, and shim rods as described in MI 506E4.	______	______
62.	Inspect lower core support plate using portable viewing equipment.	______	______
63.	Install vessel radiation specimens.	______	______
64.	Replace control rods, fuel assemblies, and shim rods as described in 506E4.	______	______
65.	Replace upper core support barrel containing upper core support plate and in-core instrumentation. (Make momentary shutdown of shutdown cooling system while lowering into place).	______	______
66.	Insert in-core instrumentation thimbles into fuel assemblies. See Instruction Book. IN-CORE INSTRUMENTATION West. Page 32.	______	______
67.	Replace guide tube support plate using plate and barrel lifting fixture.	______	______
68.	Replace 1 drive shaft. (If the drive shafts are to be reused, they must be replaced in the core location from which they were taken.	______	______
69.	Replace 1 guide tube on the unsupported drive shaft. The guide tube must be replaced in the core location from which it was taken.	______	______
70.	Repeat above two steps until all 24 drive rods and guide tubes are placed in the vessel.	______	______
71.	Replace 4 guide tube support plate plugs. 3 section boom of manipulator crane is required.	______	______
72.	Replace guide tube hold down plate using plate and barrel lifting device.	______	______
73.	Remove vessel head gaskets using gasket removal tool.	______	______

	Date Completed	Initials
a. The tool requires installation of air hose and control valve	______	______
b. Care should be taken not to damage gasket grooves in any way	______	______
74. Clean gaskets grooves with a plastic nosed underwater pipe water jet.	______	______
75. Place new head gaskets into grooves using gasket tool.	______	______
76. Replace reactor vessel head in its original orientation.	______	______
77. Turn off and remove underwater viewing lights and viewing equipment.	______	______
78. Drain pressurizer and refueling water from shield tank cavity complying with M.I. No. 506E3, REACTOR REFUELING-SHIELD TANK CAVITY - FILL AND DRAIN, Section V-B.	______	______
CAUTION: Check radiation and contamination level of shield tank cavity prior to personnel entry.		
79. Dewater the upper portion of the fuel transfer chute, remove ring and replace with solid plate.	______	______
80. Drain the dewatering system.	______	______
81. Decontaminate tools, equipment and shield tank cavity, when necessary, by scrubbing and flushing.	______	______
82. Lower necessary vessel head replacement equipment and tools from the charging floor to the reactor level.	______	______
83. Remove head lifting fixture mark legs 3 for future identification.	______	______
84. Remove guide studs and stud hole plugs. Clean and dry stud holes as required.	______	______

	Date Completed	Initials
85. Install reactor head studs. See B&W Instruction Book, Page 4-5.		
86. Install Conoseals, using gasket seals only - Do not weld. See Instruction Book, IN-CORE INSTRUMENTATION.		
87. Fill and vent main coolant system in accordance with O.I. No. 504D1, MAIN COOLANT SYSTEM - FILLING AND VENTING OF COMPLETE SYSTEM.		
88. Leak test primary system complying with M.I. No. 506B3, PRIMARY PLANT - COLD LEAK TEST.		
89. Lower pressurizer water level to below Conoseals. (This step may not be necessary if Conoseal gaskets are tight).		
90. Weld Conoseal seal caps.		
a. Larger diameter seal weld may be done by the AMF machine or by hand.		
b. Smaller diameter seal weld will be made by hand.		
91. Install thermocouple junction assemblies and flux wire tubes. See Instruction Book, IN-CORE INSTRUMENTATION, Page 22.		
92. Refill and Vent Main Coolant System (OI 504D1).		
93. Install top hat air duct and baffles.		
94. Install reactor head thermal insulation.		
95. Replace shielding.		
96. Install cable tray on north side of cavity and position manipulator crane on north side of cavity with boom to west of cable tray.		
97. Install south cable tray.		
98. Install rod drive air supply ducts.		

		Date Completed	Initials
99.	Install coil stacks.	______	______
100.	Install coil stack cables.	______	______
101.	Install equipment hatch cover.	______	______

V. Final Conditions

1. The reactor has been refueled and reassembled for operation.

2. The complete main coolant system has been leak tested and is ready for normal startup from cold condition. Refer to O.I. No. 504D4, MAIN COOLANT SYSTEM - STARTUP OF COMPLETE SYSTEM.

DRIVE RODS REMOVAL SEQUENCE AND ACCOUNTABILITY TABLE

CORE POSITION	RACK POSITION	CONDITION	REMARKS
JK-6,7	1		
HJ-5,6	2		
HJ-3,4	3		
GH-4,5	4		
GH-6,7	5		
GH-8,9	6		
FG-7,8	7		
FG-5,6	8		
FG-3,4	9		
FG-1,2	10		
EF-2,3	11		
EF-4,5	12		
EF-6,7	13		
EF-8,9	14		
DE-9,10	15		
DE-7,8	16		
DE-5,6	17		
DE-3,4	18		
CD-2,3	19		
CD-4,5	20		
CD-6,7	21		
BC-7,8	22		
BC-5,6	23		
AB-4,5	24		

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GUIDE TUBE REMOVAL SEQUENCE AND ACCOUNTABILITY TABLE 5/4/62

CORE POSITION	RACK POSITION	CONDITION	REMARKS
AB-4,5	33		
BC-5,6	32		
BC-7,8	31		
CD-6,7	30		
CD-4,5	29		
CD-2,3	28		
DE-3,4	27		
DE-5,6	26		
DE-7,8	25		
DE-9,10	24		
EF-8,9	23		
EF-6,7	22		
EF-4,5	21		
EF-2,3	20		
FG-1,2	19		
FG-3,4	18		
FG-5,6	17		
FG-7,8	16		
GH-8,9	15		
GH-6,7	14		
GH-4,5	13		
HJ-3,4	12		
HJ-5,6	11		
JK-6,7	10		

MAINTENANCE INSTRUCTION NO. 506E3

REACTOR REFUELING
SHIELD TANK CAVITY - FILL AND DRAIN

I. Objective To provide a safe and efficient method for:

A. Filling the shield tank cavity.
B. Draining the shield tank cavity.
C. Decontaminating the shield tank cavity.
D. Adding boric acid to the safety injection and shield tank cavity water tank.

II. Conditions

A. 1. Any time that filling of the cavity is anticipated, Steps Nos. 1 through 22 of M.I. No. 506E2, REACTOR REFUELING - PREPARATION OF REACTOR SYSTEMS FOR REFUELING, must preceed the filling operation.

2. Sampling of the safety injection and shield tank cavity water tank per O.I. No. 504K2, PRIMARY PLANT SAMPLING SYSTEM - AUXILIARY SYSTEMS, is required before filling the cavity. If the boric acid concentration is less than that in the main coolant, adjust the concentration per Section V-D of this maintenance instruction.

B. Any time that draining of the cavity is anticipated, the applicable portions of Section 507, RADIOLOGICAL HEALTH AND SAFETY must be followed. The reactor vessel head must be in place before Section V-B of this instruction is initiated.

C. Sufficient capacity for decontamination water is available in the gravity drain tank before decontamination of the cavity liner is started.

III. Precautions

1. The cavity upper level limit must not be exceeded during the fill operation.

2. Sampling of the cavity fill water in the safety injection and shield tank cavity water tank must establish that its boric acid content is equal to that in the main coolant before Section V-A of this instruction is initiated.

3. Do not allow cavity liner decontamination liquid effluent to drain into the safety injection and shield tank cavity water tank.

IV. Check-off List

Prior to the initiation of this M.I., the check-off list must be completed by the operator(s) and signed off.

V. Instructions

A. Shield Tank Cavity Fill

1. Remove the fill line cover in the cavity floor. Close the cavity drain line valve.

2. Unlock and open the fill line gate valves inside and outside the vapor container.

3. Check that motor operated gate valve No. CS-MOV-535 is closed.

4. Close the motor operated gate valve No. CS-MOV-533 in the safety injection pump discharge line.

5. Check that the motor operated globe valve No. CS-MOV-534 in the by-pass around the valve closed in Step No. 4 is closed.

6. Unlock and open the gate valve in the safety injection pump by-pass line.

7. Start one safety injection pump and gradually open the globe valve No. CS-MOV-534 until an observer at the cavity indicates excessive lift of the cavity water, or until the valve is full open.

   NOTE: As the cavity fills, it may be permissible to open motor operated gate valve No. CS-MOV-533.

8. Stop the safety injection pump when the upper level limit is reached in the shield tank cavity.

9. Close the valves opened in Steps Nos. 2, 6, and 7 under Section V-A. Open motor operated gate valve No. CS-MOV-533.

B. Shield Tank Cavity Drain

1. Unlock and open the fill line gate valves inside and outside the vapor container.

2. Unlock and open the gate valve in the safety injection pump by-pass for draining the shield tank cavity back into the 125,000 gal tank.

3. Check that motor operated gate valve No. CS-MOV-533 in the safety injection pump discharge line is open.

4. When the cavity is drained, close and lock the valves opened in Steps Nos. 1 and 2 of Section V-B.

C. Shield Tank Cavity Decontamination

1. Check that the vapor container drain tank is pumped down sufficiently to receive the decontamination water, or is open to waste disposal.

2. Open the valve in the shield tank cavity drain line to the lower compartment drain.

3. Decontaminate and wash down the shield tank cavity liner.

4. When decontamination of the liner is complete, briefly operate one safety injection pump by performing Section V-A, to discharge any gross debris from the cavity fill line into the cavity drain line.

5. Close the valve in the cavity drain line.

D. Boric Acid Addition to the Safety Injection and Shield Tank Cavity Water Tank

1. Open the valves in the transfer line from the boric acid transfer pump to the 125,000 gal safety injection and shield tank cavity water tank.

2. Close the boric acid recirculation loop isolation valve.

3. Check that the boric acid transfer pump suction valve is open.

4. Check that the valves in the boric acid feed line to the charging pump suction header are closed.

5. Start the boric acid transfer pump.

6. Stop the pump when:

   a. The boric acid mixing and storage tank low level alarm is actuated, or

   b. When the required amount of boric acid solution has been added to the safety injection and shield tank cavity water tank.

7. If additional boric acid solution is required, close the valve in the transfer line to the 125,000 gal tank and open the isolation valve in the recirculation loop. Prepare additional boric acid. Refer to O.I. No. 504G1, CHEMICAL SHUTDOWN SYSTEM - BORIC ACID PREPARATION. Repeat Steps Nos. 1 through 7 under Section V-D of this operating instruction until sufficient boric acid has been added.

8. Close the boric acid transfer pump suction valve.

9. Open the valve in the demineralized water flushing connection to the transfer pump suction line.

10. Put one low pressure surge tank make-up pump on manual control and flush about 100 gal of demineralized water from the pump into the safety injection and shield tank cavity water tank via the transfer line.

11. Close the valves in the transfer line and in the demineralized water flush line. Return the low pressure surge tank make-up pump to automatic control.

VI. Final Conditions

1. The shield tank cavity has been filled.

2. The shield tank cavity has been drained.

3. The shield tank cavity liner has been decontaminated.

4. Boric acid has been added to the safety injection and shield tank cavity water tank.

MAINTENANCE INSTRUCTION NO. 506E4

REACTOR REFUELING
FUEL AND CONTROL ROD REPLACEMENT

I. Objective: To provide a safe and efficient method for replacing fuel assemblies, control rods, and shim rods during core refueling.

II. Conditions

1. MI 506E2, Preparation of Reactor Systems for Refueling, is completed through removal of upper core support barrel.

2. In addition to the public address system, 3-way sound powered phone communications have been established between the control center, the shield tank cavity manipulator crane, and the spent fuel pit.

3. During any change in core geometry, except during replacement of the Ag-In-Cd control rods at the end of Core II life, two of the charging pumps are in ready standby condition for addition of concentrated boric acid to the pressure vessel. During the replacement of the Ag-In-Cd rods at the end of Core II life, at least one charging pump shall be in a ready standby condition for addition of concentrated boric acid to the pressure vessel.

4. A channel for continuous gamma monitoring is installed near each manipulator crane whenever spent control rods or spent fuel assemblies are being handled.

III. Precautions

1. Whenever a change is being made in core geometry, the equipment access opening must be closed. Either the regular hatch cover or a temporary closure of plywood construction covered with a plastic or other airtight membrane shall be in place.

2. At least two of the three channels of nuclear instrumentation must be in operation and in a position to monitor the neutron population and its time variation in the reactor whenever the core geometry is being changed. One channel will be equipped with a high count rate alarm which will sound both in the control center and in the Vapor Container.

3. The shield tank cavity water must be sampled at least once a day and analyzed for boron concentration to assure that the minimum shutdown boron concentration is maintained.

4. A record of the neutron count rate before and after any change in core geometry must be maintained at the control center and the manipulator crane operator notified of any significant changes in count rate.

5. At least one AEC licensed person shall be present at the control center at all times, and at least one AEC licensed person shall be in the vicinity of the fuel handling system whenever fuel is being moved. At all times there shall be one AEC licensed person designated as being in overall charge of operations. Normally, this person will be the Shift Supervisor.

6. If a significant unexpected increase in the count rate occurs on any one channel or if an unexpected increase in the count rate by a factor of two on two of the three channels occurs after addition of a new fuel assembly or removal of a control rod, the fuel loading operation will be suspended until the situation can be reviewed by plant technical supervisory personnel. If necessary to establish the shutdown margin of the core, a single control rod will be withdrawn using the manipulator crane and regulated by a plot of control rod position versus inverse count rate multiplication. Using the inverse count rate data obtained in this manner, the shutdown margin will be calculated. If these calculations indicate that there will be less than 5% Δ K/K shutdown with all control rods inserted in the fully loaded core, the boron concentration will be increased to provide the required 5% Δ K/K shutdown margin.

7. Foreign material must be prevented from falling into the reactor vessel while refueling and no unauthorized or unnecessary personnel (or objects) are to be allowed on the manipulator crane.

8. The Core Component Tag Board in the control center must at all times indicate the existing core geometry and the location of all core components in the reactor vessel, in the shield tank cavity, and in the spent fuel pit.

IV. OPERATING INSTRUCTIONS - CORE II - CORE III REFUELING

A. BASIC REFUELING AND INSPECTION SEQUENCE

The basic sequence for the Core II-III refueling will be as follows:

1. Replace the Core II Ag-In-Cd control rods with new control rods as soon as possible to minimize radioactive Ag contamination in the shield tank cavity. The last three control rods to be replaced and three shim rods will be given a detailed inspection in the shield tank cavity.

2. Unload the central 40 spent fuel assemblies from Core II. The last two fuel assemblies to be unloaded and two of the spent assemblies remaining will be given a detailed inspection in the shield tank cavity.

3. Concurrently, relocate the 36 spent fuel assemblies from Core II and load 32 new 4.1% and the 4 new 3.4% fuel assemblies. The 36 spent fuel assemblies will be inspected visually by Operations during the reloading sequence. Core shutdown reactivity will be checked periodically by count rate multiplication data obtained during withdrawal of an individual control rod.

   After Core III has been loaded with the exception of the 4 new assemblies adjacent to the East and West source positions, these two neutron sources may be removed and inspected. Individual control rods will be withdrawn while the source is removed to ascertain the response of external neutron detectors surface condition. Drive shafts and absorber sections will be reused or replaced depending on the results of these inspections.

3. Unload the spent fuel from one quadrant of the core following the operating instructions for removal of a fuel element from reactor to storage pit as outlined in USMC Instruction Book, Pages 47-57. (Two to eight old fuel assemblies may be left in the core to achieve higher burnup of these elements. If left in the core, these elements will be visually inspected for crud buildup and structural integrity, using the boroscope and underwater TV viewing.) Selected control rods may also be unloaded from this quadrant if required for improved visibility of the structural materials.

4. Inspect sources for structural integrity using boroscope and underwater TV viewing equipment.

5. Inspect the lower core support plate in the quadrant which was unloaded using the boroscope and TV.

6. For moving new fuel elements from the storage pit to the reactor, follow instructions in USMC Instruction Book, Pages 57-58.

7. Should a fuel element be damaged to the extent it will not fit the fuel chute or should the normal fuel handling systems become in-operative such that repair requires unwatering of the shield tank cavity, place the fuel element into the damaged fuel element container. Remove the fuel element to the spent fuel storage pit via the shipping hatch using the polar and yard cranes.

8. Should a spent fuel element become stuck in the fuel chute, the design of the chute and its dewatering system is such that no immediate action is required by the operator. Accessible areas adjacent to the chute should be checked for high radiation levels, and posted and barricaded as appropriate.

NOTE: The most critical condition would be with the element in the wait position and the lower lock valve stuck closed. The operator would be unable to recognize this condition until the following actions had been completed:

a. Equalizing valve closed
b. Upper portions of the fuel chute pumped out
c. Attempt made to open the valve

Since the fuel element under the above condition will be covered with only a small isolated volume of water, the equalizing valve should be opened immediately after ascertaining that the lower lock valve is in the stuck closed position.

9. The remaining core elements will be unloaded and replaced individually in a sequence that will effectively rotate the open quadrant so that other portions of the lower core support plant can be inspected as desired. (New assemblies will be added to one side of the quadrant and spent assemblies removed from the other side.)

10. Load the remaining assemblies into the open quadrant until the core is completely refueled.

11. Recheck all index file cards with the Reactor Engineer for accountability and completeness.

12. Reinstall internals in accordance with MI 506E2.

V. Final Conditions

The reactor is ready for assembly of remaining internals and preparation for cold startup according to steps 59-92 of MI 506E2.

MAINTENANCE INSTRUCTION NO. 506E5

REACTOR REFUELING
SITE STORAGE AND SHIPPING OF USED FUEL AND CONTROL RODS

I. Objective To provide a safe and efficient method for site storage and shipping of used fuel assemblies and control rods. Shim rods will be handled in the same manner as control rods.

II. Conditions

1. A fuel assembly or control rod is positioned in the transfer carriage in the spent fuel storage pit.

2. The spent fuel storage pit is filled with approximately 36 ft of demineralized water.

3. The manipulator crane No. 2 and the pneumatically operated tool is ready for service.

4. The required number of storage racks are available for receiving spent fuel assemblies, control rod or shim rod sections in the spent fuel storage pit.

5. Two spent fuel shipping containers, capable of shipping four fuel assemblies each, are available in the spent fuel storage pit.

6. The yard work area crane is available for service.

III. Precautions

1. The radiation level at the surface of the spent fuel pit water, as well as airborne contamination, must be checked continuously. Refer to Section 507, Radiological Health and Safety.

2. Care must be exercised in the handling of the radioactive materials that are stored and withdrawn from the spent fuel storage pit. This also applies to any piece of equipment that has been immersed in the pit water.

3. Minimum depths of water over the fuel assemblies and control rods should be maintained to limit radiation level at surface of water to tolerance as specified in Section 507, Radiological Health and Safety.

4. The tools employed should be kept free of dirt, grease and foreign matter.

5. Foreign material must be prevented from falling into the spent fuel storage pit during storage and removal of the spent fuel assemblies and control rods.

6. All spent fuel assemblies must be properly seated in the spent fuel shipping containers.

IV. Check-off List

A. Premaintenance Check-off List

A premaintenance check-off list should be completed and signed off.

1. The various tools and equipment to be employed should be checked for availability and proper functioning.

2. A premaintenance briefing of personnel is desirable before starting this M.I.; subsequent briefing of personnel during the procedure is also beneficial.

B. Maintenance Check-off List

Prior to initiation of this M.I. the maintenance check-off list must be completed by the operator(s) and signed off.

V. Instruction

1. Obtain authorization to enter spent fuel storage pit, working area after radiation survey has been completed. Refer to Section 507, Radiological Health and Safety.

2. Health and Safety representative should properly monitor pertinent activities for radiation level and airborne contamination before the maintenance people enter the working area of the spent fuel storage pit.

3. Enter working area of spent fuel storage pit.

4. By using the manipulator crane No. 2, and the pneumatically operated grappling tool, remove the spent fuel assembly or control rod vertically from the carriage and place it in the spent fuel storage rack.

   CAUTION: (a) The operator(s) must observe the crane index to position the boom accurately over the lay-down mechanism and over the storage racks.

   (b) A minimum water depth of 13 ft must be maintained above spent fuel assemblies and 8 ft above control rods and shim rods.

5. Repeat Step 4 until all the fuel assemblies, control rods and shim rods are stored in their designated storage racks.

6. Store fuel assemblies, control rods and shim rods until shipment is allowed, based on Federal and State regulations. Refer to Section 507, Radiological Health and Safety.

7. When ready to ship, remove the shipping container head, using the yard work area crane and store under water in the spent fuel storage pit.

8. After the container head is removed and stored, use the Manipulator Crane No. 2 and the pneumatically operated grappling tool and place a fuel assembly into the spent fuel shipping container.

9. Repeat Step 8 until the desired number of fuel assemblies has been placed in the spent fuel shipping container.

10. When the fuel assemblies have been placed in the container, use the yard work area crane, replace the fuel container head and secure temporarily according to the Manufacturer's Instructions.

11. Use the yard work area crane and lift the container slightly out of the pit water and conduct radiation survey. Refer to Section 507, Radiological Health and Safety.

12. When radiation survey is completed, fully remove the shipping container through the hatchway in the roof of the spent fuel storage pit and place the container on the decontamination pad.

13. Decontaminate outer surface of the container, if necessary.

14. When decontamination is completed, conduct radiation survey. Refer to Section 507, Radiological Health and Safety.

15. After completion of the radiation survey, permanently secure the shipping container head. Refer to Manufacturer's Instruction booklet.

16. Obtain necessary shipping clearances and load container onto transporting vehicle.

17. Repeat Steps 7 through 16 for the second spent fuel shipping container and subsequent shipping containers.

18. Loading and shipping of irradiated control and shim rods will be in a similar manner to fuel assemblies, except that they will be shipped with only radiation shielding provided.

VI. Final Condition

The spent fuel assemblies, control rods and shim rods have been removed from the spent fuel storage pit and placed on transporting vehicles for shipment to a processing site for fuel assemblies and to a disposal site for control rods and shim rods.

507 RADIOLOGICAL HEALTH AND SAFETY

OBJECTIVE

These Radiation Protection Instructions indicate the measures which will be taken to control the exposure of personnel to radiation and contamination incident to the operation of the plant, and the measures that will be taken to maintain and disseminate records of personnel exposures.

GENERAL

The control of exposure of personnel to radiation and contamination includes measures; to determine the level and type of radioactivity that may be present, to maintain levels consistent with safe practices, and to control access of personnel to radiation areas and potentially contaminated areas.

These Radiation Protection Instructions conform to regulatory codes and stipulations where provided by Federal, State and/or Municipal agencies. Where possible they are based on the current regulations of these agencies. References used in these Instructions are tabulated in References on page 507:21. Personnel control procedures and plant limits for contamination and radiation have been established to maintain personnel exposures within the maximum permissible limits and at a minimum possible level consistent with operating feasibility. This will continue to be the basic philosophy when further details of plant procedures or plant area limits are developed at a later date in the Radiation Protection Manual.

The plant organization and general duties of the personnel are presented in Section 501, PLANT ORGANIZATION. The Technical Manager is responsible for the radiological health and safety of personnel working at or visiting within the plant site. The Health and Safety Supervisor will implement and enforce these instructions and other plant radiological health and safety procedures. The Chemical Engineer, the Shift Supervisors, and other qualified personnel will be assigned duties involving the determination of radiological conditions, the control of plant radiological conditions, or the exposures of personnel to ionizing radiation.

Personnel with duties which include the determination of the radiological conditions within the plant site or with duties which include the handling of radioactive materials in any form qualify for their duties by satisfactorily completing a thorough training course. Detailed instruction courses are provided also for Shift Supervisors, Primary Operators, Control Technicians, and Maintenance Men. These employees will be instructed in the precepts of radiation protection and in the observance of such rules and codes of the regulatory agencies as apply to the operations of the plant and as they affect or concern the health and safety of plant employees and visitors. They will be familiar with the procedures and practices detailed in the Radiation Protection Manual as these procedures and practices are related to the individual's job responsibilities and to the general safety problems incident to the operation of the plant.

General training in radiological health and safety is given to all plant personnel. All plant personnel will be taught the basic radiological concepts. They will be familiar with, and will follow, these and other detailed safety instructions. Personnel visiting the site will either become familiar with these instructions or will be under the supervision of trained plant personnel.

RADIATION STANDARDS

The exposure limits as given below are extracted from Title 10, C.F.R., Part 20. Future amendments to Title 10, C.F.R., Part 20 pertaining to maximum permissible exposure, will automatically become part of these instructions.

Personnel Radiation Exposure Limits

A. Occupational radiation dosages for individuals 18 yr of age and older will be limited to the following:

APPENDIX A

PERMISSIBLE WEEKLY DOSE

Conditions of Exposure		Dose in Critical Organs (Mrem)			
Parts of Body	Radiation	Skin at Basal Layer of Epidermis	Blood Forming Organs	Gonads	Lens of Eye
Whole body	Any radiation with half value-layer greater than 1 mm of soft tissue.	600[1]	300[1]	300[1]	300[1]
Whole body	Any radiation with half-value-layer less than 1 mm of soft tissue	1,500	300	300	300
Hands and fore-arms or feet and ankles or head and neck.	Any radiation	1,500[2]			

[1]For exposures of the whole body to X or gamma rays up to 3 mev, this condition may be assumed to be met if the "air dose" does not exceed 300 mr, provided the dose to the gonads does not exceed 300 mrem. "Air dose" means that the dose is measured by an appropriate instrument in air in the region of highest dosage rate to be occupied by an individual, without the presence of the human body or other absorbing and scattering material.

[2]Exposure of these limited portions of the body under these conditions does not alter the total weekly dose of 300 mrem permitted to the blood-forming organs in the main portion of the body, to the gonads, or to the lens of the eye.

B. Individuals may be permitted to receive an occupational dose in excess of the above limits provided that:

a. The dose during any period of seven consecutive days does not exceed three times the limits specified in paragraph A.

b. The dose during any period of 13 consecutive weeks does not exceed 10 times the limits specified in paragraph A.

C. Individuals on the site will not be exposed to airborne radioactive materials in an average concentration in excess of the limits specified in Appendix B, Table I of Title 10, C.F.R., Part 20.

D. Individuals under 18 yr of age within the site will be limited to exposures of less than 10 per cent of the limits specified in paragraphs A and C above.

E. Materials will not be stored, used or transferred in such a manner as to create in a restricted area radiation levels which, if an individual were continuously present in the area, could result in his receiving a dose in excess of 2 mrem in any 1 hr or a dose in excess of 100 mrem in any seven consecutive days.

F. Concentrations of radioactive materials to be released to air or water outside the site will be limited to concentrations specified in Appendix B, Table II of Title 10, C.F.R., Part 20.

Personnel Contamination Limits

Survey meter measurements for beta-gamma activity shall be made with a thin window ($\leq$ 3 mg/cm^2) Geiger-Mueller survey meter, with the tube window held at a distance of less than an inch from the possible source. Measurements for alpha activity shall be made with an alpha survey meter, with its window at less than 1/2 in.

A. Contamination on the person of any individual will be immediately removed when detectable. Methods described on page 507:12, Personnel Decontamination, will be employed in an attempt to reduce the level to background.

B. Contamination on personal clothing will be reduced to a level below 0.05 mrad/hr at any point on contact. If this is not possible the contaminated clothing will be disposed of as contaminated waste, or if practical, stored for radioactive decay and reclamation.

C. Protective equipment and clothing will be given general release if contamination as determined by smear tests is less than 100 dpm/ft^2 beta-gamma and 10 dpm/ft^2 alpha and if its radiation level is less than 0.1 mrad/hr at 1 in.

D. Protective equipment and clothing may be given release for controlled use if its contamination level is less than 1,000 dpm/ft^2 beta-gamma and 100 dpm/ft^2 alpha as determined by smear tests, and if its radiation level is less than 1.0 mrem/hr at 1 in.

Protective clothing and shoes in use will be changed if found to have a radiation level in excess of 10 mrad/hr at 1 in. Shoes containing transferable contamination above the permissible limits for general release shall not be worn outside of the Potentially Contaminated Areas.

Clean Area Radiation and Contamination Limits

In the plant clean areas surface contamination will be maintained below 100 dpm/ft^2 beta-gamma and 10 dpm/ft^2 alpha, as determined by smear tests. Airborne activity will be kept below radionuclides concentration limits for unrestricted areas as tabulated in Title 10, Chapter 1, Part 20 of the Code of Federal Regulations. If it is found that these limits are or might be exceeded, steps will be taken to reduce the contamination to values permissible for a clean area. In a clean area, intensity of external radiation will be maintained below 2 mrad/hr.

Potentially Contaminated Area Radiation and Contamination Limits

The plant areas where external radiation levels and radioactive contamination are likely to be above the limits for a Clean Area are shown in the sketch on page 507:8. Access to these areas will be controlled.

For the Potentially Contaminated Areas that normally require access, surface contamination will be maintained below 1,000 dpm/ft^2 beta-gamma and 100 dpm/ft^2 alpha, as measured by smear tests, and airborne activity will be kept below radionuclide concentration limits for restricted areas as tabulated in Title 10, Chapter 1, Part 20 of the Code of Federal Regulations. In these areas radiation intensities will be below 100 mrad/hr. If it is found that these limits are exceeded, respirators are required and the area having activity in excess of these limits will be barricaded and steps will be taken to reduce the activity to within permissible values where feasible, for these areas. In Potentially Contaminated Areas which may require only occasional access of short duration, surface contamination will be held below 10,000 dpm/ft^2 beta-gamma and 1,000 dpm/ft^2 alpha as determined by smear tests and radiation intensities will be held below 1 rad/hr. Respirators will be worn in these areas unless the level of airborne activity is determined to be below the limits for restricted areas as specified in the Code of Federal Regulations.

Measures which will be taken to control access to Potentially Contaminated Areas and to minimize exposures while in these areas are described on page 507:6, General Radiation Safety Rules. The use of protective clothing and equipment is described on page 507:11, Protective Clothing and page 507:12, Respiratory Equipment.

Regulated Equipment Radiation and Contamination Limits

Regulated equipment is defined as slightly contaminated equipment of a portable nature, such as hand tools, small pumps and motors, which is of design which makes complete decontamination impractical. Regulated equipment will have contamination less than 1,000 dpm/ft^2 beta-gamma and 100 dpm/ft^2 alpha, as determined by smear tests, and will have radiation levels less than 1.0 mrad/hr at 1 in. It can be used only in Potentially Contaminated Areas and only by workers wearing protective clothing.

All portable contaminated waste disposal containers in the plant are considered to be regulated equipment. However, the contents of these containers need not be disposed of until their radiation level exceeds 5 mrad/hr at 1 in. from the container.

The Technical Manager may permit the use of equipment having a higher radiation level than 1.0 mrad/hr after consideration of all the factors involved, i.e., the nature of equipment, the frequency of its use and the length of time it may be in use.

Equipment having general release will have contamination limits of 100 dpm/ft^2 beta-gamma, and 10 dpm/ft^2 alpha as determined by smear tests and will have radiation levels less than 0.1 mrad/hr at 1 in.

Shipment and Waste Disposal Limits

All shipments of radioactive materials will comply with ICC Shipping Regulations, AEC Regulations, and other federal, state and local regulations which are applicable.

The principal radiation limits for shipments of radioactive materials by rail freight, rail express, or highway are summarized as follows:

A. Gamma emitters, only, or both gamma and alpha or beta emitters will be packed in suitable inside containers (specifications are given in Article 78.34 of ICC Regulations) and shielded so that the gamma radiation during transportation does not exceed 10 mr/hr at one meter from any point on the radioactive source or 200 mr/hr at any accessible point on the surface of the shipping container.

B. Radioactive materials which include neutron emitters will be packed so as to limit beta and gamma radiation to 10 mrad/hr at one meter, and neutron radiation to 2 mrad/hr at one meter from the source.

C. Alpha or beta emitters only will be packed in suitable inside containers which will prevent the escape of primary radiation and which will not permit the level of secondary radiation to exceed 10 mr/24 hr at any surface of the container.

D. Outside shipping containers will be of such design that gamma radiation will not exceed 200 mr/hr or equivalent at any point of readily accessible surface.

E. The design and preparation of the package will be such that there will be no significant radioactive surface contamination of any part of the container. Container designs will be in accordance with specifications given in Part 78 of ICC Regulations. The degree of fogging of undeveloped film at a distance of 15 ft will not exceed the fogging of 11.5 mr of gamma rays that have been filtered by 1/2 in. of lead.

Additional limitations, definitions and specifications for shipments from the plant may be found in ICC Regulations for Transportation of Explosives and Other Dangerous Articles. The Technical Manager will determine what restrictions will be applied to special shipments on an individual basis.

Gases and liquids released to the environment from the plant will have concentrations of radionuclides which are less than the concentrations allowed in the Code of Federal Regulations for unrestricted areas.

Personnel Radiation Exposure Control Procedures

General Radiation Safety Rules - The basic effort for radiation safety is to keep all radiation exposures to a minimum. Maintaining minimum exposures is dependent on having continual radiation information. It is necessary to know: (1) the amounts and types of radioactive sources (2) the shielding necessary to attenuate radiation (3) the actual radiation level to which personnel are exposed and (4) the dosages received. The amount and types of radioactive sources are determined by trained personnel using survey and counting meters described in Section 215, as well as by analytical chemistry methods. The radiation levels used as a basis for plant shielding design are discussed in Section 232. Radiation and contamination levels will be maintained below the plant maximum limits and at a minimum level as determined by operating feasibility for normal operating or maintenance work. Individuals permitted access to radiation areas or contaminated areas will be accompanied by specially trained personnel when this is felt to be desirable or necessary to insure against unnecessary exposures. The radiological conditions of work areas will be known at all times and access will be controlled by barriers, signs, and radiation work permits. Protection against internal radiation is based on the principle that it is easier to prevent than to control. This will be achieved by limiting the concentrations of radioisotopes in air and water to which persons are chronically exposed. Proper use of protective clothing and personal cleanliness are the first rules in preventing contamination of the body. It will be the individual responsibility of each employee to observe and comply with the safety rules and plant restrictions.

The plant areas and compartments are divided into two categories: Clean Areas and Potentially Contaminated Areas, as shown in the figure on page 507:8. Personnel restrictions and regulations in each category are given below.

A. Clean Area

a. Radioactive material or radiation may be present only below the limits given on page 507:4, Clean Area Radiation and Contamination Limits. If radiation above these limits is detected, personnel access will be controlled and the condition will be corrected as soon as possible.

b. Regulated tools and equipment may not be used in these areas.

c. Protective clothing may not be worn in these areas except when approved by individuals trained to monitor personnel.

d. Passage into a Clean Area from a Potentially Contaminated Area is permitted only after individuals have determined that they are not contaminated and that materials they may be transporting have radiation and contamination levels below the limits for a Clean Area.

e. Eating is permitted only in these areas.

f. When entering Potentially Contaminated Area via the clean locker room, maintenance personnel will remove outer clothing except shoes and socks and don protective coveralls and head covers. Supervisors or observers may substitute lab coats for coveralls. All personnel will carry shoe covers, gloves or respirators, if required, in the area they expect to enter.

B. <u>Potentially Contaminated Area</u>

a. Radiation and contamination levels will be maintained below the limits given on page 507:4, Potentially Contaminated Area Radiation and Contamination Limits.

b. Access will be restricted to individuals who are authorized to enter.

c. Access will be permitted without supervision only for individuals who are familiar with the plant radiation safety procedures.

d. Work permits will be required for entry into areas so posted.

e. Individuals will notify the Health and Safety Supervisor of their entry into any areas having barriers, the duration of their stay in these areas, dosimeter reading change while in these areas, and of any incidents that occurred involving radiation exposures.

f. Individuals will comply with all warning signs and barriers.

g. Equipment and material to be removed from the area will be surveyed and its removal will be approved by qualified personnel prior to removal.

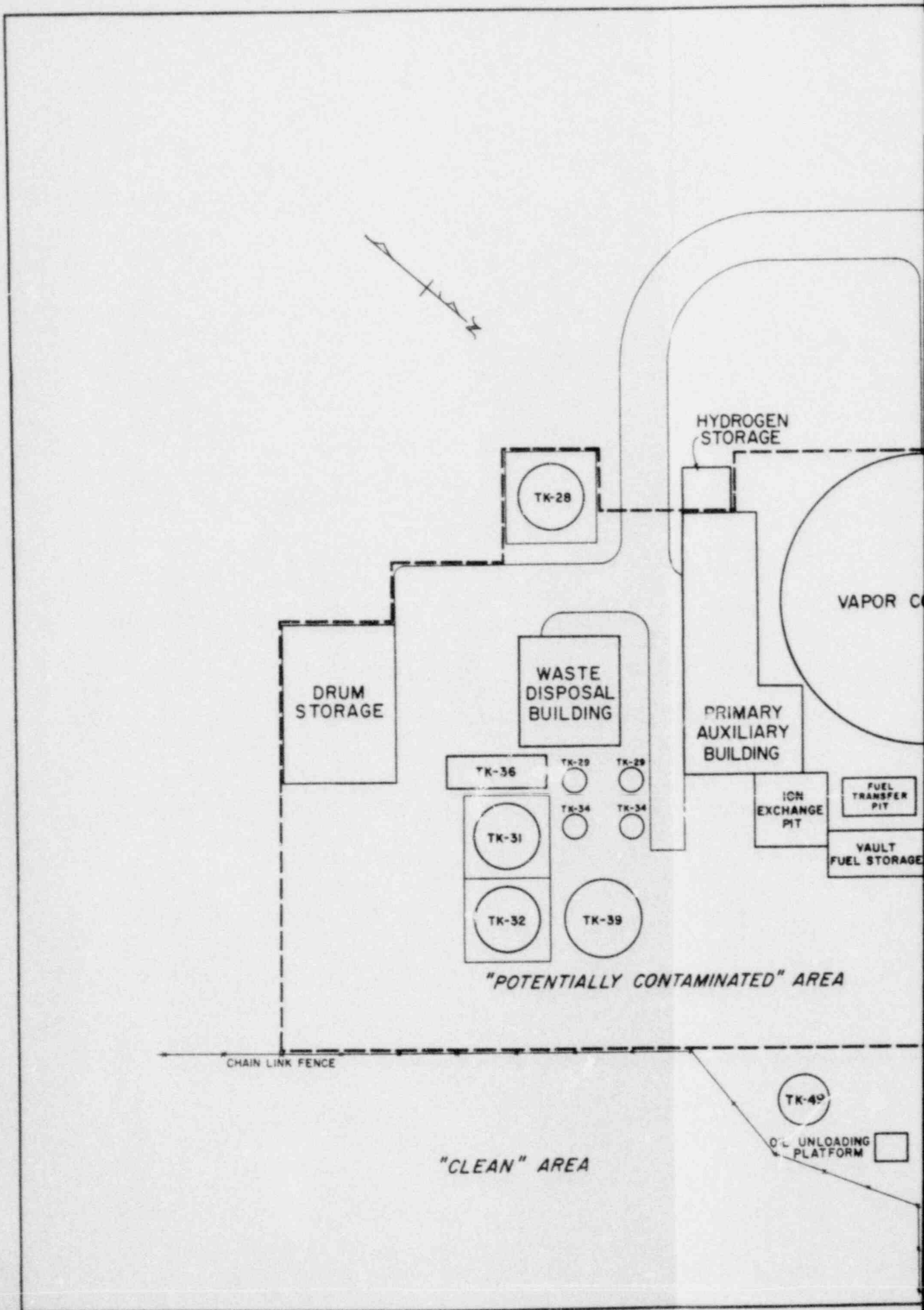
h. Smoking may be permitted in certain Potentially Contaminated Areas, at the discretion of, and subject to, the control of the Health and Safety Supervisor.

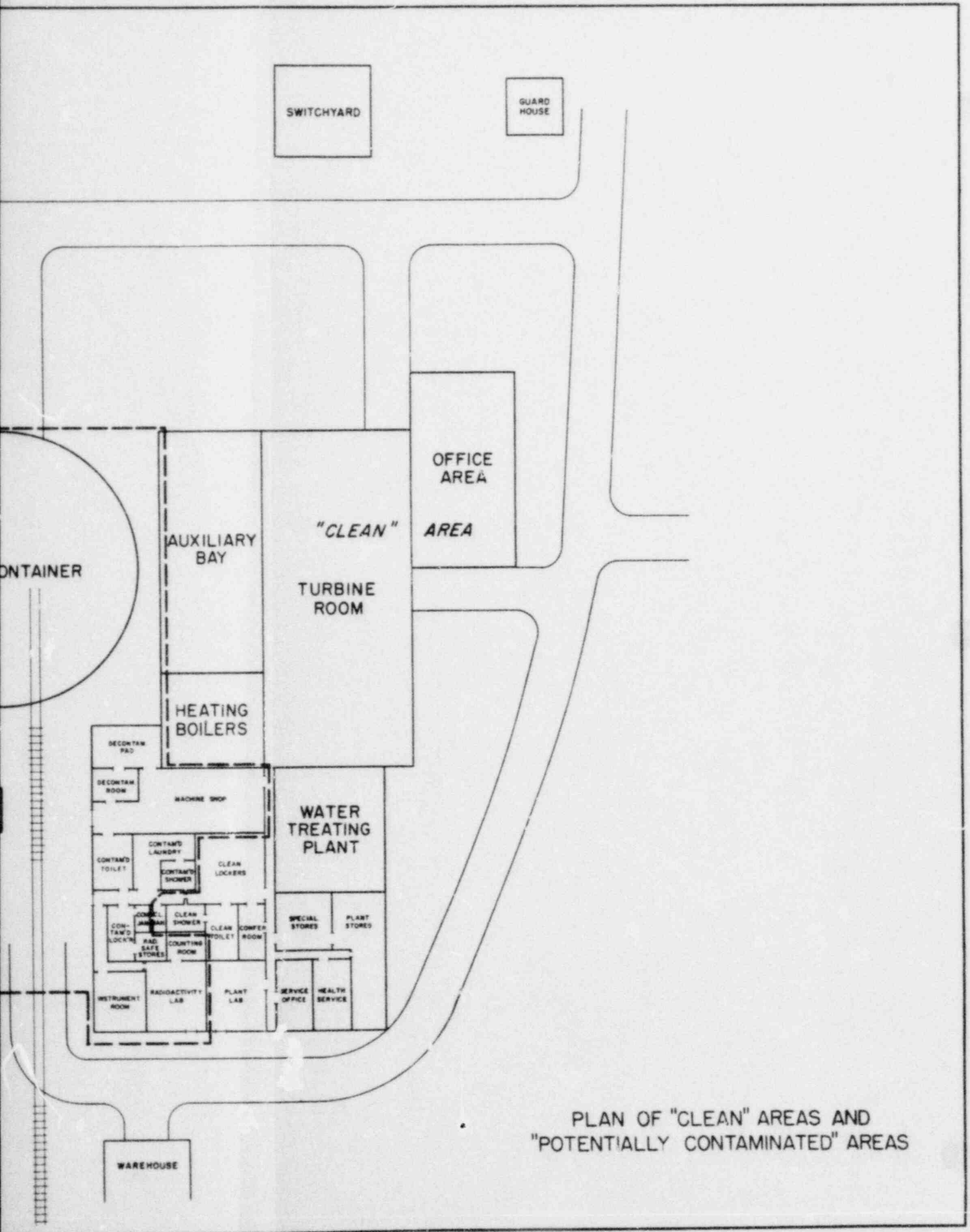
i. Hands must be washed and contamination must be removed from individuals or from their clothing before smoking in approved areas.

j. Dosimeters and protective clothing and equipment will be worn as prescribed. Dosimeters will be read frequently by the wearer while in these areas.

k. Personnel occupancy time may be limited for some work in particular locations.

l. Shielding will not be removed without approval of the Health and Safety Supervisor or his representative.


HYDROGEN STORAGE
TK-28
VAPOR C
WASTE DISPOSAL BUILDING
DRUM STORAGE
PRIMARY AUXILIARY BUILDING
TK-36
TK-29
TK-29
TK-34
TK-34
TK-31
TK-32
TK-39
ION EXCHANGE PIT
FUEL TRANSFER PIT
VAULT FUEL STORAGE
"POTENTIALLY CONTAMINATED" AREA
CHAIN LINK FENCE
TK-49
UNLOADING PLATFORM
"CLEAN" AREA



PLAN OF "CLEAN" AREAS AND
"POTENTIALLY CONTAMINATED" AREAS

m. All contaminated or possibly contaminated waste material will be pla d in radioactive waste containers.

n. All incidents and injuries occurring in these areas will be reported t the Health and Safety Supervisor at once.

o. Drinking from c ntainers or eating is prohibited.

p. Entry into Clean Areas while wearing protective clothing must be approved by the Health and Safety Supervisor or his representative.

Close coordination will be exercised between personnel doing maintenance work in Potentially Contaminated Areas and men assigned to determine plant radiological status and to control personnel radiation exposures. It will be the duty of the latter to indicate to maintenance personnel the measures necessary to minimize radiological hazards and to minimize exposures to radiation, both internal and external. Radiation Work Permits will be required for maintenance work in areas so posted. Rules to be observed during the performance of maintenance work will include the following:

a. Maintain the greatest feasible distance from sources of radiation.

b. Minimize the duration of personnel exposures to radiation.

c. Util e shielding where feasible to minimize personnel exposures.

d. Read dosimeters frequently while in radiation fields and report readings greater than 150 mr.

e. Do not disturb surface contamination unnecessarily by blowing, rubbing, splashing, etc.

f. Do not open pipes, tanks, or other containers which might release radioactive materials without adequate anti-contamination equipment or unless a trained man assigned to safeguard against unnecessary exposure is in attendance.

g. Do not grind, sand, cut, brush, etc. in Potentially Contaminated Areas without approval of Health and Safety Supervisor.

h. Observe warnings on signs and radiation barriers.

i. Wear protective clothing or equipment as prescribed for the work to be performed.

j. Wrap contaminated materials or equipment in polyethylene before being transported.

k. If gross contamination is detected on clothing while in a work area the clothing should be removed here when feasible.

Upon completion of maintenance work, during which contamination may have spread, the work area will be immediately surveyed. When contamination is located in excess of plant area limits, barriers will be erected immediately and men will be assigned to reduce levels to below plant limits as soon as this is feasible.

Personnel Dosimeters and Film Badges

A. Dosimeters

Self-reading pocket beta-gamma dosimeters will be worn by personnel that enter Potentially Contaminated Area. They will be identified and assigned to individuals by a number corresponding to his or her assigned security film badge number. The dosimeters will be stored in a rack in the gate house with the film badges and will be picked up when film badges are picked up on entering the plant. Dosimeters for use by visitors will be issued by the Health and Safety Supervisor when he feels this is advisable and their issue will be registered. Escorted visitors who will visit only the Clean Areas of the plant will not be provided with dosimeters or film badges.

All regularly assigned dosimeters will be read, recorded and rezeroed once each week. Visitors' dosimeters will be read, recorded and rezeroed daily. All readings greater than 150 mrem will be investigated immediately and the corresponding film badge will be processed.

Personnel assigned dosimeters will be expected to: wear them at all times and as near to the film badge as possible, check the dosimeter reading frequently, report to the Health and Safety Supervisor readings that exceed 150 mr, have dosimeters in the designated storage rack at the end of each work period, and report all dosimeter losses or irregularities to the Health and Safety Supervisor.

B. Beta-Gamma Film Badges

Beta-gamma film badges will be issued to all persons, with the exception of escorted visitors who remain in Clean Areas, as they enter the plant area and will be worn at all times while within the plant area, either on the upper left quadrant of the body or suspended on a chain attached around the individual's neck.

Beta-gamma film badges will be processed normally on a monthly schedule. They will be processed also when an individual's dosimeter reading is above 200 mr or is felt by the Health and Safety Supervisor to be questionable, and if a person is involved in an emergency incident.

If the exposure approaches the maximum permissible value the person will be notified and steps will be taken to prevent exceeding these values. Badge film readings will be considered to indicate whole body exposures. Personnel records are covered on page 507:13, Personnel Radiation Exposure Records.

The Health and Safety Supervisor will prescribe the use of badges to measure extremity radiation exposures if it is expected that the individual's extremities will receive a dose greater than 300 mrem per week. These badges will be serviced immediately on completion of the job for which they were assigned.

C. Neutron Film Badges

Metal neutron film badges will be assigned by the Health and Safety Supervisor to persons who will be entering a neutron radiation field. Neutron film badges will be processed upon completion of the job for which they are assigned or, in the event that unusual exposure is encountered or suspected, it will be developed at intervals during the progress of the job. In the latter case, the bearer will be restricted from further exposure until his film badge is developed and read.

Protective Clothing - Protective clothing for use in contaminated or Potentially Contaminated Areas includes the following:

a. Coveralls and lab coats

b. Cloth head covers

c. Face shield and safety goggles

d. Plastic shoe covers and rubber boots

e. Cloth and rubber gloves

f. Undershirts and shorts

g. Socks

Protective clothing will be laundered off site on a contract basis and will have contamination limits as specified on page 507:3

Special instructions or signs posted in contaminated areas and on contaminated items will reveal what equipment is necessary. The signs may state: "Shoe Covers Required", "Respirators Required", etc.

Coveralls are not to be wor over street clothes. Protective clothing is not to be worn in clear uncontaminated areas unless authorized. It should be inspected before w...ing. There should be no tears in the clothing and for some jobs it is advisable to tape ankles, wrists and neck to prevent contamination from entering these openings. Protective clothing will be donned prior to entry in Potentially Contaminated Areas if the clothing is newly issued. Some items of clothing may be carried into the Potentially Contaminated Area and donned as posted at particular locations. When leaving these locations equipment or clothing will be taken off on pads as directed on posters or orally. If a person is to re-enter these work areas with clothing possibly already contaminated, the person will don the clothing on pads provided at the entrances to the area. When protective clothing is removed it will be handled as contaminated material and placed in the proper containers when it is to be cleaned or disposed of. It should be removed from the body in such a manner as to prevent contamination of the skin or articles of clothing underneath. The normal sequence recommended for the removal of protective clothing is as follows: shoe covers, cap, gloves, coveralls, and respirators.

Respiratory Equipment - Respiratory equipment for protection against internal exposure will be issued for use when airborne radionuclide concentrations are found to be or when it is suspected they might be greater than the limits tabulated in Title 10, Chapter 1, Part 20, Code of Federal Regulations. Respirator types available for use will include:

a. Respirators with portable fresh air tanks

b. Supplied air respirators

c. Mask type respirators with filters

Only charged and sterilized respirators will be supplied. Respirators will be checked before they are issued and should be checked again by the wearer before they are placed in service.

Personnel Monitoring - Individuals leaving from Potentially Contaminated Areas will survey themselves for contamination. The survey will be made using the Hand and Foot Monitor and a Count Rate Meter with a portable probe. All employees will be trained in the use of these instruments. Detailed instructions covering the operation of these instruments will be posted permanently at the place the instruments are kept and will be contained in the Radiation Protection Manual. When contamination is greater than limits given on page 507:3, Personnel Contamination Limits, the individual will be decontaminated as described below in Personnel Decontamination, and immediate steps will be taken to locate the source of the contamination and the area to which it might have spread.

The count rate meters located in the Potentially Contaminated Areas will be used by men working in these areas to survey themselves when leaving their work area and after any incident which might have resulted in possible contamination.

Personnel Decontamination - All cases of personnel contamination are to be immediately reported to the Health and Safety Supervisor. If the contamination is slight the individual involved should go to the contaminated shower room. If the contamination is gross, and there is no injury, an attempt will be made to decontaminate the individual involved as soon as possible under the direction of the Health and Safety Supervisor.

Normally decontamination will be performed by washing the area involved for about 3 min with a special soap provided, and plenty of water. Rinsing will be thorough. If three washings do not remove the contamination sufficiently, further efforts will be made under the direction of the Health and Safety Supervisor. He may direct that the contaminated area be scrubbed with a soft brush, with liberal amounts of soap and water or that a liberal amount of a specific solvent be applied, followed by washing and application of lotions.

If the efforts directed by the Health and Safety Supervisor do not result in sufficient decontamination or if contamination is coincident with injury the Health and Safety Supervisor will contact the New England Electric System Medical Director.

Medical and Bio-assay Examination - All personnel employed at the plant shall have a routine medical physical examination before employment, at least once a year while employed, and upon termination. The examination will include the usual complete physical with a slit lens eye examination, electrocardiogram, chest X-ray, and urine, stool, and complete blood analyses. The results of these examinations will be compiled in each individual's medical record. Routine and therapeutic X-ray exposure will be listed in this record from time to time.

Employees who are working with significant quantities of radioactive materials will submit samples to the Health and Safety Supervisor for Bio-Assay analysis. The time and type of sample will be determined by the New England Electric System Medical Director.

Personnel Radiation Exposure Records - The following personnel records will be kept:

a. Dosimeter exposure readings taken weekly

b. Beta-gamma film badge exposure reading taken monthly and readings taken on badges issued for special work.

c. Special neutron film badge exposure readings

d. Radiation exposure readings taken at other installations before or during employment with Yankee Atomic Electric Company.

e. Quarterly total exposures

f. Accumulative total of all radiation to date

g. Information related to incidents of radiation exposure and of personnel contamination.

Personnel records will be stored permanently and will be made available to properly authorized persons and agencies. Periodic reports of accumulated exposures to radiation, and reports of exposure to radiation and concentrations of radioactive material in excess of the limits specified on page 507:2, Radiation Standards, will be furnished to employees in person and the significance of the exposures reported will be explained to them.

Access Control - Personnel entering the plant will enter directly into the Clean Area. Only those people who have reason to be in the Potentially Contaminated Areas will be allowed to enter them. They will enter by way of the clean locker room, unless authorized by the Health and Safety

Supervisor or his representative to enter via other routes. When departing from Potentially Contaminated Areas, individuals will pass into the Clean Areas via the clean locker room unless authorized to take another route.

Street clothing and protective clothing normally used in conventional power plants will be worn in Clean Areas. Supervisory personnel and personnel entering the Potentially Contaminated Areas for short periods, or for work at locations not posted as requiring particular items of protective clothing, may wear lab coats into these areas. All others will wear coveralls. Fresh protective clothing and equipment will be picked up in the clean locker room where street clothing will be removed. Protective clothing and equipment previously worn but which has contamination below allowable limits may be picked up in the contaminated locker room. Tools will also be picked up in the contaminated locker rooms. Lab coats, coveralls, and head covers will be donned in the locker rooms, and other protective clothing may be carried to areas where it is to be used.

Individuals not wearing protective clothing will be permitted reentry into the Clean Areas only after they have monitored themselves with the count rate meter placed in the corridor between the Clean and Potentially Contaminated Areas and have found no contamination above the limits for Clean Areas. Re-entry while wearing protective clothing or carrying tools or equipment may be permitted only after the individuals, tools, or equipment are checked by authorized personnel and found to be "clean".

On leaving the Potentially Contaminated Areas if protective clothing is found to be "clean", or to be contaminated below the limits for protective clothing to be donned, it may be placed in the contaminated locker room for re-use. Otherwise it will be placed in hampers located at the count rate meter. Street clothing checked by the wearer and found to be "clean" can be worn directly into the Clean Areas.

Individuals may not pass into the Clean Areas when contamination is detected on their person. All cases of personnel contamination are to be immediately reported to the Health and Safety Supervisor. If the contamination is located on an individual's hands it may be removed by washing in the contaminated lavatory. Contamination elsewhere on an individual will be removed in the contaminated shower room when detected by the count rate meter in the corridor. Men are allowed to enter the clean locker room from the contaminated shower room only after they have checked themselves with the count rate meter located at the shower room exit and have found no evidence of contamination.

The Health and Safety Supervisor will be informed of all shipments into or out of the plant and will take appropriate action dependent on the individual shipment. The Health and Safety Supervisor may monitor vehicles at the gate and permit the movement of vehicles, drivers, and passengers directly into the Potentially Contaminated Area or to any of the Clean Areas. He will permit shipment to points outside the plant after the material being transported is adequately surveyed, marked and logged, and the people involved are properly monitored and adequately instructed.

Area Monitoring - A radiological survey is defined as the determination of the type and quantity of radioactivity present in the air or on the surface of a particular object or area. In making radiological surveys, portable instruments described in Section No. 215 (Radiation Monitoring) are used. They will be made as required to minimize personnel exposure to radiation. All Potentially Contaminated Areas will be surveyed periodically at frequencies dependent on the type of area, its use and its potential hazard and when access is required to areas where radiological conditions are uncertain. The lunch room will be surveyed on a weekly schedule and immediately when it is felt that contamination located elsewhere might have been carried into this area. Other Clean Areas will be surveyed on a monthly schedule. Continuing surveys will be made in occupied areas if it is possible that the level of hazardous radioactivity may increase while the area is occupied. The radiation levels at selected locations in the plant are detected by fixed plant instruments described in Section No. 215.

The smear technique will be used to determine levels of radioactive surface contamination. This involves the rubbing of a small filter paper on a surface being investigated and the counting of the radioactivity level of material picked up by the paper. Smear locations will include locations which might indicate the source of contamination, and locations which might indicate the spreading of contamination, such as stairs, ladders, landings, doorways, etc.

When making a radiological survey in a plant area, a sketch of the area will be so marked as to identify the particular piece of filter paper used at each smear and to indicate the location of the area smeared. The sketch will be also marked to indicate the exact locations at which radiation level readings are taken and the locations at which airborne particulate matter is filtered. The alpha and the beta-gamma activity on both the papers used for smears and the papers used to filter airborne particulate matter will be determined by the use of counting room instruments.

Barriers, Signs, Tags - Barriers to control personnel access will consist of ropes placed approximately 3 ft above the floor surface and a yellow and magenta striped adhesive tape attached to the floor under the rope. Signs will be conspicuously posted at the barriers bearing warnings of radiological conditions and may be posted anywhere in the plant where warnings or instructions might help prevent unnecessary exposure. They will contain a prominent magenta-colored standard, three-vaned radiation symbol on a yellow background and will indicate the amount, type and location of contamination or source of radiation as well as precautions necessary for entrance into areas enclosed by barriers. Barriers and signs will be erected or removed only by authorized specially trained personnel.

In Clean Areas, barriers will be erected at sufficient distance from sources of radiation to prevent exposure at a rate greater than 2 mrem/hr and they will isolate areas having contamination levels greater than the limits given for Clean Areas on page 507:4, Clean Area Radiation and Contamination Limits.

In Potentially Contaminated Areas barriers will be placed at a sufficient distance from the source of radiation to prevent exposures at a rate greater than 5 mrem/hr. Access will be permitted past these barriers for individuals trained to comply with the plant radiation safety rules and restrictions or for individuals escorted by trained personnel. With these barriers there will be signs posted prominently with wording such as "DANGER, RADIATION AREA". Additional barriers will be placed around areas where radiation intensities are greater than 100 mr/hr. Signs will be conspicuously placed at these barriers. They will have such wording as "DANGER, HIGH RADIATION AREA, NO ENTRY PERMITTED". Individuals will be permitted entry into these areas only when issued a Radiation Work Permit or when accompanied by trained men assigned by the Health and Safety Supervisor.

When radioactive surface contamination, as determined by smear techniques, is greater than plant limits as given on page 507:4 for Potentially Contaminated Areas that normally require access, the contaminated item or area will be roped off and posted. The signs to be used will bear a radiation symbol and words such as "DANGER, RADIOACTIVE MATERIAL, NO ENTRY PERMITTED". Individuals will be permitted entry into these areas only when issued a Radiation Work Permit or when accompanied by trained men assigned by the Health and Safety Supervisor.

Barriers will be erected around Potentially Contaminated Areas found to have airborne radioactive contamination levels greater than the plant maximum permissible concentrations. Signs will be conspicuously posted bearing a radiation symbol and wording such as, "DANGER, AIRBORNE RADIOACTIVITY, NO ENTRY PERMITTED". Individuals will be permitted entry into these areas only when issued a Radiation Work Permit or when escorted by trained men assigned by the Health and Safety Supervisor.

Step-off pads of blotter paper will be placed immediately outside of barriers surrounding areas known to be contaminated or at locations, either inside or outside of barriers where it is felt that pads may prevent the spread of significant amounts of contamination. They will be vacuumed or changed periodically to prevent the spread of contamination. Personnel entering or leaving areas having step-off pads will don and remove shoe covers and other anticontamination clothing or equipment as directed by signs posted on or near the step-off pads.

All containers in which is stored, transported or used a quantity of radioactive material in excess of those quantities listed in the documents of Appendix A as requiring posting will have a tag applied which has the words "Radioactive Materials, Caution" in magenta lettering on a yellow background, and will be marked with identification of the radioisotope, amount of radioactivity and the date.

Radiation Work Permit - Plant areas barred by a rope barrier and posted with signs "NO ENTRY PERMITTED" or "RADIATION WORK PERMIT REQUIRED" may be entered by individuals who have obtained clearance in the form of a Radiation Work Permit. This procedure is established to provide radiation safety in areas where overexposure of personnel is possible within a normal work day. If the work to be done is a type which may influence plant status during operation and which requires standard tagging procedures both the work permit and the standard tagging procedure will be followed.

Radiation Work Permit form will be prepared in triplicate which will include the following:

a. Area in which work is to be done and scope of work.

b. Starting time and expected duration of the work.

c. Name of man, or men if more than one shift, in charge of working party.

d. Names of men in working party and recorded individual accumulated exposures.

e. Date and time of radiological survey just prior to entry.

f. Findings and signature of man making the radiological survey.

g. Safety precautions required of working party.

h. Monitoring required during the work (at start only, intermittent or continuous)

i. Dosimeter readings on entry and on leaving work area.

j. Signatures of men in charge of working party, of Shift Supervisors to be on duty during the performance of the work, and of the Health and Safety Supervisor when approving the permit and again when the work area is cleared and accepted as ready for service.

The original of the forms prepared will be kept by the Shift Supervisor until the work is terminated. One copy will be kept by the Health and Safety Supervisor and one will be posted at the work area barrier. No changes will be made to a permit after it is issued. Upon completion of the work, and after dosimeter readings are recorded, all copies will be returned to the Shift Supervisor who will return the area to normal status.

The Health and Safety Supervisor will provide monitoring and assistance as required to minimize exposures. He may substitute for the permit by providing a continuous escort of specially trained men when so requested by the Shift Supervisor for work of short duration.

<u>Area and Equipment Decontamination</u> - Decontamination of equipment or areas may be undertaken to reduce levels of radioactivity to below maximum permissible level, or it may be undertaken to minimize risk of exposure during maintenance or other work. A comprehensive survey map of contaminated areas or components will be furnished personnel assigned the duties of removing radioactive contamination. Men trained in radiation safety will be assigned the duty of determining the extent of radiation

hazard during decontamination and of advising personnel undertaking the decontamination of the potential hazards and of precautions necessary or advisable to safeguard against unnecessary exposures. Men undertaking decontamination will be familiar with and will observe the following rules and practices:

a. Sweeping with brooms is prohibited.

b. Liquid will be absorbed from wet contaminated areas and then the area will be vacuumed.

c. Dry contaminated areas will be vacuumed first, and then damp mopped.

d. If further decontamination is necessary, the area will be washed with water and a soapless detergent. Care will be exercised to prevent the splashing of contaminated water.

e. Assume used cleaning equipment is contaminated unless proven to be "clean".

f. Decontaminate areas of highest radioactivity first.

g. Decontaminate area no larger than 200 sq ft at one time.

h. Perform component decontamination, wh e feasible, in the decontamination room or on the de ontamination pad where the spreading of contamin may be minimized.

i. Gross cleanup by steam jetting or water flushing will be performed only if the spread of contamination is prevented by polyethylene tents, etc.

j. Final cleanup by hand brushing is allowed only if the spread of contamination is safely controlled by brushing under water, etc.

k. Mechanical abrasives may be used only where marring of surface finish and dimensional changes may be tolerated, and airborne contamination is controlled.

l. Every effort should be made to decontaminate solid scrap so that it may be disposed of as "clean" scrap.

Radioactive Shipments and Waste Disposal - All radioactive shipments will comply with the regulations of the Interstate Commerce Commission and of the Commonwealth of Massachusetts. The Health and Safety Supervisor or an authorized representative will be notified of all shipments to be made from the plant. The shipment of material that is radioactive, suspected of being radioactive or accompanying a radioactive shipment will be approved by the Health and Safety Supervisor or by his representative before being allowed by the guard to leave the Station. These shipments will be surveyed and released after proper shipping forms are completed and proper accountability records of the shipments are made.

The Health and Safety Supervisor, or his approved representative, will be notified of the arrival of radioactive shipments at the Station. He will survey the shipment and will approve the transportation, storage or use of the radioactive shipment within the Station.

Radioactive waste disposal will be made upon issuance of a "Permit for Discharge of Radioactive Waste" issued jointly by the Chemical Engineer and the Health and Safety Supervisor or their approved representatives. A complete description of the waste and its radioactivity will be recorded when waste is disposed of.

Solid combustible radioactive waste containers made of metal bearing the magenta radiation symbol and the word "COMBUSTIBLE" will be placed in areas where this type of material will be generated. They will be lined with a leakproof plastic bag to prevent the spread of contamination during the transfer from the container to the plant incinerator. The containers will be emptied when full or when the level at 1 in. from the container is 5 mrad/hr or greater.

Plastic lined metal containers, bearing the magenta radiation symbol and marked "NON-COMBUSTIBLE" will be placed in areas where waste of this type is generated. When full or when in excess of 5 mrad/hr the container will be transferred to the Waste Disposal Building. Waste requiring storage will be wrapped in protective covering to confine contamination. The remainder will be placed in a concrete mix and contained in steel drums.

All liquid radioactive waste will be dumped into drains flowing to the radioactive waste disposal system.

<u>Radiation Incidents</u> - A radiation incident is defined as: a condition or situation which results in personnel exposures beyond the maximum permissible limits or which, while not necessarily involving actual personnel exposures is an undesirable event of sufficient importance in the mind of the Health and Safety Supervisor to warrant investigative action and the recording of his findings.

Personnel exposures arising from incidents shall be evaluated promptly. This may require special bio-assays, surveys, reviews of work assignments, film studies, analyses, etc. Conditions or situations which require prompt notification of the Health and Safety Supervisor and subsequent action include the following:

a. Positive evidence of radioactive deposition on personnel such as: contaminated injury, positive nasal or sputum smears, exposures of unprotected personnel to atmosphere in excess of maximum permissible limits.

b. Medical treatment which includes an individual's exposure to radiation or contamination.

c. Radiation dose in excess of maximum permissible limits.

d. A short term dose on the order of 300 mrem.

e. Unusual events such as: fires or explosions in Potentially Contaminated Areas, accidents involving the transportation of radioactive materials, a gross discharge of radioactive material to the environment, exceeding critical mass control limits.

Personnel involved in a radiation incident and whose exposure is not known shall not be assigned work involving radiation hazards until their exposures have been evaluated. Details of radiation incidents will be made known and explained to individuals involved and will be added to their record. A report describing the incident will be reviewed by the Plant Safety Committee.

Where it is determined that an individual has suffered injury in the Potentially Contaminated Area and has become contaminated the following actions may be taken:

a. The Health and Safety Supervisor will be notified of all cases of personnel contamination and decontamination by washing should begin as soon as possible.

b. In cases of severe injuries, medical attention shall take precedence over contamination controls.

c. In inhalation cases, emergency medical attention to this may take precedence over decontamination or wound treatment.

d. In the event of an open wound sustained in a Potentially Contaminated Area:

1. Control severe bleeding and flush as required.

2. Flush wound and massage toward the injury if required.

3. Install contamination control tourniquet if appropriate.

4. Survey the injury and the area where injury occurred.

e. The Health and Safety Supervisor will notify the Medical Department if in his opinion this is desirable or necessary.

Federal and State agencies will be notified of radiation incidents as required by their regulations.

REFERENCES

Where applicable the following references were used in writing these instructions:

1. Standards for Protection Against Radiation; Part 20, Chapter 1, Atomic Energy Commission, Title 10 Atomic Energy, Federal Register Volume 22, Number 19.

2. Rules and Regulations for the Protection of the Health and Safety of Employees from Occupational Diseases Caused by Ionization Radiation; Industrial Bulletin Number 5, Department of Labor and Industry, Commonwealth of Massachusetts; Effective December 1, 1957.

3. Maximum Permissible Amounts of Radioisotopes in the Human Body and Maximum Permissible Concentrations in Air and Water; National Bureau of Standards Handbook 52, March 20, 1953.

4. Maximum Permissible Radiation Exposures To Man; Statement of National Committee on Radiation Protection and Measurement, April 15, 1958.

5. Interstate Commerce Commission Regulations for Transportation of Explosives and Other Dangerous Articles; Tariff Number 9, Bureau of Explosives of the Association of American Railroads.

508 PLANT SECURITY AND SPECIAL NUCLEAR MATERIALS CONTROL

Plant Security and Access

Plant security is under the direction of the Administrative Assistant who also has charge of security education and handling of classified material. All security procedures at the plant will be consistent with applicable AEC regulations.

Since there is only one normal point of access for traffic through the chain link fence, only one guardhouse is provided at the facility. The guardhouse is manned at all times by at least one properly authorized guard. Normal turnstile access for individuals and gate access for motor vehicles with valid passes and identification are provided. Exclusion area details are shown on drawing No. 9699-FY-5A.

The exclusion area plan provides for an interior chain link fence and a three strand, barbed wire, perimeter fence. This perimeter fence partially surrounds the plant at a radius of approximately 1,000 ft from the plant and is considered to be a barrier to prevent trespassing on plant property. The perimeter fence does not cross the Deerfield River but terminates at the east bank of the river. The area not enclosed by this perimeter fence is directly in front of the plant, and an unobstructed view of this unfenced portion of the plant site is available from the plant. Automobile parking for employees and visitors to the plant is provided outside the chain link fence.

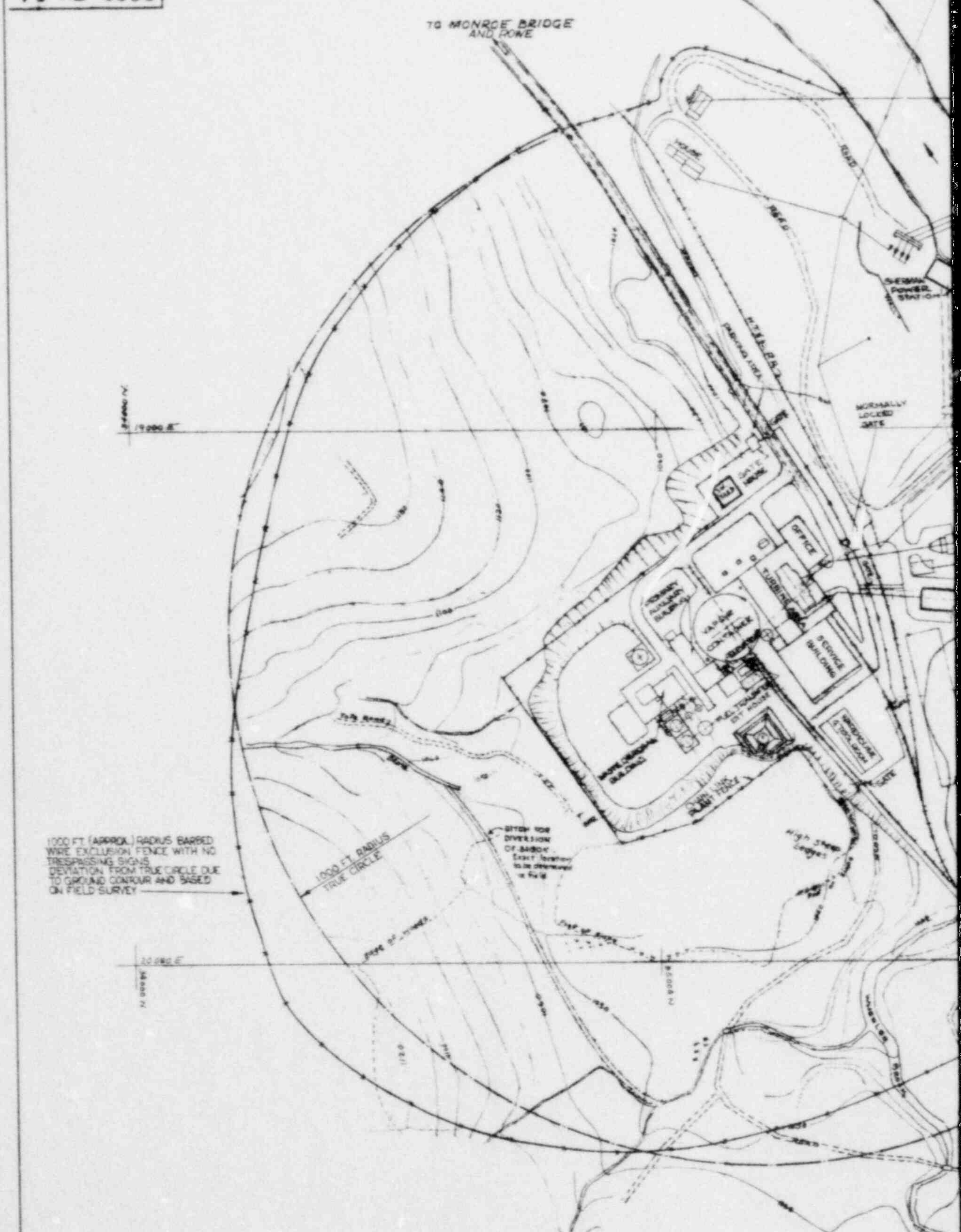
Access for a slow speed freight railroad, the Hoosac Tunnel and Wilmington Railroad, is provided through the perimeter fence with the access under the control of the guards. During freight deliveries to the plant proper, the Administrative Assistant will supervise railroad operations through the normally locked gates in the chain link fence.

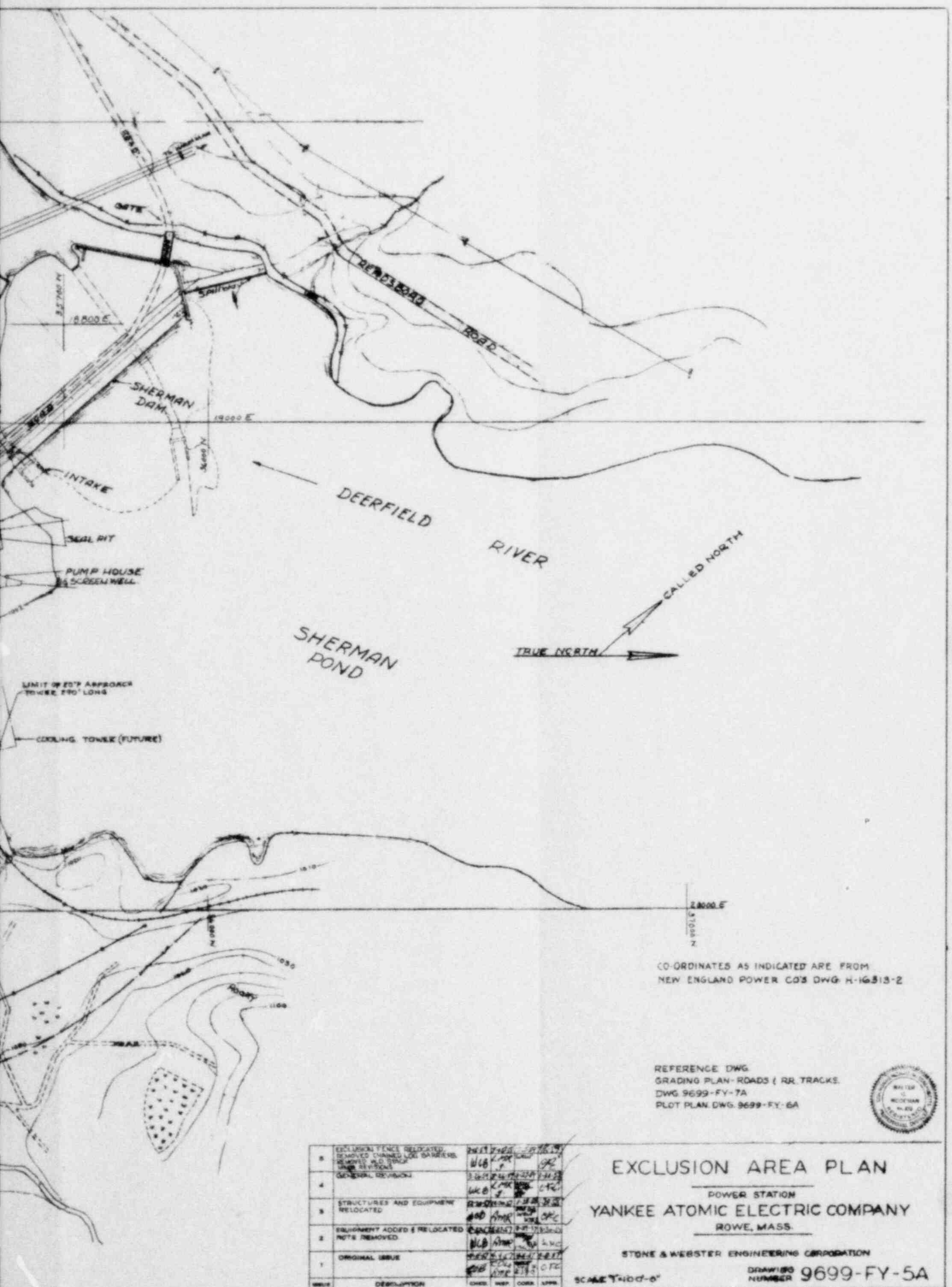
Since licensed power reactors are not classified installations, Yankee Atomic Electric Company does not propose to treat any of its plant as classified. The portion of the plant inside the vapor container, however, will not be available for visitation. Access to this part of the plant will be granted only to company employees and visiting scientists at the discretion and with the permission of the Plant Superintendent and as plant operation permits.

Classified Document Handling

Classified documents for use of properly cleared personnel at the plant will be stored in an AEC approved file safe. Such classified documents will be in the custody of a properly cleared Document Custodian. The Administrative Assistant will be in general charge of handling classified documents. A Security Manual will be prepared and issued to all personnel so that security requirements and procedures will be well understood by all employees.

9699-FY-5A


TO MONROE BRIDGE AND ROWE
1000 FT. (APPROX.) RADIUS BARBED WIRE EXCLUSION FENCE WITH NO TRESPASSING SIGNS. DEVIATION FROM TRUE CIRCLE DUE TO GROUND CONTOUR AND BASED ON FIELD SURVEY
1000 FT. RADIUS TRUE CIRCLE
SHERMAN POWER STATION
NORMALLY LOCKED GATE
GATE HOUSE
OFFICE
TURBINE
VAPOR CONTAINER
SERVICE BUILDING
GATE



GATE
SPILLWAY
RAILROAD ROAD
18800 E
35700 N
SHERMAN DAM
19000 E
INTAKE
DEERFIELD RIVER
SEAL PIT
PUMP HOUSE
SCREEN WELL
CALLED NORTH
TRUE NORTH
SHERMAN POND
LIMIT OF 20'Ø APPROACH TOWER 290' LONG
COOLING TOWER (FUTURE)
28000 E
37000 N
ROAD
CO-ORDINATES AS INDICATED ARE FROM NEW ENGLAND POWER CO'S DWG H-16313-2
REFERENCE DWG
GRADING PLAN-ROADS & RR TRACKS.
DWG 9699-FY-7A
PLOT PLAN DWG 9699-FY-6A
5 EXCLUSION FENCE RELOCATED. REMOVED CHAINED LOG BARRIERS. REMOVED W.D. STACK. GRID REVISIONS
4 GENERAL REVISION
3 STRUCTURES AND EQUIPMENT RELOCATED
2 EQUIPMENT ADDED & RELOCATED NOTE REMOVED
1 ORIGINAL ISSUE
ISSUE DESCRIPTION CHKD. INSP. CORR. APPR.
EXCLUSION AREA PLAN
POWER STATION
YANKEE ATOMIC ELECTRIC COMPANY
ROWE, MASS.
STONE & WEBSTER ENGINEERING CORPORATION
SCALE 1"=100'-0"
DRAWING NUMBER 9699-FY-5A

The senior operating personnel of the plant already hold valid "Q" clearances from the AEC, and Yankee will obtain similar clearances for any additional employees whose work will require that they have access to classified information.

The classified document repository will be located in the Administrative Assistant's office and in such a manner as to meet all AEC requirements. Classified documents will be made available by the Document Custodian only to plant personnel holding a valid AEC security clearance and having a "need to know" the contents of any classified document.

A check list of classified documents will be maintained by the Document Custodian for any documents issued to cleared personnel. He will also maintain a log sheet showing receipts and shipments of classified documents to and from the plant.

All classified document handling procedures will be in accordance with AEC requirements and as outlined in the Yankee Atomic Electric Company Security Manual.

Control of and Accounting for Special Nuclear Materials

The Yankee Plant as a licensee of the AEC will provide and maintain adequate storage facilities and will maintain accurate records of nuclear fuel balances.

The plant will not receive, ship loose, or unclad special nuclear material for use in its reactor. All such material coming into the plant will be contained in manufactured fuel assemblies ready for insertion into the Yankee reactor. These fuel assemblies will be fabricated by a contractor for Yankee and will be transported to the plant site in shipping containers. Section 101, CORE MECHANICAL DESIGN should be referred to.

A concrete storage vault will be provided for the storage of new fuel elements. The fuel elements will be placed in this vault through a roof access hatch using the yard crane for handling between transportation vehicle and the storage vault. Only authorized personnel are allowed access to the new fuel storage vault.

A water filled, concrete pit will be provided for the storage of spent fuel as removed from the reactor vessel. Section 218, FUEL HANDLING SYSTEM and O.I. No. 506E, REACTOR REFUELING should be referred to.

The Administrative Assistant will be in charge of these vaults and the movement of material into and out of them. He will inspect the incoming fuel assemblies for shipping damage, will make the necessary checks on incoming fuel with material transfer sheets as provided by core fabricators, and will make out material transfer sheets for all material shipped from the Yankee Plant. Since the size and weight of the fuel elements precludes any possibility of ordinary pilferage, it will not be necessary to provide an extensive system of locks to protect against such losses. The Administrative Assistant will at all times maintain a complete record of the material balance area. Semiannually he will prepare a Material-On-Hand Report for the AEC.

Any laboratory calibration material will be retained and stored in the laboratory under the supervision of the Chemical Engineer and will not be placed in either the new or spent fuel areas.

Actual handling of the fuel assemblies containing special nuclear material will be done under the supervision of the Plant Superintendent or his designated assistant, but the Administrative Assistant has the responsibility for recording the movement of special nuclear material even within the plant.

509 ROUTINE AND CONTINUING PLANT TESTS

General

All checks, tests, and calibrations of the general type necessary to the efficient and safe operation of any large electric generation station will be performed on a routine basis. It is anticipated that the electrical transmission equipment, the secondary plant, and certain portions of the nuclear plant will be handled with this relatively conventional approach. The test programs discussed in this section are those which have a direct connection with the safe operation of the reactor.

Routine Nuclear Tests

Power Coefficient - Measurements of power coefficients will be made during the initial startup of each fuel loading. In addition, data obtained during scheduled generator load changes throughout core life will be periodically checked for power coefficient determinations.

Temperature Coefficient at Operating Temperature - Measurements of moderator temperature coefficients will be made during the initial startup of each fuel loading. In addition, data obtained during scheduled plant shutdowns throughout core life will be periodically checked for temperature coefficient determinations.

Flux Distribution in the Core - Information concerning the flux distribution, and hence power distribution, permits an experimental verification of the calculated values of maximum-to-average power density in the core and provides information concerning operation at power levels greater than the initial level. External nuclear flux monitors located around and at different elevations with respect to the core can be analyzed in conjunction with control rod program for flux distribution in the core. In addition, the in-core instrumentation system provides a more accurate means of analyzing flux distributions.

Radiation Shielding and Plant Area Monitoring - Checking of plant radiation shielding and plant area monitoring, under the direction of technical services personnel, will maintain a regular and continuing record of radiation levels by survey methods as detailed in Section 507 - RADIOLOGICAL HEALTH AND SAFETY. Certain of these data will be regularly recorded on the appropriate station logs which are in use for that particular plant area. Other plant occupancy areas which are not regularly covered by log entries will be surveyed by use of semi-portable instruments which are located in these areas.

Routine Mechanical Tests

Control Rod Scram - Circuit Check - During plant operation it is not advisable to make any tests in the scram circuitry. All indications that are available will be noted at least once per shift, and adjustments will be made only if necessary. At no time will the scram circuitry be disconnected during operation. All rod scram tests will be made during scheduled reactor shutdown or during various emergency shutdowns.

Safety Injection System - Weekly, during power operation, all of the pumps and valves of the safety injection system will be operated individually from the safety injection control panel in the control room to determine their serviceability and correct light position indication. The pumps will be operated only on by-pass to the safety injection-shield tank cavity water storage tank. Loop fill valves will only be opened with the injection valve closed tight. All locked-open and locked-closed valves outside the vapor container will be checked at the conclusion of the tests to verify their correct position. Whenever the reactor plant is shutdown and depressurized, the entire system operation will be checked by manual operation of the safety injection control switch provided on the nuclear section of the main control board.

Pressurizer Spray System - In order to assure reliable performance, the pressurizer surge and circulation spray systems will be tested periodically, preferably during the normal startup operation. While maintaining normal operating conditions in the main coolant system and the pressure control and relief system, that is with surge spray deenergized, it is determined that correct circulation spray exists (hand control valve initially positioned so as to maintain pressurizer equilibrium conditions) by noting frequency of heater cycling while maintaining pressurizer at normal values. Verification of surge spray operation will be accomplished by obtaining maximum spray flow and observing the resultant pressurizer pressure decrease, temperature increase of water flowing through the surge line, and changes in pressurizer heater cycling.

Pressurizer Solenoid Relief Valve - The pressurizer solenoid relief valve, which is provided to limit the duty of the pressurizer safety valves, will be tested after refueling or after completion of maintenance on this valve.

The set pressure and the blowdown pressure shall be observed during the test operation and shall be compared with the design conditions. After the valve has discharged, note the downstream pipe temperatures to assure that the valve disc has properly reseated.

The steam pressure required to test the solenoid relief valve is obtained by operation of the pressurizer heaters.

Scram Alarms Check Points and Instrumentation Calibration Checks - In order to assure safe operation of the plant, certain instrumentation checks will be performed periodically. Only those checks that can be made without disconnecting the scram circuit during plant operation will be performed. No tests or checks will be made on any equipment if there is a possibility of initiating a false scram. All calibration will be made before starting or during scheduled shutdown periods, except where calibration is required at a power level.

Site Monitoring - The testing, calibrating and standardizing of the radiation monitoring equipment will be further supplemented by another routine and continuing test, ensuring the accuracy and adequacy of the radiation monitoring and radioactivity survey programs. (See Section 305 - ENVIRONMENTAL RADIOACTIVITY SURVEY.)

Environmental samples will be collected and checked twice each year. Results of these checks will be compared with radioactivity levels established by the pre-operational site survey. If a major difference exists, a detailed analysis will be contracted to an independent laboratory.

Main Coolant Water Determinations and Contamination Tests - Radiochemical analysis will be performed on the main coolant water for the determination of induced corrosion products and released fission product radioactivities. Other routine analysis will be performed to maintain water specifications as presented in Section 106 - REACTOR COOLANT CHEMISTRY.

Vapor Container Leak Test - Leakage from the vapor container will be determined using a leaktight closed volume system within the vapor container and a manometer. The closed volume system will be pressurized to 3 in. H_2O above the vapor container internal pressure corresponding to 1 1/2 psi gage at ambient temperature of 120 F, and the manometer will be used to measure the differential pressure between the closed volume system and the vapor container. A slow rise of the differential pressure between successive midnight to dawn periods will be indicative of a loss of air from the vapor container. The leak rate may be determined by the methods given in O.I. 504Q. The reading of the instrument used for monitoring vapor container leakage will be recorded routinely during plant operation.

Emergency Generator - The emergency generator set will be tested once a month to assure that the unit will be ready for use when required. The set will be run for about 20 min during each test, at which time the operating gages will be observed to check proper functioning of the set. After each test the fuel tank will be checked to ensure that an adequate fuel supply is on hand at all times.

Power Supply Reliability Check - The electrical system includes the necessary equipment to generate electric power and deliver it to the 115 kv transmission system as well as to provide power necessary to drive auxiliary equipment within the plant itself. Reliable power is assured so that sufficient coolant flow is maintained to keep the thermal rise in the core within safe limits when electrical disturbances cause a partial power loss to the electrical system. An engine driven power source is provided to maintain service to vital equipment in the unlikely event of total loss of electrical power. Normal station operation is with two separate 115 kv transmission lines in service so that a firm power supply with maximum reliability is established.

All checks, tests, and calibrations of the general type necessary to the efficient and safe operation of a large electrical plant will be performed on a routine protective maintenance basis. The engine driven power source will be started on a monthly basis to make certain of starting during an emergency.