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FOR PRESENTATION AT THE
DOE/PNC - PLANT ENGINEERING
WORKING GROUP SEMINAR
IN JAPAN
September 20-22, 1978

TRAINING EXPERIENCE AT EXPERIMENTAL BREEDER REACTOR II

by

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Idaho Falls, Idaho 83401

Work performed under the auxpices of the U. S. Department of Energy

MASTER

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ABSTRACT

The EBR-II Training Group develops, maintains, and oversees training programs and activities associated with the EBR- II Project. The group originally spent all its time on EBR-II plant-operations training, but has gradually spread its work into other areas. These other areas of training now include mechanical maintenance, fuel manufacturing facility, instrumentation and control, fissile fuel handling, and emergency activities. This report describes each of the programs and gives a statistical breakdown of the time spent by the Training Group for each program.

The major training programs for the EBR- II Project are presented by multimedia methods at a pace controlled by the student. The Training Group has much experience in the use of audio-visual techniques and equipment, including video-tapes, 35mm slides, Super 8 and 16mm film, models, and filmstrips. The effectiveness of these techniques is evaluated in this report.

INTRODUCTION

The policies of the Department of Energy, Argonne National Laboratory, and the EBR-II Project require formal programs for training, examination, and qualification of operating and maintenance personnel. The primary responsibility of the EBR-II Training Group is to train the personnel who operate and maintain the EBR-II Plant. However, the Training Group has become increasingly involved in other training activities also.

This paper describes the various training programs given by the EBR-II Training Group. We briefly discuss the history of the first EBR-II operator training program, and tell how the program grew to its present status. Examples of present qualification methods are given. Special training activities are listed with a brief explanation of each program. The education and experience of the maintenance and operations personnel and the Training Group are described. Records retention, instruction techniques, and training aids are also discussed.

HISTORICAL

The the EBR-II Operations training program began in the late 1950's when emphasis was being shifted from EBR-I to EBR-II. During 1958-1960, approximately 10 degree-level people were recruited so that they, after intensive training, would form the nucleus of the operating organization for EBR-II. Early training for this group consisted of formal classroom training in reactor technology, and also hands-on operating experience with EBR-I and, to a lesser extent, with the ZPR-III, BORAX IV, and ALPR reactors. About one day per week during this period was spent on orientation lectures given by engineering personnel with knowledge of the plant.

Construction work at EBR-II began in September 1958. Work progressed on schedule, and by September 1960, the reactor plant was ready for the installation of components. At this time the supervisory trainees were assigned to work on installation and checkout.

During the period 1958-1960, approximately 35 technicians were recruited for BORAX-V and EBR-II. Most of these were graduates of two-year technical schools, some were graduates of the local secondary schools, and a few were retirees from the U. S. Navy. All were placed under the existing training program, which consisted of lectures by staff personnel, study assignments, and hands-on experience with the ZPR-III, EBR-I, ALPR, BORAX IV, and BORAX V reactors.

In early 1961 a more formal training program for supervisory personnel was started. Training consisted of three principal parts: plant orientation, reactor technology, and systems familiarization. Members of the engineering staff presented formal lectures, prepared information sheets, and gave examinations. The training materials available at that time included the Hazards Summary Report, preliminary drafts of the Operating Instructions, vendors' equipment manuals, plant drawings, construction specifications, sketches, design criteria, system descriptions, etc. As a part of the program, the supervisory trainees were assigned responsibilities in installation and checkout work. The technician trainees also did checkout work.

In February 1961, three months before the dry-critical experiments, a special training program was started for supervisors and operating technicians who were assigned to the dry-critical experiments. Later, when dry criticality was achieved, much hands-on experience was obtained through dry startups, steady-state control, shutdowns, and fuel-handling operations. Oral and written examinations on various phases of the operation were given, and the scores were recorded to establish achievement records for each person. All technician-level personnel assigned to reactor operations gained considerable experience in reactor operations and fuel handling during the dry-critical studies.

The first phase of supervisory training ended soon after the completion of the dry-critical experiments. At that time, shift supervisors were assigned the responsibility for training future crews in the operation of the various plant systems. Six basic areas of systems were recognized: power plant, chemistry, coolant, electrical, fuel handling, and reactor console. Each of these areas was taught as part of the operator training program.

A group of trainees, usually about 12, would train in one area and then move on to another. At the same time, the trainees were assigned work in various plant activities. During the time between the dry- and wet-critical experiments, the shift supervisors were given primary responsibility for operator training. Much progress was made during this time. Qualification record sheets were revised to emphasize the operation of systems rather than their design. Training material was revised, its format was standardized, more detail was added, and more emphasis was placed on plant operation.

Nevertheless, problems developed. Conflicts arose between the needs for operator training and the demand for work by trainees in the wet-critical experiments. The loss of trained or partly trained personnel and the coming of relatively inexperienced new personnel increased the problem. Group training, on an overtime basis, was used to continue the supervisor/operator training program without too much delay to the wet-critical experiments.

The wet-critical experiments were done during November and December 1963. Planning then began for the approach-to-power experiments for early 1964. At the same time, the operator training program was changed. Group training was replaced by an on-shift program given by a formal training group. Each trainee was expected to train and qualify in one area at a time and eventually qualify in all five areas. The chemistry area was combined with power plant qualification.

Formal qualification of operators began in late 1963. By May 1965, a total of 34 operators had gained 29 area qualifications. By 1970, the number of area qualifications increased to 92, shared among 30 operators.

By January 1, 1972, 114 area qualifications were shared among 35 operators. At this time, the training program was reaching an equilibrium, that is, the number of qualifications gained was the same as the number lost through people who were transferred or promoted or left Argonne.

During the years 1972-1973, several events affected the training program. First the training and qualification requirements of the U. S. Atomic Energy Commission were strengthened. Second, dissatisfaction with working conditions, along with a shortage of experienced nuclear-power-plant operators for commercial reactors, caused many qualified operators to leave Argonne. Third, additional duties were being given to the training group, such as training in emergency programs and procedures, conducting a training program for the Fast Flux Test Facility, producing video tapes for other groups, and starting training programs for fuel-production and maintenance personnel. As a result, the training program changed. The major changes were: (1) a temporary increase in the training staff; (2) the addition of an alternate shift supervisor to each crew to provide training; and (3) the addition of a chemistry technician to each crew, which allowed the separation of the chemistry area from the power-plant qualification for operators.

EBR-II OPERATIONS TRAINING

Operator Qualification

The present training program is designed to train employees with a wide range of backgrounds. Some of the new employees may have only a high school diploma with no experience, and others may be fully qualified as Naval nuclear operators.

All trainees, whatever their backgrounds, are given an intensive orientation course that lasts one week. The course covers the following topics: the need for and the objectives of the Fast Breeder Reactor program, the basic differences between fast reactors and thermal reactors, a description of the EBR-II facility, radiation and personnel safety, criticality control, and evacuation instructions. The trainee is given several written examinations during the week.

Following the orientation week, the trainee is assigned to one of the four operating crews and is expected to qualify in five different plant areas: coolant, reactor control console, fuel handling, electrical, and power plant. The area in which the trainee begins training is determined by the shift supervisor, whose decision is based on the needs of his crew at that time. For crews that have no shortage of qualifications in any area, the normal sequence for qualification is: coolant, reactor control console, fuel handling, power plant, and electrical.

Throughout the training period, the trainee is directly responsible to the alternate Shift Supervisor for his training. An alternate Shift Supervisor is a qualified Shift Supervisor assigned to a crew and given the responsibility of on-shift training. Immediately after assignment to a crew, the trainee begins hands-on training under the direct supervision of a qualified crew member, that is, a qualified operator, foreman, or one of the supervisors. The first training consists of taking and recording the instrument readings in the primary and secondary systems to teach the trainee the location of major system components and instrumentation. During this time, the trainee is given as much practical experience as possible. This is done by having the trainee work actively in each plant procedure, for example, startup, shutdown, and adjustment of major coolant systems or subsystems. Practical experience is the most important part of the trainee's qualification.

At the same time, the trainee completes a study program consisting of lesson plans and written examinations. The trainee normally spends 4-6 hours of each 8-hour shift in study, with the rest of the time spent in active work in the plant. As an example, in the coolant area, the trainee must qualify in 15 subareas of the coolant systems (Attachment 1). In each subarea, the trainee must receive two signatures by qualified personnel in order to qualify. These two qualification signatures are for "theory" and "experience." To obtain a signature in the theory area, the trainee must pass a closed book written exam (Attachment 2). A variety of study material is available to the trainee, including training manuals, operating instructions, and system design descriptions. The training manual contains most of the general and detailed information an operator must learn for qualification (Attachment 3).

Along with the training manual, the trainee uses the operating manual, which lists the step-by-step startup and shutdown procedure for each system (Attachment 4). The operating manual is used by the trainee along with his hands-on training. The system design descriptions are used only if the trainee must obtain knowledge of a system beyond the requirements for qualification.

When the trainee completes all requirements listed on the lesson plan, the alternate shift supervisor or a qualified operator gives an oral examination to check the trainee's knowledge. If the trainee shows enough knowledge of the system, the alternate shift supervisor gives a final closed-book exam for the system. If the closed-book exam is passed, the trainee receives a signature on the theory column of the qualification card. To obtain the experience signature and complete qualification, the trainee must, in the judgment of the alternate shift supervisor, do enough hands-on work in the system to show his ability for unsupervised work.

The trainee continues step by step as described above until each of the subareas of the coolant-operator qualification card is completed. When all areas of the card have been signed, the trainee goes through a series of on-crew oral exams supervised by the alternate shift supervisor and designed to test the trainee's weak areas. The oral examination board consists of two to five persons qualified in the coolant area. Following the on-crew oral, the trainee is told of any weak areas and is given time to restudy the areas. Checkouts of the trainee continue, sometimes totaling as much as 12 hours. When the alternate shift supervisor is satisfied that the trainee has gained the knowledge and experience to competently operate all of the coolant systems, the shift foreman and shift supervisor sign the qualification card as completed in all areas in both theory and experience.

The alternate shift supervisor then recommends to the Training Supervisor that the trainee complete his final formal qualification in the coolant area. The training supervisor provides a final coolant examination to the alternate shift supervisor, who gives it to the trainee. The examination is in two major parts: Systems Training, and Emergency and Administrative. The Systems Training part (Attachment 5) is divided into six topics: (1) principles of reactor operation, (2) features of facility design, (3) generatl operating characteristics, (4) instruments and control, (5) safety and emergency systems, and (6) standard operating procedures. (The first topic is used only in the reactor-control-console area.) The topics included in the Emergency and Administrative part (Attachment 6) are: emergency procedures, health and safety, safeguards, criticality, radiological safety, and technical specifications. The test is graded by the alternate shift supervisor and reviewed by the Training Group.

If the trainee passes the final written exam, he is recommended for final oral exam. The oral board is composed of a representative of the training group, an alternate or shift supervisor, and a staff specialist who is an expert in the coolant area. Before the oral exam, each board member is supplied with an oral form (Attachment 7) which summarizes all topics to be covered, and the members are assigned specific topics so that they are able to prepare their questions before the exam. No specific assignments are made in emergency and off-normal procedures, as each board member is expected to cover these. In addition to questioning the trainee, the Training Group representative must make sure that all topics are covered in enough detail and must record all questions for filing in the trainee's official training file.

The emphasis of the questions is on operating knowledge, emergency and off-normal situations, interaction between plant systems, and diagnosis of varying instrument readings. The oral exam normally lasts from two to three hours. Each board member grades the trainee in the area of his assigned responsibility as either outstanding, satisfactory, or unsatisfactory. All board members must agree on a decision to pass or fail the trainee. Any grade in the unsatisfactory cloumn will require the trainee to take another oral exam, given at least 30 days after the first oral. The extent of the repeat exam depends on the number of areas in which the trainee was judged unsatisfactory. A failure in only one or two areas may require only a short repeat exam (30 minutes) while more extensive unsatisfactory areas may require a full repeat exam (2-3 hours). The board members for the repeat oral are the same persons who gave the first oral. Unsatisfactory areas in the first oral are described to the trainee's alternate shift supervisor, who then makes sure that the trainee studies the weak areas. The trainee must show his alternate shift supervisor that his weak areas have been strengthened and that he is ready for a repeat oral exam. Although 30 days is the minimum time between an oral and a repeat oral, the actual time is decided by the trainee's alternate shift supervisor.

After the trainee passes the oral or repeat oral, the training supervisor sends a letter of recommendation of qualification to the manager of plant operations. The Plant Operations Manager then judges the trainee as to maturity and judgment by observing him and by discussions with the trainee's foreman, alternate supervisor, and supervisor. If the trainee is judged to be satisfactory in these areas, the manager of plant operations recommends certification to the Associate Director, EBR-II Operations, who officially certifies the trainee by signature on a qualification letter; the trainee also receives a qualification certificate (Attachment 8).

The operator now becomes a trainee in the next assigned area. Qualification in the other four areas of plant operations is similar to what is described above. Attachment 9 is a list of the sections and topics for the five areas of qualification.

An operator must maintain a high level of knowledge in his qualified areas by studying all existing systems and the modifications to them. Once every two years, all operators must pass written, oral, and operating examinations in each of their qualification areas. Every year, they must also pass written, oral, and operating examinations in plant emergency procedures.

Qualification of Foremen

Foremen are qualified operators who have been promoted on the basis of their experience and leadership ability. They must maintain qualification as an operator.

Qualification of Shift Supervisors

Candidates for Shift Supervisor are obtained from two sources: either promotion of a qualified foreman, or hiring from the outside. Outside hires are required to have a college degree in an area related to reactor work. By promotion from within (usually without a degree) and hiring from outside with a degree, a balance is maintained of about one-half with degrees and one-half without degrees among the supervisors. The balance is maintained so that personnel with degrees and with a high level of plant knowledge can be supplied to support groups such as EBR-II Plant Engineering.

When a foreman is being promoted to Shift Supervisor, the training required is an expansion of past operator training. The trainee must show additional knowledge in reactor theory and adminstrative rules. To show satisfactory knowledge in these areas, the trainee must pass long written exams on reactor theory and on the overall plant, followed by oral exams. The written exams are given and graded by the Training Group. The oral examination board consists of the Manager of Plant Operations, the Operations Physicist, a Shift Supervisor, and representative from the Training Group. After the trainee passes the oral exam, he takes an operating exam by acting as a Shift Supervisor under the supervision of a qualified Shift Supervisor for a trial period of three months. If the trainee is judged to be satisfactory at the end of the trial period, he receives qualification as a Shift Supervisor.

If the trainee is an outside hire, he goes through a modified operator-training program before qualification as a supervisor. His progress is checked by a series of orals exams, and qualification by formal oral exams and written exams is required in the reactor and fuel-handling areas only. From this point, supervisor qualficiation for an outside hire is the same as for a trainee with a foreman background.

All certified Shift Supervisors are required to continue their training to: (1) maintain their ability in their assignments, (2) familiarize themselves with plant changes and their effects on plant operation, (3) maintain an in-depth familiarity with normal and emergency operating procedures, (4) increase their theoretical understanding, (5) reveal weaknesses in operational and supervisory ability, and (6) maintain a working understanding of nuclear safeguards, criticality hazards control., plant safety, personnel safety, and compliance with technical specifications.

To maintain qualificiation, a Shift Supervisor must: (1) pass a medical examination every two years and (2) pass operating, written, and oral exams every year on administrative guidelines and emergency procedures, and every two years in all other areas required for initial qualification. The operating examination for maintenance of qualification of a Shift Supervisor consists of either serving as an acting Shift Supervisor for a least eight working days per calendar quarter since the previous year, or serving a one-month trial period as an acting Shift Supervisor under the guidance of a Shift Supervisor. The oral exam for maintenance of qualification of a Shift Supervisor is given by one or more of the following persons: Operations Manager, Assistant Operations Manager, Operations Physicist, or Operations Staff Specialist. The results of the oral examination are recorded on the oral section of an examination record. The written examination for maintenance of qualification of a Shift Supervisor is given by the Training Supervisor or an alternate. A grade of 80% on each section of the written examination is required.

Failure of any one of the above exams causes an immediate loss of qualification as a Shift Supervisor. To requalify after a failure, the candidate must follow the recommendations of the Operations Manager for retraining and must pass the exam that was previously failed.

MAINTENANCE

Training of maintenance personnel consists of three levels of qualification in three different categories. The three categories are: Mechanical Maintenance, Instrument and Control Maintenance, and Electrical Maintenance.

The Mechanical Maintenance is further divided into the reactor-building area and power-plant areas. A Mechanical Technician may be qualified for maintenance work in only the power plant or the reactor building, or he may be qualified for work in both areas. The areas of qualification for Instrument and Control Technicians are reactor instruments, fuel-handling-system instruments, radiation-monitoring instruments, power-plant instruments, interlocks, and instrument power and distribution systems. The area of qualification for an Electrical Maintenance Technician is the EBR-II electrical systems.

The three levels of qualification in each of the three maintenance categories are: Level I, Basic Skills; Level II, Systems Training; and Level III, Supervisory Training.

Level I

All Maintenance Technicians are required to qualify in basic skills (Attachment 10). However, the Maintenance Supervisor may decide not to require a specific section of Level I training for maintenance personnel who have much experience in that area of qualification.

A Technician gains area qualification by giving his qualification cards, containing the required signatures, to his Supervisor. The Supervisor, on his judgment, recommends the individual to the Training Supervisor for area qualification. The Training Supervisor or an alternate gives a final written exam covering the total qualification area. If the trainee passes the written exam, the Training Supervisor recommends certification to the Manager, Critical Systems Maintenance, who will, on his judgment, certify the Technician.

Upon the recommendation of the responsible Maintenance Supervisor, the Manager, Critical Systems Maintenance, may certify a Maintenance Technician for maintenance jobs within a specific area of qualification, if the Technician has passed an appropriate examination and has shown ability in those specific jobs, as shown by his qualification cards.

For certification, the trainee must have responsibility, maturity of judgment, and the proper attitude toward plant and personnel safety. He must also have the job experience necessary to safely and efficiently carry out his duties.

Level II

Upon completion of qualification in Level I, the Technician is assigned a specific area of qualification in Level II training (Attachment 11). Qualification procedures for Level II are the same as those for Level I.

Level III

Qualification in Level III (Attachment 12) is required only for personnel serving as foremen or supervisors. Again, the procedures for qualification are the same as those for Levels I and II.

Retraining

Responsibility for retraining is shared by the individual Technicians, the Maintenance Supervisor, and the Training Group. Each Technician must maintain his knowledge of procedures, plant conditions, and plant modifications by his own effort and study. The Maintenance Supervisor must, in turn, provide time for the retraining and make sure that the retraining is done. Part of the retraining may be done as a group effort if time and conditions permit. The Training Group provides up-to-date training material for retraining.

To maintain certification in an area, the Technician must:

(1) Show his Supervisor that qualification is being kept up to date by on the job performance and by any other methods that his Supervisor may require.

(2) Go through training every year in emergency procedures.

(3) Pass a written examination on any major plant modifications or changes in the area of qualification.

(4) Pass an oral and/or written reexamination every two years on all subjects covered by the initial certification.

Failure to meet any of the above requirements results in immediate loss of certification. A Technician who loses his certification will be considered a trainee in that area until he has become recertified.

A technician is automatically recertified when he shows that he has maintained his qualified status and passes the required oral and/or written reexamination.

TRAINING OF CHEMISTRY TECHNICIAN

The training for Plant Chemistry Technicians consists of a self-teaching study program with two areas of qualification: sodium chemistry and water chemistry. The study program for the two areas is divided into four sections: general information on water chemistry, water systems, general information on sodium chemistry, and sodium systems. A new employee must complete the general sections before qualifying in the water or sodium areas, and he usually qualifies in the water area before the sodium area.

After orientation as a new employee, the trainee is assigned to day shift and completes the general-information section on water chemistry. Next, he is assigned to rotating shift as a water-chemistry trainee under the guidance of a qualified chemistry technician, who supervises the trainee's on-the-job training. A self-teaching manual directs the trainee through the program by listing the appropriate study materials, objectives, and examinations. The trainee becomes qualified by completing several operating and written examinations and a final oral exam. After qualifying as a water-chemistry technician, the trainee begins study in the sodium-chemistry area, starting with the general-information section and continuing as in the water-chemistry area.

A technician maintains qualification in an area by passing oral, operating, and written exams every year for emergency procedures and situations, health and safety, criticality, safeguards, and radiation safety. He must pass reexaminations on the systems every two years.

The EBR-II Training Department oversees and reviews study materials and examinations given to the chemistry technicians. However, the progress of the trainee is the responsibility of the Chemistry Technician Training Coordinator. The coordinator is responsible for giving training materials to trainees, giving written and operating exams, and recording the process of trainees. The coordinator is a staff member of the Plant Chemistry Group, and in the job of Coordinator, reports to the Training Supervisor and Assistant Operations Manager.

General-Information Study Section

The general-information study section (Attachment 13) is contained in Volume I of the Plant Chemistry Technician Training Manual and consists of the following topics (those with asterisks are for the sodium chemistry area):

1. General chemistry and physics
2. Chemistry of water
3. Chemistry of sodium*
4. Chemical safety
5. Emergency procedures
6. Water systems
7. Sodium systems*
8. Technical specifications.

Each of the topics is completed by written examination. The sections on water systems and sodium systems also require an oral exam by a Shift Supervisor.

Water-chemistry Study Section

After completing the appropriate sections of Volume I of the Plant Chemistry Technician Manual, the trainee receives Volume II - Sodium and Water Systems and is put on rotating shift with a Plant Chemistry Technician qualified in both sodium and water chemistry. The trainee begins self-teaching study and on-the-job training in water chemistry.

Water chemistry is divided into five sections (Attachment 14): (1) zero solids water treatment, (2) cooling tower water treatment, (3) water sampling and analysis, (4) on-line monitors, and (5) cathodic protection. The training material for each section consists of self-teaching multimedia lessons similar to those for general information.

The trainee must pass at least one written and two operating exams for each topic. The written exam covers theory and is given by the Training Coordinator. One of the operating exams covers normal operations and procedures and may be given by a staff member of the Plant Chemistry Group or by the the Plant Chemistry Foreman. The other operating exam includes emergency and off-normal operations and procedures and must be given by a Shift Supervisor.

After a trainee has completed all written and operating examinations for a topic, he may do routine work on the systems within the topic but may not work on emergency and safety systems.

After the trainee has passed all operating and written exams for all of the topics within the water-chemistry section, he must take a final oral exam. The oral board consists of the Training Supervisor and at least two other members selected from the following: a Shift Supervisor, a staff member of the Plant Chemistry Group, or an Operations Staff specialist. The Training Coordinator and Supervisor from the trainee's crew may not participate on the oral board. The oral is recorded by use of a checklist that has a list of necessary areas of knowledge and a space for recording the trainee's score in each area as outstanding, satisfactory, or failing. The actual questions asked are recorded.

If the trainee passes the oral exaimination, the Training Supervisor checks that all qualification requirements are complete and recommends by letter to the Manager, Plant Operations, that the trainee be certified. If the Manager, Plant Operations, agrees, the trainee is recommended to the Associate Director, EBR-II operations, for certification. The recommendations are done by a single letter on which approval is shown by signature. After signature, the letter is filed in the trainee's training file and the technician is a certified Water Chemistry Technician.

Sodium-chemistry Study Section

The technician now becomes a sodium-chemistry trainee and begins on-the-job training and self-teaching study in sodium chemistry in a program similar to the one for water chemistry. The Sodium Chemistry Manual is divided into four topics (Attachment 15): primary sodium, primary cover gas, secondary sodium, and secondary cover gas. All study materials for this section are produced by the EBR-II Project and consist primarily of the EBR-II Operating Instructions and the EBR-II Operator Training Manual.

The examination procedures for sodium-chemistry qualification are the same as those for water-chemistry qualification. After completing both areas of qualification, the technician receives the title of Plant Chemistry Technician.

Maintenance of Qaulification

Qualification in each area is maintained by passing oral, operating, and written exams every year for emergency procedures and systems, and every two years for systems and normal operating procedures.

TRAINING FOR FUEL MANUFACTURING FACILITY

Four types of personnel are trained for the Fuel Manufacturing Facility (FMF): Fuel Handlers, Equipment Operators, Responsible Individuals, and Operational Supervisors. All of these are required to complete the Fuel Handler training before training in any other area.

Fuel Handler Training

The training for Fuel Handler familiarizes the trainee with the overall manufacturing operation and teaches him fuel-handling procedures, with emphasis on criticality hazards control, safeguards, personal safety, and emergency procedures. The formal course includes lectures, tours, videotapes, written study material, and testing.

The trainee is given a study outline which lists the material that must be studied, lectures that must be attended, on-the-job training that must be completed, and exams that must be taken. Seven study booklets are given to each trainee: An Introduction to EBR-II, health and safety, emergencies, safe by shape, zones, basic design, and safeguards.

A "Fuel Handler Training Card" is used to record the completion of each training area. Four written exams, an operating checkout, and one oral exam are required for qualification.

Equipment Operator Training

The training for operators teaches the trainee the proper operation of equipment in his area of qualification. The training includes both theory and on-the-job training, with emphasis on criticality control, equipment description, startup procedures, normal operations, shutdown procedures, emergency procedures, hazards, and maintenance.

The areas of qualification are: glovebox operation, bonding, bond testing, preassembly construction, Chemetron welding, subassembly construction, miller welding, temperature-equilibration-device (TED) capsule welding, TED final-closure welding, and TED capsule fabrication. Each of the operating areas has a training booklet and a study outline. The booklet covers equipment design, operations, and emergency operation. The study outline lists the materials, on-the-job training, and tests that must be completed and contains self-teaching study questions. The trainee is also required to sutdy the FMF Operations Manual, review several Fuel Handler booklets, and study a booklet titled Hazards that describes nuclear and other hazards of each operation.

An "Operator Training Card" is used for each area to record the progress of the trainee. The "theory" part of the card contains four topics - equipment, normal operations, emergency procedures, and criticality - and is signed by the Training Supervisor when the trainee completes the final written exam for the area. The "experience" part of the care contains four topics - startup procedures, normal operations, shutdown procedures, and maintenance - and is signed by an Operational Supervisor when the trainee completes a final operating exam for the area.

Responsible Individual Training

The training for Responsible Individual makes sure that the trainee knows the safeguards and criticality hazards control documents for the FMF and that he is able to keep accurate transfer records. The program topics are: fuel-handling equipment, nuclear hazards, disposal of radioactive material, transfer calcualations and records keeping, zone rules, and the ciriticality-hazards-control statement.

An oral exam and three written exams are required for qualification. A "Responsible Individual Training Card" is used to record the completion of each training area.

Operational Supervisor Training

The training for Operational Supervisor makes sure that the Supervisor has a good knowledge of both equipment safety and nuclear safety. The training also makes sure that the Supervisor knows the general safety practices and hazards for all FMF operations.

The trainee receives a study outline, a copy of the FMF Operations Manual, a copy of the operator study booklets for the areas he will supervise, a self-teaching book covering nuclear and radiation theory, a copy of the zone rules (Fuel Handler "Zones" booklet), and a copy of the Hazards booklet.

The topics in this program are: operations, radiation and contamination hazards, equipment safety hazards, procedures, and health and safety. An "Operational Supervisor Training Card" is used to record the completion of training requirements for each area. An oral exam and three written exams are required for qualification.

Qualifications

After a trainee completes the qualification requirements for an FMF training program, a qualification record is signed by the oral-board examiners. All written exams for all areas of training are given by the EBR-II Training Group; examination grades of 80% or better are acceptable. Oral-board exams are given by the FMF Group. All records are kept by the EBR-II Training Group, including qualification cards, attendance records, examinations, and operator-qualification records.

Refresher Training

Annual refresher training for the FMF is required in the following areas: criticality hazards control, emergency procedures, fire-fighting instructions, use of emergency equipment, emergency exercises, safeguards, and first aid. The criticality-hazards-control, emergency-procedures, and safeguards areas are reviewed by lecture or booklet and examination. The fire-fighting-instruction and emergency-equipment areas are reviewed by demonstration and practice. The emergency exercises consist of evacuation drills and a discussion (with a walk through the plant) of all emergency alarms. The first-aid refresher includes a film and practice. Records are kept of completion of each refresher area by means of a "Refresher Training Log."

Refresher training in all other areas is done every two years or sooner if needed. In general, the refresher training consists of lectures and of oral examinations in the facility. Records of attendance are kept along with all examination records.

MISCELLANEOUS TRAINING - EBR-II PROJECT

Special Courses for Operators

Often the Training Group is required to give special training for Plant Operations because of changes in Operating Instructions, modifications to the plant, or hiring of large numbers of new personnel. The most common and convenient type of special-training session is the on-crew seminar. Either a member of the Training Group or an engineer speaks to each crew during the crew's regular shift. The on-crew seminar is most effective for training in small plant modifications and changes to the Operating Instructions.

Large modification to the plant may greatly affect the Operating Instructions, emergency procedures, etc., and more extensive training is required. The methods used to familiarize operating personnel with the changes include lectures, demonstrations, video-tapes and training bulletins. Generally, written exams are given to find out whether the operating personnel fully understand the effect of the modification on plant operation. Usually the training program is given by specialists from both the Training Group and the Operations staff. Sometimes, for extensive experiments sponsored by other companies, specialists from the staff of the sponsoring company help in giving lectures, preparing video-tapes, and preparing training information.

When many operator trainees are hired within a short time, special courses on the EBR-II systems may be taught to speed up the trainees' qualifications in the coolant and reactor areas. The courses are a combination of detailed classroom lectures and tours of the plant, with several examinations. The Training Group schedules and coordinates the courses; however additional instructors are provided by other EBR-II Project groups, especially the Procedures Group.

Training for Crane and Forklift

All personnel who operate cranes and forklifts must be trained and licensed. The EBR-II Training Group provides this training and licensing for EBR-II Project personnel.

Refresher Training for Emergency Activities, etc.

The Training Group is required to provide emergency training for anyone who has reason to enter the EBR-II reactor building. The emergency training includes but is not limited to the following:

1. A lecture and demonstration on reactor-building and sodium-boiler emergencies - a yearly requirement involving about 400 people.

2. Radiation monitoring - a yearly refresher course on radiation problems, the use of protective clothing, the use of survey instruments, etc.

3. Scott Air Paks - a refresher course in the use of Scott Air Paks, given every year to the operating crews and to others who may use such equipment.

4. Fire extinguishers - a yearly demonstration of the use of fire extinguishers for the operating crews, maintenance workers, and other groups.

5. Training in facility emergency activities - a yearly practice evacuation and demonstration of EBR-II emergency procedures to all EBR-II Project personnel. Part of this training is usually given by video-tape along with item 1 above.

6. Emergency-plan review and practice - a yearly requirement for the EBR-II operating personnel who serve as the emergency team for the ANL-W Site during night shifts and weekends.

7. Annual review of the criticality-hazards-control and safeguards documents - a yearly requirement for all persons who work with fissile material at EBR-II.

Plutonium Safety Training

All persons without escorts who must enter the Hot Fuel Examination Facility at ANL-W must complete a plutonium safety course. The course is not now required for entry into the EBR-II reactor building, but all EBR-II personnel are encouraged to complete the training.

The purpose of the course is to teach personnel the hazards of plutonium and to make sure that all personnel know the required actions in case of plutonium contamination. The Training Group gives the course for EBR-II Project personnel.

The course is divided into four areas - general physics, plutonium properties and concerns, instrumentation, and contamination control -- and requires six exams for certification. Certification is maintained by refresher training every year and by a requalification exam every two years.

Orientation of New Employees

Orientation of new employees is a one-week program of self-teaching study consisting of the following sections:

1. Overall plant
2. EBR-II orientation
3. Emergency procedures
4. Training materials and operating procedures

5. Sodium - NaK technology
6. Administrative procedures
7. Criticality hazards control
8. Fire extinguishers and and Scott Air Pak
9. Plutonium safety
10. First aid
11. ANL-W health and safety.

Each trainee completes this orientation before begining qualification in any of the EBR-II Project training programs. The purpose of the program is to give the trainee an overview of the EBR-II Project and plant and warn him of plant emergency procedures and hazards.

The material is presented by videotape, tours, and study booklets. Written exams must be completed for Sections 1, 5, 7, 9, and 11.

Training for Fissile Fuel Handler

Persons who handle fuel subassemblies must know about criticality hazards and must know and follow the criticality and safeguards rules for the area they are working in. Several nonoperating personnel are normally used to transfer fueled subassemblies between the fuel-storage vault and the EBR-II reactor building. These personnel are given a basic course in criticality hazards, and are taught the rules given in the EBR-II Criticality Hazards Control Statement and safeguards documents. Certification requires passing a written exam. Each year all fuel handlers must review the criticality hazards and safeguards and must pass a written exam.

MISCELLANEOUS TRAINING FOR PERSONS NOT IN EBR-II PROJECT

EBR-II Engineering Institute

For the past three summers, graduate students throughout the United States have been offered the opportunity to enter a 12-week program that is designed to familiarize university students with the national Breeder Reactor Program and an operating liquid-metal fast breeder reactor. The program is divided into two main parts: a two-week period of formal classroom instruction and a 10-week period of on-site job assignments under the supervision of experienced scientific and engineering personnel.

During the classroom part of the program, the students are informed of the importance of breeder reactors in solving the coming energy crisis, the national Breeder Reactor Program as it exists today, and the operation of EBR-II, the nation's only operating liquid-metal fast breeder reactor.

Of the 60 hours of formal classroom instruction, 40 are spent in orientation studies and discussions of EBR-II operations. The remaining 20 hours are spent in lectures by specialists assigned to other ANL-W projects, such as the TREAT and ZPPR reactors.

Work assignments under the supervision of experienced engineers and scientists begin when the students arrive. The students are scheduled to go to morning classes and spend the rest of the day in work assignments.

This progam has two purposes. First, it gives the students a much better understanding of what is expected from professional engineers and scientists. Second, it gives Argonne personnel the opportunity to describe the purpose of breeder reactors to people who one day may have important responsibilities in our national energy program.

Training Program for Operators of the Fast Flux Test Facility (FFTF)

The purpose of the FFTF Operator Training Program, begun in 1974, is to train future FFTF operators and supervisory personnel in the operation of a liquid-metal fast breeder reactor.

The first part of the training consists of four weeks of formal classroom instuction. This instruction is designed to add to earlier training at FFTF and to familiarize the trainees with the design and operation of the EBR-II plant. As part of this instruction, all trainees must do a hands-on startup of the Argonne Fast Source Reactor and must help in prestartup work at EBR-II.

During the on-the-job part of the training, each trainee is assigned to one of the four operating crews and given hands-on experience in the operation of plant systems and components. Each trainee is required to help in at least one startup of the EBR-II plant. After completing two months of on-the-job training, each trainee is given final written and oral exams. The results of the exams are sent to FFTF management for evaluation.

Assistance in Videotape Production for Other Groups

Videotapes are often used as study aids for operating personnel. During the past few years, Training personnel have produced many videotapes for other groups.

ANL-W Nuclear Fundamentals

To qualify as a reactor operator, a trainee must gain a general understanding of reactor physics. Lesson plans and study aids are provided by Training Group personnel, who give an informal program. Personnel from outside the EBR-II Project are encouraged to enter the program.

Work in Public Affairs, Tours, and Seminars

Because the Training Group has many training materials and has a highly trained staff, members of the Group have accepted many invitations from schools and other organizations to speak at assemblies and seminars.

Personnel from the Training Group are normally used to guide visitors through the EBR-II plant. Other duties of this type include the presentation of one-day and half-day seminars on fast-breeder-reactor technology to groups such as college engineering classes and technical societies.

STAFFING

Operations and Maintenance Staffing

The EBR-II Plant Operations Section has four operating crews, each crew consisting of 10 operators, a foreman, a chemistry technician, an alternate shift supervisor, and a shift supervisor. The Critical Systems Maintenance Department has 16 mechanical maintenance technicians and 20 instrument and control technicians. Two instrument and control technicians are assigned to each operating crew.

The operation and maintenance of EBR-II requires highly skilled persons, who together have knowledge of engineering, physics, mathematics, and chemistry. Unfortunately, there is no single source from which experienced technicians can be recruited. Excellent junior colleges and two-year vocational schools exist, but even these can do no more than teach their students the basics of mathematics, chemistry, physics, and engineering. Such schools can only provide basic knowledge, to which on-the-job training must be added.

Another excellent source of technicians is persons who have been in the nuclear branch of the U. S. Navy. In addition to their excellent Navy training and experience, these persons usually need about two years of on-the-job training to become a fully qualified EBR-II technician or operator.

A third important source of technician talent is the local secondary schools. Our experience has shown that intelligent, imaginative, and creative high-school graduates can, through on-site and on-the-job training, become fully qualified technicians and operators.

Although there are three different sources of trainees each with advantages and disadvantages, all trainees for operating and maintenance jobs, whatever their background, must receive on-site and on-the-job training as requirements for qualification. The policy of the EBR-II Project is to select trainees of high quality and put them through a full on-the-job training program.

Table I is a statistical listing of the backgrounds of the present EBR-II operating and maintenance personnel. New employees with previous nuclear experience, such as ex-Naval nuclear power plant operators, have an important advantage in both the operator and maintenance training programs. Usually 2-1/2 to 3 years are needed to train a new operator in all five qualification areas; however, if the new operator has past nuclear experience, he may complete his qualification in as little as 1-1/2 to 2 years. Maintenance personnel with previous nuclear experience may qualify in about one-third the time required for a new employee with no experience.

TABLE I

Personnel Experience

	Technical School or College Degree	Previous Nuclear Exp.	High School Only
EBR-II Operators and Foreman	11.5%	84%	4.5%
Supervisors	12.5%	75%	12.5%
Maintenance	62%	35%	3%
Maintenance Supervisors	43%	57%	0%

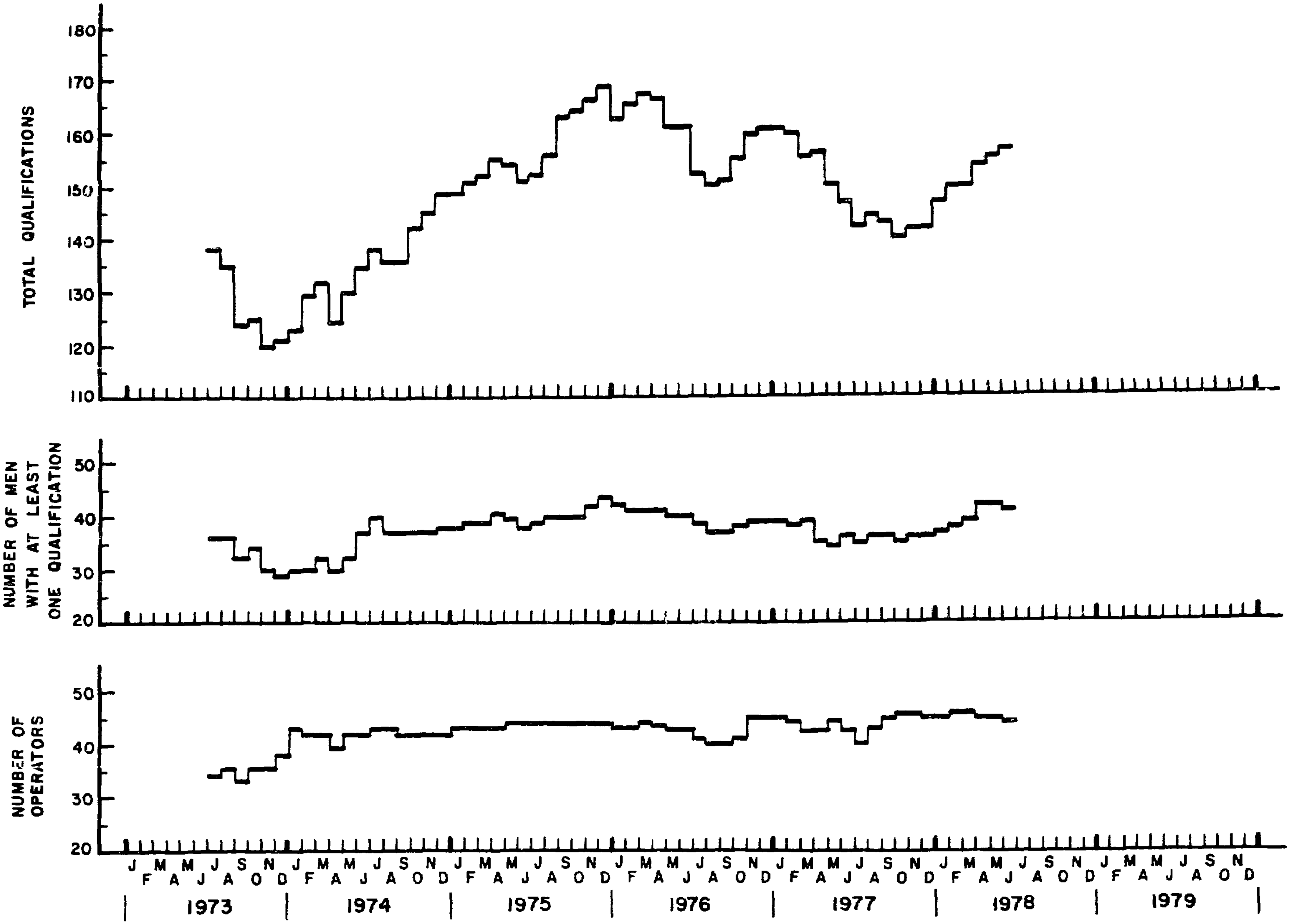
The need for training and qualification is continuous because of the loss of qualified personnel through promotion, reassignment, and leaving Argonne. At present 20 operator trainees are working toward qualification in at least one area. Twenty-four operators (including the crew foremen) are qualified in all five areas. Figure 1 is a graph of the total operator qualifications for the period from January 1973 to July 1978.

The Mechanical Maintenance Group now has 26 qualifications among 15 technicians. The Instrumentation and Control Group has 50 qualifications among 20 technicians.

Staffing of Training Group

The Training Group now has five employees. Of these, one, the Training Supervisor, is at staff level; two are at salary level, and two are at hourly-pay level. The Training Supervisor holds a masters degree in chemistry and had two years teaching experience before joining the Training Group. The present Training Supervisor has been with EBR-II Training for five years. The two salary-level positions are now filled by a fully qualified EBR-II operator and a qualified Instrumentation and Control technician. Each has about 15 years experience in nuclear power plants. One of the hourly-level positions is filled by a specialist in maintenance of audiovisual equipment, and the other is a secretarial position.

The Training Group has decreased in number from the nine members of three years ago. The decrease is primarily due to (1) a transfer of responsibility for operator on-crew training from Training Group members to the Alternate Shift Supervisors, (2) production of fewer videotapes, (3) fewer trainees from FFTF, (4) less training for FMF, and (5) improvement of methods and procedures within the Training Group by consolidation of reports and form letters, modification of the filing system, and revision of some training programs to require less help from the Training Group.



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QUALIFICATION STATUS OF EBR-II OPERATORS (INCLUDING FOREMEN)

Table II is a statistical listing of training activities as they existed in July 1975 and as they exist now in July 1978. EBR-II Operator Training now requires about 40% of the total time of the Training Group.

TABLE II

Training-group Activity in Man-years per Year

	Activity	July 1975	July 1978
1.	Administrative	1.00	0.90
2.	On-shift Training for Operators	1.00	0.02
3.	Special Courses for Operators	0.55	0.25
4.	Orientation of EBR-II New Employees	0.10	0.10
5.	Training of Plant Chemistry Technicians	0.15	0.04
6.	Training in Mechanical Maintenance	0.50	0.50
7.	Training in Instrumentation and Control Maintenance	0.50	0.50
8.	Training for Fissile Fuel Handler	0.05	0.01
9.	Training for Fuel Manufacturing Facility	0.50	0.03
10.	Preparation of Training Materials	1.00	0.80
11.	Preparation of Audiovisual Materials for EBR-II Project - related	1.60	0.80
12.	Preparation of Audio Visual Materials for Groups Outside EBR-II Project	0.25	0.20
13.	Training for Crane and Forklift Operators	0.10	.02
14.	Emergency Activity, Criticality Hazards Conrol, Plutonium, and Safeguards Training	0.35	0.18
15.	FFTF Training	0.80	0.02
16.	Engineering Institute	0.30	0.10
17.	Participaton in Public Affairs, Tours, and Seminars	0.15	0.07
18.	Safety Document Repository	0.10	0
19.	EBR-II Project Health and Safety Program	0	0.08
20.	ANL-W Nuclear Fundamentals	0	0.02
21.	Preparation of Unusual-occurrence Reports	0	0.24
22.	Management Training		
	Totals	9.00	5.00

RETENTION OF RECORDS

All training, qualification, and certification of EBR-II personnel is recorded in documents that are readily available for internal and external audits. The Training Supervisor is the person responsible for retention of records. As a minimum, each training file must contain the following documents: health certificate; summary of educational activities; summary of job-related experience; record of completed training activities; completed written exams; records of oral and operational exams; and records of initial certification and later recertification with dates and necessary approval signatures. The records for oral and operating exams must include (1) a summary of each area or type of work covered in the exam, (2) an evaluation of the trainee's answers, especially if the answers show areas of weakness in the trainee's ability, and (3) a summary of the results of an oral exam, with an evaluation of the knowledge, ability, and performance of the trainee.

The following training records are kept in an active training file: (1) education, experience, employment, and health records, (2) copies of final written exams and results of final oral exams and final operating tests for area qualification and requalification, (3) records of initial certification and recertification, and (4) records of all training programs completed.

Training records other than those listed above may be moved to an accessible but inactive file. A list of records moved to the inactive file is kept in the person's active file. Records of employees who leave Argonne are kept in an inactive file or transferred to Document Storage after the person leaves. A form showing the records transferred to Document Storage must be kept in the active file. Training records for personnel no longer serving as operating personnel may be transferred to an inactive file or to Document Storage immediately. A complete lsiting of the location of all such records must be kept in an active file. Training records for operating personnel may not be destroyed without approval from the Office of the Director, EBR-II Project.

TECHNIQUES AND TRAINING AIDS

The training aids and audiovisual techniques available to the Training Group include filmstrips, 35mm slides, overhead transparencies, movie film, videotape, still photography, drawings, training manuals, and other written materials. Each of the techniques and aids is discussed below.

Filmstrips

Filmstrips are used in the Chemistry Technician training program for basic theory and analytical techniques. The filmstrip has three advantages: (1) the equipment is small, which makes it portable and especially suitable for study in the small chemistry laboratory; (2) the filmstrips are low in cost, and (3) filmstrips in chemistry are readily available, making a large library of specialized chemical and analytical techniques possible. Filmstrips are used only for concepts and techniques that are not likely to change, since in-house production is not possible and revision is difficult. Filmstrips have been well accepted by trainees.

35mm Slides

Slide programs are used for live lectures and for still pictures in the production of videotapes. Live lectures are presented during special training programs such as systems training for operator trainees or the Engineering Institute. A slide file of general subjects is also available so that special programs can be prepared. The slide file has been especially useful for presentations to the public.

Overhead Transparencies

Overhead transparencies are used for classroom lectures, on-crew lectures, and videotape production. Transparencies are not easily stored, so they are thrown away when not needed, and no prepared lecture sets are available.

The overhead transparency is the standard type of projected picture for on-crew lectures because of lighting and space limitations. The on-crew lectures are usually given in an area that is convenient for the operating crews, but is also small and not easily darkened. The overhead transparencies are generally well accepted, especially for on-crew lectures.

Super 8 and 16mm Film

Movie films are not very useful for systems training because they cannot be produced in-house; they require much space for projection, and they are difficult to revise. Many good films are available commercially for safety training and public education. The Training Department keeps a library of public-education films, generally about nuclear power, which are shown to groups of visitors and loaned to nonprofit organizations in the local community. A library of safety films that will be available to all ANL-W personnel is being gathered by the Training Department as part of the EBR-II Project Health and Safety Program.

Parts of films that were produced in-house were used for videotape production in the past; however, in-house filming has been almost eliminated since the purchase of a color portable videotape camera.

Videotape

Videotapes are a basic part of most of the EBR-II Project's self-teaching study programs, and they are also used to a lesser extent for on-crew seminars, classroom lecture series, public relations, special engineering applciations, and refresher training.

Most of the videotapes are produced in-house by Training Group personnel. The capabilities for in-house production have been improved: in 1969 the equipment consisted of a 1/2-inch videotape recorder with two black-and-white cameras; and today it consists of a complete color studio with two studio cameras, a portable color camera, 1/2-inch videotape recorders, film chain, audio console, character generator, special-effects generator, and mixers and processors.

Over 180 videotapes are now available. About 60% of these tapes show EBR-II systems and are available to all trainees at all times. The other 40% are either of historical value, were produced for special situations, or were produced for groups other than EBR-II.

The videotapes of EBR-II systems are available as optional additions to the training programs for operations and maintenance, and the titles of these tapes are listed in the study material for each of the programs. The major use is in the reactor and fuel-handling areas of qualification. The new-employee orientation, Plant Chemistry Technician, and Fuel Manufacturing Facility programs require viewing of several videotapes as part of the study material. The orientation program, for example, requires viewing of videotapes for emergency evacuation, sodium-NaK technology, and plutonium safety. The videotape on emergency evacuation teaches proper use of the reactor-building emergency airlock and the required action for all alarms in the EBR-II reactor building and sodium boiler building. After viewing the videotape, the trainee must be taken through the plant and must leave the reactor building through the emergency airlock. The videotape for sodium-Nak technology teaches the physical, nuclear, and chemical properties of sodium, and must be viewed before completion of a study booklet on the topic. The plutonium safety program contains three videotapes that are part of a programmed-learning section on nuclear physics and three videotapes that describe plutonium hazards in the plant.

Sometimes an instructor for a special training series combines a videotape or parts of a videotape with his lecture. This technique saves time for the instructor and will be more fully used in the future.

Videotape is an excellent method for giving personnel on rotating shifts information on maintenance work and other events that occur on shifts other than their own. The portable camera is available for on-location taping, so production of such videotapes is relatively easy.

Refresher training for plutonium, emergency action, etc., requires repeating information to several groups of personnel and is generally presented by videotape. The major problem with this type of training is that the trainees do not pay attention. Inclusion of an examination usually solves the problem.

Special applications of videotape are sometimes called for by plant engineering. For example, during 1971 the video equipment was used for remote inspection and repair of a plant heat exchanger. Modification and setup of the equipment for such applications is usually done by the Training Group.

The production format of the EBR-II videotapes varies according to time and availability of equipment. The easiest videotape to produce when saving time and equipment cost is the "big talking face," a lecturer at a blackboard. The most difficult and most time-consuming format is with the lecturer off-camera, since a formal script and many visual aids are needed. The visual aids may include slides, polarized transparencies, photographs, models, and in-plant action sequences recorded by a portable camera (either film or videotape). Animation by Super 8 camera has been tried, but the product did not justify the time spent.

Videotape as a training aid at EBR-II has met with mixed acceptance. Generally, the acceptance is high if the tape is a basic part of the training program, as in the orientation and plant-chemistry training, or if the tape explains a difficult topic well, for example, nuclear theory. Videotapes on topics that are covered better by other techniques are poorly accepted. The major thing to consider in the production of a successful videotape, therefore, is the topic. The videotape material must be directly on the topic, difficult to obtain elsewhere, and presented without waste of time. Format is of lesser importance. In general, the "big talking face" format is not as well accepted as a lecturer off-camera.

The major error made in the video program in the early years was to produce large numbers of videotapes of marginal quality and limited usefulness. A better system is to produce videotapes of high quality for specific uses within the training programs.

Still Photography, Drawings, and Models

Books of photographs of EBR-II systems are available to trainees. Of special interest are photographs taken in the plant during construction, which show components and structures that are now hidden from view.

The drawing file contains more than 400 drawings of system flowpaths, cutaway drawings of components, and diagrams of control circuits. The drawings are useful for classroom lectures, and also for pictures in training materials and the Operating Instructions.

Models available to trainees include surplus plant equipment and commercially produced scale models. The surplus equipment is cut away where possible and is often used by teachers during special lectures. The scale models are especially useful during orientation of new employees and for public tours and seminars.

Training Manuals and Other Written Material

The Training Manuals were prepared by the Training Group. The purpose was to gather all the important information from other documents so that a trainee would have only two types of documents to study for qualification: the Training Manuals and the Operating Instructions. As can be seen in Attachment 3, the Training Manuals contains most of the information an operator must learn for qualification.

The first manuals were written in the early 1960's, but no method for updating was provided. As a result the manuals became out of date and were seldom used. Recently the coolant manual was completely rewritten. The manuals for the other areas are now being updated. A list is kept of all people who have the manuals, and updated copies are sent to everyone on the list.

Since EBR-II had been operating for about 10 years before a method was developed for updating the Training Manuals, the value of the manuals has been limited. However, at a new plant, a manual of this type would be a valuable training aid.

The new Training Manuals divide each area into several topical sections. Each section, in turn, is divided into eight areas: introduction and description, major instrumentation and control, interconnections to other systems and power supplies, administrative requirements, summary of operations, references, qualification objectives, and self-check test questions.

"Introduction and description" tells the purpose of the system, gives a general description and flowpath, describes the components in detail, and tells the design basis.

"Major instrumentation and control" describes the instrumentation and alarms for the system, the control systems and interlocks, and the signals to or from plant safety systems.

"Interconnections of other systems and power supplies" lists the other systems needed to operate the system being described, tells why the system is needed, and lists the power supplies for all components.

"Administrative system requirements" describes the limiting conditions for plant operation and the surveillance requirements, and discusses the bases for these conditions and requirements.

"Summary of operation" gives a short description of system operations during startup, normal operation, and shutdown.

"References" lists the documents used in preparing the section.

"Qualification objectives" is a list of what the operator must know for a minimum level of qualification.

"Self-check test questions" contains questions for the trainee to answer to make sure that he has gained a basic knowledge of the system. Each question includes a page reference so the trainee can check his answer.

Other written materials available to the trainees are the EBR-II System Design Description and the EBR-II operating Instructions, which are routinely kept up to date.

CONCLUSION

The EBR-II training program has been and will continue to be an effective way for training operators, maintenance personnel, and supervisors for the EBR-II plant. The training programs as they now exist are expected to change very little as long as the mission of the EBR-II Project remains unchanged.

COOLANT OPERATOR QUALIFICATION CARD

Attachment 1

Name ______________________________

	Theory		Experience	
	Signature	Date	Signature	Date
C-1 EM Pumps and Flowmeters				
C-2 Containment Systems				
C-3 Air Heating, Cooling and Ventilation Systems				
C-4 Support and Miscellaneous Systems				
C-5 Primary Sodium Systems				
C-6 Secondary Sodium Systems				
C-7 Sodium Purification Systems				
C-8 Sodium Monitoring Systems				
C-9 Argon Gas Systems				
C-10 Argon Monitoring Systems				
C-11 Fission Product Monitoring Systems				
C-12 Cover Gas Cleanup System				
C-13 Facilities for Experiments, and Experiments				
C-14 Sodium Fire Protection Systems				
C-15 Overall Systems Operation				
Foreman				
Shift Supervisor				

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Attachment 2

EBR-II QUALIFICATION EXAMINATION

Lesson Plan C-5

PRIMARY SODIUM SYSTEMS

Name ______________________________ Crew ________________

has successfully demonstrated qualification level on this system, its components, and controls during an actual walk-through checkout.

______________________________ ____________________
Signature of Qualified Operator Date

__________ ______________________________
Grade Administrator

Reviewed:

____
Trainee

EBR-II QUALIFICATION EXAMINATION

PRIMARY SODIUM SYSTEMS

Lesson Plan C-5
Points - 36

Points

1 1. If the console operator were to continuously hold the Primary Coolant Pumps Speed Control switches in the raise position and the Upper Plenum Pressure Trip did not shutdown the pumps, what would happen to the speed of the pumps?

1 2. What is the total flow (in gpm) through the reactor at 100% flow?

1 3. What is the purpose of the auxiliary pump?

1 4. Why does indicated total flow through the reactor increase when the reactor vessel cover is raised?

3 5. Describe the flow path of primary coolant from the primary pumps to the outlet of the intermediate heat exchanger.

1 6. When can the two "Primary Pumps Excitation Emergency Stop" pushbuttons be used to shutdown the primary pumps?

Points	
2	7. There are __________ heaters in the primary tank and each contains ______________ heating elements.
2	8. Power input to the primary tank heaters may be controlled from the _______________ or behind _________________________ ________________.
2	9. Which primary tank heaters are limited to 84Kw and why?
1	10. How is a primary pump motor cooled?
1	11. If the coolant operator was in the control room, what indication would he observe if a primary-auxiliary-pump rectifier fan tripped?
1	12. Why is an argon atmosphere maintained in each primary tank heater housing?
2	13. What effect can the auxiliary pump have on the shutdown string?

Points

1 14. What causes NaK flow in the shutdown coolers?

1 15. From which panel can you read shutdown cooler temperatures?

1 16. How would you manually open the shutdown coolers?

1 17. Why is boron steel used around the Primary - Secondary Heat Exchanger?

1 18. What is the purpose of the shutdown collers?

1 19. __________________________________ are used to monitor temperature in the Primary System.

3 20. What is the approximate value of the following primary pump parameters at 100% flow?

a. RPM

b. kW

c. Discharge Pressure

<u>Points</u>

2 21. With the reactor at 62.5 MW, what is the procedure for adjusting primary coolant flow to 100%?

1 22. Can primary tank heater W-3 be deenergized separately without deenergizing the other primary tank heaters? If so, how?

2 23. How would you decrease the argon pressure in W-1 heater if it was reading 11 psig?

1 24. Why does the primary coolant total flow recorder on the graphic panel read lower at 62.5 MW than it does at 50 kW?
<u>NOTE</u>: With no flow adjustment made.

2 25. Sodium level in the primary tank is measured by a ____________________ ____ and ____.

Attachment 3

OTM / C-5B

EBR-II

SHUTDOWN COOLING SYSTEM

U of C-AUA-USAEC

EBR-II PROJECT
ARGONNE NATIONAL LABORATORY

OPERATOR TRAINING MANUAL

EBR-II TRAINING MANUAL

APPROVAL DATE ______________

TRAINING MANUAL REVISION NO. 113

TRAINING MANUAL SECTION C-5B

TITLE: SHUTDOWN COOLING SYSTEM

PREPARED BY J. P. Webb SECTION EBR-II Training/Procedures

H. E. McNeill EBR-II Training/Procedures

R E V I E W

Signature	Date	Signature	Date
	3/2/76		
	3/5/76		
	3-15-76		

A P P R O V A L

Title	Signature	Date
Manager, Training/Proceedures	RR Smith	3/2/76
Manager, Systems Engineering	H W Buschman	3/10/76
Manager, Plant Operations	RN Smith	3/26/76

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LIST OF ILLUSTRATIONS

SHUTDOWN COOLING SYSTEM

1. INTRODUCTION AND DESCRIPTION

1.1 General

The purpose of the Shutdown Cooling System is to remove decay heat from the reactor core after shutdown when normal cooling capabilities are not available.

In a nuclear reactor, the fission reaction is used to produce heat. This heat is mainly a result of the kinetic energy of the fission fragments. In addition to being born with high velocities, the fission "fragments" (also known as "daughters", "particles", or "products") are, for the most part, intensely radioactive. It is this radioactivity that causes the problem of "decay heat". Neutron activated reactor materials contribute a small amount to decay heat.

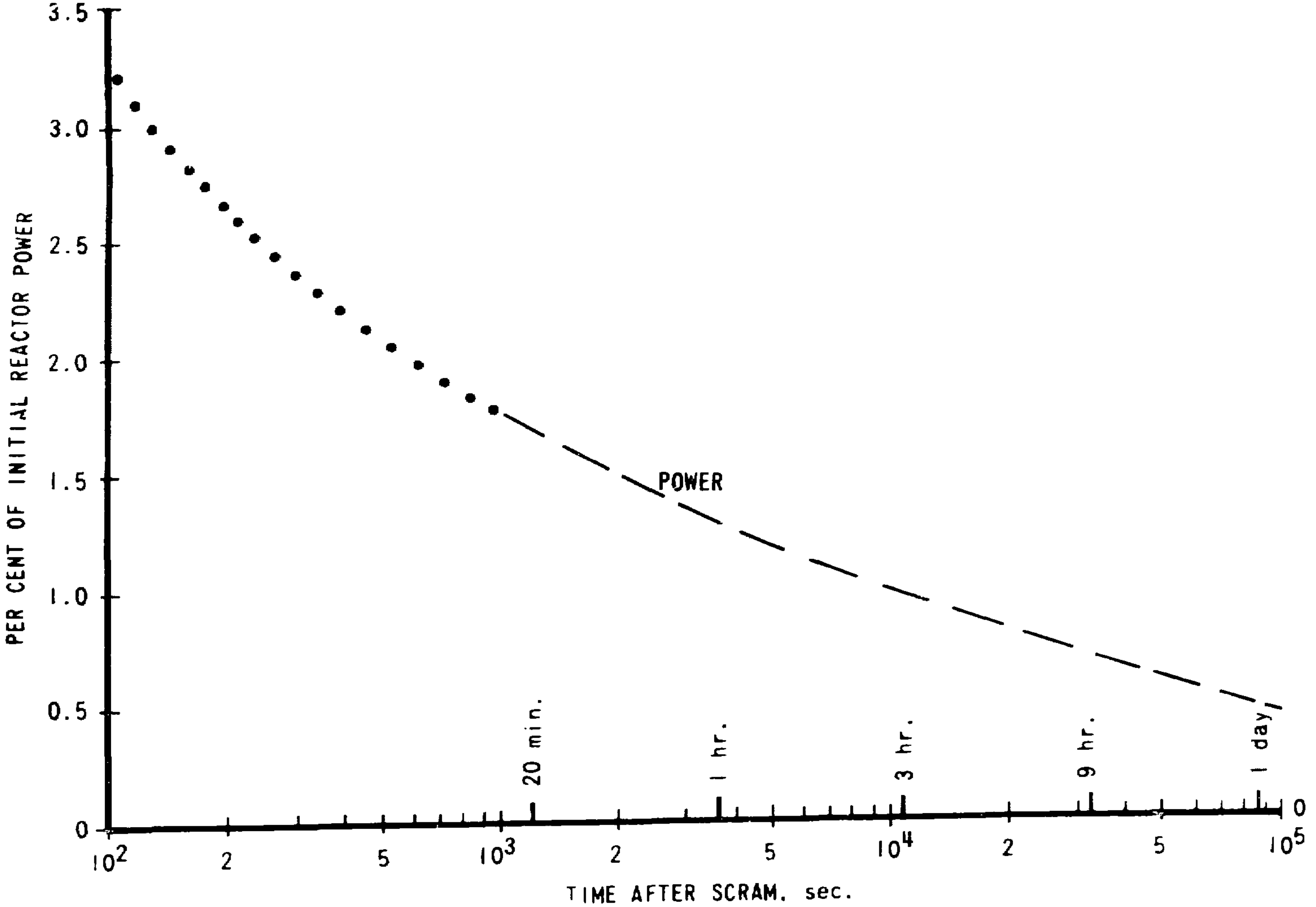
Decay heat results when the radioactive fission products decay to more stable states. These products decay in many ways, but mostly by beta-gamma emission. The beta radiation seldom escapes from the fuel region where it causes the greatest amount of heating. The gamma rays are very penetrating, and are the principal source of the high radiation levels outside the fuel region. Gamma radiation contributes to heating of not only the fuel materials, but to all components within the primary tank.

Decay heat production after shutdown will follow a general exponential decay scheme. Refer to Figure 1.1, Decay Heat Based on Initial Full Power Operation. Once the fuel has produced appreciable power in a reactor, it must thereafter be provided with cooling until the decay heat rate declines; otherwise the fuel material will melt.

Removal of fission product decay heat from the reactor after shutdown involves:

- Heat removal from the reactor by the sodium flowing through the reactor.
- Heat removal from the sodium.

After reactor shutdown, coolant flow through the reactor can be main-



T/P-C-10153-A

DECAY HEAT BASED ON INITIAL FULL POWER OPERATION

Figure 1.1

tained in any of the following ways:

Operation of the main primary coolant pumps.

Operation of the auxiliary pump.

Natural circulation flow.

Heat removal from the sodium leaving the reactor can be accomplished by three methods.

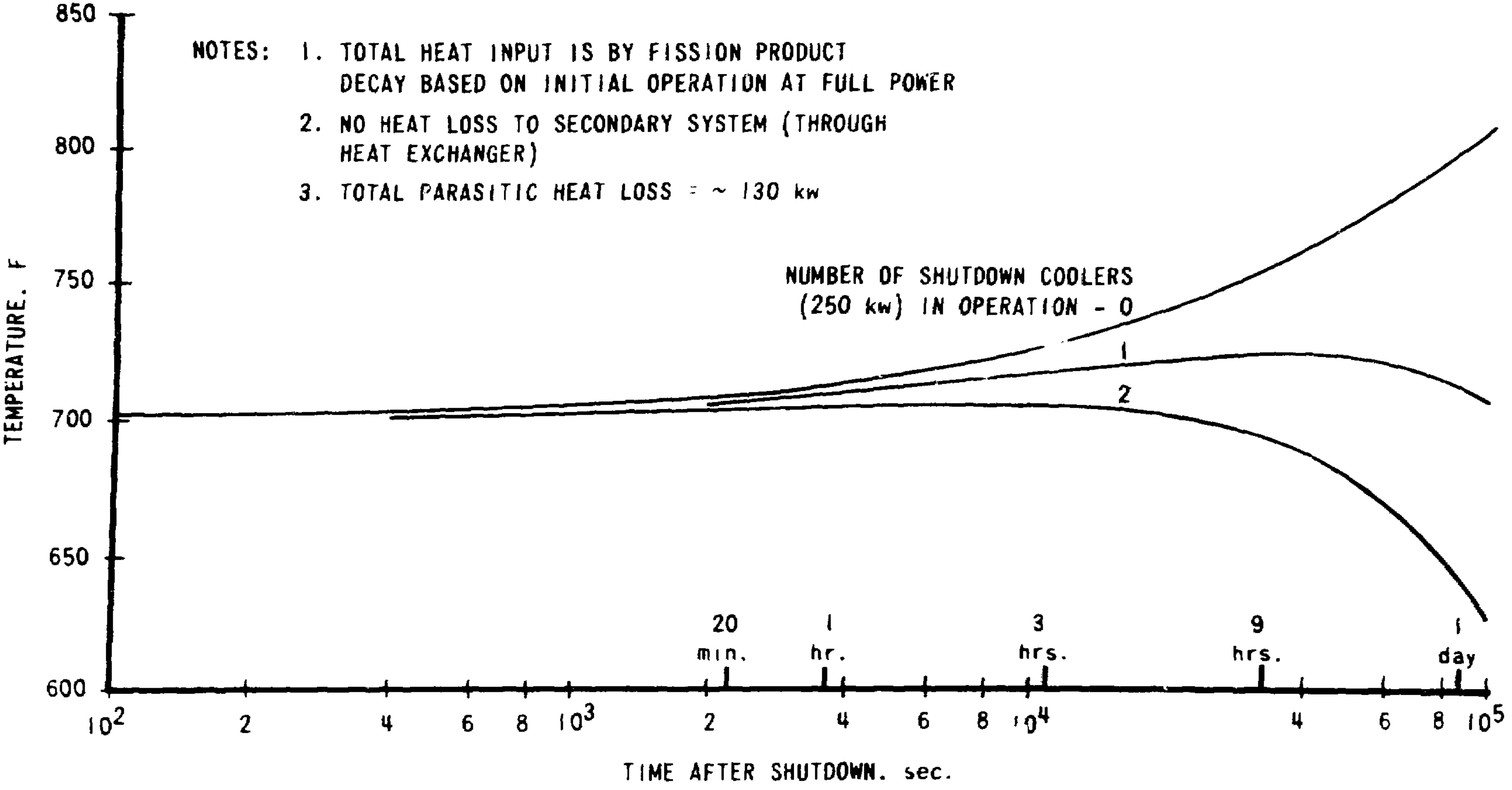
The heat can be transferred to the secondary sodium system.

The heat can be transferred to the bulk sodium and conducted through the primary tank wall to the shield cooling system.

The heat can be transferred to the bulk sodium, and then removed by the shutdown coolers, Figure 1.2.

With the reactor cover down, coolant flow through the reactor, by any of the three methods described above, follows the "normal circuit": through the heat-exchanger to bulk sodium. If the secondary sodium is operating, the heat is transferred in the heat exchanger to the steam system in the steam generator. The heat leaves the steam system via the condenser, and is transferred to the atomsphere through the main cooling tower.

If the secondary sodium system is partially or completely drained, the heat is transferred to the bulk sodium in the primary tank. The heat is then removed from the bulk sodium by the shutdown coolers which, in turn, transfer the heat to the atmosphere through a finned-tube air heat exchanger. Since the primary system has a very large thermal capacity (cometimes called thermal inertia) compared to the amount of fission product decay heat produced by the reactor, the temperature rise of the bulk sodium is slow, and high capacity shutdown coolers are not necessary. The bulk sodium can absorb decay heat in excess of shutdown cooler capacity until the decay heat production rate decreases to within shutdown cooling system capacity. This will not result in a bulk sodium temperature rise sufficient to cause damage to primary system components. The salient feature of this method of heat removal is the complete independence of any external power source. All fluid flow is due to natural circulation.


NOTES: 1. TOTAL HEAT INPUT IS BY FISSION PRODUCT DECAY BASED ON INITIAL OPERATION AT FULL POWER

2. NO HEAT LOSS TO SECONDARY SYSTEM (THROUGH HEAT EXCHANGER)

3. TOTAL PARASITIC HEAT LOSS = ~ 130 kw

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PRIMARY TANK BULK SODIUM TEMPERATURE VS TIME AFTER SHUTDOWN

1.2 System Description and Flowpath

The shutdown cooling system will remove approximately 60 KW_t (each loop) with the dampers closed and bulk sodium temperature at 700°F. The system will remove approximately 350 KW_t total with the dampers open (bulk sodium temperature $>710^{\circ}$F). The decay heat produced in the reactor, after shutdown, decreases continuously with time in a roughly exponential manner. For this reason, a nominal decay heat removal could not be selected as a reference in the design of the shutdown coolers. Instead, the total amount of decay heat produced in the reactor from shutdown to various times after shutdown was considered in the shutdown cooler design.

Two identical shutdown cooling loops are installed in EBR-II for removal of reactor decay heat. Figure 1.3 shows the arrangement of these loops. Each loop consists of the following major parts:

A bayonet-type heat exchanger immersed in the bulk sodium.
A box assembly containing a finned-tube, liquid-to-air heat exchanger and chimney, located outside the reactor building.
Associated piping to connect the two heat exchangers.
The working heat exchange fluid, NaK, which is the eutectic alloy of sodium and potassium (22% Na and 78% K).
Instrumentation and control equipment.

NaK was chosen as the working fluid in the shutdown coolers because of its good heat transfer characteristics and low freezing point ($\sim 9^{\circ}$F).

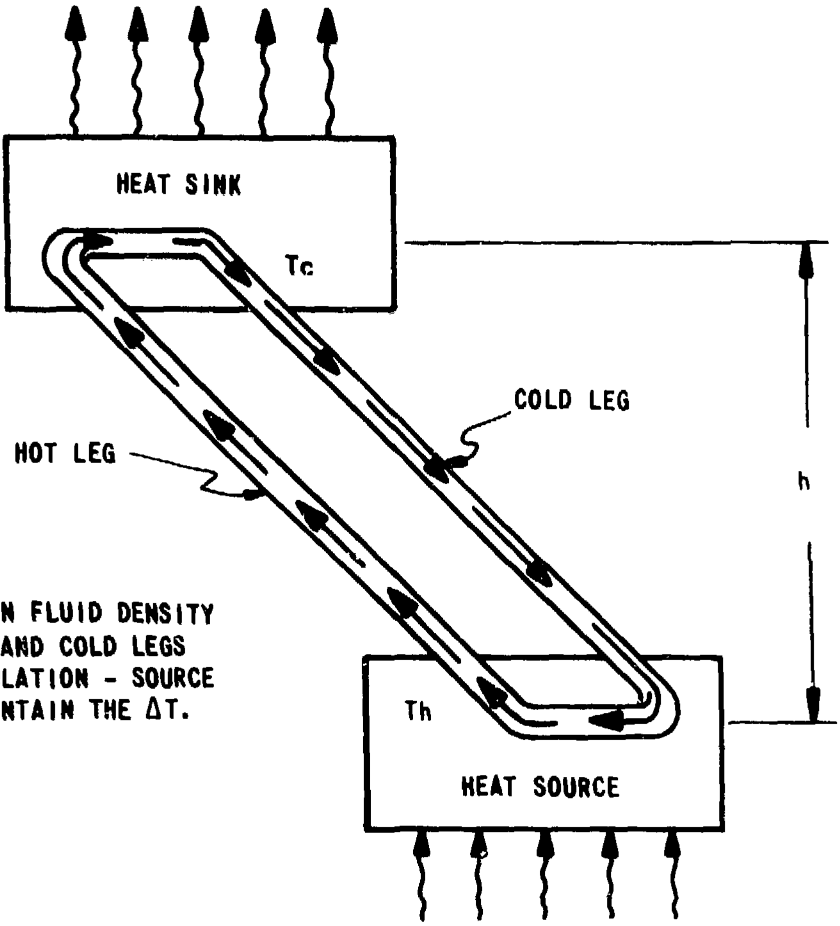
Natural circulation flow occurs between the bayonet heat exchanger and the finned-tube heat exchanger. This NaK flow varies from about 18 gpm when the reactor is operating and bulk sodium is at 700 F (louver dampers closed) to between 40 and 70 gpm when bulk sodium temperature increases to 710 F (louver dampers open), depending on the air temperature. The natural circulation flow of NaK in the closed loop is completely independent of any power source, and there is normally continuous flow through both shutdown coolers. A small surge tank, blanketed with argon gas and part of the box assembly, permits thermal expansion in the system. The transfer of decay heat from the NaK to atmosphere is accomplished by the natural convection of air past the finned-tube heat exchanger. The rate of air flow past this heat exchanger is controlled by dampers positioned above and below the heat-exchanger. The NaK cooling loop, external to the primary tank is instrumented with thermocouples, EM flow-meters, and local reading surge tank level probes.

Since the shutdown coolers rely upon "natural circultaion" for flow, let us review this concept. In a fluid system, natural circulation flow will occur anytime higher density fluid is located at a higher elevation than lower density fluid, if a flowpath is provided for the fluids. In a closed fluid system, if the fluid at the lower elevation is heated, it will tend to rise and flow will continue until all temperatures, at corresponding elevations, are equal. This is because the fluid will expand when heated, becoming less dense. If the fluid is cooled at some elevation above the heat source, it will become more dense and the natural circulation flow will continue as long as there is both a heat source and a heat sink.

The essential elements in a natural-circulation system are:

- A heat source.
- A heat sink.
- A difference in height between the source (lower) and the sink (higher).
- A fluid medium (with containment) joining the source and sink.

As can be seen in Figure 1.4, regarding flow restrictions and heat losses, higher natural circulation flows will re realized with larger temperature differences between hot and cold legs, and greater vertical separations between source and sink. Obviously, flow will be decreased by the normal hydraulic flow losses present in any fluid system, (minimized only by proper design and construction).



NOTE: DIFFERENCE IN FLUID DENSITY BETWEEN HOT AND COLD LEGS CAUSES CIRCULATION - SOURCE AND SINK MAINTAIN THE ΔT.

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$F = kh\Delta T$

WHERE F = FLOW RATE, IN gpm.

h = VERTICAL SEPARATION, IN FEET

$\Delta T = T_H - T_C$ = TEMPERATURE DIFFERENCE BETWEEN HOT AND COLD LEGS, IN F^0.

k = CONSTANT OF PROPORTIONALITY IN gpm/ft. - F^0

Figure 1.4
NATURAL CIRCULATION FLOW

In EBR-II, natural circulation flow in three separate fluid systems is used during the worst case of emergency cooling. These are:

> Primary coolant flow from the reactor (the heat source, located as low as possible in the primary tank) to the bulk sodium (the heat sink located at the discharge point of the Intermediate Heat Exchanger, as high as possible in the primary tank).
>
> The shutdown cooler loop NaK, flowing from the bayonet heat exchanger (the heat source, located as low as possible in the primary tank) and the finned-tube heat exchanger (the sink, located as high as practical above the primary tank).
>
> Atmospheric air, flowing around the finned-tube heat exchanger (the heat source, located at the base of the chimney) and up the chimney to the atmosphere (the heat sink at the top of the chimney).

Note that in the case of the primary coolant and the atmosphere, a "closed" loop , in the strictest sense, is not present. The heat sink, in each case, is a bulk of fluid that is not channeled or piped back to the source. In these fluids, convection mixing of the hot effluent with the bulk fluid occurs. Cooling of the bulk fluid is accomplished by some external means, and a continuous supply of the cooled bulk fluid is available at the inlet to the heat source.

The Shutdown Coolers utilize a true closed loop, with cold NaK being returned to the bayonet heat exchanger via a pipe.

1.3 Component Description

The major conponents in each shutdown cooling loop are:

- Shutdown cooler plug
- Shutdown cooler box assembly
- Connective piping.

1.3.1 Shutdown Cooler Plug

Sometimes called simply "the bayonet heat exchanger", each cooler plug is about 31 ft. long, and 2 ft. in diameter, and weighs close to 3 tons. Both cooler plugs are sealed to their respective primary tank cover nozzles by a flange welded to their outer shells. Each cooler plug can be separated into two functional parts: an upper shielding section, and a lower heat-exchanger section.

1.3.1.1 Shielding Section

This portion provides for the passage of inlet and outlet NaK piping while maintaining adequate biological shielding for personnel outside the primary tank. Thermal insulation is also provided. Figure 1.5 shows the arrangement of these shields.

1.3.1.2 Heat Exchanger Section

This section consits of two sets of concentric pipe assemblies that are attached to the bottom of the shielding section. The outer pair of pipes forms a thimble assembly. The inner pair of pipes serves to direct incoming NaK to the heat-transfer section.

The outer pipe pair forms an annulus whose lower portion is filled with "captive" NaK (not associated with the flowing NaK). The bottom 19 feet contain this captive NaK, the remaining length contains a partial vacuum. The captive layer provides thermal communication between the bulk sodium (outside the thimble) and the NaK flowing inside the thimble. The void space serves as both insulation and expansion space for the captive NaK. The double-walled thimble construction also serves to provide a second barrier between the bulk sodium and the NaK.

The inner pipe pair consists of a central pipe that contains the incoming (cooled) NaK, surrounded by a gas-filled insulating sleeve. This sleeve is sealed to

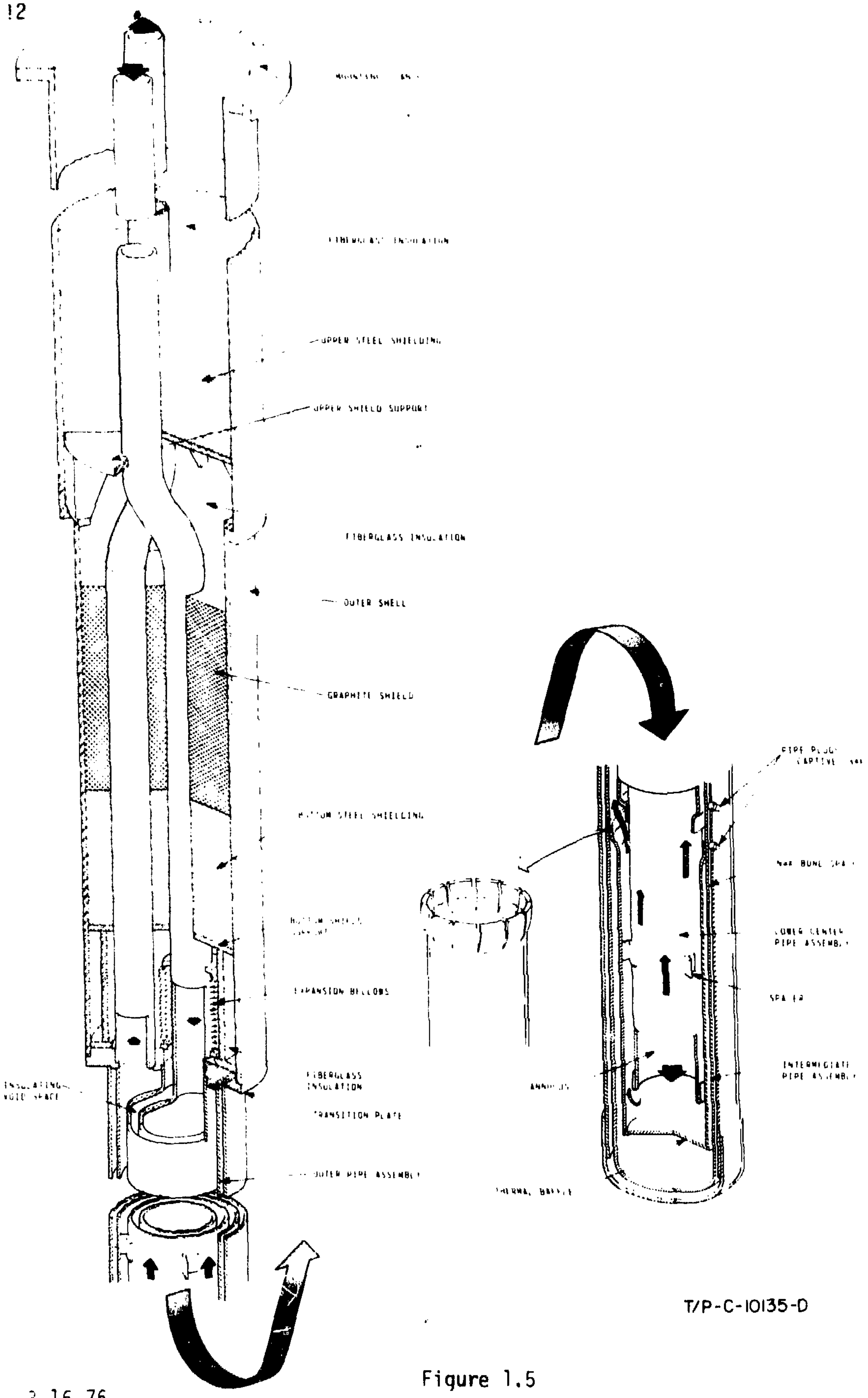

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Figure 1.5

[illegible]

the central pipe at the top (by a bellows) and about three feet from the bottom. The bellows allows for differential expansion between the two pipes. The insulating gas (air) inhibits heating of the cool NaK traveling downward in the central pipe, and thus enhances natural circulation of the NaK.

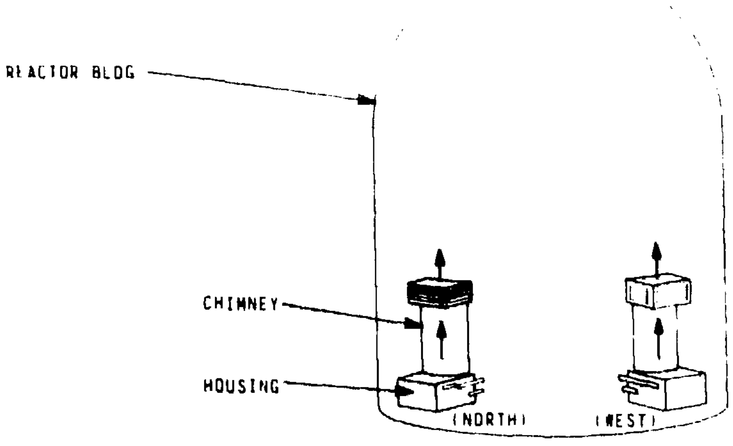
At the open end of the central pipe, NaK flow is reversed and travels upward between the center pipe pair and the outer pipe (or thimble) assembly. In this region (about three feet) heat transfer between the bulk sodium and the upward flowing NaK is permitted because the space between the lower thermal baffle and the outer pipe assembly is NaK filled. Above this region, the captive NaK in the thimble assembly provides maximum heat transfer.

To prevent undesirable thermal stresses when the cold down-flowing NaK enters the thermal-bonded region of the thimble, a thermal baffle is installed. This baffle is welded to the inner wall of the thimble assembly, but has slots at this joint that permit loop NaK to fill the space between the thimble and the baffle. This NaK is stagnant and readily conducts heat from the thimble to the flowing NaK.

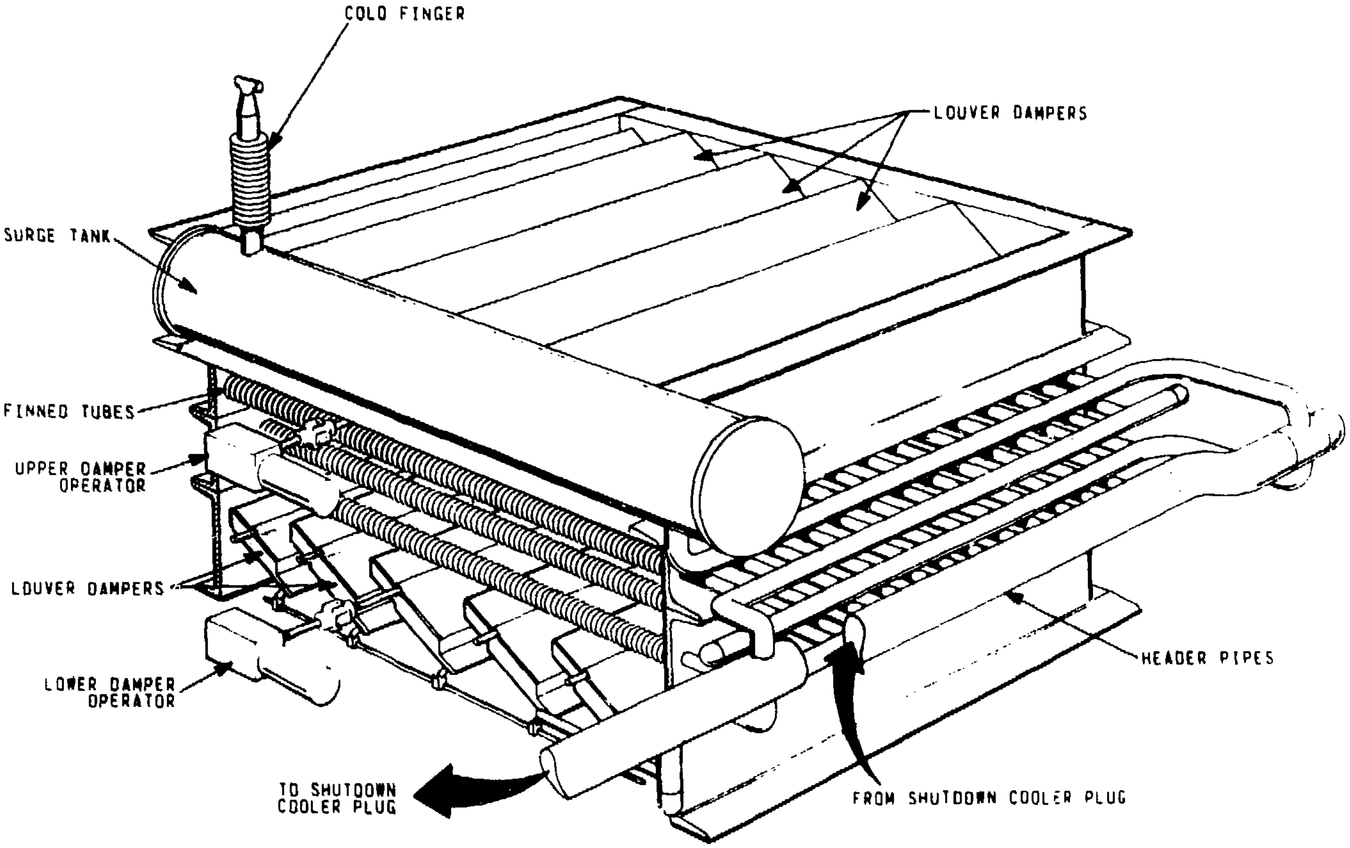
1.3.2 Shutdown Cooler Box Assembly

The shutdown cooler box assembly (see Figure 1.6) consists of a NaK-to-air heat exchanger, a surge tank, two sets of louver-dampers, an external box and chimney assembly, and associated service connections.

The NaK-to-air heat exchanger is constructed of externally finned tubes, arranged in two rows and connected in parallel to inlet and outlet manifolds. The fins are needed for additional heat transfer surface. Parallel flow of the NaK through the tubes minimizes flow resistance through the



MOUNTING DETAIL



SHUTDOWN COOLER BOX ASSEMBLY

Figure 1.6

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heat exchanger; this is necessary because natural circulation flow has a low driving head.

A surge tank of 90 gallons capacity, blanketed with argon at a pressure of 1-3 psig, provides space for volumetric changes of the NaK coolant. It is mounted on top of the heat exchanger to ensure that the circulating system is full of liquid at all times. To minimize unwanted heat loss, the surge tank is insulated (as in the cooler box and both sets of louver-dampers).

Two sets of louver-dampers, positioned above and below the finned-tube heat exchanger, control the air flow over the heat exchanger surgaces. Under normal plant operating conditions, the louvers are held closed by air pressure acting against spring force in a pneumatic actuator. Full shutdown cooler flow is established by venting the air pressure from the actuators, and allowing the springs to open the louver-dampers. Even when these dampers are fully closed, some NaK will flow in the shutdown cooling loop. This minimal flow is desirable, because:

- Freezing of the NaK is prevent (especially desirable in winter).
- Low grade natural circulation flow (in the proper direction) exists at all times and full shutdown cooler flow is more easily established.
- Thermal shock to the system by full shutdown cooler flow is reduced.

Above the finned-tube heat exchanger is a chimney assembly. This structure performs the same function as a fireplace chimney - to establish a column of hot air to promote natural circulation air flow. A weather-quard is mounted on top of the chimney.

Separate valved NaK and argon fill lines connect to the surge tank. After initial NaK filling and argon pressurization, these lines were capped. Further use of these lines is not necessary except for maintenance and/or draining of the shutdown cooler.

1.3.3 Connective Piping

A pair of insulated lines carry NaK from the cooler plug to the box, and back to the plug. There are no valves in these lines. Thus it is impossible to inadvertantly block the flow of NaK. These lines pass through the reactor building containment shell. The lack of isolation valves does not violate the containment principle, since the finned-tube heat exchanger does not connect with any other system.

Two cold-fingers are installed in the cold NaK return line to the cooler plug. These devices maintain the NaK purity through their cold-trapping action.

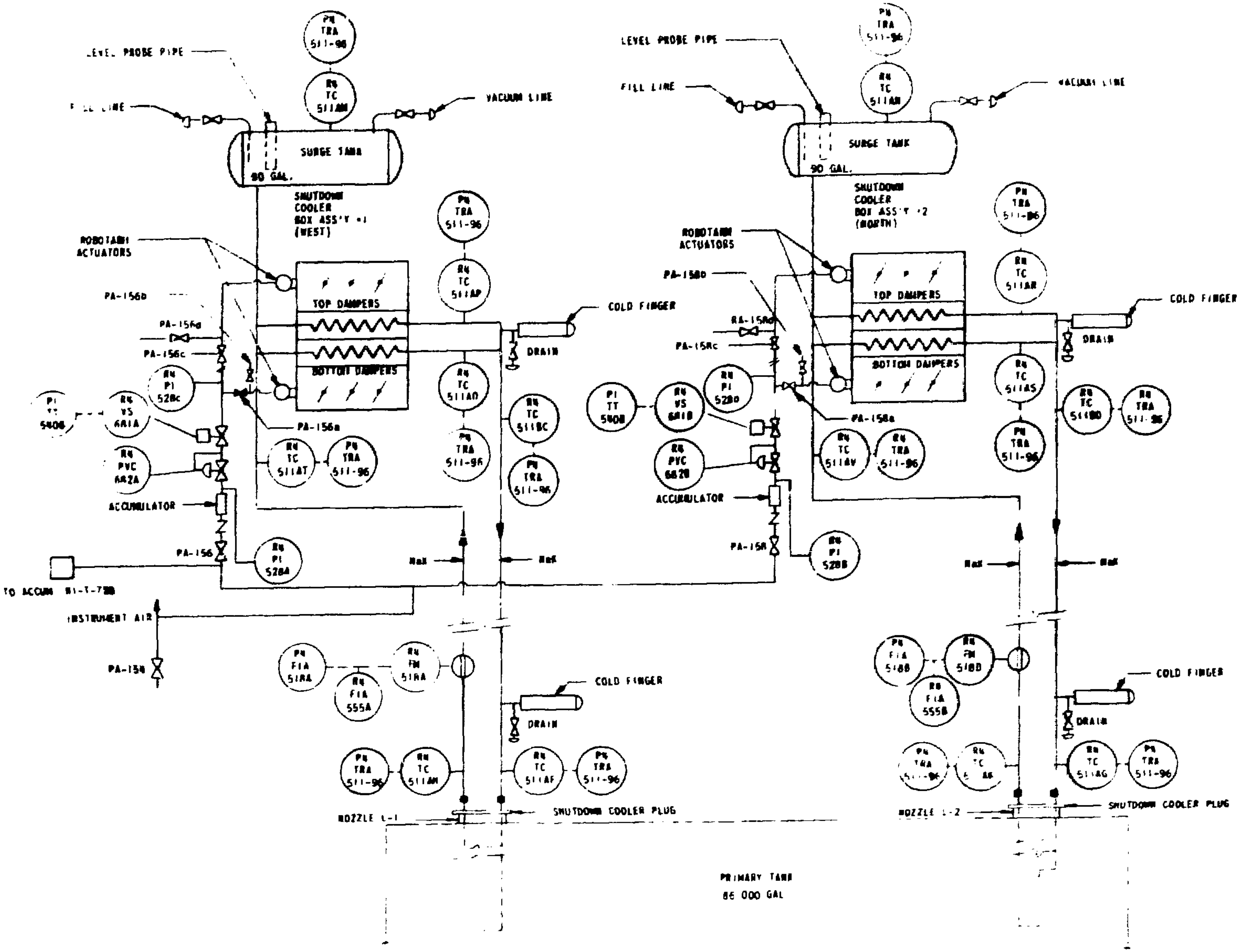
2. MAJOR INSTRUMENTATION AND CONTROL

2.1 Instrumentation and Alarms

Each shutdown cooling loop has the same installed instrumentation. No indications are derived from the shutdown cooler plug. The NaK cooling system, external to the primary tank, is instrumented with thermocouples (TC), electro-magnetic (EM) flowmeters and level indicators. Figure 2.1 shows this instrumentation.

The thermocouples associated with the shutdown cooling systems are recorded at the Auxiliary System Panel in the main control room, and may be displayed on the Auxiliary Systems Temperature Indicator on Instrument Control Center No. 1 (ICC 1) in the reactor building. Note that while many thermocouples are attached to the systems, only the T/C's welded to the inlet and outlet pipes of each shutdown cooler plug, and the T/C's immersed in the thermocouple well of each surge tank provide a reliable indication of NaK temperatures. The other T/C's are held in place with spring pressure contacts, rather than by welding or well-placement, and contact is not as positive.

A magnetic flowmeter, installed in the hot NaK line adjacent to each shutdown cooler plug, measures the NaK flow rate in each system.



SHUTDOWN COOLING SYSTEM INSTRUMENTATION

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Figure 2.1

Flow rates are indicated on both the Auxiliary System Panel in the main control room and on ICC 1 in the reactor building.

Associated with each cooling loop pneumatic control system is a pair of pressure gages. One indicates the pressure of the air supply, the other the reduced pressure applied to the actuators.

The shutdown coolers have very few alarms associated with them. Low flow annunciation for each loop is provided on the Auxiliary Systems Panel in the main control room. Annunciation of the opening of the louver dampers is provided on the Primary Systems Panel in the main control room.

2.3 Control Functions and Interlocks

Establishing full shutdown cooler flow, as stated previously, is accomplished by venting the air pressure from the pneumatic actuators. This allows spring force to open the louver-dampers. A solenoid valve located in each pneumatic control system is normally energized to pressurize the pneumatic actuators and keep the louver-dampers closed. Interrupting power to these solenoid valves will cause the valves to vent the actuators and initiate full shutdown cooler flow.

These two solenoid valves are controlled by the bulk sodium temperature averaging instrument which supplies an input signal to the bulk sodium temperature recorder on the reactor console. The bulk sodium averaging instrumentation (see Figure 2.1) uses signals from five thermocouples located in the primary tank. Two of these T/C's are attached to the suction nozzle skirt of No. 1 primary coolant pump. The other three are attached to the suction nozzle skirt of No. 2 primary coolant pump. This location of the T/C's, combined with the averaging of all five, ensures that a representative bulk sodium temperature indication is obtained. The setpoint for shutdown cooler actuation if 710°F average bulk sodium temperature.

Each pneumatic control system receives its air supply from the Instrument Air System at about 100 psig. An accumulator (or ballast tank) in the supply line reduces the effect of pressure fluctuations and reduces the chance of opening the louvers on loss of Instrument Air. Each control system contains a pressure regulating valve that reduces the air pressure to about 75 psig for closing of the actuators.

The operation of the louver-dampers may be tested by isolating and venting the actuators with the manual valves provided.

2.4 Inputs to the Plant Protective System Shutdown String

The Shutdown Cooling System provides no inputs to the Plant Protective System Shutdown String.

3. INTERCONNECTIONS TO OTHER SYSTEMS AND POWER SUPPLIES

3.1 Interconnections

The Shutdown Cooling System requires only two support systems:

Instrument Air System
Constant Power System

It must be stressed again that the shutdown cooling system does not rely on any sources of power for it operation during an emergency cooling situation. However, during normal operation when the shutdown coolers are in "standby", it is required that both instrument air and constant power supplies be maintained to the system to prevent excessive heat loss from the bulk sodium.

3.2 Power Supplies

The shutdown coolers receive power for the solenoid air valves from Process Power Panel R, breaker 1.

4. ADMINISTRATIVE SYSTEM REQUIREMENTS

4.1 Limiting Requirements for Plant Operation

4.1.1 Both shutdown coolers shall be operable for reactor power operation, with a minimum total heat rejection capability of 350 KW.

4.1.2 Never permit either shutdown cooler to remove more than 250 KW.

4.2 Surveillance Requirements

Operability of the shutdown cooler louver-dampers shall be demonstrated prior to each reactor run. Operability shall be demonstrated using a test signal simulating variations in bulk sodium temperature. Flow shall be checked by observing readings from flow meters in each cooler.

Upon discovery of current noncompliance with this limit, the test shall be undertaken immediately.

4.3 Requirements for Plant Operation Bases

4.3.1 The bases for 4.1 are as follows:

The two immersion bayonet-type shutdown coolers provide a means of removing fission-product decay heat from the primary sodium (and thus maintaining bulk sodium temperatures within established limits) should cooling by the secondary sodium system become impaired or other sources be unavailable. The shutdown coolers are normally continuously operable. They must be available during operation to provide cooling capability for high levels of decay heat. Their heat removal capability is required before startup, and loss during operation requires a normal shutdown. Following a period of extended operation it takes several days before decay heat has reached a low enough level that parasitic heat losses alone are sufficient to ensure that bulk sodium temperature is not increased. Calculations of temperature transients of the bulk sodium have been made, assuming operation at 62.5 MWt for six 2800 MWd runs at 80% plant factor with a single fuel loading. With no shutdown coolers operable, and taking credit only for parasitic heat losses from the primary tank of 130 KW, peak bulk sodium temperature reached was 1067°F and occurred 9.5 days after shutdown. With one shutdown cooler operable (with a heat rejection capability of 175 KW), peak sodium temperature reached was 780°F 1.5 days after shutdown.

In addition to the low peak temperatures reached, the transients are slow, allowing time for corrective action from other systems. (Shield and thimble cooling, for example, would effectively remove decay heat).

To attain maximum reliability, cooling by the shutdown coolers is accomplished by natural circulation of NaK coolant, with rate of heat release controlled by the position of air flow control louver-dampers. Upon failure of the controlling power supply (air pressure), the units are spring actuated to open the dampers for operation. The shutdown coolers are normally continuously operable, but are required only when there are high levels of decay heat (>130 KW).

Limiting shutdown cooler heat removal by keeping the air louver dampers closed reduces heat losses during operation of the reactor.

4.3.2 The bases for 4.2 are as follows:

The shutdown coolers are required to maintain bulk sodium temperatures within desired limits when the secondary sodium system is incapable of doing so. Control of heat removal is accomplished by louver-dampers which control air flow to a NaK-to-air heat exchanger. Normally, the louvers are automatically controlled to open if bulk sodium temperature exceeds 710°F, however, should failure of the controlling power supply air pressure occur, the units are spring actuated to open the dampers for operation.

Testing of the functions controlling action of the louver dampers as specified will ensure that the shutdown coolers will be available during conditions when fission-product decay heat in the reactor is high. Checking flow in the system will ensure that no flow blockage exists that could impair heat rejection capability.

Design heat removal capacity for the shutdown coolers was 500 kW for both, or 250 kW each. Actual measured heat removal capacity was 350 kW for both coolers. That capacity will not change except by loss or impairment of control functions or basic redesign of the system. Therefore, testing the performance of the control functions ensures that the maximum capacity of the system is maintained.

Calculations assuming loss of all secondary sodium heat removal capability at reactor shutdown and subsequent heat removal by shutdown coolers indicate a peak bulk sodium temperature of 730°F, achieved 12 hours after the incident. These calculations were based on the measured shutdown cooler heat removal capacity, plus an additional 130 kW parasitic heat loss and full-core irradiation for six 2800-MWd runs at 80% plant factor.

5. SUMMARY OF OPERATION

5.1 Startup

The shutdown coolers are normally in continuous operation, and startup consists of placing them in a standby condition by ensuring that the solenoid-operated air valves are energized and that instrument air is supplied to the louver-dampers' Robotarm actuators. In this condition, the shutdown coolers will remove minimum heat from the primary tank and are available for maximum heat removal by a signal of high bulk sodium temperature or a loss of continuous electrical power or instrument air.

5.2 Normal Operation

Data is taken each shift to ensure that the shutdown coolers have normal flow and temperature for their existing condition. Normally, no operator attention is required for proper operation of the shutdown coolers.

5.3 Shutdown

The shutdown coolers are closed loop systems with no flowpath isolation valves. If it is desired to stop system flow, a freeze seal must be applied to one of the pipes.

5.4 Abnormal Operation

The shutdown coolers may be used to augment normal cooldown methods by isolating and venting the air from the damper actuators, allowing the springs to open them. The same method may be used to open the dampers if a high bulk sodium temperature signal fails to open them.

6. REFERENCES

6.1 EBR-II System Design Descriptions, Vol. II, Chapter 7.2, Shutdown Cooling System.

6.2 Hazard Summary Report, ANL-5719, pages 25-26 and 194-195.

6.3 Addendum to Hazard Summary Report, ANL-5719, Page 22.

6.4 EBR-II Operating Instructions Division IV B.

6.5 EBR-II System Design Descriptions, Vol. II, Chapter 6.9, Temperature Measurement Systems.

7. QUALIFICATION OBJECTIVES

The operator should be able to describe the physical location of all components in the shutdown cooling system, know how to manually initiate maximum flow through the shutdown coolers, take and evaluate readings, and have thorough understanding of natural circulation systems, as a minimum level of knowledge for this system.

8. SELF-CHECK TEST QUESTIONS

8.1 What causes automatic actuation of the Shutdown Cooling System? Where does this signal originate? (C-5B-18)

8.2 What is the purpose of the shutdown coolers? (C-5B-5)

8.3 Draw the lower section of the bayonet heat exchanger and show the flowpath. (C-5B-12)

8.4 What is "natural circulation" flow and how is it accomplished? (C-5B-6)

8.5 Why is it desirable to maintain flow through the Shutdown coolers even though they are not needed to cool the bulk sodium? (C-5B-15)

8.6 How often is a functional check of the system required? (C-5B-20)

8.7 What is the heat transfer medium used in the Shutdown cooling system? (C-5B-5)

8.8 What is the power supply to the solenoid valves? (C-5B-19)

8.9 Describe the steps required to manually actuate the shutdown coolers. (C-5B-19)

8.10 What are the normal flowrates in the system when bulk sodium is at 700°F, and >710°F? (C-5B-6)

IV B. SHUTDOWN COOLING SYSTEM

This section of the Operating Instructions contains the following subsections:

This section of the Operating Instructions contains the following figures:

1. GENERAL

The purpose of the shutdown cooling system is to remove excess fission product decay heat when the normal method of heat removal is not available. Normally, secondary sodium flow through the intermediate heat exchanger is adjusted to maintain bulk sodium temperature at 700 ± 5°F. However, if the heat removal capability of the secondary sodium system is lost, or limited by plant conditions, the shutdown cooling system will aid in maintaining bulk sodium temperature within an acceptable range. The shutdown cooling system does not require electrical power or other external systems to function at maximum capacity. The system removes some heat from the bulk sodium continually.

The shutdown cooling system consists of two identical shutdown coolers which provide heat transfer by convective flow of NaK eutectic (22% Na and 78% K) in a closed system. NaK flow varies from approximately 20 gpm per cooler with bulk sodium temperature at 700°F (dampers closed) to approximately 40 gpm per cooler with bulk sodium temperature 710°F (dampers open).

NaK is used as the heat transfer medium because of its low melting point (∿9°F), the good heat transfer properties, and the fact that it does not react with sodium.

The shutdown cooling system is fail-safe; the dampers will open on loss of instrument air or total loss of electric power.

There is indication of shutdown cooler flow for each cooler on ICC-1 and on the auxiliary section in the control room. Annunciation of low flow is provided on the auxiliary section annunciator. Annunciation is provided on the primary section annunciator when the dampers are open.

The major components of the system are:

1. Shutdown cooler plug

The shutdown cooler plugs are immersion type bayonet heat exchangers. The cooler plugs are located in the L1 and L2 nozzles. NaK flow enters at the top of the plug and flows downward through an inner pipe in the plug. At the bottom of the pipe, flow reverses direction and flows upward around the inner pipe, through an annulus, to the top of the plug.

There is a closed annulus of "captive" NaK between the outer wall of the flow annulus and the pipe section which forms the barrier between bulk sodium and the cooler plug internals. The NaK in this closed annulus thermally bonds the inner pipe containing the NaK coolant, provides a greater thermal head for natural convection, and reduces thermal stresses.

The upper portion of the cooler plug is stepped and shielded to minimize radiation streaming. The bottom of the shield is thermally insulated with fiberglass.

An expansion bellows is used on the NaK inlet pipe to relieve stresses, due to differential thermal expansion, between the inlet and outlet piping.

2. Shutdown cooler box assembly

The shutdown cooler box assembly consists of a NaK-to-air heat exchanger, surge tank, two sets of louver dampers, chimney, and housing.

The heat exchanger is a finned type consisting of two rows of finned tubes connected in parallel to the inlet and outlet of the cooler plug.

The surge tank (90 gal. capacity) provides space for thermal expansion and contraction of the NaK coolant. It is mounted above the heat exchanger to ensure that the system is full at all times.

The louver dampers, positioned above and below the heat exchanger, control air flow over the heat exchanger surface. The dampers are controlled by the bulk sodium temperature averaging instrumentation which feeds the "Bulk Sodium Temperature" recorder (PI-TR-504) on the reactor console. When bulk sodium temperature is ∿709°F or less, the dampers are closed by air pressure on a piston in the "Robotarm" actuators. If bulk sodium temperature increases to 710°F, air pressure to the actuators is released when R4-VS-681a and R4-VS-681b are de-energized, allowing the return spring in each actuator to open the dampers. This action increases the convective air flow over the heat exchanger, which removes more heat from the bulk sodium. The combined heat removal of the two coolers with the dampers open is approximately 350 kW. When the bulk sodium temperature decreases to approximately 709°F, the actuators close both sets of dampers. With the dampers closed, approximately 60 kW of heat is removed by the shutdown coolers. The lower louvers are insulated to minimize heat losses during normal reactor operation.

Even when the dampers are fully closed, there is some flow in the NaK cooling system. This flow prevents the NaK from freezing in cold weather and reduces thermal shock to the system when the dampers are opened.

2. STARTUP

The shutdown cooling system is not started up in the normal sense. When air and electrical power are secured to the system, it is operating at maximum capacity. The following procedure establishes conditions for normal indication and automatic operation of the louvered dampers.

a. Preparatory Procedures

P1. Verify the following circuit breakers are closed:

Circuit Breaker No. and Panel	Location	Equipment Energized
Breaker No. 14, Panel 1B	Power plant-Cable routing room	Constant power panel 'B'
Breaker No. 15, Panel 1B	Power plant-Cable routing room	Auxiliary panel
Breaker No. 17, Panel 1B	Power plant-Cable routing room	Primary system panel
Breaker No. 13, Panel 1B	Power plant-Cable routing room	Secondary system panel
Breaker No. 1, Panel R	Reactor building-Operating floor	Instrument control center No. 1

P2. Verify the instrument air system is in operation per Section X A, "Plant and Instrument Air."

b. Direct Procedures

(1) Verify the following valves are closed:

Valve No.	Description
PA-156b	Vent valve - Air to lower damper (west unit)
PA-156d	Vent valve - Air to upper damper (west unit)
PA-158b	Vent valve - Air to lower damper (north unit)
PA-158d	Vent valve - Air to upper damper (north unit)

(2) Verify the following valves are open:

Valve No.	Description
PA-154	Isolation valve - Instrument air to SBB, S/D coolers, and outside ventilation units for the reactor building.
PA-156	Isolation valve - Air to west unit
PA-156a	Isolation valve - Air to lower damper (west unit)
PA-156c	Isolation valve - Air to upper damper (west unit)
PA-158	Isolation valve - Air to north unit
PA-158a	Isolation valve - Air to lower damper (north unit)
PA-158c	Isolation valve - Air to upper damper (north unit)

(3) Adjust regulator R4-PVC-682a to 75 psig as indicated on pressure gauge R4-PI-528c. The louvered dampers in the west unit are now closed (if bulk sodium temperature is 709°F or less), and will open automatically at 710°F.

(4) Adjust regulator R4-PVC-682b to 75 psig as indicated on pressure gauge R4-PI-528d. The louvered dampers in the north unit are now closed (if bulk sodium temperature is 709°F or less), and will open automatically at 710°F.

3. NORMAL OPERATION

During normal operation the following routine checks and operations are required:

a. Parameters recorded on Log No. 4-D, "Primary Systems":

(1) Shutdown cooler flow (5-30 gpm)

(2) Shutdown cooler inlet temperature (30°F min.)

(3) Shutdown cooler outlet temperature (<Bulk Na temperature)

b. Automatic operation of the shutdown cooler dampers is checked monthly as part of the "Interlock Checksheet (Reactor Operation)". When this check is made, verify that the dampers open at 710 ± 2°F.

4. SHUTDOWN

The shutdown cooling system is in continuous operation. Electric power and instrument air can be secured to the system. However, it will continue to operate a maximum capacity (with the dampers wide open) as long as the bulk sodium temperature is greater than the outside air temperature.

5. ABNORMAL OPERATIONS

a. Cooldown of the Bulk Sodium System

The shutdown cooling system can be used to provide additional cooling in attaining a desired cooldown rate for the bulk sodium system. To operate the system for this purpose, proceed as follows:

(1) Close the following valves:

Valve No.	Description
PA-156	Isolation valve - Air to west unit
PA-158	Isolation valve - Air to north unit

(2) Open the following valves:

Valve No.	Description
PA-156b	Vent valve - Air to lower damper (west unit)
PA-156d	Vent valve - Air to upper damper (west unit)
PA-158b	Vent valve - Air to lower damper (north unit)
PA-158d	Vent valve - Air to upper damper (north unit)

(3) Verify that the dampers for both units are open.

(4) To return the units to automatic operation, close vent valves PA-156b and d, and PA-158b and d, and open isolation valves PA-156 and PA-158.

b. Shutdown Coolers Fail to Operate in Automatic

If the dampers fail to open automatically under actual high bulk sodium temperature conditions, proceed as follows:

(1) Close isolation valves PA-156 and PA-158.

(2) Open vent valves PA-156b, PA-156d, PA-158b, and PA-158d.

(3) Manually operate the damper operating linkage to open the dampers, if necessary.

Attachment 5

EBR-II SYSTEMS TRAINING

QUALIFICATION EXAMINATION COVERSHEET

NAME ____________________ CREW ____________________

AREA ____________________ DATE ____________________

EXAM ADMINISTERED BY ____________________

EXAM GRADED BY ____________________

TOPICS	MIN. POINTS	POINTS POSSIBLE	POINTS REC'D	GRADE
*PRINCIPLES OF REACTOR OPERATION	20			
FEATURES OF FACILITY DESIGN	20			
GENERAL OPERATING CHARACTERISTICS	25			
INSTRUMENTS AND CONTROL	25			
SAFETY AND EMERGENCY SYSTEMS	25			
STANDARD OPERATING PROCEDURES	25			
TOTAL (OPTIONAL)				

EACH TOPIC MUST BE REVIEWED AND A GRADE ASSIGNED. IF ANY TOPIC IS BELOW 80% RETRAINING AND RETESTING IN THAT TOPIC IS REQUIRED.

REMARKS:

*COVERED ONLY FOR REACTOR CONTROL CONSOLE

0-20-003 (1/78)

Attachment 6

EMERGENCY AND ADMINISTRATIVE EXAMINATION

EBR-II SYSTEMS TRAINING PROGRAM - EXAMINATION COVER SHEET

NAME ______________________________ CREW __________

EXAM ADMINISTERED BY ______________________ DATE __________

EXAM GRADED BY __________________________ DATE __________

AREAS OF EXAMINATION:

☐ REACTOR CONTROL CONSOLE

☐ FUEL HANDLING

☐ COOLANT SYSTEMS

☐ POWER PLANT

☐ ELECTRICAL

☐ QUALIFICATION

☐ REQUALIFICATION

* EXAM TOPICS	MINIMUM POINTS	POINTS POSSIBLE	POINTS RECEIVED	GRADE %
EMERGENCY PROCEDURES	(60)			
HEALTH & SAFETY	(10)			
SAFEGUARDS	(10)			
CRITICALITY	(10)			
RADIOLOGICAL SAFETY	(10)			
TECHNICAL SPECIFICATIONS	(15)			
______________				
______________				
TOTAL				

* EACH TOPIC MUST BE REVIEWED AND A GRADE ASSIGNED. IF ANY TOPIC IS BELOW 80% OR IF THAT AREA IS JUDGED WEAK FOR SOME REASON, RETRAINING AND RETESTING IN THAT TOPIC IS REQUIRED.

REMARKS:

Attachment 7

OPERATOR QUALIFICATION
EXAMINATION RECORD
COOLANT SYSTEMS

Name ________________________

Operating Date ________________

Oral Date ____________________

		Oral			Operating		
		Outs.	Sat.	*Fail	Outs.	Sat.	*Fail
**2.1	Primary and Auxiliary Systems						
2.1.1	Reactor Building Containment						
2.1.2	Sodium Purification Theory						
2.1.3	Primary Sodium Purification						
2.1.4	Primary Sodium Sampling/Plugging Loops						
2.1.5	RSCL and NITF						
2.1.6	Smoke/Fire Provisions for RSCL, NITF and Purification Cell						
2.1.7	Argon Supply System						
2.1.8	Argon Blanket Gas System						
2.1.9	Cooling Water System						
2.1.10	PTCGSSS						
2.1.11	Fission Products Surveillance						
2.1.12	Plant Air System						
2.1.13	Instrument Air System						
2.1.14	Thimble Cooling System						
2.1.15	Shield Cooling System						
2.1.16	Primary Coolant Pumps						
2.1.17	Primary Coolant Flowpath						
2.1.18	Primary Tank and Shielding						
2.1.19	EM Pumps & Flowmeter Theory & Operation						
2.1.20	Power Supplies						
2.1.21	Follows Procedures						
2.1.22	CGCS						
2.2	Secondary System						
2.2.1	Secondary System Components						
2.2.2	Heatup and Fill						
2.2.3	Methods of Determining Na/H_2O Leak						
2.2.4	Emergency Pushbutton						

		Oral			Operating		
		Outs.	Sat.	*Fail	Outs.	Sat.	*Fail
2.2.5	Fire Pushbutton	☐	☐	☐	☐	☐	☐
2.2.6	Met-L-X Systems	☐	☐	☐	☐	☐	☐
2.2.7	Overpressure Relief System	☐	☐	☐	☐	☐	☐
2.2.8	Argon Gas System	☐	☐	☐	☐	☐	☐
2.2.9	Heating Systems	☐	☐	☐	☐	☐	☐
2.2.10	Main EM Pump Operation	☐	☐	☐	☐	☐	☐
2.2.11	Recirculation Pumps Operation	☐	☐	☐	☐	☐	☐
2.2.12	Purification System	☐	☐	☐	☐	☐	☐
2.2.13	Storage Tank	☐	☐	☐	☐	☐	☐
2.2.14	Plugging Loop Sampling Loop	☐	☐	☐	☐	☐	☐
2.2.15	Leak Detection System	☐	☐	☐	☐	☐	☐
2.2.16	Power Supplies	☐	☐	☐	☐	☐	☐
2.3	Theory and Safety						
2.3.1	Sodium Properties	☐	☐	☐	☐	☐	☐
2.3.2	Sodium Activation	☐	☐	☐	☐	☐	☐
2.3.3	Sodium Cleanup	☐	☐	☐	☐	☐	☐
2.3.4	Radiation Safety	☐	☐	☐	☐	☐	☐
2.3.5	Tagging Procedure	☐	☐	☐	☐	☐	☐
2.3.6	Protective Clothing & Equipment	☐	☐	☐	☐	☐	☐
2.3.7	Technical Specifications	☐	☐	☐	☐	☐	☐

Examiner(s) ______________________________ ______________________________

______________________________ ______________________________

Comments: ____

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*Examiner must comment on weaknesses and any failures. Use reverse side if necessary.

**Examiner must cover at least one item under each of these major sections.

NOTE: Anyone who fails a qualification oral should talk to each of the board members before coming up for reoral.

Attachment 8

Argonne National Laboratory

EXPERIMENTAL BREEDER REACTOR II

THIS CERTIFIES THAT

HAS SATISFACTORILY COMPLETED THE REQUIRED TRAINING PROGRAM AND IS QUALIFIED TO OPERATE THE EBR-II

COOLANT SYSTEMS

TRAINING SUPERVISOR

DATE

ASSOCIATE DIRECTOR, EBR-II OPERATIONS

ATTACHMENT 9

A. REACTOR CONTROL CONSOLE

I. Reactor Technology
   a. Mathematics
   b. Atomic Physics
   c. Nuclear Physics
   d. Reactor Physics
   e. Reactor Characteristics
   f. Heat Transfer

II. Reactor Vessel and Neutron Shield
   a. Grid Plenum Assembly
   b. Reactor Vessel
   c. Reactor Vessel Top Cover
   d. Shielding

III. Subassemblies
   a. Construction
   b. Fuel Elements
   c. Inner & Outer Blanket
   d. Source Assembly
   e. Control & Safety Rods

IV. Reactor Instrumentation
   a. Detection Principles
   b. Neutron Detectors
   c. Period Circuits
   d. Non-nuclear Instrumentation

V. Reactor Control
   a. Control Rod Drives
   b. Safety Rod Drives
   c. Reactor Shutdown System
   d. Thermal & Flow Effects on Reactor Power

VI. Reactor Surveillance Systems
    a. Data Acquisition System
    b. Local & Remote System Monitor Readouts

VII. Overall Systems Operation
    a. Console Operator Procedures
    b. Overall System Interactions

B. COOLANT

I. EM Pumps and Flowmeters
    a. Basic Sodium and NaK Instruments
    b. Pumps and Flowmeters

II. Containment Systems
    a. Primary Containment
    b. Building Containment
    c. Penetrations
    d. Primary Tank Structure and Shielding
    e. Sodium Boiler Building Construction
    f. Reactor Building Isolation System

III. Air Heating, Cooling and Ventilation Systems
    a. Reactor Building Ventilation System
    b. Shield Cooling Sstem
    c. Thimble Cooling System
    d. Sodium Boiler Building Ventilation System

IV. Support and Miscellaneous Systems
    a. Reactor Auxiliaries Cooling Water System
    b. Plant Cooling Water System
    c. Instrument Air System
    d. Plant Air System

V. Primary Sodium Systems
  a. Primary Coolant System
  b. Shutdown Cooling System
  c. Primary Tank Heating System

VI. Secondary Sodium Systems
  a. Secondary Coolant System
  b. Secondary Sodium Recirc System
  c. Induction and Resistance Heating System
  d. Secondary Sodium-Relief System

VII. Sodium Purification System
  a. Primary Sodium Purification System
  b. Secondary Sodium Purification System

VIII. Sodium Monitoring Systems
  a. Primary Plugging Loop
  b. Secondary Plugging Loop
  c. Primary "Sodium Sampling" System
  d. Secondary Sodium Sampling System
  e. Radioactive Sodium Chemistry Loop (RSCL)
  f. Appendix 1 Cell A
  g. Appendix 2 Cell B
  h. Appendix 3 Cell C

IX. Argon Gas Systems
  a. Fresh Argon Supply and Distribution
  b. Primary Tank Cover Gas System
  c. Argon Purge System
  d. Primary Tank Annulus Gas System
  e. Secondary Blanket Gas System

X. Argon Monitoring Systems
   a Primary Tank Cover Gas Sampling Supply System (PTCGSSS)
   b. Primary Gas Chromatograph
   c. Secondary Gas Chromatographs

XI. Fission Product Monitoring Systems
   a. Reactor Cover Gas Monitor (RCGM)
   b. Fission Gas Monitor (FGM)
   c. Xenon Tag Recovery System (XTRS)
   d. Fuel Element Rupture Detector System
   e. Germanium-Lithium Argon Scanning System (GLASS)

XII. Cover Gas Cleanup System
   a. Cover Gas Cleanup System Main Loop
   b. Cover Gas Cleanup Tag Trap Analysis System
   c. Cover Gas Cleanup Nitrogen System
   d. Cover Gas Cleanup System Chromatographs
   e. Cover Gas Cleanup Building Ventilation System

XIII. Facilities for Experiments and Experiments
   a. Nuclear Instrument Test Facility (NITF)
   b. Appendix 1 NITF (J2 Thimble) Experiment
   c. Appendix 2 NITF (01 Thimble) Experiment
   d. ANL/HEDL Ge(Li) Cover Gas Monitoring System
   e. Incore Instrument Test Facilities (INCOT)
   f. Appendix 1 INCOT No. 1 Experiment
   g. Appendix 2 INCOT No. 2 Experiment
   h. Appendix 3 INCOT No. 3 Experiment
   i. Acoustical Monitoring

XIV. Sodium Fire Protection Systems
   a. Secondary MET-L-X System
   b. Primary Sodium MET-L-X Systems

XV. Overall Systems Operation
  a. Overall Plant Operation
  b. Overall Coolant Systems Operation

C. FUEL HANDLING

I. Reactor Loading Control
  a. Core Loading
  b. Storage Basket Loading
  c. Criticality Hazards
  d. Safeguards and Security

II. Rotating Plugs
  a. Freeze Seals
  b. Small & Large Plug
  c. Festoon Cables

III. Gripper and Holddown
  a. Gripper Mechanism
  b. Gripper Operation
  c. Holddown Mechanism
  d. Holddown Operation

IV. Transfer Arm & Fuel Transfer Port
  a. Construction
  b. Operation

V. Fuel Unloading Machine
  a. Shielding
  b. Construction
  c. Controls

VI. Argon Cooling System and Transfer Coffin
  a. Construction
  b. Operation
  c. Cooling

- VII. Storage Basket
  - a. Construction
  - b. Support and Drive Operation
  - c. Shield Plug

- VIII. Reactor Vessel Cover Drive and Holddown
  - a. Construction
  - b. Operation

- IX. Control Rod Lifting Platform
  - a. Platform Assembly
  - b. Spacer Block Assembly
  - c. Drive Mechanism
  - d. Operation

- X. Special Operation
  - a. Safety Rod Thimble Replacement
  - b. Safety Rod Replacement
  - c. Control Rod Thimble Replacement
  - d. Subassembly Rotation (180°)
  - e. Neutron Source and Thimble Handling
  - f. Rotating Plug Seal Cleaning

- XI. Fuel Handling Console Procedures
  - a. Unrestricted Operations
  - b. Restricted Operations
  - c. Special Operations
  - d. Emergency and Off-Normal Operation

D. POWER PLANT

- I. Thermodynamic Theory

II. Steam Generation System
  a. Steam Drum
  b. Evaporators
  c. Superheaters

III. Steam System
  a. Main Steam Stop
  b. Main Steam Header
  c. Bypass System
  d. Condensate Isolation
  e. 150 Pound Steam
  f. Auxiliary Steam

IV. Blowdown System
  a. Flash Tanks
  b. Blowdown Cooler
  c. After cooler

V. Condensate System
  a. Main Surface Condenser
  b. Air Ejectors
  c. Pumps
  d. Feedwater Heaters #1 and #2
  e. Condensate Storage

VI. Feedwater System
  a. Pumps
  b. Feedwater Heaters
  c. Main Feed System
  d. Feedwater Heating

VII. Circulating Cooling Water Systems
  a. Condensate Cooling

- b. Plant Cooling
- c. Reactor Auxiliary Cooling
- d. Cooling Tower

VIII. Generator
- a. Generator Cooling
- b. Gas Seal System
- c. Lubrication System

IX. Turbine Theory & Control

X. Power Plant Operator Procedures
- a. Administrative Procedures
- b. General Operating Procedures
- c. Special Operating Procedures
- d. Emergency Operating Procedure

E. <u>ELECTRICAL SYSTEMS</u>

I. Electrical Theory

II. 138 KV System
- a. Substations
- b. Main Transformers
- c. Neutral Ground System
- d. Protective Relaying
- e. Generator

IV. 2400 Volt System
- a. Transformers
- b. Loads
- c. Switchgear
- d. Control Panels
- e. Protective Relaying
- f. Systems Operation

V. 480 Volt Electrical System
  a. Transformers
  b. Switchgear
  c. Motor-control Centers
  d. Diesels and Emergency Systems
  e. Protective Relaying
  f. Systems Operation

VI. Uninterrupted Power Supplies
  a. Components
  b. Supplies
  c. Annunciation
  d. Batteries
  e. DAS System
  f. System Operation

VII. Power Generation
  a. Main Generator
  b. 3-Phase Power Generation

VIII. Electrical Operator Procedures
  a. Operating Procedures
  b. Emergency Procedures
  c. Electrical Safety

Attachment 10

NAME ______________________ PR # ______________

LEVEL I I&C MAINTENANCE TECHNICIAN
QUALIFICATION CARD

		Signature	Date
2.	Basic Skills		
2.1	CSM Administrative Procedures		
2.1.1	Work Requests		
2.1.2	History Cards		
2.1.3	Work Log		
2.1.4	Procedures--Working Copies		
2.1.5	Surveillance Requirements		
2.1.6	PM-WAF Pkg Requirements		
2.1.7	Electrical House Rules		
2.2	Special Nuclear Materials Handling		
2.3	Maintenance Procedures		
2.4	Test Instruments		
2.5	Troubleshooting Techniques		
2.6	Print System		
2.7	EBR-II Tech. Specifications		
2.8	Basic Systems		
2.9	Data Requirements for Shift Techs		
2.10	Use of Special Tools		
2.10.1	Drill Press		
2.10.2	Oxy-Acetelene Torches		
2.10.3	Hydraulic Chassis Punches		
2.10.4	M-I Cable Stripper		
2.10.5	Engraver		
2.11	Basic Trade Skills		
2.11.1	Soldering		
2.11.2	Wire Terminations		
2.11.3	Panel Layout		
2.11.4	Fabrication		
2.11.5	Silver Soldering		
2.11.6	Wire Sizes and Uses		
2.11.7	Recorder Maintenance		
Foreman			
Supervisor			

Attachment 11

Name ____________________ PR# ____________________

LEVEL II I & C MAINTENANCE

TECHNICIAN QUALIFICATION CARD

1. Systems	Signature	Date
1.1 Reactor Instruments	____________	____________
1.2 Fuel Handling System Instruments	____________	____________
1.3 Coolant System Instruments	____________	____________
1.4 Radiation Monitoring Instruments	____________	____________
1.5 Interlocks	____________	____________
1.6 Instrument Power and Distribution	____________	____________
1.7 Power Plant Instruments	____________	____________
Foreman	____________	____________
Supervisor	____________	____________

Attachment 12

LEVEL III ADMINISTRATIVE QUALIFICATION

EXAMINATION RECORD

NAME ______________________ ☐ QUALIFICATION ☐ ORAL

DATE ______________________ ☐ REQUALIFICATION

	Pass*	Fail*
ANL-W Health and Safety Manual		
1. Section II, Chapter 1 Safe Work Permit	☐	☐
2. Section II, Chapter 2 Working Alone	☐	☐
3. Section II, Chapter 3 Notification, Investigation and Reporting of Occurrences		
ANL - Quality Assurance Policy and Practice Manual, Chapter V, Section M	☐	☐
4. Section II, Chapter 4 Near Occurrences	☐	☐
5. Section II, Chapter 8 Injury and Illness	☐	☐
6. Section III, Chapter 10 Welding, Cutting, Brazing and Flame Soldering	☐	☐
7. Section VII, Chapter 12 Radiation Work Permit	☐	☐

EBR-II Departmental Procedures Manual

			Pass*	Fail*
	1.	OPS-II-2, Organizational Responsibilities for Compliance with Technical Specifications Requirements	☐	☐
	2.	OPS-III-2, Preparation, Review, Approval and Control of EBR-II Special Procedures	☐	☐
	3.	OPS-III-3A, Assignment of Surveillance Responsibilities for the Technical Specifications Surveillance System	☐	☐
	4.	OPS-III-10, EBR-II Unusual Occurrence Reports	☐	☐
	5.	OPS-III-12, Preventative Maintenance System Description (Critical Systems Maintenance)	☐	☐
	6.	OPS-IV-3, EBR-II Training, Qualification and Certification Programs - Maintenance Technicians and Foreman	☐	☐
(I&C Only)	7.	OPS-VI-1, EBR-II Plant Protective Systems (PPS) Definition of Components and Control of Work	☐	☐
	8.	OPS-VII-1, The Use of MCN's for Implementing Maintenance Activities	☐	☐
	9.	OPS-VII-2A, Critical Systems Maintenance Work Requests for EBR-II Only	☐	☐
	10.	OPS-VII-2B, Job Safety Analysis	☐	☐
	11.	OPS-VII-4, Tagging of Used Components or Equipment	☐	☐
	12.	OPS-VII-5, Critical Systems Maintenance "Work Ready List"	☐	☐
(Crew E Only)	13.	OPS-VII-6, Administrative Guidelines for EBR-II Hoisting and Rigging Gear	☐	☐

			Pass*	Fail*
(I&C Only)	14.	OPS-VII-7, Administrative Control of Maintenance and Test Equipment (MT & E)		
(I&C Only)	15.	OPS-VII-8, Instrumentation Calibration Intervals	☐	☐
(I&C Only)	16.	OPS-VII-9, Computer Procedure for Maintenance and Test Instruments	☐	☐
(Crew E Only)	17.	OPS-VII-10, Instructions for Use of the EBR-II Weld Specifications and Inspection Record Form	☐	☐
(Crew E Only)	18.	OPS-VII-11, Administrative Control of Hoisting and Rigging Instructions as Contained in EBR-II CSM Special Procedures	☐	☐
(Crew E Only)	19.	OPS-VII-12, Procedural Requirements and Considerations for Personnel Safety When Working on Sodium Systems	☐	☐
(I&C Only)	20.	OPS-VIII-3, Appendix B - Safeguards Procedure and User Rules for Instrument Maintenance Facility (Critical Systems Maintenance)	☐	☐

Engineering Department Procedures Guide

		Pass*	Fail*
1.	Section III, EDP-3-2, Engineering Change Notices	☐	☐
2.	Section III, EDP-3-8, Type B Modifications	☐	☐
3.	Section III, EDP-3-9, Plant Modifications	☐	☐

PASS/FAIL

EXAMINER(S) ______________________________ ______________

______________________________ ______________

COMMENTS: ____

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*Examiner must comment on weaknesses and failures.

Attachment [illegible]

PLANT CHEMISTRY TECHNICIAN

TRAINING CARD

NAME____

GENERAL INFORMATION

TOPIC

Signature Date

GENERAL CHEMISTRY AND PHYSICS

CHEMISTRY OF WATER

CHEMISTRY OF SODIUM

CHEMICAL SAFETY

EMERGENCY PROCEDURES

- EP 1-1
- EP 1-2
- EP 1-4
- EP 1-5
- EP 1-10
- EP 1-11
- EP 3-1
- EP 3-8
- EP 3-11
- EP 3-12
- EP 5-9

WATER SYSTEMS

On-Shift Check-Out

- Feedwater
- Condensate
- Blowdown
- Main Tower and Condenser Cooling Water
- Auxiliary Tower, Plant and Reactor Auxiliary Cooling Water Systems

SODIUM SYSTEMS

On-Shift Check-Out

- Primary Purification
- RSCL
- PTCGSSS
- Secondary Purification
- Secondary Cover Gas Sampling
- Cover Gas Cleanup System

Attachment 14

NAME ______________________________

WATER CHEMISTRY

TOPIC	OPERATIONAL KNOWLEDGE				EXAM COMPLETED
	Systems & Proc.		Emergency Sys. & Proc.		
	Signature	Date	Signature	Date	Date
ZERO SOLIDS WATER TREATMENT					
Primary Demineralizer System					
Mixed Bed Demineralization Systems					
Hydrazine & Morpholene Injection Systems					
Phosphate Treatment					
COOLING TOWER WATER TREATMENT					
Chromate Addition & Reduction					
Acid System					
Chlorine Systems					
Other Chemical Additions and Analyses					
Conductivity					
Caustic Neutralization System					
WATER SAMPLING AND ANALYSIS					
Sampling Techniques					
pH					
Conductivity					
Chromate					
Hydrazine					
Oxygen					
Run Analysis					
Spectrophotometer					
Flame Photometry					
ON-LINE MONITORS					
pH					
Conductivity					
Hydrazine					
Oxygen					
Sodium Ion					
CATHODIC PROTECTION SYSTEM					

Attachment 15

NAME ______________________________

SODIUM CHEMISTRY

TOPIC	OPERATIONAL KNOWLEDGE Systems & Proc. Signature (PCG)	 Date	 Emergency Sys. & Proc. Signature (SS)	 Date	EXAM COMPLETED Date
PRIMARY SODIUM					
Sodium Sampling System					
Plugging Temp. Indicators (Cell A)					
Vacuum Distillation Sampler (Cell A)					
O-H-T Module (Cell B)					
Equilibration Device (Cell C)					
PRIMARY COVER GAS					
Chromatographs					
Grab Samples					
Hydrocarbon Analyzer (CGCS)					
Anacon Oxygen Analyzer (CGCS)					
SECONDARY SODIUM					
Plugging Temp. Indicator					
Sodium Sampling					
Equilibration Device					
O-H Module					
HMLD's					
SECONDARY COVER GAS					
Chromatographs					
Grab Samples					