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Revision B

October 1965

Westinghouse Astronuclear Laboratory

WANEF OPERATIONS MANUAL

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Introduction

This manual contains the WANEF administrative controls, personnel responsibilities, and operating procedures. Also included in the manual are a brief description of the facility and its control and safety systems.

Changes to the Operations Manual which deviate from the limits specified in the operating limits document or from the intent of the currently approved Operations Manual must be reviewed by the Nuclear Safeguards Committee (NSC) and then together with the necessary supporting analysis referred to the Aerojet-General Corporation (AGC) and the Space Nuclear Propulsion Office (SNPO) with a request for approval. Changes to the Operations Manual which do not change the intent of the currently approved Operations Manual and do not exceed the limits of the operating limits document and do not introduce the possibility of an accident not analyzed in the Safety Report and do not increase the probability or the consequences of any accident analyzed in the Safety Report or its supplements, must be reviewed by the NSC and recommended by them for approval to the Project Manager. Recommendation for approval for such changes in the Operations Manual may be made to the Project Manager by an appointed subcommittee of the NSC providing that the decision is unanimous and action is documented and submitted to the Chairman of the NSC.

Copies of all changes and revisions to the Operations Manual will be sent to AGC and SNPO/C.

Operations will be conducted within the boundaries of this document, of WANL-TME-1295, "WANEF Operating Limits", and within the framework of WANL-TNR-099, "Safety Report for the Westinghouse Astronuclear Experimental Facility" and its supplements.

Chapter 1 - Administrative Controls

1.1 General

It is generally recognized that by their very nature, critical facilities require latitude in their operation. It is necessary, therefore, to establish carefully the ground rules under which facility operations are performed. Described below are the administrative controls which will ensure safe operation of WANEF. These controls coupled with the complete set of facility operating procedures of Chapter 5 will provide the required personnel and equipment safety.

1.2 Operating Standards

Presented below are the regulations governing the operations of WANEF. They cover certain personnel requirements and restrictions, safety instrumentation, and general operating regulations which specify procedural requirements for operations. Listed with each rule is a statement of the intent to be used in conjunction with the rule to aid personnel in adhering to the desired purpose of the rules.

1.2.1 Personnel Rules

Rule 1. The Scientist-in-Charge must approve all experimental, operating, fuel handling, and emergency procedures before they are put into effect.

Intent of Rule 1. The intent of this rule is to ensure that all procedures governing operations at WANEF receive a complete review by the Scientist-in-Charge prior to the issuing of the procedure so that he may compare it to the latest technical and programmatic requirements and to ascertain its consistency with AEC requirements, Nuclear Safety Committee decisions and management instructions.

Rule 2. An Experimentalist-in-Charge will be designated by the Scientist-in-Charge to execute each experimental procedure, and operating personnel will be notified of his identity.

Intent of Rule 2. To provide the required efficiency and safety in the WANEF experimental procedures, it is necessary that one competent person be assigned the overall responsibility for each procedure. This person will be responsible for all operations carried out during the experiment and will thus prevent the possibility of dual responsibility conditions from arising. The elimination of dual responsibility situations cannot be overstressed since, in conducting an experiment, situations may arise where independent crews may be performing modifications required of the experiment and if these crews are not properly coordinated, the end product of the modifications may be other than that desired.

Rule 3. All persons in the "Operational Areas" (See Figure 2.1) are subject to the direction of the Experimentalist-in-Charge. NOTE: The following areas are considered as "Operational Areas."

1. Test Cell	4. Fuel Vault
2. Labyrinth	5. Yard Area
3. Fuel Assembly Room	6. Storage Room

Intent of Rule 3. The intent of this rule is to assure that the Experimentalist-in-Charge is cognizant of all operations being carried out in the "Operational Areas" (Figure 2.1) and also to assure that dual responsibility does not occur from independent operations being performed by separate working teams. It is the responsibility of each person working in the various operational areas to contact the Experimentalist-in-Charge and receive his approval prior to beginning work.

Rule 4. During all critical experiments, at least three persons will be present in the control room. One shall be rated equal to or greater than Experimentalist and another equal to or greater than Experimentalist-in-Charge. The third person may be from the categories 1 through 8 of Section 2.5.1.

Intent of Rule 4. It is the intent of this rule to assure that the reactor is always adequately attended during operation. Reactor operation begins when the "Reactor Status Lights" are placed in the "Reactor On" condition. During the operation of the reactor, one and only one person will be in charge of the reactor operation. In no case may there be dual responsibility in the control room for reactor operations. The two qualified persons required in the control room (Experimentalist-in-Charge and Experimentalist) assures that the responsible person has available a qualified person with whom he can cross-check his decisions. The third person required in the control room is to be available for emergency action. Prior to beginning reactor operation, the three required persons in the control room must sign the Operations Log indicating that all conditions for reactor operation have been satisfied.

Rule 5. There shall be a person qualified as Reactor Operator in the control room at all times when the "Master Key Switch" is ON.

Intent of Rule 5. The purpose of this rule is to ensure that a person who is familiar with the reactor control systems and can interpret the indication on the various control channels be in the control room when the "Master Key" is in the console thus enabling the magnetic clutches to be energized. This rule shall be in effect during all operations where the Master Key is in the console even though other interlocks, such as the Cell Veto, prevents startup.

Rule 6. No person is to be allowed in the Test Cell while changes in the critical assembly are made remotely, if these changes are of a type that may credibly produce a condition of criticality.

Intent of Rule 6. Whenever any changes are made in the reactivity status of the core, there is a possibility that an accidental criticality could occur from a number of unpredicated events which, although they are

unlikely, are a possibility. In cases where manual changes in the reactivity status of the core are being made, a very deliberate sequence of operations is followed to prevent such a situation from arising. But in the case where remote changes are being made in conjunction with a core modification, or an experimental program, or a test of the reactor control system, no such procedure exists. For this reason, whenever remote changes in reactivity are being made, with the exception of those required by the "Daily Checkout", all personnel will be removed from the test cell prior to starting the change.

Rule 7. The critical assembly must be shutdown on demand of any member of the operating staff.

Intent of Rule 7. At any time during reactor operation if a condition is observed by any of the WANEF Operating Staff which is hazardous to personnel or equipment, that person may demand that the reactor be "Scrammed" and the person at the controls of the reactor must immediately scram the reactor. It is expected that this rule will govern any differences of opinion on hazards situations such that the reactor is shutdown until the difference is resolved. It is possible that, during reactor operation, personnel working in other areas of the facility may observe a condition that could be hazardous to personnel and equipment. This hazardous condition may or may not be directly connected to the operation of the reactor, but in any case, if the person observing the condition feels that the reactor operation should be terminated, he may demand that the reactor be "Scrammed" and the person at the controls must immediately scram the reactor.

Rule 8. Personnel not part of the WANEF Operating Staff will take no action affecting facility operation or safety without first obtaining the permission of the Scientist-in-Charge.

Intent of Rule 8. The operation of a critical facility requires that all operations which are carried out be according to a predetermined plan and that these operations be regulated to the extent that personnel safety is not compromised. The WANEF Operating Staff is aware of the regulations that apply and the methods to be employed in performing any tasks required of the various programs. This is not the case with visitors to WANEF whether they are there to perform a specific task or whether they are there just to observe operations. In some cases, what may seem like the proper method of performing a task to personnel not familiar with the present experimental program may, in fact, be dangerous to personnel or the facility. To prevent the occurrence of such situations, it is required that all personnel, not part of the WANEF Operating Staff (i.e., maintenance men), receive the permission of the Scientist-in-Charge prior to performing any work in any of the "Operational Areas" of the facility. The Scientist-in-Charge, after approving the requests of visitors, will ensure that the WANEF Operating Staff members concerned are notified of the presence of the visitors and their purpose for being at WANEF.

Rule 9. All facility personnel are required to be familiar with the facility emergency plans and equipment.

Intent of Rule 9. It is almost impossible to cover in any emergency plan, all the various events that could occur which would be dangerous to personnel or equipment. The emergency plan (Section 5.9) in use at WANEF covers some of the major emergency conditions in detail such as accidental criticality, fire, excursion, and also the emergency procedures are flexible enough to cover, in general, all emergency conditions. But, an emergency plan of action is of no use whatsoever if all the personnel are not completely familiar with, and have a complete understanding of the details of the plan. It is the primary intent of this rule to ensure that all personnel know precisely what actions are required of them in the event that an emergency condition arises at WANEF or at any other Waltz Mill Site facility. Also, since visitors at WANEF cannot be expected to know the emergency plan as precisely as the

WANEF Staff does, it is the responsibility of each member of the WANEF Operating Staff to ensure that each visitor assigned to him is safely removed from the facility under emergency conditions.

Rule 10. All experimental procedures and activities must be understood and agreed upon in advance by the Experimentalists participating in the experiment.

Intent of Rule 10. A necessary requirement for successful performance of any experimental procedure is that each individual participating in the program have a complete understanding of program objectives. The requirement, which ensures that safe practices are maintained and that the maximum benefits from the experiment are achieved, is primarily satisfied by completion of the Experimental Details Checklist by the Experimentalist. A thorough understanding of the experimental plan promotes safe practices in that it ensures that each participating person has read and understood the experimental plan and know precisely what his task is in the overall plan. Also, by each person reviewing the experimental plans, prior to the start of a test, the methods employed in conducting the test receive a final review insofar as their safety aspects are concerned. Another important reason for reviewing and agreeing on the plans prior to the start of the experiment is to ensure that all participating members know precisely what experimental data is required to satisfy the test objectives. Anomalies in experimental data can then be recognized and potentially dangerous operational situations can be avoided.

Rule 11. Two persons authorized and instructed by the Scientist-in-Charge must be present when the reactivity of the reactor assembly is being changed by adding, removing, or re-arranging material. One of the persons at the reactor assembly must be qualified as Experimentalist-in-Charge and must inspect the critical assembly before, during and after any changes in core loading. A third person qualified as reactor operator must be on duty at the console.

Intent of Rule 11. It is possible, by improper handling of a core change, that an unsafe core configuration could be assembled. This type condition could be generated in a number of ways, with the most common errors being inadequate guidance of the personnel making the change, improper maintenance of change records, and inadequate inspections before, during and after the changes. To prevent such conditions from arising at WANEF, the above rule has been formulated and its primary intent is to ensure that the following practices are maintained:

- 1) All adjustments in the core are performed only by those personnel who have been adequately trained and authorized by the Scientist-in-Charge.
- 2) Complete records indicating each individual core change will be maintained by the reactor operator in the control room. Each change will be indicated on the record immediately upon completion of the change.
- 3) Upon completion of the core change a person qualified as Experimentalist-in-Charge will examine the core and the change records to ensure that they have been properly completed.

Since the performance of manual core adjustments is made on a reactor of very low shutdown, it is considered that this operation deserves at least the minimum personnel coverage required for remote operation. Instrumentation for neutron multiplication is also required and its operability must be assured prior to any manual change.

Rule 12. Two persons authorized and instructed by the Scientist-in-Charge must be present when fuel elements are being handled, assembled, or disassembled, in the fuel storage and/or fuel assembly areas.

Intent of Rule 12. Since it is possible that errors in the handling, assembling or disassembling of fuel materials can result in conditions which potentially can lead to nuclear hazards, effort must be made to minimize the possibility of such errors. Thus, two authorized persons must be present when such operations are performed to provide some measure of cross-checking actions and decisions.

Rule 13. Names of persons authorized by the Scientist-in-Charge to be contacted in emergency situations in the test cell, fuel storage area, or the fuel assembly area will be posted outside of these areas in a location that is accessible to the security guards.

Intent of Rule 13. The primary purpose of this rule is to provide the security guard or other personnel with a list of personnel who are thoroughly familiar with the various areas in case there is an emergency in that area. By doing this, the time required to contact a person who knows the area and thus knows what actions should be and can be taken for various types of emergency conditions, can be kept to a minimum. By this assignment, one can minimize the possibility of untrained personnel performing corrective procedures that could extend the hazards.

Rule 14. The maximum number of personnel allowed within three feet of the pressure vessel or critical assembly during any test cell activity, shall be approved by the Scientist-in-Charge and shall be the more restrictive of (a) three (3) persons or (b) a number consistent with the minimum shutdown of that particular reactor.

Intent of Rule 14. It is calculated that the reactivity effect produced by one person in the near vicinity of the PAX or the FCX type cores is of such magnitude that under certain conditions where a number of persons are near the core the shutdown of the core could drop to a value which would violate the minimum shutdown required by the WANEF Operating Limits. A further consideration in this area is that any part of a human body or other hydrogenous material can cause a significant reactivity increase by insertion into the nozzle end of the core or into a hole left by the removal of a cluster. Continuous vigilance must be exercised to prevent this occurrence. It is the primary intent of this rule to limit the number of people to a safe reactivity value and also as a secondary consideration the number of people is limited to minimize confusion in the difficult task of inventory control and criticality prevention.

Rule 15. The maximum number of personnel allowed in the Control Room at any time when the "Master Key Switch" is ON shall be four persons, one of whom must be a qualified Reactor Operator.

Intent of Rule 15. The intent of this rule is to limit confusion in the control room when the operating staff is in the process of checking-out, starting up, or operating the reactor. Personnel not required in the control room can observe operations through the large window in the control room wall.

Rule 16. At all times when the cover is not on the PAX reactor and operations requiring persons in the Test Cell are in progress, a minimum of two authorized persons must be in the cell.

Intent of Rule 16. The primary intent of this rule is the protection of personnel in the Test Cell. Since operations in the Test Cell are by nature potentially hazardous, it is desirable to have a minimum of two individuals in the cell at all times when work is in progress. This provides a measure of protection in that if any hazardous condition arises, a man is available to sound the alarm and take whatever other steps required to protect the personnel in the cell. Also, this rule provides a method for cross-checking work and decisions.

1.2.2 Safety Devices and Instrumentation Controls

Rule 1. The required minimum operational instrumentation for reactor operation shall include:

- 1) One source range neutron - sensitive detector and indicator with associated "flux-up" interlock.
- 2) Three neutron-sensitive detectors driving amplifier systems with the capability of flux level monitoring and including one period and three flux level scrams. Two of the channels must be recorded and the source level must be visible on at least one of the recorded channels.
- 3) Three BF_3 data channels capable of monitoring the loading operations are also required for the initial approach to critical of any new core.
- 4) One gamma monitor with high level alarm.

Intent of Rule 1. It is the intent of this rule to ensure that the required minimum instrumentation for safe operation of the reactor be available at all times when reactor operation is contemplated. During startup of the reactor, it is required that a startup range channel be functioning properly and that

this channel be so interlocked that reactor startup is prohibited if the required count rate is not obtained.

Three level channels and one period channel are required at all times to provide a multiplicity of shutdown signals to scram the reactor in case of excessive reactivity additions. In addition, two of the channels will be displayed on a recorder and at least one channel will be of such sensitivity that it displays the source level on the recorder prior to startup. The limits at which scrams will be initiated should, in general, be set as low as possible. This condition should be satisfied on safety channels required by this rule. Sensitivity adjustments, if any, on safety instrumentation channels should be designed or located so that a channel cannot be inadvertently made inoperative by adjustment of the sensitivity control. Safety channels have been designed and tested to assure that they do not saturate in the operating range for which they are affording protection. When utilizing equipment with damping controls, these controls should be set to provide the minimum amount of damping consistent with operational requirements of avoiding excessive scrams from spurious noise signals.

Rule 2. The test cell shall include equipment designed to protect personnel in the cell from inadvertent radiation exposure. Specifically, the following items are included in the test cell design:

- (1) Means shall be provided in the test cell for manual activation of shutdown system.
- (2) An audible indication of source range multiplication is required for operations involving personnel in the test cell. An extension of this circuit shall provide an audible indication in the control room.
- (3) A test cell area-to-control room intercommunication system shall be in operation and be of sufficient sensitivity so that communications or noise from any part of the test cell area which might indicate an emergency can be heard clearly in the control room.

- (4) A neutron-source-out-of-storage indicator will be conspicuously located in the test cell area.
- (5) An audible alarm system will be available to indicate to area personnel that reactor operation is about to begin.

Intent of Rule 2. Protection of personnel from radiation hazards is of the utmost importance in the operation of a critical facility. Shielding walls and exclusion fences are used to ensure that there is no hazard to anyone outside of the exclusion area during normal reactor operation. Also, warning lights are provided inside the exclusion fences to warn personnel outside the test cell of possible hazardous conditions. In the test cell itself an additional problem exists since during operations in the cell radiation conditions could arise which would be hazardous to personnel. This problem is intensified in that several separate operations could be in progress in the cell at the same time and since it is not possible to see all points in the cell from any single location, personnel in one group could be subjected to high radiation levels caused by the other group. Although personnel are trained to inspect the test cell and warn all persons prior to commencing any operation involving a radiation hazard, it is conceivable that a person out of sight may not be warned. To prevent this type of incident from occurring and to alert personnel of a possible hazardous condition before it actually occurs, the safety devices listed above are specified as the minimum requirement for any test cell operations. These devices provide both visual and audible warning to personnel in all areas of the cell whenever any changes in the radiation levels in the cell occurs. Also to protect personnel from an inadvertent reactor startup from the control room, a CELL VETO is provided in the test cell and this VETO can override any attempt to start the reactor.

Rule 3. Radiation monitoring instrumentation for the protection of personnel in the various areas where radioactive materials are present shall include:

- (1) Gamma monitors in each such area, set to alarm at a level consistent with Federal Regulations or, if in the Test Cell, at 100 mrem/hr.
- (2) Portable survey instruments in the control room.
- (3) A manually actuated general alarm.

Intent of Rule 3. The protection from radiation hazards of personnel working in the various areas where radioactive materials are present is of the utmost importance. It is the intent of this rule to ensure that this protection is provided at all times by the radiation monitoring equipment. If at any time it is found that the stationary gamma monitor in any particular area is not functioning properly, operations in that area will be halted until adequate portable instruments are available. Also in the event that a portable instrument is being used in any area, for purposes of monitoring an operation, whether or not it is replacing a stationary monitor, there shall be a minimum of two persons in the area. The function of the one person will be to monitor the radiation levels while the other person performs the required operation.

Rule 4. Each component or system which affects the safety response and operation of the facility will undergo periodic maintenance and calibration to ensure its operational integrity.

Intent of Rule 4. It is the primary purpose of this rule to ensure that all systems which affect the safe operation of the facility are maintained in an operational condition. In particular these systems include the shutdown systems, the safety and interlock circuits and the radiation monitoring system.

1.2.3 General Operating Procedures

Rule 1. Before any critical experiment is performed, standard operating procedures including hazards considerations must be developed and appropriately approved.

Intent of Rule 1. It is the intent of this rule to ensure that each experiment is given considerable review prior to the initiation of the experiment. Such a review is provided by the execution of the Experimental Details Checklist. Also, by providing an experimental procedure for each experiment, an established method for performing the particular experiment is set forth. Using this method all the personnel involved in the experiment can review the procedure and thus gain an understanding of exactly what the objectives of the experiment are and the method to be used in accomplishing these objectives.

Rule 2. Each day, prior to beginning experimental operations, satisfactory operation of all pertinent systems must be demonstrated and recorded. A system checkoff sheet will be employed and logged.

Intent of Rule 2. It is the intent of this rule to be sure that the reactor is always adequately reviewed and checked out for operation. It is the Scientist's-in-Charge responsibility to see that these checkouts are performed by qualified personnel. This checkout will be done under the cognizance of a person qualified as Experimentalist or higher. The pre-startup checkout forms for the reactor will be signed personally by the Experimentalist-in-Charge prior to the start of the reactor operations.

A visual check of the facility and core by the Experimentalist-in-Charge, as well as a check of safety instrumentation, will be made any time operations are interrupted and personnel could have had access to the core assembly.

Rule 3. Each approach to critical after a major core change on a new core must be accompanied by neutron multiplication measurements, which can be used to predict the point of criticality by appropriate extrapolation. During the fuel loading phase of initial criticality, a special loading source will be utilized.

Intent of Rule 3. A requirement for the safe operation of an experimental critical facility is that a core's critical condition must be predictable within reasonable limits. The prediction should be based on experimental results supplemented by calculations. It is the intent of this rule to provide the

experimental basis, that is, a series of subcritical multiplication measurements for a prediction of the critical condition for a new core. The various sub-critical conditions should be obtained by changes in fuel and poison loading, geometry changes, and changes in control element position. The procedure should be such that at the end of each step the experimental values of the next step can be predicted by extrapolation. The selected values for the next step, based on the extrapolation, should not exceed the amount to go one-half the distance to criticality. The final increment is then selected by the Scientist-in-Charge or the Experimentalist-in-Charge such that criticality is achieved and the resulting period (if elements are fully withdrawn) does not exceed the facility limitations. For initial approaches to criticality, the first step will not exceed: (1) 20 percent of the initial poison content in the PAX reactors, or (2) 20 percent of the total number of clusters (fuel and reflector) required for criticality in the FCX reactor. In addition no more than 30 percent of the number of fueled clusters will be initially loaded for a reflected FCX core. Frequently, cores may be constructed or a loading change made using previously tested fuel or poison components. In such instances portions of the detailed approach procedure may not be necessary. The details will differ in specific cases. The Scientist-in-Charge must determine that the approach procedure selected for each core operated will prevent a surprise criticality.

Rule 4. Remote increases in reactivity shall be made in a safe and reversible manner wherein the rate of increase is less than the available rate of decrease.

Intent of Rule 4. It is the purpose of this rule to ensure that at any time when increases in the reactivity of the core are being made remotely the method used for inserting the positive reactivity be also capable of removing it at a faster rate than the rate of insertion.

Rule 5. Manual additions of positive reactivity can be made to the core only when the reactor is subcritical, and it has been clearly demonstrated that the reactor will remain subcritical throughout the operation.

Intent of Rule 5. The intent of this rule is to ensure that all manual changes in core reactivity are evaluated prior to making the change. The method of making manual changes to the core reactivity is covered by the "Manual Reactivity Change Procedure" of Chapter 5 in all instances when changes are to be made, the sequence of steps outlined in the procedure should be followed.

Rule 6. Reactivity may be added in only one manner at a time. The reactivity rates of insertion for the PAX and the FCX cores are as follows:

1. PAX - rate of insertion must not exceed 0.064\$/sec. when the core is shutdown by less than 2.8\$.
2. FCX - rate of insertion must not exceed 0.20\$/sec. when the core is shutdown by less than 10.0\$.

Intent of Rule 6. A critical assembly operator should not be expected to anticipate the effects of simultaneous additions of reactivity. There are circumstances under which it would be possible to increase reactivity by more than one method simultaneously, for example, when moving counters in the core or danger coefficient dynamic measurements. Normal operations will not allow such operational freedom unless all but one of the effects has been demonstrated to be very small. Under all circumstances, the combined reactivity insertion rate should not exceed that specified in the rule. The values of 0.064\$/sec. for the PAX cores and 0.20\$/sec. for FCX has been chosen as a maximum rate of reactivity insertion by any given manner. The conservativeness of this rate of reactivity insertion is justified by the following:

1. PAX (0.064\$/sec.)
 - a) it would take about 15 seconds to become prompt critical from the delayed critical condition,
 - b) a full second at the maximum rate produces a period of about 155 seconds, and,
 - c) the response time of the safety instrumentation for inserting control drums completely into the core is less than one second.

2. FCX (0.20\$/sec.)

- a) It would take about 5 seconds at the maximum rate to become prompt critical from the delayed critical condition but since the FCX is limited to a maximum excess of 0.50\$ the prompt critical condition could not be attained and thus the minimum period that could be attained would be about 5 seconds, and
- b) The response time of the safety instrumentation for inserting the control elements completely into the core is less than one second.

Rule 7. Criticality must be attained only by the motion of control elements.

Intent of Rule 7. Reactivity can be controlled more easily and in a more predictable manner with element motion than by any other means. Specifically, criticality shall not be achieved by the addition or the removal of experiments or other devices used to measure or monitor reactor parameters.

Rule 8. No core will be operated critical with a control element pattern which prevents achieving shutdown with a single control element stuck in the full out position.

Intent of Rule 8. Any core which is assembled in a manner that could produce criticality by the withdrawal of a single control element is to be considered as an unsafe configuration. In such a core not only should the "stuck rod" incident be considered but also in the event that personnel not aware of the present core loading, should, for maintenance or other purposes, begin checking drive speeds, etc., over the operating range of a control element a serious accident could occur

Rule 9. A "key box" that can only be opened by the Scientist-in-Charge or the Experimentalist-in-Charge will be provided for storage of the following keys:

- (1) Control console master key
- (2) Fuel assembly room key
- (3) Test cell access door key
- (4) Control element keys
- (5) PAX cover key
- (6) Labyrinth door key
- (7) Interlock panel key
- (8) Yard gates keys

Intent of Rule 9. It is the purpose of this rule to provide absolute control of critical areas and equipment by ensuring that the Scientist-in-Charge and/or the Experimentalist-in-Charge is made aware of the work in progress in the areas or on the equipment listed above.

Rule 10. Keys to the control element locks will be under the control of the Scientist-in-Charge or an Experimentalist-in-Charge at all times when not in the "key box" specified above. When fewer than twelve (12) control elements are operational in a reactor, the excess keys will be captured in the console by-pass key switches.

Intent of Rule 10. It is the purpose of this rule to ensure that the SIC and/or EIC is cognizant of all operations that require unlocking any of the control elements on either the PAX or FCX reactors. Also, as a guarantee against control elements of both reactors being in the unlocked condition at any given time, all control element keys not in use on one reactor will be captured in the console key switches.

Rule 11. Water or other liquids are not permitted in the test cell when a reactor is present except under one of the following conditions:

- 1) Required liquids are used in containers and with procedures such that it will be incredible for the fluid to get into the core. The Nuclear Safety Committee will review and recommend for approval the container design and the procedures to be used such that the incredibility of fluid getting into the core is assured.
- 2) When the reactors are shutdown, liquids may be used in limited amounts such that if the entire contents of the container is introduced into the core the reactivity insertion is $< 50\%$ in PAX and $< 1.00\%$ in FCX.

Intent of Rule 11. The presence of water or any other liquids in the test cell when a reactor is present presents a potentially hazardous condition arising from an accidental criticality. It is the purpose of this rule 1) to guarantee through proper container design and procedures that such liquids cannot get into the reactor, or 2) to limit the amount of such liquids to quantities which, if spilled into a shutdown reactor, could not bring it critical.

Rule 12. If an unanticipated reactivity change of the FCX occurs on a day-to-day basis, as evidenced by a corresponding change in rod bank and/or period measurements, which exceeds 0.20\$, the reactor shall be shutdown and the EIC notified and the situation evaluated. Attention is called to the fact that a change less than 0.20\$ will require reactor shutdown if the limit on K_{ex} is exceeded.

Intent of Rule 12. It is the purpose of this rule to ensure that a proper evaluation of the reactivity swing in the FCX reactor is performed on a day-to-day basis. The FCX can contain KIWI type fuel and on a day-to-day basis reactivity changes in the core may occur due to changing cell conditions. Since the FCX is limited to 0.50\$ K_{ex} , small changes in the core reactivity could cause the K_{ex} limit to be violated thus close surveillance of daily changes must be maintained.

1.3 Weekly Operational Memoranda

The Scientist-in-Charge of the operation of WANEF will prepare a weekly forecast of experimentation for the forthcoming week. This summary, known as the "Weekly Operational Memorandum" will be forwarded to the Manager, Reactor Analysis Department, with information copies to the Chairman of the Nuclear Safety Committee, and to the Waltz Mill Site Health Physics Supervisor. Also, the appropriate sections of the memorandum indicating expected radiation levels, etc., will be forwarded to the WREC Supervisor. The planned operations covered by the Operational Memorandum will not be commenced until the Memorandum and Experimental Details Checklist are approved by the Manager, Reactor Analysis. The Weekly Operational Memorandum serves several purposes. First, the Memorandum supplemented by the Experimental Details Checklist, provides the principal written means used by the Scientist-in-Charge in communicating with the Reactor Analysis Department on matters relating to nuclear safety. Secondly, it provides a means for the Nuclear Safety Committee to keep abreast of the experimental program. Furthermore, the Weekly Operational Memorandum broadly identifies the experimental plans to be followed along with a clear indication that these plans have been examined carefully and adequate shutdown is provided.

The Weekly Operational Memorandum is divided into two major sections as described below:

1. Prior Operations:

Under this section the operation covered by the period of the previous memorandum will be discussed. Mention should be made of unanticipated events occurring during prior operations such as loading errors, unusual mechanical troubles and scrams and other similar events. Also, mention should be made of the status of any experiments covered under the previous memorandum.

2. Proposed Operations:

In the section covering the proposed operations, specific statements should be made indicating the scope of the work to be performed in the forthcoming week. This statement should include the proposed experiments to be performed with expected power levels and should indicate the appropriate procedures involved in conducting the experiment. Also, in describing the experiments, the Scientist-in-Charge should include references to previous experiments, operational letters, and safeguards reports where appropriate.

Other items outside the scope of the experimental test plan should also be discussed in brief. These items could include such things as (1) status of modifications underway at WANEF, (2) proposed changes in operating procedures, (3) proposed changes in non-critical systems, and (4) changes in personnel responsibilities.

1.4 Logs and Records

1.4.1 General

Accurate records of all pertinent information concerning the operation of a facility is a necessity. This information offers not only evidence of adequate safe practices, but provides basic data sources of value in current operations and data which can be applied to future safe practices. This section has been written to provide a reference for standard practices to be used in using the various logs in use at WANEF.

1.4.2 WANEF Reactor Operations Log

The WANEF Reactor Operations Log is the primary evidence of compliance with the restrictions imposed by the WANEF Safety Report and any other restrictions placed on the facility operation by WANL or SNPO. Thus, it is

important that accurate entries are made in the Log and all pertinent information concerning the operation of the reactor is entered.

The Log will consist, where applicable, of one or more of the following completed forms which are chronologically filed and identified by consecutive page numbers:

- (1) Daily Checklist
- (2) Experimental Details Checklist
- (3) Manual Reactivity Change Checklist
- (4) Reactor Loading Sheet
- (5) Pre-Startup Checklist
- (6) Reactor Run Sheet
- (7) Periodic Maintenance Checklists

1.4.3 WANEF Facility Log

The WANEF Facility Log is a ledger type book in which daily events affecting, or possibly affecting, the operation of the facility are recorded. Entries in the Facility Log should be precise and should contain enough detail to provide clarity of the entry. Examples of some of the types of entries to be made in the Facility Log include: unusual occurrences during reactor operation or experimental changes; explanations of all unscheduled shutdowns including the causes and the corrective action taken; receipt of fuel; control system malfunction (noisy micromicroammeter); inspection tours; and power outages. Entries in the Log can be made by any WANEF staff member and should be identified by his initials.

NOTE: The facility log will be cross-referenced to the Operations Log, when required.

1.4.4 Experimental Details Checklist

The Experimental Details Checklist identifies the requirements and details of each experiment to be conducted at WANEF. The checklist, which is prepared

by an Experimentalist, describes the materials required, the hazards involved, the general method and the experimental procedure to be employed, and the data required to successfully complete the experiment. The Experimental Details Checklist (EDC) must be reviewed and recommended for approval by the Scientist-in-Charge (SIC). If the Manager, Reactor Analysis, decides that it is within the limits of this document, and is consistent with portions of one or more SOP's in the Operations Manual and does not involve either unevaluated questions of safety* or operations which are expected to exceed the radiation exposure limits (AEC Manual Chapter 0524), then he will approve it and send information copies to cognizant non-line personnel. If it does not fall clearly into this category, he must submit it to the NSC for review and a determination made as to whether or not it does fall into the above category. If the NSC finds that it does fall into the category, it will recommend for approval to the Project Manager. If the NSC finds, however, that it does not fall into the above category, a description of the experiment will be submitted to AGC and SNPO with a request for approval. The approval will include a supporting safety analysis and/or a description of the appropriate engineered safeguards.

* Unevaluated questions of safety exist if 1) there is a possibility of an accident occurring which has not been analyzed in the WANEF Safety Report or its Supplements, or if 2) there is an increase in either the probability of an accident previously analyzed or if 3) there is an increase in the consequences of an accident previously analyzed.

EXPERIMENTAL DETAILS CHECKLIST

TITLE OF EXPERIMENT:

OBJECTIVE:

EQUIPMENT REQUIREMENTS:

HAZARDS CONSIDERATIONS:

EXPERIMENTAL DETAILS: (OP - _____)

DATA REQUIRED:

EXPERIMENTALIST: _____ Date: _____

SIC: _____ Date: _____

MANAGER, REACTOR ANALYSIS: _____ Date: _____

Figure 1.1 Experimental Details Checklist

1.5 WANEF General Security Regulations

Access to the WANEF premises is governed by the security measures as summarized in this section. The WANEF facility is divided into two areas insofar as security and/or safety are concerned. These are:

1.5.1 Operational Areas

The WANEF Operational Areas are shown in Figure 2.1. Access to these areas or the reactor console master key requires the physical presence at WANEF of at least one of the following persons when fuel is present in that area:

- (1) Scientist-in-Charge
- (2) Experimentalist-in-Charge

The keys and lock combinations for all Operational Areas and the reactor control keys are kept in a safe assigned to the Scientist-in-Charge. The persons, as listed above, have the combination to this safe.

1.5.2 Non-Operational Areas

The areas at WANEF which are considered as Non-Operational Areas are shown in Figure 2.1. Access to these areas requires the presence of at least one WANEF Staff member. Listed below are the names and telephone numbers of the staff who are authorized to open the WANEF Non-Operational Areas:

1.	W.P. Kovacik, Scientist-in-Charge	TE 7-0494
2.	C.E. Barksdale, Experimentalist-in-Charge	UN 3-9213
3.	W.D. Rankin	653-5397
4.	W.E. Freidhof	WA 5-3268
5.	B. Jennings	GI 6-6661
6.	F.S. Frantz	653-5522
7.	J.J. Makovich	MU 4-3429
8.	G.E. Kubancsek	751-7903
9.	G.S. Thomas	722-4705
10.	H.D. Poe	461-1741
11.	R.W. Brawdy	WA 9-7012
12.	W.H. Williams	276-4910
13.	J.L. Greenawalt	628-1199
14.	Doris V. Christ	TE 4-8271

1.5.3. Security Checks

1.5.3.1 Facility Closed

When the building has been secured, the security patrolman will make periodic rounds throughout the entire "Non-Operational Areas", as previously defined, performing checks to ensure all desks, safes, classified files and doors providing access to "Operational Areas" or points of entry to the WANEF building are secured in accordance with the Industrial Security Manual. Guard reporting stations, utilizing Deltex keys and clock, are located at various points throughout the WANEF premises to ensure periodic checks in these areas. A checklist indicating all areas requiring inspection is provided and will be utilized on each periodic guard round. The Scientist-in-Charge is

responsible for all areas of the WANEF facility and will be notified by the guard in case of emergency.

Access to the WANEF premises is controlled during normal working hours by a "Card Lock" on the main entrance of the facility which permits entrance to only those persons who have a "WANEF Door Card." Persons other than the WANEF operating staff must ring the bell for admittance and upon entry will be handled according to Section 2.3, "WANEF Visitors." All Westinghouse Astronuclear employees shall be identified by picture badges issued and controlled by the Security Office, and the Westinghouse identification badge, which contains a photograph and identifying information. All other persons will be handled in accordance with the Industrial Security Manual. The Scientist-in-Charge shall act as Security Officer for WANEF.

Chapter 2 - Personnel Responsibilities

2.1 General

The protection of all personnel at a critical facility from nuclear as well as non-nuclear accidents is the responsibility of all persons connected with the operation of the facility. This protection should be of primary and continuous concern to all managers and supervisors whose organizations provide personnel to assist in the operation of the facility.

The purpose of this section is to set forth the responsibilities of the personnel insofar as safety is concerned and to indicate the various methods to be employed in ensuring personnel safety.

2.2 Project Line Responsibility

2.2.1 General Responsibility - Scientist-in-Charge

The direct responsibility for preventing injury to personnel at WANEF rests with the Scientist-in-Charge. He is responsible for ensuring that no accidents or injuries to personnel result from the operation of the facility or reactors. Within the latitude of the minimum safeguard requirements which have been established by WANL policy and AEC regulations, the Scientist-in-Charge has the authority to institute whatever provisions he deems necessary to discharge his safety responsibilities. In no case may he deviate from the safety measures which have been established by WANL management as in the posted rules, or the WANEF Safety Report. Whenever, in the judgment of the Scientist-in-Charge, conditions exist in the area of the reactor which compromise the principle of absolute personnel safety, he will not start up the reactor, or if operating he will shutdown and take whatever corrective action required to eliminate the unsafe condition.

2.2.2 Specific Responsibilities of Scientist-in-Charge

The following represents a detailed assignment of the responsibilities, authorities and accountabilities of the Scientist-in-Charge necessary for the safe operation of the facility and reactors.

2.2.2.1 The Scientist-in-Charge is responsible for:

1. Safe operation of the WANEF facility.
2. Reviewing the WANEF Experimental Details Checklist and procedures and approving those which fall within bounds of this manual and which do not represent an unevaluated safety question.
3. Requesting reviews by the WANL Nuclear Safety Committee of all procedures which require changes in this manual or the "WANEF Operating Limits" document or which involve an unevaluated safety question.
4. Requesting review and a recommendation for approval by the WANL Nuclear Safety Committee for changes in this manual.

2.2.2.2 The Scientist-in-Charge is authorized to:

1. Approve the Experimental Details Checklist and submit copies to the Manager, Reactor Analysis, and the test requester.
2. Execute the weekly program approved by the Manager, Reactor Analysis.
3. Approve procedures which fall within the bounds of this manual and do not represent an unevaluated safety question.
4. Approves modifications and additions to the WANEF facility which do not represent an unevaluated safety question.

2.2.2.3 The Scientist-in-Charge is accountable for:

1. The safe operation of the WANEF facility.
2. The existence of an approved Experimental Details Checklist and procedure for each reactor operation, reactor experiment and reactor modification.
3. Obtaining reviews by the WANL Nuclear Safety Committee of all:
 - a. Changes in this manual.
 - b. Modifications and additions to the WANEF facility representing an unevaluated safety question.
4. Obtaining a semi-annual review by the WANL Nuclear Safety Committee of the WANEF program for the next six months.

2.2.3 Specific Responsibilities of Experimentalist-in-Charge

The Experimentalist-in-Charge is responsible for execution of approved programs including reactor operation in accordance with the approved procedures and is authorized to conduct such programs in the absence of the Scientist-in-Charge.

2.3 WANEF Visitors

All visitors to WANEF will be required to sign a "Visitors' Register" upon entering the Waltz Mill Site and will be given two pocket dosimeters which must be worn at all times on the site. Additional visitor sign-in is required at WANEF for security and personnel safety. Dosimeters can also be obtained at WANEF.

NOTE: The term "visitor" is used to designate all persons for whom "personnel monitoring equipment" (WANEF film packs) are not provided on a routine basis. In addition to the "Visitors' Register, " all visitors who require entry into any of the "Operational Areas" as defined in Figure 2.1 or the control room will be required to have an escort. The escort must be a permanent member of the WANEF Operating Staff. Prior to entering any "Operational Area," the approval of the Scientist-in-Charge must be obtained and while

Figure 2.1 WANEF Operational Areas

in the area the visitors will comply with the specific instructions given them. Also, uncleared visitors to WANEF will be escorted by a member of the WANEF Operating Staff at all times while at the facility.

2.4 Health Physics

Health Physics coverage for the WANEF operations is provided by the Waltz Mill Site Health Physics Section. This section is responsible for all normal health physics functions at the Waltz Mill Site including the advising of operating personnel on health hazards incident to the handling, use of and exposure to radioactive material and their associated ionizing radiation. The site Health Physics Section also has the authority to "stop" any operation that it feels is hazardous to the operating personnel, until necessary corrective measures are taken to ensure personnel safety. In addition, the site Health Physics Section is responsible for ensuring that adequate steps are taken to ensure compliance with appropriate Federal and Commonwealth radiation regulations.

As a supplement to the health physics coverage as described above, a Health Physics Manual will be used by the WANEF facility as a guide to safe operations. This manual, with which all WANEF personnel will be required to be familiar, will include standards, procedures, and regulations intended as precautionary measures to govern all work involving radiation or contamination hazards.

2.5 Operating Staff

2.5.1 General

An important part of the safe operation of any critical facility is the clear designation of the personnel responsibilities and limitations. To ensure that all personnel are cognizant of their responsibilities and that each person is properly qualified for the position he holds, a list of position descriptions and the required minimum qualifications for each position is presented below.

2.5.1.1 Scientist-in-Charge (WANEF Supervisor)

The Scientist-in-Charge has the overall final responsibility for the operation and safety of the WANEF. He makes decisions concerning personnel employed, operating procedures, equipment purchased, visitors admitted, personnel training program, and all other matters that concern the safe and efficient operation of the WANEF. These decisions are subject to review and approval by higher management, but this does not relieve him of the final responsibility for the decisions.

2.5.1.2 Experimentalist-in-Charge

The Experimentalist-in-Charge assists the Scientist-in-Charge in meeting his responsibility for reactor operation. He has the authority to execute the experimental plan established by the Scientist-in-Charge, but not to change it in any way.

2.5.1.3 Experimentalist

The Reactor Experimentalist assists the Scientist-in-Charge or the Experimentalist-in-Charge to execute the experimental plan.

2.5.1.4 Reactor Operator

A Reactor Operator can be authorized to change the reactivity of a critical experiment from the control console as instructed by the designated Experimentalist-in-Charge. A Reactor Operator must be qualified to act in this capacity through training and formal qualification.

2.5.1.5 Operator-in-Training

An Operator-in-Training is the lowest category of personnel who can change the reactivity of a critical experiment from the control console. He is only permitted to operate the control console under the direct supervision and control of the Experimentalist-in-Charge.

2.5.1.6 Fuel Handler

The duties of the Fuel Handler include assisting with the loading and unloading of reactor fuel, poison wires and other operations dealing with changes to the reactor assembly. The Fuel Handler is only permitted to make changes in the reactor under the direct supervision of the Experimentalist-in-Charge and in accordance with a written procedure defining the changes and the sequence to be followed in making the changes.

2.5.1.7 Technicians

The duties of the technicians are to assist the above personnel in the performance of the experimental program. These duties include fabricating and maintaining experimental equipment, taking experimental data, and performing any other work necessary for the proper performance of the reactor and its associated equipment. Those technicians who show promise of becoming reactor operators are trained under the supervision of qualified personnel. When they demonstrate their competence and reliability in operating the reactor to the satisfaction of the WANEF supervisor, they may be given qualification tests to become Reactor Operators.

2.5.1.8 Other Personnel

Non-technical personnel provide additional program assistance. These include a secretary for correspondence, filing and other related administrative functions; a handyman-chauffeur for transport and messenger service; health physics technician; and other personnel required for the normal functions and upkeep of the facility.

2.5.2 Position Qualifications

To aid the Scientist-in-Charge in selecting personnel to fill the various categories of responsibility as described above, the following minimum qualifications have been established for the positions in the operation of the reactors.

2.5.2.1 Fuel Handler

Those technicians who, through past performance, have demonstrated that they possess the following characteristics will be designated as Fuel Handlers:

1. A mature and stable character.
2. An ability to understand and follow instructions.
3. An understanding of the potential hazards involved in fuel operations.

2.5.2.2 Operator-in-Training

Selected and approved by the Scientist-in-Charge on the basis of previous performance record. In addition, he must possess the characteristics of the Fuel Handler and have a detailed knowledge of the reactor control system.

2.5.2.3 Reactor Operator

1. Operator-in-Training for at least three months, during which time he has completed fifteen reactor checkouts, ten approaches to critical and thirty hours of critical operation under the direct observation of at least an Experimentalist-in-Charge. It is intended that the approach time be included in the thirty hours of reactor operation.
2. Demonstrate familiarity with the reactor, its systems, and its operation.

3. Pass an oral, written, and operating examination equivalent to those given by the AEC.
4. Approved as Reactor Operator by the Scientist-in-Charge.

2.5.2.4 Experimentalist

1. An Experimentalist must satisfy the requirements for Reactor Operator as given above and in addition must hold a bachelor's degree or have had equivalent training.
2. Approved as Experimentalist by the Scientist-in-Charge.

2.5.2.5 Experimentalist-in-Charge

1. An Experimentalist-in-Charge must satisfy the conditions for Experimentalist and in addition hold a master's degree or have had equivalent training.
2. A person qualified as Experimentalist-in-Charge shall have a detailed knowledge of the critical facility. His judgment and understanding of the facility and its programs shall be such that the Scientist-in-Charge may delegate the performance of experiments to him with confidence that they will be performed safely and efficiently.
3. Pass an oral review by an examining board composed of the Scientist-in-Charge, Chairman of the Nuclear Safety Committee and Supervisor of Safeguards Engineering.
4. Approved as Experimentalist-in-Charge by the Scientist-in-Charge.

2.5.2.6 Scientist-in-Charge

1. The Scientist-in-Charge must be a qualified Experimentalist-in-Charge.

2. The Scientist-in-Charge must be a Supervisor of mature judgment, with a general knowledge of reactor physics and safety procedures, experimental physics background, and a specific knowledge of the design objectives of the project. He shall have the ability to train personnel assigned to him and to instill in them a cautious attitude with regard to safe experimental procedures.
3. Appointed by the Project Manager.

2.6 Training

In addition to the qualifications identified in Section 2.5.2, a formal sequence and demonstration of competence is required for each progressive step of staff responsibility. The staff position along with the documentation with which a person must show detailed knowledge before appointment to the position is given below.

Demonstration of the knowledge is judged by the Scientist-in-Charge except where the document is followed by the work "Test".

- 2.6.1 Technician - Health Physics Manual, Security Manual, Emergency Procedures, Operating Standards.
- 2.6.2 Fuel Handler - As in 2.6.1 plus criticality guidelines for NERVA fuel.
- 2.6.3 Operator-in-Training - As in 2.6.2 plus WANEF Safety Report (Test).
- 2.6.4 Operator - As in 2.6.3 plus Training Manual (Test) Operator's Examination (Test)
- 2.6.5 Experimentalist - As in 2.6.3 plus Operator's Examination (Test).
- 2.6.6 Experimentalist-in-Charge - As in 2.6.5 plus Review Board (Test).

Chapter 3 - Facility Description

The description of the WANEF facility is limited, in this presentation, to a number of figures which show the location of the WANEF buildings and the various systems which make up the WANEF service systems. If a more detailed description of the site and the meteorological conditions existing at the site are desired, reference should be made to the WANEF Safety Report (WANL-TNR-099) which covers these areas in detail.

3.1 Site Description

The following figures indicate the location of the WANEF facility in relation to the various other operations at the Waltz Mill Site.

Figure 3.1 Waltz Mill Site Layout

Figure 3.2 WANEF-WREC Building Layout*

Figure 3.3 WANEF Facility Layout

3.2 Service Systems

The various systems which service WANEF are presented in this section. These systems, where applicable, are accompanied by a brief description of their operation and functions. The systems covered are as follows:

The Utility Water System

The Electrical System

The Heating and Ventilation System

The Natural Gas System

*WREC is an acronym for Westinghouse Reactor Evaluation Center; an operation of the Westinghouse Atomic Power Division

3-2

SHUTDOWN FACILITIES

Figure 3.1 Waltz Mill Site Layout

3-3

LEGEND
CONCRETE

610789-8B

Figure 3.2 WANEF-WREC Building Layout

Figure 3.3 WANEF Facility Layout

Figure 3.4 City Water System Layout

Figure 3.5 City Water System Schematic

Figure 3.6 Location of Power Distribution Panels

Figure 3.7 Electrical System Schematic

Figure 3.8 Heating and Ventilating System Layout

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Figure 3.9 Ventilating System Schematic of Assembly Room-Vault Area

Figure 3.10 Heating and Ventilating System Schematic of Test Cell

Figure 3.11 Location of Fire Extinguishers

Figure 3.12 Natural Gas System Layout

Figure 3-13 Natural Gas System Schematic

Chapter 4 - Control and Safety Systems

4.1 General

The design and operation of the nuclear control and safety systems is a major factor in the safe operation of the critical facility. Presented below is a brief description of the systems employed at WANEF to insure safety in the operation of the facility. For a more detailed presentation of the nuclear instrumentation reference should be made to the WANEF Safety Report - WANL-TNR-099.

4.2 Nuclear Instrumentation

A block diagram of the nuclear instrumentation is shown in Figure 4.1. As can be seen from the figure, the system is composed of one BF_3 startup channel, three linear level channels, and two log level channels. The design of the system provides the following safety features.

1. A minimum of two linear level, one log level, and one period scrams for all operations.
2. A "patch panel" arrangement is provided to switch the control and detector system from the PAX reactor to the FCX reactor. This patch arrangement, shown in Figure 4.2 prevents operation of either reactor if any of the "patch panels" are not properly aligned.
3. Display of one linear and one log channel on a recorder.
4. Speakers located in both the control room and the test cell to provide an audible indication of the count rate.
5. A "Flux-up" interlock on the startup range channel which prevents control drum movement below the minimum 120 CPM count rate.

In addition to the nuclear instrumentation system as shown in Figure 4.1, an experimental system is available for use during experimental operation of the reactor. This system consists of three BF_3 channels and their associated equipment.

Figure 4.1 Nuclear Instrumentation Block Diagram

K16 - PAX SELECT RELAY
 K17 - FCX SELECT RELAY
 K-5 - KEY SWITCH
 K15 - TIME DELAY RELAY
 K24 - KEY CAPTURE BYPASS CIRCUIT RELAY
 K50 - AC POWER RELAY
 K51 - BYPASS REPLY

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Figure 4.2 PAX/FCX Patch Panel Logic

4.3 Control Element Drive System

A functional presentation of the control element drive system is given in Figure 4.3. The system design has incorporated a number of features which insure that the required safety of operation of the system is maintained. These features are as follows:

1. All actuating drive switches are spring loaded in the deenergized direction to insure that positive pressure is necessary to add reactivity to the core.
2. All actuating "IN" switches must always have the capability of driving the control element "IN" regardless of the operating conditions.
3. The control element "IN-OUT" switches are designed to allow only one element to be moved in an outward direction at a time. This can be seen in Figure 4.4.
4. Relays inserted into the system must be energized to add reactivity. Relay failure interrupts the operation.
5. The control element speeds are designed to allow speeds from 7.5 degrees/minute to a maximum of 90 degrees/minute for PAX and 5 inches/minute to 40 inches/minute for FCX. Also, the speed changes are provided in five equal steps.
6. In the event that a motor overload condition arises due to a "stuck rod" or other malfunction, the control elements automatically scram and the drive motor power supply is turned off automatically.
7. Each control element is equipped with a "capture key lock" and prior to "withdrawal" of the element, the key must be in the lock.
8. Prior to withdraw of any control elements, the "flux up" interlock and the "warning horn" interlocks must be satisfied.
9. The control element drive is coupled to the control element through an electromagnetic clutch which must be energized to permit withdrawal. Power or electromagnet failure results in the rapid insertion of the control element.
10. Multiple control element insertion is possible by depressing one switch which energizes all drives in the "IN" direction.

Figure 4.3 PAX and FCX Control Element Drive Circuit

Figure 4.4 Control Drum In-Out Switch Operation

11. In Table 1 are given the interpretation of the FCX status lights (IN and OUT limits, SCRAM, and MAGNET lights) for various FCX rod conditions. These are compared to the PAX control element status light and the differences noted.

TABLE 1
FCX STATUS LIGHT CONDITIONS

CONT ON	Magnet	Rod	Rack	IN Light	OUT Light	SCRAM Light	Different from PAX
on	E.	full in	full in	on	off	off	no
off	deE.	full in	full in	on	off	on	no
off	deE.	full in	full out	off	off	on	yes
on	E.	full out	full out	off	on	off	no
on	E.	full out	full out	off	off	off	no

4.4 Scram Circuits

Figure 4.5 shows a simplified schematic of the scram circuits that have been incorporated in the design of the WANEF control and safety systems. The system has been designed to provide the following safety features.

1. Individual control element scram switches are provided to allow one control element or any combination of elements to be scrammed. This feature provides flexibility in the experimental operation of the reactor.
2. Heavy duty scram relays (K21, K22, and K23) are provided for total scrams. These relays each have two normally open contacts wired in series in the positive leg of the magnet power supply to reduce the possibility of the failure of scram action due to contact welding. Also, the normally open contacts insure that a scram occurs under a condition of power or component failure.
3. All relay contacts which indicate a scram under abnormal conditions are normally open contacts and must have power applied to the relay to pick up the contacts.

4.5 Interlock System

The interlock system has been designed to insure that all critical items required for the safe operation of the reactor are properly aligned prior to commencing reactor operation. Also, if any critical item becomes misaligned during operation of the reactor, the operation will be automatically terminated.

The various items interlocked and the method of interlocking are tabulated in Table I.

To provide the flexibility required in the maintenance of such reactor systems as the control element drive system, bypasses have been provided for a number

Figure 4.5 Simplified Scram Circuits - Functional Logic

TABLE 2
Scram and/or Interlock Conditions

<u>Interlocked</u>	<u>Method</u>	<u>Scram Condition</u>
Reactor Power	Electronic Trip	High power on either of two controlling linear compensated ion chamber channels.
Reactor Power	Electronic Trip	High power level on the controlling Log N compensated ion chamber channel.
Reactor Period	Electronic Trip	Short period on the controlling reactor period compensated ion chamber channel.
Test Cell Veto	Manual Switch	Opened and reset manually by operating personnel. Located adjacent to the test stand in the test cell.
Door Interlock ¹	Limit Switches	<p>Opening one of the interlocked doors or gates. These interlocks are in series and all must be satisfied to close relay K-22. Switches are located on:</p> <ul style="list-style-type: none"> Door at entrance to test cell labyrinth. Personnel door to test cell. Rear truck door to test cell. Emergency exit - south side of WANEF. Gate between WANEF and WREC. Gate in front fence. Truck door in storage area. Personnel door to storage area.
Control Element Drive Motor Current	Simplytrol Meter	25% overload of normal motor operating current.
Console	Key Switch & Manual Scram Button	Key off or buttons depressed.
Control Element Drive	Relay Microswitch On Recorder	Either a minimum source range count rate or minimum level on recorder must exist for power to be supplied for outward motion of control elements.
Neutron Source	Relay	Reactor status must be "Reactor On" to permit any motion of the neutron source.

Bypasses exist for:

¹ Door Interlocks

² Minimum count rate - when bypassed, Simplytrol meter limits current to supply only one magnet.

of the interlocks. These bypasses have been designed in such a manner that reactor operation is not possible whenever any interlock is bypassed. This is accomplished by limiting magnet current to that required for one magnetic clutch and by requiring that eleven of the twelve control element drive keys be inserted in a special capture key lock prior to bypassing an interlock circuit. A master bypass switch is provided to override all door interlocks simultaneously.

4.6 Radiation Monitors

Located throughout the facility, as shown in Figure 4.6, are a number of gamma radiation detectors which provide an immediate audible alarm in the event of high radiation levels resulting from accidental nuclear criticality.

Each monitor, as shown in Figure 4.7, consists of a gamma sensing ion chamber detector, a local indication and alarm, and an indication and alarm in the Control Room. The system is provided with a standby emergency power supply which is automatically switched in when the line voltage decreases to approximately 70% of its normal value.

Figure 4.6 Location of Radiation Monitors

Figure 4.7 Radiation Monitors Block Diagram

Each detector is equipped with an Sr^{90} calibrating source to enable remote calibration of the detectors and a variable alarm setpoint. The ranges of the various channels and their set points are as follows:

Channel No.	Location	Range	Typical Alarm Setpoints
1	Test Cell	0.01R/hr to 10,000 R/hr	0.1 R/hr
2	Test Cell	0.01R/hr to 10,000 R/hr	1.0 R/hr
3	Counting Room	0.001R/hr to 1.0 R/hr	0.02 R/hr
4	Fuel Assembly Room	0.001 R/hr to 1.0 R/hr	0.02 R/hr
5	Fuel Storage Room	0.001 R/hr to 1.0 R/hr	0.02 R/hr

In addition to the five (5) area monitors listed above, an air monitor samples air in the Test Cell on a continuous basis. This monitor has a range from 50 to 50,000 CPM and will provide a local and remote (Control Room) alarm if the airborne activity level exceeds 10,000 CPM.

Chapter 5 - Standard Operating Procedures (S.O.P.)

OP-5.1 Daily Checkout Procedure

5.1.1 General

The daily checkout procedure ensures that a systematic check of all instrumentation necessary to the safe operation of the reactor is completed on a routine basis. Listed below are the conditions under which the check-out must be completed.

1. Daily
2. Prior to reactor operation if the reactor has been shutdown for more than eight hours.
3. At any time when changes to the reactor and/or systems have been made which may have affected the calibration of any safety system a recheck of the affected systems will be made according to the checkout procedure.

It is essential that the person completing the checklist understand the importance of each item included on the checklist and the method to be used in completing the check. Presented below are the proper methods to be followed in completing the checklist. After completing each of the checks covered below, the person making the check will indicate that the check has been successfully completed by indicating in the appropriate blank on the "Daily Checkout" form.

5.1.2 Power Checks

5.1.2.1 Console - ON

1. Ensure that the console power is on by observing that the "GREEN-CONSOLE POWER" light is illuminated.

5.1.2.2 Master Key Switch - ON

1. Obtain "MASTER KEY" from Experimentalist-in-Charge.
2. Turn on "MASTER SWITCH" and ensure that the "REACTOR STANDBY" light is illuminated.

5.1.2.3 Master By-Pass ON

1. Unlock the Interlock Panel - Panel A and place the MASTER BY-PASS switch in the BY-PASS position.
2. Place 11 control element keys in the 11 by-pass key locks.

5.1.2.4 Magnet Power

Clear all "SCRAM CONDITIONS" and ensure that magnet power is on by observing that PAX or FCX light is on. Indicate on the checklist which reactor is being checked out, either PAX or FCX. Check the patch panels in the cell to ensure that the control system is connected to the proper reactor.

5.1.2.5 Magnet Currents

Check the value of magnet current to the clutches/magnets. Ensure that current is within tolerances and that the SIMPLYTROL setting for clutch/magnet current and drive motor current are correct.

5.1.2.6 Recorder

1. Check recorder and ensure that the CHART DRIVE is functioning properly.
2. Check chart and ink supply.

5.1.3 Instrument Calibrations**5.1.3.1 Startup Range Calibration**

1. Power - ON
 - (1) Ensure that power to the startup channel is ON.
2. 10^2 Calibration
 - (1) Place the CALIBRATE switch in the 10^2 position and if Log CRM does not read 10^2 , carefully adjust the Cal. 10^2 screwdriver adjustment until it does.

3. 10^6 Calibration

- (1) Place the CALIBRATE switch in the 10^6 position and if the Log CRM does not read 10^6 , carefully adjust the Cal. 10^6 screwdriver adjustment until it does.

NOTE: Repeat steps 2 and 3 several times until no further adjustments are required with the CALIBRATE switch in the 10^2 and 10^6 positions.

4. Calibration

- (1) Place the CALIBRATE switch in the OPERATE position.
- (2) Place pulse generator switch to the ON position and ensure that the Log CRM reads on the red CALIBRATE mark.
- (3) Return the pulse generator to OFF.

5.1.3.2 Linear Level Ranges

1. Power - ON

- (1) Ensure that power to each micromicroammeter is on.

2. Polarity (+)

- (1) Ensure that the POLARITY switch is in the (+) position.

3. Scram Check

- (1) Turn the RANGE switch to the 10×10^{-9} position and position "LIN CH SEL SWITCH" to channel No. 1.
- (2) Unlock a control element, reset and drive to 10%.
- (3) Adjust ZERO CONTROL to obtain LEVEL TRIP. Check that the following occur:
 - 1) Control element scram occurs at trip point.
 - 2) LEVEL TRIP point is positioned properly.
 - 3) Recorder follows meter.
 - 4) Appropriate LIN CH TRIP LIGHT is illuminated at TRIP POINT.

(4) Repeat steps (1), (2), and (3) for Linear Channel No. 2.

(5) Repeat steps (1), (2), and (3) for Linear Channel No. 3.

4. Zero Set

- (1) Depress the ZERO CHECK BUTTON and adjust linear channel meter to read zero.

5. 1. 3. 3 Log N - Period Channels

1. Power - ON

- (1) Ensure that power to the Log N - Period amplifiers is ON.

2. Scram Check

- (1) Unlock a control element, reset and drive to 10%.
- (2) Depress the Log N Channel No. 1 RECOVERY button and adjust the 10^{-13} adjustment until PERIOD TRIP occurs.
Ensure that control element scrams at trip point and that the trip point is set at the specified value.
- (3) Adjust the 10^{-7} adjustment until LEVEL TRIP occurs.
Ensure that trip point is set at specified value.
- (4) Repeat steps (1), (2), and (3) for Log N Channel No. 2.

3. 10^{-13} Cal.

- (1) Depress RECOVERY button and adjust 10^{-13} screwdriver adjustment until meter reads 10^{-13} .

4. 10^{-11} Cal.

- (1) Turn the OPERATE switch to the 10^{-11} position and ensure that LEVEL METER reads 10^{-11} . If it does not read 10^{-11} , adjust the 10^{-11} screwdriver adjustment until it does.

5. 10^{-7} Cal.

- (1) Turn the OPERATE switch to the 10^{-7} position and ensure that LEVEL METER reads 10^{-7} . If it does not read 10^{-7} , adjust the 10^{-7} screwdriver adjustment until it does.

NOTE: Repeat steps 4 and 5, above, several times due to interaction.

6. 00 Check

- (1) Depress INFINITY CHECK switch; PERIOD METER should read 00. If it does not read 00, adjust set 00 control until it does.

5.1.3.4 Radiation Monitors

1. Power - ON

- (1) Ensure that power to the monitoring system is ON.

2. Calibration.

- (1) Depress the Cal. button and ensure that the meter reads the value specified on the meter face.

CAUTION: DO NOT SET OFF ALARMS.

3. Alarm Set

- (1) Check each alarm setpoint to ensure that it is set at the value specified on the meter.

5.1.4 Interlock By-Pass Check

1. Ensure that all control element SCRAM/MAGNET buttons are in the SCRAM position.
2. Unlock a control element, reset and drive to 10%.
3. Reset another control element; both elements should SCRAM.
4. Reset the BY-PASS OVERLOAD relay meter.

5.1.5 Source Check

1. Record the reading on each of the safety and data collection channels with and without the source in the reactor. When driving the source into the reactor, check the two "FLUX-UP" interlock settings.

5.1.6 Cell Veto Check

1. Drive control element to 10% and then place the Cell Veto switch in the VETO position. Ensure that element "scrams."
2. Reset the Cell Veto switch.

5.1.7 After completing all steps on the Daily Checkout, complete the following steps to secure the system or proceed as directed by the Experimentalist-in-Charge:

1. Remove source from reactor
2. Remove the master key
3. Turn off recorder chart drive.
4. Lock all control elements
5. Place Cell Veto in VETO position.
6. Remove the keys from the interlock key switches.
7. Place the Master By-pass in the OFF position.
8. Lock the Interlock Panel
9. Ensure that startup range switch is in OPERATE position.
10. Return all keys to the Experimentalist-in-Charge.

DAILY CHECKOUT

1. Power Checks

- 1) Patch Panel Ck PAX____, FCX____
- 2) Console On _____
- 3) Master Key On _____
- 4) "Reactor Standby" On _____
- 5) Mag. Power On _____
- 6) Mag. Current Ck _____
- 7) Recorder Ck _____
- 8) Simplytrol Setting _____

2. Interlock Bypass Ck _____ Control Element No. _____, _____

3. Inst. Cal. and Scram Checks

1) Startup Range

- (1) 10^2 Cal. _____
- (2) 10^6 Cal. _____
- (3) Cal. _____

2) Radiation Monitors

	1	2	3	4	5
(1) Cal.	_____	_____	_____	_____	_____
(2) Alarm Set	_____	_____	_____	_____	_____

3) Linear Channels

	Ch. 1	Ch. 2	Ch. 3
(1) Scram Ck	_____	_____	_____
(2) Zero Set	_____	_____	_____

4) Log N Channels

	Ch. 4	Ch. 5
(1) Period Cal. (∞)	_____	_____
(2) Scram Ck	_____	_____
(3) Cal. 10^{-13} , 10^{-11} , 10^{-7}	_____	_____

4. Instrument Readings

1) "Reactor On" On _____

2) Operational Channels

	Source Out	Source In
(1) Ch. 1	M _____ R _____	_____
(2) Ch. 2	M _____ R _____	_____
(3) Ch. 3	M _____ R _____	_____
(4) Ch. 4	M _____ R _____	_____
(5) Ch. 5	M _____ R _____	_____
(6) S.U.	_____ CPM	_____ CF

3) Flux Up Setting - Log _____ S.U. _____

4) Data Channels High Voltage
On _____

	Gain	CPM
(1) Ch. 1	_____	_____
(2) Ch. 2	_____	_____
(3) Ch. 3	_____	_____

5. Cell Veto Ck _____

6. Console Secured _____

Completed by _____

Date _____ Time _____

Page _____

OP-5.2 Pre-Startup-Manual Change Checklist

5.2.1 General

The Pre-Startup-Manual Change Checklist serves two purposes: 1) it ensures that all the required checks of systems and components are successfully completed prior to making any core changes, and 2) it serves as the final check and alignment of the various operating systems that is made immediately prior to reactor operation. The checklist also serves as a means for assuring that the required personnel are aware of the reactor condition and proposed operations.

There are several rules which should be followed in using the "Pre-Startup-Manual Change Checklist; these are listed below.

1. At all times when the checklist is employed, Part 1 (Core Changes) and Part 2 (General Checks) must be completed in addition to identifying the Run no. and applicable Experimental Details Checklist.
2. If a change in the core is to be made which does not require reactor startup (minor core change $< +0.05\%$), then the Pre-Startup portion of the checklist need not be completed.
3. If no core changes have been made, then Part 3 (Manual Core Change Checks) need not be completed prior to reactor startup.

5.2.2 Description of Checks

It is extremely important that the person completing the checklist understands each check and the correct method to be used in performing the check. For this reason, the method to be employed in completing each check is discussed below.

1. Core Changes

This section of the checklist should be completed by the Experimentalist or Experimentalist-in-Charge prior to making any core changes and/or starting up the reactor. The person completing this section should give a brief description of the change along with the estimated magnitude of the core change. In addition, the excess and shutdown reactivities of the reactor after the change has been effected should be listed. The values used for the magnitude of the change and the K_{ex} and K_{sd} should be based on experimental and analytical evaluations and the source of these evaluations should be indicated on the checklist.

If no core changes were made prior to starting up the reactor, then this should be indicated and the K_{ex} and K_{sd} values should be the same as the previous run.

2. General Checks

Control Room

Daily Checkout Complete

The person completing this checkout should ensure that the Daily Checkout has been completed within the appropriate time limit.

Recorder On

Check the Log-Linear recorder to ensure that the drive is on and that the chart and ink supplies are adequate.

Test Cell

Truck Door Closed

If the Truck Door is not locked, the yard area inside the fence will be checked to ensure that no personnel are present and then the door will be closed and locked.

PAX Cover Condition

If the cover is on the PAX reactor and this reactor is to be operated, obtain the keys from the Experimentalist-in-Charge and unlock and remove the dome. If FCX is to be operated, ensure that the cover is on the PAX reactor.

3. Manual Core Change Checks

Control Room

Log CRM Level

Record the count rate on the Log CRM to establish a basepoint prior to starting the core changes. During the course of the changes, this instrument should be monitored for any indications of a change in the count rate.

Linear Recorder Channel

Indicate the linear channel selected to be displayed on the recorder and record the linear level as displayed on the recorder.

"Popper" Audible

The "popper" in the control room and in the test cell should be checked to ensure that it is audible in both places. The frequency of the "popper" should be set at a point where changes in the frequency are readily detected.

Test Cell

Cell Veto - "Veto"

The Cell Veto switch will be placed in the VETO position. This step ensures that the reactor cannot be started until the personnel in the cell are ready.

Critical Assembly Check

The critical assembly will be inspected by the Experimentalist-in-Charge to ensure that all required work around the assembly has been completed prior to initiation of the change. Also, a careful examination of the reactor may bring to light possible hazards which could arise during the change.

Control Elements

Prior to beginning the core changes, check all the control elements to ensure that they are all locked and cannot be driven out.

4. Pre-Startup Checks

Test Cell

Critical Assembly

Inspect the critical assembly to ensure that all required work on and around the assembly has been completed and the assembly is in operating condition. Verify that the inactive reactor, that is the one not connected to the control console, is in an inactivated condition. An inactivated condition is defined as one where the reactor control elements are locked in their most reactive position and the reactor is at least 10\$ subcritical.

Control Element Drives Unlocked

Obtain the control element lock keys from the Experimentalist-in-Charge and unlock each control element. Visually inspect each drive unit for possible signs of malfunctioning.

Personnel Check

Visually inspect all areas of the test cell to ensure that no personnel are present.

Cell Veto Reset

After all personnel are removed, reset the Cell Veto.

Doors Closed

Close and lock the test cell storage room, labyrinth and Emergency doors. If any outside doors have been open, check the area inside the fence and then close the doors.

Control RoomReactor Status Lights

Place the reactor status lights in the "Reactor On" condition.

Interlocks

Check the interlock panel lights to ensure that all lights indicate that the interlocks are satisfied. Ensure that the by-pass light is not illuminated.

Scrams Clear

Ensure that all scram conditions as indicated by red lights on the console scram panel are clear.

Source In

Insert the neutron source into the core and observe that all instrumentation responds accordingly. Ensure that the "flux-up" interlock is satisfied.

Log CRM Level

Record the Log CRM count rate after the source has been inserted and the count rate has stabilized.

Linear Recorder Level

Select the linear channel to be displayed on the recorder and record its reading after the source has been inserted.

WREC Power Level

Check the WREC power level indicator and record its reading. If WREC is operating, notify the Experimentalist-in-Charge prior to starting up.

Scram Check

Withdraw all control elements to 10% and depress the manual scram button. Ensure that all elements scram.

Responsible Persons

Four blanks are included. All core changes and/or reactor operations require a minimum of three qualified persons. Each person's name appearing on these lines will be affixed by that person. This is, in effect, a "sign-off" by persons cognizant of the operation and an indication of their approval. If, at any time during the operation any of the above-mentioned personnel must leave their designated post, operations will be terminated until a qualified replacement is available.

OP-5.3 Reactor Operating and Experimental Procedure

5.3.1 General

The reactor operating and experimental procedure is a logical sequence of steps to be followed during critical experiments involving reactor startup, operation, and shutdown. In all instances when the reactor is operating, the rules and regulations contained in the Operations Manual are governing.

5.3.2 Reactor Operating Procedures

5.3.2.1 Reactor Startup

1. Ensure that the Pre-Startup and Manual Change Checklist has been completed and that the required Control Room staff is present. The Experimental Details Checklist will be completed prior to initiation of a new experiment.

PRE-STARTUP-MANUAL CHANGE CHECKLIST

Run No. _____ Exp. Details Checkout No. _____ Date _____

1. Core Changes

Type _____

Magnitude _____ ϕ K_{ex} _____ \$ K_{sd} _____ \$

2. General Checks

Control Room

Daily Checkout Comp _____

Recorder On _____

Test Cell

Truck Door Closed _____

PAX Cover Cond. _____

3. Manual Core Change Checks

Control Room

Log CRM _____ CPM

Lin Rec Ch _____ Amps.

"Popper" - Aud _____ (Cont. Rm.)

Test Cell

Cell Veto - "Veto" _____

Crit. Ass'y. Ck _____

"Popper"-Aud. _____

Control Elements Locked _____

4. Pre-Startup Checks

Control Room

"Reactor On" Lights On

Interlocks Satisfied

Scrams Clear

Source In

Log CRM

Lin Rec Ch no. _____ Level _____ Amps

Log Rec Ch no. _____ Level _____ Amps

WREC Level Ck _____

Scram Check _____

Remarks _____

Test Cell

Crit. Ass'y. Ck _____

Control Element Unlocked _____

Personnel Ck _____

Veto Reset _____

Doors Closed _____

Responsible Persons

Operator _____

EIC _____

Exp. _____

Other _____

Completed by _____

Time _____ Page _____

2. Ensure that all members participating in the experimental operation are familiar with the experimental plan and are cognizant of their responsibilities.
3. Select the desired control element speed as specified by the Experimentalist-in-Charge.
4. Slowly withdraw each control element, individually, to a position which is at least 20% below the predicted critical position. While withdrawing the elements closely observe the Log CRM and the linear level recorder and if it appears that the reactor will go critical at or before this position; insert all control elements and notify the Experimentalist-in-Charge.
5. Slowly withdraw each control element in small increments until the reactor is critical as indicated by a slow but steady increase in count rate. The reading on the Log N period meters should not be shorter than 14.7 seconds (+33 % period).
6. After criticality is achieved and indication is observed on the Log N channels, the source will be removed and the startup channel turned off. In addition, the critical control element positions will be logged and the K_{ex} and K_{sd} will be estimated from the critical control element positions. This estimate will be compared with K_{ex} and K_{sd} of the Pre-Startup and Manual Change Check List and any appreciable differences resolved prior to proceeding with the operations.
7. As power level increases, adjust the linear level meters to keep them on scale. Record reactor period and control element positions.

8. As the power level approaches the desired level (never greater than 1 Kw), the control elements will be inserted to increase the reactor period, and the reactor will be manually stabilized at this desired power, using the control elements.
9. The operator will continuously monitor all control channels and if any malfunctions are observed, the operator will reduce power and notify the Experimentalist-in-Charge.
10. After the reactor power is leveled, the control elements will be adjusted so that the maximum deviation between drum positions is 1% unless specified differently by an approved experimental test procedure.

5.3.2.2 Level Operation

1. During level operation of the reactor, the linear level channel displayed on the recorder will be the control channel of preference.
2. The following minimum data will be recorded at 15-minute intervals during level operation.
 - (1) Control element positions.
 - (2) Linear and log level readings from the recorder.

5.3.2.3 Power Level Adjustment

1. Record data as in 5.3.2.2.2, above.
2. Adjust control elements to obtain desired period (never less than +14.7 sec). Observe all instruments closely to ensure that power level adjustment is as desired. Record period and control element positions.
3. When desired power is reached as indicated by linear channel displayed on recorder, adjust control elements to level power. (In no instance shall power exceed 1 Kw.)
4. Record data as in step 5.3.2.2.2.

5.3.2.4 Reactor Shutdown

1. Record data as in step 5.3.2.2.2.
2. Unless otherwise specified by the Experimentalist-in-Charge, the reactor will be shutdown by scrambling all control elements.
3. After the reactor is shutdown, as determined by observation of the neutron level decay on the record and observation of insertion of the control elements as indicated by the "IN" limit lights and indicators, the reactor operator will perform the following shutdown operations;
 - (1) Turn off recorder drive.
 - (2) Turn micro-micro ammeters to their most sensitive range.
 - (3) Ensure that the run log and experimental data are complete.
 - (4) Remove the "Master Key" from the console.
 - (5) Turn on the startup range.
 - (6) At the earliest practical time, the following steps should be completed in the test cell:
 - 1) Make a radiological survey of the cell area.
 - 2) Place the Cell Veto in the VETO position.
 - 3) Remove the control element keys from each control element drive.
 - 4) Place the cover on the reactor if no core work is anticipated.
 - (7) Sign off the "Reactor Secured" entry on the last run sheet for the day.

5.3.3 Experimental Procedure

5.3.3.1 PAX Fuel Loading

1. Objective

To safely and efficiently assemble fuel in a NERVA-type reactor.

2. Special Precautions and Limitations

- (1) The reactor will be assembled with adequate shutdown.
Shutdown of the assembled reactor will be at least -10\$ for a fuel loading that has been previously utilized and at least -20\$ for a fuel loading that has not been previously utilized.
- (2) A loading source will be properly installed at the beginning of the loading. Normally, the loading source will be located in the center region of the initial fuel increments.
- (3) An adequate source-core-detector geometry will be utilized to ensure significant detector response.
- (4) The limits and procedures in the WANEF Operating Limits document and the Operations Manual are governing.

3. General Method

The fuel will be added to the reactor in an incremental manner. Count rate data will be obtained after each increment with the control elements at 0 degrees and a plot of inverse count rate versus amount of fuel in the reactor constructed. The initial fuel increment will not exceed 10% of the total fuel complement in the assembled reactor. Each succeeding increment will be either 20% of the total fuel complement or one-half of the extrapolated additional fuel loading required for criticality, whichever is less.

4. Hazards Considerations

This procedure, when performed within the limitations described herein and in the WANEF Operating Limits document presents no significant safety hazard.

5.3.3.2 PAX Initial Criticality

1. Objective

Removal of poison from core in order to achieve criticality with $K_{ex} < 33 \%$. Determination shutdown.

2. Special Precautions and Limitations

- (1) An adequate source-core-detector geometry will be utilized to ensure significant detector response.
Normally, the geometry established during core loading will be maintained during this procedure.
- (2) The limits and procedures in the WANEF Operating Limits document and the Operations Manual are governing.
- (3) Initial criticality will be attained with $K_{ex} < 33 \%$.

3. General Method

Poison will be removed from the core in an incremental manner. Count rate data will be obtained after each incremental removal for 0, 50%, and 100% control element withdrawal and a plot made of the inverse count rate versus the amount of poison in the reactor. The initial increment of poison removed will be no more than 20% of the initial content. Each succeeding increment removed will be either 20% of the initial poison content or one-half of the extrapolated additional poison removal required for criticality, whichever is less. Data obtained with the control elements withdrawn to 100% will be utilized for the prediction of criticality. The final poison increment to be removed will be specified by the Experimentalist-in-Charge such that the 33 % excess reactivity is not exceeded. After attainment of criticality,

a "rod drop" measurement of shutdown will be performed.

4. Hazards Considerations

This procedure , when performed within the limitations described herein and in the WANEF Operating Limits document presents no significant safety hazards.

5.3.3.3 Core Reactivity and Control Worths

1. Objective

To determine 1) the critical control element position with poison removed, 2) the core excess reactivity and 3) the control element worths.

2. Special Precautions and Limitations

(1) The limits and procedures in the WANEF Operating Limits document and the Operations Manual are governing.

3. General Method

After initial criticality, the remainder of the poison wires will be removed in steps such as not to exceed the facility operating limits. The withdrawals will be in accordance with OP-5.4. The resulting incremental change in core reactivity is then determined by period, delayed critical and rod drop techniques. These measurements are made in accordance with procedure OP-5.3.2. The measured reactivity changes are then related to incremental control and poison wire worths. Core reactivity is then related to the integral control or poison wire worths. Adjustment of the clean (poison removed) critical control position can be made by changing the shim content in the core. Changes in shim content will be made in accordance with OP-5.4. Control element worths can be measured by the period-bump or rod drop technique while shimming with other control elements or core inserts.

4. Hazards Considerations

This procedure, when performed within the limitations described herein and in the WANEF Operating Limits document presents no significant safety hazard.

5.3.3.4 Material, Structural Worths and Environmental Worths

1. Objective

To determine the reactivity worth or effect of materials and structures in or adjacent to a reactor. To determine the effect of environment upon the reactor.

2. Special Precautions and Limitations

- (1) The limits and procedures in the WANEF Operating Limits document and the Operations Manual are governing.
- (2) Considerable care must be taken to insure the stability of any experimental insert or structure of interest in order to preclude the possibility of sudden reactivity insertion due to failure.

3. General Method

Material reactivity worths, usually expressed in cents per kilogram, will be obtained by measuring the change in core reactivity (e.g., period measurements or changes in delayed critical control element positions) due to the insertion or removal of a specified mass of material. The amount of material and the installation or removal is governed by OP-5.4. Measurement of large amounts of material (structures) near the reactor will also be governed by OP-5.4. Operation of the reactor will be in accordance with OP-5.3.

4. Hazards Considerations

This procedure, when performed within the limitations described herein and in the WANEF Operating Limits document presents no significant safety hazard.

5.3.3.5 Power and Flux Measurements

1. Objective

To determine the spatial and spectral behavior of the neutron and gamma fluxes in and about the reactor.

2. Special Precautions and Limitations

- (1) The limits and procedures in the WANEF Operating Limits document and the Operations Manual are governing.
- (2) The integrated power developed during an experiment will be kept at a minimum consistent with the experimental requirements.

3. General Method

The spatial and spectral distribution of the neutron and gamma fluxes will be determined by positioning detectors with different spectral responses at specified locations in and about the reactor. The detectors will be in the form of limited amounts of material (wire, foil, fuel, material, electronic devices, etc.) Startup and delayed critical operation of the reactor in accordance with OP-5.3.2 will provide sufficient flux to irradiate or operate the detectors. After shutdown, the activated materials will be removed from the reactor for activation analysis.

4. Hazards Considerations

This procedure, when performed within the limitations described herein and in the WANEF Operating Limits document presents no significant safety hazard.

5.3.3.6 Neutron Generator Measurements (PNG)

1. Objective

Measurement of the response of the reactor to controlled variation of neutrons injected into the reactor by a neutron generator.

2. Special Precautions and Limitations

- (1) Installation of the target assembly of the neutron generator in the reactor will be done in accordance with OP-5.4.
- (2) Positive addition of reactivity will not be made while the neutron generator is operating, if the generator causes a visual response in the operational detector channels.

3. General Method

The neutron generator, a small electrostatic accelerator utilizing the d-t reaction injects a modulated source of neutrons into the reactor. By observing the flux response in the reactor, the dynamic characteristics of the reactor can be determined. The common procedure is to produce bursts of neutrons in the core and determine the resulting decay of the prompt neutron populations. This measurement will determine β/λ in a critical reactor or the shutdown in a subcritical reactor. Changes in shutdown caused by material changes to the reactor are directly related to the reactivity worth of the material. The flux response due to a modulated neutron source can also be cross-correlated with the source driving function to determine the reactor transfer function. This measurement is analogous to the reactivity oscillator. After installation of the generator target in or near the reactor (in accordance with OP-5.4), the reactor will be brought to the condition of interest (subcritical, delayed critical or supercritical) accord-

ing to OP-5.3.2. The neutron generator will then be operated in the desired manner (steady state, pulsed or modulated) and the reactor flux response determined.

4. Hazards Considerations

The nuclear safety implications of the neutron source experiment are quite minimal since operation of the neutron source does not change the reactivity of the reactor. Under certain conditions, the operational channels will respond to significant changes in flux level due to the neutrons from the generator. This would occur, for example, when the flux level in the core is low and the generator is operated at high beam currents. Therefore, the insertion of positive reactivity will not be made when the generator is causing a significant response to the operational detector channels. The yield of the neutron generator and flux level in the reactor will be adjusted such that scram limits on the operational channels will not be exceeded.

It is concluded that no significant safety hazard is presented by this procedure when it is performed within the limits described herein and in the WANEF Operating Limits document.

5.3.3.7 Reactivity Oscillator Measurements

1. Objective

Measurement of the response of the reactor to controlled reactivity variations induced by a reactivity oscillator.

2. Special Precautions and Limitations

- (1) Installation and removal of the oscillator will be performed in accordance with OP-5.4.

- (2) Considerable care must be taken to ensure the stability of any experimental insert or structure of interest in order to preclude the possibility of sudden reactivity insertion due to failure.
- (3) The 33 $\%$ limit of core supercriticality will be observed at all times. For example, operation of the oscillator in the reactor which is 10 $\%$ supercritical restricts the maximum reactivity swing of the oscillator to 23 $\%$.
- (4) Positive addition of reactivity by adjustment of the control elements will not be made while the oscillator is operating.

3. General Method

A reactivity oscillator or pile oscillator, as it is commonly called, is a device which can vary, in a periodic manner, a limited amount of reactivity in the core. Mechanically it normally consists of two sections of absorber that are movable with respect to each other such that the total reactivity of the device can be varied. Varying the frequency and waveform of the mechanical movement results in a similar variation in reactivity.

After installation of the oscillator (in accordance with OP-5.4), the reactor is adjusted to the condition of interest in accordance with OP-5.3.2. The oscillator is then operated and the variation in reactor flux determined as a function of wave shape and frequency of the oscillator. By cross-correlating the reactivity and flux waveforms, one can determine the response characteristics (transfer function, impulse function) of the reactor from which kinetic parameters (β/λ , delayed precursor data, shutdown) can be extracted.

4. Hazards Considerations

The reactivity swing of the oscillator is restricted to that which would produce supercriticality of less than 33 β should the oscillator fail in its most reactive configuration. As the oscillator is independent of the operational control elements, its failure will be effectively countered by normal reactor shutdown.

The instantaneous reactivity insertion rate produced by the oscillator can exceed the 6.4 β /sec rate limitation. However, this facility limit is interpreted to refer to a steady state addition rate which results in a net insertion of reactivity. The amplitude frequency of the oscillator will be adjusted such that the scram levels on the operational channels will not be exceeded. It is concluded that no significant safety hazard is presented by this procedure when it is performed within the limits described herein and in the WANEF Operating Limits document.

5.3.3.8 FCX Loading and Criticality (Bare Core)

1. Objective

To safely and efficiently assemble fuel and achieve criticality in an FCX-type reactor with a $K_{ex} \leq 50 \beta$.

2. Special Precautions and Limitations

- a. Based on analytical and experimental data, the total fuel complement required in the assembled reactor will be determined prior to starting the loading operation.
- b. A loading source will be properly installed at the beginning of the loading. Normally, the loading source will be located in the center region of the initial fuel increment.

- c. An adequate source-core-detector geometry will be utilized to ensure significant detector response.
- d. The limits and procedures of WANEF Operating Limits document and the Operations Manual are governing.
- e. Initial criticality will be attained with K_{ex} less than 33 $\%$.
The final core reactivity will be adjusted so that $K_{ex} \leq 50 \%$.

3. General Method

Clusters will be added to the core in an incremental manner. Count rate data will be obtained after each loading increment for 0, 50, and 100% control element withdrawal and a plot made of the inverse count rate as a function of the total number of clusters loaded into the reactor. The initial cluster increment will not exceed 20% of the total complement in the fully assembled reactor. Each succeeding increment will be either 20% of the total complement of the fully assembled reactor or one-half of the extrapolated additional fuel required for criticality, whichever is less. Count rate data obtained with the control elements withdrawn to 100% will be utilized for the prediction of criticality.

The final increment to be inserted will be specified by the Experimentalist-in-Charge such that the 33 $\%$ excess reactivity is not exceeded when all control elements are 100% withdrawn. After attainment of criticality, a "rod drop" measurement of shutdown will be performed.

4. Hazards Considerations

The procedure, when performed within the limitations described herein and in WANEF Operating Limits document presents no significant safety hazard.

5.3.3.9 FCX Loading and Criticality (Reflected Core)

1. Objective:

To safely and efficiently assemble fueled clusters and unfueled reflector clusters to achieve criticality in an FCX-type reactor with a $K_{ex} \leq 50\%$.

2. Special Precautions and Limitations

- a. Based on analytical and experimental data, the total fuel and reflector complement required in the assembled reactor will be determined prior to starting the loading operation.
- b. A loading source will be properly installed at the beginning of the loading. Normally, the loading source will be located in the center region of the initial fuel increment.
- c. An adequate source - core - detector geometry will be utilized to ensure significant detector response.
- d. The limits and procedures of the WANEF Operating Limits Document and the Operations Manual are governing.
- e. Initial criticality will be attained with K_{ex} less than 33%. The final core reactivity will be adjusted such that $K_{ex} \leq 50\%$.
- f. The fueled region of the core will be loaded approximately 10% in excess of the calculated critical reactor configuration prior to placing the reflector clusters around the periphery of the core. This precaution is taken to allow for any under-estimate of the critical mass for a reflected core.

3. General Method

Fueled clusters will be added to the core in an incremental

manner. Count rate data will be obtained after each loading increment for 0, 50 and 100% control element withdrawal and a plot made of the inverse count rate as a function of the total number of clusters loaded into the reactor. The initial cluster increment will not exceed 20% of the total complement in the fully assembled reactor, unfueled reflector clusters included or 30% of the fueled cluster loading. Each succeeding increment will be either 20% of the total complement of the fully assembled reactor or 30% of the fuel clusters for the assembled reactor or one-half of the extrapolated additional clusters required for criticality, whichever is less. Count rate data obtained with the control elements withdrawn to 100% will be utilized for the prediction of criticality.

The final increment to be inserted will be specified by the Experimentalist-in-Charge such that the $33\frac{1}{3}\%$ excess reactivity is not exceeded when all control elements are 100% withdrawn. After criticality has been attained, a "rod drop" measurement of shutdown will be performed. In order to obtain the desired reflector thickness, reflector clusters will be substituted for fueled clusters at the core-reflector interface using Section 5.4, Manual change procedure.

If after adding the reflector clusters criticality is not attained, (1) the reflector clusters will be removed (2) counts will be taken and compared to previous counts for the same core configuration and, if necessary normalized. Additional fueled clusters will then be added to the core periphery in the incremental manner. Based on the previous inverse multiplication curve a sufficient quantity of fueled clusters will

be loaded to allow criticality to be obtained when all reflector clusters have been replaced. Reflector clusters will also be replaced in increments as previously defined with counts taken after each incremental change.

4. Hazards Considerations

The procedure, when performed within the limitations described herein and in the WANEF Operating Limits Document presents no significant safety hazard.

OP-5.4 Manual Changes in Reactivity Procedure

5.4.1 General

Presented below are the procedures to be employed whenever manual changes in the reactivity of the shutdown reactor are to be made by either inserting or removing material from the reactor. The categories of changes are as follows:

1. Minor reactivity changes - those which produce a demonstrated reactivity effect of less than +0.05\$.
2. Minimal reactivity changes - those which produce a demonstrated reactivity effect greater than +0.05\$ but less than +0.33\$.
3. Major reactivity changes - those which may produce a reactivity effect greater than +0.33\$.
4. Changes that involve the movement of fuel clusters.

The final paragraph of the procedure presents a summary of the basic rules to be followed in making any manual changes. No changes will be performed except in accordance with an approved Experimental Procedure.

5.4.2 Evaluation Made Prior to Any Changes

Prior to making any manual change in the reactivity status of the reactor, investigations will be made by the Experimentalist-in-Charge to ensure that the operations are safe and within the operational limits. These evaluations are as follows:

5.4.2.1 Evaluate Reactor Status

A check of present reactor status shall be made to determine the shutdown reactivity, the critical drum positions, and the present reactor loading configuration. In making this evaluation, reference

should be made to the "WANEF Reactor Operations Log" for prior operating history and present loading.

5.4.2.2 Evaluate Change

A complete evaluation of the desired change based on experimental and/or analytical data will be made to determine the magnitude of the change. In making this evaluation, the effect of the proposed change on the present reactor status will be considered in detail.

If the change is to be made to the PAX core, a conservative evaluation of the change magnitude shall be employed to ensure that the minimum shutdown is not less than 2.8\$ at any time during the change. An allowance of 15¢ for each of three men shall be made in the evaluation of the minimum shutdown. If the change is to be made to the FCX core where a large shutdown margin is always present consideration must be given to the 0.50\$ limit on excess reactivity which is allowed in any FCX core. If the magnitude of the change(s) is large enough so that the 0.50\$ maximum limit on excess reactivity would be violated, then a suitable negative reactivity must be inserted into the core to compensate for the proposed change. At all times, no matter what changes are being made to an FCX core, the limit on the excess reactivity must be observed and at no time may it exceed 0.50\$.

5.4.2.3 Select Appropriate Course of Action

Based on the results of the evaluation of the reactor status and the type and magnitude of the change, the appropriate course of action to be applied will be selected. The various courses of action and the required conditions for each are listed below:

1. Minor changes ($< +0.05\%$)

A reactivity change of $< +0.05\%$ can be made directly in accordance with section 5.4.3 if the following conditions exist:

- (1) The proposed change plus all previous changes made since the last experimental shutdown reactivity determination does not exceed $+0.05\%$.
- (2) No more than ten such changes have been made since the last shutdown reactivity measurement.
- (3) The reactor has been operated in the previous 48 hours.

NOTE: If the above conditions cannot be met, the change will be considered a "Minimal Change" and carried out according to Section 5.4.3.

2. Minimal Changes ($> +0.05\%$ and $< +0.33\%$)

Reactivity changes which are greater than 0.05% but less than 0.33% can be made in one step in accordance with Section 5.4.3 if the following conditions exist:

- (1) The proposed change plus any previous minor changes made since the last experimental shutdown reactivity determination does not exceed 0.33% .
- (2) The reactor has been operated in the previous 48 hours.

NOTE: If the reactor has not been operated in the previous 48 hours, it will be operated prior to making the change.

3. Major Changes ($> +0.33\%$)

Reactivity changes which are greater than 0.33% will be made in steps with the maximum change per step limited to 0.33% .

These changes will adhere to the rules of step 2, above.

4. Fuel Cluster Changes

Reactivity changes which involve the movement of fuel clusters or elements will be made in accordance with the rules listed below:

(1) The removal and reinsertion of a fuel cluster(s) or element(s) can be considered as a "Minor Reactivity Change" if the following conditions exist:

- 1) The conditions of Part 1 (Minor Changes) are met.
- 2) The lapsed time from removal to insertion is less than 48 hours.
- 3) If no more than four clusters are involved.

(2) If more than four equivalent clusters be removed from the core at one time, the clusters must be poisoned prior to reinsertion into the core. After replacing the clusters, the poison may be removed in steps (0.33% maximum) in accordance with Part 2 (Minimal Changes).

(3) At any time when more than three adjacent clusters or more than a total of four clusters are to be removed from the core, the core assembly frame will be used.

5. Fuel Loading and Poison Wire Removal

Reactivity insertions when $K_{ex} < 0$ are governed by fuel loading and initial criticality procedures.

5.4.3 Change Procedure

1. Complete the appropriate portions of the "Pre-Startup-Manual Change Checklist," OP-5.2.

2. Inspect the item(s) to be moved to ensure that correct material has been selected and that quality of item(s) is suitable for reactor use.
3. Prepare and assemble any hardware, such as the vacuum system, fixtures, assembly frame (when required), and any other special items required to make the core change. See the Experimental Details Checklist.
4. Establish communications with the Control Room.
5. Slowly insert or withdraw the item(s).

NOTE: 1. When movement of the item(s) is in progress, the suction line to a suitable vacuum system should be placed as near the object being moved as is possible. This minimizes the possibility of spreading contamination due to dust created by the move.

2. The person making the core change should always be prepared to terminate the operation in the event that the personnel in the control room observes any unusual readings on the nuclear instrumentation.
6. Record the change on the "Reactor Loading Sheet" and in the WANEF Reactor Operations Log.
 7. If the change was a "Minor Change" ($< +0.05\%$) per Section 5.4.2.3, Part 1, secure the reactor in accordance with the "Reactor Operating Procedure, OP-5.3" unless otherwise directed by the Experimentalist-in-Charge.
 8. If the change is of the type covered by the "Minimal Change" ($> +0.05\%$ but $< 0.33\%$) per Section 5.4.2.3, Part 2, or one step of a "Major Change" ($> 0.33\%$), complete the following steps:
 - (1) Complete the Pre-Startup portion of the "Pre-Startup-Manual Change Checklist," OP-5.2, and start the reactor in accordance with the "Reactor Operating Procedure," OP-5.3, and any special instructions contained in the appropriate Experimental Details Check List.

- (2) After achieving criticality, proceed as per "Reactor Operating Procedure, "OP-5.3, to obtain the information required to evaluate the change.
- (3) Shut the reactor down and evaluate the effect of the change. If it is found that the preliminary considerations of Section 5.4.2 were correct, proceed as per Steps 1 through 8 in making any further changes.
- (4) If it is found that the change was not in accordance with the preliminary considerations of Section 5.4.2, re-evaluate any further changes prior to making them.
- (5) After all changes are completed, secure the reactor in accordance with the "Reactor Operating Procedure, " OP-5.3.2.

5.4.4 Summary of Basic Rules

1. All standard operating procedures must be reviewed and approval recommended by the Nuclear Safety Committee and the Scientist-in-Charge and agreed upon in advance by the experimentalists participating in the experiment.
2. No change in the reactivity will be made under the duress of a time limit.
3. When manual changes in the reactivity of the core are being made, a person qualified as "Experimentalist-in-Charge" will supervise the operation.
4. When manual changes in the reactivity are made, a person qualified as "Reactor Operator" will be in the control room observing the flux level monitors.
5. The maximum number of personnel allowed within three feet of the pressure vessel or the critical assembly during any test cell activity shall be approved by the Scientist-in-Charge and shall be the more restrictive of (a) three (3) persons or (b) a number consistent with the minimum shutdown of that particular reactor.
6. All control elements must be locked in their zero position (maximum shutdown) for manual reactivity changes.

7. When manual changes in reactivity are being made and personnel are in the cell, the "Cell Veto" button will be in the "Veto" position.
8. An instrumentation system capable of visual and audible indication of radiation levels with associated alarms must be operable.
9. Reactor startup after a change has been made will proceed as though no prior knowledge of critical conditions exist.

OP-5.5 "Facility Secured" Check

5.5.1 General

At the completion of each operating day, a number of items must be checked to ensure that the reactor and its systems are properly secured. These items must be checked and secured prior to the Scientist-in-Charge or the Experimentalist-in-Charge leaving for the day.

5.5.2 Test Cell Checks

1. Ensure that the truck door is closed and locked. If the door is open, check the yard area prior to locking the door.
2. Ensure that the cover is on the critical assembly and that it is seated and locked. After the cover is locked, the keys will be given to the Experimentalist-in-Charge.
3. Check each of the control element drives and ensure that it is locked. Remove all the control element keys and give them to the Experimentalist-in-Charge.
4. Ensure that the Cell Veto is in the "Veto" position.
5. Check the test cell and ensure that no personnel are present and then lock the test cell access door. After the door is locked, the key will be given to the Experimentalist-in-Charge.

5.5.3 Control Room Checks

1. Turn off the Master Switch and give the Master Key to the Experimentalist-in-Charge.
2. Ensure that the interlock panel is locked and that there are no interlock by-passes in the "on" position.
3. Reset all the interlocks and ensure that the "Interlock" light on the console is out. This ensures that the test cell door light in the Guard Station is in operation.

4. Check the "Power Failure" and "Water Level" lights on the console and ensure that they are off.
5. Turn off the T.V. monitor.

OP-5.6 Source Storage and Handling Procedure

5.6.1 General

The procedure presented below outlines the methods to be employed and the regulations to be observed when handling any of the sources used at the facility. Also given are the requirements for storage and leak testing of the various sources designated as "by-product material".

5.6.2 Source Handling

Manual handling of any source, when required, will be conducted according to the following regulations:

1. Approval of the WANEF Scientist-in-Charge or Experimentalist-in-Charge must be obtained prior to handling.
2. Appropriate handling equipment will be employed to minimize radiation exposure.
3. If the source strength is greater than 1.0 curie, Health Physics monitoring will be required.
4. All radiation safety precaution as given in this manual and the Waltz Mill Site Health Physics Manual, WCAP-2304, will be observed.

5.6.3 Source Storage

Given below is a brief description of the storage devices employed for the various sources at the facility:

1. Po₂₁₀Be Startup Source (7.5 curie)

This source is normally stored in a 3-ft. diameter steel storage container located on the test cell wall approximately 20 feet above the operating floor. The container is filled with borated paraffin and movement in and

out of the container to the reactor core is performed by means of a Teleflex system. When the source is out of the storage container (in the guide tube) either at the core or anywhere between the core and the container, adequate instrumentation coverage is provided by permanent neutron detection devices, warning lights, and an audible "popper".

2. PuBe Calibration Source (0.5 curies)

This source is normally stored in a paraffin-filled drum in the test cell. The source is attached with a 5-ft. long pole and the pole is equipped with a red flashing light which is manually turned on when the source is out of storage.

3. Co-60 Calibration Source (20 microcuries)

This source, which is used as a portable calibration source for the gamma detectors, is mounted on a 3-ft. pole and stored in a container under the test cell floor.

4. Sr⁹⁰ Calibration Sources

(2 sources, 10 microcuries each and 3 sources, 3 microcuries each)

These sources are permanently mounted in the gamma detector units located in the test cell, fuel storage vault, fuel assembly room, and the counting room. The sources are used for remote calibration of the various units.

5. Tritiated (H³) Neutron Generator Targets

The tritium (H³) is in the form of tritiated titanium disks which are used as targets in a neutron generator. Each target, which contains about 5 curies of H³, is essentially a solid source emitting 18 kev betas. WANEF is licensed for a maximum of 50 curies of tritiated targets. One target will normally be contained in the evacuated drift tube of the neutron generator. The spare targets, in closed containers, will be stored in a prominently identified area of the reactor test cell.

In general, handling procedures will be in accordance with the Health Physics Manual (WCAP-2304) for the Waltz Mill Site. Specifically, handling of the targets will require the use of surgeon's gloves and any close visual inspection, the use of glasses. Monthly smears for tritium contamination will be taken of the storage area, the generator and any other suspect area. Additional smears will be obtained whenever the targets are handled, such as replacing a spent target in the generator. Spent targets will be disposed of as radioactive waste by approved Health Physics Methods.

6. Cs¹³⁷ Source (20 curies)

This source is employed in the irradiation facility in the test cell basement and is stored in an appropriate container. In general, handling procedures will be in accordance with the Health Physics Manual (WCAP-2034) for the Waltz Mill Site.

5.6.4 Source Leak Testing

Leak testing of all the sources at the facility will be performed in compliance with 10CFR34 which stipulates that tests be performed at intervals not exceeding six months. The following method should be employed in testing the sources:

1. The external surface of each source will be wiped with a filter paper or cotton swab. Care will be taken to minimize exposure of the surveyor by using long-handled tongs when necessary.
2. The shielding cask will be surface-wiped in the same manner.
3. The filter papers or swabs will then be counted in a scintillation counter with 32% efficiency for alpha radiation or in a GM counter having a 10% efficiency for beta radiation, whichever is pertinent to the source being tested.
4. Permanent records of leak test results will be maintained in units of microcuries and will be retained for inspection by the Commission.
5. In the event a test reveals the presence of 0.005 microcurie or more of removable contamination the source will be withdrawn from use immediately. Normally, leaking sources will be returned to the supplier for repairs. Appropriate reports will be filed with the Division of Licensing and Regulations in compliance with existing regulations.
6. Leak tests will be performed under the direction of the WANL Radiological Protection Office.

OP-5.7 Radiation Safety Regulations**5.7.1 Test Cell**

The following procedures have been established to control operations on an irradiated core in order to minimize personnel radiation dosage and to prevent the spread of contamination.

1. Before entering the test cell, personnel must equip themselves with a radiation film badge and self-reading dosimeters. If a possibility of floor contamination exists, they must also wear shoe covers. Eating, drinking and smoking will not be permitted in the test cell. Appropriate signs will be positioned around the facility to remind personnel of these limitations.
2. Personnel entering the test cell to perform work which will bring them into contact with any potentially contaminated object or surface are also required to wear either a laboratory coat or coveralls as well as gloves and shoe covers. For particular situations where airborne activity may be encountered, the use of respirators is also required.
3. Prior to initial entry into the test cell following a power run on the reactor, Health Physics personnel will survey the area to ensure that high radiation will not be encountered. Also, where radiation levels are sufficiently high, continuous Health Physics monitoring will be required to ensure that the permissible dosages are not exceeded by any of the personnel.
4. Where operations such as the removal of fuel from the core will create significant additional radioactivity or contamination, the operations will be monitored by Health Physics personnel.

NOTE: The above Health Physics responsibilities can be delegated, with permission of the Health Physics Section and the WANEF Scientist-in-Charge to other competently trained WANEF personnel.

5. For high exposure dose conditions, efforts will be made to rotate personnel in order to decrease both immediate and cumulative dosage received by any one person on the staff.
6. Personnel doses in excess of permissible levels, as given in the Health Physics Manual, WCAP-2034, must be promptly reported to WANEF supervision and to the Health Physics Section, and recorded in appropriate radiation safety records.
7. Large personnel doses must not be accumulated under pressure of a schedule or working shift when a reasonable waiting period for decay of radiation levels can markedly reduce the dosage received.
8. Personnel leaving the test cell area are required to check themselves for contamination using the personnel monitor, which is in continuous operation.
9. All material leaving the test cell area must be checked for activation or surface contamination. Where conditions warrant, decontamination procedures will be carried out on the material.
10. Personnel decontamination proceedings shall be carried out in the Change Room, which is equipped for the purpose with clothing lockers, hot sinks, decontamination supplies, shower, and radiation monitoring equipment.
11. The test cell area will be surveyed for contamination by Health Physics personnel on a routine basis and whenever operations in the area are likely to have increased the contamination present. Notice of the current state of contamination in the test cell area will be posted at the entrance to the area as a reminder to the WANEF staff. Decontaminating procedures are carried out whenever required.
12. Any operations found to be spreading contamination will be suspended until an investigation has determined the cause of the contamination and methods for eliminating it.

5.7.2 Irradiated Material

In many reactor experiments at the WANEF facility, particularly in the flux and power distribution measurements, it is necessary to handle irradiated and activated materials. These materials have to be removed from the reactor assembly and transported out of the test cell area. The procedures and precautions mentioned in the previous section must be rigidly adhered to in these operations. Certain other additional procedures are set forth in this section.

1. All operations are to be monitored with appropriate alpha, beta, or gamma detectors unless activation levels are demonstrated to be safe.
2. All radioactive materials will be handled as much as possible with forceps, tongs, or similar equipment.
3. Transportation of numbers of radioactive pieces out of the test cell area will employ appropriate containers.
4. Where radiation or contamination levels warrant, all operations on the irradiated materials which are required after removal from the reactor are to be carried out in the fuel assembly area.
 - (1) "Step-Off Pad" procedures will be established in accordance with standard radiation safety practices. An appropriate barrier to prevent accidental violation of the contamination area must be provided.
 - (2) Surgeon's gloves will be used for handling these materials. Chemical and equipment required for the experiment will be located in the assembly room when possible and on the stainless steel laboratory work surface when necessary or advisable. No equipment external to those areas will be handled with contaminated gloves.
5. Respirators will be used where additional precautions against dust or gaseous radioactive products are necessary.
6. Where activity levels warrant eye protection, glasses and other shielding will be employed.

7. Care will be exercised that irradiated materials are attended constantly or appropriately zoned or shielded and labeled to prevent accidental radiation exposure of personnel.
8. Material removed to the counting room for activity measurements continue to be treated in this manner as long as the activity level or contamination problem exists.
9. Upon termination of the experiment, decontamination procedures are initiated by the experimentalist in the areas affected. Additional measures, as necessary, are instituted, including request for Health Physics advice and assistance.
10. Upon completion of decontamination effort, a survey will be made of the working and adjacent areas and equipment. Techniques appropriate to the contaminant present, will be used to ascertain the effectiveness of decontamination. Contamination is assumed to exist until the contrary is demonstrated.

OP-5.8 Maintenance Procedures5.8.1 General

Each component or system which affects the safe and efficient operation of the facility will be subjected to a periodic maintenance checkout. This checkout may take the form of either a visual inspection or a test of operation depending on the nature of the component or system to be checked. To ensure that each critical system receives the necessary maintenance checks and to ensure its safe operation, a number of maintenance checklists have been formulated. These checklists, which are set up on a weekly, monthly, six-month, and yearly basis, are to be used in conjunction with the WANEF Maintenance Log. The various checks to be performed are contained in this report and presented below are some basic rules that should be followed by the person(s) completing them.

1. The person completing the check should initial the check and indicate the time it was completed.
2. For all checkouts requiring data on operation, such data should be presented in detail in the Maintenance Log.
3. All comments on the operation of a component and/or system will be made in the Maintenance Log in sufficient detail as is required for clarity.
4. After the completion of any maintenance repairs, replacements, or field changes, the affected components or systems will be subjected to a checkout and/or test to ensure that the hazards associated with the operation of the facility have not been increased above those analyzed in WANL-TNR-099, WANEF Safety Report.
5. The applicable portions of the following procedures do not apply to the reactor not connected to the console.

5.8.2 Weekly Maintenance Checks

1. Control Element Drives

Visually inspect each control element drive unit. Check, in particular, for any dust or dirt accumulation, oil leakage, loosened bolts, frayed cables, or misaligned mechanical stops.

2. Basement Water Detectors

Actuate each water detector and ensure that the control room and guard house lights come on.

3. Reactor Status Lights

Place the status lights on "Reactor Standby" and then on "Reactor On" and ensure that each remote light functions properly.

4. Gamma Hazard Lights

Check the Labyrinth and Rear Gate gamma lights to ensure that they are functioning properly.

5. Test Cell Inspection

Visually inspect the test cell area for cleanliness.

5.8.3 Monthly Maintenance Checks

1. BF₃ Voltage Plateau *

Check and set as required the detector voltage on each BF₃ channel.

This should be accomplished as follows:

- 1) Place the PuBe source at a position near the detector which produces 1000 cps.
- 2) Lower the detector voltage to a value that produces zero counts.
- 3) Increase the voltage in 100 volt steps and plot voltage vs. counts.
- 4) Set the detector voltage at a value which is on the detector voltage plateau.

Indicate below when each of the BF₃ channels were checked.

Startup Range	PAX _____	FCX _____
DAS No. 1	PAX _____	FCX _____
DAS No. 2	PAX _____	FCX _____
DAS No. 3	PAX _____	FCX _____

2. BF₃ Discriminator *

Check and set as required the disc. bias on each BF₃ channel

- 1) Position the PuBe source in the same position as in 1(1).
- 2) Vary the disc.bias from its minimum value to its maximum.
- 3) Record and plot disc. voltage vs. counts. Repeat for various settings of the amplifier gain and set the disc. voltage at the midpoint of the disc. plateau.

Indicate below when each of the BF₃ channels disc. settings were checked.

*Checks on the DAS channels will be performed when these channels are required for loading and initial criticality.

Startup Range	PAX _____	FCX _____
DAS No. 1	PAX _____	FCX _____
DAS No. 2	PAX _____	FCX _____
DAS No. 3	PAX _____	FCX _____

3. Area Monitors Source Check

- 1) Calibrate each area monitor per the "Daily Checkout".
- 2) Place a gamma source near each detector and record reading.
- 3) Compare reading with previous measurements.

4. Test Cell Count Rate Lights

Check the CR lights in the Test Cell to ensure that they are functioning properly.

5. Control Room-Test Cell Intercom

Check out the control room-to-test cell intercom to ensure that it is functioning properly.

6. Assembly Room Ventilation

- 1) Check the operation of the vacuum table and the auxiliary exhaust system.
- 2) Visually inspect main supply, main exhaust, and auxiliary exhaust units on roof.
- 3) Check condition of vacuum table filter and replace if necessary.

7. Test Cell Ventilation

Check the automatic stop under high radiation conditions by tripping the high level alarm and ensuring that the exhaust fan stops.

8. Neutron Detectors

Check each detector battery supply under loaded conditions to ensure that it is functioning properly.

9. Portable Radiation Instruments

Check and calibrate each of the portable radiation instruments of the facility.

10. Emergency Lights

Check each of the emergency lights through the facility and adjust as required. See also Section 6.1.2.9.

11. Building Alarm System

Actuate the Building Alarm from each station and ensure that the alarm sounds. Check the emergency power supply and adjust as required.

5.8.4 Six-Month Maintenance Checks

1. Nuclear Instrumentation

Each of the following instruments should be checked and calibrated according to the instructions in the "WANEF Console Operating and Service Manual".

Startup Range

Linear Channels No.'s 1, 2, and 3

Log Channels No.'s 4 and 5

Log-Lin Recorder

Radiation Monitoring System

2. PAX Control Element Drives

Inspect each of the items listed below on all of the PAX drive mechanisms.

1) Magnetic Clutch

a. Bolts at taper lock, torque as required

b. Armature return springs

c. Gap between rotor and armature

- d. Rotor and armature faces
 - e. Mechanical couplings of rotor to shaft
- 2) Mechanical Stops
 - a. Fastening bolts, torque as required
 - b. Max. and min. positions
 - c. Shaft key
- 3) Scram Mechanism
 - a. Fastening bolts, torque as required
 - b. Oil leakage
 - c. Adjusting valve lock, align as required
- 4) Limit Switches
 - a. Spring loaded actuators
 - b. Switch electrical and mechanical operation
- 5) Position Indicators
 - a. Gear alignment
 - b. Operate all elements of the system
- 3. FCX Control Rod Drives

Inspect each of the items listed below on each of the FCX control rod drive mechanisms.

 - 1) Magnet
 - a. Universal joint
 - b. Cable connections
 - c. Magnet and armature alignment
 - 2) Limit Switches
 - a. Check operation and positioning of each of the limit switches.
 - 3) Position Indicators
 - a. Gear alignment
 - b. Operate all elements of the system

4) Shock Absorbers

- a. Check operation of each of the shock absorbers to ensure proper operating characteristics

4. Cell Sump Pump System

Inspect the following items for proper operation

- 1) Float and float switch
- 2) Pump
- 3) Check valve

5. Assembly Room Ventilation

Inspect all coarse and absolute filters on the system

6. Source Leak Test

Test each source per the Source Storage and Handling Procedure (OP 5.6)

7. Crane Drip Pan

Inspect the drip pan on the crane and if any abnormal amount of oil is found in the pan, check the crane for oil leakage and repairs.

5.8.5 Yearly Maintenance Checks

PAX and FCX Control Element Drive Systems

1. Inspection

Inspect each of the items listed below on all of the drives.

1) Electric Motors

Check in particular the brushes, fastening bolts, couplings, and the electrical connections.

2) Gear Reducers and Gear Boxes

Check the oil level and condition on the PAX gear reducers and check the gear conditions and lubricant on the FCX drives.

3) Bearings

Check bearings for excessive wear or binding and lubricate as required.

2. PAX Scram Mechanism

Inspect at least one of the PAX scram mechanisms for spring wear, evidence of binding, and condition of the rack and pinion. If any evidence of excessive wear is found, inspect the remaining mechanisms.

3. Operational Tests

After completing the inspections of steps 1 and 2 check the operation of each mechanism as follows.

- 1) Operate each mechanism over its entire operating range and check the operating currents, the speeds, and the position of all mechanical stops and limit switches.
- 2) Scram each mechanism from the full out position and measure and record the scram time. Compare these scram times with the previously measured scram times.

4. FCX Control Element Inspection

Disassemble an FCX control rod to assess the overall mechanical integrity including dimensional changes to the polyethylene.

5. FCX Shock Absorbers

Check each of the FCX shock absorbers to ensure proper operation and inspect for any oil leakage.

OP-5.9 Emergency Procedures

5.9.1 General

The function of emergency procedures is to provide a plan of action to be followed under emergency conditions in which calm planning is difficult. The following paragraphs describe the alarm system used at WANEF and the interconnecting alarms which connect the WANEF facility with the other facilities at the Waltz Mill Site. Also described are categories of emergency conditions and prescribed action for each, followed by emergency notification, and drills that will be practiced by WANEF. All WANEF personnel are required to be familiar with the various alarms and the action associated with the alarm conditions.

5.9.2 Alarm Systems

The alarm systems at the WANEF facility are composed of three separate alarm systems as described below.

5.9.2.1 Local Area Evacuation Alarm

1. Description

A condition of high radiation above a preset level in any area controlled by WANEF "Area Radiation Monitors" will cause a buzzer to sound in that particular area and in the control room. Airborne activity in the test cell is continuously monitored and activates a remote audible alarm if excessive airborne contamination exists. Refer to Figure 4.5 for the radiation monitor locations.

2. Alarm Point

Radiation levels required to trigger the "Area Radiation Alarms" are set to meet the requirements of Federal Regulations as amended, except as established for units in the test cell. The

trip levels associated with each area monitor are listed in Chapter 4, Section 4.6.

3. Action

- (1) All personnel in the immediate area of the alarm will immediately evacuate the area and, if the reactor is in "Standby" or "Reactor ON" condition, they will notify the control room of the nature of the alarm. For non-operating situations, the Scientist-in-Charge will be notified.
- (2) The senior staff member (Experimentalist-in-Charge or Scientist-in-Charge) will notify all personnel of the condition.
- (3) If, upon immediate investigation, it is determined that a hazardous condition exists, the Building Alarm will be sounded and the building procedure carried out. Normally one would expect the senior staff member to direct that this alarm be activated, but any staff member may activate it if his evaluation indicates the necessity to do so.

5.9.2.2 WANEF-WREC Building Alarm

1. Description

The WANEF-WREC Building Alarm is an interconnected alarm system which provides for the notification of both WREC and WANEF personnel in the event that a hazardous condition arises at either facility. The system has horns located throughout both facilities which can be actuated manually from three stations at WANEF and either manually or automatically from various stations at WREC. Figure 5.1 shows the location of the alarm horns and the actuating stations at WANEF.

Figure 5.1 Location of General and Emergency Alarms

2. Action

- (1) Upon continuous sounding of the Building Alarm, the reactor will be immediately shutdown. The flux level channels and the recorder will be left operating.
- (2) Unless conditions or instructions dictate otherwise, all personnel will promptly assemble in the control room. Personnel cognizant of the emergency condition will be responsible for redirection of assembly if such is advisable.
- (3) The senior staff member (Experimentalist-in-Charge or Scientist-in-Charge) present will ascertain the nature and the extent of the problem and assume responsibility for the appropriate countermeasures and communications as follows:
 - 1) One person will be directed to make necessary preliminary radiation surveys.
 - 2) Communications will be immediately set up by the senior staff member with the WREC facility to keep them informed, or, if the alarm originated from WREC, to determine the extent of the hazardous condition.
 - 3) One person will be selected by the senior staff member to communicate the existing conditions to other appropriate persons and/or agencies.
 - 4) One person will be directed to ensure that all classified material is secured if this action is not detrimental to the health and safety of personnel.
- (4) Personnel not necessary to assist in bringing the emergency condition under control will evacuate the facility to a designated reassembly point when it is safe or expedient to do so. Prescribed action for the emergency conditions is outlined in Section 5.9.3.

- (5) Detailed and separate reports will be prepared by all personnel at the earliest opportunity, but not later than 24 hours after the alarm. Consolidation of these reports will be accomplished by the directing staff member.

5.9.2.3 General Site Alarm

1. Description

The general site alarm is the ALERT signal (a high-pitched rapid warbler sound) which can be actuated at WREC, WANEF and the Health Physics office in the WAPD Facilities Building. All emergency conditions requiring general site cognizance will be announced over the public address system in conjunction with the ALERT signal. The ALL CLEAR signal is a steady tone over the public address system.

2. Action

Detailed instructions for emergency conditions are contained in the Waltz Mill Site Emergency Procedures. In brief, the following actions should be exercised by WANEF personnel upon receipt of the alarms listed above:

(1) Alert

- 1) Report to the control room and standby for instructions over the Voice Command System. If ordered to evacuate by the senior staff member secure all systems and proceed to the designated assembly point.

- 2) All members of the Fire Brigade should prepare to report to the scene of a fire unless otherwise directed. (Two members of the WANEF staff are in the Fire Brigade.)

(2) All Clear

- 1) All personnel, upon hearing this signal, shall return to their designated work areas.

5.9.3 Categories of Emergency Conditions and Prescribed Action

5.9.3.1 Accidental Criticality

1. If WANEF area monitoring systems indicate an excursion has occurred, the building alarm will be sounded and the steps outlined in Section 5.9.2.2 will be carried out. Also, in addition to the steps outlined in Section 5.9.2.2 the following steps will be followed:
 - (1) If the excursion has been contained by the building, personnel not required to assist with the emergency will be instructed to go to the site dispensary for dosage evaluation.
 - (2) If the excursion is not contained by the building, a radiation survey of the area will be performed to determine evacuation procedures.
 - (3) The senior staff member will promptly assign evacuation routes based on the location of the accident.
 - (4) While evacuation of all personnel is being effected, methods of correcting the radiological condition will be evaluated.
 - (5) When operational control of the critical area has been established, direction of the operation will be released

to the Site Emergency Control Staff. Any required action by Health Physics will be in accordance with the Waltz Mill Site Emergency Team Procedure, including Appendix A Nuclear Accident and Dosimetry Evaluation.

5.9.3.2 Fire

1. Detection of a fire of a magnitude to endanger personnel or nuclear source material in the facility will be cause to sound the Building Alarm.
2. Personnel will assemble in the control room unless circumstances or instructions indicate otherwise.
3. Personnel unnecessary to the fire control will be instructed to go to the site dispensary.
4. In fighting the fire, the following regulations will be followed.
 - (1) Only Type 1 (CO₂) extinguishers may be used in any areas where fuel is being used or stored.
 - (2) Fire fighting will be directed by WANEF staff members who are cognizant of the hazards involved in fighting fires on or around WANEF type fuel.
 - (3) If nuclear source materials are involved, respirators are mandatory.
 - (4) No attempts to combat fires in Radioactive Materials Areas will be made without adequate radiation survey during all phases of the operation.

5.9.3.3 Radioactive Material Spill

1. The Building Alarm will not be sounded. Minimizing personnel movement in the immediate vicinity of the hazard is necessary.
2. The senior staff member present will define necessary initial prophylactic measures.

3. Radiation safety personnel (Health Physics Staff) will perform a definitive area survey and then a detailed personnel survey, and will outline appropriate personnel procedures for evaluation of the extent of the ingested radioactive materials.

5.9.4 Emergency Notification

The person designated to notify appropriate persons and agencies will complete the appropriate calls indicated as follows. These, in turn, assume the responsibility for further notification. WANL will report promptly to Aerojet-General and the Contracting Officer any changes in the physical condition of the reactor or its operating characteristics that might affect the safe operation of the reactor.

1. Reactor Excursion

- (1) Scientist-in-Charge, WANEF (if not at WANEF)
- (2) Senior site supervisors
- (3) Site Health Physics
- (4) Site Security Guard

2. Uncontrolled Criticality

- (1) Scientist-in-Charge, WANEF (if not at WANEF)
- (2) Senior site supervisors
- (3) Site Health Physics
- (4) Site Security Guard

3. Fire

- (1) Site Fire Brigade
- (2) Senior site supervisors
- (3) Scientist-in-Charge, WANEF (if not at WANEF)
- (4) Site Health Physics

- (5) The Yukon Fire Department will not be allowed access to the WANEF premises except by permission of the Scientist-in-Charge, and then only to put out fires exterior to the building.
- (6) Site Security Guard

4. Radioactive Materials Spill

- (1) Scientist-in-Charge, WANEF (if not at WANEF)
- (2) Site Health Physics

5. Additional Notification (Only as required)

Additional notification responsibilities are assigned as follows:

- (1) Senior staff Member:
 - Pennsylvania State Police
 - Westmoreland Hospital
 - WANL Reactor Analysis
 - WANL Industrial Hygiene
- (2) Scientist-in-Charge
 - Pennsylvania Department of Health
 - SNPO Health and Safety
 - REON, AGC
- (3) Site Security Guard
 - WAPD Security Officer
 - WANL Security Officer

5.9.5 Emergency Drills

Periodic emergency drills will be conducted to ensure that all personnel recognize and understand the various alarm signals and the emergency action associated with the alarm.

5.9.6 Emergency Notification Roster

1. Scientist-in-Charge, WANEF

Name: W. P. Kovacik
Address: 211 Blackridge Drive, Greensburg, Pennsylvania
Home Phone: TEmple 7-0494
Office Phone: 722-3030

2. Senior Site Supervisors

(1) Manager, WREC

Name: D. F. Hanlen
Address: 209 Woodbury Drive, Greensburg, Pennsylvania
Home Phone: TEmple 4-6618
Office Phone: 722-3041

(2) Supervisor, Plant Services

Name: C. J. Ferrell
Address: RD No. 2, Mt. Pleasant, Pennsylvania
Home Phone: TUrner 7-8995
Office Phone: 722-3011, Ext. 267, 268

(3) Supervisor, Hot Labs - PIF

Name: D. T. Galm
Address: 630 Steck Street, Greensburg, Pennsylvania
Home Phone: TEmple 4-0424
Office Phone: 722-3011, Ext. 223, 230

3. Site Health Physics

(1) Supervisor

Name: A. T. Sabo
Address: 326 Maple Avenue, Pittsburgh 18, Pennsylvania
Home Phone: PEnnhurst 1-8075
Office Phone: 722-3011, Ext. 241

4. Site Fire Brigade

- (1) Site Central Control Office (HP Office)

Phone: 722-3011, Ext. 242 Alternate Phone Ext. 243

- (2) Captain - Fire Brigade

Name: R. Kearns
Address: 250 Glencoe Drive, Dravosburg, Pennsylvania
Home Phone: HObart 6-7091
Office Phone: 722-3011, Ext. 230

5. Yukon Fire Department

Phone: 722-3101 (Cicci Motors) 722-9790 (Central Hotel)

6. Pennsylvania State Police

Phone: TEmple 4-4400

7. Westmoreland Hospital

Phone: TEmple 7-0100 - Nursing Supervisor: Ext. 237

8. WANL Reactor Analysis

Manager: J. G. Gallagher
Home Phone: 835-8009
Office Phone: 892-5600, Ext. 8307, 287

9. WANL Industrial Hygiene

Manager: M. R. Beebe
Home Phone: 531-8737
Office Phone: 892-5600, Ext. 8159, 547

10. Pennsylvania Department of Health

Phone: Area 717, 787-2480, Ext. 849 - Tom Gerusky - Health Physicist
787-6436, Ext. 5027 - Mr. Mason

11. SNPO Health and Safety

R. Hartfield/David Smith

Phone: Area 216, 433-4000, Ext. 6821, 6739

12. A. A. Spritzer, M. D.

Medical Director, Westinghouse Astronuclear Laboratory
Large, Pennsylvania

Phone: 892-5600, Ext. 345

13. C. C. Ross

Vice President, Reactor Engines Operations - Nuclear
P. O. Box 1947

Sacramento, California

ATTENTION: J. B. Philipson

Phone: Area 916, 355-5848, Ext. 4276

OP-6.1 Control of Liquids in the Test Cell when Reactors are Present

6.1.1 General

Rule 4.3.11 of the Operating Limits states:

"Water or other liquids are not permitted in the test cell when a reactor is present except under one of the following conditions:

- 1) Required liquids are used in containers and with procedures such that it will be incredible for the fluid to get into the core. The Nuclear Safety Committee will review and recommend for approval the container design and the procedures to be used such that the incredibility of fluid getting into the core is assured.
- 2) When the reactors are shutdown, liquids may be used in limited amounts such that if the entire contents of the container is introduced into the core the reactivity insertion is $< 50\%$ in PAX and $< 1.00\%$ in FCX."

The introduction of liquids into the PAX or FCX core could present a very serious hazard and thus all liquids in the cell must be kept to a minimum. In order to effectively control the amounts of liquids allowed in the cell and to establish the manner in which these liquids will be handled, the following procedures have been established. These procedures define what liquids are required in the test cell for effective operation as well as the type of containers which are to be employed, and the procedures for handling and periodically checking the condition of the liquids.

6.1.2 Procedures

6.1.2.1 Test Cell Crane

The overhead crane in the test cell has approximately 5 gallons of oil which is used for lubrication of the crane gear box. The crane is equipped with a splash pan which is designed to prevent any normal

oil leakage from dropping to the test cell floor or onto either of the cores. This pan is capable of holding about 1 gallon of oil. To insure that no inadvertent oil leakage from crane comes in contact with either the FCX or the PAX cores the following guidelines have been established:

- 1) When not in use, the crane will be positioned such that it is not over either core.
- 2) The oil in the splash pan will be checked on a periodic basis.
- 3) At any time when repairs are in progress on the crane, wherein the oil is exposed, the crane will be positioned at the northeast corner of the cell away from the reactors.

6.1.2.2 Drum Drive Shock Absorbers

Each of the drum drive shock absorbers contains about 140 ml of oil which is used to absorb the shock of the scram spring and to lubricate the scram mechanism. This oil is in a unit where leakage is kept to a minimum by the use of seals. In the event of a small leak in the shock absorber, there is a gland which can be tightened to stop the leakage. The entire drive unit will be removed from the cell if major repairs are required.

6.1.2.3 FCX Rod Drives

The FCX rod drive mechanisms each contain about one pint of grease in the speed reducer gears. This is a very thick grease and it is contained in a sealed housing with the only penetrations being the motor shaft and the shaft to the pinion gear. Leakage through these penetrations is minimal but to ensure that no excessive leakage goes unnoticed these penetrations will be inspected on a periodic basis. If at any time the mechanism is disassembled to the point where there exists a possibility of the grease escaping from the mechanism, then measures will be taken to ensure that this leakage does not go beyond the rod drive platform.

6.1.2.4 FCX Shock Absorbers

The FCX shock absorbers, which are mounted in the core tank under the FCX core, contain about 350 ml of oil apiece. These units are completely sealed and their only penetrations are the shaft of the plunger and a small drain plug on the bottom. Leakage from these units is very improbable but to ensure that no excessive leakage goes unnoticed, each unit will be inspected periodically. If at any time any of these units require disassembly, the disassembly process will be performed outside the test cell.

6.1.2.5 Seepage Water in Test Cell Basement

A situation exists in the WANEF test cell basement wherein water enters due to ground seepage. This is a chronic condition that has existed since construction of the test cell. A sump pump is installed in a hole at a low point in the basement floor and removes water accumulation automatically. However, this pump has on previous occasions stopped either due to power failure or the buildup of minerals in the mechanism. This allows water to accumulate on the basement floor. Two water detectors are installed to give indication that water exists by an annunciator light on the console and another at the site guard station. The sump pump is then reset or cleaned and all water is removed.

6.1.2.6 PNG Transformer

A high voltage transformer is required for operation of the PNG and will be located at floor level in the test cell. This transformer contains 60 gallons of oil and is completely sealed at all times. If at any time the container must be opened for any reason, the entire process will be performed outside the test cell area.

6.1.2.7 Vacuum Pump for PNG

A vacuum pump is required for initial pumpdown of the PNG. This pump contains approximately five quarts of oil and is completely contained except for a ventilation pipe extending through the top of the pump housing. This pump will be utilized as a roughing pump for the PNG and therefore is periodically required in the test cell. The position of this pump when operating is on the test cell floor. Since the pump is portable all maintenance, including oil changes, will be accomplished outside the test cell.

6.1.2.8 Turning Stand Gear Reductor

The turning stand, used to invert the assembled reactor or reflector, contains approximately 2.5 quarts of oil in the gear reductor. This stand is located in the southeast corner of the test cell at a distance in excess of 15 feet from either PAX or FCX. The gear reductor is totally enclosed and sealed; therefore it is inconceivable that this oil could affect the FCX or PAX reactors.

6.1.2.9 Test Cell Emergency Lights

Each of the emergency lights in the test cell is equipped with a storage battery containing about one gallon of water. The batteries are sealed units except for small breather holds on the top of each cell and thus no hazard should arise from inadvertent water spillage. Periodically water must be added to the cells. When this is necessary the water will be added using a small squeeze bottle containing no more than 450 ml of water. If, at any time, it is necessary to disassemble an emergency light unit such that the water in the battery is exposed, then this operation will be performed outside the test cell area.

6.1.2.10 Vehicles in the Test Cell

Occasionally it is necessary to bring vehicles into the test cell to load or unload materials and hardware. When these occasions arise the following rules will be followed to ensure that no inadvertent hazard arises:

- 1) The vehicle will be moved into the cell only as far as is necessary to accomplish the loading or unloading operation.
- 2) The time required for the vehicle to be in the cell will be minimized
- 3) The vehicle will not be left unattended while in the cell.
- 4) No liquids will be removed from the vehicle when in the cell.
- 5) The vehicle will contain no exposed liquids while in the cell.

6.1.2.11 Use of Liquids in the Test Cell

When a reactor is shutdown the use of small quantities of liquids are necessary in the test cell. Examples of these requirements are 1) oil cans containing cutting oil for drilling operations or for lubrication purposes, 2) small squeeze bottles which contain water or solvents for cleaning purposes, 3) small cans of paint for "touch up" purposes, and 4) damp mop for cleaning and decontamination purposes. These containers will contain no more than 450ml which, if inadvertently dumped into the reactor, would increase core reactivity no more than 50¢ in PAX or \$1.00 in FCX. However, these liquids will be used only when the reactors are secured. In this situation PAX and FCX will be shutdown by a minimum of 2.8\$ and 10.00\$, respectively.