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Operations Division
Reactor Operations Section

OPERATING MANUAL FOR THE HIGH FLUX ISOTOPE REACTOR

Operating Procedures

Part 1

Compiled by

High Flux Isotope Reactor Staff

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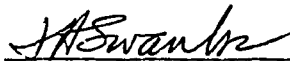
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DEPARTMENT OF ENERGY

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1. INTRODUCTION AND GENERAL PRINCIPLES OF OPERATION

The operation of a nuclear reactor requires careful attention to procedures in order that all safety precautions will be observed. All of the hazards associated with an industrial plant are present along with those associated with a high-performance nuclear reactor. Since an accident could release large amounts of radioactivity, careful operation and strict enforcement of procedures are necessary. To provide for safe operation, detailed procedures have been written for all phases of the operation of this facility.

This volume of the HFIR Operating Manual is devoted to the detailed operating procedures and methods which will be employed. A minimum amount of descriptive material is included. In all cases where applicable, a standard format is used in presenting these procedures. This format is as follows.

References. All appropriate drawings, specifications, design reports, and other material, which might aid in understanding the operation under discussion, are listed.

Introduction. A very brief introduction is sometimes presented if it is thought to be of some value to the operator.

Precautions. The precautions and/or hazards, if any, are presented in detail. Such things as protective clothing required, the potential radiation problems involved, etc., are included.

Normal operation limits. The parameters for normal operation, usually in chart or tabular form, as well as the alarm and other set-points are listed.

Place in service. Step-by-step manipulations required to place the component or system in service are presented in detail.

Normal operation. The conditions to be observed and the checks to be made during normal operation are described in this section.

Remove from service. Step-by-step procedures required to remove the component or system from service are presented in detail.

Alternate modes of operation. Any alternate methods of operation, especially under emergency conditions, are described.

All normal and most emergency operation conditions are covered by procedures presented in this volume. These procedures are designed to be followed by the shift crew unless specifically countermanded by a senior staff member. Strict adherence to these procedures is expected for the following reasons.

1. To provide a standard, safe method of performing all operations, the procedures were written by reactor engineers experienced in supervising the operation of reactors and were reviewed by an organization with over 30 years of reactor operating experience. In many cases the specific techniques have evolved from long, and sometimes costly, experience in operating reactors and handling radioactive material.
2. To insure standardization of routine jobs among the shift crews, it is necessary to follow written standard procedures. Many jobs, by virtue of their simplicity and frequent performance, can be completed without reference to written procedures, however, if this occurs, slight variations develop among the individuals performing the job and supervision may no longer be aware of the exact procedure being used. Although many procedures can, and will, be improved by the shift operators, such improvements must be incorporated into the formal procedures so they can be reviewed and evaluated.
3. To provide detailed instructions for nonroutine, infrequently occurring operations where the operator may have forgotten the

procedure, a written procedure is necessary. Some jobs are performed at intervals of at least five years and perhaps longer. Detailed procedures were prepared for these operations while the reactor designers were available for consultation and the procedures could be checked with a "cold" system. In the event the original staff is not available when these jobs must be performed, the detailed, step-by-step procedures must give enough background and instruction so that staff not present during the original startup can carry out the operation safely.

4. To have an up-to-date description of operating techniques available at all times for reference and review it is necessary that the procedures be written. In addition to reference by the operating staff, the procedures furnish a valuable text for training new staff members and it is absolutely essential that they represent the current practices. Various DOE and ORNL committees periodically review the HFIR operation; and for these reviews to function constructively, it is necessary that an accurate description of the operating procedures be available.

The initial printing and subsequent reprinting of the procedures manual provided some bound copies plus some copies in loose-leaf form. One loose-leaf copy is kept in the reactor control room, one in the shift supervisor's office, and others in permanent files. The loose-leaf copies provide a means of maintaining up-to-date copies of the standard operating procedures since additions and changes do occur frequently. A standard method is used to change the operating procedures so that all persons concerned are notified of the change and a permanent

record is made. Any procedure change must be formally written and approved by two senior staff members. It is then assigned a revision number and dated. A copy of the revised procedure is placed in each of the loose leaf manuals and in a chronological file as a permanent record. A copy is also issued to all individuals concerned with the HFIR operation; i.e., each individual on the official procedure distribution list.

All operating procedures are reviewed every two years for applicability and correctness. In addition, individual procedures are updated as necessary in the interval between reviews. The assistant reactor supervisor, with assistance from staff members is assigned this responsibility. All revisions and additions are reviewed by appropriate staff members and by the Reactor Operations Review Committee as appropriate.

Temporary procedure changes and/or deviations from the standard operating procedures may be authorized by issuing special operating instructions. The Special Operating Instructions Memos must be signed by two senior staff members. A copy of all current special operating instructions is kept on file in the control room and in the reactor supervisor's office. A copy is also issued to all HFIR engineers and supervisors.

2. REACTOR OPERATION

2.1. Startup

2.1.1 Responsibility

Although the various subsystems can be checked extensively before starting up the reactor, the overall system performance can be evaluated only when the reactor is at power. In this sense, each reactor startup involves the uncertainty of a critical experiment and thus demands the undivided attention of a qualified supervisor. To avoid situations in which some prestartup checks are neglected or abnormal conditions are not noted because of dual supervision, only one supervisor will be in charge of a startup. Normally this will be the reactor shift supervisor. The supervisor in charge must assure himself that all requisite conditions for a reactor startup have been met. He must be present in the control room while the startup is in progress and must remain in charge until an accountable power level (normally 10 MW) is attained.

The minimum required personnel in the control room for a normal reactor startup are a shift supervisor and a reactor operator. Occasionally, an instrument mechanic and/or instrument engineer is needed for standby service. Other personnel are superfluous and may indeed present confusion and distraction to the operation. During reactor startup, it is the responsibility of the supervisor in charge to evaluate the number of personnel required and to excuse bystanders from the control room to the observation area outside the control room. There are special occasions when extra personnel (i.e., trainees, committees, etc.) will necessarily be present. During such times, those observing should be instructed to avoid confusing and/or interfering with the startup.

Reactor safety. Reactor operations work requires constant vigilance on the part of the operating personnel to ensure that safety requirements for personnel, the reactor facility, and the general public are met. Since procedures cannot be written for all conceivable situations, the operating personnel must be relied upon to evaluate the situations and to exercise good judgment, based on knowledge of the facility, in reacting to any given set of circumstances.

If any doubt exists in the mind of the operator and/or supervisor as to the seriousness of any circumstance concerning reactor or personnel safety, the conservative action must be taken. This includes reactor power reduction or reactor shutdown while further evaluations are being made or corrective actions are being taken.

2.1.2. Personnel hazards during startup

Each startup of a clean core is a test of fuel element integrity. If any defect exists, it will probably release fission products to the primary coolant system. Therefore, during each startup, it must be assumed that the primary coolant system will become highly radioactive. Based on this assumption, the obvious general safety rules must be followed. Personnel must be excluded from areas which contain unshielded primary coolant lines (demineralizer and deaerator cells). Any operation which releases primary coolant (sampling water, testing pressure switches, etc.) must be discontinued during startup.

2.1.3. General procedures

Startup checks, itemized on the startup checklist (Example 11.8, Section 11.2.1) must be made prior to every startup following any work in the reactor core. Startups following brief accidental shutdowns are discussed in Section 2.1.7 and 2.1.8. In all cases the supervisor in charge of the startup must be satisfied that all shutdown work has been

completed, the proper checks have been made, and the reactor is ready to be started. The supervisor will then direct the operator to proceed with the startup. The supervisor must remain in the control room while the startup is in progress.

2.1.4. Preparation for startup - Mode 1

Instrumentation. The minimum reactor control and safety instrumentation required for the reactor startup is as follows:

1. two operating safety channels each consisting of the following systems:
 - a. neutron flux level,
 - b. neutron flux rate of change,
 - c. heat power,
 - d. reactor water inlet temperature,
 - e. primary system pressure,
 - f. reactor primary coolant flow,
 - g. failed fuel element detector, and
 - h. main pump cutoff

[If any subsystem of a safety channel is known to be defective and therefore inoperative, the channel must be tripped manually. In this case any trip signal in either of the two remaining safety channels will shut down the reactor.];
2. two operating count-rate channels;
3. two operating servo channels (A "withdraw error signal" from all three servo channels is required to obtain "start.");
4. one SBHE flow meter in the reactor bay branch; and
5. one CHOG monitor and one instrument air pressure monitor.

Equipment. All critical equipment is interlocked so that a reactor startup to power is not possible unless this equipment is operating.

The following auxiliary equipment must be either operating or in standby ready to operate for such a reactor startup:

1. two of the three pony motors associated with the operating main circulating pumps;
2. two diesel-generators in standby [If one diesel-generator is known to be inoperative, the other unit must be tested weekly.];
3. one SBHE fan in service and one in standby;
4. one OHOG fan operating; and
5. one CHOG fan operating.

Visual inspection. The following areas should be visually inspected for abnormal conditions before startup:

1. reactor and storage pools,
2. heat exchanger cells and pipe tunnel,
3. beam holes,
4. experiment facilities,
5. demineralizer and deaerator cells, and
6. subpile room.

Monitoring. Arrange for radiation monitoring of critical areas during startup, if required.

Startup checklist - completed. When it is determined that all start-up checks per Section 3.1.4 and Section 11.2.1 have been completed and that everything is in order for startup, the control desk operator will announce over the public-address system, "The reactor is starting up." This should be repeated at least once.

2.1.5. Startup to N_L (10 MW)

The following console switch handles should be placed in the position indicated:

S-1 - Key switch - on

S-7 - Shim actuating switch - "off" (vertical) and "normal" (pushed in)

S-9 - Raise test switch - "normal"

S-12, S-13, S-14 - Fission Chamber Drive Switches - "off" (vertical) and "auto" (pushed in)

S-10 - Scram - "normal"

S-15 - Scram reset P.B. - push to reset scram

S-18 - Shim computer bypass switch - "off"

S-22 - Mode switch - "mode 1"

An automatic startup to N_L will occur when the "start request" button, S-2, is pushed. The following conditions and permissives are satisfied in sequence as the startup progresses.

1. The "start request" button picks up the "start request" relay K-501.
2. Relay K-501 causes the "start" relay K-502 to be energized if:
 - a. all three servo channels indicate a withdraw error,
 - b. the regulating cylinder is at its withdraw limit, and
 - c. the servo demand is at its lower limit on all three servo channels.
3. When either the K-501 or K-502 relay is picked up, the "servo on" relay, K-504, is de-energized which activates the servo systems.
4. The "start" relay, K-502, causes the "group withdrawal request" relay, K-514, to be energized, provided the following conditions are met:
 - a. the shim actuating switch, S-7, is in the NORMAL position,
 - b. the regulating cylinder is at its withdraw limit,

- c. there is "confidence" in two and a period greater than 30 s in these two CRM channels, and
 - d. two of the three servo channels indicate a rate of power increase less than 5 MW/s.
5. Activation of the "group withdraw request" relay, K-514, withdraws all shims, subject to the 30-s period inhibit, provided the following conditions are met for each shim:
- a. mode 1 is selected;
 - b. raise-test switch, S-9, is in "normal;"
 - c. clutch switch is activated;
 - d. there is no insert request; and
 - e. the shim is not at its withdraw limit.
6. All shims continue to withdraw until one of the three count-rate channels indicates a period shorter than 30 s. When this occurs, the "group withdraw request" relay, K-514, drops out and stops shim withdrawal. This relay is automatically picked up again when all count-rate channels indicate >30-s period. The entire process is repeated as often as necessary to maintain approximately 30-s period until N_L (10 MW) is reached. (Shim withdrawal can be stopped at any point in the startup by pulling the shim actuating switch handle to its BLOCK position. The period can be manually cancelled and the reactor power held at any power level below N_L .)
7. When reactor power reaches 10 MW, the servo systems insert the regulating cylinder to hold the power at this level. The "group withdraw request" relay drops out when the regulating cylinder leaves its withdraw limit, leaving the reactor at 10 MW under servo control in the "start" mode.

2.1.6. Power increases above N_L

The power level should be held at N_L until all instruments have reached equilibrium and it is determined that all conditions are normal. Any malfunctioning instrument and/or equipment required for operation of the reactor at power should be repaired immediately. Should it be necessary to make repairs and the nature of the repairs is such that if performed at a power level of N_L it may endanger personnel or the reactor, the reactor will be shut down.

When it is determined that everything is in order and that all conditions are ready for the power to be raised, the control desk operator will proceed as follows:

1. Before reactor power can be raised above N_L , the "run" mode must be established. "Run" mode is established by pushing the "run" button, S-3, provided the following conditions are met:
 - a. all three safety heat-power meters are indicating >5 MW,
 - b. all three count-rate channels are indicating approximately an infinite period,
 - c. the regulating cylinder is not at its withdraw limit, and
 - d. two of the three count-rate channels are indicating a power greater than 300 MW.
2. Balance rods 1-4. Have the bank 1-4 symmetrical with rod 5.
3. Visually check the rod drives positions in the subpile room to make sure they are the same as the selsyn indicators on the console.
4. Announce over the public-address system: "The reactor is going to power." Repeat once.
5. After the "run" mode is established, the reactor power can be raised with the "group servo demand" switch, S-11. This switch

causes the demand motors in all three servo systems to raise the servo demand signal at a linear rate of approximately 1.5 MW/s. The individual servo demand switches are used to adjust the demands until the dead bands of the three servo systems coincide.

6. As reactor power is increased, secondary coolant flow rate through the primary heat exchangers must be increased to remove heat produced. This is done by manually opening FCV-377 valve sufficiently to keep the automatically operated valve, FCV-377A, within its control range.

2.1.7. Startup following a shutdown due to the dropping of one or more shim-safety plates

The reactor must be restarted quickly following an accidental shutdown from power, or it cannot be restarted at all. When the neutron flux is reduced, the xenon concentration increases rapidly and poisons the core. In spite of the incentives for bringing the reactor to power quickly, safety must never be jeopardized in a reactor startup. An analysis to determine the reason for the dropped plate or plates and to ensure the safety of the reactor upon restart must be made prior to restart. This usually can be done during plate withdrawal and before N_L is reached. If any doubt exists as to the safety of restarting the reactor, the power level should not be raised above N_L .

The startup procedures differ slightly depending on whether one plate or the entire bank was dropped. However, the purpose of both procedures is to return the reactor to power as quickly as possible in a safe manner subject to restrictions imposed in Section 2.1.11. CAUTION: The No. 5 shim-regulating cylinder must not be withdrawn further than any shim-safety plate if it is out further than the symmetric critical

position which existed just prior to dropping the plate. The procedures are as follows:

1. Complete reactor restart checklist (Example 11.9, Section 11)
2. Startup following a shutdown caused by dropping one shim-safety plate.
 - a. The servo demands will be set back automatically by the shim asymmetry circuits.
 - b. Select "rods No. 1 through No. 4" position on the shim-drive-selector switch.
 - c. After the servo demand setpoint is reduced to 10 MW, allow the servo systems to attain this power level by manually withdrawing shim-safety plates 1 through 4 with the shim actuating switch.
 - d. Balance shims at 10 MW as follows:
 - (1) Move the shim-drive-selector switch to select the plate which dropped.
 - (2) Withdraw this plate by turning the shim actuating switch to "fast withdraw" and holding it in this position. The control system will insert all shims intermittently while the out-of-balance plate is being withdrawn. The insert signal will come when the regulating cylinder reaches its "auto shim insert" limit switch. The out-of-balance plate will be momentarily inserted when all shims insert, but due to the relative worths, the overall effect will be to bring the shims into balance. Continue this action until the dropped plate is approximately even with the rod bank.

- (3) Bring all shims symmetrical as required by manipulating the individual drives.
- e. Raise reactor power per procedures 3 through 6 in Section 2.1.6.
3. Startup following a shutdown caused by a false scram
 - a. The servo demands will be set back automatically by the shim asymmetry circuit.
 - b. Select "rods No. 1 through No. 4" position on the shim drive selector switch.
 - c. After the servo-demand setpoint is reduced to 10 MW, withdraw shim-safety plates 1 through 4 until they are symmetrical with shim-regulating cylinder No. 5 by manually operating the shim actuating switch.
 - d. Select "all rods" position on the shim drive selector switch. Manually withdraw all shims by operating the shim actuating switch until a power level of 10 MW is reached.
 - e. Balance shims at 10 MW.
 - f. Raise the reactor power per procedures 3 through 5 in Section 2.1.6.
4. Startup following a shutdown caused by dropping two or more shim-safety plates
 - a. Scram all shim-safety plates by momentarily placing the scram switch in the "scram" position and then clearing the scram.
 - b. The servo demands will be set back automatically by the shim asymmetry circuits.
 - c. Select "rods Nos. 1 through 4" position on the shim drive-selector switch.

- d. After the servo demand setpoint is reduced to 10 MW, withdraw shim-safety plates 1 through 4 until they are symmetrical with shim-regulating cylinder No. 5 by manually operating the shim actuating switch.
- e. Select "all rods" position on the shim drive selector switch. Manually withdraw all shims by operating the shim actuating switch until a power level of 10 MW is reached.
- f. Balance shims at 10 MW.
- g. Raise the reactor power per procedures 3 through 5 in Section 2.1.6.

2.1.8. Return to full power following a normal-power outage

Emergency power supplies and standby equipment are designed to maintain a reactor power level of 10 MW during a normal-power outage. Operation at this power level retards the rapid growth of xenon which would occur if the reactor were completely shut down. However, the xenon concentration increases during 10-MW operation under these conditions, so it is desirable to raise the reactor power level as soon as possible after normal power is restored. This should be done in the following manner:

- 1. Stop auxiliary secondary coolant pump, PU-14.
- 2. Press the "auto-process start" button. This will start a pressurizer pump, three main circulating pumps, and the two secondary coolant circulating pumps in a timed sequence designed to minimize electrical surges.
- 3. The smaller process pumps are designed to restart automatically upon restoration of normal power. Check for proper operation of the following pumps and normal flow conditions in their respective subsystems.

- a. primary cleanup pump - PU-2A or -2B, FI-258;
- b. pool coolant pump - PU-9A or -9B, FI-425, -468, and -441;
- c. pool demineralizer pump - PU-7A or -7B, FI-426.
4. Check the SBHE, CHOG, and OHOG systems to make sure power has been restored to these circuits.
5. Check the cooling tower fan indicator lights on the process panel board to make sure power has been restored to these circuits.
6. Return PU-14 switch to "auto" position.
7. Start one of the plant demineralized water pumps, PU-18A or -183.
8. Perform experiment checks as necessary.
9. Increase reactor power to the desired level per Section 2.1.6 consistent with Section 2.1.11.
10. Stop the following equipment which was started by the normal-power failure.

NOTE: Return all mode switches to "auto" position after starting equipment.

 - a. Auxiliary pressurizer pump, PU-11
 - b. Diesel-electric generators.
11. If any of the following equipment was started while in standby condition, it should be stopped and returned to standby condition.
 - a. Instrument air compressor, C-1A, C-1B or C-1C
 - b. Emergency instrument air compressor, C-3
 - c. SBHE fan, FN-1 or FN-2
 - d. CHOG fan, FN-3 or FN-4
 - e. OHOG fan, FN-5 or FN-6.

12. Restart the chiller compressor using the local control start switch, if chilled water is required.
13. Reset TS-476-2 near the pool deaerator cell entrance so that steam will again be supplied to the deaerator ejectors.
14. Restart the subpile room ventilation blower.
15. As soon as possible, check all areas to make sure that the various systems are operating properly. Particular attention should be given to the following:
 - a. Determine that the fire alarm system has not been affected by the power outage (see Section 8.2).
 - b. Check the battery banks and give them a freshening charge.
 - c. Determine that the sulphuric acid and chemical pumps at the cooling tower restarted automatically.

2.1.9. Mode 2 startup and operation

Mode 2 is a manually-controlled operation at low power levels with no system pressure requirements. Primary system flow from at least two pony motors, however, is required.

Instrumentation and equipment requirements are identical to those listed in Section 2.1.4 for Mode 1 startup except no system pressure monitor or neutron rate of change or operating servo channels are required. The startup checklist must be completed prior to Mode 2 startup.

1. Place the console switches in the positions indicated in Section 2.1.5 except switch S-22, which should be in the Mode 2 position.
2. Press the "start request" button.
3. Place the shim actuating switch, S-7, in the withdraw position. All four shim-safety plates and No. 5 shim-regulating cylinder

will withdraw subject to period limitations identical to for Mode 1 operation. CAUTION: Do not allow the shim-regulating cylinder to withdraw farther than any shim-sa plate.

4. Continue withdrawing all five plates while maintaining symmetry until criticality and the desired power level is reached.

2.1.10 Mode 3 startup and operation

Mode 3 is a manually-controlled operation at low power levels with no system pressure or flow requirements.

Instrumentation. The minimum reactor control and safety instrumentation required for the reactor startup is as follows:

1. two operating safety channels each consisting of neutron flux level instrumentation;
2. two operating count-rate channels;
3. one reactor bay flow rate monitor in the SBHE system;
4. one closed hot off-gas system monitor; and
5. one instrument air system pressure monitor.

Equipment. The following auxiliary equipment must be either operating or in standby ready to operate for a reactor startup:

1. two diesel generators in standby (If one diesel generator is known to be inoperative, the other unit must be tested weekly while there is a need for an emergency power supply.);
2. one SBHE fan in service and one in standby;
3. one CHOG fan operating;
4. one OHOG fan operating; and
5. one instrument air compressor.

The startup checklist must be completed prior to Mode 3 startup.

1. Place the console switches in the positions indicated in Section 2.1.5, except switch S-22 which should be in the Mode 3 position.
2. Press the "start request" button.
3. Place the shim-actuating switch, S-7, in the withdraw position. All four shim-safety plates and No. 5 shim-regulating cylinder will withdraw subject to period limitations identical to those for Mode 1 operation. CAUTION: Do not allow the shim-regulating cylinder to withdraw farther than any shim-safety plate.
4. Continue withdrawing all five plates, while maintaining symmetry, until criticality and the desired power level are reached.

2.1.11. Programmed restart after 100-MW operation

At any time during the fuel cycle if the reactor should shut down from 100-MW operation, the power level may be raised immediately to 100 MW if the down time does not exceed 10 minutes. If the down time exceeds 10 minutes, the procedure for restart of the reactor after shut-down from 100-MW operation is given in the following table.

Time operated at 100 MW (days)	Power escalation on restart		
	First step (MW)	Duration of first step (h)	Second step (MW)
<1	42	1 3/4	100
1 to 8	70	1 1/2	100
8 to 13	90	2/3	100
>13	100	---	---

If it should be observed that the control plates continue to come out at the first-step power level, the power level should be increased to the "break-even" power level and held there for the duration indicated in the first step.

2.2. Steady-State Operations

2.2.1. Continuous power operation

During continuous power operation, numerous checks must be made and pertinent data recorded on a routine schedule. Other miscellaneous duties associated with an operating reactor must be performed as required.

The reactor power is held constant at a predetermined level by the servo control system. Although the various subsystems are placed in operation prior to reactor startup, numerous "tune-up" adjustments are required to attain equilibrium operating conditions. When the system reaches equilibrium, fewer adjustments are required; however, no less attention should be given to the operation of the reactor. A qualified reactor operator must be present in the control room in the following situations:

1. when the reactor is critical; and
2. when the reactor is capable of criticality and the key is inserted in the control power key switch.

The HIFR shift supervisor must remain in the HFIR area during reactor operation. If it is necessary for him to leave the area when the reactor is operating, a qualified substitute must be available or the reactor must be shut down.

During continuous power operation, the following duties must be performed:

1. Console operator

The console operator must keep the reactor control instrumentation under constant surveillance. Any misoperation, malfunctioning instrument, or abnormal condition should be recorded and reported to the supervisor on duty. Data must be recorded hourly as per the data accumulation sheet described in Section 11.1.1.

2. Roving Operators

The roving operators make periodic checks on the water systems and stack area, record readings as per the data accumulation sheets described in Section 11.1, perform pool work, assist experimenters as needed, check the operation of emergency equipment, and perform other duties of a non-routine nature as may be required.

- 2.2.2. Heat power calculations

The operating power level of the reactor is determined by the heat power produced; that is, the heat gain in the primary system and reactor pool coolant systems. Accurate calculations of heat-power level must be made for all power levels of N_L and above. Detailed instructions for recording heat power are on the "HFIR Hourly Readings" data sheet described in Section 11.1.1.

Accumulated heat power must be maintained for fuel burnup and isotope production calculations. It is calculated by the following equation:

Accumulated heat power (MW-h) = Power level (MW) x Time operated (h).
This quantity is recorded on the various forms as described in Section 11.

2.2.3. Shim positions

To maintain a uniform flux distribution around the center of the core, the shim plates must be kept as nearly even as is practical. During normal operation, the center servo-controlled cylinder will slowly withdraw to maintain a constant power level. The outer shim plates must be kept as nearly even as possible to maintain flux symmetry. Any imbalance of these plates will cause a radial flux tilt. The console position indicators of all shim plates, including the inner cylinder, should be maintained within 1/2 in. of each other.

Standard rod position. Each time the plates are shimmed, the symmetric plate position should be compared with the standard rod position curve (Fig. 2.1) at the same number of megawatt-days. If there is a discrepancy greater than 1/2 in. (under steady-state conditions), the plate positions should be checked immediately by comparing the selsyn indicators with the yard stick readings in the subpile room. The standard rod position curve will vary because of varying experiment loads which should be taken into account.

2.2.4. Minimum instrumentation for continuous power operation

1. Two operating safety channels each consisting of the following subsystems:
 - a. neutron flux level and rate of change,
 - b. heat power,
 - c. reactor water inlet temperature,
 - d. primary system pressure,
 - e. reactor primary coolant flow,
 - f. failed fuel element detector, and
 - g. main pump cutoff.

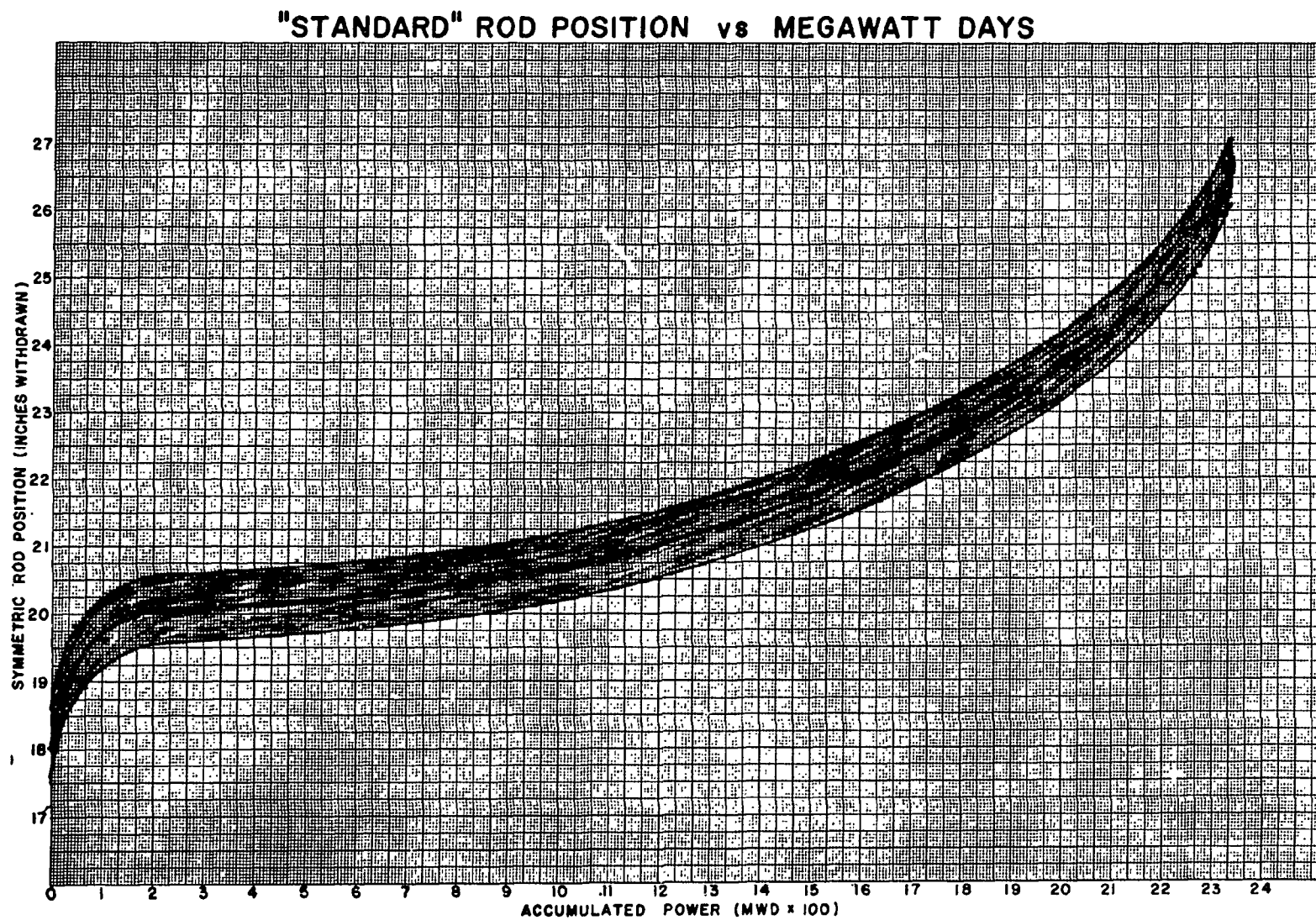


Fig. 2-1. Standard rod position curve.

If any subsystem of a safety channel is known to be defective and therefore inoperative, the channel must be tripped manually. In this case, any trip signal in either of the two remaining safety channels will shut down the reactor.

2. One SBHE flow meter in the reactor bay branch.
3. One CHOG monitor and one instrument air pressure monitor.

2.3. Shutdowns

2.3.1 Refueling shutdowns

In general, refueling shutdowns will not be scheduled at a definite time, but will occur when the reactor loses its excess reactivity and shuts itself down. Actually, the shutdown time can be predicted within a few hours and shutdown work scheduled accordingly.

All work to be accomplished during a shutdown will be listed on a shutdown sheet or schedule prepared in advance. This schedule lists in detail all the work to be done as well as special procedures to be followed, if required. The schedule may be fairly elaborate when major maintenance is required or it may be quite simple for a routine refueling. In either case, it should be followed as closely as possible.

2.3.2. Shutting the reactor down

1. When all control rods reach their withdraw limit switches, announce the forthcoming shutdown over the public address system.
2. Insert the control rods according to the method specified in the shutdown sheet.
3. Turn the key switch to the "off" position and remove the key.
4. Turn the scram switch to "scram" and leave it in this position.
5. Lower the reactor inlet temperature set-point to equalize the primary and pool water temperatures.

6. Maintain the normal water flow rate at operating pressure for at least one hour and then stop the main circulating pump motors.
7. After at least four hours cooldown and water cleanup, depressurize the system per Section 6.1.5, while maintaining coolant flow with the pony motors. WARNING: Forced circulation coolant flow must be maintained as long as an irradiated element is in the core.
8. Complete the "HFIR Shutdown Checklist" (see Example 11.12.).

2.3.3. Reporting reactor shutdowns

To maintain consistency in reporting reactor shutdowns, a rubber stamp form, Example 2.1., is used in the log book. Each shutdown from an accountable power level should be reported in this manner regardless of the number of shutdowns that occur. The minimum accountable power level is 10 MW.

No more than one form should be used for each shutdown. The supervisor on whose shift the shutdown occurs will make initial use of the form for reporting the shutdown. The supervisor on whose shift the reactor reaches the minimum accountable power level on the subsequent startup will be responsible for completing the form with respect to "up," "lost time," "time distribution," and startup information.

A guide to the use of the form follows:

Time

Down - Refers to the time that the reactor power level drops below the minimum accountable power level.

Up - Refers to the time that the reactor, upon startup, reaches a power level equal to, or in excess of, the minimum accountable power level.

SHUTDOWN INFORMATION									
TIME:	down	_____	up	_____	lost time	_____	h		
SCHEDULE:	scheduled	☐	☐	unscheduled	☐	☐			
MODE:	scram			setback			reverse		
CAUSE:	equipment	☐	☐	HE	☐	other	☐	unknown	☐
TIME DIST:	operations	_____	h	research	_____	h			
STARTUP:	Supervisor	_____	Operator	_____					
CIRCUMSTANCES:	_____								

Example 2-1. Shutdown information.

- Schedule Check the appropriate square
- "R" and "O" refer to "research" and "operations" and the checked square indicates the group responsible for the shutdown, whether scheduled or unscheduled. An unscheduled shutdown is defined as any shutdown which is required to correct an abnormality upon 30 minutes or less notification.
- Mode Check the appropriate square
- Scram - A shutdown caused by the release of shim-safety rods.
- Setback - An automatic reduction in power by the servo system. If the setback signal clears before the reactor power falls below the minimum accountable power level, it does not constitute a shutdown and the form should not be used. All setbacks, however, must be reported in the log book.
- Reverse - A reduction in power by an automatic or manual insertion of a shim rod. If, as in the case of the setback, the reactor power does not fall below the minimum accountable level, the reverse does not constitute a shutdown and the form should not be used.
- Cause - Check the appropriate square
- Equipment - If the shutdown was the result of equipment failure, check whether the failure was mechanical (M) or an instrument (I) failure. At times it is difficult to distinguish between instrument and mechanical failures. The mechanical failure of a limit switch or a similar device in an instrument, for example, is confusing; however, since the switch is a component of the instrument, the failure is classed as instrument failure. Compressor failures, pump failures, etc., are clear-cut examples of mechanical failures.

HE - Indicates human error, whether due to poor judgement or inadvertence.

Other - Calls for an explanation under the heading "Circumstances," as to the cause of the shutdown. If adequate space is not provided, a continuation of the explanation should be made in the customary manner.

Unknown - Self-explanatory

Time distribution. Make a reasonable estimate of the down time for which the research group and/or the operating group are responsible.

2.3.4. Accidental scrams

An accidental scram is the unintentional dropping of one or more shim-safety rods. It may be caused by human error or component failure. Following an accidental scram, a detailed description of the shutdown and subsequent startup attempts, if applicable, should be prepared by the shift supervisor and submitted to the reactor supervisor. This description should include an account of control system action, operator response, and any equipment malfunction noted.

2.3.5. Radiation control measures

1. Regulations for pool entry

Entry to the HFIR pools is subject to "contamination zone" and "radiation zone" regulations. These regulations are restated to emphasize their importance.

- a. The pool and associated entry area must be established as a "contamination zone."
- b. A valid "Radiation Work Permit" must be on hand.
- c. The minimum personnel monitoring requirements shall be: pencil meters, direct-reading pocket dosimeters, and a film badge.

- d. The pool monitron must be in position and checked for proper operating condition.
- e. Upon exiting from a pool, each person shall be checked for contamination and his exposure record shall be brought up to date.

It is the responsibility of the shift supervisor to assure that all regulations are followed.

2.4. Annunciator Procedures

2.4.1 References

1546-01-E-2129	Elementary Control Diagrams - Annunciators 1E, 2E, 3E and 4E
1546-01-E-2130	Elementary Control Diagrams - Annunciators A, B, C, D, FG, and HI

2.4.2. Introduction

In general, annunciator alarms indicate abnormal conditions in the process or nuclear systems. Their purpose is to alert the operator to the abnormal conditions so that appropriate action may be taken.

The annunciator procedures which follow are used by the control room operator as a quick reference whenever an alarm is actuated. Each group of procedures is preceded by a panel diagram and a tabular listing of annunciators in use. The procedures cover the following:

1. condition which actuates the alarm,
2. alarm setpoint,
3. actuator and its location,
4. sensor and its location,
5. possible causes of the abnormal condition,
6. immediate action to be taken upon receipt of the alarm,
7. operator response, and
8. follow-up action.

2.4.3. Annunciator panel "A"

1	4	7	10	13	16	19
2	5	8	11	14	17	20
3	6	9	12	15	18	21

	<u>Condition</u>	<u>Setpoint</u>	<u>Actuator</u>
A-1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			
13.	Be Δ P low	6.5 psi	FSS-RP-1/RP-3
14.			
15.			
16.	EF-2 facility flow low	0.8 gpm	FE-1201
17.	Horizontal beam tube flow low	15 gpm	FS-HB1, -HB2, -HB3, -HB4
18.	Hydraulic rabbit facility flow low	<2 gpm	Relay K5-A
19.			
20.			
21.			

Annunciator A-13

Condition: Be ΔP low

Setpoint: 6.5 psi

Actuator: FSS-RP-1/RP-3 (Be-R)

Location: Auxiliary control room

Sensor: FT-RP-1/RP-3 (Be-R)

Location: Monitoring platform

Possible causes

1. Plugging of orifices in the shroud flange
2. A drastic restructuring of flow paths within the core region would reduce the pressure drop across the permanent beryllium
3. A drastic reduction of total flow such as is experienced during a normal power outage

Immediate action

1. Should an alarm be received from this annunciator during normal full flow operation, shut the reactor down at once.

Operator response

1. Obtain a set of hydraulic data from the computer to analyze the situation.
2. If a hydraulic data printout cannot be obtained from the computer, read the transmitter output (0-100% corresponds to 0-15 psi ΔP) at the monitoring platform in the experiment room. The transmitter is labeled RP-1/RP-3.
3. Observe the total flow signals, the reactor ΔP (PdR-106) and the strainer ΔP (PdR-103) for indications of flow anomalies.

Annunciator A-16

Condition: EF-2 facility flow low

Setpoint: 0.8 gpm

Sensor: FE-1201

Location: Near EF-2 facility in the experiment room

Actuator: FS-1201

Possible causes

1. Loss of external coolant flow due to valve misoperation or line blockage

Operator response

1. Check flow rate on FR-1201 located in the experiment room. Also check supply water pressure on gauge just above EF-2 facility.
2. If loss of supply pressure is evident, check valving from the pool cleanup system.

Follow-up action

1. If flow cannot be re-established within a short time, the reactor must be shut down to prevent overheating of the facility tube.
2. If loss of flow is due to pool cleanup system troubles, flow may be re-established in the beam tube by throttling pool coolant valves FCV-464, -465, and -466.

Annunciator A-17

Condition: Horizontal beam tube flow low

Setpoint: 15 gpm

Sensors: Orifices in cooling flow lines

Actuator: FS-HB-1, -HB2, -HB3, and -HB4

Location: Auxiliary control room

Possible causes

1. Loss of flow due to restrictions in beam tube coolant passages

Operator response

1. Print out hydraulic data on computer and verify low flow condition.
2. Check local dP cell indication at monitoring platform.

Follow-up action

1. If flow decreases to less than 15 gpm and cannot be re-established within a reasonable length of time, the reactor power must be lowered or shut down as directed by the reactor supervisor.

Annunciator A-18

Condition: Hydraulic rabbit facility flow low

Sepoint: Hydraulic tube flow <2 gpm, servo flow <15,000 gpm

Sensor: FE-4, FSS-1, -2, and -3

Location: Loading station, east clean pool

Actuator: Relay K5, Contact A

Location: Relay control cabinet

Possible causes

1. Ejection of rabbit due to low primary flow (<15,000 gpm) as sensed by two-of-three flow element relay matrix (FSS-1, -2, -3)
2. Manual ejection of rabbit
3. Low flow in facility

Operator response

1. Determine if low primary flow or low facility flow caused the alarm. Check that the ejection was effective and complete.

Follow-up action

1. When the cause has been determined and remedied, reinsert the rabbits and check that proper flow has been established in the facility.

2.4.4 Annunerator panel "B"

1	4	7	10	13	16	19
2	6	8	11	14	17	20
3	7	9	12	15	18	21

	<u>Condition</u>	<u>Setpoint</u>	<u>Actuator</u>
B-1.			
2.	Slow scram channel 1		K101
3.	Reverse channel 1		K520C
4.			
5.	Rate trip "channel 1"	20 MW/s	IC-26
6.	5-s period "channel 1"	5-s period	K107B
7.	Heat power trip "channel 1"	120 MW	IC-76
8.	Level trip channel 1	1.3	IC-28
9.	1.5 N _L "channel 1"	1.5 N _L	IC-59, IC-29, KB503C
10.			
11.	Inlet temperature trip "channel 1"	130°F	IC-30
12.	1.1 N _F "channel 1"	1.1 N _F	IC-60, IC-31, KB502E
13.			
14.	Low pressure trip "channel 1"	600 psi	IC-32
15.	Low-low-flow trip "channel 1"	1775 gpm	IC-79
16.			

17.	CRM trouble "channel 1"		K104C
18.	Ion chamber voltage-module continuity		IC-73
19.			
20.	FFED trip "channel 1"	120% normal	IC-85
21.	Instrument air pressure low "channel 1"	32 psig	PS-656

Annunciator B-2

Condition: Slow scram "channel 1"

Sensor: K-101

Location: Auxiliary control room

Possible causes

1. Key switch (S-1) in "off" position
2. Scram switch (S-10) in "scram" position
3. Raise-test switch (S-9) in "test" position
4. Ionization chamber voltage low
5. Module removed from channel 1 safety system
6. dc power failure

Operator response

1. Check switch positions and check modules for fully inserted condition.
2. Check "chamber voltage monitor and test unit" module for affected channel; "normal" lamp should glow and "latch" lamp should be extinguished.
3. Check dc power supply; a general failure of the battery or branch circuit will affect other functions and should be apparent.

Follow-up action

1. Take all steps necessary to place channel in operable condition.
2. Depress scram reset pushbutton (S-15) to restore safety channel to service.
3. Observe restoration of normal current output from magnet amplifiers.

Annunicator B-3Condition: Reverse "channel 1"

Sensor: K-250

Location: Auxiliary control room

Possible causes

<u>Mode of operation</u>	<u>Condition</u>	<u>Actuator</u>
1. Mode 1 - Run	(A) Reset flux $>1.1 N_F$	IC-23 located in auxiliary flux comparator in safety channel 1
	(B) Heat power $>1.1 N_F$	IC-22 located in auxiliary heat power comparator in safety channel 1
2. Mode 1 - Start	(A) Reset flux $>1.5 N_L$	IC-23 located in auxiliary flux comparator in safety channel 1
	(B) Heat power $>1.5 N_L$	IC-22 located in auxiliary heat power comparator in safety channel 1
	(C) Period <5 s	IC-7 located in auxiliary period comparator in count-rate channel 1
3. Mode 2	(A) Raw flux $>1.1 N_F$ (for mode 2)	Same as for mode 1 - Run
	(B) Heat power >11 MW	Same as for mode 1 - Run
	(C) Period <5 s	Same as for mode 1 - Start
4. Mode 3	(A) Raw flux $>1.1 N_F$ (for mode 3)	Same as for mode 1 - Run
	(B) Period <5 s	Same as for mode 1 - Start
	(C) Heat power $>1.1 N_F$ but not effective	Same as for mode 1 - Run

Operator response

1. Investigate cause of reverse request. Two channels must indicate a reverse in order for the control action to occur.

Follow-up action

1. Restore reactor power level after the condition causing the reverse is cleared.

Annunciator B-5

Condition: Rate trip "channel 1"

Setpoint: (Mode 1) >20 MW/s

Sensor: IC-26

Location: Rate comparator in safety channel 1

Possible causes

1. If two or three channels trip, producing a scram, cause may be reactor power transient. A transient might result from void formation, cold slug, etc.
2. Single channel trip may indicate a malfunction.

Operator response

1. If a scram occurs determine the cause and act accordingly. Two channels must be in "scram" condition in order for the scram to occur.
2. Investigate possible channel malfunctions.

Follow-up action

1. Investigate cause of scram and restart reactor if permissible.
2. If it is impractical to repair faulty safety channel, that channel must be secured in scram request condition except during brief test intervals.

Annunciator B-6

Condition: 5-s period "channel 1"

Sensor: IC-7

Location: Period comparator in CRM channel 1

Possible causes

(In Mode 1 - start, Mode 2, or Mode 3, this annunciator should be accompanied by a "reverse" annunciation in channel 1.)

1. Control system malfunction, causing or permitting excessive withdrawal of control plates.
2. Reactor power transient, which may be due to void formation, cold slug, etc.

Operator response

1. Investigate cause of the reactor power transient and act accordingly.
2. Make sure that the count-rate channel malfunction, if any, has not caused the fission chamber to insert too close to the core. Withdraw the chamber manually if it has inserted too far.

Annunciator B-7

Condition: Heat power trip - "channel 1"

Setpoint: Mode 1: 120 MW (1.2 N_P)

Mode 2: 12 MW

(Setpoint unchanged between Modes 2 and 3; however, there is no effective measurement of heat power in Mode 3.)

Sensor: IC-724

Location: Heat power trip comparator in safety channel 1

Possible causes

1. If two or three channels trip, producing a scram, cause may be excessive reactor power. This could result from a malfunction of the servo or control systems. Normally, the reset flux/flow ratio trip elements would be expected to recognize a power excursion before the heat power elements are affected; however, chamber difficulties could prevent the proper flux response.
2. Single channel trip may indicate a malfunction.

Operator response

1. If a scram occurs, investigate cause and act accordingly.
2. Investigate possible channel malfunctions.

Follow-up action

1. Investigate causes of scram and restart reactor if permissible.
2. If it is impractical to repair faulty safety channel, that channel must be secured in scram request condition except during brief test intervals.

Annunciator B-8

Condition: Level trip "channel 1"

Sepoint: Mode 1: Reset flux/flow ratio exceeds 1.3 (based on a ratio of 1 when reactor power is 100 MW and 16,000 gpm primary coolant exists).

Mode 2: Output signal of flux amplifier exceeds 3.25 MW.

Mode 3: Output signal of flux amplifier exceeds 130 kW.

Sensor: IC-28

Location: Flux/flow trip comparator in safety channel 1

Possible causes

1. If two or three channels trip, producing a scram, cause is excessive reactor power or reduced coolant flow. Servo and control systems should reduce reactor power rapidly in the event of a coolant flow failure. If they respond too slowly, the flux/flow ratio trip comparator will produce a scram.
2. Single channel trip may indicate a malfunction.

Operator reponse

1. If a scram occurs, investigate cause and act accordingly.
2. Investigate possible channel malfunctions.

Follow-up action

1. Investigate causes of scram and restart reactor if permissible.
2. If it is impractical to repair faulty safety channel, that channel must be secured in scram request condition except during brief test intervals.

Annunciator B-9

Condition: $1.5 N_L$ "channel 1"

Setpoint: 15 MW ($1.5 N_L$ in mode 1 - start)

Sensors: IC-29 and IC-59

Locations: IC-29 is located in reset flux comparator in safety channel 1.

IC-59 is located in heat power comparator in safety channel 1.

Possible causes

1. Reactor power transient, which may be due to void formation, cold slug, etc.
2. Control system malfunction, causing improper regulation of reactor power
3. Malfunction in safety channel

Operator response

1. A "reverse" annunciator should accompany this alarm. If more than one channel experiences the same condition simultaneously, control plate insertion should occur to lower the power. Ensure this action does occur.
2. Investigate cause of reactor power excursion via all pertinent readouts (e.g., inlet water temperature, regulating drive position, reset flux, period, etc.).
3. If a Technical Specification violation has occurred, report this to appropriate supervision.

Annunciator B-11

Condition: Inlet temperature trip "channel 1"

Setpoint: 130°F

Sensor: IC-30

Location: Inlet temperature comparator in safety channel 1

Possible causes

1. Secondary cooling system difficulties
2. Primary heat exchanger difficulties
3. Single channel trip may indicate a malfunction

Operator response

1. If a scram occurs, investigate cause and act accordingly.
2. Investigate possible channel malfunctions.

Follow-up action

1. Investigate cause of scram and restart reactor if permissible; conditions may permit only limited power level but sufficiently high to burn out xenon.
2. If it is impractical to repair faulty safety channel, that channel must be secured in scram request condition except during brief test intervals.

Annunciator B-12

Condition: $1.1 N_F$ "channel 1"

Setpoint: Mode 1: Reset flux or heat power exceeds 110 MW ($1.1 N_F$).
Mode 2: Output signal of flux amplifier exceeds 2.75 MW or
heat power exceeds 11 MW.
Mode 3: Output signal of flux amplifier exceeds 100 kW.

Sensors: IC-31 and IC-60

Locations: IC-60 is located in heat power comparator in safety
channel 1.

IC-31 is located in reset flux comparator in safety
channel 1.

Possible causes

1. Reactor power transient, which may be due to void formation, cold slug, etc.
2. Control system malfunction in Mode 1, causing improper regulation of reactor power
3. Incorrect manual operation in Modes 2 or 3

Operator response

1. A "reverse" annunciator should accompany this alarm. If more than one channel experiences the same condition simultaneously, a control plate insertion should occur to lower the power. Ensure this action does occur.
2. Investigate cause of reactor power excursion and take appropriate action.
3. Investigate cause of control system malfunction and take appropriate action.

Annunciator B-14

Condition: Low pressure trip "channel 1"

Setpoint: 600 psig

Sensor: IC-32

Location: Pressure comparator in safety channel 1

Possible causes

1. Failure of pressurizer pumps
2. Rupture in coolant loop, including pressure relief elements
3. Malfunction of pressure regulating systems 127 and 128,
including the letdown and block valves

Operator response

1. If a scram occurs, investigate and take appropriate action.

Follow-up action

1. Investigate cause of scram and correct promptly if possible.
Since this form of scram also shuts down the main ac primary pump motors at 400 psig, it is not possible to restart the reactor in mode 1 until loop pressure is restored.

Annunciator B-15

Condition: Low-low-flow trip "channel 1"

Setpoint: Primary coolant flow less than normal delivery by two pumps at pony motor speed, but greater than from one pump at pony motor speed; approximately 1775 gpm.

Sensor: IC-756

Location: Low-low-flow comparator in safety channel 1

Possible causes:

1. Failure of pony motors in Modes 1 and 2
2. Flow blockage in Modes 1 and 2

Operator response

1. If a scram occurs, investigate and take appropriate action.
Note that the extreme reduction (or total loss) of coolant flow may present afterheat removal problems if the reactor was scrammed from a high power level.

Follow-up action

1. If trip is caused by a flow blockage, remove the conditions which caused it prior to restarting the reactor.
2. If a Technical Specification violation has occurred, report it to appropriate supervision.

Annunciator B-17

Condition: CRM trouble "channel 1"

Sensors: IC-2 and IC-3

Location: Both are located in CRM "confidence" comparators in CRM channel 1

Possible causes

1. Chamber drive not in automatic for Mode 1 operation
2. Count-rate meter "operate-calibrate-off" switch not in "operate" position
3. Count-rate less than 10 counts/s
4. Count-rate greater than 50,000 counts/s

Operator response

1. If the condition causing this alarm interferes with reactor startup, it is necessary to correct the troubles before proceeding.
2. If the annunciation occurs when there is appreciable neutron flux, check immediately to determine the alarm origin. When this is for count rate more than 50,000 counts/s, and chamber is not withdrawn sufficiently, withdraw and secure chamber from excessive flux.
3. Should the output from the CRM decrease, the chamber will automatically drive toward the core, which could result in damage to the fission chamber. To prevent this, the chamber should be withdrawn and left in "manual."

Annunciator B-18

Condition: Ion chamber voltage - module continuity "channel 1"

Setpoint: Less than 150 V on ionization chamber of safety channel

Sensors: IC-73 and IC-69

Location: Both are located in safety channel 1

Possible causes

(Condition causes slow scram in channel 1.)

1. Power supply troubles
2. Module improperly installed or a faulty connector

Operator response

1. Investigate origin of trouble and initiate repairs. The channel must be left in "trip" condition until repairs are completed.

Annunciator B-20

Condition: FFED trip "channel 1"

Setpoint: 120% of normal background

Sensor: Faulty fuel element detector RE-255-A

Location: Detector is located in pipe tunnel

Actuator: IC-85

Location: FFED comparator in safety channel 1

Possible causes

(If condition exists in two channels, a fast scram will occur. If two FFED "latches" occur, letdown block valves close.)

1. Faulty fuel element
2. Faulty detector shield rotation motor
3. Faulty detector

Operator response

1. If a scram occurs:
 - a. stop the primary pump ac motors and continue water circulation from the pony motors only;
 - b. stop the operating pressurizer pump;
 - c. place the auxiliary pressurizer pump, PU-11, control switch in "off" position;
 - d. place the standby pressurizer pump control switch in the "stop" position; and
 - e. allow the primary system pressure to decrease through leakage to atmospheric pressure.
2. Investigate for high level radiation in the vicinity of the pipe corridor, pipe tunnel, heat exchanger cells, deaerator cell, and demineralizer cells. (The letdown block valves close automatically if two channels sense a faulty fuel element.

Therefore, large amounts of contamination should not enter the low pressure system.) Precautionary measures should be employed, however, to prevent personnel overexposure in the event of high radiation levels outside the primary water system. Refer to Section 8.4, Radiation-Contamination Emergencies, of the operating manual for further instructions pertaining to the fission-product release.

3. Notify appropriate supervision of conditions as soon as practicable.

Annunciator B-21

Condition: Instrument air pressure low "channel 1"

Setpoint: 32 psig

Sensor: PSS-656

Location: On discharge header of air receiver AR-7A

Possible causes

1. Normal and emergency compressor failure
2. Misvalving (shutoff or blowdown)
3. Filter plugging
4. Line rupture

Operator response

1. Observe supply pressure readout (PI-625) on process panelboard. If it appears that entire instrument air header is losing pressure, prepare to shut down the reactor manually.
2. Scram the reactor when the header pressure reaches 20 psig. Note that when header pressure reaches 20 psig, there still may be adequate reserve in the individual air receiver to supply the servo channels to receive their normal heat power information, thus preventing plate withdrawals in response to false indications of reduced power. Earlier loss of other instrument functions determines the necessity to shut down the reactor.
3. If air pressure failure affects one servo alone, observe the servo heat power recorders. If the recorder of the affected channel alone indicates reactor power decreasing, observe the consequent servo flux reset action. When the reset action stops, probably at minimum reset gain, reduce the demand setting in the affected servo channel only until the servo drive motor of that channel is no longer attempting to withdraw the No. 5 cylinder.

2.4.5. Annunciator Panel "C"

1	4	7	10	13	16	19
2	5	8	11	14	17	20
3	6	9	12	15	18	21

	<u>Condition</u>	<u>Setpoint</u>	<u>Actuator</u>
C-1.	Shim request	ASW actuation	K511A
2.	Slow scram channel 2		K201C
3.	Reverse channel 2		K521C
4.	2/3 servo insert error	1 MW	
5.	Rate trip channel 2	20 MW/s	IC-37
6.	5-s period channel 2	5-s period	K207B
7.	Heat power trip channel 2	120 MW	IC-77
8.	Level trip channel 2	1.3	IC-39
9.	1.5 N _L channel 2	1.5 N _L	IC-62, IC-40
10.	Rod asymmetry	0.6, 1.7 in.	IC-88
11.	Inlet temperature trip channel 2	130°F	IC-41
12.	1.1 N _F channel 2	1.1 N _F	IC-63, IC-42
13.	Cladding failure	200 c/m	IC-89, RS-200
14.	Low pressure trip channel 2	600 psig	IC-43, PSS-128B
15.	Low-low-flow trip channel 2	<1775 gpm	IC-80
16.	1.1 Ø/F fast reverse	1.1 Ø/F ratio	2 of 3 coinci- dence matrix

17. CRM trouble channel 2	<10, >50,000 CPS	K204C
18. Ion chamber voltage-module continuity	<150 V	IC-70, IC-74
19. ac control bus - power off		K546A
20. FFED trip channel 2	120% Norm	IC-86
21. Instrument air pressure low channel 2	32 psig	PS-655

Annunciator C-1

Condition: Shim request

Sepoint: Regulating drive of No. 5 cylinder withdrawn beyond
"automatic shim withdraw" limit and no permit for shim
withdrawal

Sensor: Automatic shim withdraw limit switch, LS-17

Possible cause

1. Annunciation will occur in Mode 1 - run whenever the regulating drive withdraws the No. 5 control cylinder to the point where shimming is required.

Operator response

1. Initiate shimming by placing the shim calculator bypass switch, S-18, in "bypass" position or by manually shimming.

Annunciator C-2

Condition: Slow scram "channel 2"

Sensor: K-201

Location: Auxiliary control room

Possible causes

1. Key switch (S-1) in "off" position
2. Scram switch (S-10) in "scram" position
3. Raise-test switch (S-9) in "test" position
4. Ionization chamber voltage low
5. Module removed from channel 2 safety system
6. dc power failure

Operator response

1. Check switch positions and check modules for fully inserted condition.
2. Check "chamber voltage monitor and test unit" module for affected channel; "normal" lamp should glow and "latch" lamp should be extinguished.
3. Check dc power supply; a general failure of the battery or branch circuit will affect other functions and should be apparent.

Follow-up action

1. Take all steps necessary to place channel in operable condition.
2. Depress scram reset pushbutton S-15 to restore safety channel to service.
3. Observe restoration of normal current output from magnet amplifiers.

Annunciator C-3Condition: Reverse "channel 2"

Sensor: K-521

Location: Auxiliary control room

Possible causes

<u>Mode of operation</u>	<u>Condition</u>	<u>Actuator</u>
1. Mode 1 - Run	(A) Reset flux $>1.1 N_F$	IC-34 located in auxiliary flux comparator in safety channel 2
	(B) Heat power $>1.1 N_F$	IC-33 located in auxiliary heat power comparator in safety channel 2
2. Mode 1 - Start	(A) Reset flux $>1.5 N_L$	IC-34 located in auxiliary flux comparator in safety channel 2
	(B) Heat power $>1.5 N_L$	IC-33 located in auxiliary heat power comparator in safety channel 2
	(C) Period <5 s	IC-14 located in auxiliary period comparator in count-rate channel 2
3. Mode 2	(A) Raw flux $>1.1 N_F$ (for mode 2)	Same as for mode 1 - Run
	(B) Heat power >11 MW	Same as for mode 1 - Run
	(C) Period <5 s	Same as for mode 1 - Start
4. Mode 3	(A) Raw flux $>1.1 N_F$ (for mode 3)	Same as for mode 1 - Run
	(B) Period <5 s	Same as for mode 1 - Start
	(C) Heat power $>1.1 N_F$ but not effective	Same as for mode 1 - Run

Operator response

1. Investigate cause of reverse request. Two channels must indicate a reverse in order for the control action to occur.

Follow-up action

1. Restore reactor power level after the condition causing the reverse is cleared.

Annunciator C-4

Condition: 2/3 servo insert error

Setpoint: Two of three channels request >1 MW insert

Sensor: IC-68

Actuator: Two output contacts from relay K-202 of each channel are connected to a two-out-of-three matrix that provides alarm.

Operator response

(This annunciation would result if the control rods become stuck when a reactivity addition occurs.)

1. Try to lower power in the following order:
 - a. lower servo demand;
 - b. reverse the control rods; and
 - c. scram the reactor.
 - d. If all the preceding fail to lower reactor power level, shut the reactor down by using the poison injection system.

Follow-up action

1. Leave the reactor shut down until the malfunction is located and corrected.

Annunciator C-5

Condition: Rate trip "channel 2"

Setpoint: (Mode 1) >20 MW/s

Sensor: IC-37

Location: Rate comparator in safety channel 2

Possible causes

1. If two or three channels trip, producing a scram, cause may be reactor power transient. A transient might result from void formation, cold slug, etc.
2. Single channel trip may indicate a malfunction.

Operator response

1. If a scram occurs, determine the cause and act accordingly.
Two channels must be in "scram" condition in order for the
scram to occur.
2. Investigate possible channel malfunctions.

Follow-up action

1. Investigate cause of scram and restart reactor if permissible.
2. If it is impractical to repair faulty safety channel, that channel must be secured in scram request condition except during brief test intervals.

Annunciator C-6

Condition: Five-second period "channel 2"

Sensor: IC-14

Location: Period comparator in CRM channel 2

Possible causes

(In Mode 1 - start, Mode 2, or Mode 3, this annunciator should be accompanied by a "reverse" annunciation in channel 2.)

1. Control system malfunction, causing or permitting excessive withdrawal of control plates
2. Reactor power transient which may be due to void formation, cold slug, etc.

Operator response

1. Investigate cause of the reactor power transient and act accordingly.
2. Make sure that the count-rate channel malfunction, if any, has not caused the fission chamber to insert too close to the core. Withdraw the chamber manually if it has inserted too far.

Annunciator C-7

Condition: Heat power trip "channel 2"

Setpoint: Mode 1: 120 MW (1.2 N_P)

Mode 2: 12 MW

(Setpoint unchanged between Modes 2 and 3; however, there is no effective measurement of heat power in Mode 3.)

Sensor: IC-755

Location: Heat power trip comparator in safety channel 2

Possible causes

1. If two of three channels trip, producing a scram, cause may be excessive reactor power. This could result from a malfunction of the servo or control systems. Normally, the reset flux/flow ratio trip elements would be expected to recognize a power excursion before the heat power elements are affected; however, chamber difficulties could prevent the proper flux response.
2. Single channel trip may indicate a malfunction.

Operator response

1. If a scram occurs, investigate cause and act accordingly.
2. Investigate possible channel malfunctions.

Follow-up action

1. Investigate causes of scram and restart reactor if permissible.
2. If it is impractical to repair faulty safety channel, that channel must be secured in scram request condition except during brief test intervals.

Annunciator C-8

Condition: Level trip "channel 2"

Setpoint: Mode 1: Reset of flux/flow ratio exceeds 1.3 (based on ratio of 1 when reactor power is 100 MW and full flow of primary coolant exists).

Mode 2: Output signal of flux amplifier exceeds 3.25 MW.

Mode 3: Output signal of flux amplifier exceeds 130 kW.

Sensor: IC-28

Location: Flux/flow trip comparator in safety channel 2

Possible causes

1. If two or three channels trip, producing a scram, cause may be excessive reactor power or reduced coolant flow. Servo and control systems should reduce reactor power rapidly in the event of a coolant flow failure. If they respond too slowly, the flux/flow ratio trip comparator will produce a scram.
2. Single channel trip may indicate a malfunction.

Operator response

1. If a scram occurs, investigate cause and act accordingly.
2. Investigate possible channel malfunctions.

Follow-up action

1. Investigate causes of scram and restart reactor if permissible.
2. If it is impractical to repair faulty safety channel, that channel must be secured in scram request condition except during brief test intervals.

Annunciator C-9

Condition: $1.5 N_L$ "channel 2"

Setpoint: 15 MW ($1.5 N_L$ in Mode 1 - start)

Sensors: IC-40 and IC-62

Location: IC-40 is located in reset flux comparator in safety channel 2.

IC-62 is located in heat power comparator in safety channel 2.

Possible causes

1. Reactor power transient, which may be due to void formation, cold slug, etc.
2. Control system malfunction, causing improper regulation of reactor power
3. Malfunction in safety channel

Operator response

1. A "reverse" annunciator should accompany this alarm. If more than one channel experiences the same condition simultaneously, a control plate insertion should occur to lower the power. Ensure this action does occur.
2. Investigate cause of reactor power excursion via all pertinent readouts (e.g., inlet water temperature, regulating drive position, reset flux, period, etc.).
3. If a Technical Specification violation has occurred, report it to appropriate supervision.

Annunciator C-10

Condition: Rod asymmetry

Setpoint: Spread of withdrawal distances of the quadrant plates exceeds 0.6 in. or spread of withdrawal distances of all plates (quadrant and cylinder) exceeds 1.7 in. Setback occurs at 1.2 in. and 2.4 in., respectively. NOTE: The setback condition is electrically clamped to the demand until the demand potentiometers drive to N_L .

Sensor: Position potentiometers on plate drives; comparison output via IC-88

Possible causes

1. Different speeds among shim drive motors
2. Improper manual operation

Operator response

1. Trim plate positions by manual controls at the end of the automatic startup and later whenever needed.
2. Restore demand setting to intended level if a setback accompanies this annunciation.

Follow-up action

1. Investigate cause of lag in plate drive, if indicated.

Annunciator C-11

Condition: Inlet temperature trip "channel 2"

Setpoint: 130°F

Sensor: IC-41

Location: Inlet temperature comparator in safety channel 2

Possible causes

1. Secondary cooling system difficulties
2. Primary heat exchanger difficulties
3. Single channel trip may indicate a malfunction

Operator response

1. If a scram occurs, investigate cause and act accordingly.
2. Investigate possible channel malfunctions.

Follow-up action

1. Investigate cause of scram and restart reactor if permissible; conditions may permit only limited power level, but sufficiently high to burn out xenon.
2. If it is impractical to repair faulty safety channel, that channel must be secured in scram request condition except during brief test intervals.

Annunciator C-12

Condition: 1.1 N_F "channel 2"

Setpoint: Mode 1: Reset flux or heat power exceeds 110 MW (1.1 N_F)
 Mode 2: Output signal of flux amplifier exceeds 2.75 MW or
 heat power exceeds 11 MW
 Mode 3: Output signal of flux amplifier exceeds 110 kW

Sensors: IC-63 and IC-42

Location: IC-63 is located in heat power comparator in safety
 channel 2.
 IC-42 is located in reset flux comparator in safety
 channel 2.

Possible causes

1. Reactor power transient, which may be due to void formation, cold slug, etc.
2. Control system malfunction in Mode 1, causing improper regulation of reactor power
3. Incorrect manual operation in Modes 2 or 3

Operator response

1. A "reverse" annunciator should accompany this alarm. If more than one channel experience the same condition simultaneously a control plate insertion should occur to lower the power. Ensure this action does occur.
2. Investigate cause of reactor power excursion and act accordingly.
3. Investigate cause of control system malfunction and take appropriate action.

Annunciator C-13

Condition: Cladding failure detector

Setpoint: 200 c/m

Sensor: RE-200

Location: Pipe corridor

Actuator: Fast trip comparator

Location: Auxiliary control room

Possible causes

1. Leaky or contaminated fuel element
2. Leaky or ruptured experiment
3. Leaky or ruptured target

Operator response

The BF_3 neutron detector detects small quantities of delayed neutrons from fission products in the primary coolant water.

1. Read RR-200 in the auxiliary control room and RR-1000 (point 16) for an indication of delayed neutron count intensity. If a very slow increase is shown, sample the primary coolant water and have a fission-product analysis made to determine the relative size of the leak. CAUTION: Avoid overexposure during sampling.
2. Read RR-1000 (point 1) for an indication of fission-product - activity increase. Also, check RI-253 in the auxiliary control room for an indication of - activity.
3. If contamination level warrants, reduce the reactor power to minimum level consistent with xenon burnout requirements. In the event conditions warrant action, the reactor should be shut down.

Follow-up action

1. Investigate type of contamination, track buildup, and determine source.

Annunciator C-14

Condition: Low pressure trip "channel 2"

Setpoint: 600 psig

Sensor: IC-43

Location: Pressure comparator in safety channel 2

Possible causes

1. Failure of pressurizer pumps
2. Rupture in coolant loop, including pressure relief elements
3. Malfunction of pressure regulating system 127 and 128,
including the letdown and block valves

Operator response

1. If a scram occurs, investigate and take appropriate action.

Follow-up action

1. Investigate cause of scram and correct promptly, if possible.
Since this form of scram also shuts down the main ac primary
pump motors at 400 psig, it is not possible to restart the
reactor in Mode 1 until loop pressure is restored.

Annunciator C-15

Condition: Low-low-flow trip "channel 2"

Setpoint: Primary coolant flow less than normal delivery by two pumps at pony motor speed, but greater than from one pump at pony motor speed; approximately 1775 gpm.

Sensor: IC-734

Location: Low-low-flow comparator in safety channel 2

Possible causes

1. Failure of pony motors in Modes 1 and 2
2. Flow blockage in Modes 1 and 2

Operator response

1. If a scram occurs, investigate and take appropriate action.

Note that the extreme reduction (or total loss) of coolant flow may present afterheat removal problems if the reactor was scrammed from a high power level.

Follow-up action

1. If trip is caused by a flow blockage, remove the conditions which caused it prior to restarting the reactor.
2. If a Technical Specification violation has occurred, report it to appropriate supervision.

Annunciator C-16

Condition: 1.1 Ø/F fast reverse

Sensor: Relay drivers in safety systems trip comparators which feed
a coincidence matrix

Possible causes

1. This reverse will most likely occur during a flow coastdown from loss of primary pumps.
2. Reactor power transient due to cold slug or void formation in target region

Operator response

1. Determine reason for control action and initiate corrective action.

Annunciator C-17

Condition: CRM trouble - "channel 2"

Sensors: IC-9 and IC-10

Location: Both are located in CRM "confidence" comparators in CRM channel 2.

Possible causes

1. Chamber drive not in automatic for Mode 1 operation
2. Count-rate meter "operate-calibrate-off" switch not in "operate" position
3. Count-rate less than 10 cps
4. Count-rate greater than 50,000 cps

Operator response

1. If the conditions causing this alarm interfere with reactor startup, it is necessary to correct the troubles before proceeding.
2. If the annunciation occurs when there is appreciable neutron flux, check immediately to determine the alarm origin. When this is for count rate more than 50,000 cps, and chamber is not withdrawn sufficiently, withdraw and secure chamber from excessive flux.
3. Should the output from the CRM decrease, the chamber will automatically drive toward the core, which could result in damage to the fission chamber. To prevent this the chamber should be withdrawn and left in "manual."

Annunciator C-18

Condition: Ion chamber voltage module continuity "channel 2"

Setpoint: Less than 150 V on ionization chamber of safety channel 2

Sensors: IC-70 and IC-74

Locations: Both are located in safety channel 2

Possible causes

(Condition causes slow scram in channel 2.)

1. Power supply troubles
2. Module improperly installed or a faulty connector

Operator response

1. Investigate origin of trouble and initiate repairs. The channel must be left in "trip" condition until repairs are completed.

Annunciator C-19

Condition: Power failure - ac control bus

Sensor: Relay K546

Possible cause

1. Failure of local power supply circuit, PIB, L6

Operator response

1. Shim drive motors are inoperative. Normal reactor power level should be maintained by the regulating cylinder if the ac failure is not area wide.
2. Reclose circuit breaker L6 in PIB, located behind the process panel
3. In the event the complete power panel PIB is lost, additional symptoms such as loss of power to all CAMs and monitrons, cladding failure instrumentation, etc. will be observed. The reactor must be shut down if this occurs, pending restoration of power.

Annunciator C-20

Condition: FFED trip "channel 2"

Setpoint: 120% of normal background

Sensor: Faulty fuel element detector RE-255-B

Location: Detector is located in pipe tunnel

Actuator: IC-86

Location: FFED comparator in safety channel 2

Possible causes

(If condition exists in two channels, a fast scram will occur. If two FFED "latches" occur, block valves close.)

1. Faulty fuel element
2. Faulty detector shield rotation motor
3. Faulty detector

Operator response

1. If a scram occurs:
 - a. stop the primary pump ac motors and continue water circulation from the pony motors only;
 - b. stop the operating pressurizer pump;
 - c. place the auxiliary pressurizer pump, PU-11, control switch in "off" position;
 - d. place the standby pressurizer pump control switch in the "stop" position; and
 - e. allow the primary system pressure to decrease through leakage to atmospheric pressure.
2. Investigate for high level radiation in the vicinity of the pipe corridor, pipe tunnel, heat exchanger cells, deaerator cell, and demineralizer cells. (The letdown block valves close automatically if two channels sense a faulty fuel element.

Therefore, large amounts of contamination should not enter the low pressure system.) Precautionary measures should be employed, however, to prevent personnel overexposure in the event of high radiation levels outside the primary water system. Refer to Section 8.4, Radiation-Contamination Emergencies, of the operating manual for further instructions pertaining to the fission-product release.

3. Notify appropriate supervision of conditions as soon as practicable.

Annunciator C-21

Condition: Instrument air pressure low - "channel 2"

Setpoint: 32 psig

Sensor: PSS-655

Location: On discharge header of air receiver AR-7B

Possible causes

1. Normal and emergency compressor failure
2. Misvalving (shutoff or blowdown)
3. Filter plugging
4. Line plugging

Operator response

1. Observe supply pressure readout (PI-625) on process panelboard. If it appears that entire instrument air header is losing pressure, prepare to shut down the reactor manually.
2. Scram the reactor when the header pressure reaches 20 psig.
NOTE: When header pressure reaches 20 psig, there still may be adequate reserve in the individual air receiver to supply the servo channels to receive their normal heat power information, thus preventing plate withdrawals in response to false indications of reduced power. Earlier loss of other instrument functions determines the necessity to shut down the reactor.
3. If air pressure failure affects one servo alone, observe the servo heat power recorders. If the recorder of the affected channel alone indicates reactor power decreasing, observe the consequent servo flux reset action. When the reset action stops, probably at minimum reset gain, reduce the demand setting in the affected servo channel only until the servo drive motor of that channel is no longer attempting to withdraw the No. 5 cylinder.

2.4.6. Annunciator panel "D"

1	4	7	10	13	16	19
2	5	8	11	14	17	20
3	6	9	12	15	18	21

	<u>Condition</u>	<u>Setpoint</u>	<u>Actuator</u>
D-1.			
2.	Slow scram channel 3		K301C
3.	Reverse channel 3		K522C
4.			
5.	Rate trip channel 3	20 MW/s	IC-48
6.	5-s period channel 3	5-s period	K307B
7.	Heat power trip channel 3	120-MW	IC-78
8.	Flux-to-flow trip channel 3	1.3	IC-50
9.	1.5 N_L channel 3	1.5 N_L	IC-65, IC-51
10.			
11.	Inlet temperature trip channel 3	130°F	IC-52
12.	1.1 N_F channel 3	1.1 N_F	IC-66, IC-53
13.			
14.	Low pressure trip channel 3	600 psig	IC-54
15.	Low-low-flow trip channel 3	<1775 gpm	IC-81

16.			
17.	CRM trouble channel 3		K304C
18.	Ion chamber voltage module		
	continuity	<150 V	IC-71, IC-75
19.			
20.	FFED trip channel 3	120%	IC-87
21.	Instrument air pressure low		
	channel 3	32 psig	PS-654

Annunciator D-2

Condition: Slow scram "channel 3"

Sensor: K-301

Location: auxiliary control room

Possible causes

1. Key switch (S-1) in "off" position
2. Scram switch (S-10) in "scram" position
3. Raise-test switch (S-9) in "test" position
4. Ionization chamber voltage low
5. Module removed from channel 3 safety system
6. dc power failure

Operator response

1. Check switch positions and check modules for fully inserted condition.
2. Check "chamber voltage monitor and test unit" module for affected channel; "normal" lamp should glow and "latch" lamp should be extinguished.
3. Check dc power supply; a general failure of the battery or branch circuit will affect other functions and should be apparent.

Follow-up action

1. Take all steps necessary to place channel in operable condition.
2. Depress scram reset pushbutton S-15 to restore safety channel to service.
3. Observe restoration of normal current output from magnet amplifiers.

Annunciator D-3Condition: Reverse "channel 3"

Sensor: K-522

Location: Auxiliary control room

Possible causes

<u>Mode of operation</u>	<u>Condition</u>	<u>Actuator</u>
1. Mode 1 - Run	(A) Reset flux $>1.1 N_F$	IC-45 located in auxiliary flux comparator in safety channel 3
	(B) Heat power $>1.1 N_F$	IC-44 located in auxiliary heat power comparator in safety channel 3
2. Mode 1 - Start	(A) Reset flux $>1.5 N_L$	IC-45 located in auxiliary flux comparator in safety channel 3
	(B) Heat power $>1.5 N_L$	IC-44 located in auxiliary heat power comparator in safety channel 3
	(C) Period <5 s	IC-21 located in auxiliary period comparator in count-rate channel 3
3. Mode 2	(A) Raw flux $>1.1 N_F$ (for Mode 2)	Same as for Mode 1 - Run
	(B) Heat power >11 MW	Same as for Mode 1 - Run
	(C) Period <5 s	Same as for Mode 1 - Start
4. Mode 3	(A) Raw flux $>1.1 N_F$ (for Mode 3)	Same as for Mode 1 - Run
	(B) Period <5 s	Same as for Mode 1 - Start
	(C) Heat power $>1.1 N_F$ but not effective	Same as for Mode 1 - Run

Operator response

1. Investigate cause of reverse request. Two channels must indicate a reverse in order for the control action to occur.

Follow-up action

1. Restore reactor power level after the condition causing the reverse is cleared.

Annunciator D-5

Condition: Rate trip "channel 3"

Setpoint: (Mode 1) >20 MW/s

Sensor: IC-48

Location: Rate comparator in safety channel 3

Possible causes

1. If two or three channels trip, producing a scram, cause may be reactor power transient. A transient might result from void formation, cold slug, etc.
2. Single channel trip may indicate a malfunction.

Operator response

1. If a scram occurs, determine the cause and act accordingly.
Two channels must be in "scram" condition in order for the
scram to occur.
2. Investigate possible channel malfunction.

Follow-up action

1. Investigate cause of scram and restart reactor if permissible.
2. If it is impractical to repair faulty safety channel, that channel must be secured in scram request condition except during brief test intervals.

Annunciator D-6

Condition: Five-second period "channel 3"

Sensor: IC-21

Location: Period comparator in CRM channel 3

Possible causes

(In Mode 1 - start, Mode 2, or Mode 3, this annunciator should be accompanied by a "reverse" annunciation in channel 3.)

1. Control system malfunction, causing or permitting excessive withdrawal of control plates
2. Reactor power transient, which may be due to void formation, cold slug, etc.

Operator response

1. Investigate cause of the reactor power transient and act accordingly.
2. Make sure that the count-rate channel malfunction, if any, has not caused the fission chamber to insert too close to the core. Withdraw the chamber manually if it has inserted too far.

Annunciator D-7

Condition: Heat power trip "channel 3"

Setpoint: Mode 1: 120 MW (1.2 N_F)

Mode 2: 12 MW

(Setpoint unchanged between Modes 2 and 3; however, there is no effective measurement of heat power in Mode 3.)

Sensor: IC-762

Location: Heat power trip comparator in safety channel 3

Possible causes

1. If two or three channels trip, producing a scram, causes may be excessive reactor power. This could result from a malfunction of the servo or control systems. Normally, the reset flux/flow ratio trip elements would be expected to recognize a power excursion before the heat power elements are affected; however, chamber difficulties could prevent the proper flux response.
2. Single channel trip may indicate a malfunction.

Operator response

1. If a scram occurs, investigate cause and act accordingly.
2. Investigate possible channel malfunctions.

Follow-up action

1. Investigate cause of scram and restart reactor if permissible.
2. If it is impractical to repair faulty safety channel, that channel must be secured in scram request condition except during brief test intervals.

Annunciator D-8

Condition: Level trip "channel 3"

Setpoint: Mode 1: Reset flux/flow ratio exceeds 1.3 (based on a ratio of 1 when reactor power is 100 MW and full flow of primary coolant exists)

Mode 2: Output signal of flux amplifier exceeds 3.25 MW

Mode 3: Output signal of flux amplifier exceeds 130 kW

Sensor: IC-50

Location: Flux/flow trip comparator in safety channel 3

Possible causes

1. If two or three channels trip, producing a scram, cause may be excessive reactor power or reduced coolant flow. Servo and control systems should reduce reactor power rapidly in the event of a coolant flow failure. If they respond too slowly, the flux/flow ratio trip comparator will produce a scram.
2. Single channel trip may indicate a malfunction.

Operator response

1. If a scram occurs, investigate cause and act accordingly.
2. Investigate possible channel malfunctions.

Follow-up action

1. Investigate cause of scram and restart reactor if permissible.
2. If it is impractical to repair faulty safety channel, that channel must be secured in scram request condition except during brief test intervals.

Annunciator D-9

Condition: $1.5 N_L$ "channel 3"

Setpoint: 15 MW ($1.5 N_L$ in mode 1 - start)

Sensors: IC-51 and IC-65

Locations: IC-51 is located in reset flux comparator in safety channel 3

IC-65 is located in heat power comparator in safety channel 3

Possible causes

1. Reactor power transient, which may be due to void formation, cold slug, etc.
2. Control system malfunction, causing improper regulation of reactor power
3. Malfunction in safety channel

Operator response

1. A "reverse" annunciator should accompany this alarm. If more than one channel experiences the same condition simultaneously a control plate insertion should occur to lower the power. Ensure this action does occur.
2. Investigate cause of reactor power excursion via all pertinent readouts (e.g., inlet water temperature, regulating drive position, reset flux, period, etc.).
3. If a Technical Specification violation has occurred, report it to appropriate supervision.

Annunciator D-11

Condition: Inlet temperature trip "channel 3"

Setpoint: 130°F

Sensor: IC-41

Location: Inlet temperature comparator in safety channel 3

Possible causes

1. Secondary cooling system difficulties
2. Primary heat exchanger difficulties
3. Single channel trip may indicate a malfunction

Operator response

1. If a scram occurs, investigate cause and act accordingly.
2. Investigate possible channel malfunctions.

Follow-up action

1. Investigate cause of scram and restart reactor if permissible; conditions may permit only limited power level, but sufficiently high to burn out xenon.
2. If it is impractical to repair faulty safety channel, that channel must be secured in scram request condition except during brief test intervals.

Annunciator D-12

Condition: $1.1 N_F$ "channel 3"

Setpoint: Mode 1: Reset flux or heat power exceeds 110 MW ($1.1 N_F$)
 Mode 2: Output signal of flux amplifier exceeds 2.75 MW or
 heat power exceeds 11 MW
 Mode 3: Output signal of flux amplifier exceeds 110 kW

Sensors: IC-53 and IC-66

Location: IC-66 is located in heat power comparator in safety
 channel 3
 IC-53 is located in reset flux comparator in safety
 channel 3

Possible cause

1. Reactor power transient, which may be due to void formation, cold slug, etc.
2. Control system malfunction in Mode 1, causing improper regulation of reactor power
3. Incorrect manual operation in Modes 2 or 3

Operator response

1. A "reverse" annunciator should accompany this alarm. If more than one channel experience the same condition simultaneously a control plate insertion should occur to lower the power. Ensure this action does occur.
2. Investigate cause of reactor power excursion and take appropriate action.
3. Investigate cause of control system malfunction and take appropriate action.

Annunciator D-14

Condition: Pressure low trip "channel 3"

Setpoint: 600 psig

Sensor: IC-54

Location: Pressure comparator in safety channel 3

Possible causes

1. Failure of pressurizer pumps
2. Rupture in coolant loop, including pressure relief elements
3. Malfunction of pressure regulating system 127 and 128,
including the letdown and block valves

Operator response

1. If a scram occurs, investigate and take appropriate action.

Follow-up action

1. Investigate cause of scram and correct promptly if possible.
Since this form of scram also shuts down the main ac primary
pump motors at 400 psig, it is not possible to restart the
reactor in Mode 1 until loop pressure is restored.

Annunciator D-15

Condition: Low-low-flow trip "channel 3"

Setpoint: Primary coolant flow less than normal delivery by two pumps at pony motor speed, but greater than from one pump at pony motor speed; approximately 1775 gpm.

Sensor: IC-768

Logic: Low-low-flow comparator in safety channel 3

Possible causes

1. Failure of pony motors in Modes 1 and 2
2. Flow blockage in Modes 1 and 2

Operator response

1. If a scram occurs, investigate and take appropriate action.
Note that the extreme reduction (or total loss) of coolant flow may represent afterheat removal problems if the reactor was scrammed from a high power level.

Follow-up action

1. If trip is caused by a flow blockage, remove the conditions which caused it prior to restarting the reactor.
2. If a Technical Specification violation has occurred, report it to appropriate supervision

Annunciator D-17

Condition: CRM trouble "channel 3"

Sensors: IC-16 and IC-17

Location: Both are located in CRM "confidence" comparators in CRM channel 3

Possible causes

1. Chamber drive not in "automatic" for Mode 1 operation
2. Count-rate meter "operate-calibrate-off" switch not in "operate" position
3. Count rate less than 10 cps
4. Count rate greater than 50,000 cps

Operator response

1. If the conditions causing this alarm interfere with reactor startup, it is necessary to correct the troubles before proceeding.
2. If the annunciation occurs when there is appreciable neutron flux, check immediately to determine the alarm origin. When this is for count rate more than 50,000 cps, and chamber is not withdrawn sufficiently, withdraw and secure chamber from excessive flux.
3. Should the output from the CRM decrease, the chamb. will automatically drive toward the core, which could result in damage to the fission chamber. To prevent this the chamber should be withdrawn and left in "manual."

Annunciator D-18

Condition: Ion chamber voltage module continuity "channel 3"

Setpoint: Less than 150 V on ionization chamber of safety channel 3

Sensors: IC-71 and IC-75

Location: Both are located in safety channel 3

Possible causes

(Condition causes slow scram in channel 3.)

1. Power supply troubles
2. Module improperly installed or a faulty connector

Operator response

1. Investigate origin of trouble and initiate repairs. The channel must be left in "trip" condition until repairs are completed.

Annunciator D-20

Condition: FFED trip "channel 3"

Setpoint: 120% of normal background

Sensor: Faulty fuel element detector RE-255-C

Location: Detector is located in pipe tunnel

Actuator: IC-87

Location: FFED comparator in safety channel 3

Possible causes

(If condition exists in two channels, a fast scram will occur. If two FFED "latches" occur, block valves close.)

1. Faulty fuel element
2. Faulty detector shield rotation motor
3. Faulty detector

Operator response

1. If a scram occurs:
 - a. stop the primary pump ac motors and continue water circulation from the pony motors only;
 - b. stop the operating pressurizer pump;
 - c. place the auxiliary pressurizer pump, PU-11, control switch in "off" position;
 - d. place the standby pressurizer pump control switch in the "stop" position; and
 - e. allow the primary system pressure to decrease through leakage to atmospheric pressure.
2. Investigate for high level radiation in the vicinity of the pipe corridor, pipe tunnel, heat exchanger cells, deaerator cell, and demineralizer cells. (The letdown block valves close automatically if two channels sense a faulty fuel element.

Therefore, large amounts of contamination should not enter the low pressure system.) Precautionary measures should be employed, however, to prevent personnel overexposure in the event of high radiation levels outside the primary water system. Refer to Section 8.4, Radiation-Contamination Emergencies, of the operating manual for further instructions pertaining to the fission-product release.

3. Notify appropriate supervision of conditions as soon as practicable.

Annunciator D-21

Condition: Instrument air pressure low "channel 3"

Setpoint: 32 psig

Sensor: PSS-654

Location: On discharge header of air receiver AR-7C

Possible causes

1. Normal and emergency compressor failure
2. Misvalving (shutoff or blowdown)
3. Filter plugging
4. Line rupture

Operator response

1. Observe supply pressure readout (PI-625) on process panelboard. If it appears that entire instrument air header is losing pressure, prepare to shut down the reactor manually.
2. Scram the reactor when the header pressure reaches 20 psig. Note that when header pressure reaches 20 psig, there still may be adequate reserve in the individual air receivers to supply the servo channels to receive their normal heat power information, thus preventing plate withdrawals in response to false indications of reduced power. Earlier loss of other instrument functions determines the necessity to shut down the reactor.
3. If air pressure failure affects one servo alone, observe the servo heat power recorders. If the recorder of the affected channel alone indicates reactor power decreasing, observe the consequent servo flux reset action. When the reset action stops, probably at minimum reset gain, reduce the demand setting in the affected servo channel only until the servo drive motor of that channel is no longer attempting to withdraw the No. 5 cylinder.

2.4.7 Annunciator Panel "1E"

1	5	9	13	17	21
2	6	10	14	18	22
3	7	11	15	19	23
4	8	12	16	20	24

	<u>Condition</u>	<u>Setpoint</u>	<u>Actuator</u>
1E-1.	PU-1A motor temperature very high	284°F	TG-13A
2.	PU-1B motor temperature very high	284°F	TG-14A
3.	PU-1C motor temperature very high	284°F	TG-15A
4.	PU-1D motor temperature very high	284°F	TG-16A
5.	PU-1A motor temperature high	221°F	TG-13
6.	PU-1B motor temperature high	221°F	TG-14
7.	PU-1C motor temperature high	221°F	TG-15
8.	PU-1D motor temperature high	221°F	TG-16
9.	PU-1E current high	36 amp	EIS-113A
10.	PU-1F current high	36 amp	EIS-117A
11.	PU-1G current high	36 amp	EIS-121A
12.	PU-1H current high	36 amp	EIS-198A
13.	PU-1E current low	3 amp	EIS-113B
14.	PU-1F current low	3 amp	EIS-113B
15.	PU-1G current low	3 amp	EIS-121B
16.	PU-1H current low	3 amp	EIS-198B

<u>Condition</u>	<u>Setpoint</u>	<u>Actuator</u>
1E-17. Reactor pressure high	800 psig	PS-127C
18. Reactor pressure low	700 psig	PS-127A-2
19. No. 5 rod pressure balance system ΔP high	65 psig	PdS-260
20. Process water systems not OK		
21. Reactor ΔP high	150 psig	PdS-106A
22. Reactor ΔP low	125 psig	PdS-106B
23. Strainer ΔP high	350 in. H ₂ O	PdS-103A
24. PU-11 switch "off"		SS-60, SS-6

Annunciator 1E-1

Condition: PU-1A motor temperature very high

Setpoint: 284°F

Sensor: TG-13A

Location: Motor stator

Possible causes

1. Electrical fault in motor windings
2. Motor overload
3. High or low voltage
4. Failure of heat exchanger cell cooling

Operator response

1. Place the standby heat exchanger-pump combination in service and remove the defective pump from service.

Follow-up action

1. Determine the cause of the high temperature and correct the failure.
2. Inspect the motor windings and bearings before placing back in service.

Annunciator 1E-2

Condition: PU-1B motor temperature very high

Setpoint: 284°F

Sensor: TG-14A

Location: Motor stator

Possible causes

1. Electrical fault in motor windings
2. Motor overload
3. High or low voltage
4. Failure of heat exchanger cell cooling

Operator response

1. Place the standby heat exchanger-pump combination in service and remove the defective pump from service.

Follow-up action

1. Determine the cause of the high temperature and correct the failure.
2. Inspect the motor windings and bearings for damage before placing back in service.

Annunciator 1E-3

Condition: PU-1C motor temperature very high

Setpoint: 284°F

Sensor: TG-15A

Location: Motor stator

Possible causes

1. Electrical fault in motor windings
2. Motor overload
3. High or low voltage
4. Failure of heat exchanger cell cooling

Operator response

1. Place the standby heat exchanger-pump combination in service and remove the defective pump from service.

Follow-up action

1. Determine the cause of the high temperature and correct the failure.
2. Inspect the motor windings and bearings before placing back in service.

Annunciator 1E-4

Condition: PU-1D motor temperature very high

Setpoint: 284°F

Sensor: TG-16A

Location: Motor stator

Possible causes

1. Electrical fault in motor windings
2. Motor overload
3. High or low voltage
4. Failure of heat exchanger cell cooling

Operator response

1. Place the standby heat exchanger-pump combination in service and remove the defective pump from service.

Follow-up action

1. Determine the cause of the high temperature and correct the failure.
2. Inspect the motor windings and bearings before placing back in service.

Annunciator 1E-5

Condition: PU-1A motor temperature high

Setpoint: 221°F

Sensor: TG-13A

Location: Motor stator

Possible causes

1. Electrical fault in motor windings
2. Motor overload
3. High or low voltage
4. Failure of heat exchanger cell cooling

Operator response

1. Check EiI-111, motor current indicator, for any abnormalities.
2. Check heat exchanger cell 113 temperature.
3. Check motor bearing temperature on points 1 and 2 of TR-1025.
If these are abnormally high, place the standby heat exchanger-pump combination in service. Remove the defective pump from service.

Annunciator 1E-6

Condition: PU-1B motor temperature high

Setpoint: 221°F

Sensor: TG-14

Location: Motor stator

Possible causes

1. Electrical fault in motor windings
2. Motor overload
3. High or low voltage
4. Failure of heat exchanger cell cooling

Operator response

1. Check EII-115, motor current indicator, for any abnormal current flow.
2. Check heat exchanger cell 112 temperature.
3. Check motor bearing temperature on points 3 and 4 of TR-1025.
If these are abnormally high, place the standby heat exchanger-pump combination in service. Remove the defective pump from service.

Annunciator 1E-7

Condition: PU-1C motor temperature high

Setpoint: 221°F

Sensor: TG-15

Location: Motor stator

Possible causes

1. Electrical fault in motor windings
2. Motor overload
3. High or low voltage
4. Failure of heat exchanger cell cooling

Operator response

1. Check EII-119, motor current indicator, for any abnormal current flow.
2. Check heat exchanger cell 111 temperature.
3. Check motor bearing temperature on points 5 and 6 of TR-1025. If these are abnormally high, place the standby heat exchanger-pump combination in service. Remove the defective pump from service.

Annunciator 1E-8

Condition: PU-1D motor temperature high

Setpoint: 221°F

Sensor: TG-16

Location: Motor stator

Possible causes

1. Electrical fault in motor windings
2. Motor overload
3. High or low voltage
4. Failure of heat exchanger cell cooling

Operator response

1. Check EiI-123, motor current indicator, for any abnormal current flow.
2. Check heat exchanger cell 110 temperature.
3. Check motor bearing temperature on points 7 and 8 of TR-1025.
If these are abnormally high, place the standby heat exchanger-pump combination in service. Remove the defective pump from service.

Annunciator 1E-9

Condition: PU-1E current high

Setpoint: 36 amps

Sensor: EIS-113A

Location: Auxiliary control room

Possible causes

1. Motor overload
2. Ground fault in motor

Operational limitation

There must be at least two dependable pony motors in service for Mode 1 operation.

Operator response

1. This alarm will most likely occur when the ac motors are de-energized and only shutdown coolant flow is required. The troubles should be eliminated before the reactor is restarted. If repairs cannot be made immediately, the standby heat exchanger-pump combination should be placed in service.
2. If the alarm should occur during Mode 1 or 2 operation, the standby heat exchanger-pump combination should be placed in service and the defective pump removed from service.

Annunciator 1E-10

Condition: PU-1F current high

Setpoint: 36 amps

Sensor: EIS-117A

Location: Auxiliary control room

Possible causes

1. Motor overload
2. Ground fault in motor

Operational limitation

There must be at least two dependable pony motors in service for Mode 1 operation.

Operator response

1. This alarm will most likely occur when the ac motors are de-energized and only shutdown coolant flow is required. The troubles should be eliminated before the reactor is restarted. If repairs cannot be made immediately, the standby heat exchanger-pump combination should be placed in service.
2. If the alarm should occur during mode 1 or 2 operation, the standby heat exchanger-pump combination should be placed in service and the defective pump removed from service.

Annunciator 1E-11

Condition: PU-1G current high

Setpoint: 36 amps

Sensor: EIS-121A

Location: Auxiliary control room

Possible causes

1. Motor overload
2. Ground fault in motor

Operational limitation

There must be at least two dependable pony motors in service for Mode 1 operation.

Operator response

1. This alarm will most likely occur when the ac motors are de-energized and only shutdown coolant flow is required. The troubles should be eliminated before the reactor is restarted. If repairs cannot be made immediately, the standby heat exchanger-pump combination should be placed in service.
2. If the alarm should occur during Mode 1 or 2 operation, the standby heat exchanger-pump combination should be placed in service and the defective pump removed from service.

Annunciator 1E-12

Condition: PU-1H current high

Setpoint: 36 amps

Sensor: EIS-198A

Location: Auxiliary control room

Possible causes

1. Motor overload
2. Ground fault in motor

Operational limitation

There must be at least two dependable pony motors in service for Mode 1 and 2 operation.

Operator response

1. This alarm will most likely occur when the ac motors are de-energized and only shutdown coolant flow is required. The troubles should be eliminated before the reactor is restarted. If repairs cannot be made immediately, the standby heat exchanger-pump combination should be placed in service.
2. If the alarm should occur during Mode 1 or 2 operation, the standby heat exchanger-pump combination should be placed in service and the defective pump removed from service.

Annunciator 1E-13

Condition: PU-1E current low

Setpoint: 3 amps

Sensor: EIS-113B

Location: Auxiliary control room

Possible causes

1. Pony motor battery troubles
2. Pony motor battery charger troubles
3. Open circuit between battery and pony motor
4. Breaker inside battery room open

Operational limitation

There must be at least two pony motors in service for Mode 1 and 2 reactor operation.

Operator response

1. Push the pony motor "test" button to check the operation of the pony motor under load.
2. Check battery voltage by momentarily turning off the ac power to the battery charger. If the voltage is low (<120 V), set the adjustable timer for a four-hour freshening charge.
3. Check battery charger output voltage. If the charger has failed and there are two other reliable pony motors in service, initiate maintenance on the charger immediately and switch the standby heat exchanger-pump combination in service.

Annunciator 1E-14

Condition: PU-1F current low

Setpoint: 3 amps

Sensor: EIS-117B

Location: Auxiliary control room

Possible causes

1. Pony motor battery troubles
2. Pony motor battery charger troubles
3. Open circuit between battery and pony motor
4. Breaker inside battery room open

Operational limitation

There must be at least two pony motors in service for Mode 1 and 2 reactor operation.

Operator response

1. Push the pony motor "test" button to check the operation of the pony motor under load.
2. Check battery voltage by momentarily turning off the ac power to the battery charger. If the voltage is low (<120 V), set the adjustable timer for a four-hour freshening charge.
3. Check battery charger output voltage. If the charger has failed and there are two other reliable pony motors in service, initiate maintenance on the charger immediately and switch the standby heat exchanger-pump combination in service.

Annunciator 1E-15

Condition: PU-1G current low

Setpoint: 3 amps

Sensor: EIS-121B

Location: Auxiliary control room

Possible causes

1. Pony motor battery troubles
2. Pony motor battery charger troubles
3. Open circuit between battery and pony motor
4. Breaker inside battery room open

Operational limitation

There must be at least two pony motors in service for Mode 1 and 2 reactor operation.

Operator response

1. Push the pony motor "test" button to check the operation of the pony motor under load.
2. Check battery voltage by momentarily turning off the ac power to the battery charger. If the voltage is low (<120 V), set the adjustable timer for a four-hour freshening charge.
3. Check battery charger output voltage. If the charger has failed and there are two other reliable pony motors in service, initiate maintenance on the charger immediately and switch the standby heat exchanger-pump combination in service.

Annunciator 1E-16

Condition: PU-1H current low

Setpoint: 3 amps

Sensor: EIS-198B

Location: Auxiliary control room

Possible causes

1. Pony motor battery troubles
2. Pony motor battery charger troubles
3. Open circuit between battery and pony motor
4. Breaker inside battery room open

Operational limitation

There must be at least two pony motors in service for Mode 1 and 2 reactor operation.

Operator response

1. Push the pony motor "test" button to check the operation of the pony motor under load.
2. Check battery voltage by momentarily turning off the ac power to the battery charger. If the voltage is low (<120 V), set the adjustable timer for a four-hour freshening charge.
3. Check battery charger output voltage. If the charger has failed and there are two other reliable pony motors in service, initiate maintenance on the charger immediately and switch the standby heat exchanger-pump combination in service.

Annunciator 1E-17

Condition: Reactor pressure high

Setpoint: 800 psig

Sensor: PT-127

Location: Beam room

Actuator: PS-127C

Location: Beam room

Possible causes

1. Failure of PRC-127
2. Failure of letdown valves
3. Loss of instrument air to letdown valves
4. Loss of pressurizer pump speed control

Operator response

1. Check PRC-127 for pressure indication and controller setpoint.
If the pressure cannot be controlled automatically, it may be necessary to place the controller in manual and control the letdown flow manually.
2. Decrease speed of pressurizer pump.
3. Remove defective pressurizer pump from service and place standby in service.

Annunciator 1E-18

Condition: Reactor pressure low

Setpoint: 700 psig

Sensor: PT-127

Location: Beam room

Actuator: PS-127A-2

Location: Auxiliary control room

Possible causes

1. Failure of PRC-127
2. Failure of pressurizer pump (The standby pressurizer pump will start.)
3. Failure of letdown valves
4. Leak in the high pressure system

Operator response

1. Check PRC-127 for pressure indication and controller setpoint. Compare makeup flow to letdown flow. These should agree. If the pressure cannot be held to an acceptable level, the pumps will be stopped and a scram will occur.

NOTE: The primary pumps stop at 400 psig and the scram occurs at 600 psig. These actions are initiated by PSS-128 coincidence matrix.

Annunciator 1E-19

Condition: No. 5 Rod Pressure Balance System Δ P High

Setpoint: >65 psi (reset when pressure drops to <18 psi - hysteresis)

Sensor: PdS-260

Location: Subpile room

Possible causes

1. Loss of balance fluid (water, oil, water)
2. Blocked line, particularly valve closed during maintenance
3. Failure of No. 5 control rod lead screw or gearbox

Operator response

1. Check the No. 5 control rod position to determine if there is a lead screw failure. If so, the reactor must be shut down while repairs are made.
2. Check the fluid in the accumulators in the subpile room.
3. Check the pressures on the primary water and balance oil high pressure gauges and ascertain that the alarm response is appropriate.

Annunciator 1E-20

Condition: Process water system not OK

Sensors: Relay matrix

Location: Auxiliary control room

Possible causes

1. Any one or more of the following equipment in the de-energized condition:
 - a. Three primary pumps
 - b. Two secondary pumps
 - c. One pressurizer pump
 - d. One primary cleanup pump

Operator response

1. Check pump control switch lights to locate the inoperative pump and restart it if practicable.
2. If failed pump will not restart, start the standby pump.
3. If all pumps listed above fail, press the "auto process start" pushbutton to get the equipment restarted.
4. Determine reason for pump failure and initiate repairs.

Annunciator 1E-21

Condition: Reactor Vessel ΔP High

Setpoint: 150 psi

Sensor: PdT-106

Location: Beam room

Actuator: PdS-106A

Location: Auxiliary control room

Possible causes

1. Obstruction to water flow through the core
2. High flow rate through core
3. Obstruction to water flow through the strainer

Immediate action

1. Shut the reactor down.

Operator response

1. Check core ΔT . If an increase has occurred, flow blockage should be suspected.
2. Check primary coolant flow rate.
3. Check the strainer ΔP . If indications are such that an obstruction to flow through the core exists, scram the reactor and investigate.
4. Obtain a hydraulic data printout from the computer to determine the exact core region where flow blockage may have occurred.

Annunciator 1E-22

Condition: Reactor ΔP low

Setpoint: 125 psi

Sensor: PdT-106

Location: Beam room

Actuator: PdS-106B

Location: Auxiliary control room

Possible causes

1. Any loss of or decrease in primary water flow
2. Decrease in total pressure drop across the core due to abnormally high flow rates through regions which require relatively low flow. Perturbations in flow paths sufficient to cause this alarm would increase the total flow rate ~ 1000 gpm. A corresponding increase in strainer ΔP may cause an alarm at 350 in. H_2O
3. Loss of an operating primary pump

Immediate action

1. If the pressure vessel ΔP decreases to 125 psi (alarm setpoint) during normal operation with a corresponding flow increase of ~ 1000 gpm, shut the reactor down.
2. If the pressure vessel ΔP instrumentation malfunctions, shut the reactor down.

Operator response

1. If flow decreased due to the loss of a primary pump, attempt to restart the pump. If unsuccessful, valve in the spare primary pump-heat exchanger and return to full power operation.

Follow-up action

1. If flow has bypassed the core, observe the total flow, the vessel ΔP , the strainer ΔP , and the hydraulic data printout from the computer to determine the source of trouble.
2. If the reactor is shut down because of a malfunction of PdT-106, initiate repairs immediately so that the reactor may be restarted.
3. If a primary pump is lost, initiate repairs as soon as possible.

Annunciator 1E-23

Condition: Inlet strainer Δ P high

Setpoint: 375 in. water

Actuator: PdS-103A

Location: Main control room

Possible causes

1. Plugged strainer caused by the introduction of foreign material from elsewhere in the primary system or cleanup system
2. An increase in total flow due to flow bypassing the core

Immediate response

1. Reactor power should be reduced to 50 MW while an evaluation is being made. If this alarm occurs simultaneously with a flow increase of greater than 1000 gpm, shut the reactor down.
2. If the strainer Δ P instrumentation malfunctions, observe the safety flow recorders continuously while repairs are being made. If the total flow increases 1000 gpm, shut the reactor down.
3. If a slight decrease in total system flow and a slight increase in the vessel Δ P occurs, the reactor may have to be shut down to remove the foreign material from the strainer.

Annunciator 1E-24

Condition: PU-11 switch "OFF"

Sensor: SS-60, SS-6

Location: Pump control circuit SS-60 in control room and SS-6
locally mounted at a pump

Possible causes

1. Switch SS-60 in "stop" position (in control room)
2. Switch SS-6 in "off" position (locally mounted)
3. Loss of control circuit power

Operator response

1. Return SS-60 to "remote control" position and/or SS-6 to "auto" position immediately if the reactor is above 10 MW.
2. Check for control circuit power loss in starter panel located in motor control center "N."

2.4.8 Annunciator panel "2E"

1	5	9	13	17	21
2	6	10	14	18	22
3	7	11	15	19	23
4	8	12	16	20	24

	<u>Condition</u>	<u>Setpoint</u>	<u>Actuator</u>
2E-1.	PU-1A Seal	50 psig 20 psig 5 gpm	PS-195A&B, FS-158
2.	PU-1B Seal	50 psig 20 psig 5 gpm	PS-196A&B, FS-159
3.	PU-1C Seal	50 psig 20 psig 5 gpm	PS-197A&B, FS-160
4.	PU-1D Seal	50 psig 20 psig 5 gpm	PS-565A&B, FS-558
5.	Primary pumps motor bearing temperature high	185°	TR-1025
6.	Primary pump vibration switches		
7.			
8.	Cell flooded	+1 in.	
9.	Reactor inlet temperature "A" high	125°F	TSS-100-4-A
10.	Reactor inlet temperature "B" high	125°F	TSS-100-5-A

<u>Condition</u>	<u>Setpoint</u>	<u>Actuator</u>
2E.11. Reactor inlet temperature "C" high	125°F	TSS-100-5-A
12.		
13. Primary coolant temperature "A" low	80°F	TSS-100-5-B
14. Primary coolant temperature "B" low	80°F	TSS-100-5-B
15. Primary coolant temperature "C" low	80°F	TSS-100-6-B
16. PU-14 switch "off"		SS-1-3
17. Secondary temperature high	87°F	TS-310K
18. Tower basin level low	36 in. below grid level	LS-332
19. Secondary coolant radiation high	1 mr/h	RS-326
20. Tower bypass valve open		
21.		
22.		
23.		
24. Isolation switches TB No. 9		

Annunciator 2E-1

Condition: PU-1A pump seal

Setpoints: A. Chamber C high pressure - 50 psig
 B. Chamber C low pressure - 20 psig
 C. Low water flow to seals - <5 gpm

Sensors: A. PS-195A
 B. PS-195B
 C. FS-160

Location: Outside cell walls

Possible causes

1. Loss of seal water flow
2. Loss of pressure drop across seals
3. Loss of primary system pressure
4. Seal failure

Operator response

This alarm is actuated by low water flow to the seals or by high or low water pressure in the low pressure side of the seals.

1. Check flow and pressure indications on instruments located outside the cell wall as follows:

FI-160	Total flow to seals	>5 1/6 gpm
PI-161	Pressurizer pump pressure	750 psig
PI-186	Seal chamber "A" pressure	~750 psig
PI-189	Seal chamber "B" pressure	~350 psig
PI-195	Seal chamber "C" pressure	~25 psig
FI-194	Seal chamber "C" flow	~1/6 gpm

2. If flows and pressures cannot be returned to normal in a very short time, place the standby heat exchanger-pump combination in service and remove the defective pump from service. Minimum conditions for primary coolant pump operation are:

FI-160 - 5 1/6 gpm PI-186 - 225 psig PI-195 - 25 psig

PI-161 - 225 psig PI-189 - 125 psig FI-194 - 1/6 gpm

Caution: If the water cooled bearing on the pump is deprived of its 5 gpm cooling flow rate, it will cause the bearing to overheat and fail. The pump should not be operated over extended periods without this coolant flow.

Annunciator 2E-2

Condition: PU-1B pump seal

Setpoints: A. Chamber C high pressure - 50 psig
 B. Chamber C low pressure - 20 psig
 C. Low water flow to seals - <5 gpm

Sensors: A. PS-196A
 B. PS-196B
 C. FS-159

Location: Outside cell walls

Possible causes

1. Loss of seal water flow
2. Loss of pressure drop across seals
3. Loss of primary system pressure
4. Seal failure

Operator response

This alarm is actuated by low water flow to the seals or by high or low water pressure in the low pressure side of the seals.

1. Check flow and pressure indications on instruments located outside the cell wall as follows:

FI-159	Total flow to seals	>5 1/6 gpm
PI-162	Pressurizer pump pressure	750 psig
PI-187	Seal chamber "A" pressure	~750 psig
PI-190	Seal chamber "B" pressure	~350 psig
PI-196	Seal chamber "C" pressure	~25 psig
FI-193	Seal chamber "C" flow	~1/6 gpm

2. If flows and pressures cannot be returned to normal in a very short time, place the standby heat exchanger-pump combination in service and remove the defective pump from service. Minimum conditions for primary coolant pump operation are:

FI-159 - 5 1/6 gpm PI-187 - 225 psig PI-196 - 25 psig
PI-162 - 225 psig PI-190 - 125 psig FI-193 - 1/6 gpm

Caution: If the water cooled bearing on the pump is deprived of its 5 gpm cooling flow rate, it will cause the bearing to overheat and fail. The pump should not be operated over extended periods without this coolant flow.

Annunciator 2E-3

Condition: PU-1C pump seal

Setpoints: A. Chamber C high pressure - 50 psig
 B. Chamber C low pressure - 20 psig
 C. Low water flow to seals - <5 gpm

Sensors: A. PS-197A
 B. PS-197B
 C. FS-158

Location: Outside cell walls

Possible causes

1. Loss of seal water flow
2. Loss of pressure drop across seals
3. Loss of primary system pressure
4. Seal failure

Operator response

This alarm is actuated by low water flow to the seals or by high or low water pressure in the low pressure side of the seals.

1. Check flow and pressure indications on instruments located outside the cell wall as follows:

FI-158	Total flow to seals	>5 1/6 gpm
PI-163	Pressurizer pump pressure	750 psig
PI-188	Seal chamber "A" pressure	~750 psig
PI-191	Seal chamber "B" pressure	~350 psig
PI-197	Seal chamber "C" pressure	~25 psig
FI-192	Seal chamber "C" flow	~1/6 gpm

2. If flows and pressures cannot be returned to normal in a very short time, place the standby heat exchanger-pump combination in service and remove the defective pump from service. Minimum conditions for primary coolant pump operation are:

FI-158 - 5 1/6 gpm PI-188 - 225 psig PI-197 - 25 psig

PI-163 - 225 psig PI-191 - 125 psig FI-192 - 1/6 gpm

Caution: If the water cooled bearing on the pump is deprived of its 5 gpm cooling flow rate, it will cause the bearing to overheat and fail. The pump should not be operated over extended periods without this coolant flow.

Annunciator 2E-4

Condition: PU-1D pump seal

Setpoints: A. Chamber C high pressure - 50 psig
 B. Chamber C low pressure - 20 psig
 C. Low water flow to seals - <5 gpm

Sensors: A. PS-562A
 B. PS-562B
 C. FS-558

Location: Outside cell walls

Possible causes

1. Loss of seal water flow
2. Loss of pressure drop across seals
3. Loss of primary system pressure
4. Seal failure

Operator response

This alarm is actuated by low water flow to the seals or by high or low water pressure in the low pressure side of the seals.

1. Check flow and pressure indications on instruments located outside the cell wall as follows:

FI-558	Total flow to seals	>5 1/6 gpm
PI-556	Pressurizer pump pressure	750 psig
PI-559	Seal chamber "A" pressure	~750 psig
PI-560	Seal chamber "B" pressure	~350 psig
PI-562	Seal chamber "C" pressure	~25 psig
FI-561	Seal chamber "C" flow	~1/6 gpm

2. If flows and pressures cannot be returned to normal in a very short time, place the standby heat exchanger-pump combination in service and remove the defective pump from service. Minimum conditions for primary coolant pump operation are:

FI-558 - 5 1/6 gpm PI-559 - 225 psig PI-562 - 25 psig

PI-556 - 225 psig PI-560 - 125 psig FI-561 - 1/6 gpm

Caution: If the water cooled bearing on the pump is deprived of its 5 gpm cooling flow rate, it will cause the bearing to overheat and fail. The pump should not be operated over extended periods without this coolant flow.

Annunciator 2E-5

Condition: Primary pumps bearing temperature high

Setpoint: 185°F

Sensors: TE-130A&B, 131A&B, 132A&B, 133A&B (Readout on TR-1025)

Location: Motor and pump bearings

Actuator: TR-1025

Location: Control room

Possible causes

1. Bearing failure
2. Loss of secondary cooling water to the motor bearing oil lubricant

Operator response

1. Check TR-1025 to determine which pump bearing is overheating. If temperature continues to increase, place the standby heat-exchanger pump in service and remove the pump which is defective from service.

Annunciator 2E-6

Condition: Primary pump vibration

Sensor: Vibration switches/0.5-A breaker

Location: Attached to pump/vibration "counting" room

Possible causes

1. Excessive vibration of any of the primary coolant pumps. The 2.4-kV motor is stopped on the affected pump. The pony motor continues to run. Vibration cutout is automatically reset when the motor stops, but the motor must be restarted manually.

Operator response

1. Note which pump is affected by checking the indicator lights. Restart the pump once. (A time delay relay will allow the pump to be restarted even if excessive vibrations still exist.)
2. If the pump is stopped due to vibration again, place the standby heat exchanger-pump combination in service and return the reactor to full power. Valve the defective heat exchanger-pump combination out of service.
3. Observe that the demand is set back to the flow rate when the pump is off. Reactor power must be reduced to a level consistent with the heat removal capacity of two heat exchangers.

Annunciator 2E-8

Condition: Heat exchanger cell flooded

Setpoint: 1 in. above floor level

Actuator: Any one water level sensor in each of the four heat
exchanger cells

Possible causes

1. Heat exchanger cell flooded because of a ruptured secondary water line
2. Plugged floor drain while water is being drained from the heat exchanger or from a process water line inside the cell

Operator response

1. This alarm is common to all four cells. Its source can be determined by observing which of the four lights is brightened at the board behind the main control room panel board.
2. After determining which cell is flooded, take it out of service and place the standby cell in service. (Both secondary and primary systems must be isolated from the cell being removed from service.) Allow sufficient time for radioactive decay of the primary water contamination, then enter the cell to observe visually the source of water.

Annunciator 2E-9

Condition: Reactor Inlet Temperature "A" High

Setpoint: 125°F

Actuator: TSS-100-4A

Possible causes

1. Secondary cooling system difficulties
2. Primary heat exchanger difficulties

Operator response

1. Lower power to clear alarm.
2. Investigate cause of alarm; remedy and return to full power
 - a. Establish normal secondary flow
 - b. Operate fans manually if automatic control is out of order on secondary system
 - c. Check heat exchanger temperatures and place standby heat exchanger in service if fault is found with an operating heat exchanger.

Annunciator 2E-10

Condition: Reactor Inlet Temperature "B" High

Setpoint: 125°F

Sensor: TSS-100-5A

Possible Causes

1. Secondary cooling system difficulties
2. Primary heat exchanger difficulties

Operator Response

1. Lower power to clear alarm.
2. Investigate cause of alarm; remedy and return to full power
 - a. Establish normal secondary flow
 - b. Operate fans manually if automatic control is out of order on secondary system
 - c. Check heat exchanger temperatures and place standby heat exchanger in service if fault is found with an operating heat exchanger.

Annunciator 2E-11

Condition: Reactor Inlet Temperature "C" High

Setpoint: 125°F

Sensor: TSS-100-6A

Possible Causes

1. Secondary cooling system difficulties
2. Primary heat exchanger difficulties

Operator Response

1. Lower power to clear alarm.
2. Investigate cause of alarm; remedy and return to full power
 - a. Establish normal secondary flow
 - b. Operate fans manually if automatic control is out of order on secondary system
 - c. Check heat exchanger temperatures and place standby heat exchanger in service if fault is found with an operating heat exchanger.

Annunciator 2E-13

Condition: Primary Coolant Temperature "A" Low

Setpoint: 80°F

Actuator: TSS-100-4B

Possible Causes

1. Secondary cooling system valve or cooling fan misoperation
2. Secondary cooling valves to heat exchangers open during shutdown

Operator Response

Do not pressurize the system when temperature is <70°F.

1. Observe that there is agreement in the three channels.
2. Decrease secondary flow to primary heat exchangers to equalize primary temperature >80°F.
3. Check secondary system and heat exchangers for proper valving and operation.

Annunciator 2E-14

Condition: Primary Coolant Temperature "B" Low

Setpoint: 80°F

Sensor: TSS-100-5B

Possible Causes

1. Secondary cooling system valve or cooling fan misoperation
2. Secondary cooling valves to heat exchangers open during shutdown

Operator Response

Do not pressurize the system when temperature is <70°F.

1. Observe that there is agreement in the three channels.
2. Decrease secondary flow to primary heat exchangers to equalize primary temperature >80°F.
3. Check secondary system and heat exchangers for proper valving and operation.

Annunciator 2E-15

Condition: Primary Coolant Temperature "C" Low

Setpoint: 80°F

Sensor: TSS-100-6B

Possible Causes

1. Secondary cooling system valve or cooling fan misoperation
2. Secondary cooling valves to heat exchangers open during shutdown

Operator Response

Do not pressurize the system when temperature is <70°F.

1. Observe that there is agreement in the three channels.
2. Decrease secondary flow to primary heat exchangers to equalize primary temperature >80°F.
3. Check secondary system and heat exchangers for proper valving and operation.

building. These relays are labeled and are on the east wall of the electrical room. A fire alarm bypass switch and indicating lights have been installed to allow the resetting of the relays in the event there is no fire. This allows fan restart while the fire alarm system is actuated. If there is actually a fire at the cooling tower, do not reset the relays. Reset the relays after the fire is extinguished.

5. If the trouble is due to failure of TC-310, place the fan controls in manual and push the slow speed buttons on the control panel. If necessary, place some or all fan control switches in the fast-forward position.
6. If the trouble cannot be located and corrected immediately, reduce nonessential cooling loads on the secondary water system. Cold makeup water flow can be increased by placing FIC-325 (blow-down flow controller) in manual and running the setpoint full scale. This will allow temporary operation above 10 MW in order to lengthen the period of xenon chase.
7. If temperature and humidity conditions result in a cooling tower loss of efficiency, the reactor power may have to be lowered.

Annunciator 2E-18

Condition: Tower Basin Level Low

Setpoint: 36 in. below grid level

Actuator: LS-332

Location: In PU-6B pump sump

Sensor: LE-332

Location: In PU-6B pump sump

Possible Causes

1. Loss of makeup water supply
2. Failure of level control valve LCV-335
3. Dirty pump screens

Operator Response

1. Check basin water level to determine if the condition is real.
2. If the condition is real, check the operation of LCV-335. If this valve has failed, provide another means to supply makeup water to the basin. Potable water may be piped into the basin from a nearby fire hydrant.
3. If dirty pump suction screens cause the low level alarm, pull the screens out and clean them with the equipment provided.

Annunciator 2E-19

Condition: Secondary Coolant Radiation High

Setpoint: 1 mr/h

Actuator: RS-326

Location: Cooling tower equipment building

Sensor: RE-326

Location: Strapped to tower return line from the reactor building

Possible Cause

1. Ruptured tube in primary heat exchangers

Operator Response

1. Read point 4 of RR-1000 to see if signal is greater than 1 mr/h (10% full scale).
2. Check indication of tower blowdown activity on point 8 or RR-1000 and on RRC 702 in the auxillary control room.
3. Check the head tank makeup flow recorder to determine extent of leakage from the primary to secondary systems.
4. Sample secondary water on the exit of each heat exchanger to determine which is leaking.
5. Place the standby heat exchanger-pump combination in service and remove the leaking one from service.

Annunciator 2E-20

Condition: Tower Bypass Valve Open

Setpoint: Full open (FCV-362A)

Sensor: Limit switch

Location: Tower bypass valve

Possible Causes

1. Bypass valve manually open
2. PU-14 on - slow winding energized
3. Failure of valve positioner
4. Failure of limit switch

Operator Response

1. Close the valve via the manual switch.
2. Check secondary pumps; ascertain that the main secondary pumps are operating.
3. Shut off the emergency secondary pump and place in standby if running.

CAUTION: Damage may result from excessive flow rates if more than one pump is operated while the bypass valve is open.

Annunciator 2E-24

Condition: Isolation Switches TB No. 9

Sensor: One or more of the 54 isolation switches on TB No. 9

Location: TB No. 9 in the auxiliary control room

Possible Cause

1. One or more of the isolation switches left open, probably after performing maintenance on process equipment

Operator Response

1. Assure that the maintenance has been completed, then close the isolation switch. The maintenance supervisor should be contacted to assure that all work has been completed.
2. The following is a list of the 54 switches and the circuits they disable:

IS-39	PU-1A	main circulating pump, ac motor
-40	PU-2A	primary coolant cleanup pump, control circuit
-41	PU-11	primary coolant emergency pressurizer pump
-42	PU-1B	main circulating pump, ac motor
-43	PU-2B	primary coolant cleanup pump, control circuit
-44	PU-6A	secondary water pump, control circuit
-45	FCV-144 & HCV-182B	primary coolant inlet valves to EX-1C
-46	FCV-153	primary coolant discharge valve from EX-1C
-47	FCV-348	secondary water valve to EX-1C
-48	FCV-142 & HCV-181B	primary coolant inlet valves to EX-1B

IS-49	FCV-151	primary coolant discharge valve from EX-1B
-50	FCV-346	secondary water valve to EX-1B
-51	FCV-349	secondary water valve from EX-1C
-52	PU-14	high-speed winding control, secondary water pump
-53	PU-14	low-speed winding control, secondary water pump
-54	FCV-347	secondary water valve from EX-1B
-55	PU-9A	pool coolant pump
-56	PU-18A	plant demineralized water pump
-57	PU-7A	pool demineralizer pump
-58	FN-4A1	cooling tower fan
-59	FN-4A2	cooling tower fan
-60	PU-7B	pool demineralizer pump
-61	FN-4B1	cooling tower fan
-62	FN-4B2	cooling tower fan
-63	FCV-464	pool water to reactor pool
-64		
-66	FCV-465	pool water control valve to center pool
-67	FCV-466	pool water control valve to east pool
-75	PU-1C	main circulating pump, ac motor
-76	PU-4A	pressurizer pump, auto start mode of operation

IS-77	PU-6B	secondary water pump, control circuit
-78	PU-1D	main circulating pump, ac motor
-79	PU-4B	pressurizer pump, auto start mode of operation
-80	PU-6C	secondary water pump, control circuit
-81	FCV-140 & HCV-180B	primary coolant inlet valve to EX-1A
-82	FCV-149	primary coolant discharge valve from EX-1A
-83	FCV-344	secondary water valve to EX-1A
-84	FCV-551	primary coolant discharge valve
-85	FCV-552	secondary water inlet valve to EX-1D
-87	FCV-345	secondary water exit valve from EX-1A
-88	PU-9B	pool coolant pump
-89	PU-18B	plant demineralized water pump
-90	FCV-553	secondary water exit valve from EX-10
-91	FN-4E1	cooling tower fan (future)
-92	FN-4E2	cooling tower fan (future)
-94	FN-4C1	cooling tower fan
-95	FN-4C2	cooling tower fan
-96		
-97	FN-4D1	cooling tower fan
-98	FN-4D2	cooling tower fan

2.4.9 Annunciator Panel "3E"

1	5	9	13	17	21
2	6	10	14	18	22
3	7	11	15	19	23
4	8	12	16	20	24

	<u>Condition</u>	<u>Setpoint</u>	<u>Actuator</u>
3E-1.	Primary deaerator overflow	100%	R-45-2 (LSS-204)
2.	Primary deaerator water high	72%	LS-202A
3.	Primary deaerator water low	15%	LS-202B
4.	Primary deaerator pressure high	4.5 psia	PS-201
5.	Pool deaerator overflow	100%	R-20-2 (LSS-476E)
6.	Pool deaerator water high	72%	LS-454A
7.	Pool deaerator water low	15%	LS-454B
8.	Pool deaerator pressure high	4.5 psia	PS-400
9.	Reactor pool level high	+1 in.	LS-422A
10.	Reactor pool level low	-6 in.	LS-422B
11.	Diluent gas flow low	10 scfm	FS-917
12.	Deaerator CHOG temperature high	150°F	TE-476
13.	East pool water level high	+1 in.	LS-463A
14.	East pool water level low	-6 in.	LS-463B
15.			

	<u>Condition</u>	<u>Setpoint</u>	<u>Actuator</u>
3E-16.	Pool surge tank level low	10%	LS-401
17.	Center pool water level high	+1 in.	LS-458A
18.	Center pool water level low	-6 in.	LS-458B
19.			
20.			
21.	Critical pool water level high	+1 in.	LS-457A
22.	Critical pool water level low	-6 in.	LS-457B
23.			
24.			

Annunciator 3E-1

Condition: Primary Deaerator Overflow

Setpoint: 100% of control range

Sensor: LSS-204

Location: Locally mounted in the deaerator cell

Possible Causes

This alarm cuts off the steam supply to the vacuum ejectors. An alarm, "primary deaerator pressure high," will probably be received soon afterwards. When the water level drops below this alarm point, the steam is automatically turned back on.

1. Failure of the operating primary coolant cleanup pump. There is no automatic start feature on the standby pump.
2. Failure of LCV-202, which controls the deaerator water level.
3. Rupture in the deaerator condenser coils which would allow secondary coolant water to flood the deaerator.
4. Plugging of cleanup system filters or demineralizer columns.

Operator Response

1. If failure of the operating primary coolant cleanup pump is the cause, start the standby pump immediately. A pump failure is indicated by extinguished running lights.
2. If pump failure is not the cause, the first action to take is to place the standby pressurizer pump selector switch in the "off" position and then immediately lower the operating pressurizer pump speed so that the cleanup flow rate (FR-216) is

reduced to ~30 gpm. This action will cause the automatic startup of the emergency pressurizer pump. (Allow it to run.) This will reduce the deaerator overflow rate (deaerator overflow is into the ILW).

3. When reducing the operating pressurizer pump speed to lower the flow rate, it is very important to maintain sufficient flow for main circulating pump seal lubrication. If the flow rate is reduced too much, an alarm "main circulating pump seal troubles" will be initiated. If this occurs, increase the flow rate sufficiently to clear the seal-water trouble alarm.
4. Check pressure drops across both demineralizer columns as well as the prefilter and afterfilter to determine the location of the flow restriction. Take necessary action to eliminate the restriction.

Annunciator 3E-2

Condition: Primary Deaerator Water High

Setpoint: 72% of control range

Actuator: LS-202A

Location: Auxiliary control room

Sensor: LCT-202

Location: PC deaerator cell

Possible Causes

1. Failure of the primary coolant cleanup pump
2. Failure of LCV-202, which controls the deaerator water level
3. Rupture in the deaerator condenser which would allow secondary water to fill the deaerator
4. Plugging of cleanup system filters or demineralizer columns

Operator Response

1. If failure of the operating primary coolant cleanup pump is responsible, start the standby pump immediately. A pump failure is indicated by its running light being extinguished.
2. If pump failure is not the cause, place the standby pressurizer pump selector switch in the "off" position and then lower the operating pressurizer pump speed so that the cleanup flow rate (FR-216) is reduced to ~30 gpm. This will cause the emergency pressurizer pump to start. Allow it to continue to run. When reducing the pump speed, be very careful not to completely stop the flow. This would cause

an alarm from "main circulating pump seal "troubles" and damage the pump seals.

If the water level continues to increase, a "primary coolant deaerator water level very high" alarm will be received.

3. Check pressure drops across both demineralizer columns as well as the prefilter and afterfilter to determine the location of the flow restriction. Take necessary action to eliminate the restriction.

Annunciator 3E-3

Condition: Primary Deaerator Water Low

Setpoint: 15% of control range

Actuator: LS-202B

Location: Auxiliary control room

Sensor: LCT-202

Location: PC deaerator cell

Possible Cause

1. Failure to LCV-202 which controls the deaerator water level.
This level switch also stops the primary coolant cleanup pump.
Upon clearing of the alarm, the pump restarts automatically.

Operator Response

1. Check the water level on LI-202.
2. Check running light on the operating cleanup pump. The light should be off while in the alarm condition.
3. Enter the cleanup pump cell (CAUTION: High radiation levels may be encountered) and check the air-operated level-control valve LCV-202 for proper operation.

Annunciator 3E-4

Condition: Primary Deaerator Pressure High

Setpoint: -20 in. Hg (4.5 psia)

Actuator: PS-201

Location: Auxiliary control room

Sensor: PT-201

Location: Entrance to deaerator cell

Possible Cause

1. Loss of vacuum in the deaerator due to:
 - a. failure of LCV-202 in the closed position which would cause high deaerator water level and the closing of the steam supply valve;
 - b. failure of the steam supply;
 - c. failure of the operating cleanup pump; or
 - d. high temperature on the deaerator CHOG.

Operator Response

1. Check PI-201 - deaerator pressure.
2. Check PI-400 - pool deaerator to determine if the trouble is common to both.
3. Check LI-202 - deaerator water level
 - a. If a loss of supply steam has occurred, pressures in both deaerators will be high
 - b. Attempt to restart the cleanup pump if it has failed or start the standby pump
 - c. Enter the cleanup pump cell and attempt to correct the malfunction of LCV-202.
4. Check deaerator CHOG temperature - an alarm should have sounded (3E-12) if this is at fault.

Annunciator 3E-5

Condition: Pool Deaerator Level Overflow

Setpoint: 100% of control range

Sensor: LSS-476

Location: Pool deaerator cell

Possible Causes

1. Failure of pool cleanup pump
2. Failure of LCV-454, which controls the deaerator water level
3. Rupture in the deaerator condenser which would allow secondary coolant water to flood the deaerator
4. Plugging of cleanup system filters or demineralizer columns

Operator Response

1. If failure of the operating cleanup pump is the cause, start the standby pump.
2. Attempt to repair the malfunctioning level-control valve.
3. If indications are that the condenser is ruptured, remove the deaerator from service and valve out the secondary water to the condenser.

After this alarm is received, the "pool deaerator pressure high" alarm will probably also be received since the steam supply valve is closed automatically.

4. Backwash dirty filter or demineralizer. Chemically clean filter. Bypass filter.

Annunciator 3E-6

Annunciator: Pool Deaerator Water Level High

Condition: 72% of control range

Actuator: LS-454A

Location: Auxiliary control room

Sensor: LCT-454

Location: Pool deaerator cell

Possible Causes

1. Failure of pool cleanup pump
2. Failure of LCV-454, which controls the deaerator water level
3. Plugging of cleanup system filters or demineralizer columns

Operator Response

1. If failure of the operating cleanup pump is the cause, start the standby pump.
2. Attempt to repair the malfunctioning level-control valve.
3. Check pressure drops across both demineralizer columns as well as the prefilter and after filter to determine the location of the flow restriction. Take necessary action to eliminate the restriction.

Annunciator 3E-7

Condition: Pool Deaerator Water Level Low

Setpoint: 15% of control range

Actuator: LS-454B

Location: Auxiliary control room

Sensor: LE-454

Location: Pool deaerator cell

Possible Cause

1. Failure of LCV-454. The demineralizer pumps are stopped on low water level and restarted automatically when the level returns to normal.

Operator Response

1. Check FI-460 - pool deaerator flow.
Check LE-454 - pool deaerator water level.
2. Attempt to repair LCV-454 if it has failed.

Annunciator 3E-8

Condition: Pool Deaerator Pressure High

Setpoint: -20 in. Hg (4.5 psia)

Actuator: PS-400

Location: Auxiliary control room

Sensor: PT-400

Location: Entrance to pool demineralizer

Possible Causes

1. Loss of vacuum in the deaerator due to:
 - a. closing of steam supply valve when "very high water level" alarm is received;
 - b. loss of main steam supply; or
 - c. high temperature on the deaerator CHOG.

Operator Response

1. Check PI-400 - pool deaerator pressure.
Check PI-201 - primary coolant deaerator pressure.
Check LI-454 - pool deaerator water level.
2. If both PI-400 and PI-201 indicate high pressure conditions, the trouble is probably in the supply steam or high temperature on the deaerator CHOG.
3. If only PI-400 shows high pressure, the trouble is local.

Annunciator 3E-9

Condition: Reactor Pool Water Level High

Setpoint: 1 in. above normal level

Actuator: LS-422A

Location: Reactor pool

Sensor: LE-422

Location: Reactor pool

Possible Causes

1. High water level due to:
 - a. imbalance in flows to the various pools, or
 - b. scupper drains clogged.
2. This condition shuts off the pool coolant pumps. The pumps will restart automatically if the condition is cleared within one minute.

Operator Response

1. Check PU-9A and -9B running lights (pool coolant pumps).
2. Restart one pump and determine the cause of high water level. Adjust flow-control valves FCV-467, -466, -465, and -464 if necessary.
3. Check scupper drains for flow blockage.

Annunciator 3E-10

Condition: Reactor Pool Water Level Low

Setpoint: 6 in. below normal level

Actuator: LS-422B

Location: Reactor pool

Sensor: LE-422

Location: Reactor pool

Possible Causes

1. This alarm will probably be received when removing a carrier from the clean pools with the pool separation dam out.
2. Improper valving during a pumping operation.

Operator Response

1. If water is being transferred, check the valving arrangement.
2. Check for possible leaks in the pool cooling system.

CAUTION: Highly radioactive materials could be stored in this pool. Extreme care should be taken to prevent uncovering them. During Mode 1 operation, the pool must remain full.

Annunciator 3E-11

Condition: Diluent Gas Flow Low

Setpoint: 10 scfm

Actuator: FE-917

Location: Pool demineralizer cell outer wall

Possible Causes

1. Loss of steam to the primary deaerator ejectors
2. Misvalving

Operator Response

1. Return steam supply to ejectors so that deaerator pressure can be reduced to normal.
2. Check valving setup.

Annunciator 3E-12

Condition: Deaerator CHOG Temperature High

Setpoint: 150°F

Actuator: TS-476-1, pool deaerator; TS-476-2, primary deaerator;
alarm actuates for either deaerator.

Location: Deaerator off-gas line, pool deaerator cell

Possible Causes

1. High water temperature input to deaerator
2. Loss of secondary coolant to deaerator steam condensers

Operator Response

(Operates primary and pool deaerator steam automatic valves; closes both steam supply valves.)

1. Check deaerator temperatures to determine which is giving the alarm.
2. Check that the deaerator secondary water supply is normal.

Annunciator 3E-13

Condition: East Clean Pool Water Level High

Setpoint: 1 in. above normal level

Actuator: LS-463A

Location: East clean pool

Sensor: LE-463

Location: East clean pool

Possible Causes

1. High water level due to:
 - a. imbalance in flows to the various pools, or
 - b. scupper drains clogged.
2. This condition shuts off the pool demineralizer pumps. The pumps will restart automatically if the condition is cleared within one minute.

Operator Response

1. Check PU-7A and -7B running lights (pool demineralizer pumps).
2. Check scupper drains for flow blockage.
3. Check flows to the various pools.
4. CAUTION: Do not allow water to overflow into the SBHE ducts.

Annunciator 3E-14

Condition: East Clean Pool Water Level Low

Setpoint: 6 in. below normal level

Acuator: LS-463B

Location: East clean pool

Sensor: LE-463

Location: East clean pool

Possible Causes

1. This alarm will probably be received when removing a carrier from the pool.
2. Improper valving during a pumping operation

Operator Response

1. If water is being transferred, check the valving arrangement.
2. Check for possible leaks in the pool cooling system.
3. Check the pool cooling flow rates.

CAUTION: Highly radioactive materials are stored in this pool.

Extreme care should be taken to prevent uncovering them.

Annunciator 3E-16

Condition: Pool Surge Tank Water Level Low

Setpoint: 10%

Actuator: LS-401

Location: Auxiliary control room

Sensor: LCT-401

Location: Pool surge tank

Possible Cause

This alarm causes the pool coolant pump to stop. The pump will restart automatically if the condition is cleared within one minute.

1. Failure of LCV-401-demineralized water makeup to the pool surge tank.

Operator Response

1. Check LI-401 - pool surge tank water level.
2. Check LCV-401 for proper operation. Also check the demineralized water supply.

Annunciator 3E-17

Condition: West Clean Pool Water Level High

Setpoint: 1 in. above normal level

Actuator: LS-458A

Location: West clean pool

Sensor: LE-458

Location: West clean pool

Possible Cause

This alarm causes the pool demineralizer pumps to stop. The pumps will restart automatically if the condition is cleared within one minute.

1. High water level due to:
 - a. imbalance in flows to the various pools, or
 - b. scupper drains clogged.

Operator Response

1. Check scupper drains for flow blockage.
2. Check flows to the various pools.
3. CAUTION: Do not allow water to overflow into the SBHE ducts.

Annunciator 3E-18

Condition: West Clean Pool Water Level Low

Setpoint: 6 in. below normal level

Actuator: LS-458B

Location: West clean pool

Sensor: LE-458

Location: West clean pool

Possible Cause

This alarm will probably be received when removing a carrier from the pool.

1. Improper valving during a pumping operation

Operator Response

1. If water is being transferred, check the valving arrangement.
2. Check for possible leaks in the pool cooling system.
3. Check pool cooling flow rates.

CAUTION: Highly radioactive materials are stored in this pool. Extreme care should be taken to prevent uncovering them.

Annunciator 3E-21

Condition: Critical Pool Water Level High

Setpoint: 1 in. above normal level

Actuator: LS-457A

Location: Critical pool

Sensor: LE-457

Location: Critical pool

Possible Cause

This alarm causes the pool coolant pump to stop. The pump will restart automatically if the condition is cleared within one minute.

1. High water level due to:
 - a. clogged scupper drains, or
 - b. imbalance in flows to the various pools.

Operator Response

1. Check scupper drains for flow blockage.
2. Check flows to the various pools.

Annunciator 3E-22

Condition: Critical Pool Water Level Low

Setpoint: 6 in. below normal level

Actuator: LS-457B

Location: Critical pool

Sensor: LE-457

Location: Critical pool

Possible Cause

1. Improper valving during a pumping operation

Operator Response

1. If water is being transferred, check the valving arrangement.
2. Check for possible leaks in the pool cooling system.

CAUTION: Highly radioactive materials may be stored in this pool.
Extreme care should be taken to prevent uncovering them.

2.4.10 Annunciator Panel "4E"

1	5	9	13	17	21
2	6	10	14	18	22
3	7	11	15	19	23
4	8	12	16	20	24

<u>Condition</u>	<u>Setpoint</u>	<u>Actuator</u>
4E-1. Demineralized water tank high	90%	LS-605B
2. Demineralized water tank low	50%	LS-605A
3. Plant demineralizer conductivity high	500,000 ohm-cm	CI-374
4. Demineralized water pressure low	20 psig	PS-614
5. Secondary coolant pH high	6.9	ApHS-334A
6. Secondary coolant pH low	6.3	ApHS-334B
7.		
8. Primary demineralizer outlet conductivity high	250,000 ohm-cm	CS-217A
9. Primary coolant pH high	5.2	ApHS-1200
10. Primary coolant pH low	4.8	ApHS-1200
11. Primary head tank level low, No. 1	50%	LS-214A
12. Reactor primary water head tank level low, No. 2	50%	LS-214A-1
13. Sample station No. 1, radiation high	7 mr/h	RS-250

<u>Condition</u>	<u>Setpoint</u>	<u>Actuator</u>
4E-14. Sample station No. 2, radiation high	7 mr/h	RS-251
15. Primary deaerator off-gas radiation high	9 mr/h	RS-252
16. Head tank makeup	15 gpm	FS-215
17. Reactor pool, radiation high	9 mr/h	RS-423
18. Leaky fuel, radiation high	90 mr/h	RS-427
19.		
20.		
21. Primary demineralizer outlet, radiation high	9 mr/h	RS-213
22. Primary coolant radiation high	90 mr/h	RS-253
23.		
24.		

Annunciator 4E-1

Condition: Demineralized Water Tank Level High

Setpoint: 90%

Actuator: LS-605B

Location: Auxiliary control room

Sensor: LCT-605

Location: Demineralized water storage tank

Possible Cause

1. Failure of LCV-605 which controls tank water level

Operator Response

1. Check LCV-605 for proper operation.
2. Check LC-605, located on top of the tank, for proper operation.
3. If tank is overflowing to PWD, the level control valve LCV-605 should be kept closed to prevent loss of water.

Annunciator 4E-2

Condition: Demineralized Water Tank Level Low

Setpoint: 50%

Actuator: LS-605A

Location: Auxiliary control room

Sensor: LCT-605

Location: Demineralized water storage tank

Possible Causes

1. Failure of LCV-605, which controls the tank level
2. Excessive use of demineralized water while the plant demineralizer is being regenerated

Operator Response

1. Check LCV-605 for proper operation.
2. Check LC-605 for proper operation.
3. If usage is exceeding the plant demineralizer makeup capacity (90 gpm), restrict use to essential services until the tank level is again normal.

Annunciator 4E-3

Condition: Plant Demineralizer Conductivity High

Setpoint: 500,000 ohm-cm

Actuator: CS-374

Location: Plant demineralizer

Sensor: CE-374

Location: Plant demineralizer

Possible Cause

1. Plant demineralizer needs regeneration and has automatically shut itself down. Approximate capacity of the demineralizer between regenerations is 30,000 gallons at a maximum rate of 90 gpm. Regeneration time is approximately three hours.

Operator Response

1. Make sure an adequate supply of demineralized water is on hand in the storage tank and then start the demineralizer regeneration procedure.

Annunciator 4E-4

Condition: Demineralized Water Pressure Low

Setpoint: 20 psig

Actuator: PS-614

Location: Water wing, first floor, at pumps

Possible Causes

1. Failure of operating demineralized water pump (PU-18A or -18B)
2. Surge of demineralized water to head tank or surge tank
3. Empty storage tank

Operator Response

1. Check pump switches; if neither is operating, start PU-18A.
2. Check demineralized water supply tank DT-4.
3. Refill tank.

Follow-Up Action

1. Regenerate plant demineralizer if it has shut down due to high conductivity.

Annunciator 4E-5

Condition: Secondary Coolant pH High

Setpoint: 6.9

Actuator: ApHS-334A

Location: Auxiliary control room

Sensor: ApHE-334

Location: Secondary coolant water line entering the water wing

Possible Causes

1. Failure of ApHC-331, secondary water pH controller
2. Failure of the operating acid metering pump
3. Failure of ApHE-334 to which the alarm is connected
4. Empty acid tank

Operator Response

1. Read points 4, 8, and 12 of ApHR-1010 which indicate pH as measured by ApHE-334. Compare this with the reading indicated by points 3, 7, and 11 on ApHR-1010 which indicate pH as measured by ApHE-331.
2. Check acid metering pump for proper operation.
3. Check ApHC-331 which controls the acid metering pumps.
4. Check level of acid in the storage tank.
5. If necessary add sulfuric acid manually to control the pH between 6.4 and 6.8.

Annunciator 4E-6

Condition: Secondary Collant pH Low

Setpoint: 6.3

Actuator: ApHS-334B

Location: Auxiliary control room

Sensor: ApHE-334

Location: Secondary coolant water line entering the water wing

Possible Causes

1. Failure of ApHC-331, secondary water pH controller
2. Failure of ApHE-334, to which the alarm is connected

Operator Response

1. Read points 4, 8, and 12 of ApHR-1010 which indicate pH as measured by ApHE-334. Compare this with the reading indicated by points 3, 7, and 11 of ApHR-1010 which indicate pH as measured by ApHE-331.
2. Check ApHC-331 which controls the acid metering pumps.

Annunciator 4E-8

Condition: Primary Demineralizer Outlet Conductivity High

Setpoint: 250,000 ohm-cm resistivity

Sensor: CS-217A

Location: Control room process panel board

Possible Causes

1. Depletion of demineralizer resin
2. Chemicals which might remain in lines after demineralizer regeneration
3. Stale water from a demineralizer which has been in standby

Operator Response

1. In conjunction with this alarm, further control actions occur. At 200,000 ohm-cm a local alarm is actuated by CS-217B which then causes the demineralizer outlet valve to close, thus shutting down the demineralizer and preventing poor quality water from reaching the head tank. If this occurs, lower the pressurizer pump speed to zero to decrease the primary system makeup flow rate to no less than that required by the primary pump seals. The auxiliary pressurizer pump, PU-11, will start. This water will eventually overflow the deaerator to ILW.
2. Switch from the depleted demineralizer to the standby unit. The standby unit should be rinsed before it is placed in service.
3. The outlet valve may be bypassed by placing the local control switch in the bypass position.

Annunciator 4E-9

Condition: Primary Coolant pH High

Setpoint: 5.2

Sensor: ApHS-1200

Location: Sample station No. 1

Possible Causes

1. Failure of the ApHS-1200 system to start the acid pump
2. Loss of acid addition (plugged line, closed valve, empty tank, pump failure, etc.)

Operator Response

1. Start the pump manually. Adjust the primary system to a pH of 5.0 ± 0.1 , and control the pump manually to remain at this pH.

Follow-Up Action

1. Initiate repairs of ApHS-1200 system.
2. Control the pump action to give a primary coolant pH of 5.0 ± 0.1 .
3. The acid addition pump, PU-101, is stopped automatically by FS-216 when the flow rate from the main pressurizer pumps decrease to <75 gpm. The pump can be restarted only by increasing the flow to >75 gpm.

Annunciator 4E-10

Condition: Primary Coolant pH Low

Setpoint: 4.8

Sensor: ApHS-1200

Location: Sample station No. 1

Possible Causes

1. Failure of ApHS-1200 pH control system to shut down in its operating range
2. Loss of demineralizer capacity

Operator Response

1. Turn off acid pump PU-101. Allow the system pH to build up to 5.0, then restart the pump. Control the level by manual adjustment of pump speed.
2. Check demineralization of cleanup water; switch to the second demineralizing units.

Follow-Up Action

1. Initiate repair of ApHS-1200 system.
2. Control the pump action to give a pH of 5.0 ± 0.1 .
3. Regenerate demineralizers as necessary.

Annunciator 4E-11

Condition: Primary Coolant Head Tank Level Low No. 1

Setpoint: 50%

Actuator: LS-214A

Location: Auxiliary control room

Sensor: LT-214A

Location: Primary coolant head tank

Possible Causes

Auto Action: Shuts off pressurizer pumps PU-4A and -4B at 25%.

1. Failure of demineralized water makeup from the plant demineralized water system
2. Failure of LC-214 which controls the demineralized water makeup through LCV-214
3. Leak in the primary coolant high pressure or low pressure systems which exceeds ~85 gpm, the maximum demineralized water makeup rate

Operator Response

1. Check running lights on the demineralized water pumps PU-18A and PU-18B.
2. Check LI-214, head tank level indicator.
3. Check LC-214 for proper operation.
4. If a leak is discovered in the primary cleanup system, lower the pressurizer pump speed so that the flow rate is at a minimum of 30 gpm.

5. If a leak is discovered in the primary coolant high pressure system (most likely in a heat exchanger), the leak must be isolated in order to continue reactor operation. Sample the secondary water discharging from each heat exchanger and analyze each sample for radioactive contamination. After the leak is located, place the standby heat exchanger-pump combination into service and remove the defective unit from service.

Annunciator 4E-12

Condition: Reactor Primary Water Head Tank Level Low, No. 2

Setpoint: 50%

Actuator: LS-214A-1

Location: Auxiliary control room

Sensor: LT-214A-1

Location: Primary coolant head tank

Possible Causes

Auto action: shuts off pressurizer pump PU-4A and -4B at 25%.

1. Failure of demineralized water makeup from the plant demineralized water system
2. Failure of LC-214, which controls the demineralized water makeup through LCV-214
3. Leak in primary coolant high pressure or low pressure systems which exceed ~85 gpm, the maximum makeup rate

Operator Response

1. Check running lights on the demineralized water pumps PU-18A and PU-18B.
2. Check LI-214, head tank level indicator.
3. Check LC-214 for proper operation.
4. If a leak is discovered in the primary cleanup system, lower the pressurizer pump speed so that the flow rate is at a minimum of 30 gpm.

5. If a leak is discovered in the primary coolant high pressure system (most likely in a heat exchanger), the leak must be isolated in order to continue reactor operation. Sample the secondary water discharging from each heat exchanger and analyze each sample for radioactive contamination. After the leak is located, place the standby heat exchanger-pump combination into service and remove the defective unit from service.

Annunciator 4E-13

Condition: Sample Station No. 1, Radiation High

Setpoint: 7 mr/h

Actuator: RS-250

Location: Sample station No. 1

Sensor: RE-250

Location: Sample station No. 1

Possible Cause

1. High radiation in the water being sampled

Operator Response

1. Close sample valve and survey the area to determine extent of high radiation levels. Take necessary actions to prevent overexposure.

Annunciator 4E-14

Condition: Sample Station No. 2, Radiation High

Setpoint: 7 mr/h

Actuator: RS-251

Location: Sample station No. 2

Sensor: RE-251

Location: Sample station No. 2

Possible Cause

1. High radiation in pipe corridor

Operator Response

1. Check pipe corridor area to determine source of high radiation. Rope area off if radiation level warrants action.

Annunciator 4E-15

Condition: Primary Deaerator Off-Gas

Setpoint: 9 mr/h

Below scale reading

Sensor: RE-252

Actuator: RS-252

Location: Pool demineralizer cell

Possible Causes

1. Leaky fuel element
2. Leaky or ruptured experiment
3. Leaky or ruptured target
4. Low alarm (activity <0) on RT-252 at pool demineralizer cell entrance

Operator Response

1. Check both odd (crystal) and even (G-M tube) points of RE-252 recorder in control room.
2. Check cladding failure instrumentation (RR-1000, points 1, 15; RT-253, auxiliary control room) for intensity of activity in the primary coolant.
3. Analyze deaerator inlet water using the multichannel analyzer in the Health Physics office.

Annunciator 4E-16

Condition: Head Tank Makeup

Setpoint: 15 gpm

Actuator: FS-215

Location: Control room panel

Possible Causes

1. Leak in primary system
2. Leak in primary cleanup system
3. Normal makeup from filling heat exchanger, filter, or demineralizer
4. Misvalving

Operator Response

1. Check magnitude of makeup.
2. Check flow rate to waste collection systems.
3. Check for activity in secondary system.
4. Check for a misvalving operation.

Follow-Up Action

1. If leak is to secondary system, valve in spare primary heat exchanger and remove leaking unit from service.
2. If leak is in primary cleanup system, isolate it and place spare unit in service.

Annunciator 4E-17

Condition: Reactor Pool Radiation High

Setpoint: 9 mr/h

Below scale reading

Actuator: RS-423

Sensor: RE-423

Location: Near pool surge tank in line 1217

Possible Causes

1. High radioactivity in the overflow from one of the pools
2. Low alarm (activity <0) on RT-423 at pool coolant pumps

Operator Response

1. Determine the source of the radioactive contamination and if possible isolate it. Further action depends upon the nature of the problem.
2. Read point 6 on RR-1000 for an indication of the intensity of the radiation.

Annunciator 4E-18

Condition: Leaky Fuel, Radiation High

Setpoint: 90 mr/h

Below scale reading

Actuator: RS-427

Sensor: RE-427

Location: Line 1257 in pipe corridor

Possible Causes

1. High radioactivity in the water coming from the defective fuel element storage racks
2. Low alarm (activity <0) on RT-427 at pool coolant pumps

Operator Response

1. Check point 3 on RR-1000 for an indication of the intensity of the radiation.
2. If a defective element is stored in the rack, it is most likely the source of the high radiation. Disposal of the defective element depends upon the length of time it was in the reactor. An element with a short irradiation may be removed and shipped almost immediately; however, an element which has been in the reactor a full cycle must be allowed to decay for approximately 9 months before shipment.

Follow-Up Action

1. Check RT-498 (pool deaerator off-gas radiation) and RT-497 (pool demineralizer effluent radiation) to see that no activity is escaping the cleanup system.

Annunciator 4E-21

Condition: Primary Demineralizer Outlet, Radiation High

Setpoint: 9 mr/h (normal <1 mr/h)

Below scale range

Actuator: RS-213

Sensor: RS-213

Location: Line 1040

Possible Causes

1. High activity in the cleanup water caused by demineralizer inefficiency
2. Low alarm (activity <0) on RT-213 at pool coolant pumps

Operator Response

1. Check point 2 of RR-1000. This indicates the intensity of the radioactivity.
2. Check point 1 of CR-1020 to determine if the resistivity is low.
3. Check point 1 of ApHR-1010 for an indication of the pH.
4. If the pH and resistivity indicate the need, take the operating demineralizer out of service for regeneration. Place the standby demineralizer in service.

Annunciator 4E-22

Condition: Primary Coolant Radiation High

Setpoint: 90 mr/h (high alarm)

Below scale range (low alarm)

Sensor: RE-253

Location: Pipe corridor

Actuator: RS-253

Location: Auxiliary control room

Possible Causes

1. Leaky fuel element
2. Leaky or ruptured experiment
3. Leaky or ruptured target
4. Inefficient primary coolant demineralizers

Operator Response

1. Read RR-1000 (points 1, 15) for an indication of the intensity of the activity and rate of increase.
2. Read RT-253 in the auxiliary control room to determine the alarm condition (high or low) and activity intensity.
3. Examine cladding failure instrumentation to determine fission activity in the primary coolant (see alarm C-13).
4. If a slow increase in β - γ activity is shown, sample the primary water and analyze it for amount and type of activity.

Follow-Up Action

1. Investigate type of contamination; track buildup; determine source.

2.4.11 Annunciator Panel "FG"

1	5	9	13	17	21
2	6	10	14	18	22
3	7	11	15	19	23
4	8	12	16	20	24

	<u>Condition</u>	<u>Setpoint</u>	<u>Actuator</u>
FG-1.	Tower waste radiation high β - γ	125 c/m	RRC-702A
2.	Process waste radiation very high β - γ	600 c/m	RRC-703B
3.	Process waste radiation high	500 c/m	RRC-703A
4.	Process waste drain sump high	72%	LS-710
5.			
6.	Process waste radiation very high α	150 c/m	RS-717
7.	Process waste radiation high α	125 c/m	RS-717
8.	Isolation switches TB No. 58		8 isolation switches
9.	SBHE standby fan on	80% normal 10,500 scfm	FS-903A-1, 913A-1, 904A-1, 914A-1
10.	West SBHE low flow	85% normal 11,500 scfm	FS-903B-1, 913B-1
11.	East SBHE low flow	85% normal 11,500 scfm	FS-904B-1, 914B-1

12. Reactor bay ΔP low	-0.10 in. H_2O	PdS-900
13. CHOG standby fan on	-35 in. H_2O	PS-915-1
14. CHOG vacuum low	-40 in. H_2O	PS-905-1
15. OHOG standby fan on	-35 in. H_2O	PS-916-1
16. OHOG vacuum low	-40 in. H_2O	PS-906-1
17. Cell 111 temperature high	104°F	RT-10
18. Cell 112 temperature high	104°F	RT-11
19. Cell 113 temperature high	104°F	RT-12
20. Cell 110 temperature high	104°F	RT-21
21. Electric and battery room exhaust		R-120-1, R-121-2
22. Electrical building exhaust		R-30-1
23. Instrument battery room exhaust		R-21-1
24. Isolation switches TB No. 6B		7 Isolation switches

Annunciator FG-1

Condition: Tower Waste Radiation High β - γ

Setpoint: 125 c/m/ml (50% full scale)

Actuator: RS-702A

Location: Cooling tower equipment building control panel

Sensor: RE-702

Location: Monitoring station No. 1 (west of cooling tower)

Possible Cause

1. Contamination of secondary coolant water due to a ruptured tube in a primary coolant heat exchanger. Secondary water blowdown is taken from the return line to the tower from the heat exchangers. This blowdown is then monitored before being dumped into Melton Creek. Simultaneously with this alarm, FCV-702B closes and FCV-702A opens, thus diverting the blowdown to the east retention pond.

Operator Response

1. Check valve-position lights for FCV-702A and FCV-702B on the liquid-waste panel.
2. Check point 8 of RR-1000 to verify the presence of contamination in the secondary system. Should contamination be excessive, the reactor should be shut down to prevent spreading it by evaporation from the tower.
3. Check the makeup rate to the primary coolant system on FR-215, located in the control room. If an appreciable increase in makeup is noted, there is probably a heat-exchanger tube ruptured. Locate the defective heat exchanger and valve the standby unit in service.

Follow-Up Action

1. Sample the secondary water to determine the degree of contamination and determine if reactor operation is advisable in light of the contaminated condition of the secondary system.

Annunciator FG-2

Condition: Process Waste Radiation Very High β - γ

Setpoint: 600 c/m

Actuator: RS-703B

Location: Auxiliary control room

Sensor: RE-703

Location: Monitoring station No. 2 (southwest of reactor building)

Possible Cause

1. Highly contaminated waste in the process waste drainage system. Previous to this alarm the FG-3 alarm, "process waste radiation high," should have diverted waste from pond No. 1 to pond No. 2.

Operator Response

1. Check point 9 of RR-1000 for process waste radiation level.
2. Check position lights of FCV-703A and FCV-703B to make sure diversion to pond No. 2 has taken place.
3. Check liquid level in ILW tank (LR-700) in case diversion is necessary. Waste with activity greater than 5.8×10^3 dis min^{-1} ml^{-1} should be diverted to ILW tank, unless flow is of short duration. Flow may be diverted to the ILW tank by using selector switch SS-20 located on the liquid-waste panel or by manual selection at valve station 3.

Annunciator FG-3

Condition: Process Waste Radiation High β - γ

Setpoint: (500 c/m) (50% full scale)

Actuator: RS-703A

Location: Auxiliary control room

Sensor: RE-703

Location: Monitoring station 2 (southwest of reactor building)

Possible Cause

1. Contamination in the process waste. Simultaneously with this alarm, FCV-703B should open; then FCV-703A should close. This diverts process waste from pond No. 1 to pond No. 2.

Operator Response

1. Check point 9 on RR-1000 to determine the level of activity.
2. Check FR-707 on the liquid-waste panel to determine the flow rate.
3. Make sure FCV-703B opens and FCV-703A closes.
4. Check the waste level in the ILW tank in case the activity of the waste increases significantly.

Annunciator FG-4

Condition: Process Waste Drain Sump High

Setpoint: 72%

Sensor: LS-710

Location: On wall at southwest corner of the beam room

Possible Causes

1. Most likely normal drainage into the PWD sump. When the accumulation of waste in the sump reaches 33 in. (72% full), as measured by LE-710, the steam jets begin operation almost simultaneously with the alarm. The jets continue to operate until the waste is jetted out and the water level is lowered to 15% on the level indicator. A check of flow recorder FR-707 should show a flow rate of ~150 gpm. If all is normal, the jets will cut off when the water level reaches 15%.
2. Abnormal conditions exist when too frequent alarming and jetting occurs or when the alarm condition persists longer than usual. Possible causes are gross water leakage into the system or failure of the steam jets.

Operator Response

1. Check FR-707 to make sure that ~150 gpm is being jetted. When the alarm clears, the flow should stop soon afterward. If the alarm does not clear, either the steam jets are defective or an abnormal process flow is occurring. If the alarm occurs frequently, determine the source of excessive waste.

Annunciator FG-6

Condition: Process Waste Radiation Very High α

Setpoint: 150 counts per minute

Actuator: RS-717

Location: Auxiliary control room

Sensor: RE-717

Possible Cause

1. Highly contaminated waste in the process waste drainage system. Previous to this alarm, the FG-7 alarm, "Process Waste Radiation High α ," should have diverted waste from pond No. 1 to pond No. 2.

Operator Response

1. Check point 10 or 24 on RR-1000 for process waste radiation level.
2. Check position lights of FCV-703A and FCV-703B to make sure diversion to pond No. 2 has taken place.
3. Check liquid level in ILW tank (LR-700) in case diversion is necessary. Flow may be diverted by using selector switch SS-20 located on the liquid-waste panel or by manual selection at valve station 3.

Annunciator FG-7

Condition: Process Waste Radiation High α

Setpoint: 125 counts per minute

Actuator: RS-717

Location: Auxiliary control room

Sensor: RE-717

Possible Cause

1. Contamination in the process waste. Simultaneously with this alarm, FCV-703B should open; then FCV-703A should close.
This diverts process waste from pond No. 1 to pond No. 2.

Operator Response

1. Check point 10 or 24 on RR-1000 for process waste radiation level.
2. Check FR-707 on the liquid-waste panel to determine the flow rate.
3. Make sure FCV-703B opens and FCV-703A closes.
4. Check the waste level in the ILW tank in case the activity of the process waste increases significantly. Diversion to ILW may be necessary.

Annunciator FG-8

Condition: Isolation Switches TB No. 5B

Possible Cause

1. One or more of the following eight manual isolation switches has been opened:

- IS-1 disables PU-4A - ILW transfer pump;
- 2 disables SS-20 to FCV-700;
- 3 disables position indicator lights for FCV-702A;
- 4 disables position indicator lights for FCV-703A;
- 5 disables PU-4B - ILW transfer pump;
- 6 disables SS-20 to FCV-701;
- 7 disables position indicator lights for FCV-702B; and
- 8 disables position indicator lights for FCV-703B.

Annunciator FG-9

Condition: SBHE Standby Fan On

Setpoint: 80% normal air flow in either duct; 6,800 scfm

Actuators: FS-903A-1 and FS-913A-1 - Beam and experiment rooms SBHE
flow

FS-904A-1 and FS-914A-1 - Reactor bay SBHE flow

Location: Fan shed

Sensors: PT-1 and PT-3 - Beam and experiment rooms SBHE flow

PT-2 and PT-4 - Reactor bay SBHE flow

Location: Flow sensors and transmitters are located in manholes
over the SBHE ducts at the northwest corner of the
reactor building

Possible Causes

1. Fan failure or flow blockage. A sudden drop in flow can be caused by loss of electric power to the fan motor, by the loss of a fan motor or belt, or by misvalving at the filter pit.
2. A gradual loss of flow can be caused by filter plugging.
3. At this alarm, the standby fan should start. Immediate clearing of the alarm should indicate the standby fan has started and that normal flow has been re-established. If air flow drops to 75% of normal, air conditioners AC-2, -5, -10, and -14 are turned off automatically by flow switches FS-903A-2, -913A-2, -904A-2, or -914A-2.

Operational Limitations

1. The reactor should be shut down when the reactor bay SBHE flow decreases to less than 6,000 cfm.

Operator Response

1. Check fan indicator lights to determine which is running.
2. Check flow indicators FI-903B, -904B, and -914B for SBHE flow.
3. Check differential pressure indicators PdI-900, -901, and -902 for building negative pressures.

Annunciator FG-10

Condition: West SBHE Flow Low

Setpoint: 85% flow; 7,225 scfm "

Actuators: FS-913B-1; FS-903B-1

Location: Fan shed

Sensor: PT-1; PT-3

Location: PT-1 and PT-3 are located in manholes over the west SBHE duct at the northwest corner of the reactor building

Possible Causes

1. A sudden drop in flow is probably due to loss of power to the fan or to improper valving at the filter pit.
2. A gradual drop in flow is probably due to filter plugging either at the filter pit or at the fresh air intake dampers.

Operator Response

1. Check FI-903B and -913B on the gaseous waste panel. If both instruments indicate the same low flow, the condition is real. If only one indicates the alarm condition, instrument failure may be suspected.
2. Check PdI-901 and -902, beam and experiment room ΔP , for abnormal conditions. A larger ΔP than usual would indicate less supply air and FAI filter plugging. A smaller ΔP may indicate SBHE filter plugging.

Follow-Up Action

1. Check ΔP across FAI and SBHE filters. Check SBHE manual dampers and FAI automatic dampers.

Annunciator FG-11

Condition: East SBHE Flow Low

Setpoint: 85% of normal flow; 7,225 scfm

Actuators: FS-904B-1; FS-914B-1

Location: Fan shed

Sensors: PT-2; PT-4

Location: PT-2 and PT-4 are located in manholes over the east SBHE duct at the northwest corner of the reactor building

Possible Causes

1. A sudden drop in flow is probably due to loss of power to the fan or to improper valving at the filter pit.
2. A gradual drop in flow is probably due to filter plugging either at the filter pit or at the fresh air intake dampers.

Operator Response

1. Check FI-904B and -914B on the gaseous waste panel. If both instruments indicate the same low flow, the condition is real. If only one indicates the alarm condition, instrument failure may be suspected.
2. Check PdI-900, reactor bay ΔP , for abnormal conditions. A larger ΔP than normal would indicate less supply air and FAI filter plugging. A smaller ΔP than normal would indicate SBHE filter plugging.

Follow-Up Action

1. Check ΔP across FAI and SBHE filters. Check SBHE manual dampers and FAI automatic dampers.

Annunciator FG-12

Condition: Reactor Bay ΔP Low

Setpoint: 0.10 in. H_2O

Actuator: PdS-900

Location: Control room

Sensor: PdT-900

Location: Reactor bay (north wall)

Possible Causes

1. Failure of SBHE fans
2. Flow blockage in SBHE reactor bay duct
3. Failure of FAI modulating louvers
4. Leaky door seals

Technical Specification Limitation

1. Reactor containment is provided by the reactor bay branch of the SBHE system. The reactor must not be operated with a reactor bay SBHE flow of less than 6000 cfm.

Operator Response

1. Check PdI-900, reactor bay ΔP , located on the gaseous waste panel.
2. Check PdI-901 and -902, beam room and experiment room ΔP .
3. Check the reactor bay SBHE flow indicators, FI-904B and -914B.
4. Check the SBHE fan indicator lights to determine if fan failure is causing the alarm.

Follow-Up Action

1. Arrange for door seal repair.

Annunciator FG-13

Condition: CHOG Standby Fan On

Setpoint: -35 in. H₂O

Actuator: PS-915-1

Location: Fan shed

Sensor: ST-3

Location: Fan side of the filters

Possible Cause

1. Fan failure or a large volume of air flooding the duct. Improper valving at the filter pit could also cause the alarm. Simultaneously with the alarm, the standby fan should start. If the alarm clears immediately, the system is operating properly.

Operator Response

1. Check fan indicating lights on the gaseous waste panel.
2. Check PI-905 which indicates the vacuum on the reactor side of the CHOG filters.

Follow-Up Action

1. If both fans are running unnecessarily, turn one fan off and place it in standby.

Annunciator FG-14

Condition: CHOG Vacuum Low

Setpoint: -40 in. H₂O

Actuator: PS-905-1

Location: Main control room

Sensor: ST-1

Location: Reactor side of the filters

Possible Cause

1. Fan failure, filter plugging, or large volume of air flooding the duct

Operator Response

1. Check CHOG fan indicating lights to see if one or both have failed.
2. Check PI-905 on the gaseous waste panel.

Follow-Up Action

1. Read PI-915, vacuum on the fan side of the filters, and PdI-13, -16, -19, and -22, filter pressure differentials. These indicators are located in the fan shed.
2. Check damper positions at the filter pit.

Anunciator FG-15

Condition: OHOG Standby Fan On

Setpoint: -35 in. H₂O

Actuator: PS-916-1

Location: Fan shed

Sensor: ST-4

Location: Between the filters and the fan

Possible Cause

1. Fan failure or a large volume of air flooding the duct.
Improper valving at the filter pit could also cause the alarm. Simultaneously with the alarm, the standby fan should start. If the alarm clears immediately, the system is operating properly.

Operator Response

1. Check fan indicating lights on the gaseous waste panel.
2. Check PI-906 which indicates the vacuum on the reactor side of the OHOG filters.

Follow-Up Action

1. If both fans are running unnecessarily, turn one fan off and place it in standby.

Annunciator FG-16

Condition: OHOG Vacuum Low

Setpoint: -40 in. H₂O

Actuator: PS-906-1

Location: Main control room

Sensor: ST-2

Location: On the reactor side of the filters

Possible Cause

1. Fan failure, filter plugging, or a large volume of air flooding the duct

Operator Response

1. Check OHOG fan indicating lights to see if one or both fans have failed.
2. Check PI-906 on the gaseous waste panel.

Follow-Up Action

1. Read PI-916, vacuum on the fan side of the filters, and PdI-15, -18, -21, and -24, filter pressure differentials. These indicators are located in the fan shed.
2. Check damper positions at the filter pit.

Annunciator FG-17

Condition: Cell 111 Temperature High

Setpoint: 104°F

Sensor: RT-10

Location: In heat exchanger cell 111

Possible Causes

1. Failure of thermostat which controls the cell cooling
2. Loss of electric power to the unit cooler fans
3. Local control switch in "off"

Operator Response

1. Check circuit No. 1 on panel P-28 for loss of electric power to the cooler fans.
2. If multiple alarms occur (i.e., from all three operating cells), check secondary water flow to the coolers and check circuits 1, 2, 3, and 4 on panel P-28 for loss of electric power to the fans.
3. Keep a close check on the pump motor winding temperature. If it increases too much, the standby heat exchanger-pump combination must be placed in service.

Annunciator FG-18

Condition: Cell 112 High Temperature

Setpoint: 104°F

Sensor: RT-11

Location: In heat exchanger cell 112

Possible Causes

1. Failure of thermostat which controls the cell cooling
2. Loss of electric power to the unit cooler fans
3. Local control switch in "off"

Operator Response

1. Check circuit No. 2 on panel P-28 for loss of electric power to the cooler fans.
2. If multiple alarms occur (i.e., from all three operating cells), check secondary water flow to the coolers and check circuits 1, 2, 3, and 4 on panel P-28 for loss of electric power to the fans.
3. Keep a close check on the pump motor winding temperature. If it increases too much, the standby heat exchanger-pump combination must be placed in service.

Annunciator FG-19

Condition: Cell 113 Temperature High

Setpoint: 104°F

Sensor: RT-12

Location: In heat exchanger cell 113

Possible Causes

1. Failure of thermostat which controls the cell cooling
2. Loss of electric power to the unit cooler fans
3. Local control switch in "off"

Operator Response

1. Check circuit No. 3 on panel P-28 for loss of electric power to the cooler fans.
2. If multiple alarms occur (i.e., from all three operating cells), check secondary water flow to the coolers and check circuits 1, 2, 3, and 4 on panel P-28 for loss of electric power to the fans.
3. Keep a close check on the pump motor winding temperature. If it increases too much, the standby heat exchanger-pump combination must be placed in service.

Annunciator FG-20

Condition: Cell 110 Temperature High

Setpoint: 104°F

Sensor: RT-21

Location: In heat exchanger cell 110

Possible Causes

1. Failure of thermostat which controls the cell cooling
2. Loss of electric power to the unit cooler fans
3. Local control switch in "off"

Operator Response

1. Check circuit No. 4 on panel P-28 for loss of electric power to the cooler fans.
2. If multiple alarms occur (i.e., from all three operating cells), check secondary water flow to the coolers and check circuits 1, 2, 3, and 4 on panel P-28 for loss of electric power to the fans.
3. Keep a close check on the pump motor winding temperature. If it increases too much, the standby heat exchanger-pump combination must be placed in service.

Annunciator FG-21

Condition: Electric and Battery Room Exhaust

Sensors: R-120-1; R-121-2

Location: Relays located in control circuit of the exhaust fan
motor

Possible Causes

1. Overload on exhaust fan motor or ventilating unit motor
2. Loss of exhaust air flow
3. Fire alarm in the reactor building
4. Low temperature in ventilating unit coils

Operator Response

1. Check motors for overloading.
2. Check exhaust air flow rate.
3. Restart unit and check ΔP across filters.
4. Check for UV-1 and FN-5 in MCC "D," located on ground floor in the southeast corner of the building.

Annunciator FG-22

Condition: Electrical Building Exhaust

Sensor: R-30

Location: Control circuit of the electrical building exhaust
fan FN-1

Possible Causes

1. Fan motor overload
2. Loss of electric power to fan motor

Operator Response

1. Check overloads at fan motor controls.
2. Check circuit breaker at MCC "F," located in the electrical building.

Annunciator FG-23

Condition: Instrument Battery Room Exhaust

Sensor: R-21

Location: Relay R-21 is located in the control circuit of
exhaust fan FN-9.

Possible Cause

1. Loss of electrical power to motor of fan FN-9. Since this fan is on normal power only, the alarm will always be received upon failure of normal power.

Operator Response

1. Check fan fuse and circuit D-8 in lighting panel P-26.

Annunciator FG-24

Condition: Isolation Switches TB No. 6B

Possible Cause

1. One or more of seven isolation switches open. These switches disable indicating lights in the control room as follows:

IS-13	SBHE	FN-1
-14	CHOG	FN-3
-15	OHOG	FN-5
-16	SBHE	FN-2
-17	CHOG	FN-4
-18	OHOG	FN-6
-19	SBHE	FN-3

Operator Response

1. These isolation switches are not opened unless maintenance is being performed on their associated equipment. Therefore, no action is taken until the maintenance is completed.

2.4.12 Annunciator Panel "HI"

1	5	9	13	17	21
2	6	10	14	18	22
3	7	11	15	19	23
4	8	12	16	20	24

	<u>Condition</u>	<u>Setpoint</u>	<u>Actuator</u>
HI-1.	Instrument air aftercooler temperature high	110°F	TS-653
2.	Instrument air low	53 and 43 psig	PS-624, PS-651
3.	High pressure steam low	120 psig	
4.	Stack ionization chamber high level monitor	5 r/h	
5.	Radiation instruments	7 mr/h	
6.	Stack activity	60% full scale	
7.	Stack iodine inert gas radiation high	60% full scale	
8.	Building radiation	5 r/h	
9.	PU-1E pony motor battery trouble		
10.	PU-1F pony motor battery trouble		
11.	PU-1G pony motor battery trouble		
12.	Fire alarm		
13.	PU-1H pony motor battery trouble		
14.	Instrument battery trouble		

15. Switchgear battery trouble
16. 2.4-kV zig-zig transformer breaker trip
17. Diesel generator No. 1 battery
18. Diesel generator No. 1 misoperation
19. Fuel oil day tanks level low 25% full LS-648,
LS-649,
LS-647
20. 2.4-kV main breaker trip
21. Air starting pressure low 100 psig
22. Diesel generator No. 2 misoperation
- 23.
24. Isolation switches TB-7

Annunciator HI-1

Condition: Instrument Air Aftercooler Temperature High

Setpoint: 110°F

Sensors: TS-653

Location: TS-653 is at the common discharge of all after-coolers.

Possible Cause

1. Low cooling water flow to the aftercooler. This may be caused by failure of the solenoid valve which opens and admits water when the compressor is operating.

Operator Response

1. To avoid damage to the compressor, it must be taken out of service quickly. Cooling water is essential to the operation of the compressor and aftercoolers and compressed air is essential to reactor operation. Secondary water supply to the compressors can be checked by observing the flow gauge on the cooling water discharge line.

Annunciator HI-2

Condition: Instrument Air Low

Setpoints: 53 psig; 43 psig

Sensors: PS-624 closes at 53 psig to energize relay R-153 which in turn gives the alarm and starts the standby compressor. PSS-651a opens at 43 psig and starts the emergency compressor through PSS-651b.

Location: PSS-651 is located on air header which supplies the three servo channel air receivers (near output of emergency compressor C-3). PS-624 is located near air receiver AR-6.

Possible Causes

System pressure has dropped to the alarm point due to:

1. an air leak in the distribution system;
2. demand is greater than supply; or
3. the operating compressor has become defective.

Operator Response

1. Check indicator lights on panel HI to find out which compressor is running. If two are running and pressure is increasing, no emergency action is necessary. At least one compressor should remain in the "On" position after pressure is normal.
2. If a standby compressor only is running, the trouble is with the selected compressor.

3. If all normal compressors are off, the emergency compressor should be running.
4. For the failure of one compressor, check:
 - a. MCC "A" breaker for C-1A.
 - b. 225-amp bus duct breaker for C-1B.
 - c. MCC "E" breaker for C-1C.

Annunciator HI-3

Condition: High Pressure Steam Low

Setpoint: 120 psi (clears at 130 psi)

Sensor: RI-1, steam flow meter

Location: Northwest corner of ground floor

Possible Causes

1. Pressure reducer failure
2. Low pressure in steam supply header (normally 240 psig)

Operator Response

1. Check steam pressure gauges located in the northwest corner of the ground floor for abnormally low indications.
2. Check with the steam plant personnel if the supply pressure is less than 200 psig.
 - A. Steam Outage with Outside Temperature <32°F
 1. Projected outage less than one hour
 - a. Shut down the following fresh air intake units: AC-2, AC-5, AC-10, AC-14, AC-15, FN-1, and UV-1.
 - b. Turn off exhaust fans FN-7, FN-8, and FN-9 in reactor building.
 - c. Turn off exhaust and intake fans in office and auxiliary buildings.
 2. Projected outage more than one hour
 - a. Complete actions in Item 1 above.
 - b. Shut down reactor and turn off SBHE fans.
 - c. Maintain coolant circulation through reactor.
 - d. Open cooling tower bypass and turn off large secondary circulating pumps.
 - B. Steam Outage with Outside Temperature <25°F
 1. Projected outage more than 10 minutes
 - a. Complete actions in A.1 and A.2 above.

Annunciator HI-4

Condition: Stack Ionization Chamber High Level Monitor

Setpoint: 5 r/h

Sensor: RE-909

Location: Auxiliary control room

Possible Causes

1. Activity release into the SBHE or HOG systems from the HFIR or from TRU
2. Failure of the SBHE or HOG filter systems
3. Instrument failure of low alarm

Operator Response

1. Check recorders on the gaseous waste panel to determine the source of the alarm.
2. Check the building CAM's.
3. Notify the Laboratory Shift Supervisor.

Annunciator HI-5

Condition: Radiation Instruments

Setpoints: Monitrons - 7.5 mr/h

CAM's - >1,000 c/m

Sensors: All building CAM's; all building monitrons

Location: As noted on graphic panel "H"

Possible Causes

1. Air activity in the building >1,000 c/m at CAM
2. Surge of local radiation >7.5 mr/h at monitron

Operator Response

1. Determine the source of the activity and, using accepted ORNL Health Physics procedures, remedy the situation.
2. If any two monitrons or any two constant air monitors are in alarm condition simultaneously, the building evacuation air horns are sounded and the building should be evacuated. At the same time, the signal is transmitted to guard headquarters and the laboratory emergency center.

Annunciator HI-6

Condition: Stack Activity

Setpoint: 60% of full scale

Actuator: Alarm panel

Location: Auxiliary control room

Sensors: RE-907; RE-908; RE-912

Location: Stack platform and in fan shed

Possible Cause

1. Activity release into the SBHE or HOG systems from the HFIR or from TRU.

RE-907: Stack β - γ

RE-908: Stack α

RE-912: Duct β - γ

Operator Response

1. Check recorders on the gaseous waste panel to determine which monitor is causing the alarm.
2. Check building CAMs.
3. If the excess activity is determined to be coming from HFIR, locate its source and take appropriate remedial action.
4. If the source of activity is from TRU, notify them so they may take remedial action.
5. If the source within HFIR cannot be isolated, the reactor may have to be shut down to prevent excessive release to the atmosphere.

Annunciator HI-7

Condition: Stack Iodine - Inert Gas Radiation High

Setpoint: 60% of full scale

Sensors: RE-910: Stack iodine
RE-911: Stack inert gas

Location: Stack platform

Possible Causes

1. Activity release into the SBHE and HOG systems from the HFIR or from TRU
2. Failure of HOG and SBHE charcoal filters

Operator Response

1. Check recorders on the gaseous waste panel to determine which monitor is causing the alarm.

Follow-Up Action

1. Check ΔP across the charcoal filters.
2. Check building CAMs.
3. If source is within HFIR, determine its cause and initiate remedial action.
4. If source within HFIR cannot be isolated, the reactor may have to be shut down to prevent excessive release of activity to the atmosphere.

Annunciator HI-8

Condition: Building Radiation >5 r/h

Setpoint: 5 r/h

Sensor: RE-1001

Location: Column D-5, north wall reactor bay

Possible Causes

1. Water level low in pools
2. Exposed irradiated equipment

Operator Response

1. Shut the reactor down and follow Emergency Operating Procedure in Section 8.3.

Annunciator HI-9

Condition: PU-1E Pony Battery Trouble

Sensor: Trouble sensing relays

Location: Relays within charger

Possible Causes

1. Charger failure
2. dc ground
3. Loss of ac power
4. Loss of output current

Technical Specifications Limitation

There must be at least two (2) dependable pony motors for Mode 1 or 2 operation.

Operator Response

1. Locate the failed charger and have the electrician initiate repairs.
2. The spare charger should be connected to the output terminals of the faulty charger for continued operation.
3. Place the standby heat exchanger-pump into service to assure compliance with Technical Specifications.

Annunciator HI-10

Condition: PU-1F Pony Battery Trouble

Sensor: Trouble sensing relays

Location: Relays within charger

Possible Causes

1. Charger failure
2. dc ground
3. Loss of ac power
4. Loss of output current

Technical Specifications Limitation

There must be at least two (2) dependable pony motors for Mode 1 or 2 operation.

Operator Response

1. Locate the failed charger and have the electrician initiate repairs.
2. The spare charger should be connected to the output terminals of the faulty charger for continued operation.
3. Place the standby heat exchanger-pump into service to assure compliance with Technical Specifications.

Annunciator HI-11

Condition: PU-1G Pony Battery Trouble

Sensor: Trouble sensing relays

Location: Relays within charger

Possible Causes

1. Charger failure
2. dc ground
3. Loss of ac power
4. Loss of output current

Technical Specifications Limitation

There must be at least two (2) dependable pony motors for Mode 1 or 2 operation.

Operator Response

1. Locate the failed charger and have the electrician initiate repairs.
2. The spare charger should be connected to the output terminals of the faulty charger for continued operation.
3. Place the standby heat exchanger-pump into service to assure compliance with Technical Specifications.

Annunciator HI-12

Condition: Fire Alarm

Sensors: Heat detectors and supervisory system

Location: Master box No. 2 (reactor building)

Possible Cause

High temperature at heat detector or fire alarm troubles.

When this annunciator alarms, plantwide call 842 should also be heard, as well as alarm horns on the floor which signal the alarm. The affected zone of the building can be determined from the no-fire lights on the zone panel in Room 102B. This is master box No. 2.

Zone 1 ground floor

2 first floor

3 second floor

4 third floor

5 sprinkler supervisory circuit which actuates the alarm when the manual valve is shut off, when water pressure is low, or when air pressure is low.

6 trouble in fire alarm system

Any master box No. 2 alarm shuts off AC-15 and building ventilation fan FN-1. These must be manually reset after the alarm clears. In addition, UV-1 is shut off when Zone 1 alarms. It must also be manually reset.

Operator Response

1. The control room operator will page "fire alarm in the reactor building." The roving operator and shift supervisor will determine from the zone panel in Room 102B the location of the fire and attempt to extinguish it. One person must meet the fire truck and direct fire department personnel to the scene of the fire.
2. Should there be a fire in essential areas, such as the control room, auxiliary control room, pony motor battery room, etc., shut down the reactor and assist in extinguishing the fire.
3. If there is a fire in any other area of the building which might progress to the point of threatening the safety of the reactor, give serious consideration to shutting the reactor down.

Follow-Up Action

1. After the fire alarm is cleared, AC-15, FN-1, and UV-1 must be restarted.

Annunciator HI-13

Condition: PU-1H Pony Battery Trouble

Sensor: Relays

Location: Three relays in each charger

Possible Causes

1. Charger failure
2. dc ground
3. Loss of ac power
4. Loss of output current

Technical Specification Limitation

There must be at least two (2) dependable pony motors for Mode 1 or 2 operation.

Operator Response

1. Locate the failed charger and have the plant electrician initiate repairs.
2. The spare charger should be connected to the output terminals of the faulty charger for continued operation.
3. Place the standby heat exchanger-pump into service to assure compliance with Technical Specifications.

Annunciator HI-14

Condition: Instrument Battery Trouble

Sensor: Relay K2 in each charger

Location: Battery chargers are located in the instrument
battery room

Possible Causes

1. Charger failure
2. Loss of output current

Technical Specification Limitation

There must be at least two (2) battery banks and chargers
operable for reactor operation.

Operator Response

Batteries are sized to carry the instrument load for two hours
on loss of charger. Therefore, the trouble must be corrected within
this length of time.

1. Determine which charger has failed and initiate repairs
immediately. This can be done by observing the six "power
on" lights and the ammeters and voltmeters.
2. Connect the spare charger to the output terminals of the
faulty charger for continued operation.

Annunciator HI-15

Condition: Switchgear Battery Trouble

Sensor: "No-charge" alarm circuit and ground detection circuit

Location: Both circuits are located in the battery charger.

Possible Causes

1. Charger failure
2. dc ground

Technical Specification Limitation

The reactor cannot be operated without a reliable switchgear battery.

Operator Response

The switchgear battery is sized to carry the load for two hours on loss of normal-emergency power. Therefore, the trouble must be corrected within this length of time.

1. Determine the cause of failure and have the shift electrician make repairs immediately. Do not disconnect the dc output breaker.
2. Connect the spare pony motor battery charger to the output terminals of the faulty charger for continued operation.

Annunciator HI-16

Condition: 2.4-kV Zig-Zag Transformer Breaker Trip

Sensor: Relay in breaker control circuit

Location: At breaker in electrical building

Possible Causes

1. Motor starter ground relay failure
2. 2400-V bus ground fault
3. Overload on zig-zag grounding transformer or neutral resistor

Operator Response

1. With the breaker open, the 2400-V system converts from a wye system to a delta system, and operation may continue with the single line to ground fault. However, remedial action should be initiated immediately, since the occurrence of a second ground fault could cause serious damage to the electrical equipment.
2. Reclose the breaker once to see if it will hold. If not leave it open until the problem is isolated.
3. Isolate the 2400-V motors one at a time to determine which has caused the breaker trip.

Annunciator HI-17

Condition: Diesel Generator No. 1 Battery

Sensor: Ground detection and "no-charge" detection circuits

Location: Both circuits are located in the charger which is in the No. 1 diesel-generator room of the electrical building.

Possible Causes

1. Charger failure
2. dc ground

Operator Response

Determine the cause of the failure and direct the shift electrician in making immediate repairs. Do not disconnect the dc output breaker without starting the No. 2 diesel.

Annunciator HI-18

Condition: Diesel Generator No. 1 Misoperation

Causes and Setpoints

1. High cooling water temperature (209°F)
2. Low lubricating oil pressure (<18 psi) or low fuel oil pressure (12 psi)
3. Engine overspeed
4. Very low lubricating oil pressure (<8 psi)
5. Overcranking (engine has not started after three 15-s cranking cycles)
6. Failure to reset the rack solenoid

Overspeed, overcrank, and very low oil pressure will stop the diesel.

Operator Response

1. If an alarm occurs during diesel operation, check the indicator lights on panel "I" in the main control room to determine if the engine has stopped.
2. Check the engine-generator room to determine which condition actuated the alarm. Corrective action should be initiated immediately.
3. If overspeed caused the alarm, restart the diesel one time. If it trips out again, do not restart it.
4. After completion of the weekly diesel test run, verbal confirmation must be given to the diesel operator that the alarm has cleared. Failure to do so may leave the diesel generator inoperative.

Annunciator HI-19

Condition: Fuel Oil Day Tanks Level Low

Setpoint: 25% full (approximately 1/2-hour supply)

Sensors: LS-648; LS-649; LS-647

Location: Day tanks

Possible Causes

1. Failure of a fuel oil transfer pump
2. Failure of LSS-633 or LSS-635 to actuate the pump
3. Low fuel oil level in the underground storage tank (<40%)

Operator Response

Since only a 30-min supply remains in the day tank, action must be taken immediately. The day tank affected can be refilled by manually valving the unaffected fuel oil transfer pump to supply oil to the affected day tank. The pump must be operated manually. If conditions exist so that continuous running of the diesel is necessary, the day tank level should be checked and refilled hourly.

Follow-Up Action

1. Initiate repairs on faulty pump or level switch.
2. Call the ORNL stores attendant or the Laboratory Shift Supervisor to refill the underground storage tank.

Annunciator HI-20

Condition: 2.4-kV Main Breaker Trip

Sensor: Relay in breaker control circuit

Location: At breaker in electrical building

Possible Causes

1. A fault on the 2.4-kV bus. This includes all four primary coolant water pumps, three main secondary coolant water pumps, both pressurizer pumps, and the air conditioning chiller.
2. Top front door open on the breaker cubicle

Operator Response

If the breaker trips during full-power operation, reactor power will automatically be set back to 10 MW by the control system. Primary coolant water flow and secondary coolant water flow will be lost. The auxiliary pressurizer pump will start upon loss of main pressurizer pump water flow.

1. Make sure power is reduced to 10 MW.
2. Make sure the auxiliary pressurizer pump started.
3. Make sure pony motor flow is adequate for afterheat removal.
4. Start the emergency secondary water pump.
5. Locate 2.4-kV fault by:
 - a. Reclosing the breaker. If the breaker remains closed, start the motors, using the auto process start circuit until the defective motor is located. If a primary pump motor is found defective, valve in the standby pump-heat exchanger combination and return the reactor to power. If one secondary water pump motor is found defective, the spare pump should be started.

Annunciator HI-21

Condition: Air Starting Pressure Low

Setpoint: 100 psig

Sensor: PS-645

Location: Diesel-generator No. 2 room in the electrical
building

Possible Causes

1. Air leak in the receiver
2. Failure of PS-629 to start the compressor at 205 psig (stop at 240 psig)
3. compressor failure

Operator Response

1. Attempt starting the compressor using the manual switch.

Follow-Up Action

1. Make immediate repairs if the compressor has failed.
2. If the ability to start No. 2 diesel-generator is lost, the No. 1 diesel-generator must be in reliable condition for continued reactor operation.

Annunciator HI-22

Condition: Diesel Generator No. 2 Misoperation

Causes and Setpoints

1. High cooling water temperature (209°F)
2. Low lubricating oil pressure (<18 psi) or low fuel oil pressure (<12 psi)
3. Engine overspeed
4. Very low lubricating oil pressure (<8psi)
5. Overcranking (engine has not started after a 75-s cranking period)
6. Failure to reset the rack solenoid

Overspeed, overcrank, and very low oil pressure will stop the diesel.

Operator Response

1. If the alarm occurs during diesel operation, check the indicator lights on panel "I" in the main control room to determine if the engine has stopped.
2. Check the engine-generator control panel, located in the No. 2 diesel-generator room, to determine which condition actuated the alarm. Corrective action should be initiated immediately.
3. After completion of the weekly diesel test run, verbal confirmation must be given to the diesel operator that the alarm has cleared. Failure to do so may leave the diesel generator inoperative.

Annunciator HI-24Condition: Isolation Switches TB-7Possible Cause

1. One or more of the following isolation switches is open:

IS-25	disables indicating lights for diesel-generator No. 1;
-26	disables indicating lights for diesel-generator No. 2;
-27	disables indicating lights for switchgear No. 1 (480 V);
-28	disables indicating lights for switchgear No. 2 (480 V);
-29	disables indicating lights for switchgear No. 3 (480 V);
-30	disables indicating lights for switchgear No. 4.(480 V);
-31	disables indicating lights for preferred 13.8-kV feeder;
-32	disables indicating lights for alternate 13.8-kV feeder;
-33	disables indicating lights for 13.8-kV bus transfer;
-34	disables indicating lights for 2.4-kV switchgear main breaker
-35	disables instrument air compressor C1A;
-37	disables instrument air compressor C1B;
-38	disables instrument air compressor C3 running lights; and
-C1C	disables instrument air compressor C1C.

3. INSTRUMENTATION AND CONTROL

3.1. Reactor Control and Safety Systems

3.1.1 Introduction

The safety, servo, control, and wide-range counting systems control the core reactivity by positioning the poison plates. The four systems interact to some extent, with a broad division of functions as follows: (1) control system exercises final control of the shim drives on the four quadrant plates and one cylindrical plate; it includes the relaying which actuates the shim drives, the selector switches that set up the various reactor operating modes, and other switches which enable direct manual control of the plates; (2) servo system continuously compares power demand setting with reactor power and positions the cylindrical plate within a small range about the position established by the shim drive; the servo system also initiates requests for automatic shimming via the control system when the required reactivity change exceeds the range of the servo drive; (3) wide-range counting channel governs plate withdrawal at all times; and (4) safety system independently monitors neutron flux and other parameters, and initiates scram of the quadrant plates before safe levels are exceeded.

Normal operation of the reactor in Mode 1 fully utilizes the automatic features of the servo and control systems. Operator attention is required only to enter appropriate instructions into these systems, perform certain trimming adjustments, and monitor the various readouts and alarm to determine that the reactor and the systems are performing

properly. The operator must also shim the reactor by manual control. Operation in Modes 2 and 3, for purposes of tests at low power, involves manual control of the plate drives. The use and application of the various system controls, readouts, and alarms to operate the reactor are discussed in Section 2.

The same reliability objectives that governed the design of the four systems also apply to their maintenance and operation. These are that the safety system must be capable of preventing serious core accidents under all operating conditions, and that unnecessary shutdowns or power reductions should be minimized for economic reasons. To this end, the comprehensive maintenance and testing program ensures that the equipment receives all necessary attention during scheduled reactor shutdown periods. The operating considerations for maximum reliability of the systems are discussed in this section. They include use of the in-service testing features of the safety system, procedures covering partial failures in each system, correction of failures by means of module exchanges, and interpretation of certain annunciations and readouts to determine whether the equipment is operating correctly. The information is arranged mostly according to reactor operating status, with some general considerations presented initially.

3.1.2 General Considerations

The safety, control, servo, and count-rate systems are intended to remain in service continuously, except as necessary for system maintenance or tests, module replacements, or emergency. The only provisions for de-energizing the electronic equipment are the supply bus and

branch circuit disconnects, and the connectors between modules and drawers in panels B, C, and D in the control room. Air supplies to the pneumatic instruments are via local regulators, which can be shut off.

Check sheets covering the routine operational tests described in the following paragraphs are to be executed and retained as a part of the reactor operating records.

The plate time-of-flight tests, described on page 3-11, check the performance of the four shim-safety plates. To test the servo drive of the regulating plate requires the introduction of signals from an external generator.

3.1.3 Safety System Tests

As described in detail in Volume I, the safety system incorporates test facilities which, on command, either: (1) perturb any of the variables measured by the safety system sensors; or (2) provide simulated signals equivalent to the chamber responses to changes in neutron flux. The test facilities for each channel are identical with, and independent of, those of the other channels; they are used to verify the performance of the safety system during each phase of reactor operation, generally in the manner described below. Certain details of the tests and responses vary with reactor operating status and are classified accordingly in subsequent sections.

It is usually desirable to order a sequence of tests by channels. Accordingly, all tests are completed on one channel and the channel entirely restored to "unperturbed" condition before initiating any tests on another channel. This minimizes the risk of accidentally

scramming the reactor and provides continuous reference by two unperturbed channels for comparison with the channel being tested.

Basic Safety System Test Procedure

1. Select on the console the test-initiate push button corresponding to:
 - a. intended or actual mode of reactor operation,
 - b. channel to be tested, and
 - c. type of test to be performed.
2. Observe readout instrument indications of variables to be affected by test. Note particularly that pretest conditions are normal; if not, either correct the conditions or modify the test sequence according to "Safety System Administration for Abnormal Response," Section 3.1.6.
3. Depress selected test-initiate push button and hold only long enough to observe appropriate responses (i.e., loss of magnet current).
4. Observe and evaluate response of safety channel:
 - a. indicating instruments and recorders;
 - b. scram trip indications at intended level of perturbed variable: appropriate trip comparitor "trip" and "latch" lamps light, and "normal" lamps extinguish; output current of four magnet amplifiers of affected channel decreases to near zero; annunciation of condition that initiated channel scram request; one of the three "shim regulating cylinder inhibit" lamps on the console extinguishes; and
 - c. flux reset action, where appropriate.

5. Release test-initiate push button and observe that affected readouts restore to normal values, in agreement with the two channels not under test. "Trip" lamps extinguish and "normal" lamps light; magnet amplifier outputs restore to normal.
6. Reset system
 - a. Depress scram-request comparator "reset" push button and observe that "latch" lamps extinguish.
 - b. Reset annunciators.
 - c. Depress "reset" push button on console, associated with the extinguished "withdraw inhibit" lamp, and observe lamp turn on.

Additional Details Concerning Specific Tests

1. The "chamber add" test effectively increases the plate area of the safety ionization chamber by 50% as an indirect means of ascertaining that the chamber is supplying the flux amplifier with a valid signal. Proper chamber performance is indicated primarily by the magnitude of the initial increase in the readout values of reset flux and reset flux/flow ratio, which should be approximately in the same proportion as the increase in chamber plate area; i.e., approximately 50%. However, the extent of the readout increase can be determined satisfactorily only when the instruments are registering a "sensible" level, perhaps above N_L . In Mode 1, the test readings must be taken promptly following the chamber addition, before the flux reset mechanism can operate to restore agreement between reset flux and heat power. All three "chamber add" test-initiate push buttons for each channel perform identical functions.

Other responses to the sudden increase in flux signal depend on the pretest reactor power level and the operating mode:

- a. Rate trip. When the reactor power level is greater than 10% of the rated level for Mode 1, rate-of-power increase trip action will produce a momentary scram request by the channel under test. Below approximately 10% of the rated power level for Mode 1, the rate trip electrical network will "soak up" the sudden signal increase without response.
 - b. Level trip. Level trip action will produce channel scram request whenever the immediate increase in flux signal, due to the chamber addition, drives the reset flux/flow ratio signal above the threshold value of 1.3. In Modes 2 and 3 there is no actual flow signal or reset action, but level trip still occurs when the "flux/flow ratio" readout exceeds 1.3.
 - c. Flux reset action. The flux reset mechanism operates in Mode 1 only, in the direction to bring the reset flux signal into agreement with heat power. Normally, the test condition is not to be held long enough to produce appreciable reset action.
2. The "current ramp" tests each add an artificial signal to the safety ionization chamber output, to simulate a steady increase of neutron flux at the rate of 5% of N_F per second. These ramp signals are initiated by Mode 1, Mode 2, or Mode 3 test-initiate push buttons, and are scaled to the N_F levels of the respective modes. Together with evidence from the "chamber add" test that the ionization chamber is functioning properly, correct responses to the ramp signal demonstrate that a safety

channel can recognize a reactor neutron flux excursion and can initiate scram request at the intended level. Consequently, the most significant responses are: (a) steady increase in the readout values of reset flux and reset flux/flow ratio; and (b) channel scram request by level trip action when reset flux/flow ratio readout value reaches 1.3. In Modes 2 and 3, both of the foregoing readouts are actually indications of uncorrected neutron flux signal only but do not have the same scale factors. Note also that the level trip scram response is not obscured here by any rate trip action. Reset action, in the direction to bring agreement between reset flux and heat-power outputs, should begin immediately after the "current ramp" test is begun in Mode 1.

3. The "rate" tests are identical with the "current ramp" tests except that the ramp signals are steeper, corresponding typically to a neutron flux increase of about 30 MW per second in Mode 1. Of primary concern is the ability of the channel to develop a scram request by rate trip action, when the reactor power increase rate becomes excessive. Under ideal test conditions of low reactor power (and full flow, in Mode 1), level trip action will not occur until about 6 seconds after the rate trip. At full power, the delay is reduced to about 1 second, requiring very close attention to ascertain that the rate trip comparator actually produces the scram request. When the rate trip cannot be clearly distinguished from the level trip, the "trip" test switch on the rate trip comparator may be used to determine that the comparator is able to produce channel scram request.
4. The "low-low-flow" test, provided for Modes 1 and 2 only, causes the flow-measuring differential pressure cell of the

associated safety channel to be bypassed. In Modes 1 and 2 the results verify the low-low-flow trip.

5. The "heat power" test provided for Modes 1 and 2, consists of injecting hot water into the primary coolant loop, directly adjacent to a safety channel core outlet temperature sensor. The channel responses of most interest are (a) heat power calculator output signal increases proportionally with the temperature difference between core inlet and outlet temperatures, and (b) the heat power trip element produces channel scram request at the correct level. The heat power trip is calibrated for 120 MW in Mode 1 and 12 MW in Mode 2. For the usual conditions of 100% flow in Mode 1 and 10% flow in Mode 2, the differential temperature for heat power trip is about 55°F. required differential temperature increases in direct proportion to any reduction in flow. At substantially reduced flow in Mode 1, the injection water temperature may not be high enough to produce heat power trip.

The channel readout indications of heat power calculator output appear on the heat power recorder and panel indicating instrument. The amount of the heat power signal increase must be verified from readings of the inlet and outlet temperature recorders.

The flux reset system will operate in Mode 1 in response to the heat power test, but the effect should be insignificant over the short test interval.

Localized flow differences may cause the ultimate values of heat power core outlet to vary somewhat among the three safety channels during the tests. This is of no concern, provided the readings agree among the channels when no test is in effect.

6. The "inlet temperature" test, provided for Modes 1 and 2, consists of injecting hot water into the primary coolant loop directly adjacent to a safety channel core inlet temperature sensor. The channel responses of most interest are: (a) heat power calculator output signal decreases proportionately with the temperature difference between core inlet and out temperatures; and (b) the inlet temperature trip element produces channel scram request at about 130°F. The channel readout indications of heat power calculator output appear on the heat power recorder and panel indicating instrument. The amount of the heat power signal decrease must be verified from readings of the inlet and outlet temperature recorders. In Mode 1, the flux reset system will operate during the inlet temperature test, in the direction to decrease the reset flux and reset flux/flow signals. This will impair the response of the affected safety channel to flux excursions, both during the test and for the reset restoration period thereafter. Safety considerations indicate that each test should be completed promptly and reset flux should be restored to its "unperturbed" level before a corresponding test is initiated in another channel.
7. The "pressure" test, provided for Mode 1 only, reduces the pressure at the safety channel pressure switch. The only response in this test is immediate channel scram request, originated by the "low pressure" trip comparator.
8. The "failed fuel element detector" test, for all three modes, removes lead shielding from between the reactor core outlet

pipng and the ionization chamber that senses gamma radiation in the outlet cooling water. This increases the amount of "normal" radiation reaching the chamber of the affected channel by a factor of about 1.4. The panel meter indicating coolant radiation level should register the 40% increase and channel scram request should result. The motion of the shield is fairly slow, so the signal increase response is also slow.

9. The "flux/flow" test, provided in Mode 1 only, reduces the pressure drop across the main flow dp cell and produces a channel scram request on the flux/flow trip element. Channel responses include immediate decreases in heat power and flow indications and an increase in flux/flow indication. The 1.1 flux/flow element, which gives a fast reverse, is also tripped.
10. Auxiliary circuitry of each safety channel will respond to the "chamber add," "current ramp," "rate," and "heat power" tests, resulting in channel reverse requests and permissive appropriate to the reset flux or heat power limits for the modes. The reverse requests are not "accountable" safety actions and are not required for continued reactor operation. The requests are identified by annunciations and lights on auxiliary control trip comparators.
11. Additional auxiliary functions of the safety system which are neither accountable safety actions nor subject to routine tests by Operations personnel, are the block valve closures associated with FFED scram and run permissives associated with heat power.

Safety plate time of-flight tests. Time-of-flight tests traditionally determine the ability of the clutch devices to release the shim-safety plates from their drives and of the plates to insert promptly. Built-in equipment permits such tests to be performed as a routine operating procedure on the HFIR. The use of the test equipment in the auxiliary control room and the computer is as follows:

1. Computer Time-of-Flight Measurement

a. Execute Task SHUTDN.

On the control room DECwriter, type the following:

>RUN SHUTDN

The computer will type out:

(date) (time)

>IS THE FUEL CYCLE OVER? (Y OR N)

Answer Y for yes, N for no.

The computer will type out:

MW-DAYS DURING THIS CYCLE = _____

b. Set rod drop permissives.

(1) Turn on the power to the rod release timer chassis.
The power light should brighten.

(2) Make sure that switch S1 on the rod release transfer chassis is in the "computer" position.

(3) Place the three isolation switches (located in drawers S-4 on the nuclear safety panels) in the "test" position. CAUTION: If these switches are placed in "test" before the rod release timer chassis is energized, the reactor will be scrammed.

c. Execute Task FLTIME.

- (1) When the withdraw limit is reached, type the following on the control room DECwriter:

>RUN FLTIME

The computer will type out the following:

TASK FLTIME	ROD	TIMER	READY	(date)	(time)
	#1	#2	#3	#4	
RELEASE TIME	_____	_____	_____	_____	
RESPONSE TIME	_____	_____	_____	_____	
FLIGHT TIME	_____	_____	_____	_____	

- (2) Upon completion of the tests, return the three isolation switches in drawers S-4 to the "normal" position.

- (3) Turn off the power to the rod release timer chassis.

2. Backup Procedure for Safety Plate Time-of-Flight Tests

The digital timers should be used only if the computer is unavailable for time measurements. The following steps should be taken to verify the operation of the digital timers and to obtain rod time data. Steps with the asterisk (*) are performed in the control room; the remainder are performed in the auxiliary control room.

a. Preparation.

- (1) Turn on the power to the rod release time chassis and the four digital timers. The five power lights should brighten. Allow approximately 15 minutes warmup time.
- (2) Place switch S1 on the rod release transfer chassis in the "timers" position. This will transfer clutch, seat, and response switch information from

the computers to the digital timers.

- (3) Place the "function-selector" switch in the "test" position.
- (4) Reset the four digital timers to zero display by depressing the four "reset" push buttons.
- (5) Depress the "scram" button on the rod release timer chassis. The timers should start.
- (6) Immediately after the preceding step, depress the "stop all timers" button. The four timers should stop. The indicated times should agree.

b. Procedure.

- (1) When the withdraw limit is reached, place the "function-selector" switch in the "time-of-flight" position.
- *(2) Place the three isolation switches (located in drawers S-4 on the safety panels) in the "test" position. (CAUTION: If these switches are placed in "test" before the rod release timer chassis is energized, the reactor will be scrambled.)
- (3) Clear the timers by depressing the four "reset" buttons.
- (4) Depress the "scram" button on the rod release timer chassis. The four rods will be scrambled at this time, and flight times will be displayed by the digital timers.

- (5) Record the times indicated by the digital readouts.
- (6) To obtain magnet release times, place the "function-selector" switch in the "clutch" position.
- *(7) Raise the four rods 6 in. Repeat steps 3, 4, and 5 except that clutch times will be displayed.
- (8) To obtain the push-rod-response times, place the "function-selector" switch in the "response" position.
- *(9) Raise the four rods 6 in. Repeat steps 3, 4, and 5 except that response times will be displayed.
- *(10) Upon completion of these tests, return the three isolation switches in drawers S-4 to the "normal" position.
- (11) Turn off the power to the rod release timer chassis and to the four digital timers.
- (12) Return switch S1 to the "computer" position.

3. Observe timer readings. Acceptable response times are

	2 of 3	3 of 3
	<u>Channels</u>	<u>Channels</u>
a. Push rod (Response, ms)	34	34
b. Plate declutched (Release, ms)	18	12
c. Plate seated (Time-of-Flight, ms)	450	450
when released from withdraw limit.		

4. Make the following observations of control responses incidental to the test scam:
 - a. Fast rundown air motors operate to insert the shim drives from withdraw limit to insert limit in about 30 s.
 - b. Seat light appears immediately after scam initiation.
 - c. For each plate that is actually dropped in the test, current to all three magnet coils remains off between the time the plate is seated and the time the drive reaches insert limit.
 - d. During the same interval as in (c) above, the clutch light is illuminated for each plate actually dropped.

Magnet drop current measurement. Magnet drop current is normally measured at the end of each cycle after the safety plate time-of-flight measurements are made. It should be done at shutdown, rather than at startup, so that if any abnormalities are discovered, they can be corrected at that time. Magnet drop current should normally range between 3.1 amperes and 3.4 amperes. At no time should they exceed 3.6 amperes or be less than 2.9 amperes.

1. Withdraw all four safety plates out 10 in.
2. Lower all magnet current amplifiers output in two channels to 1.0 amperes each.
3. Slowly decrease the magnet current amplifier outputs, one at a time, in the third channel until each rod just drops. When the air motor drives the rod down to re clutch, current will again be turned on. The drop current for each magnet will then be the total of all three amplifier outputs - one in each channel.

3.1.4 Startup preparations

The preliminary requirements in preparation for starting the reactor are (1) all equipment necessary to the intended mode of operation assembled, (2) all scheduled maintenance, testing, and calibration completed, and (3) any known significant malfunctions corrected. Where an appreciable time has elapsed since the previous run, or where vital components have been worked upon, it is further necessary to verify that (1) certain equipment is turned on and operating properly, and (2) that the control and safety systems have not been disabled during the shutdown by such factors as connector failures (e.g., during exchange of modules), neglect in removing test gear, random component failure, etc. The basic check procedures pertaining to the reactor control and safety systems are summarized below and on the "startup check list" (see Example 11.8.).

General

1. Electric and pneumatic supplies.
 - a. Check that battery chargers are turned on and battery voltages normal.
 - b. Observe that indicating lamps are "on" at each control and safety system panel, signifying that power is reaching the cabinets.
 - c. Clear annunciator and note that ac control bus power and instrument air pressure are normal.
2. Count-rate channels.
 - a. Observe that selector switches on pulse amplifier panels are set to the amplification and pulse height factors established by maintenance calibrations (per I&C Maintenance and Test Procedures).

- b. Observe that log count-rate meter indicates greater than 10 cps, but not more than 10,000 cps if chamber control switch is in "automatic" (pushed in), or not more than 50,000 cps if chamber control switch is in "manual" (pulled out). "Automatic" chamber control is required for Mode 1 operation.

Safety System Tests Required for Mode 1 Operation. The following tests apply to all "normal" startups; i.e., following refueling. The test requirement is waived for recovery from scram, or for restart following a short duration shutdown in which the safety instrumentation remained in service.

- 1. Prepare system for tests:
 - a. three primary loop circulating pumps operating and pony motors energized;
 - b. pressurizer pump running and system pressure at 750 psi;
 - c. key switch in "operate;"
 - d. raise-test switch in "normal;"
 - e. mode selector switch in "Mode 1;"
 - f. all plate drives inserted to limits;
 - g. reset slow scram and observe normal (1.85 amps) output from each of the 12 magnet amplifiers;
 - h. reset annunciators and observe that no channel scram request alarms persist;
 - i. reset shim-regulating cylinder inhibit circuits, and observe that all lamps glow;
 - j. reset all scram-request trip comparators; and
 - k. note that all flux reset mechanisms have proceeded to maximum reset gain and corresponding lamps are illuminated.

2. Start primary loop main (ac) circulating pump motors and establish full flow condition.
3. Perform the following safety tests:
 - a. Obtain "start" condition and withdraw all shim-safety plates at least 6 in. from their seats. Scram the plates using the following combinations:
 - (1) Rate test channels 1 and 2.
 - (2) Rate test channels 2 and 3.
 - (3) Rate test channels 1 and 3.
4. Perform remaining tests by channels:
 - a. "Inlet temperature" - No heat power or flux reset response is expected at zero power at the reactor.
 - b. Mode 1 "current ramp" - Flux reset mechanism is expected to proceed toward minimum gain.
 - c. "Pressure"
 - d. "Low-low-flow"
 - e. "Heat power"
5. Perform time-of-flight tests as previously outlined.
6. Test shim-regulating cylinder withdraw inhibit by holding two safety channels in scram request condition (e.g., by holding rate test, inlet temperature test, etc., push buttons) and at the same time attempting to withdraw No. 5 plate by manual control. Withdraw should remain blocked until the scram requests are terminated, and the shim-regulating cylinder withdraw inhibit relays are reset via "reset" push buttons on console.

Safety system tests required for Mode 2 operation. The following tests apply to a single Mode 2 run. Where a sequence of Mode 2 runs is intended, without disturbance to the safety system, performance of

all tests is required only for the initial run. For subsequent runs "current ramp" test is necessary.

1. Prepare system for tests - Same as Mode 1 operation, except primary system is not pressurized, mode selector switch in "Mode 2", and the rate trip is disabled.
2. Perform the following tests:
 - a. Mode 2 "current ramp"
 - b. "Inlet temperature"
 - c. "Low-low-flow"
 - d. "Heat power"
3. Depress "start request" push button and observe appearance of "start" light.
4. Perform time-of-flight tests. However, in a series of Mode 3 runs where the safety system is not disturbed, this test may be eliminated for all but the first run.

3.1.5 Startup

The procedures for starting the reactor are described in Section 2.1 and generally assume that the control and safety system is functioning properly. The material of this section supplements the basic startup procedures and concerns mainly the methods for checking the control and safety system while startup is in progress.

Either prestart tests or recent reactor operation will have checked the process sensors and protective actions of the safety system, but not the response of the ionization chambers to sensible neutron flux. Consequently, the safety chamber performance must be verified during startup by observing the development of flux indications on the readout instruments.

The remaining checks concern the servo and count-rate systems, and the correct translation of their responses into control actions. It is desirable, but not mandatory, that all channels of these systems perform properly. The prerogative, subject to HFIR Technical Specifications limitations, to continue operation and raise power before or during repairs to the control system, servo and count-rate systems is left to Operations supervision.

Mode 1 startup to 10 MW. During the automatic progression to 10 MW, safety considerations require that the operator monitor the plate positions and the safety system power level charts as follows:

1. All plate clutch lights remain extinguished; when any light, the group withdrawal must be blocked by pulling out the handle of the shim plate actuate switch.
2. All plate seat lights should extinguish on initial plate motion; if any remain lit, block group withdrawal.
3. All plates should withdraw continually at approximately the same rate. Any gross difference among plate positions is an indication of drive or control difficulties, which should be eliminated promptly. No attempt should be made at this time to trim plate positions relative to each other.
4. The development of sensible reset flux and heat power indications on the readout instruments is very important. These indications should first appear at about the same time on 15 recorders (i.e., servo and safety reset flux and heat power, and safety reset flux/flow ratio). The indications for each type of signal should increase at approximately the same rate. The reset flux readings will generally be higher than the heat power during the power increase due to the initial maximum reset gain and the slow reset action.

In addition to the above required responses, the following behavior is expected of the control, servo, and count-rate systems:

1. Counting rate increases from source or residual level, with reasonable agreement among the log count-rate meters of the three count channels. Each fission chamber should withdraw when the count rate of its channel exceeds approximately 10,000 cps. "Noise" should not be excessive on any period recorder. Period shorter than 30 s in a channel will inhibit plate withdrawal, and period shorter than 5 s in two channels will initiate reverse. If 5-s or shorter periods persist or recur on two channels, without annunciation or automatic reverse, the operator may elect either to scram the reactor or to block further plate withdrawal. If a 5-s period reverse recurs, operator should block further plate withdrawal and investigate.
2. The servo (and safety) reset flux and reset flux/flow ratio indications will reach their respective equivalents of 10 MW (i.e., 10% and 0.1) a minute or so before the heat power indication. When the reset flux reaches 10%, the 10-MW demand is initially satisfied, even though the actual core power may be much less. Meanwhile, the flux reset mechanism is operating to reduce the reset flux signal to the level of the heat power signal. In terms of servo response, the regulating drive is expected to insert the regulating cylinder in two "steps," (1) when the reset flux initially reaches 10%, and (2) when reset action is completed. The first step slows the power rate-of-rise to a rate corresponding to the reset gain change. The second step halts the rise.

On completion of the automatic startup, the reactor should be permitted to operate at a steady 10 MW for a few minutes in order to permit the instruments to reach equilibrium. All of the safety, servo, and count-rate systems are checked during this interval, subject to the following considerations:

1. All safety and servo system reset flux and heat power recorders read within the range of 9 to 11% (of N_F), and appear to have approached their final levels at about the same rate.
2. All reset flux/flow ratio recorders in the safety and servo systems read within the range of 0.09 to 0.11.
3. All safety system flow recorders read approximately 17,000 gpm, unless one or more pumps have been deliberately shut off.
4. Reasonably good agreement exists among the inlet, outlet, and differential temperature recorders, respectively, and the readings are consistent among the groups of instruments (i.e., outlet temperature minus inlet temperature equals differential temperature).
5. Reasonably good agreement obtains among the safety and servo reset gain values at equilibrium.
6. Log count-rate indicating instruments all indicate about 10,000 cps, and chambers partly withdrawn.
7. Count-rate reactor power recorders read about 10%.
8. Count-rate period recorders read about infinity.
9. No trouble indications; e.g., annunciations, scram requests, abnormal signal fluctuations, power cycling, more than one-inch difference between extreme shim plate positions, etc.

Note that the regulating drive servo motors are not expected to stop, but will probably be operating in opposition to each other. The regulating drive itself may be oscillating slightly about an intermediate position.

Mode 1 startup; power increase beyond 10 MW. With the above described conditions satisfied, the control system will enter "run" condition when the "run" push button is depressed. After the "run" light appears and prior to raising demand, the position of all five shim plate drives should be trimmed to close agreement.

Reactor power may then be increased to any desired level within 100 MW, using the "group raise demand" switch. The three servo demand settings should track reasonably well on the master control, and minor differences may be trimmed by the individual controls.

The normal rate of rise in reactor power follows the demand increase very closely and is, therefore, limited to 1 1/2 MW per second, corresponding to the speed of the servo demand pot drives. It is possible to effect a power increase from 10 to 100 MW through regulating action only, with the regulating drive withdrawn almost a constant amount during the entire increase. However, automatic shim withdrawal may occur at any time during the power increase, provided permission is given, causing a corresponding insertion of the regulating drive.

During power increases in "run," the operator must continue to monitor the safety system heat power and reset flux recorders. These should track reasonably well during transient conditions, and should come to agreement within a 7.5-MW band after a few minutes of operation at steady power. If there appears to be any serious discrepancy among the power recorders while power is being raised, the increase should

be interrupted to allow reset action to "catch;" if diversity greater than 7.5 MW persists the condition should be investigated.

During the power increases, the operator should also observe that no one servo motor operates persistently at a speed and direction much different from the others. The fission chambers are expected to withdraw, maintaining the three count rates at about 10,000 cps. The counting channel pile power recorders are not required to agree with the servo and safety power recorders to within any arbitrary limits, but after some experience is gained in calibrating the chamber position compensating networks, fairly good agreement is expected.

Upon attaining a reactor power level desired for steady operation, the servo system should be checked as follows:

1. In succession, the demand setting of each channel is adjusted above and then below the power level. After each adjustment observe on the velocity meters that the servo motor of the adjusted channel attempts to position the regulating drive in the proper direction (i.e., to withdraw when demand is above reactor power, and vice-versa). Observe, also, that the servo motors in the other two channels oppose the motor of the adjusted channel (but not necessarily at the same speed).
2. Trim the individual demand pot settings to minimize the servo motor operation.
3. Observe that the "percent power" readings on the reset flux and heat power recorders of the safety system, and on the reset flux recorders of the servo system (a) agree within a 7.5-MW band, (b) have reached their readings at about the same rate, and (c) are not fluctuating excessively.

4. Observe that the regulating rod position reading on the appropriate recorder chart is not fluctuating rapidly or excessively.

Upon reaching 100 MW, those safety tests which are not effective when the reactor is shutdown should be completed. They are:

1. "FFED,"
2. "chamber add," and
3. "flux/flow."

Mode 2 and 3 startup. During plate withdrawal, the operator is required to monitor the plate positions and the safety system power level charts in essentially the same manner as for Mode 1 start. The following exceptions are noted:

1. Plate withdrawal is not automatic and will cease whenever the shim actuate switch handle is released.
2. Most plate withdrawal will be on a group basis, but position trimming is permitted at any level. Consequently, the operator will have to observe the responses carefully in order to detect malfunctioning drives.
3. The heat power recorders will register very little or no power.
4. The reset flux recorders will register "percent power," referred now to the respective mode limits. Since there is no heat power compensation, the "reset flux" signals are simply direct indications of the chamber outputs, and only approximate agreement is expected among the three reset flux recorders of the safety system.

The count-rate channels provide information and automatic control actions as in Mode 1 start. The fission chambers

may be exposed to neutron flux greater than that corresponding to 50,000 cps on the panel (uncorrected) log count-rate meter. The servo system simply holds the shim-regulating cylinder in its fully withdrawn position. The servo system reset flux signal is not subject to range change, as it is for the safety channels, so servo reset flux recorder readings will read essentially zero throughout Modes 2 and 3 operation.

3.1.6 Extended operation

The practices described thus far generally establish that the control and safety system is in good order at the beginning of an extended run. It is further necessary to ensure through monitoring and testing that the system continues to function properly.

Annunciation signals indications of control and safety system malfunction. A number of annunciator alarm points are provided to signal that certain nuclear and process variables are out of range, and others are specifically to monitor portions of the control and safety system. However, the nuclear and process annunciators also monitor control and safety system integrity to some extent. Routine confirmation of the alarmed condition will usually disclose the origin of any alarm. Where the variables are displayed, as for reset flux and heat power, such confirmation is obtained by comparison of readings within the affected channel and with corresponding readings in other channels. Condition lights on the initiating trip comparator panel, or associated with the chamber voltage supply, are particularly useful in identifying intermittent or momentary malfunctions, since many of these lights seal in tripped condition.

The appearance of annunciator alarms for the same condition in two or three channels, without consequent control action, signifies control malfunction. In such cases, the operator should exercise appropriate corrective action.

Routine surveillance of indicating and recording instruments as a means of detecting malfunctions. Periodic readings of the indicating and recording instruments are logged routinely, as described in Section 11. Systematic inspection and comparisons of these readings, as well as continual surveillance of the displayed information, may disclose control and safety system difficulties in their early stages. Some salient points in this regard are as follows:

1. One of the most troublesome problems is that of disagreement among different measurements of the same or related quantities. In assessing such disagreement, judgment must be exercised with the main objectives firmly in mind: (1) there must be absolute confidence that the reactor is safely under control, but there is no safety requirement that the actual power level be closer than perhaps within 10% of indicated level; (2) that the discrepancies are not such that the safety system is seriously impaired. Where reactor safety and controllability are not seriously affected, sizable discrepancies may be tolerated without immediate instrument maintenance attention or reactor power reduction. Any attempt to improve calibration during a run will involve temporary outages of one or more safety, servo, or count-rate channels.
2. In Mode 1, at power levels exceeding 10 MW, and after allowing the reset servos to stabilize, there should be agreement

within a 7.5-MW band among the three safety reset flux recorders, the three servo reset flux recorders, and the three safety heat power recorders. When one reset flux recorder alone reads high and the associated reset gain is at its "minimum" limit, chamber trouble would be suspected. When associated reset flux and heat power together read high or low in one channel, the trouble would appear to be in the process system.

3. In Modes 2 and 3, the heat power and servo reset flux recorders are not read. The safety reset flux recorders display readings in terms of percent of power allowed in the Mode (i.e., percent of 2.5 MW in Mode 2, and percent of 100 kW in Mode 3). However, these "reset flux" signals are not actually subject to heat power reset action, as in Mode 1, and may disagree by varying amounts depending on prior reactor operating history. Disagreements of +10% from average should be investigated; if there is question concerning advisability of reactor shutdown, this may be resolved through information from the count-rate channels (reactor power and period recorders, and log CRMs).
4. The signals driving the count-rate system reactor power recorders are affected by calibration of the fission chamber position compensating networks, and by local variations with time and core history in relative neutron flux seen by the chambers. Hence the pile power recorders are not expected to track closely the other power instruments.
5. Substantial differences among reset gain servo positions, where there is agreement among heat power and reset flux

- indications, suggest chamber or flux amplifier troubles.
6. Excessive regulating cylinder oscillation, or continued high speed operation of one servo motor in opposition to the other two should be investigated.
 7. Any unusual oscillation of "spiking" on any of the power or period recorder charts should be investigated.
 8. All CRMs should read at approximately chamber drive servo setpoint value, 10,000 cps, when the chambers are on automatic position control. When in "manual," they should not be exposed to neutron flux greater than that corresponding to 50,000 cps on the panel (uncorrected) log count-rate meter.

On-line tests of safety system. The standard tests of the safety system will be performed by the operator (1) whenever surveillance of the system discloses some significant malfunction or discrepancy and (2) routinely, at regular intervals consistent with the performance objectives HFIR Technical Specifications, and the equipment service experience. The individual tests and responses are as described earlier.

Particular caution is required during the tests to prevent accidental scram of the reactor at high power levels. Accordingly, in Mode 1 it must be ascertained that, when one channel is to be placed in scram request condition, the other two channels remain "normal." This requires of the two undisturbed channels that: (1) all magnet amplifiers have correct output current, (2) all trip comparators are in "normal" condition, and (3) reset gain of the flux amplifiers is about normal, so that reset flux/flow ratios in both channels are well below the trip value of 1.3. Ordering the tests by channels, as recommended

earlier, reduces the risk of accidental scram. The test sequence is interrupted and/or modified, as described further on, when a system malfunction is detected.

For the sake of completeness, the initial descriptions of the individual tests of the safety system mentioned action of the flux reset mechanism as a conditional Mode 1 response in six out of the eight tests. The reset function is, in effect, continually "tested" during Mode 1 operation, agreement between reset flux and heat power being adequate evidence that the mechanism is performing correctly. Therefore, during the tests, it is necessary only to note that there is some reset response, and that agreement is restored at the end of the test sequence for each channel.

The Mode 1 "chamber-add" test is the only one for which the scram trip response may be significantly affected by the initial value of reset gain. For example, at 100 MW of reactor power a reset gain value of 20% or more below the correct value would preclude flux/flow ratio trip. On the other hand, a preliminary runup of the reset gain could be used as a means of affecting trip in response to "chamber add" at a reduced reactor power level. The foregoing "chamber-add" test considerations are the only ones that need influence on the sequence of the following tests:

1. "chamber add" - all modes,
2. "current ramp" - all modes,
3. "rate" - Mode 1 only,
4. "inlet temperature" - Modes 1 and 2 only,
5. "heat power" - Modes 1 and 2 only,
6. "low-low-flow" - Modes 1 and 2 only,

7. "pressure" - Mode 1 only,
8. "failed fuel element detector" - Modes 1 and 2 only, and
9. "flux/flow ratio" - Mode 1 only.

Safety system administration for abnormal responses. When readouts of critical quantities, annunciators, or the formal tests disclose a malfunction of the safety system, including the installed test apparatus, the necessary level of protection must be restored either by correcting the trouble or by locking one channel into tripped or "scram" condition. The general method for restoring full protection is described below. It will be noted that operation on the basis of "two channels-out-of-two" or "one-out-of-one" to obtain reactor scram may be required for short periods during test. Such operation is prohibited for periods exceeding the few minutes required to exchange one or two suspected faulty modules. These requirements do not apply to "reverse" control actions initiated by the safety system auxiliary relaying but do apply to "inhibit shim-regulating cylinder withdrawal," which is a safety action.

The module exchanges called for below will be executed only by qualified I&C personnel and in rare instances by reactor operators trained to perform this function.

1. When trouble first observed is a momentary scram indication on one channel (i.e., annunciation and "trip-latch" light but magnet current restored to normal), confirm by checking appropriate readouts. If readouts are normal but charts "spiked," test channel to ascertain that the portion of the channel which caused trip action is still operable. Refer incident promptly to I&C maintenance.

2. When trouble first observed is a persistent scram indication of one channel or failure of channel to scram on tests, check appropriate readouts. If readouts are normal, exchange affected trip comparator or other suspected module with spare from the storage rack. Confirm apparent correction by conventional trip test of affected portion of channel.
3. Should the initial corrective measures in (2) above be inadequate to secure the affected channel against false trip (i.e., scram request) condition, it is permitted to forego testing of the other two channels for a period equal to the maximum allowable interval between tests (one week). This period shall be calculated from time to time on the basis of the safety system reliability record. The affected channel must be locked in scram request condition by means of the "trip-lock" control until the trouble is corrected, except for short intervals (not exceeding 30 minutes) as may be required for maintenance checks associated with service restoration.
4. In the event the failed channel cannot be repaired within the time allowed by (3) above, it is required either to test the other two channels following each "maximum allowable interval" or to shut down the reactor. The tests can be performed only if the channel can be secured against false trip by substituting special "no-trip" comparator modules.
5. In the event the failure in (2) above does not produce or threaten false trip of the affected channel, testing of the other two channels shall be carried out according to the

normal schedule. The failed channel must be locked in scram request condition at all times except (1) during tests of the other two channels, and (2) short intervals as may be required for maintenance checks associated with service restoration.

6. Under the operating conditions of (3) or (5) above, a false trip of a channel other than the one locked in trip will automatically scram the reactor.
7. It is possible for a safety channel to function correctly in all respects except its ability to participate in "shim-regulating plate withdraw inhibit" (e.g., by failure of a relay to drop out, etc.). This condition is evidenced by the channel "shim-regulating plate with draw inhibit" pilot light on the console remaining lit when the channel is tripped, or by the three shim drive ammeters on the console showing normal current division among themselves during plate withdrawal when one channel is tripped. As long as such a condition exists, it is necessary to leave the handle of the "plate actuate" switch in pulled-out position to block shim withdrawals. The restriction may be removed for short intervals as required for reactor shimming.

Control system - on - line tests and abnormal performance of count-rate system. Malfunction of a count-rate channel may result in (1) abnormal indication of reactor power or period, (2) spurious period reverse requests, (3) improper insertion or withdrawal of fission chamber, or (4) excessive oscillation of fission chamber. Automatic insertion of the chamber during operation at any appreciable power may result in radiation damage to the chamber; if such insertion occurs, it may be detected by an increase in the count-rate reading far above the normal 10,000 cps. Under these conditions, the chamber

should be withdrawn by use of the chamber position control, and secured against automatic reinsertion by leaving the control handle in "manual" (pulled-out) position. Although case (2), spurious reverse period, has no control effect in Mode 1, it is advisable to repair the condition. Repairs to one count-rate channel may be effected at any time when the reactor is in service; all count-rate channels may be disabled simultaneously in Mode 1-run until shimming is required.

Control system-switches, relays, circuitry. Abnormal control responses due to faulty relays, switches, etc., may generally be traced by qualified maintenance personnel during reactor operation. It is permissible to de-energize the ac control bus for short periods during reactor operation, as required for troubleshooting repairs.

3.1.7 Termination of run

Information concerning reactor temperature effects on the ability of the shim plates to scram can be obtained only by actual scram from power. Accordingly, extended runs are terminated by means of the "time-of-flight initiate test" control, which scrams the reactor.

It is desirable to perform all safety system tests immediately before or after run termination, in order that any malfunctions may be corrected during shutdown.

3.2. Process Instrumentation

3.2.1 Introduction

The process instrumentation monitors and regulates the reactor heat, ventilation, and waste discharge systems. Portions of this instrumentation which directly influence control of the reactor are discussed in Section 3.1 covering "Reactor Control and Safety System." Operation of the remainder is considered below.

As set forth in detail in Volume I, Section 3.3, most of the process instrumentation functions automatically. Surveillance of this equipment to detect gross failures in the major operating requirement, although proper performance is confirmed primarily by means of routine maintenance testing. The remaining operational responsibilities concern (1) adjustment of controller setpoints, (2) exercise of correct procedures in transferring control systems between automatic and manual modes, (3) proper use of various controls on the instruments, and (4) correct understanding and interpretation of the instrument readouts, alarms, and control functions.

Several instrumentation systems are administered by ORNL service organizations, as are the corresponding systems in other ORNL reactors. These systems are:

1. building radiation and contamination monitoring equipment, for which the Applied Health Physics Department is responsible:
 - a. portable radiation detecting devices;
 - b. radiation warning and communication system, including the local constant air monitors and monitrons (except for those at the sampling coolant stations), the system alarm

panel in the control room, the evacuation horns and beacons, and connections to the ORNL central radiation monitoring point; and

2. gaseous and liquid waste disposal monitoring and control equipment, for which the Laboratory Facilities Department is responsible:
 - a. stack radiation monitoring systems 907 and 911, the stack iodine concentration monitoring system 1400, the stack gas sampling filter system, the stack gas flow anemometer, and the duct radiation monitoring system 912, and
 - b. liquid waste discharge monitoring systems 702, 703, 707, and 708, which include radiation and flow measurement and sample collection equipment, and motor operated valves for flow diversion.

Detailed information is presented below concerning the operation of the process controllers, process radiation monitors, and the radiation warning and communication system. In general, the instrument calibrations are a maintenance function and are covered by the I&C Maintenance Procedures.

3.2.2 Process radiation monitors

Fuel cladding failure detection. Systems 200 and 253 monitor fission product activity in a continuous sample stream of water withdrawn from the primary loop. Flow of the sample stream is held constant at about 2000 ml/min by flow control valve FCV-200, with proper adjustment of flow indicator-controller FIC-200 on the pipe tunnel outside wall. The counting information is processed by count-rate meters in the fuel cladding failure detector cabinet in the auxiliary control room.

System 200 is arranged to detect primarily neutrons from fission product iodine decay. It utilizes type Q-2614 pulse amplifier and count-rate meter, the same unit appearing in the wide-range counting channels. The two controls on the Q-2614 front panel will usually be set to values derived from calibration of the BF_3 chamber. The controls are:

1. pulse height selector, and
2. "operate-calibrate-off" selector switch.

In the "operate" sector, this switch determines the attenuation applied to the input pulses, according to factors indicated for the switch positions. The "calibrate" sector contains the "off" position, "period test" which is not used in this application, "10" and "10,000 cps." The latter two positions substitute signals from internal oscillators at the CRM input and are for test purposes. The log count-rate output signal is displayed on recorder RR-200 at the detector cabinet and on one point of RR-1000 in the control room.

System 253 detects beta and gamma activity in fission products. It employs G-M tube detectors, a preamplifier, and a W-2353 linear-log count-rate meter. Details of the count-rate meter operation are presented below, under "coolant activity monitors." Output signals are displayed only by the indicating instrument on the count-rate meter.

When the log count-rate signal output of system 200 exceeds a constant reference signal, the trip comparator RS-200 enters "trip" condition. This actuates annunciator point C-13, "radiation-high." The trip comparator element is the same as those used in the reactor control and safety systems and is connected so that "trip" condition will clear automatically when the radiation signal returns to normal. The comparator has "normal," "trip," and "trip-latch" pilot lights;

"trip-latch" must be cleared by the adjacent "reset" push button. Annunciator contacts for system 253 are an integral part of the count-rate meter; they cause point 4E-22 to alarm for either high linear count-rate or downscale failure of the instrument.

The alarm points for both systems are intended to be about double the background count rates. Setting the alarm point for the system 200 trip comparator is performed by maintenance personnel, using a local potentiometer to vary the reference signal.

Cooling system radiation monitors

1. System 213 - Primary cleanup system effluent
2. System 423 - Reactor pools effluent
3. System 427 - Defective fuel element storage cell effluent
4. System 326 - Secondary water system, primary heat exchangers discharge
5. System 252 - Primary loop deaerator off-gas
6. System 497 - Pools deaerator off-gas

The above-grouped systems are based on the ORNL type Q-2353 electrometer, and are all connected to provide control room readout on multipoint recorder RR-1000. Each electrometer is equipped with a relay contact output which will open either on high radiation or on downscale failure of the electrometer; these contacts are connected to individual annunciator points in the control room.

The electrometers are locally installed and display count-rate information on indicating instruments on their front panels. A selector switch determines what is being read on the indicator, as follows:

1. Linear

Radiation level in mr/h on the linear scale of the indicator.

2. Low Set*

The low level setpoint; when the electrometer output is below the level read on the linear scale, alarm will occur.

3. High Set*

The high level setpoint; when the electrometer output exceeds the level read on the linear scale, alarm will occur.

4. Log

Radiation level in mr/h on the logarithmic scale of the indicator; this switch position is provided to enable readings to be made when the radiation level is beyond the range of the linear scale.

It is important to note that setting the selector switch to the "log" position does not affect remote reading on RR-1000, nor does it affect the actual high radiation and downscale failure alarm levels. The selector is normally left in "linear" position, correct for routine readings. When alarm condition exists, the "alarm" lamp on the electrometer panel is extinguished.

The radiation detectors are G-M tubes, sensitive to beta and gamma. Operational checks on the overall systems may be made by exposing the detectors to conventional test sources.

*Setpoint adjustments are provided for use by maintenance technicians.

Stack and duct monitors

1. System 907 - Stack beta and gamma
2. System 911 - Stack alpha
3. System 1400 - Stack iodine concentration
4. System 9120 - Duct beta and gamma

The above-grouped systems employ ORNL type Q-2351 count-rate meters, located with the associated system control and monitor panels in the auxiliary control room. An annunciator point in the control room is assigned to each system; the cause for any annunciation may be identified as either high radiation or CRM downscale failure, by observing the CRM output on the associated individual miniature recorder on panel G. Further confirmation may be obtained from the indicating meter, high radiation warning lamp, and instrument failure lamp on each CRM panel; these lamps glow in their respective alarm conditions.

Whenever any high radiation alarm or equipment malfunction is observed for the stack or duct systems, the Laboratory Facilities Department must be notified immediately. In the case of high radiation alarm on the stack systems, prompt attention should also be given to the duct monitor and to the other HFIR building radiation detection systems, in an effort to determine the origin of the stack radiation.

Liquid waste monitors

1. System 702 - Secondary cooling system (tower) blowdown
2. System 703 - Process waste disposal effluent

The above-grouped systems employ ORNL type Q-2350 count-rate meters, installed at the sampling locations. A relay in the system 702 CRM causes an annunciator point in the control room to alarm on high radiation or downscale failure; at the same time, valves in the blowdown line are actuated automatically to divert the flow to a holding pond.

System 703 operates in the same manner, diverting PWD flow to retention pond No. 2. In addition, system 703 has a second annunciator point which alarms on very high radiation so that flow can manually be diverted to ILW. Both systems have control room readouts on recorder RR-1000.

The reactor operator has no responsibility for either of these systems, other than to notify the Laboratory Facilities Department immediately upon observing an alarm in the control room. The Laboratory Facilities Department monitors the systems, withdraws the collected samples periodically, and is responsible for directing the waste effluents. However, the reactor operator is expected to determine the origin of the radioactive waste material, and take all appropriate actions.

3.2.3 Radiation warning and communication system

Radiation, contamination, and instrument failure signals from the local constant air monitors and monitrons are collected and processed at the radiation warning panel in the control room. It is intended that the reactor operator monitor the radiation warning panel, and report promptly to local representatives of the Applied Health Physics Department any abnormal condition that appears. The HP personnel are responsible for determining the extent of any radiation or contamination hazard according to their procedures and for establishing suitable safeguards. They are also responsible for maintaining the systems, and for all operations on and routine surveillance of the local CAMs and monitrons.

In monitoring the radiation warning panel, the reactor operator is concerned with the following features:

1. Indicator modules

Alarm lamps normally glow dimly, becoming bright to signal their respective alarm conditions: white lamp for local instrument failure, yellow lamp for intermediate radiation, and red lamp for high radiation. Reset button on each module dims the alarm lamps; they remain dimmed after release of the push button provided the alarm condition no longer exists.

2. Buzzer modules

Any alarm condition signaled by an indicator module is called to the operator's attention by actuation of annunciator HI-5. The audible alarm is silenced by the annunciator acknowledge pushbutton.

3. Evacuation alarm modules

One evacuation alarm module is actuated by two monitron high radiation signals and the other by two CAM high radiation signals. A red lamp glows brightly on the module which is in "alarm" condition.

4. Evacuation system

- a. Horns

Evacuation alarm module in "alarm" condition turns on the evacuation horns, which continue to sound for 3 or 4 min until their compressed gas reservoirs are exhausted. After sounding, their reservoirs must be replaced and the solenoid trip valves manually reset.

- b. Beacons

Evacuation alarm module in "alarm" condition turns on the flashing beacons. They remain in operation until the "alarm" condition is cleared; i.e., until sufficient

indicator modules have been reset so that neither evacuation alarm module remains in "alarm" condition.

c. Manual control for evacuation alarm

The evacuation alarm push button, located on a separate module of the radiation panel, actuates the evacuation horns and beacons; the beacons stop when the push button is released.

5. System monitor and test features

a. Power supply

Power supply lamp (green) glows bright when power supply is normal.

b. Horn trouble

One red lamp for each horn; normally dim and glows bright when supply pressure to horn is abnormal.

c. Local instrument removal

All three lamps on the associated indicator module glow bright when the local instrument is disconnected. If the instrument is a part of the evacuation system, its removal is equivalent to a high radiation alarm.

d. "Normal-disable" test switch

Key operated switch prevents the evacuation horns and beacons from operating when an evacuation alarm module is in "alarm" condition. However, in the "disable" position, the switch signals an evacuation alarm condition to the emergency control center; the center should therefore be notified before the switch is operated.

3.2.4 Process controllers

Various electric and pneumatic controllers are referred to as

elements of process instrumentation systems in the Descriptive Section of the Operating Manual. The simplest type is the manually-adjustable pressure regulator, which supplies the desired control pressure directly to an output device such as a pneumatic valve operator. An "automatic" controller compares a manually-adjustable setpoint with a measured variable, and signals its output device to operate in a direction to reduce the error. The "cascade" control system resembles the automatic controller but the setpoint is determined by a second measured variable, usually independent of the controlled variable.

Many automatic controllers feature switching arrangements whereby they may be used alternatively as simple pressure regulators. Cascade control systems may offer the options both of automatic mode and simple pressure regulator operation. In some applications, particularly level controllers, the controller function is combined in the same case with measurement and signal transmitter functions. Although similar in principle, the readouts, switching, and manual adjustment details vary greatly among the controllers applied in the HFIR. It is the purpose of the following paragraphs to describe these details, and to indicate correct procedures for operating the controllers. Observance of the switching procedures is particularly important in avoiding unnecessary disturbances to the controller process systems.

Recorder-controller PRC-127

1. Application

Regulates primary coolant loop pressure by gang-controlling four pressure letdown valves, PCV-127-4, -5, -6, and -7; located on panel E of control room.

2. Function

Automatic or manual mode. In automatic mode controller

response to increasing primary loop pressure is to increase its output pressure, which is in the 3- to 15-psig range. Increased output pressure opens the pressure letdown valves.

3. Operation

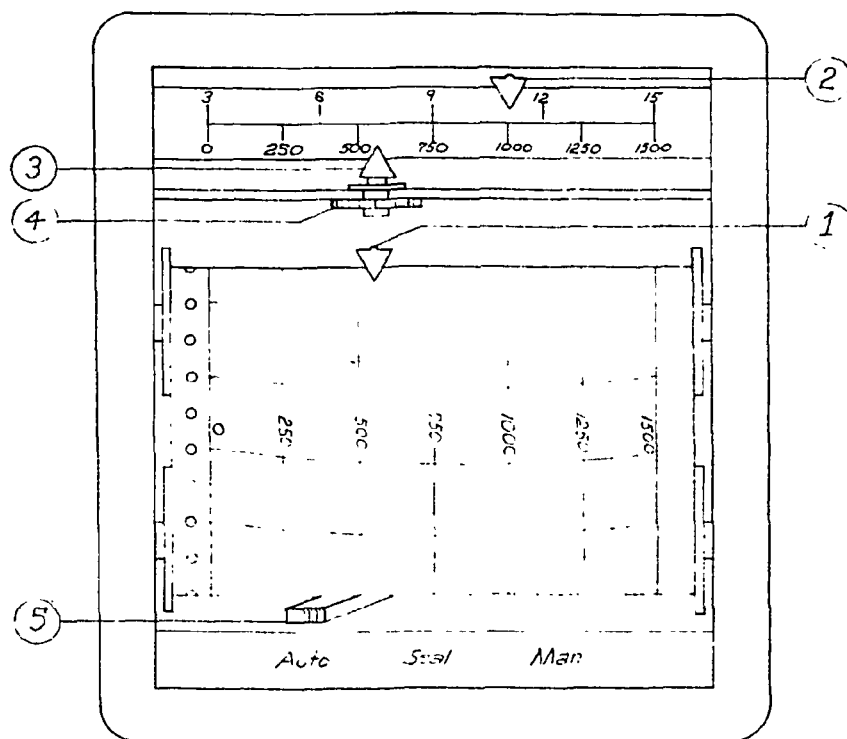
Refer to Fig. 3.1, front panel of controller.

- Item 1. Chart pen; registers process variable at all times; 0-1500 psig scale.
- Item 2. Controller output pointer; registers controller output; 3- to 15-psig scale.
- Item 3. Setting index pointer; registers controller setpoint on 0-1500 psig scale of process variable when controller is in automatic mode; registers pressure regulator setting when controller is in manual mode (setting should agree with controller output pointer, Item 2, in manual mode).
- Item 4. Setpoint regulator; adjusts setpoint when controller is in automatic mode; adjusts controller output pressure (pressure regulator) directly in manual mode; regulator position readouts are via pointer, Item 3.
- Item 5. Transfer switch; selects desired operating mode; intermediate "seal" position used in transferring between modes as described below.

Mode Transfer Procedures

a. Manual to automatic

- (1) Move transfer switch (5) to "seal."
- (2) Move setpoint regulator (4) so that setting index pointer (3) position matches chart pen (1) position.



1. Chart pen
2. Controller output pointer
3. Setting index pointer
4. Set point regulator
5. Transfer switch

Fig. 3.1. Recorder-controller PRC-127.

- (3) Allow about 15 s for pneumatic system to balance.
- (4) Move transfer switch (5) to "auto."
- (5) Adjust setpoint to desired loop pressure.
- b. Automatic to manual
 - (1) Move transfer switch (5) to "seal."
 - (2) Move setpoint regulator (4) so that setting index pointer (3) matches controller output pointer (2).
 - (3) Move transfer switch (5) to "man."
 - (4) Adjust controller output as desired; increasing output pressure opens the letdown valves.

Indicator-controller HIC-248

1. Application

Provides direct manual control of the position of valve HCV 248, which regulates water flow in the line from the pressurizer pumps to the primary coolant loop. Locally mounted on wall outside of heat exchanger cells.

2. Function

Manually-adjustable pressure regulator; 3- to 15-psig output.

3. Operation

Refer to Fig. 3.2., front panel of controller.

Item 1. Output pressure indicator; 0- to 15-psig scale; pressure is applied directly to valve positioner; increasing pressure closes valve.

Item 2. Pressure regulator control; used for manual adjustment of output pressure.

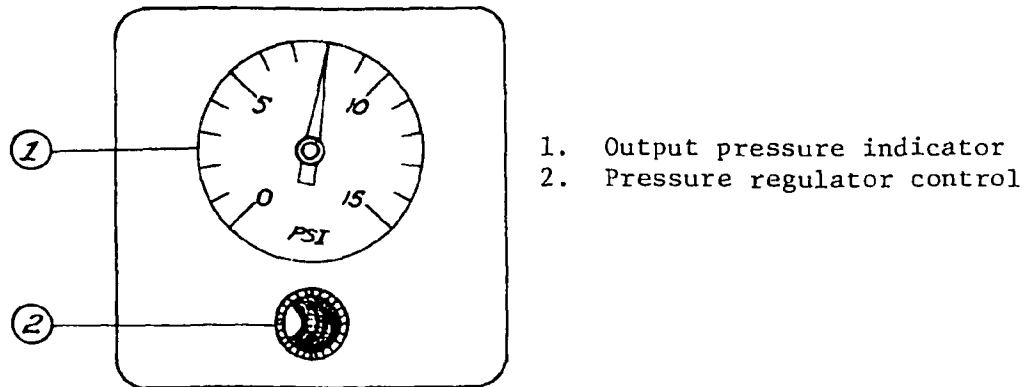


Fig. 3.2. Indicator-controller HIC-248.

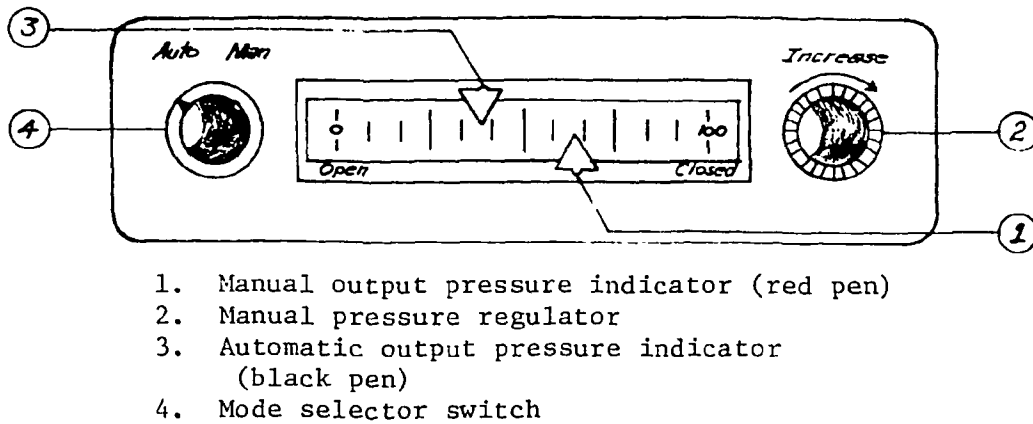


Fig. 3.3. Indicator-controller HIC-377A.

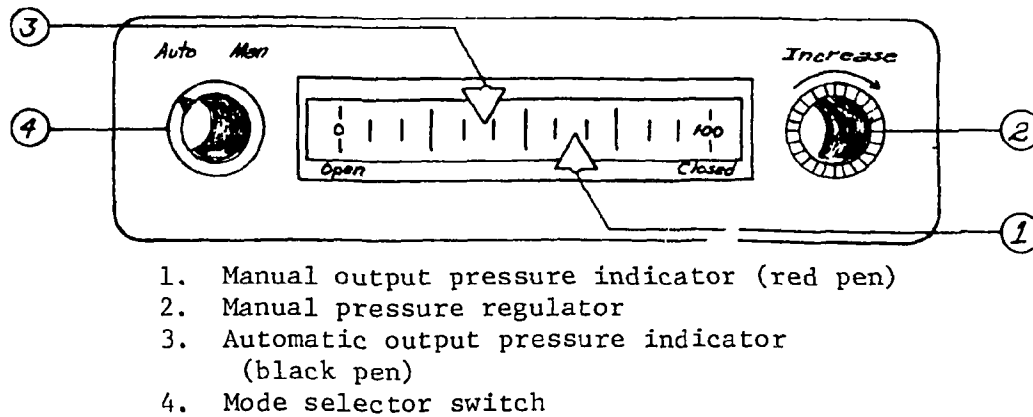


Fig. 3.4. Indicator-controller HIC-377.

Indicator-controller HIC-377A

1. Application

Provides direct manual or automatic control of the position of valve TCV-377A, which maintains the primary inlet temperature constant at the desired operating power level; located in the control room on Panel E.

2. Function

Manually or automatically adjusted pressure output; in automatic mode the pressure is regulated by the medium-error signal output from the three servo inlet temperature recorder-controllers; 3- to 15-psig output.

3. Operation

Refer to Fig. 3.3, front panel of controller.

Item 1. Manual output pressure indicator; 3- to 15-psig scale; pressure is applied directly to valve; increasing pressure closes valve; inoperative in automatic mode.

Item 2. Manual pressure regulator; used for adjustment of output pressure; inoperative in automatic mode.

Item 3. Automatic output pressure indicator of the medium error signal from the three servo inlet temperature recorder-controllers; 3- to 15-psig scale which corresponds to valve position.

Item 4. Mode selector switch.

4. Procedures for Mode Switching

a. Manual to automatic with TCV-377 valve in either mode

- (1) If valve TCV-377 is in manual control, slowly adjust the outputs of HIC-377A and HIC-377 in opposite

directions while maintaining a constant inlet temperature until the red pointer of HIC-377A indicates approximately 25% valve closed. If TCV-377 is under automatic control, HIC-377A should already be indicating this approximate value.

- (2) Record the output pressure as indicated by the red pointer of HIC-377A in psig (percent scale reading $\times 12 + 3$).
 - (3) Place the three recorder-controllers TRC-100-4, TRC-100-5, and TRC-100-6 (auxiliary control room) in manual control.
 - (4) Adjust their outputs to the same value as recorded in Step (2) above.
 - (5) At HIC-377A observe that the red and black pointers agree, then place HIC-377A in the "auto" mode. The 10-in. valve is still under manual control through the recorder-controllers.
 - (6) Quickly place the transfer switch of TRC-100-4 from "man" to "auto" and adjust the setpoint until the output pressure reads the same value as recorded in Step (2).
 - (7) Repeat Step (6) with TRC-100-5 and TRC-100-6.
 - (8) Slowly adjust the setpoints of the controllers to the desired operating temperature.
- b. Automatic to manual with valve TCV-377 in either mode
- (1) Adjust the manual output of HIC-377A until the manual output (red pointer) agrees with the automatic output (black pointer).

- (2) Place the HIC-377A transfer switch in the "man" position.
- (3) Adjust the HIC-377A manual output as required to maintain the desired operating temperature.

Indicator-controller HIC-377

1. Application

Provides direct manual control of the position of valve TCV-377, which has a single function of keeping TCV-377A valve within its automatic control range; located in control room on panel E.

2. Function

Manually adjusted pressure output; 3- to 15-psig.

3. Operation

Refer to Fig. 3.4, front panel of controller.

Item 1. Manual output pressure indicator; 3- to 15-psig; pressure is applied directly to valve; increasing pressure closes valve.

Item 2. Manual pressure regulator; used for adjustment of output pressure.

Item 3. Disabled mode.

Item 4. Mode selector switch.

Recorder-controllers TRC-100-4, -5, -6

1. Application

Regulates primary coolant loop temperature by controlling the position of valve TCV-377A; located in the auxiliary control room.

2. Function

Automatic or manual mode. In automatic mode, controller's responses to increasing primary loop temperature is to decrease their output pressures, which are in the 3- to 15-psig range. Decreased output pressures open the temperature control valve.

3. Operation

Refer to Fig. 3.5, front panel of controller.

- Item 1. Chart pen; registers process variable at all times; 0-250°F.
- Item 2. Controller output pointer; registers controller output; 3- to 15-psig scale.
- Item 3. Setting index pointer; registers controller setpoint on 0-250°F scale of process variable when controller is in automatic mode; registers pressure regulator setting when controller is in manual mode.
- Item 4. Setpoint regulator; adjusts setpoint when controller is in automatic mode; adjusts controller output pressure (pressure regulator) directly in manual mode; regulator position readouts are via pointer, Item 3.
- Item 5. Transfer switch; selects desired operating mode; intermediate "seal" position not applicable in this system.

Mode transfer procedures

The transfer switch, Item 5, is normally left in automatic at all times with the manual or automatic control selection performed at

- Fig. 3.5. Recorder-controllers TRC-100-4, -5, -6.

station HIC-377A. However, in switching from manual to automatic control, the transfer switch, Item 5, must be used in conjunction with the HIC-377A mode selector switch. See Indicator-controller HIC-377A, this section, for detailed instructions.

Indicator-controller TIC-330

1. Application

Regulates pool inlet temperature by controlling valve TCV-330 in the secondary-coolant water inlet line to the pool heat exchangers; mounted locally near the heat exchangers.

2. Function

Automatic mode only; receives temperature signal directly from bulb sensor via capillary tube; develops a 3- to 15-psig outlet signal; increasing output in response to decreasing temperature, and tends to close valve TCV-330.

3. Operation

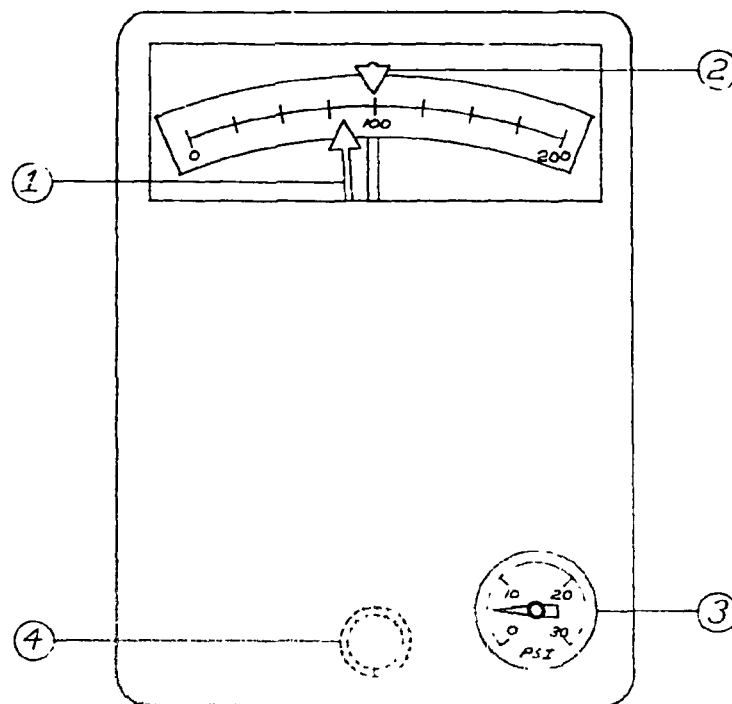
Refer to Fig. 3.6, front view of controller.

Item 1. Process variable indicator; indicates pool inlet temperature on a scale of 2 to 200°F.

Item 2. Setpoint indicator; indicates controller setpoint on same scale as (1).

Item 3. Output indicator; indicates controller output pressure in psig to positioner of valve TCV-330; high pressure drives valve toward closed condition.

Item 4. Setpoint adjustment; located inside cabinet; manual adjustment for setpoint, directly linked to setpoint indicator (2).



1. Process variable indicator
2. Set point indicator
3. Output indicator
4. Set point adjustment (inside cabinet)

Fig. 3.6. Indicator-controller TIC-330.

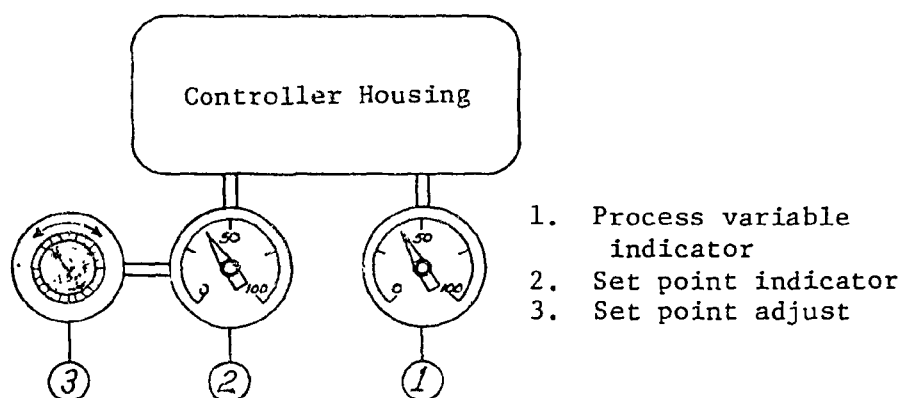


Fig. 3.7. Controller LC-214

Controller LC-214

1. Application

Regulates primary coolant head tank level by controlling tank makeup valve LCV-214; located in auxiliary control room.

2. Function

Automatic mode only; receives tank level information by pneumatic signal from LT-214, and develops 3- to 15-psig output control signal; decreasing output in response to high level in tank, and causes valve to close.

3. Operation

Refer to Fig. 3.7, which shows grouping of the blind controller and its associated equipment.

Item 1. Process variable indicator; registers tank level on a 0 to 100 scale; signal is supplied by LT-214.

Item 2. Setpoint indicator; registers setpoint pressure input to controller on a 0 to 100 scale corresponding to 3- to 15-psig; increasing setpoint causes controller to control at higher water level in tank.

Item 3. Setpoint adjust; manually controlled pressure regulator for setpoint adjustment.

Indicator-controller FIC-325

1. Application

Regulates blowdown flow from the secondary coolant system (cooling tower basin) by controlling valve FCV-325; located on cooling tower panel board.

2. Function

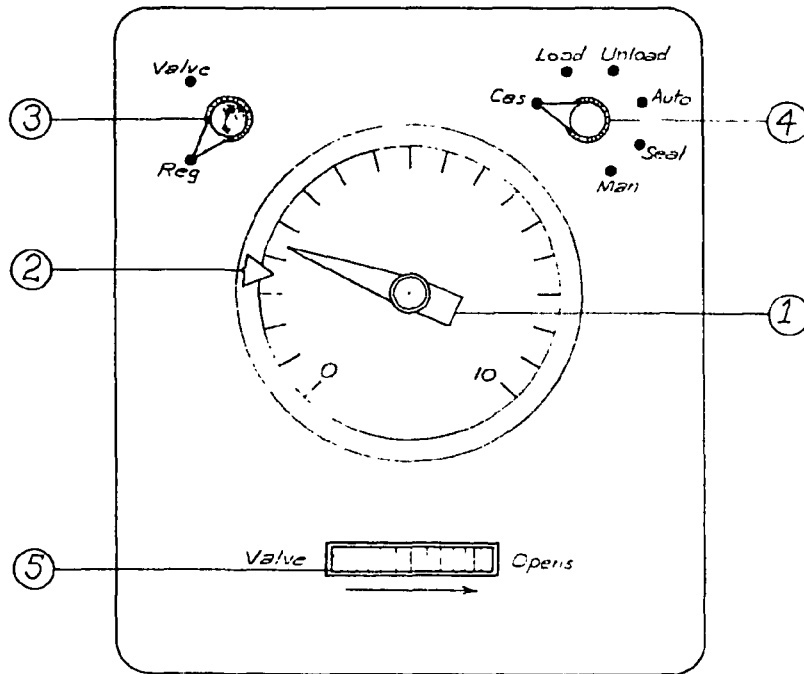
Cascade, automatic, or manual mode; in cascade mode, a 3- to

15-psig signal directly proportional to blowdown flow is compared with a setpoint that is automatically varied within the controller. The signal to vary the setpoint is received from ratio subpanel FM-325, and is 3- to 15-psig directly proportional to makeup flow. Controller output is 3- to 15-psig, increasing in response to increasing blowdown flow and decreasing in response to increasing makeup flow (setpoint signal); increasing output signal acts to close valve FCV-325.

3. Operation

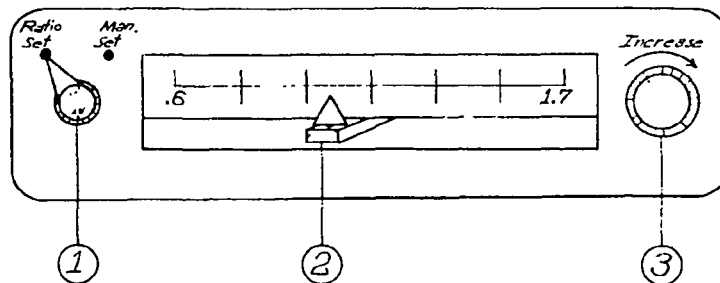
Refer to Fig. 3.8, front panel of controller.

- Item 1. Process measurement pointer; registers process variable on a 0 to 10 scale at all times; full scale corresponds to blowdown flow rate of 150 gpm.
- Item 2. Setting index pointer; normally registers controller setpoint when controller is in cascade or automatic modes; normally registers controller output pressure to valve when controller is in manual mode; when switch, Item 3, is flipped upward, pointer registers controller output regardless of operating mode.
- Item 3. Switch; determines pointer reading as described for Item 2; two positions, "valve" for controller output reading and "reg" for setpoint reading.
- Item 4. Transfer switch; selects desired operating mode; intermediate positions used in transferring among modes as described below.
- Item 5. Setpoint regulator; adjusts setpoint when controller



1. Process measurement pointer (black)
2. Setting index pointer (red)
3. Index pointer selector switch
4. Transfer switch
5. Set point regulator

Fig. 3.8. Indicator-controller FIC-325.



1. Mode switch
2. Ratio adjust lever
3. Pressure regulator

Fig. 3.9. Ratio subpanel FM-325.

is in automatic mode; adjusts controller output, and hence valve position, directly when controller is in manual mode; is not to be used in cascade mode.

Mode Transfer Procedures - all transfers must be effected in single steps, as follows:

a. Manual to automatic

- (1) Turn transfer switch (4) to "seal."
- (2) Adjust setpoint regulator (5) so that the setting index pointer (2) agrees with the process measurement pointer (1); switch (3) must remain in "reg" position.
- (3) Turn transfer switch (4) to "auto"; controller is now in automatic mode, attempting to hold the process flow at the same value as before the transfer.
- (4) Adjust setpoint regulator (5) to desired process flow.

b. Automatic to cascade

- (1) With switch (3) in "reg," note position of setting index pointer (2); leave switch in "reg."
- (2) Turn transfer switch (4) from "auto" to "unload."
- (3) Adjust setpoint regulator (5) so that setting index pointer (2) reads 0.
- (4) Turn transfer switch (4) to "load."
- (5) On ratio subpanel FM-325, (a) set mode switch to "ratio set," and (b) set ratio adjust lever to whatever ratio value required so that the controller

setting index pointer (2) reads the same as noted in step 1 above. (Subpanel is described below.)

- (6) Turn transfer switch (4) to "cas."
- (7) Adjust the ratio adjust lever on FM-325 to the desired ratio value.

c. Cascade to automatic

- (1) Turn transfer switch (4) from "cas" to "unload."
- (2) Adjust the setpoint regulator (5) so that the setting index pointer (2) agrees with the process measurement pointer (1), with switch (3) allowed to remain in "reg."
- (3) Turn transfer switch (4) to "auto."
- (4) Adjust setpoint regulator (5) as desired.

d. Automatic to manual

- (1) Lift switch (3) to "man" and observe controller output on setting index pointer (2); return switch to "reg."
- (2) Turn transfer switch (4) from "auto" to "seal."
- (3) Adjust setpoint regulator (5) so that setting index pointer (2) reads the same as in Step 1 when the switch (3) was lifted.
- (4) Turn transfer switch (4) to "man."
- (5) Adjust setpoint regulator (5) to achieve desired controller output pressure, as indicated now on the setting index pointer (2); increasing output pressure closes valve FCV-325.

Ratio subpanel FM-325

1. Application

Provides the setpoint pressure signal for cascade-mode operation of FIC-325; located on cooling tower panel board.

2. Function

FM-325 accepts the pneumatic signal output of flow transmitter FT-336, which is proportional to makeup flow to the secondary coolant system. It develops a secondary output signal which is also proportional to the makeup flow; however, the output proportionality factor is different from the input. The output proportionality factor is adjustable.

3. Operation

Refer to Fig. 3.9, front of subpanel.

Item 1. Mode switch; to be left in "ratio set" position at all times.

Item 2. Ratio adjust lever; adjusts proportionality between output and input signals over a multiplying range of 0.6 to 1.7. The use of this control in cascade operation of FIC-325 is discussed under operation of FIC-325.

Item 3. Pressure regulator; has no effect when mode switch (1) is in "ratio set" position.

Controller ApHC-331

1. Application

Regulates pH of secondary cooling system water by controlling the stroke of the acid-addition pump; located on cooling tower panel board.

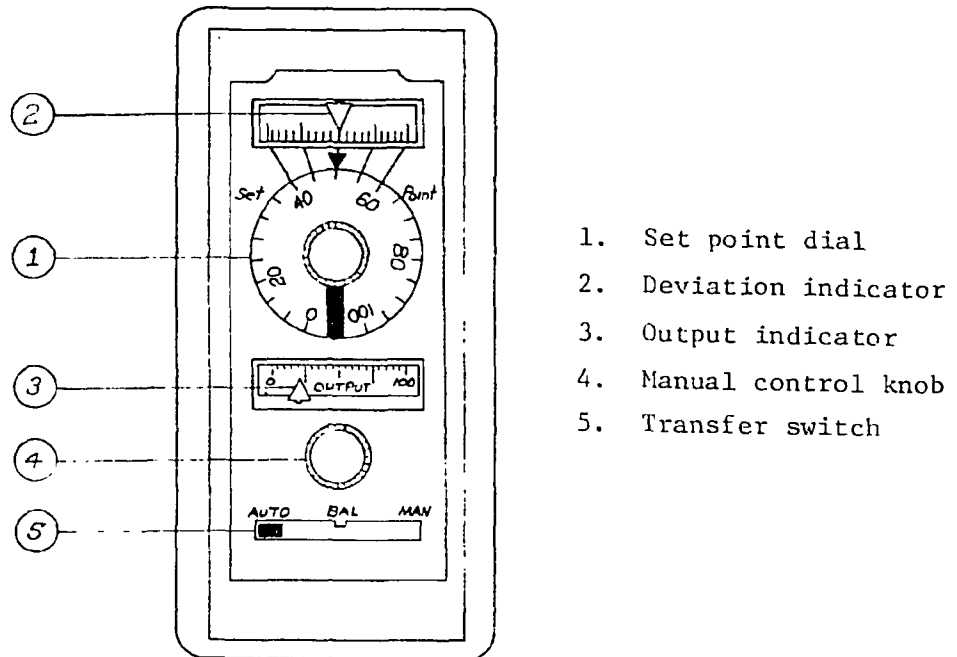
2. Function

Automatic or manual mode; receives a 10- to 50-mA electric signal from ApHT-331, proportional to pH of 0 to 14; develops an output electric signal of 10- to 50-mA, with increasing signal calling for increasing acid-addition rate.

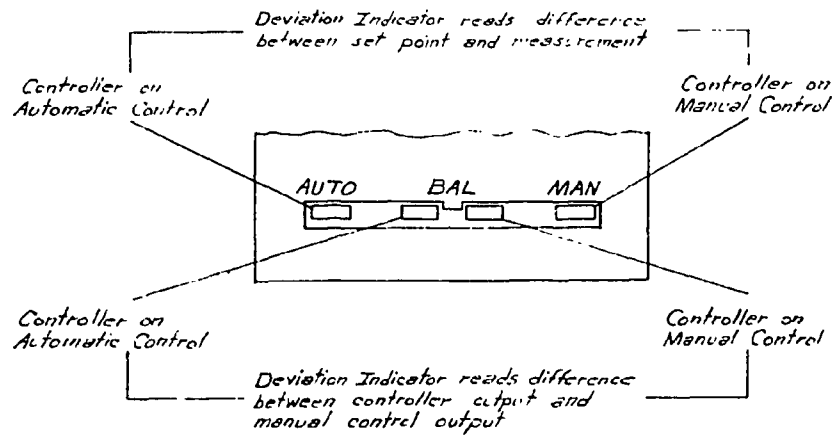
3. Operation

Refer to Fig. 3.10, front panel of controller.

- Item 1. Setpoint dial; used to adjust setpoint of automatic controller section. Scale of 0 to 100, corresponding to pH setpoint of 0 to 14.
- Item 2. Deviation indicator; indicates deviation of process measurement from setpoint dial (1) setting on same 0 to 100 scale as dial, when controller transfer switch (5) is in "auto" or "man" positions. When switch (5) is in either intermediate position during mode transfer, indicator reads difference between automatic and manual controller signals. Indicator range is limited to plus or minus 10% of instrument span.
- Item 3. Output indicator; indicates controller output; scale of 0 to 100 corresponds to 10- to 50-mA output signal; increasing output signal corresponds to increasing demand for acid addition (i.e., increased pump stroke).
- Item 4. Manual control knob; regulates controller output directly when controller is in manual mode.
- Item 5. Transfer switch; selects desired operating mode;



Controller - Front View



Four Positions of Transfer Switch

Fig. 3.10. Controller ApHC-331.

intermediate "balance" positions used in transferring between modes as described below.

Mode transfer procedures

a. Manual to automatic

- (1) Move transfer switch (5) to manual side of center stop ("manual-balance"). The deviation indicator (2) now reads the difference between automatic controller signal and the actual controller output which is still under manual control.
- (2) Turn the setpoint dial (1) until the deviation indicator (2) pointer is centered over the main reference arrow (i.e., the automatic control signal is the same as actual controller output).
- (3) Move the transfer switch (5) to the extreme left, or "auto," position. The deviation indicator (2) now reads the deviation of process measurement from setpoint dial (1) setting.
- (4) Adjust setpoint dial (1) for desired pH control point, recalling that 0 on the dial corresponds to pH of 0 and 100 on the dial to pH of 14.

b. Automatic to manual

- (1) Move transfer switch (5) to automatic side of center stop ("automatic-balance" position). The deviation indicator (2) now reads the difference between the manual control signal and the actual controller output which is still determined by the automatic controller section.
- (2) Turn the manual control knob (4) until the deviation

indicator (2) pointer is centered over the main reference arrow (i.e., manual control signal is the same as the actual controller output).

- (3) Move the transfer switch (5) to the extreme right, or "man," position. The deviation indicator now reads the deviation of process measurement from setpoint dial (1) setting.
- (4) Adjust manual control knob (4) for desired controller output, as indicated on output indicator (3), recalling that increasing controller output corresponding to increased rate of acid addition.

Level controller-transmitters LCT-454, LCT-202, LCT-401, LCT-605

1. Application of LCT-454*
Regulates level in pool deaerator tank by controlling valve LCV-454; develops signal proportional to level to actuate control switches and LI-454 in the control room.
2. Application of LCT-202*
Regulates level in primary loop deaerator tank by controlling valve LCV-202; develops signal proportional to level to actuate control switches and LI-202 in the control room.
3. Application of LCT-401*
Regulates level in pool surge tank by controlling valve LCV-401; develops signal proportional to level to actuate control switches and LI-401 in the control room.

*Level controller-transmitters are mounted on the respective tanks whose levels are controlled.

4. Application of LCT-605*

Regulates level in demineralized water supply tank by controlling valve LCV-605; develops signal proportional to level to actuate control switches and local indicator LI-605.

5. Function

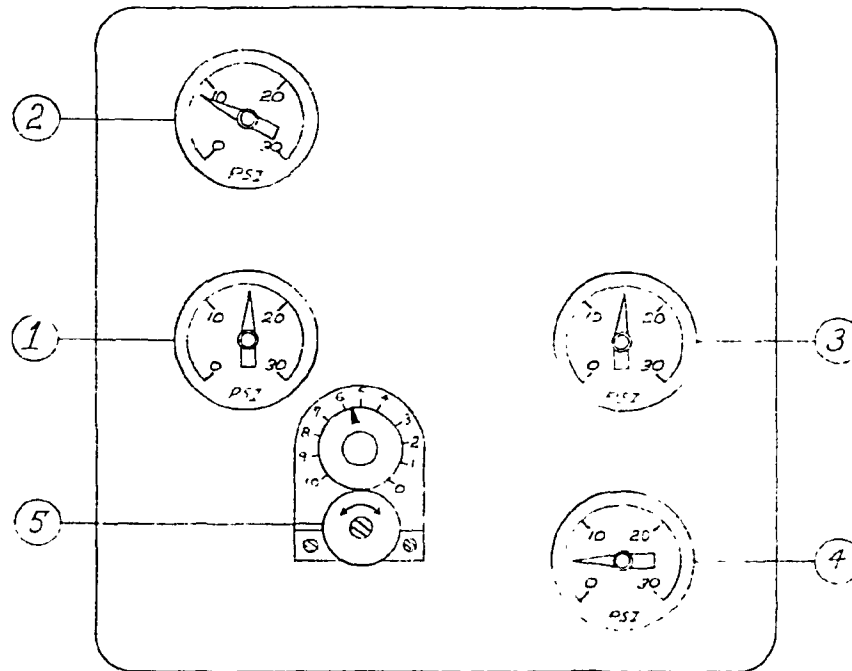
Tank levels are measured directly by displacement force. The transmitter section develops a 3- to 15-psig pneumatic signal for external use. The controller operates independently of the transmitter, has automatic mode only, and develops a 3- to 15-psig signal output to actuate the associated controlled valve. In all cases, decreasing output of the controller drives the controlled valve toward closure. In LCT-454, -202, and -401, the output signal is more or less proportional to measurement deviation from setpoint.

LCT-605 is called a "differential gap" controller, and performs essentially in an on-off fashion. The "gap" is the difference between two levels, the width being adjustable in terms of "percent of range" on a differential gap scale, and the average of the two levels being adjustable as the instrument setpoint. Thus, when the level in the tank decreases to the bottom of the "gap," the controller suddenly develops a large output pressure signal to open the tank inlet valve, LCV-605; when the tank fills to the top of the "gap," the controller output pressure signal suddenly decreases and permits the inlet valve to close.

6. Operation

Refer to Fig. 3.11, arrangement of components inside controller case.

Item 1. Transmitter supply pressure indicator.



1. Transmitter supply pressure indicator
2. Transmitter output pressure indicator
3. Controller supply pressure indicator
4. Controller output pressure indicator
5. Set point adjustment

Fig. 3.11. Level controller-transmitters LCT-202, -401, -454, and -605.

- Item 2. Transmitter output pressure indicator.
- Item 3. Controller supply pressure indicator.
- Item 4. Controller output pressure indicator.
- Item 5. Setpoint adjustment; determines level of liquid in the tank which the controller will attempt to maintain. Minimum (0) and maximum (10) settings correspond to the 0 and 100% levels on the level indicators actuated by the transmitter sections.

Valve positioners. The process pneumatic valves are actuated by arrangements of diaphragms and springs. The diaphragms may receive air pressure directly from a primary controller, or may be positioned more precisely by a valve positioner, which is itself a secondary controller. In the latter case, the positioner receives the primary controller "setpoint" signal and develops an output signal. The output signal is proportional to the position deviation from "setpoint." The positioners are provided with the following indicators:

- 1. Supply - Air supply pressure.
- 2. Instrument - Signal pressure received from the primary controller.
- 3. Output - Pressure applied to valve operator diaphragm. The positioners also have bypass switches, whereby the signals from the primary controllers may be applied directly to the operator diaphragms.

Recorder-controller ApHRC-1200

- 1. Application
Regulates the pH of the primary system by controlling the speed of the acid-delivery pump; located in instrument rack near acid day tank.

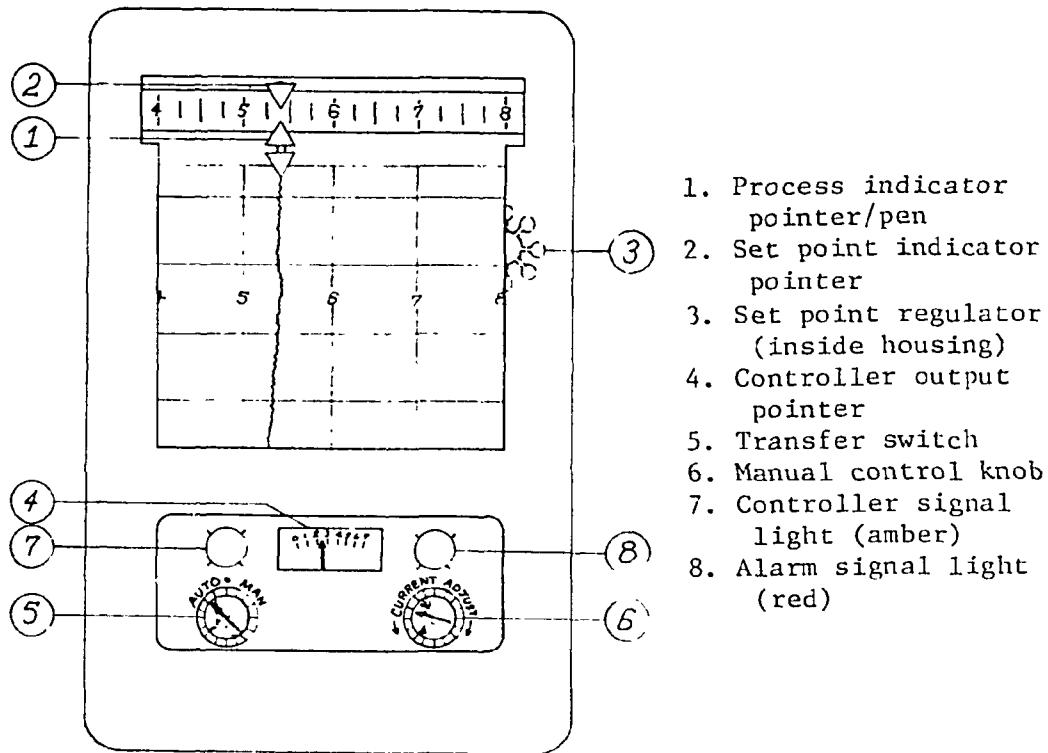
2. Function

Automatic or manual mode. Receives a 21.428-32.857 mV dc electric signal from ApHT-1200, proportional to pH of 4 to 8. Develops an output electric signal of 1- to 5-mA dc, with increasing signal calling for increasing acid addition rate.

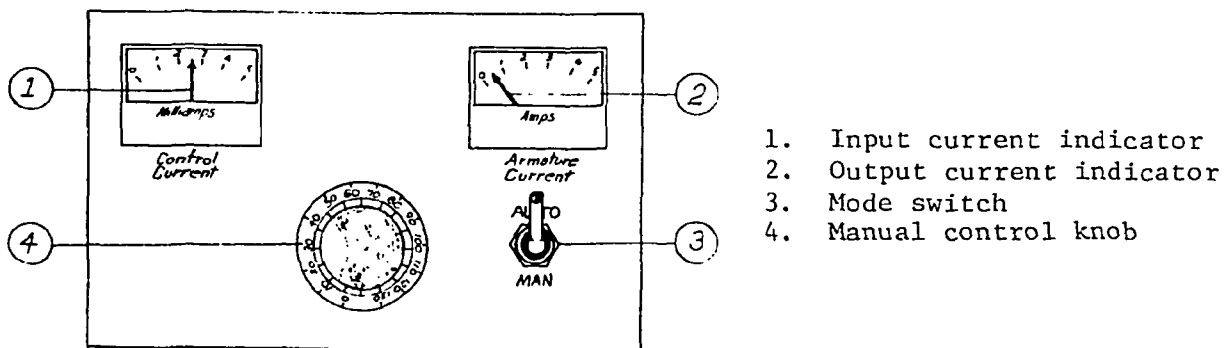
3. Operation

Refer to Fig. 3.12, front panel of recorder-controller.

- Item 1. Process indicator pointer/pen; registers process variable at all times; 4-8 pH scale.
- Item 2. Setpoint indicator pointer; registers controller setpoint on 4-8 Ph scale of process variable.
- Item 3. Setpoint regulator; adjusts setpoint for automatic operation; located inside cabinet.
- Item 4. Controller output pointer; registers controller output signal when in automatic mode; registers manual output when in manual mode or when transfer switch (5) is in "dot" position; should agree with Item 1 of ApHO-1200 when transfer switch (5) is in "auto" or "man" position.
- Item 5. Transfer switch; selects desired operating mode; intermediate "dot" position used in transferring between modes as described below.
- Item 6. Manual control knob; marked "current adjust;" regulates controller output directly when controller is in manual mode.
- Item 7. Signal light; amber; glows when the control unit is energized except when the transfer switch (5) is in the "dot" position.



Recorder-Controller ApHRC 1200



Pump Operator ApHO 1200

Fig. 3.12. pH controller 1200.

- Item 8. Signal light; red; glows when the controlled variable goes above the safety switch setting while the process is on automatic control, i.e., while the transfer switch (5) is in "auto" or "dot" position.

Mode transfer procedures

See ApHO-1200 for preferred procedures of mode switching. The following steps for mode switching, pertaining to ApHRC-1200, are included for general information only and, under normal operating conditions, are not to be used.

a. Manual to automatic

- (1) Place the mode switch (Item 3) of ApHO-1200 in "auto" position.
- (2) With the transfer switch (5) in "auto" position observe controller output pointer (4) reading.
- (3) Move the transfer switch (5) to "dot" position and adjust the manual control knob (6) marked "current adjust" - so that controller output pointer (4) reads the same as in step 1. Actual controller output is still under automatic control.
- (4) Move the transfer switch (5) to "man" position.
- (5) Adjust the manual control knob (6) for desired output as indicated on controller output pointer (4), recalling that increasing controller output corresponds to increasing the rate of acid addition.

Acid pump operator ApHO-1200

1. Application

Provides controlled 0- to 120-V dc to the acid-delivery pump motor; located in instrument rack near acid day tank.

2. Function

Automatic or manual mode. In automatic mode, a 1- to 5-mA signal from recorder-controller ApHRC-1200 is converted to a 0- to 120-V dc range to regulate the speed of the acid-delivery pump motor.

3. Operation

Refer to Fig. 3.11, front panel of operator.

Item 1. Input current indicator; registers input signal from recorder-controller ApHRC-1200; should agree with controller output pointer (Item 4) of ApHRC-1200 when the transfer switch (Item 5) of ApHRC-1200 is in "auto" or "man" position.

Item 2. Output current indicator; registers operator output current at all times to armature of acid pump motor.

Item 3. Mode switch; selects desired operating mode.

Item 4. Manual control knob; regulates operator output directly when mode switch (3) is in "man" position.

4. Mode Transfer Procedures

a. Manual to automatic

- (1) Verify that the transfer switch (Item 5) of ApHRC-1200 is in the "auto" position.
- (2) At ApHRC-1200, adjust the setpoint regulator (Item 3) until the setpoint indicator pointer (Item 2) indicates the desired control value.
- (3) Move the mode switch (3) of ApHRC-1200 to the "auto" position. The system is now in automatic operation, and the output signal from operator ApHRC-1200 is determined by the error signal developed by recorder-controller ApHRC-1200.

b. Automatic to manual

- (1) Move the mode switch (3) of ApHO-1200 to the "man" position.
- (2) Adjust the manual control knob (4) of ApHO-1200 until the desired pH is reached as indicated by the process indicator pointer/pen (Item 1) of ApHRC-1200, recalling that an increase in output results in an increase in the acid-addition rate. Note that it is not necessary to place the transfer switch (Item 5) of recorder-controller ApHRC-1200 in the "man" position.

4. REACTOR COMPONENTS

4.1. Reactor Component Handling and Storage

4.1.1 References

Drawings:

E-42118	Inner Fuel Element Assembly
M-10070-ØA-200-E	Inner Fuel Element Handling Tool
M-20978-EL-003-D	Shipping Container for Inner Element
M-20978-EL-002-D	Shipping Container for Outer Element
E-42126	Outer Fuel Element Assembly
M-10070-ØA-100-E	Outer Fuel Element Handling Tool
1546-01-M-5015	Fuel Element Seat, Clean Pool
M-10191-EL-001-D	Shielded Transfer Cask Assembly

4.1.2 Introduction

After shutdown for refueling, the elements are cooled for a minimum of four hours, and until they are removed from the vessel, with a minimum flow rate equivalent to the output of at least two pony motors. The elements are then removed from the core and stored in approved storage racks. The elements must be stored in rack positions 1 and/or 2 which are provided with thermal shields to protect the concrete from overheating. If the decay time is greater than 24 h, the elements may be stored in any pool, preferably as far from the pool gate gaskets as possible. The elements will be allowed to decay at least eight months prior to shipping to Savannah River for chemical processing.

4.1.3 Precautions

Fuel elements must always be stored at approved locations and moved according to approved procedures. There are three major hazards which must be considered when moving fuel elements. These are (1) the criticality potential involved in assembling a fuel element under water or moving a fuel element section near another fuel element; (2) the quantity of radiation emitted by a freshly irradiated fuel element which can damage adjacent structures if not properly stored; and (3) the heat generated in a freshly irradiated fuel element which can melt the plates if the element is not kept in a vertical position with unobstructed coolant passages.

A new fuel element assembly must be treated as though it would be supercritical when submerged in water. Therefore, a complete element must never be assembled under water except in approved storage locations which contain built-in neutron absorbers, or in the core. The rod drives must be completely inserted and the drive motors locked if (1) an element is to be placed in the core, or (2) the target bundle is to be removed from a core. The fuel elements must be handled only with the approved tools.

The afterheat is so intense following shutdown that the elements must be maintained in a vertical position with unrestricted cooling water convection paths. For the first 24 h after removal from the vessel, the elements must be placed in the approved storage racks which are provided with gamma shadow shields.

Count Rate instrumentation must be operating and an observer must be stationed in the control room when inserting fuel elements and targets into the reactor vessel.

A reactor component should not be disconnected from its handling tool unless properly seated whether in the reactor or in the storage rack. Force should not be used to insert a component into the reactor. Orientation requirements of a component in relation to the reactor and a tool in relation to a component are always described in the procedure and should be adhered to in all cases. Failure to properly orient a tool may prevent correct seating both in the reactor and storage racks and prevent safe hookup to the component itself. All hookups between the tools and components should be double checked before lifting the component.

When moving a heavy component from the reactor to storage in another pool or outside the pools or when loading or unloading a shipping cask, always avoid passing over fuel or targets stored in the pools. Heavy shipping casks should never be moved directly over the vessel. Heavy shipping casks should be set on the pool floor only in the approved area in the northwest section of the west clean pool.

It is the responsibility of the shift engineer to supervise all component handling operations.

4.1.4 Refueling Procedures

1. The reactor supervisor will inform the shift engineer which element is to be used during the next operating cycle and arrange for the element to be transferred to the reactor bay just prior to its insertion into the reactor.
2. The new element should be left in its shipping container until ready for use.
3. The shift engineer should inspect the new fuel element for possible damage and cleanliness.
4. At the scheduled time, shut down the reactor and complete the shutdown checklist.

5. Following the shutdown, continue to cool the element with at least two-pony-motor flow until it is removed from the reactor.
6. Complete the applicable reactor component replacement procedures in Section 4.2.

4.1.5 Receipt of new fuel elements

1. New elements will be received in the reactor bay in the standard shipping containers.
2. Using the approved fuel handling tools, remove the elements from the shipping containers.
3. Inspect the elements. Verify the numbers. Inspect the edges for burrs. Check the plates for damage. Inspect for cleanliness.
4. After the element has been inspected, install it in the reactor according to the shutdown instructions.

4.1.6 Storage of depleted elements

1. Following removal of a depleted element from the core, place the element in the pool storage rack - positions 1 and/or 2 - and place screens over them if the decay time is less than 24 h. These positions are provided with thermal shields to protect the pool concrete.
2. To distribute gamma heating in the pool concrete, these elements should be arranged such that the newest element is stored in a location as far away from the next hottest element as possible.

4.1.7. In-pool and inter-pool transfers

1. Attach the element handling tool to the tool carriage assembly and engage the element.

2. Raise the element out of the seat and identify the element number and assure that the rack position and element number are the correct ones.
3. Transfer the element to the new location, taking precautions not to raise the element high enough to increase the background radiation intensity. Do not allow the element to pass too closely to any pool wall penetration thimbles, as this will result in an increase in the radiation intensity in the areas outside the pool.
4. Place the element in the designated storage location and check to make sure it is seated properly.

4.1.8 Defective element handling procedures

See Section 8.4.1, .2, .3, .4, and .5

4.1.9 Loading and shipping depleted elements for chemical reprocessing

1. As soon as the shipping cask is received, flush the inside thoroughly to the ILW system. The inside volume is approximately 40 gal; therefore, a flush of approximately 80 gal is required. This is accomplished by connecting the demineralized water supply to nozzle No. 2 and the ILW drain line to nozzle No. 1 (see Fig 4.1).
2. The outside of the cask should be decontaminated to less than 1,000 dpm transferable β - γ and 30 dpm transferable alpha.
3. Arrange the depleted elements in the pool to facilitate their loading.
4. Attach the lifting sling assembly (drawing M-10191-EL-006-D) to the 50-ton overhead crane (see Fig. 4.2).

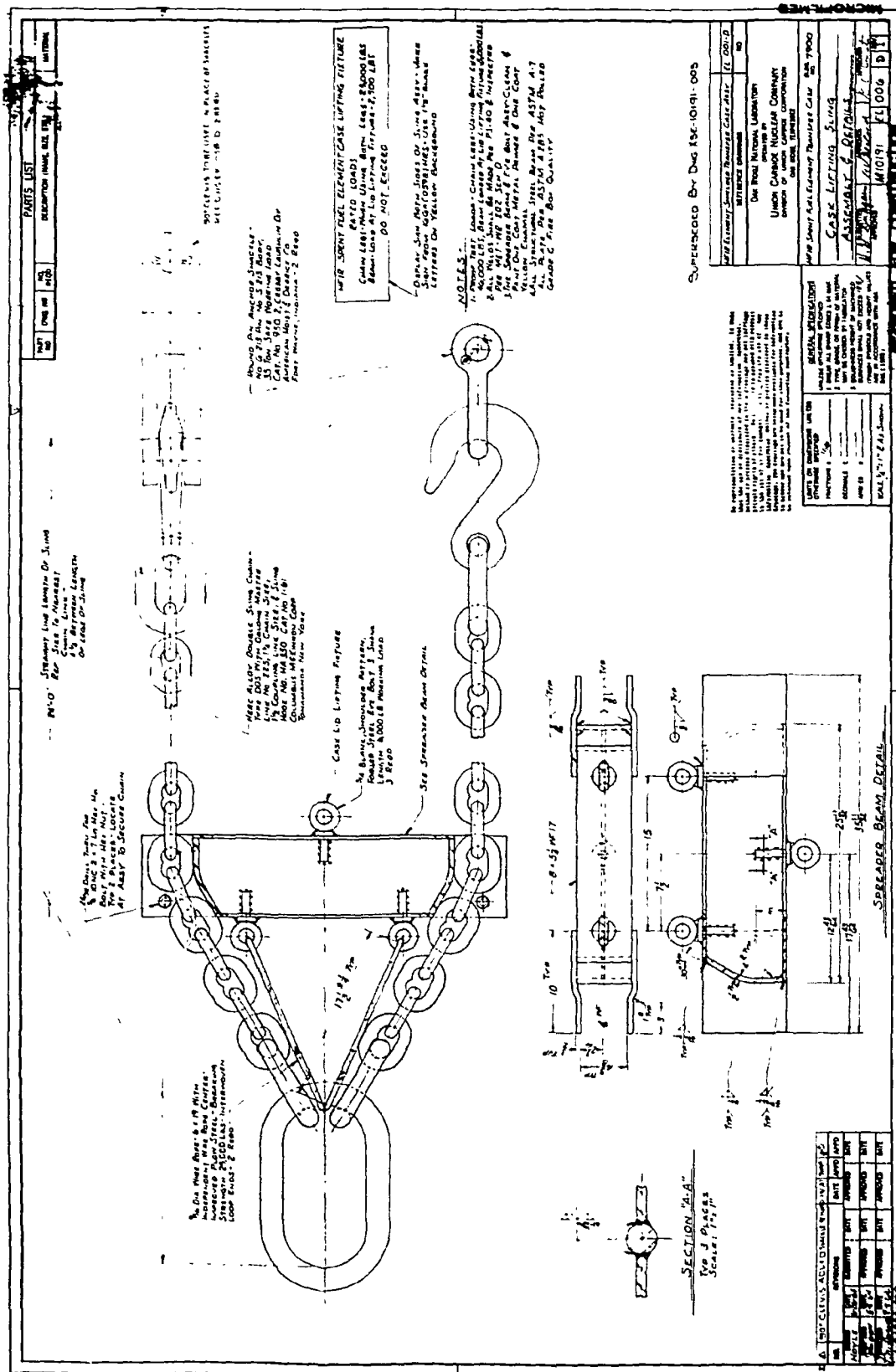


Fig. 4.2. Lifting sling.

5. Attach the cask lifting sling assembly to the transfer cask and attach the lid lifting device. Remove the fourteen 1-1/2-in. lid holddown nuts using a 2-3/8-in. socket.
6. Lift the assembly 1 in. off the floor and check the rigging to assure that a proper and adequate hookup has been made.
7. Attach the aluminum disc to the bottom of the carrier to prevent contamination of the carrier from the pool floor.
8. Move the transfer cask to the spent fuel shipping container pad in the west clean pool (see Fig. 4.3). CAUTION: When making this move, do not permit the cask to pass over the vessel or any stored elements.
9. Raise the lid to clear the cask and move it aside.
10. Remove the outer element holddown ring with the tool provided.
11. Load the outer element into the cask.
12. Load the inner element and insert the outer element hold-down ring. Make sure the silicon rubber gasket is in place. (This gasket is identifiable by the three notches cut in its inner diameter.)
13. Replace the transfer cask lid.
14. While continuously monitoring the radiation intensity, slowly raise the transfer cask. Stop raising the cask when it is high enough to permit replacement of the lid holddown nuts.
15. Replace the holddown nuts and torque to 150 ft-lbs.
16. While monitoring the radiation intensity, raise the cask all the way out of the water and rinse it thoroughly with demineralized water.

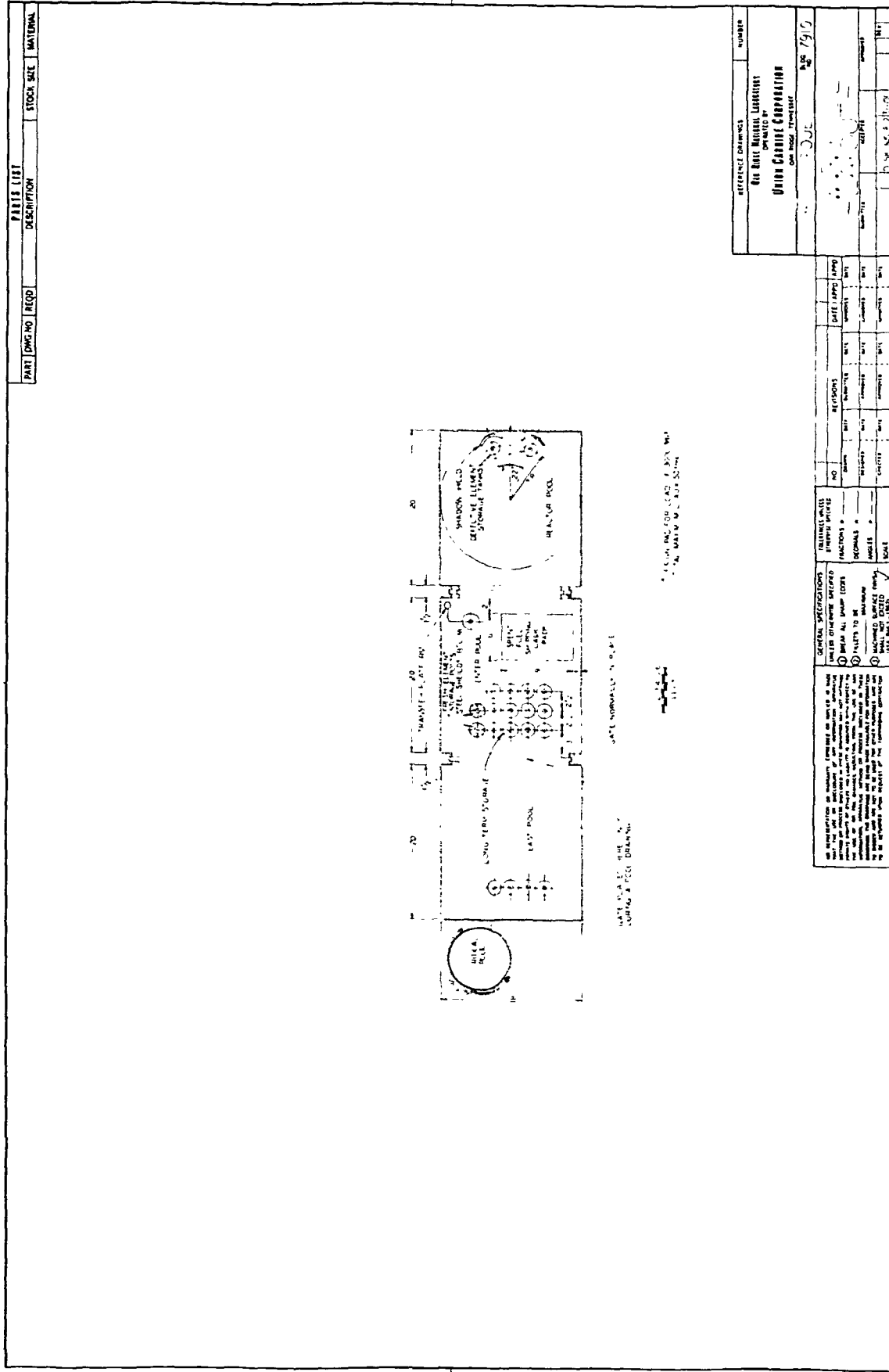


Fig. 4.3. Loading area.

17. When the cask has dripped dry, transfer it to the decontamination pad, while monitoring the radiation intensity.
18. Perform a leakage test as follows:
 - a. The cask lead cavity should hold an air pressure of 10 psig for 15 min. Connect the pressure gauge and valve 5 assembly between the quick disconnect and nozzle No. 4 on the cask. Apply 10 psig to the cask lead cavity by opening valve 4 and valve 5. Adjust the regulator to obtain the desired pressure.
 - b. The plug lead cavity should hold an air pressure of 10 psig for 15 min. Move the pressure gauge assembly to nozzle No. 3 and apply 10 psig for this test.
 - c. The element cavity should be pressure tested at 20 psig for 30 min. Move the pressure gauge assembly to nozzle No. 2 for this test.
 - d. After the tests are complete, close valve 4 and valve 5.
19. To drain the cask to ILW and to purge the moisture out to the required less than 1,000 ppm complete the following:
 - a. Attach both hoses to the quick disconnects (valve 4 should be connected to nozzle No. 1 and valve 5 to nozzle No. 2.)
 - b. Open valves 13 (to ILW), 6, 14, 5 and 4. Adjust rotometer flow to 24%.
 - c. Leave in this condition for approximately 24 h to purge all water out.
 - d. To check moisture content in cask, close valve 2, open valve 7, close valve 8, open valve 1, and throttle valve

6 to read 100 cc/min on sample flow rotometer 15.

Switch water vapor control on Hygrometer from standby to the 1,000 scale. The reading required for shipment is less than 1,000 ppm.

20. To place system in standby, complete the following:
 - a. Close valve 1.
 - b. Open valves 2 and 8.
 - c. Close valves 7 and 4.
 - d. Set pressure regulator 9 at 4 psi and adjust rotometer 15 to read 100 cc/min.
 - e. When pressure indicator 12 is at 0 psi, close valves 5, 13, and 14, then disconnect hoses.
21. Remove the pressure gauge and valves from nozzels No. 1 and 2. Plug these nozzles.
22. Decontaminate the outside of the cask to less than 1,000 dpm β - γ and 30 dpm alpha transferable contamination. DOT regulations require that the dose rate at the surface should not exceed 200 mrem/h nor 10 mrem/h at a distance of 1 m.
23. Have the Health Physics representative check and tag the cask.
24. Secure the tamper seal to the cask lid and complete appropriate forms for shipment.

4.1.10 Replacing ORR fuel basket with HFIR poison post and liner

PRECAUTIONS: The HFIR spent fuel shipping cask must have the poison post and liner installed prior to loading a spent element into the cask for shipment.

1. Remove the cask lid with the lid lifting device. Set it aside.
2. Loosen the Hex head Allen screw which holds down the ORR fuel basket. Remove the basket with the four-armed lifting tool. Set the basket aside and store.
3. Use the HFIR liner lifting tool and the three-ton crane hook to insert the liner into the cask (Fig. 4.4).
4. Install the poison post using the four-fingered expansion type tool lifting device. Install the holddown bolt, nut, and washer and lock in place.
5. Initial the "Neutron Absorber in Place" item on the Spent Fuel Element Shipping Checklist.
6. Reverse Items 1 through 4 for installing the ORR fuel basket.

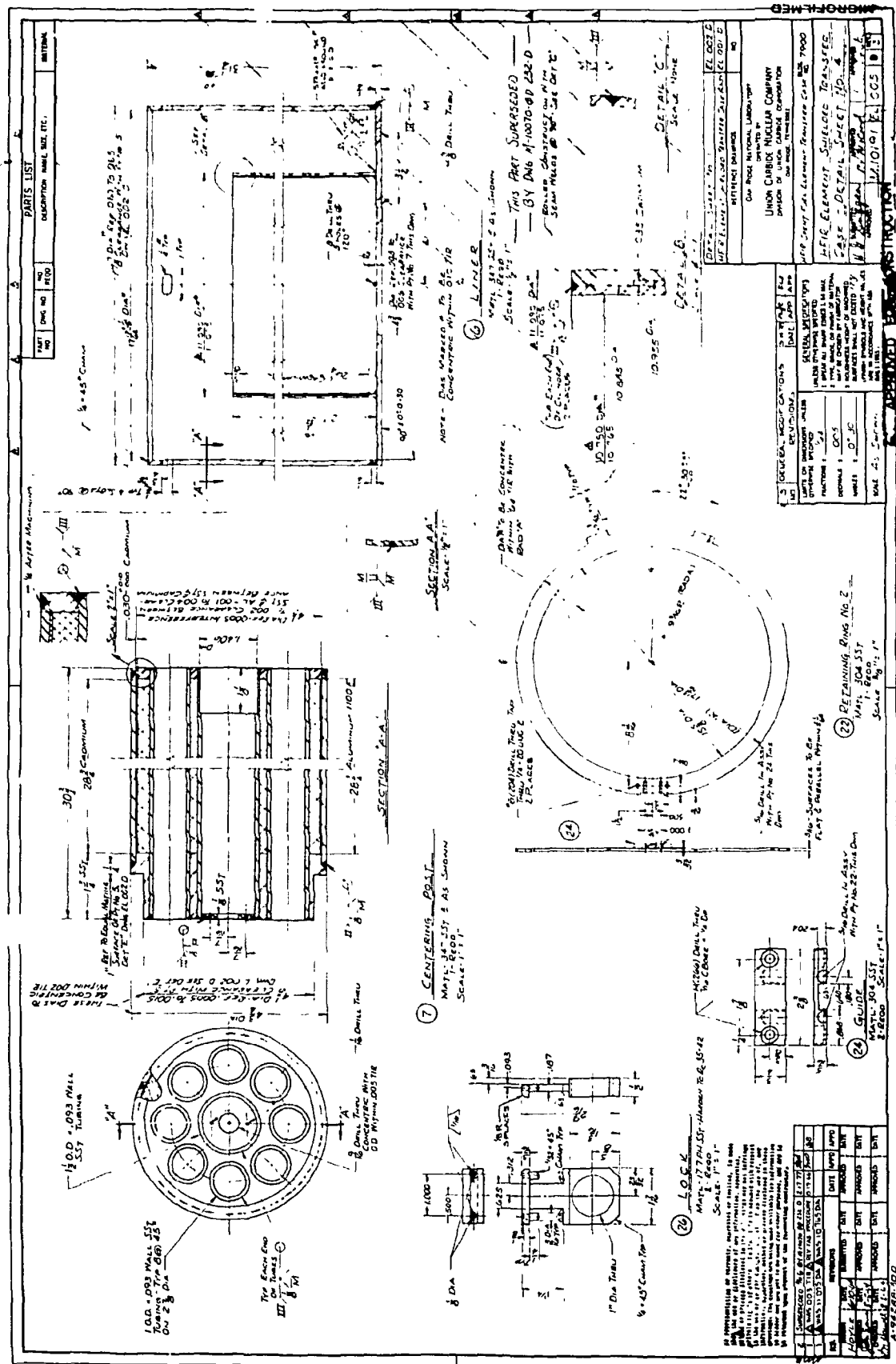


Fig. 4.4. HFIR cask poison post and liner.

4.2 Reactor Component Replacement

4.2.1 Introduction

The reactor components in the vessel may be considered as consisting of three stacks - an inner stack, an intermediate stack, and an outer stack - proceeding out radially from the vertical axis. The components which make up the stacks are as follows:

<u>Inner Stack</u>	<u>Intermediate Stack</u>	<u>Outer Stack</u>
Inner shroud	Shroud flange	Outer shroud
Inner fuel element	Control rods	Permanent beryllium
Outer fuel element	Upper tracks	Reflector container and pedestal assembly
Fuel grid	Removable beryllium Semi-permanent beryllium	Lower track support
Targets	Beryllium control rod access plugs	
Fuel grid support	Lower tracks	Fuel and reflector support and sleeve assembly

The pools were designed to serve primarily as a storage area for irradiated fuel elements. Accommodation has been provided for other components, however.

4.2.2. Precautions

It must be assumed that all material in the HFIR pools is highly radioactive and contaminated until proven otherwise. Components removed from the vessel are extremely radioactive as a result of the intense neutron flux. Items which are brought to the pool surface

must be under close radiation surveillance and every precaution must be taken to prevent the spread of contamination. When it is necessary to use the overhead crane, additional precautions must be followed as specified in Section 12.1. The attachment of the handling tools to the core components must be verified by the shift engineer and one operator. This should minimize the possibility of damage to the components due to mishandling.

4.2.3 Hydraulic tube assembly

1. Removal Procedure

- a. Depressurize the primary system according to the procedure in Section 6.1.5.
- b. Using the ratchet tool provided, run the lead screw down (clockwise) approximately 1/2 turn or until it tightens up.
- c. Unlatch both bayonet latches using the disconnect tool.
- d. Place the lifting tool into the eye of the U-bend and, with the bridge lifting device, apply approximately 150 lbs force.
- e. Back the lead screw off approximately 3 turns counterclockwise. At this time the vessel end of the U-bend should come out. If not, increase the lifting force to approximately 200 lbs and back the lead screw off another 1/2 turn.
- f. After the vessel end of the U-bend is out, back the lead screw 22 more turns counterclockwise (this makes a total of 25 turns.)
- g. Rotate the U-bend to the north side of the pool while supporting approximately 25 lbs with the bridge lifting device.
- h. Latch the U-bend in place on the north side of the reactor pool.

2. In-Core Section Removal

- a. Lower the in-core section removal tool into the pool.
- b. Rotate the large knurled knob counterclockwise 10 turns from its seat position.
- c. Lower the tool onto the in-core section and rotate the "T" handle until it seats. Rotate the "T" handle either direction approximately 1/4 turn until it reaches the stop. Hold it in this position.
- d. Rotate the large knurled knob clockwise approximately 7 turns or until it tightens down on the in-core section. The small knurled knob will not move up or down in this position.
- e. Slowly lift the in-core section out of the vessel being careful not to brush it against any components.
- f. Lower it into its storage location until it is seated.
- g. Rotate the large knurled knob counterclockwise approximately 7 turns.
- h. Rotate the "T" handle to its mid position and push the small knurled knob downward to disconnect the tool from the in-core section. Check to make sure it is disconnected.

3. Replacement Procedure

- a. Insert the hydraulic tube in-core section.
- b. Place the lifting tool into the eye of the U-bend and support approximately 25 lbs while swinging it in place over the vessel.
- c. Remove the lifting device from the lifting tool and roll it out of the way.

- d. Run the lead screw down approximately 20 turns clockwise.
- e. Use the lifting tool pry bar to apply slight force either upward or downward as needed until the U-bend is aligned in the north-south direction.
- f. Turn the lead screw clockwise until both ends of the U-bend insert into place. This will require up to 5 additional turns in the clockwise direction if both ends fit properly.
- g. Rotate the bayonet latches on each end of the U-bend.
- h. Rotate the lead screw counterclockwise until some pressure on the bayonet latches is felt in the upward direction. (This step relieves from the lead screw the force resulting when the primary system is pressurized.)

4.2.4 Quick-opening hatch

1. References

Drawings:

43-401-357	Quick-Opening Hatch
43-302-055	Operation of Hatch Ring
43-501-066	Vessel and Components Assembly
43-501-169	Sheet 1 (Lug Tool)
S-20978-EF-006-E	Hatch Ring Modification
S-20978-EF-004-E	Access Hatch Lift Assembly

2. Tools Required

- a. Access Hatch Lift Assembly
- b. Lug Tool
- c. 20,000-lb Capacity Scale and Chain Fall

3. Data

- a. Weights: Hatch and Hatch Ring
and Target Hole Plug - dry 5,300 lbs
underwater 4,650
- b. Dimensions: ~30-in.-O.D., ~16 3/8-in.-thickness
- c. Materials: 304 SST with 0.001-in. chrome plate

4. Removal Procedure

- a. Complete removal procedure 4.2.3 - Hydraulic Tube Assembly. (The target hole plug normally will be removed with the quick-opening hatch.)
- b. Place the lug tool over the locking bar (43-501-066, item 55.) Rotate the tool clockwise. Lean the tool back. This permits the hatch ring to clear the locking bar.
- c. Attach the 20,000-lb capacity scale and chain fall to the overhead crane. Pick up the hatch lift assembly, and then center the crane over the reactor vessel (see Fig. 4.5).
- d. Lower the lift assembly and position it under the three lift bars (see Fig. 4.6). The hatch ring and hatch will be removed as a unit.
- e. Slowly exert an upward force on the hatch ring with the chain fall until a force of approximately 2,600 lbs is obtained. While maintaining this force, rotate the lift assembly; and thus, the hatch ring approximately 23° counterclockwise until it is stopped by the stop pin.



Fig. 4.5. Hatch lift assembly.

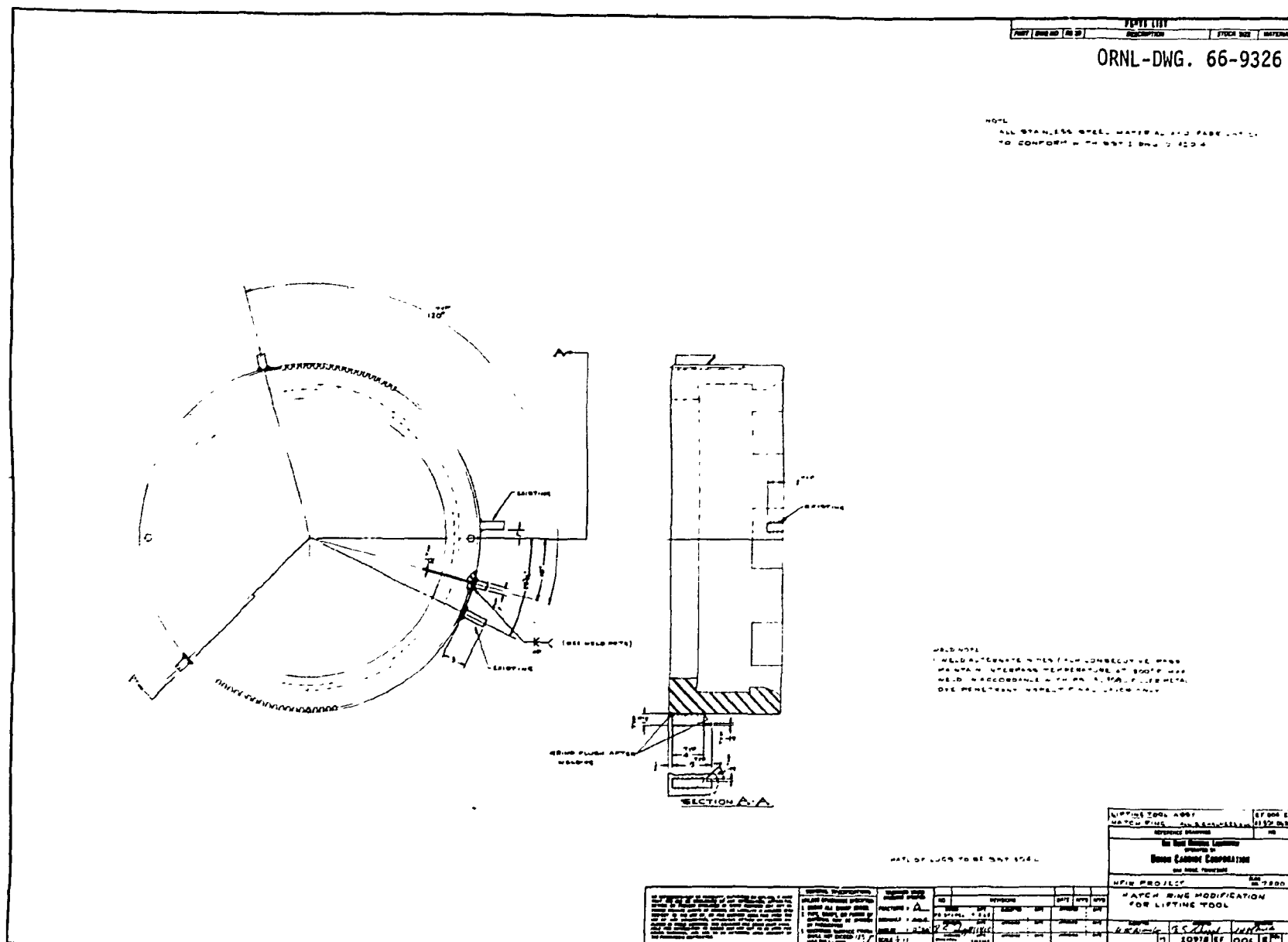


Fig. 4.6. Hatch ring.

- f. Slowly exert an upward force on the hatch ring, using the chain fall. The breaking force as indicated by the scales should be approximately 8,000 lbs. Continue raising the hatch assembly with the chain fall until the hatch is clear of the vessel.
- g. Lift the hatch ring and hatch assembly slowly out of the water and monitor the underside of the hatch for radiation.
- h. Place the hatch ring and hatch assembly and lifting tool in their storage location at the decontamination pad.
- i. Inspect the condition of the two O-rings and initiate replacement if necessary.

5. Replacement Procedures

- a. Using the 20,000-lb capacity scales, chain fall, and 50-ton overhead crane, and lift assembly, lift the hatch assembly; then position it directly over the reactor vessel to within 1 ft of the access hatch flange.
- b. Slowly lower the hatch the remaining distance with the chain fall while watching the scales for any decrease in weight which might indicate binding.
- c. When the hatch and ring are in place, and while maintaining approximately 2600 lbs weight on the crane, rotate the hatch ring clockwise by turning the lift assembly clockwise until stopped by the stop pin.
- d. Insure the locking bar is in place so the hatch ring is locked.
- e. Remove all tools to storage.

4.2.5 Target holder and tower assembly

1. References

Drawings:

E-49722	Target Holder Assembly, Model "D"
E-49772	Target Tower, Strainer, and Spider Assembly
E-49973	Target Tower Lifting Tool
M-10070-0C-250-E	Target Holder Handling Tool
10300-R-008-E	Latch Tool

2. Tools Required

- a. Latch Tool
- b. Tower Lifting Tool
- c. Target Assembly Handling Tool

3. Data

- a. Weights: Tower Assembly - dry 279 lbs
underwater 193 lbs
Tower Lifting Tool - dry 35 lbs
Target Assembly - dry 34 lbs
underwater 22 lbs

4. Removal Procedure

- a. Complete removal procedure 4.2.3 and 4.2.4.
- b. Using the latch tool, depress each of the four latch assemblies (E-49772-21) approximately 1/4 in. and rotate counterclockwise 90° (see Fig. 4.7).
- c. Attach the tower lifting tool to the tool carriage assembly and position the tool over the tower.
- d. Lift up on the outer sleeve (E-49973-8) and rotate the tool counterclockwise until stopped. Lower the outer

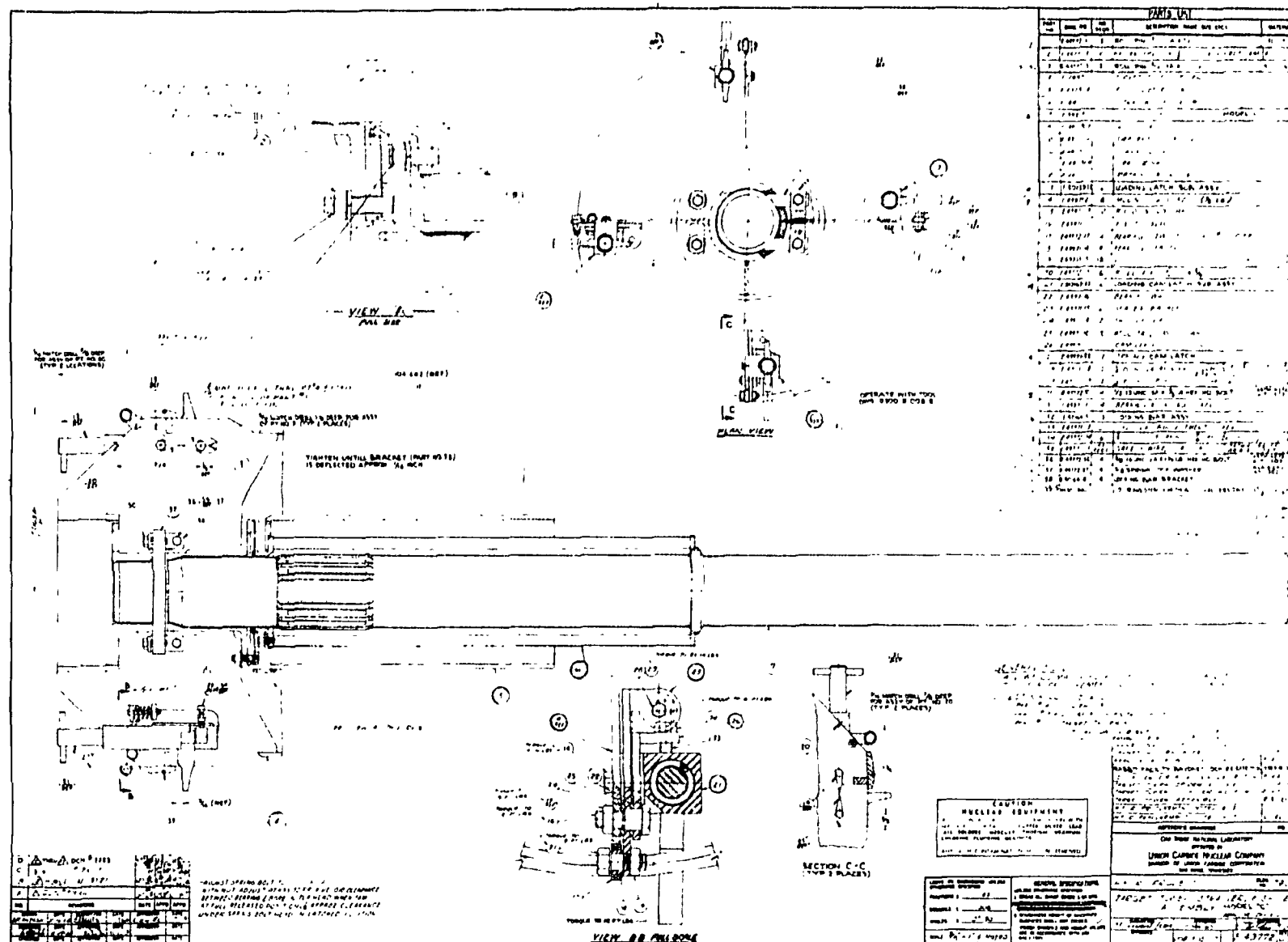


Fig. 4.7. Target tower, strainer, and spider assembly.

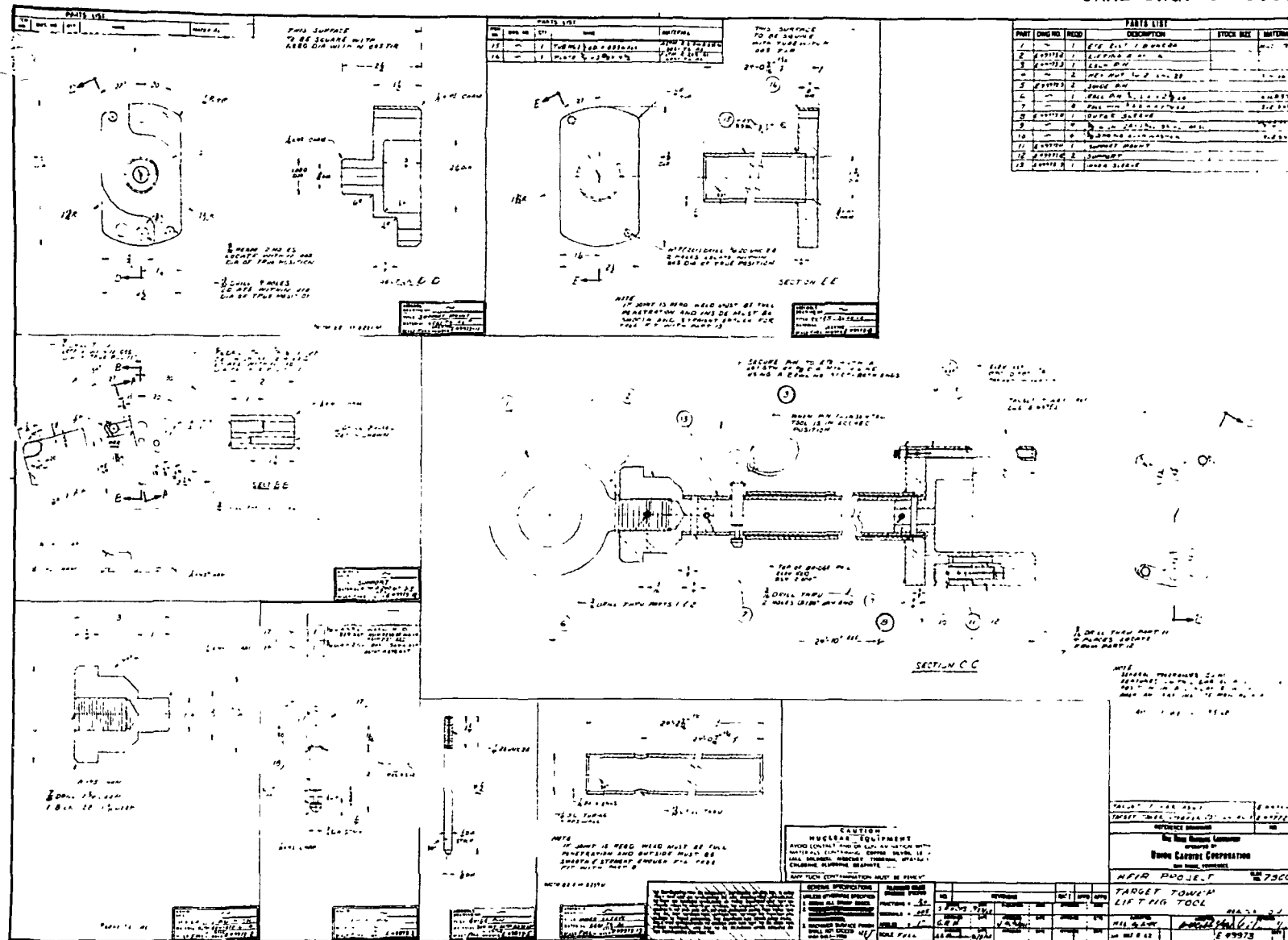


Fig. 4.8. Target tower lifting tool.

sleeve and lock it in position with the locking pin (E-49973-2) (see Fig. 4.8).

- e. While observing the spring scales, lift the tower approximately 2 in. Check the scales and determine if the tower is attached. The scales should increase to approximately 210 lbs if the tower is attached. A lifting force greater than 215 lbs probably indicates that the target assembly is still attached. In case of binding, a lifting force greater than approximately 400 lbs should not be exerted. Check to make sure that the target assembly is not attached to the tower by swaying the tower so that the bottom moves away from the island to expose the assembly.
- f. Slowly remove the tower from the vessel. The lifting force should decrease as the tower is removed from the water flow streams.
- g. Store the tower in its storage facility in the reactor pool (see Fig. 4.9).
- h. Remove the lifting tool to the tool storage facility.
- i. Attach the target holder handling tool to the tool carriage assembly and position the tool over the target bundle.
- j. Rotate the actuating nut counterclockwise until stopped. Lower the tool gently into the target holder (see Fig. 4.10). Rotate the tool carefully until it drops into the keyway which orients it with the lifting slots.
- k. Rotate the actuating nut clockwise approximately 9 turns. This causes the pickups to expand into the holder and secures the target assembly to the tool.
- l. Lift the target assembly approximately 3 in. and verify that

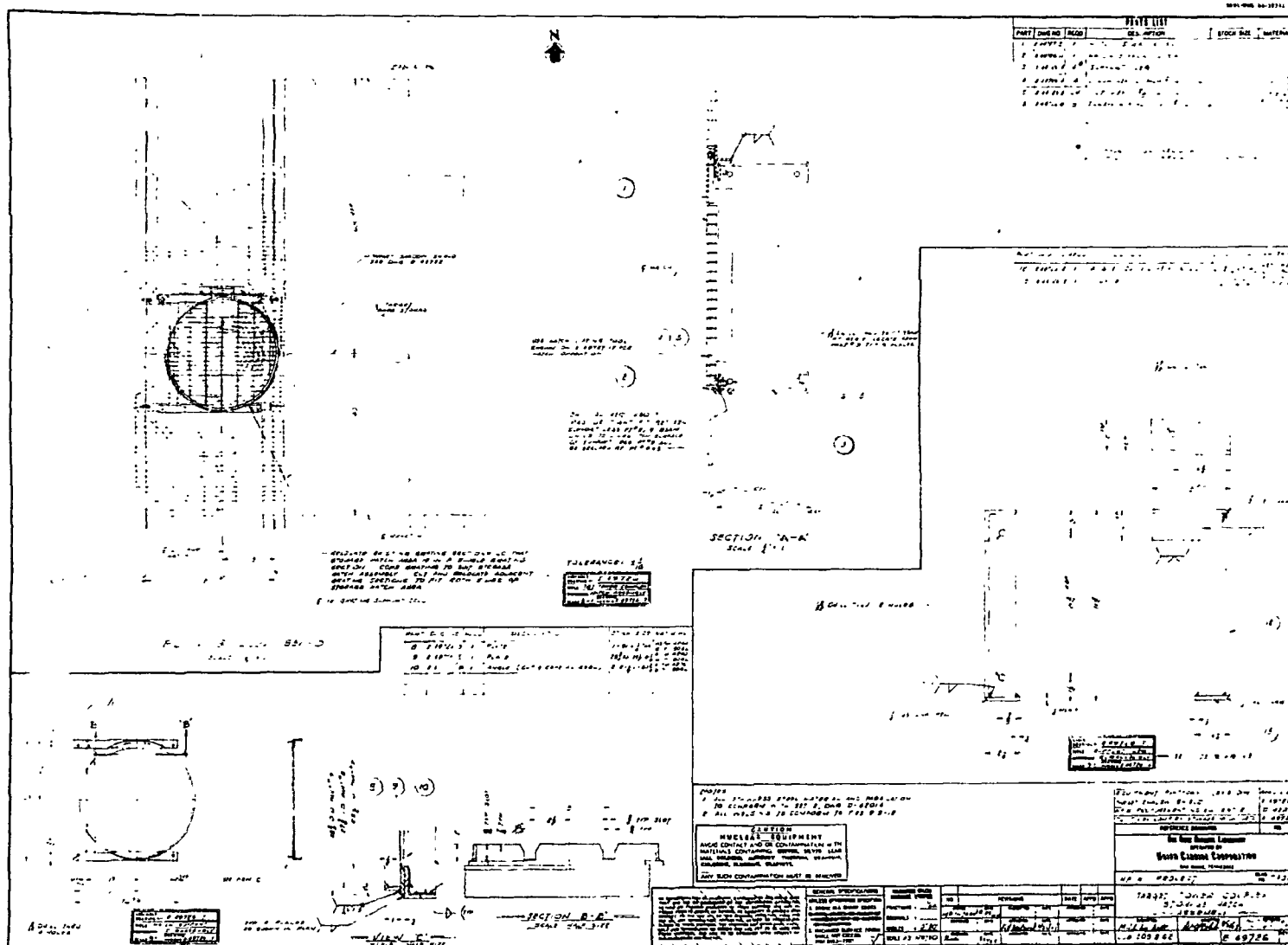
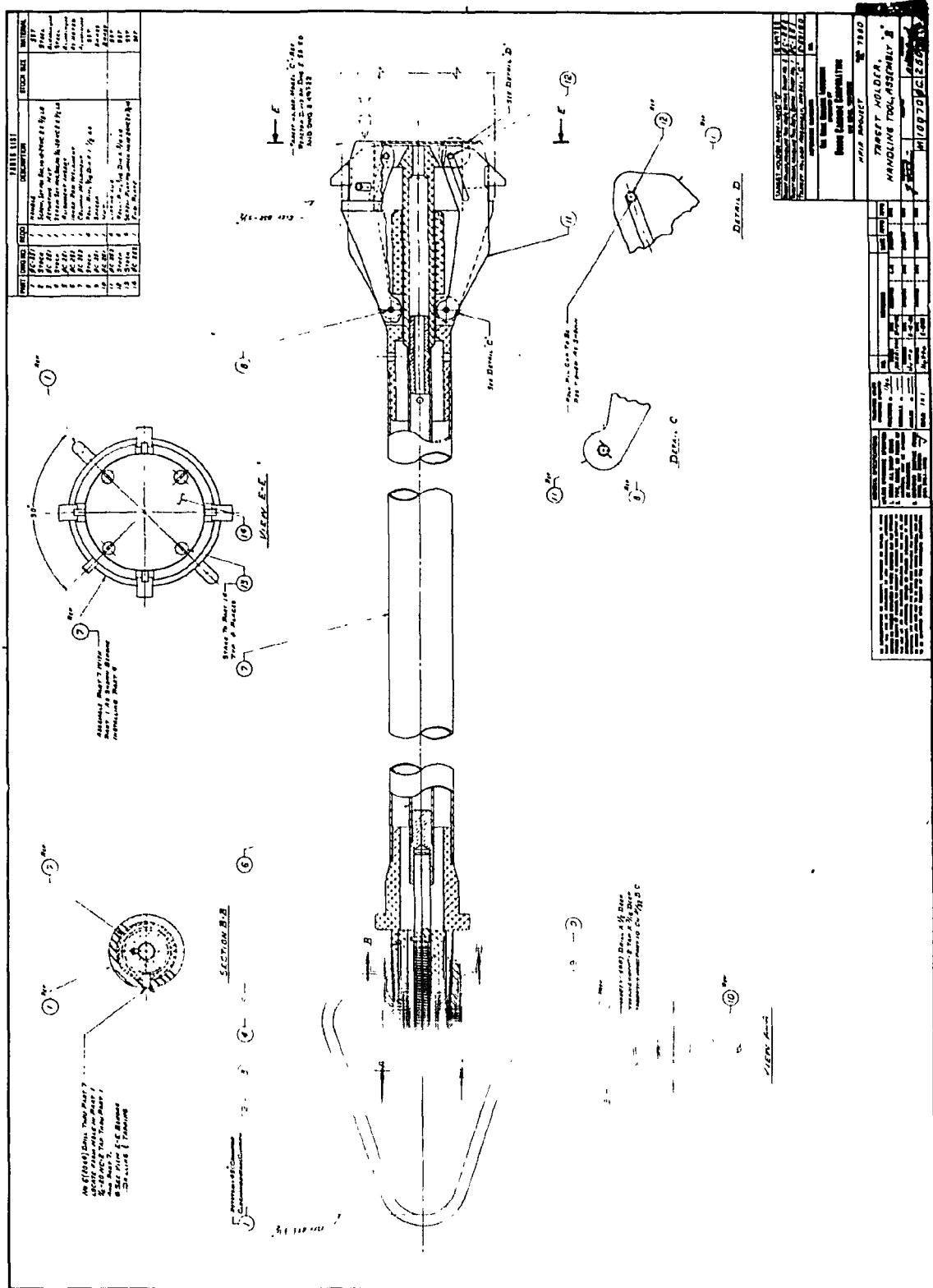


Fig. 4.9. Tower storage facility.



it is securely attached. An increase to approximately 48 lbs on the lifting scales should be indicated.

- m. Slowly remove the assembly from the vessel. A lifting force of approximately 48 lbs will be indicated on the spring scales, but this weight will vary depending on the water flow. A lifting force greater than 100 lbs should not be required.
- n. Transfer the assembly to the storage facility.
- o. Remove the tool to storage.

5. Replacement Procedure

- a. Reverse the removal procedure. Install the target assembly and check the markings on the tool to assure that it is seated.
- b. Install the target tower assembly and lock it in place by depressing the four latch assemblies and rotating them 90° clockwise.
- c. Remove all tools.

4.2.6 Inner fuel element

1. References

Drawings;

E-42081	Reactor Assembly - Elevation 817 ft, 10 in. to 822 ft, 3 in.
E-42118	Inner Fuel Element Assembly
M-10070-ØA-200-E	Inner Fuel Element Handling Tool Assembly
M-10070-ØA-500-E	Personnel Bridge Tool Carriage Assembly

2. Tools Required

- a. Inner Fuel Element Handling Tool

3. Data

- a. Weights: Inner Fuel Element - dry, 103 1/2 lbs
Handling Tool - dry, 40 lbs
- b. Dimensions: Length, 30.250 in; OD, nominal, 10.590 in.
- c. Material: 93% $^{235}\text{U}_3\text{O}_8$ -Al cermet; Al 6061-T6 cladding and sideplates.

4. Removal Procedure

- a. Complete removal procedure Fig. 4.7 - Hydraulic Tube Assembly; Fig. 4.8 - Quick-Opening Hatch; and Fig. 4.9 - Target Element and Tower Assembly.
- b. Attach the inner fuel element handling tool to the tool carriage assembly (see Fig. 4.11).
- c. While observing the spring scales, lower the tool (positioned to miss the inner shroud lugs) until the base plate of the tool rests on top of the outer adapter of the inner fuel element. This position may be determined by the marking on the tool extension lift rod.
- d. Attach the tool to the inner element by rotating the worm gear extension rod approximately 15 turns clockwise. The number of turns must be verified by the shift engineer and one operator.
- e. Lift the inner fuel element approximately 3/4 in. by exerting an upward force of approximately 315 lbs as indicated by the spring scales. This disengages the close tolerance fit to the outer fuel element. The

lifting force will vary according to the water flow. A force of 315 lbs has been observed with a flow of 3,000 gpm. A force greater than approximately 500 lbs should not be required.

- f. Continue lifting the element slowly with the tool positioned to miss the inner shroud lugs until it clears the inner shroud and vessel. If there is water flow, the lifting force will gradually decrease as the element is removed from the water flow stream.
- g. Store the element in the fuel storage rack, position No. 1, located in the west clean pool and place a screen over it.

5. Replacement Procedure

- a. Reverse the order of the removal procedure. The attachment of the tool to the element must be verified by the engineer and one operator.
- b. Position the tool base plates (guides) so they will not hit the inner shroud lugs as the tool passes through the shroud.
- c. If the weight on the scales decreases before the element is seated, it is an indication that the element is making an improper contact while being inserted. If this occurs, lift the element approximately 2 in. and try reseating it.
- d. After seating the element, check the tool extension handle to determine that the element is properly seated.
- e. Remove the fuel element handling tool to storage.

4.2.7 Inner shroud

1. References

Drawings:

E-42080	Reactor Assembly - Elevation 822 ft, 3 in to 826 ft, 0 in
E-42352	Inner Shroud
E-49716-9	Spring Latch Subassembly
M-10070-ØA-300-E	Inner Shroud Handling Tool Assembly
M-10070-ØA-400-E	Handling tools Guide Post Assembly

2. Tools Required

- a. Handling Tool Guide Post
- b. Inner Shroud Handling Tool
- c. Hook

3. Data

- a. Weights: Inner Shroud - dry 178 lbs
Tool and Shroud - dry 290 lbs
underwater 250 lbs

4. Removal Procedure

- a. Complete removal procedure 4.2.3, .4, .5, and 6.
- b. Attach the tool guide post and its handling tool to the tool carriage assembly (see Fig. 4.12).
- c. Lower the tool guide post into the vessel and seat it in the fuel grid.
- d. Disengage the guide post handling tool by rotating the handle counterclockwise. Remove and store.
- e. Using a hook tool, lift each of the four spring loaded latches approximately 3/4 in. and rotate approximately 90° clockwise (see Fig. 4.13).

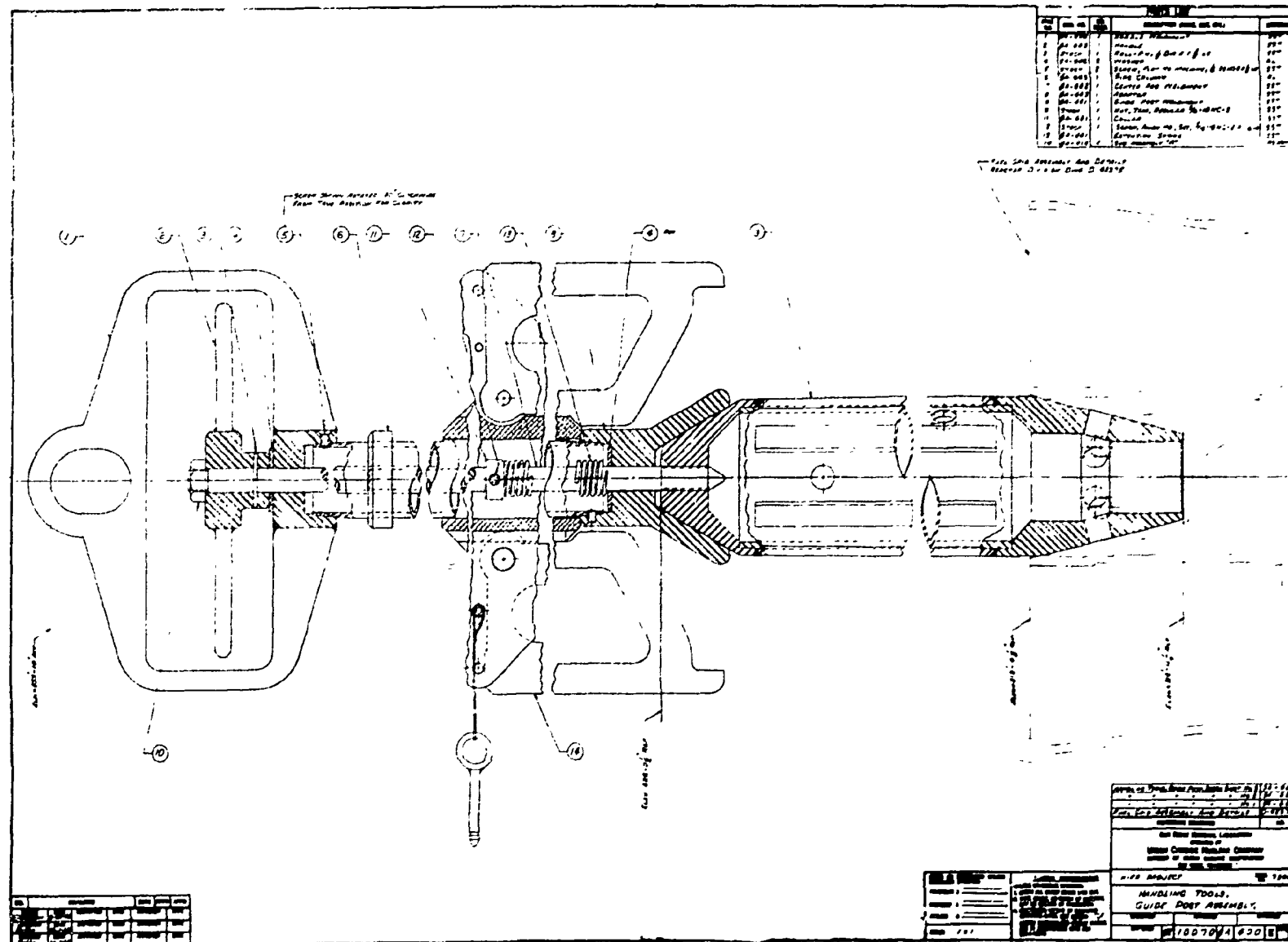


Fig. 4.12. Guide post assembly.

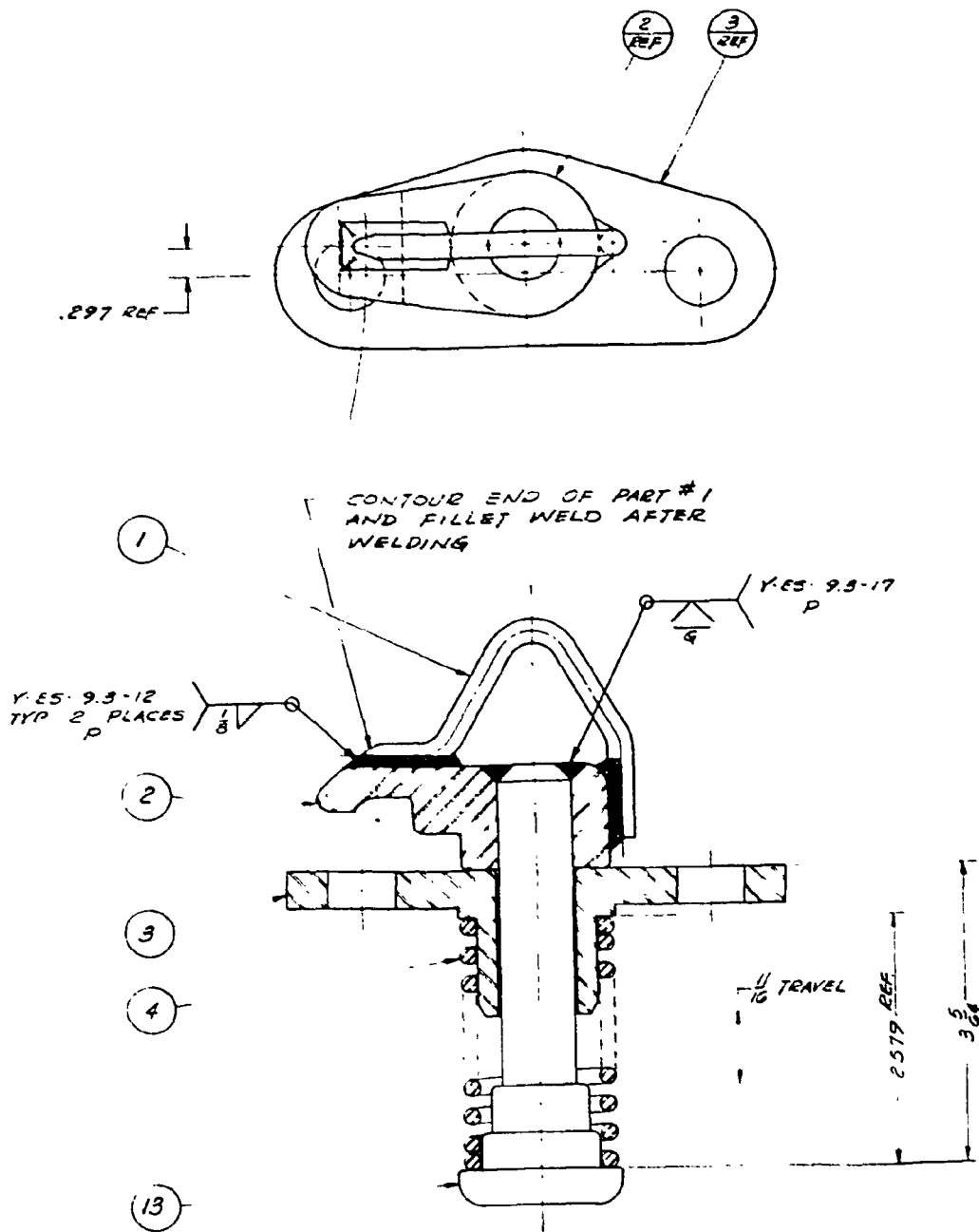


Fig. 4.13. Spring latch assembly.

- f. Remove and store the hook tool.
- g. Attach the shroud handling tool to the tool carriage assembly (see Fig. 4.14).
- h. Lower the shroud handling tool and permit it to telescope over the tool guide post. Allow the support flange of the tool to rest on the top of the shroud. Then exert a lifting force on the tool of approximately 90 lbs to relieve friction between the tool and shroud.
- i. Rotate the tool counterclockwise until it stops. This permits the lower flange of the tool to slide under the three lugs (see Fig. 4.15). These lugs are located near the bottom of the shroud and serve as a positive mechanical backup to the friction lifting mechanism. Release the 90 lbs weight on the tool.
- j. While holding the locking handle of the tool, rotate the actuating handle counterclockwise approximately 5 turns. This compresses the two rubber expanding rings enough to hold the weight of the shroud when it is lifted.
- k. Carefully exert an upward force of approximately 400 lbs and lift the shroud $\frac{3}{4}$ in. to clear the close fit at the top of the outer fuel element. The force required to lift the shroud may vary according to the water flow. A force greater than approximately 600 lbs should not be required.
- l. Continue lifting the shroud slowly until clear of the guide post and vessel. The force required to lift the shroud will gradually decrease as the shroud is removed from the water flow stream.

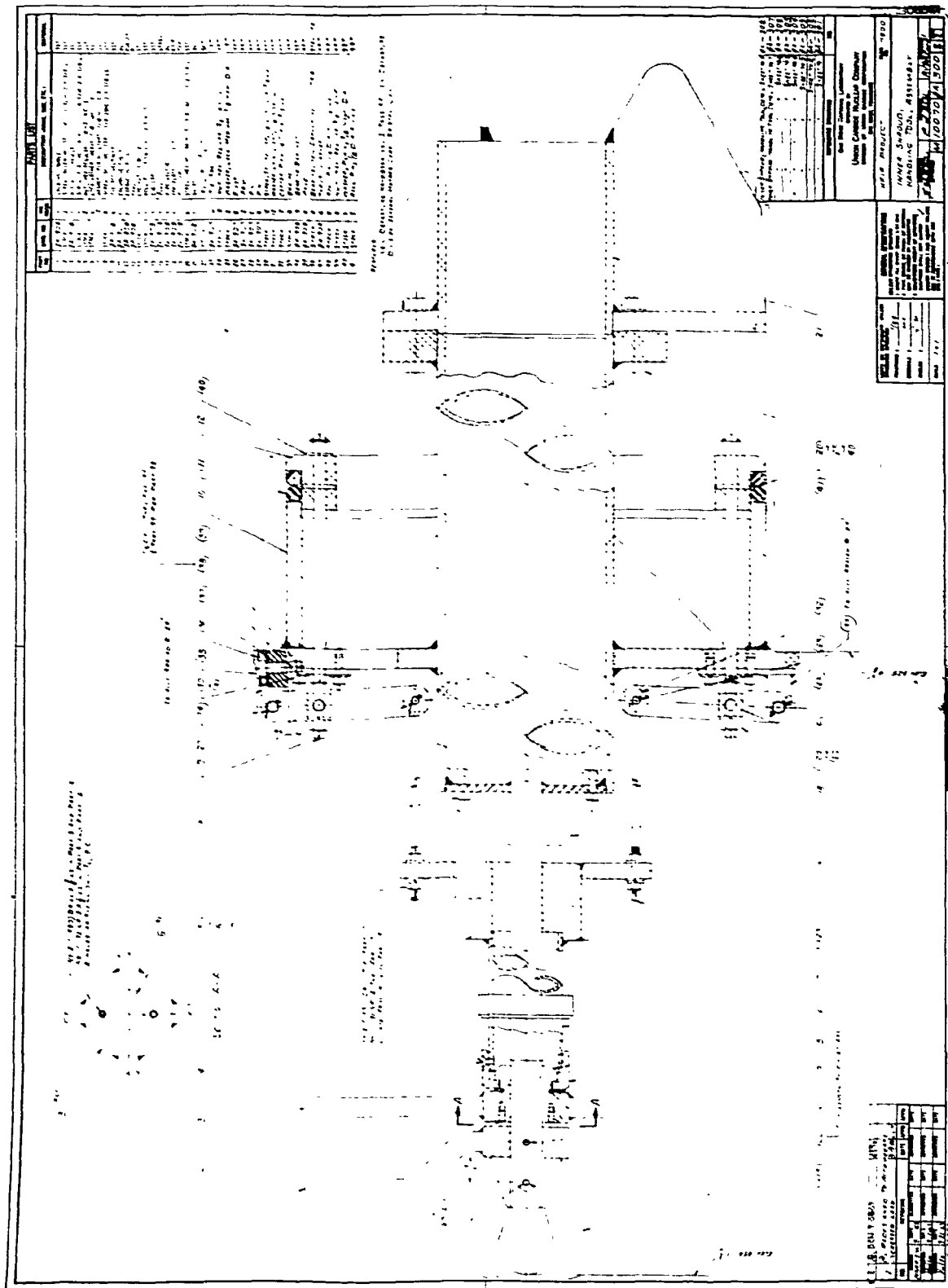


Fig. 4.14. Inner shroud handling tool.

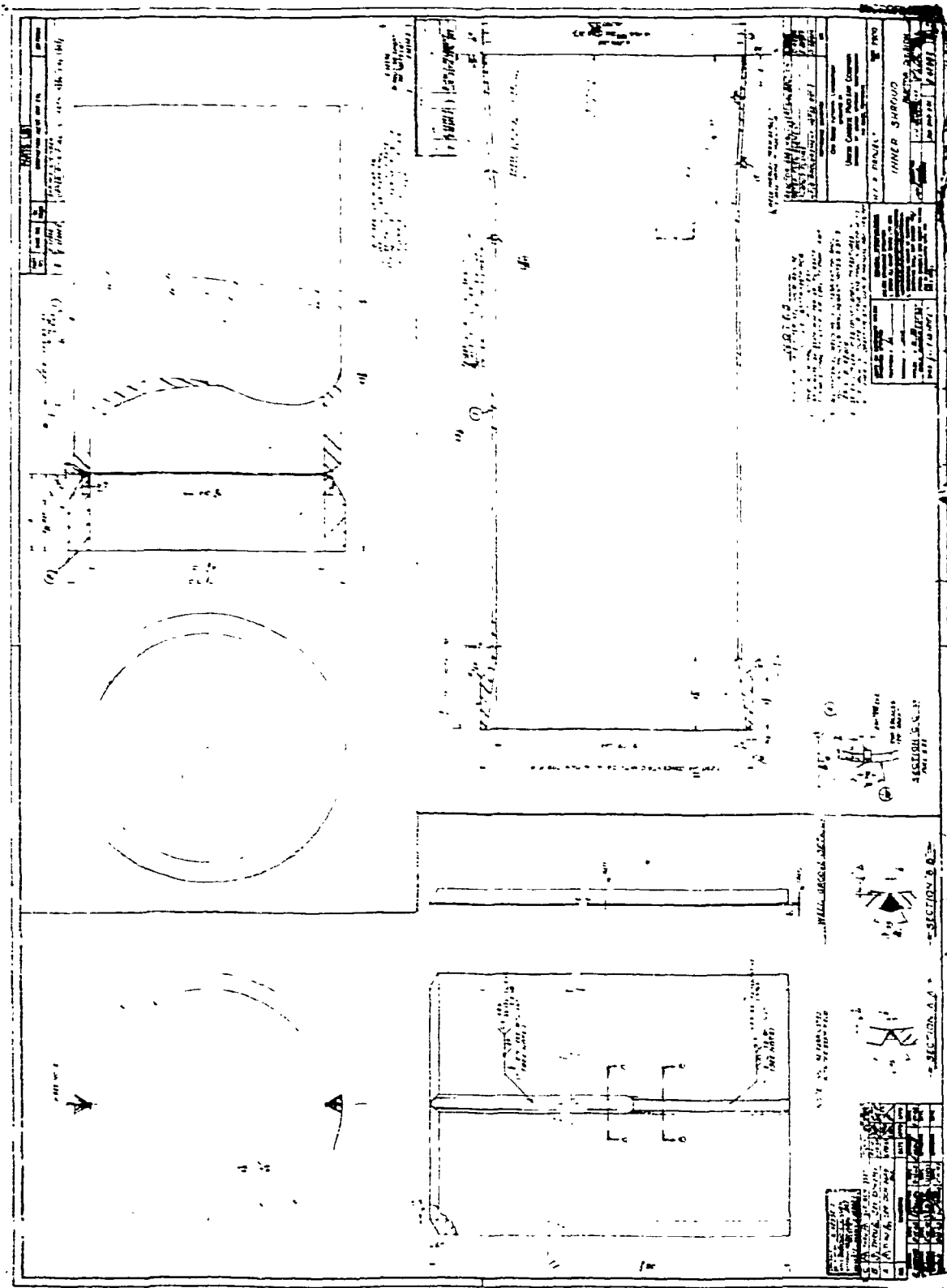


Fig. 4.15. Inner shroud.

m. Remove the shroud and tool to storage.

5. Replacement Procedure

a. Reverse the removal procedure.

b. NOTE: If the weight on the scales decreases before the shroud is seated, it is an indication that the shroud is sticking. Stop insertion immediately and slowly remove the shroud and try again.

c. The inner shroud should be seated in a manner such that the "pick-up" lugs will be aligned with the three vessel flange lugs. Thus, when the inner element is inserted, the guides of the inner element handling tool can be positioned so they will miss the shroud lugs as the element is seated.

d. When the shroud is seated, check the elevation marking on the tool extension handle.

e. Exert an upward force of approximately 90 lbs to relieve the friction between the tool and shroud and disengage the tool from the shroud.

f. Remove the inner shroud handling tool and guide post to storage.

4.2.8 Outer fuel element

1. References

Drawings:

E-42126 Outer Fuel Element Assembly

M-10070-QA-100-E Outer Fuel Element Handling Tool Assembly

2. Tools Required

a. Outer Fuel Element Handling Tool

b. Guide Post Assembly and Handling Tool

3. Data

- a. Weights: Outer Fuel Element - dry 205 lbs,
underwater 120 lbs
Tool and Element - underwater 205 lbs
Tool-underwater 85 lbs
- b. Dimensions: 31.125-in. Length, 17.134-in.-OD
- c. Material: 93% $^{235}\text{U}_3\text{O}_8$ -Al cermet; Al 6061-T6
cladding and sideplates

4. Removal Procedure

- a. Complete removal procedure 4.2.3, .4, .5, .6, and 7.
(NOTE: The guide post must be in position as it was for removal of the inner shroud.)
- b. Attach the outer fuel element handling tool to the tool carriage assembly (see Fig. 4.16).
- c. Lower the fuel element tool, permitting it to telescope over the guide post. Allow the support flange of the tool to rest over the inner adaptor (see Fig. 4.17).
- d. Engage the tool with the element by rotating the worm gear extension rod approximately 16 turns clockwise. This rotates the cam lugs so that they will support the weight of the element. The attachment of the tool to the element must be verified by the engineer and one operator.
- e. Slowly exert an upward force of approximately 435 lbs and lift the element approximately 3/4 in. to disengage the close tolerance fit to the fuel grid. The force required to raise the element will vary according to the water flow. A force of 450 lbs has

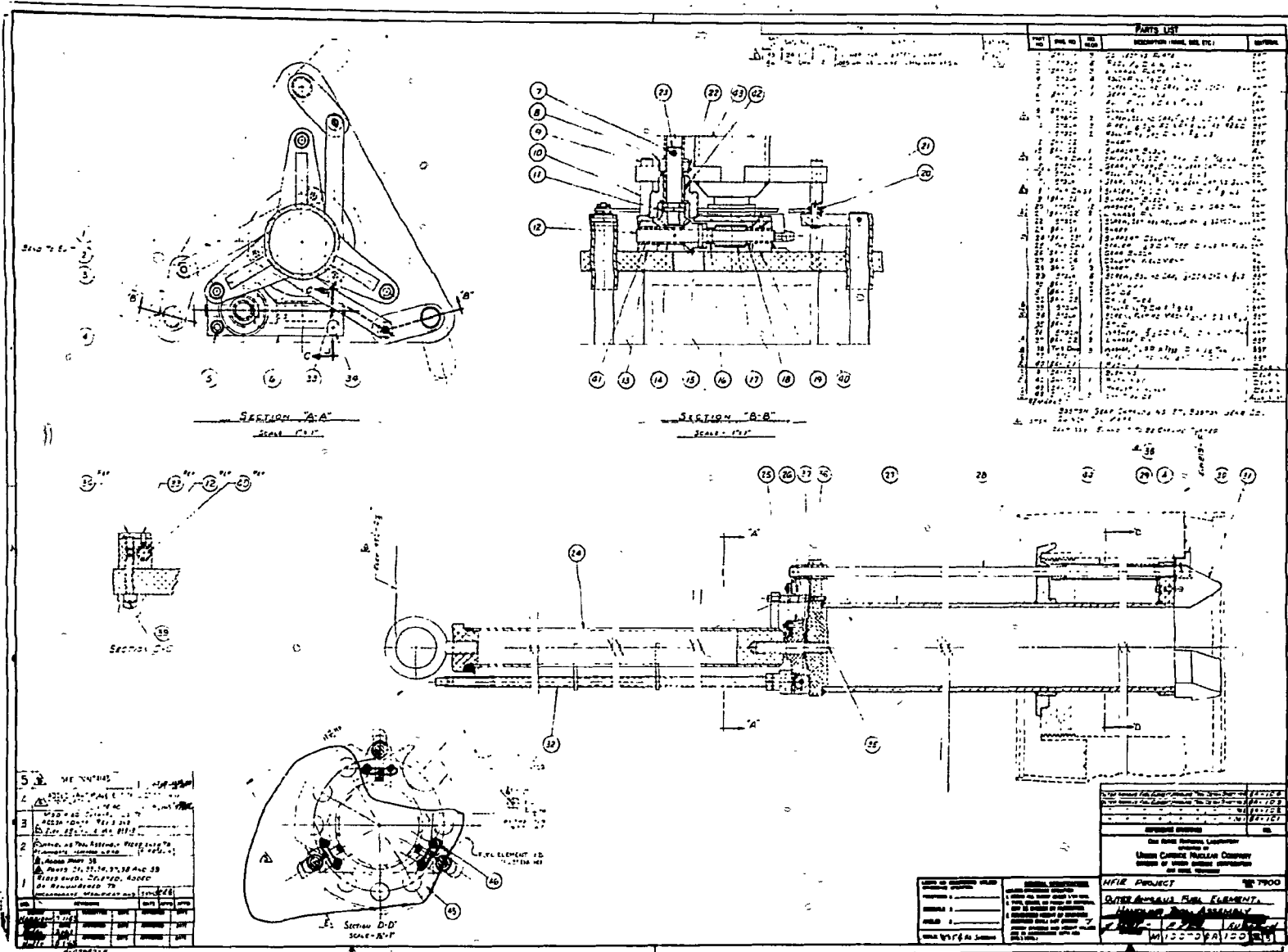
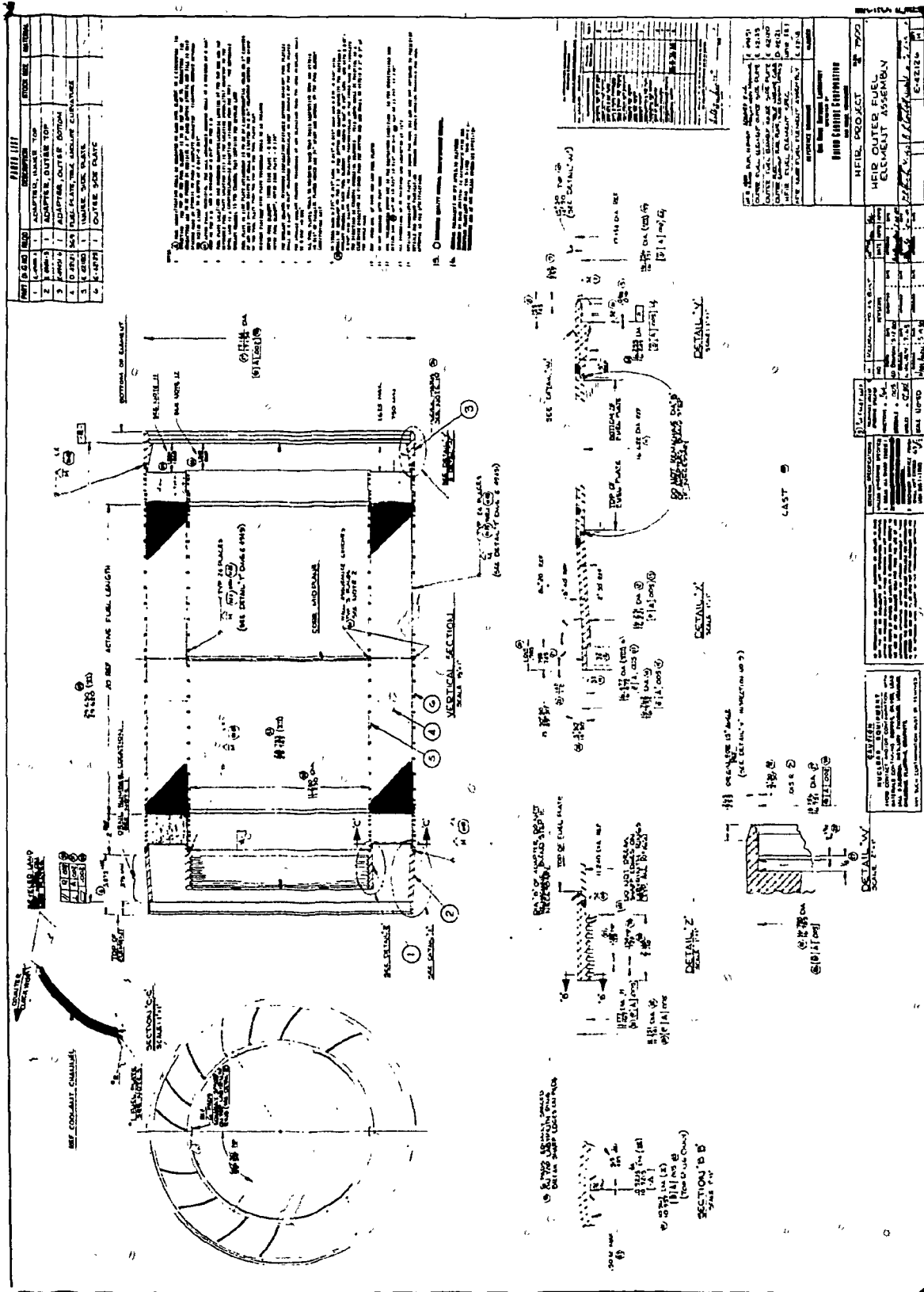


Fig. 4.16. Outer fuel element handling tool.



been observed with a flow of approximately 3,000 gpm. A breaking force - to separate the element from the fuel grid - greater than 900 lbs should not be required.

- f. Slowly raise the element until it clears the outer shroud, tool guide post and vessel. The lifting force should decrease as the element is removed from the water flow stream.
- g. Store the element in a storage rack, position No. 2, in the west clean pool and place a screen over it.

5. Replacement Procedure

- a. Reverse the removal procedure. The attachment of the tool to the element must be verified by an engineer and one operator.
- b. If the weight on the scales decreases during insertion, stop and withdraw the element slowly; then try again. A decrease in the scale reading before seating may indicate binding.
- c. After seating the element, check the elevation markings on the tool to assure the element is properly seated.
- d. Remove the tools to storage.

4.2.9 Fuel grid assembly

1. References

Drawings:

E-42081 Reactor Assembly - Elevation 817 ft, 10 in.
to 822 ft, 3 in. (see
Fig. 4.18)

E-42375 Fuel Grid Assembly

Fig. 4.18. Fuel region.

M-10070-0A-600-E Fuel Grid Assembly, Handling Tool
Assembly

M-10070-0A-610-E Fuel Grid Assembly, Bolt Handling Tool

2. Tools Required

- a. Fuel Grid Handling Tool
- b. 15/16 in. Socket Head Bolt Handling Tool

3. Data

- a. Weights: Fuel Grid - dry 54 lbs,
underwater ~45 lbs
Fuel Grid Tool - underwater 60 lbs

b. Dimensions: 17-in.-OD, 8 3/16 in.-height

c. Material: SST-347, outer cylinder SST-336

4. Removal Procedure

- a. Complete removal procedure 4.2.3, 4, .5, .6, .7, and .8.
- b. Remove the tool guide post.
- c. Attach the fuel grid handling tool to the tool carriage (see Fig. 4.19).
- d. Lower the tool, allowing the guide to engage with the shroud flange.
- e. Continue lowering the pipe column (through the guide) until the pipe column engages the fuel grid.
- f. Rotate the assembly clockwise so the lifting hooks are positioned under the ribs of the fuel grid (see Fig. 4.20).
- g. Rotate the drive tube counterclockwise approximately 28 turns until hand tight. This causes the lifting hooks to move upward, clamping the grid to the tool.
- h. Insert the 15/16 socket head fuel grid bolt tool over



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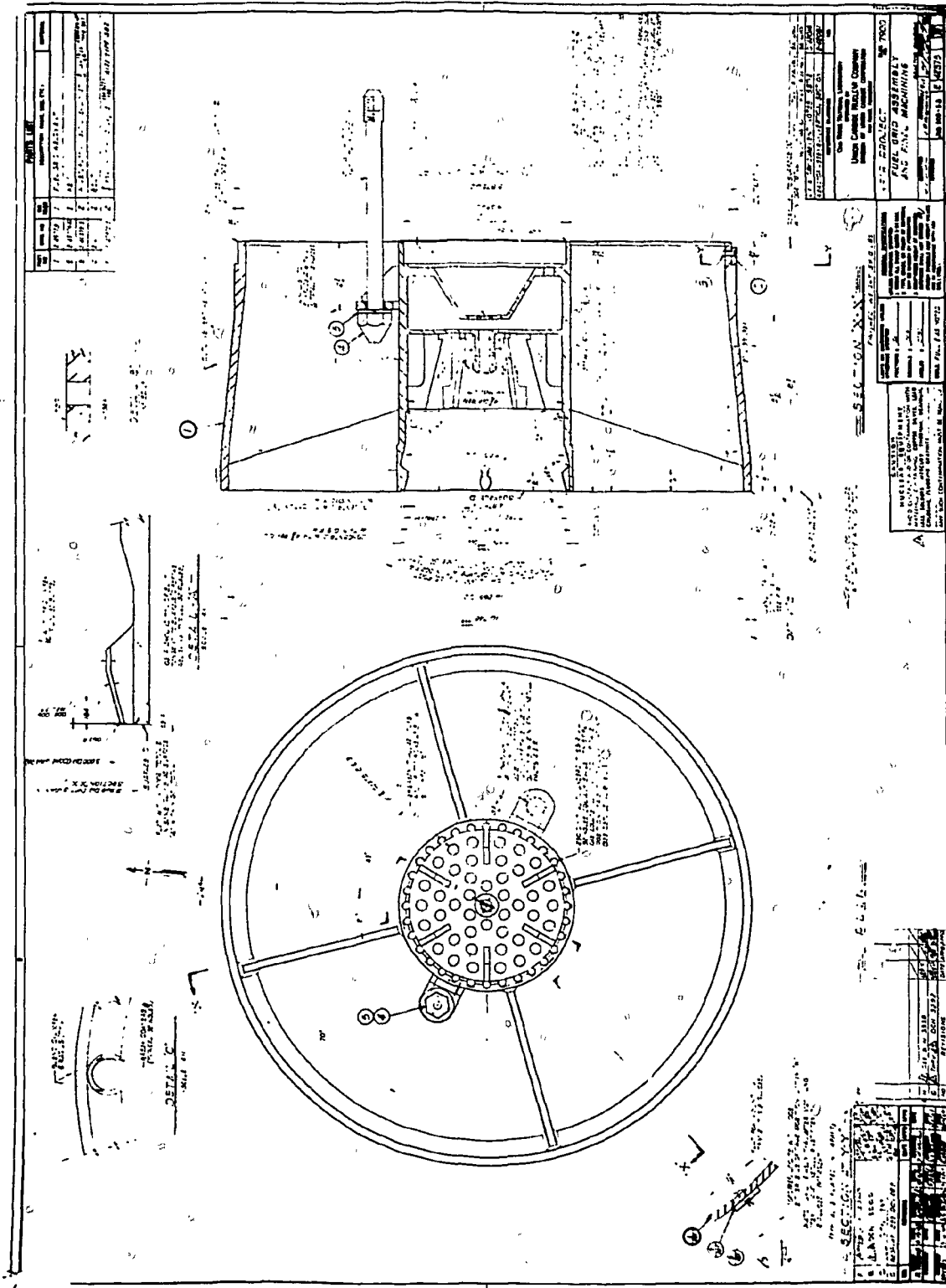


Fig. 4.20. Fuel grid.

the bolt. Engage the inner rod of the tool into the bolt head by rotating it clockwise approximately 4-7 turns until snug.

- i. Loosen the fuel grid bolts by rotating the T-handle part of the tool approximately 6 turns counterclockwise until it is free. Backthread the bolt 2 turns after lifting it upward to the stop.
- j. Loosen the center rod and remove the tool.
- k. Slowly exert a lifting force of 105 lbs and lift the grid $3/4$ in. This disengages the grid from its close tolerance fit to the fuel support pedestal. The lifting force will vary according to the water flow. A lifting force greater than approximately 300 lbs should not be required.
- l. Remove the grid from the vessel to storage.

5. Replacement Procedure

- a. Back thread the two holddown bolts in the assembly to prevent interference during installation.
- b. Attach the grid handling tool to the grid.
- c. Attach the handling tool and grid to the tool carriage assembly.
- d. Lower the tool with the grid attached and allow the tool guide to engage the shroud flange.
- e. Slowly continue to lower the grid and pipe column through the guide. (NOTE: The insertion of the grid should be done slowly and carefully, since horizontal movement of the grid could result in damage to the control plates.)

- f. When the grid is positioned on the top of the fuel support pedestal, rotate the grid so the positioning keys are in the NE and SW position, and thus fit into the slots provided in the fuel grid support.
- g. Bolt the grid 4-7 turns to the grid support. A torque of 30 ft-lbs is required.
- h. Remove the tool by rotating the drive tube approximately 28 turns clockwise. Then rotate the tool assembly counterclockwise, and slowly raise the assembly. Visually check to see that the grid was not displaced when the tool was removed.
- i. Slowly remove the tool from the vessel to storage.
- j. Check the scales to assure that the grid is detached.

4.2.10. Shroud flange

1. References

Drawings:

E-42080

Reactor Assembly - Elevation 822 ft, 3
in. to 826 ft, 0 in.

E-42383-2

Gasket Metallic O-Ring

E-49717

Shroud Flange Model "D"

M-10070-0A-900-E

Shroud Flange Handling Tool Assembly

M-10070-0B-810-E

Shroud Flange Spring Clamp Tool

2. Tools Required

- a. Shroud Flange Handling Tool and Guide Post
- b. Spring Clamp Handling Tool
- c. O-Ring Handling Tool

the bolt. Engage the inner rod of the tool into the bolt head by rotating it clockwise approximately 4-7 turns until snug.

- i. Loosen the fuel grid bolts by rotating the T-handle part of the tool approximately 6 turns counterclockwise until it is free. Backthread the bolt 2 turns after lifting it upward to the stop.
- j. Loosen the center rod and remove the tool.
- k. Slowly exert a lifting force of 105 lbs and lift the grid $3/4$ in. This disengages the grid from its close tolerance fit to the fuel support pedestal. The lifting force will vary according to the water flow. A lifting force greater than approximately 300 lbs should not be required.
- l. Remove the grid from the vessel to storage.

5. Replacement Procedure

- a. Back thread the two holddown bolts in the assembly to prevent interference during installation.
- b. Attach the grid handling tool to the grid.
- c. Attach the handling tool and grid to the tool carriage assembly.
- d. Lower the tool with the grid attached and allow the tool guide to engage the shroud flange.
- e. Slowly continue to lower the grid and pipe column through the guide. (NOTE: The insertion of the grid should be done slowly and carefully, since horizontal movement of the grid could result in damage to the control plates.)

- f. When the grid is positioned on the top of the fuel support pedestal, rotate the grid so the positioning keys are in the NE and SW position, and thus fit into the slots provided in the fuel grid support.
- g. Bolt the grid 4-7 turns to the grid support. A torque of 30 ft-lbs is required.
- h. Remove the tool by rotating the drive tube approximately 28 turns clockwise. Then rotate the tool assembly counterclockwise, and slowly raise the assembly. Visually check to see that the grid was not displaced when the tool was removed.
- i. Slowly remove the tool from the vessel to storage. Check the scales to assure that the grid is detached.

4.2.10. Shroud flange

1. References

Drawings:

E-42080	Reactor Assembly - Elevation 822 ft, 3 in. to 826 ft, 0 in.
E-42383-2	Gasket Metallic O-Ring
E-49717	Shroud Flange Model "D"
M-10070-0A-900-E	Shroud Flange Handling Tool Assembly
M-10070-0B-810-E	Shroud Flange Spring Clamp Tool

2. Tools Required

- a. Shroud Flange Handling Tool and Guide Post
- b. Spring Clamp Handling Tool
- c. O-Ring Handling Tool

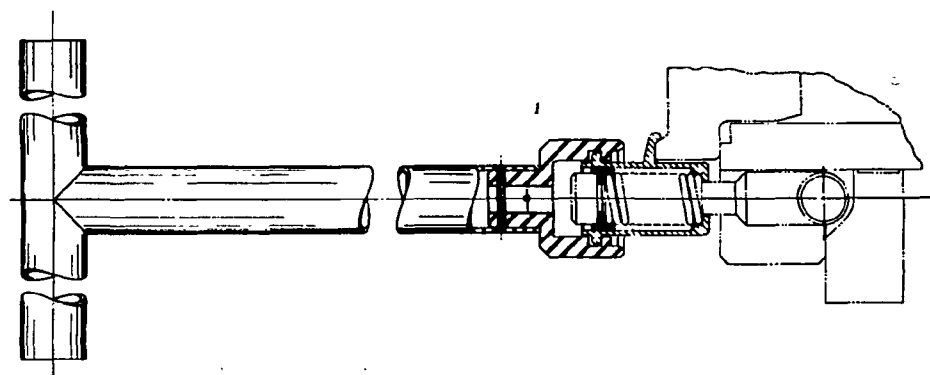
3. Data

- a. Weights: Shroud Flange - dry 206 lbs,
underwater ~180 lbs
Flange and Tool - underwater 270 lbs
- b. Dimensions: 17 1/4-in.-ID nominal; 29 7/8-in.-OD
maximum

4. Removal Procedure

- a. Procedures 4.2.3, .4, .5, .6, and .7 must be completed prior to the removal of the shroud flange.
- b. Use the spring clamp handling tool to rotate the 10 spring clamps which hold the shroud flange down (see Fig. 4.21). This tool is operated by placing it on the spring clamp and rotating it counterclockwise until a stop is reached. Lift slightly and then rotate the clamp further to the second stop.
- c. Attach the flange handling tool to the tool carriage and lower the tool into position (see Fig. 4.22).
- d. Continue inserting the tool until the aligning and lifting nose of the tool is in position. This occurs when the positioning screws contact the top of the flange and prevent further insertion of the tool.
- e. Using a hook tool, lift each of the four spring-loaded latches approximately 3/4 in. and rotate so that the latch engages the tool.
- f. Slowly exert a lifting force of approximately 270 lbs and lift the flange so that the two positioning lugs of the flange disengage from the outer shroud at the same time. This should prevent binding by either of the lugs.

PARTS LIST			
PART	DWG NO	REQD	
DESCRIPTION		STOCK SIZE	MATERIAL



4-50

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1. BREAK ALL SHARP EDGES		2. TYPE, GRADE, OR FINISH OF MATERIAL MAY BE CHOSEN BY FABRICATOR		3. MACHINED SURFACE FINISH SHALL NOT EXCEED (SEE DWS 1-1967)		FRACTIONS =		DECIMALS =		ANGLES =		CHECKED		APPROVED	
SCALE		✓													

REFERENCE DRAWINGS		PLANNER
ONE SOME NATIONAL LABORATORY		
OPERATED BY		
UNION CARBIDE CORPORATION		
ONE MOORE, TENNESSEE		
BLDG NO		
SHOGUO FLANGE SPRING CLAMP-MODEL 'A' HANDLING TOOL ASSEMBLY & DETAILS		
DESIGNED BY		APPROVED BY
DEF DWG		00 010 010 010

Fig. 4.21. Spring clamp handling tool.

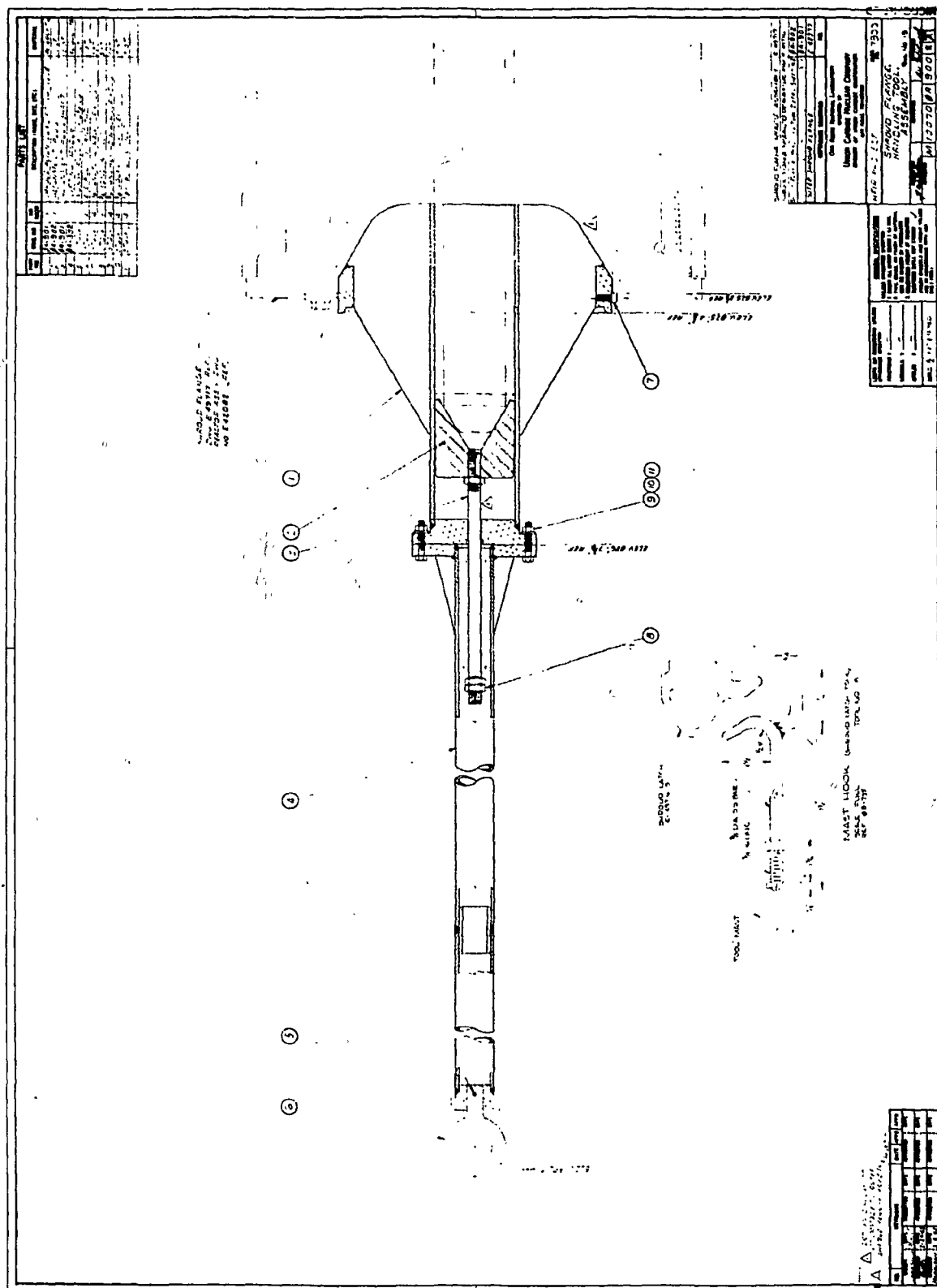


Fig. 4.22. Shroud flange handling tool.

- g. Remove the flange to storage.
- h. Inspect the stainless steel O-ring (E-42383-2) which remains on top of the shroud.

5. Replacement Procedure

- a. The tool guide post is required.
- b. The O-ring should be replaced only if damage is verified.
- c. Reverse the removal procedures.
- d. The positioning lugs make it necessary to properly orient the flange in order for the lugs to engage the outer shroud.

4.2.11 Inner control cylinder

1. References

Drawings:

E-42081	Reactor Assembly - Elevation 817 ft, 10 in. to 822 ft, 3 in.
E-42209	Inner Control Rod Drive Rod, Bearing and Connector Assembly
M-10070-ØB-420	Inner Control Rod Holddown Nut Model "B" Handling Tool Assembly
M-10070-ØB-500	Inner Control Rod Assembly, Handling Tool Assembly
M-10070-ØB-510	Inner Control Rod Storage Stand Assembly

2. Tools Required

- a. Holddown Nut Tool
- b. Inner Control Rod Handling Tool

3. Data

- a. Weights: Control Cylinder - dry 144 lbs
Tool and Cylinder - underwater 190 lbs
Holddown Nut Tool - underwater ~50 lbs
- b. Dimensions: Control Cylinder - 68 3/8 in.-length
17.842 in.-OD, 17.342 in.-ID
- c. Material: White region - aluminum 6061
Gray region - 40 vol % tantalum in aluminum
Black region - 33 vol % Eu_2O_3 clad with
aluminum

4. Removal Procedure

- a. Complete removal procedures 4.2.3, .4, .5, .6, .7, .8, .9, and 10.
- b. The drive unit should be at the insert limit.
- c. While standing on top of the vessel, use a 1-in. socket tool to loosen the lockscrew counterclockwise approximately 12 turns.
- d. Lower the locknut removal tool onto the locknut. Rotate the nut locking device to the locked position as shown on top of the tool. Test lift the tool to make sure it is attached to the lockscrew (see Fig. 4.23).
- e. Rotate the entire tool counterclockwise approximately 12 turns until the locknut is free of the drive rod.
- f. Carefully remove the tool with the locknut contained within the locking device of the tool.
- g. Attach the inner control rod handling tool to the tool carriage (see Fig. 4.24). Position the assembly over the quick-opening hatch opening.

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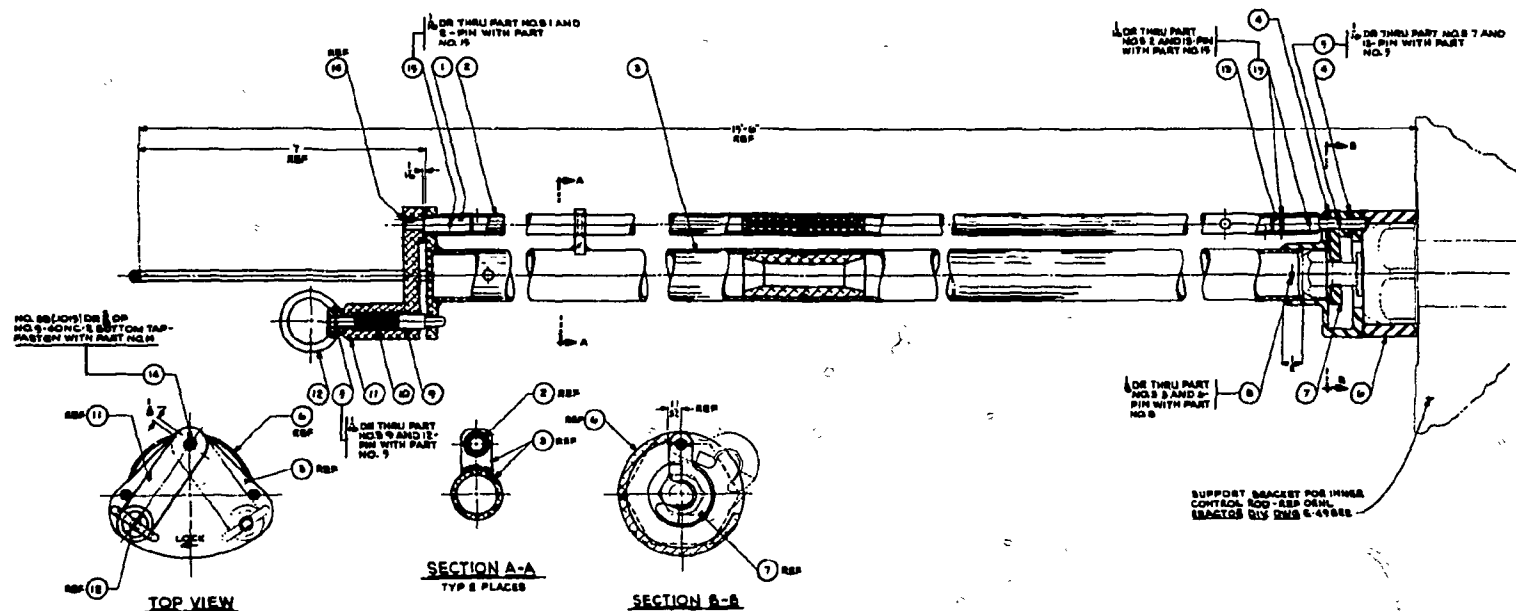


Fig. 4.23. Holddown nut tool.

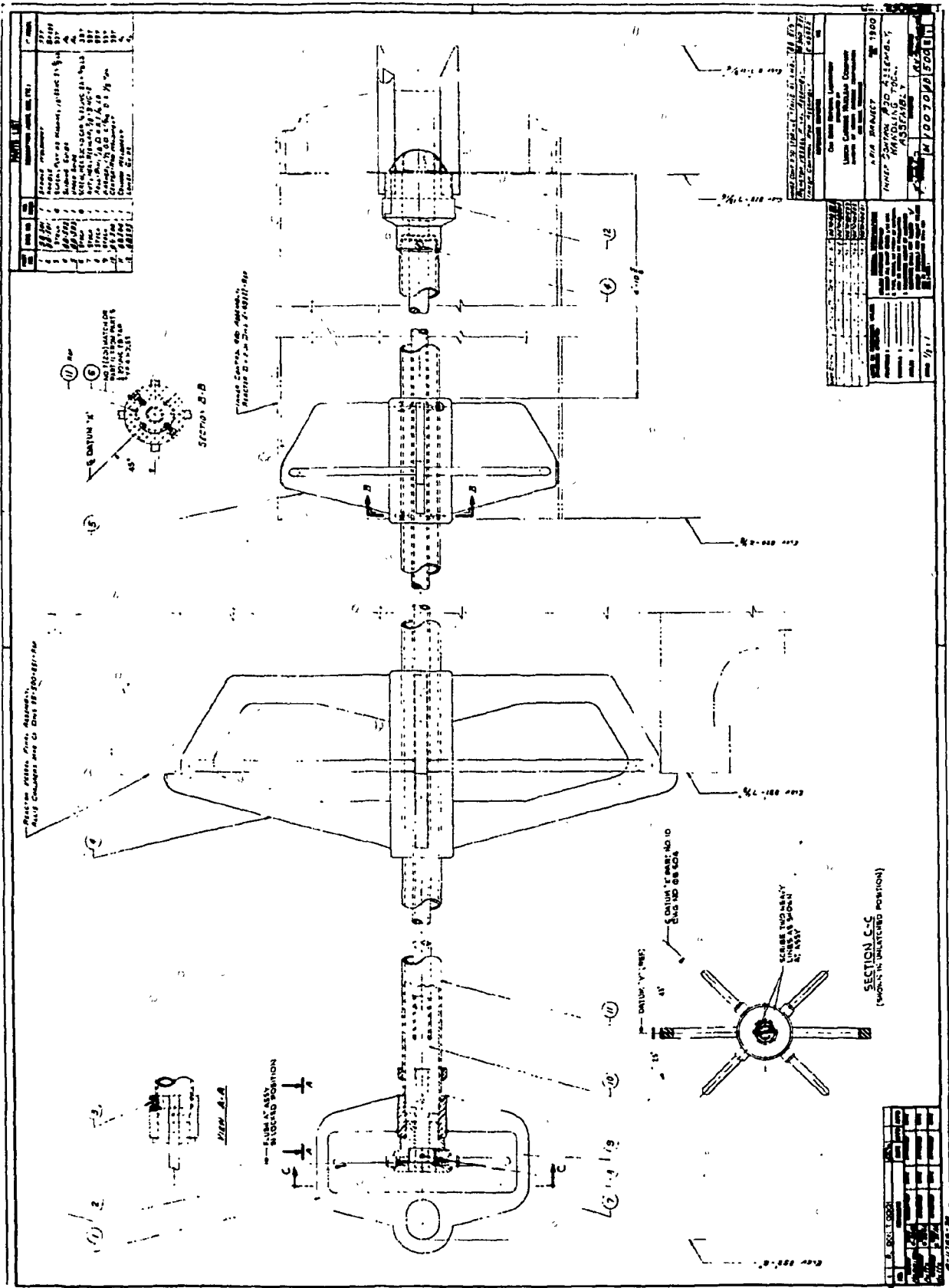
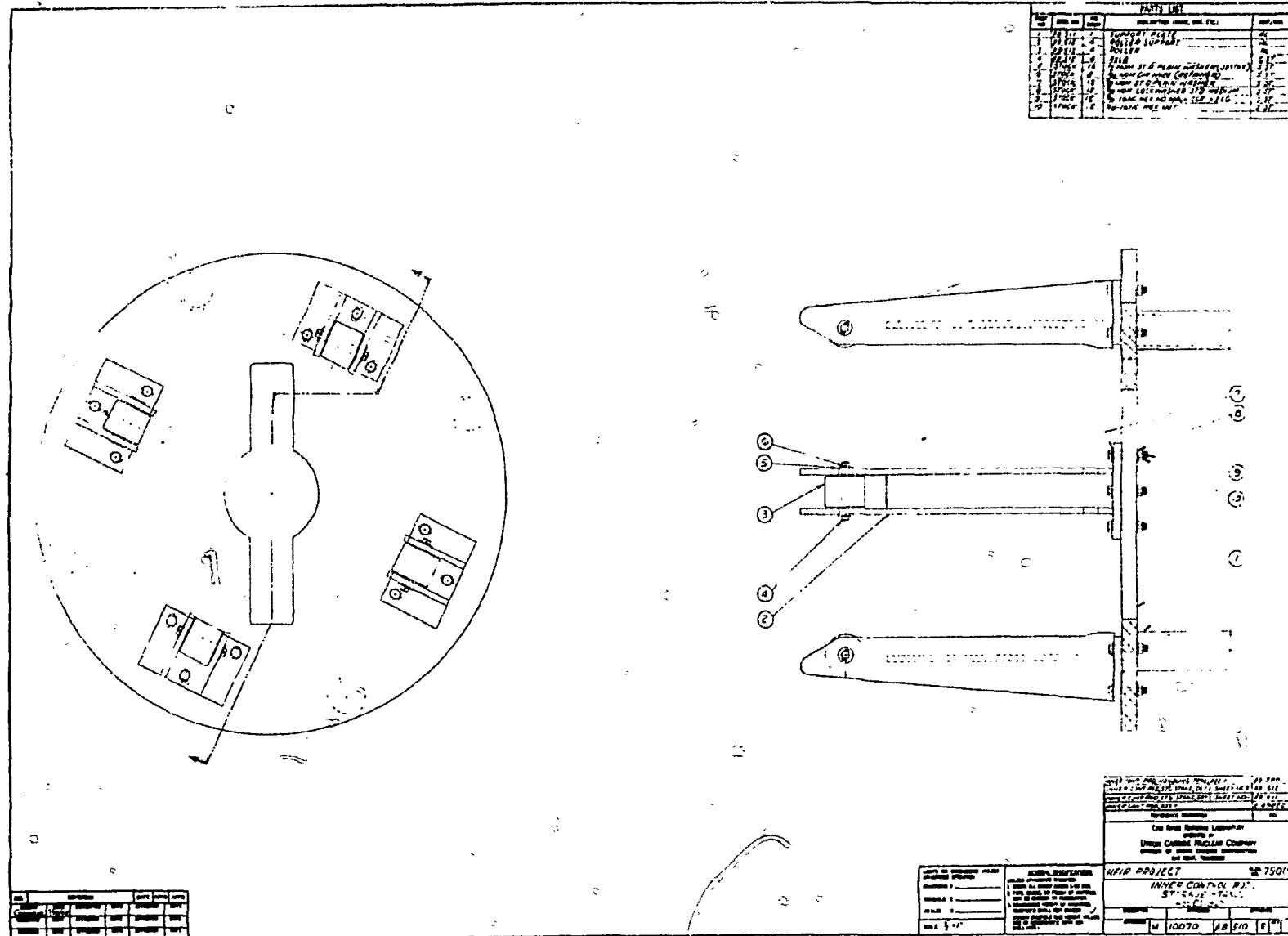


Fig. 4.24. Inner control rod handling tool.

- h. Slowly lower the tool through the opening and allow the sliding guide to engage the vessel flange as shown. Observe and maintain the direction of the pick-up fingers which should be in alignment with the openings in the control-rod-drive bracket.
 - i. Continue lowering the tool until the upper guide engages the control cylinder.
 - j. Lower the tool still further and allow the lower guide and the pickups to enter the control-rod-drive bracket.
 - k. Rotate the handle of the center rod weldment clockwise. This causes the pick-ups to rotate under the arms of the control-rod-drive bracket. Continue to rotate the handle clockwise. This causes the pickups to move up to the bracket arm, and thus secure the control rod to the handling tool. The top of the hex nut of the center rod weldment should be flush with the top of the hub of the handwheel when the control cylinder is engaged and locked.
 - l. While closely observing the spring scales, exert a lifting force of approximately 190 lbs and raise the tool and control rod assembly off the inner drive rod.
 - m. Remove the control rod and tool from the vessel and store it in the inner control rod storage stand assembly (see Fig. 4.25).
5. Replacement Procedure
- a. Attach the handling tool to the tool carriage and engage the inner control rod. Position the assembly



over the hatch opening. Orient the control cylinder brackets to coincide with the slots in the fuel grid support pedestal.

- b. Lower the assembly into the hatch opening and allow the sliding guide to engage the vessel flange.
- c. Continue lowering the assembly slowly, allowing control rod drive bracket to telescope over the drive rod. When the control rod is in position, check the position markings on the tool.
- d. When assured that the control rod is in position, remove the control rod handling tool by rotating the handle counterclockwise until the pick-ups are free of the bracket arm and remove the tool to storage.
- e. Lower in the locknut tool, which still retains the locknut, into place and turn the entire tool clockwise approximately 12 turns until tight. Apply approximately 10 ft-lbs torque on the locknut.
- f. Rotate the nut locking device to the unlocked position and remove the tool.
- g. Tighten the lockscrew approximately 12 turns with a 1-in. socket tool. Apply approximately 5 ft-lbs torque to tighten the lockscrew.

4.2.12 Control plate access plugs

1. References

Drawings:

E-42310	Reactor Assembly - Elevation 821 ft, 6 1/2 in.
E-42380	Control Rod Access Plug Assembly

E-49660 Control Rod Access Plug, Curium Rod
Facility

2. Tools Required
 - a. Hook Tool
 - b. Curium Rod Facility Handling Tool
3. Data
 - a. Weights: Plug-dry 15 lbs
 - b. Material: Plug-beryllium: hanger weldment, eye, and rod-aluminum 6061.
4. Removal Procedure (Standart Access Plug)
 - a. Procedures 4.2.3, .4, .5, .6, and .7 must be completed prior to removal of the access plugs.
 - b. Insert the plug handling tool hook into the tie rod eye of the plug assembly and lift up (see Figs. 4.27 and 4.28).
 - c. Remove the plug from the vessel and store in the plug storage rack. The plug may be stored within the upper tracks if the tracks are to remain in the vessel.
5. Replacement Procedure
 - a. Engage the plug assembly tie rod eye with the hook. Lower the plug into place and make sure it is seated.
 - b. Remove the tools from the vessel to storage.
6. Removal Procedure (Curium Rod Facility Access Plug)
 - a. Complete step 4.1. above.
 - b. Carefully lower the curium rod facility handling tool (see Fig. 4.26) into the tracks at the specified location and allow it to come to rest atop the plug.

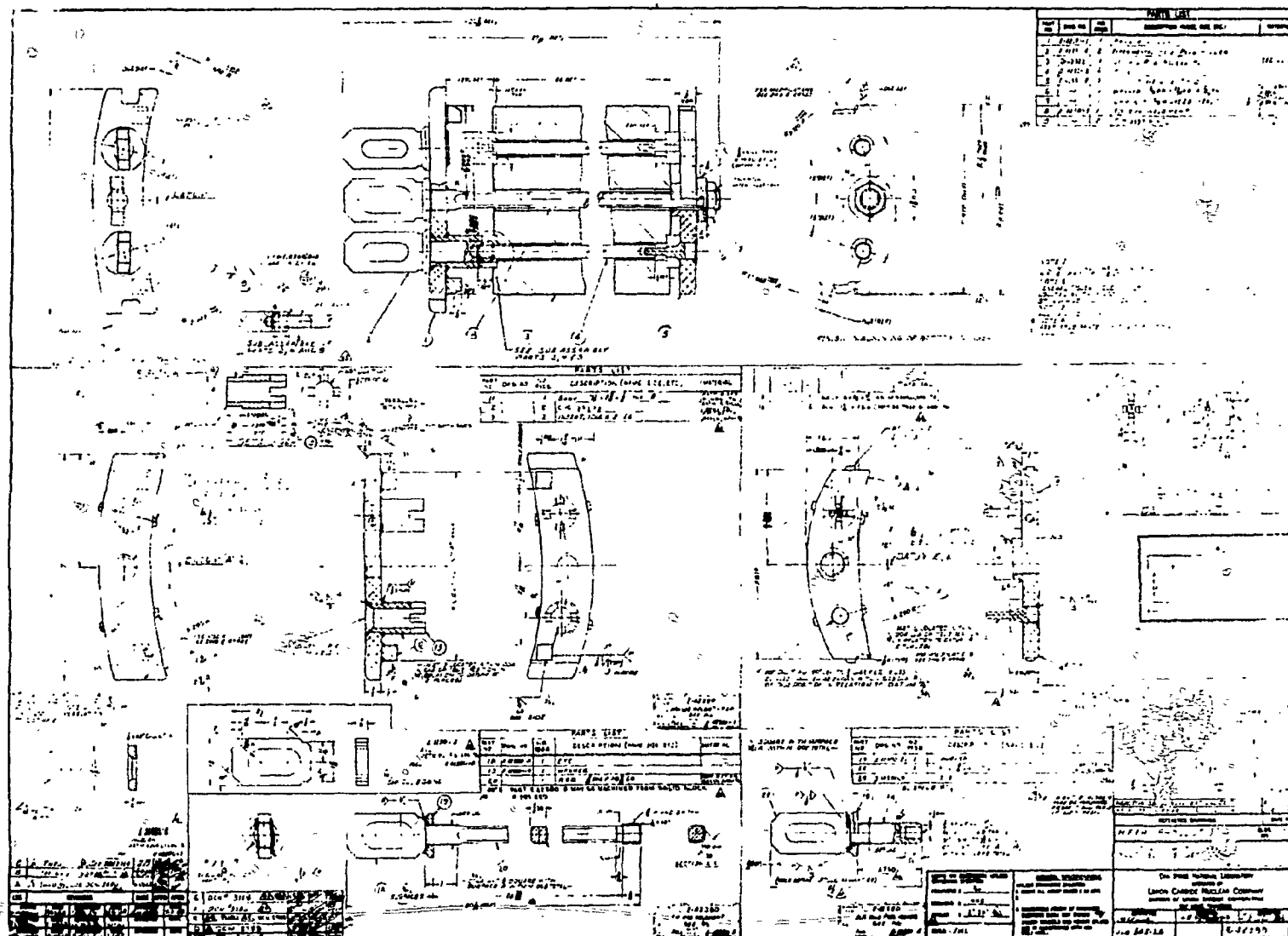


Fig. 4.27. Access plug assembly.

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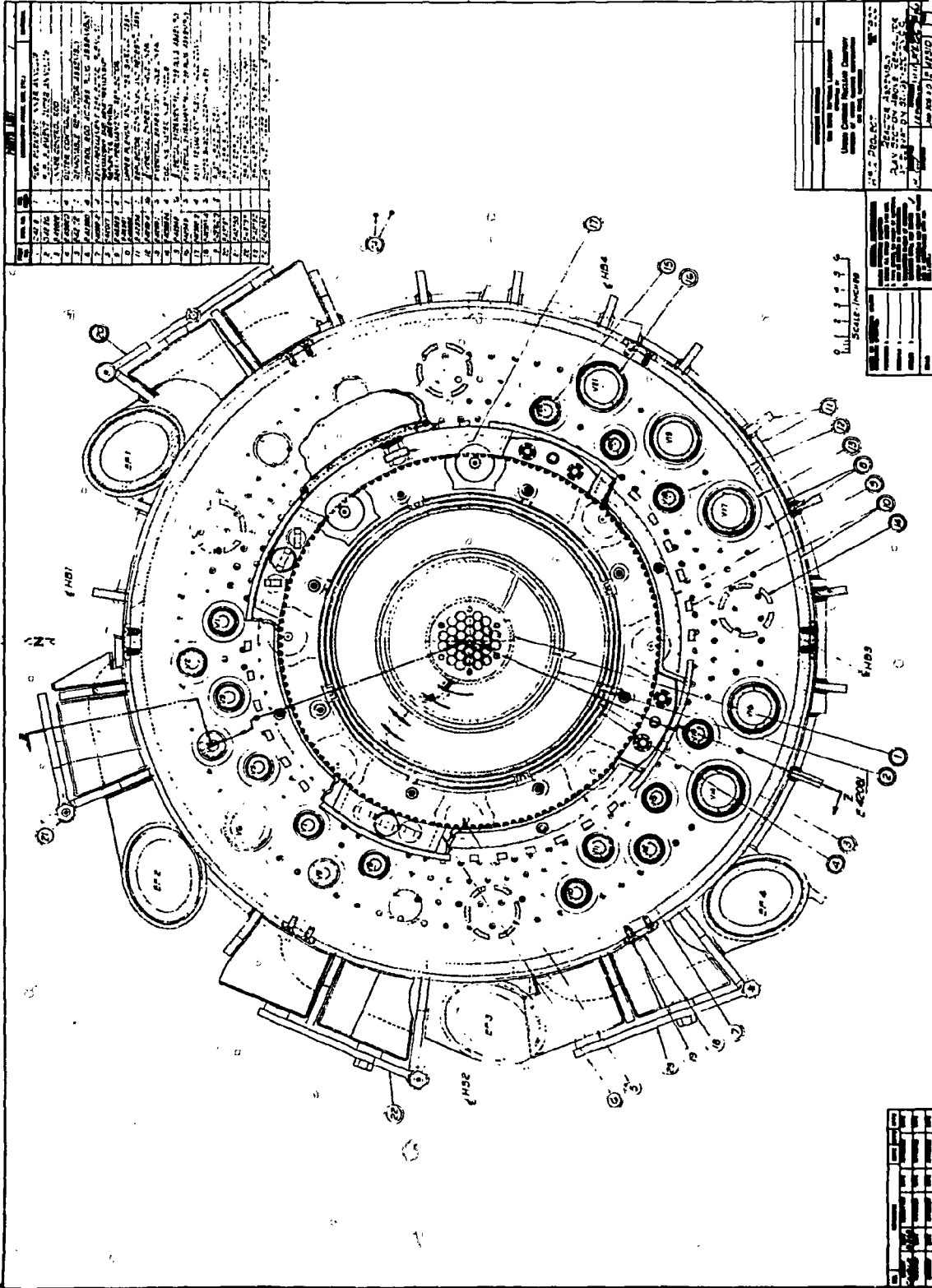


Fig. 4.28. Assembly at elevation 821 feet.

Proper alignment and positioning of the tool in necessary for safe handling.

- c. Rotate the tool operator approximately 12 turns clockwise or until it is hand tight.
- d. Remove the plug from the vessel and store in the plug storage rack.

7. Replacement procedure

Reverse the removal procedure.

4.2.13 Outer control plate

1. References

Drawings:

E-49820	Outer Control Rod Assembly
E-42337-22	Piston and Coupling Subassembly
M-10070-OB-730-E	Outer Control Rod Storage Stand Assembly
M-10070-OB-620-E	Outer Control Rod Coupling Tool Assembly

2. Tools Required

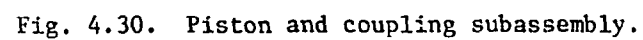
- a. Coupling Tool
- b. Special Hook Tool

3. Data

- a. Control Plate: Weight - dry 38 lbs
 Length - 66 3/16 in, with 13 9/16 in.
 Material - White region: aluminum 6061
 Gray region: 40 vol %
 tantalum in
 aluminum clad-
 ding
 Black region: 33 vol% Eu_2O_3
 in aluminum
 cladding

4. Removal Procedure

- a. Complete procedures 4.2.3, .4, .5, .6, .7, .8, .9, .10, .11, and 12 prior to removal of the outer control plate. The drive mechanism for the particular control plate should be fully inserted and the motor locked mechanically and electrically.
- b. Place the coupling tool through the control plate access into the coupling actuator so that the tapered end of the guide column weldment fits into the center of the coupling actuator and the push-button plunger fits into the spring-loaded locking pin hole in the coupling actuator (see Figs. 4.29 and 4.30).
- c. Push the plunger to hold the spring-loaded locking pin down.
- d. Rotate the saddle weldment counterclockwise approximately 30° . This allows the balls to recess into the cavity of the coupling ball cage, which in turn releases the coupling assembly from the piston adapter. Remove and store the coupling tool. The control rod can now be removed. The coupling assembly is fixed to the control rod flange and will be removed with the control plate.
- e. Insert the special hook tool into the upper hole in the center of the control plate. Test lift the plate to make sure the hook is fully inserted.
- f. Lift the control plate upward manually until the upper bearing touches the upper track support ring. Lower the plate approximately 1 in.



- g. Insert the second special hook tool into the hole near the bottom of the control plate and pull the bottom end of the plate approximately 10 in.
- h. When the bottom of the control plate is near the center of the reactor, lift the control plate upward and toward the reactor centerline, using the hook tool inserted into the upper hole. CAUTION: Do not bump the control plate against the tracks.
- i. Lift the control plate out with the special hook tool and move it to a storage rack (see Fig. 4.31).

5. Replacement Procedure

- a. Lower the control plate into the reactor vessel using the special hook tool.
- b. Insert the upper bearings into the upper tracks and while pushing outward at the bottom, insert the lower bearings into the lower tracks.
- c. Lower the control plate gently to its seat.
- d. Lock the control plate to the extension tube by rotating the coupling tool clockwise until the spring-loaded locking pin pushes the plunger of the tool upward. Check the lock by attempting to rotate the tool clockwise.
- e. Insert the special hook tool into the large hole near the top of each control plate and, by lifting, determine that the plates are locked to the extension tube.

4.2.14 Upper track Assembly

1. References

Drawings:

E-42080	Reactor Assembly - Vertical Section
E-49809	Upper Track and Bearing Assembly
M-10070-ØA-400-E	Guide Post Handling Tool
M-10070-ØA-800-E	Removable Reflector and Track Handling Tool Assembly
M-10070-ØA-810-E	Removable Reflector and Track Handling Tool Guide Post
M-10070-ØA-820-E	Removable Reflector and Track Handling Tool Arrangement
M-10070-ØA-850-E	Upper Track and Bearing Assembly Storage Stand

2. Tools Required

- a. 13/16-in. Socket Head Tool
- b. Track Handling Tool
- c. Track Handling Tool Guide Pose
- d. 15/16-in. and 5/8-in. Socket Head Tool

3. Data

- a. Weights: Track Assembly - dry 276 lbs
Track Assembly Handling Tool - dry 150 lbs
Guide Post - 85 lbs
Guide Post Handling Tool - dry 80 lbs
- b. Dimensions: Track Assembly - 38 5/8-in.-length, 24 1/2-in.
- width, OD nominal

4. Removal Procedure

- a. Complete removal procedures 4.2.3, .4, .5, .6, .7, .8, .9, .10, .11, .12, and .13.

- b. Attach the guide post handling tool to the guide post and then attach the assembly to the tool carriage assembly (see Fig. 4.32).
- c. Position the guide post onto the fuel support pedestal. Care should be exercised to clear the ^{16}N and fission chamber tubes. Remove the guide post handling tool.
- d. Using the 13/16-in. socket head tool, loosen the four hex nuts from the jam bolt by rotating the tool counterclockwise approximately 3 turns. Then use the removal tool, which will retain the nut, and remove the four nuts. Approximately 15 additional turns will be required (see Figs. 4.33 and 4.34).
- e. Loosen one centering roller locknut $1/2$ turn counterclockwise using the outside socket (15/16 in.) of the tool provided.
- f. Engage the inner sock (5/8 in.) of the tool and rotate the centering screw counterclockwise approximately three turns or until the roller is fully retracted.
- g. Repeat steps e and f for each of the four upper and four lower centering rollers.
- h. Attach the track handling tool to the tool carriage and lower into the reactor (see Fig. 4.35). Allow the middle flange of the tool column weldment to engage the top flange of the upper track assembly as shown in Fig. 4.36. Position the cams so they are just adjacent to four of the eight guide tubes which are located approximately in the middle of the track flange.



Fig. 4.32. Guide post.



Fig. 4.34. Reactor assembly.

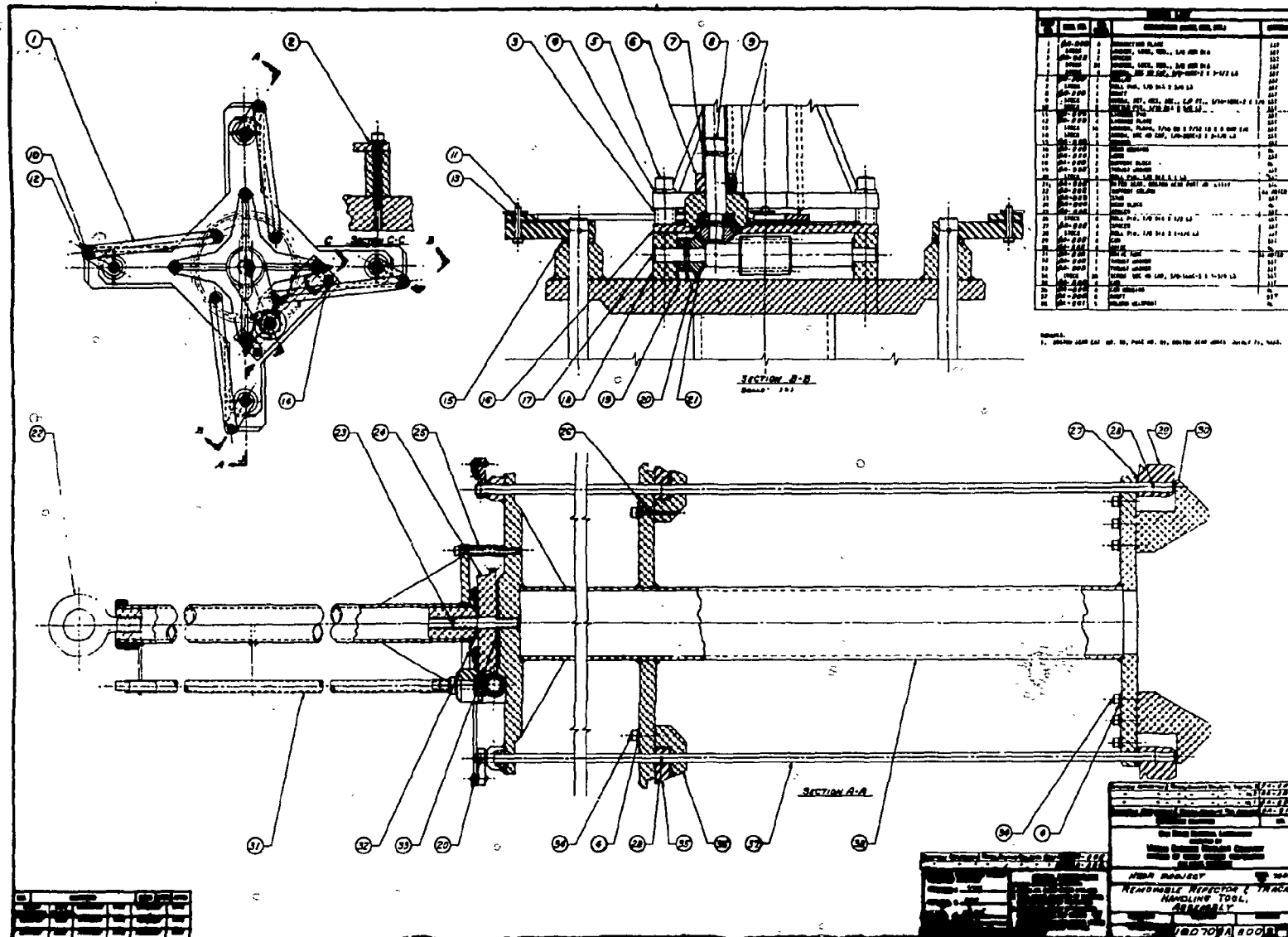


Fig. 4.35. Removable reflector and track handling tool.

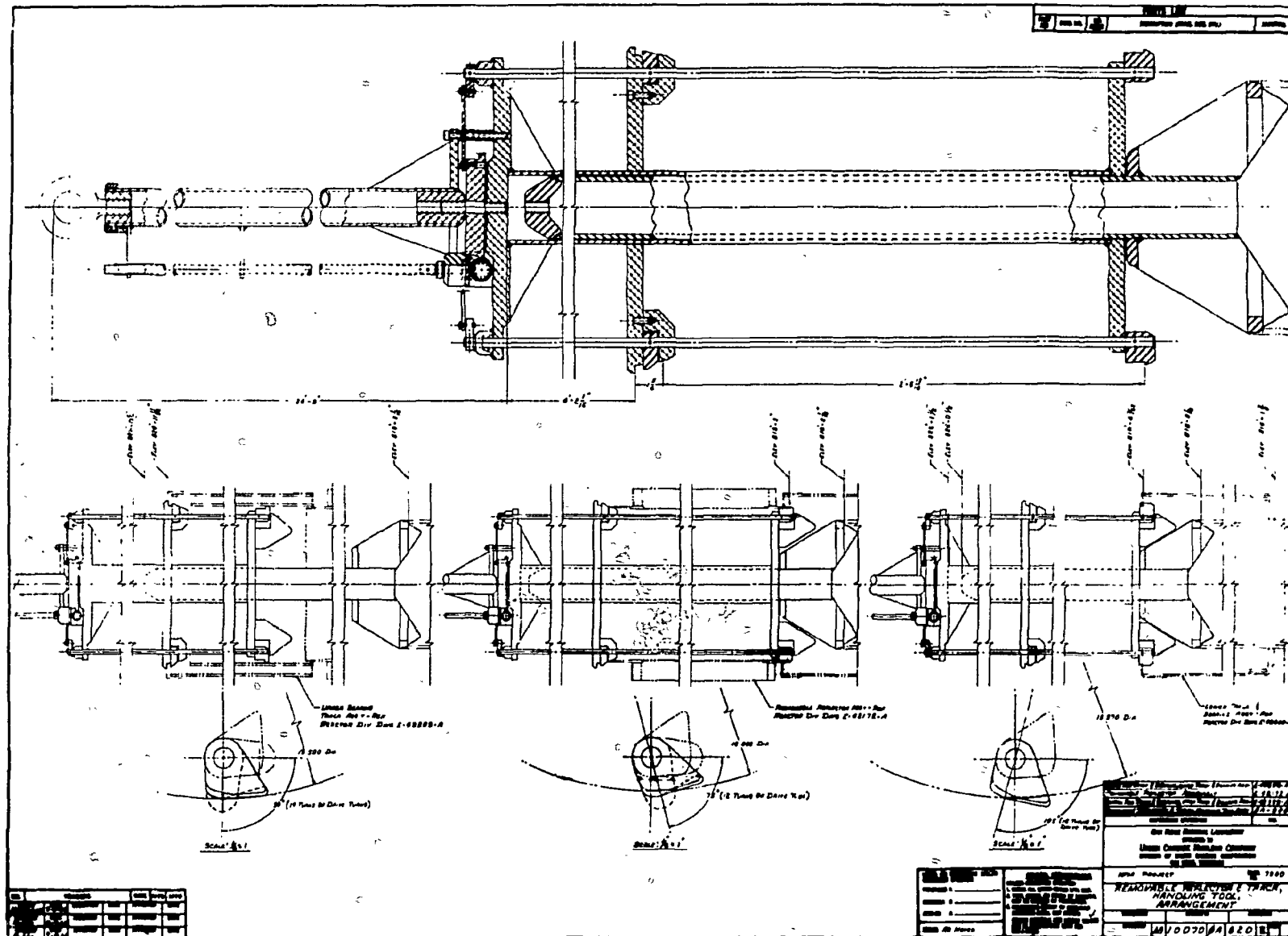


Fig. 4.36. Removable reflector and track handling tool arrangement.

- i. Engage the upper cam of the tool with the track assembly flange by rotating the tool drive counterclockwise approximately 7 turns. This should secure the track assembly to the track handling tool.
- j. Raise the track assembly slowly approximately 2 in. until the jam bolt is free of the support bracket. A lifting force of approximately 300 lbs will be required.
- k. Remove the track assembly and store it on the storage stand in either the reactor or clean pool (Fig. 4.37).

5. Replacement Procedure

- a. Attach the track handling tool to the tool carriage assembly and then to the track assembly.
- b. Transfer the track assembly to the vessel and lower into position.
- c. The proper orientation of the track assembly must be obtained, since this will give the minimum deviation from concentricity. The operator handling the track must orient it such that the arrow with an N in the middle, stamped on the top flange, is pointed north. This will also allow the four 1/2-in. locators on the lower ring of the track assembly to fall into the appropriate slots in the removable reflector containment ring.
- d. Slowly allow the holddown flange to position down over the jam bolt. At the same time that this occurs, the bottom flange of the track assembly will position over the containment ring of the removable reflector assembly. Then centering devices will also be bearing against the the outer shroud springs.

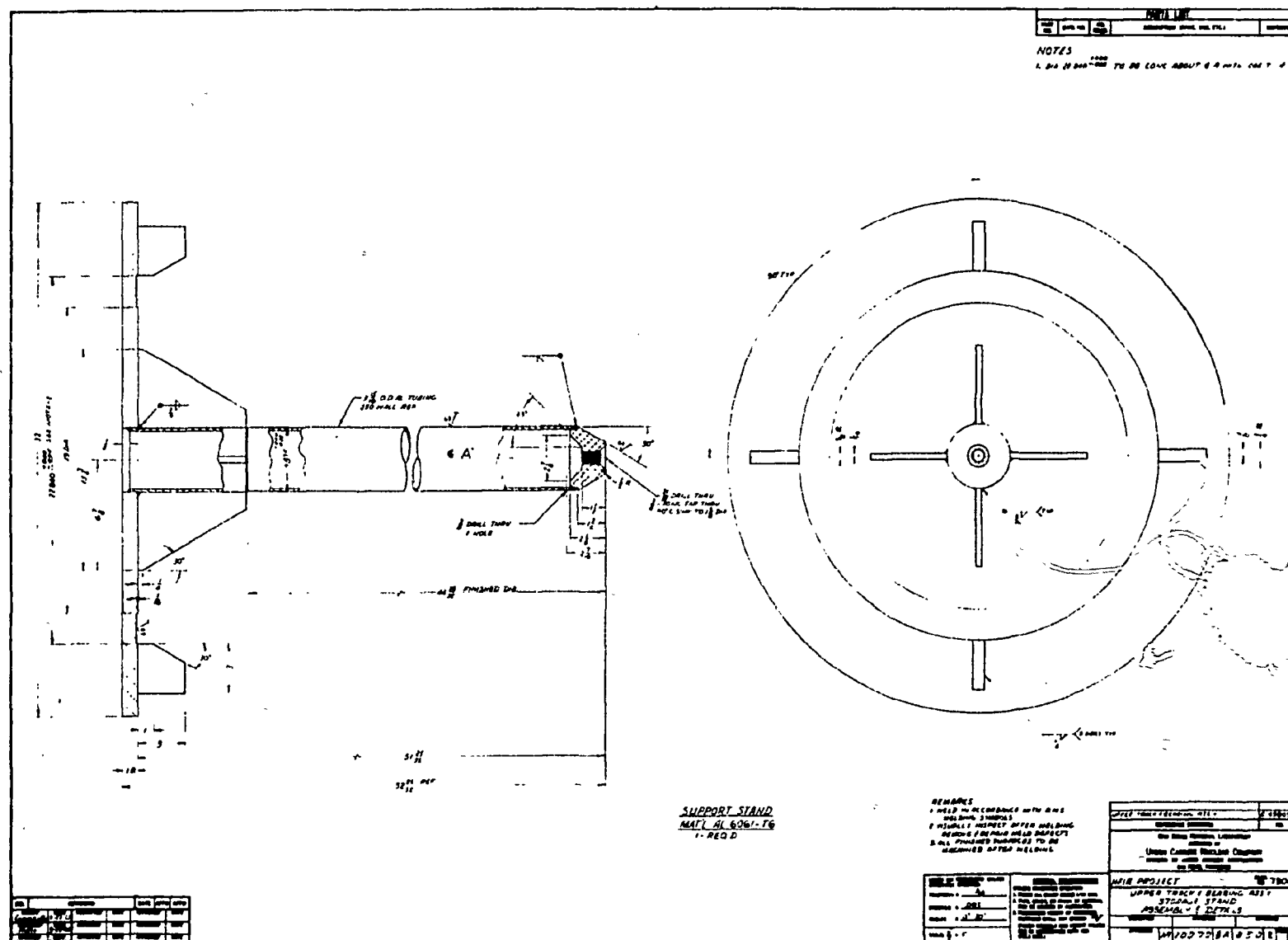


Fig. 4.37. Upper track storage stand.

- e. Check the elevation markings on the tool; and if the proper elevation has been obtained, remove the track handling tool by rotating the tool drive clockwise approximately 7 turns.
- f. Replace the four 13/16-in. hex nuts onto the hex bolts. This locks the track assembly in place. Apply approximately 16 to 18 turns and a torque of approximately 30 ft-lbs.
- g. Loosen one centering roller locknut 1/2 turn counter-clockwise using the outside socket (15/16 in.) of the tool provided.
- h. Engage the inner socket (5/8 in.) of the tool and rotate the centering screw clockwise until the centering roller is fully extended. Apply approximately 20 ft-lbs force to tighten.
- i. Tighten the locknut.
- j. Repeat steps 7, 8, and 9 for each of the four upper and four lower centering rollers.
- k. Remove all tools.

4.2.15 Removable and semipermanent reflector

Removable Reflector:

1. References

Drawings:

E-49445	Removable Reflector Assembly
E-42031	Reactor Assembly-Vertical Section Z-Z, 817 ft, 10 in. to 822 ft, 3 in.
M-10070-0A-400-E	Guide Post Handling Tool

M-10070-0A-800-E	Removable Reflector and Track Handling Tool Assembly
M-10070-0A-810-E	Removable Reflector and Track Handling Tool Guide Post
M-10070-0A-820-E	Removable Reflector and Track Handling Tool Arrangement
M-10070-0A-840-E	Removable Reflector Assembly, Storage Stand Assembly and Details

2. Tools required

- a. Reflector handling tool
- b. Reflector handling tool guide post

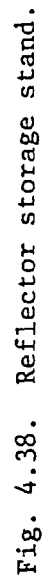
3. Data

- a. Weights: Reflector assembly - dry 279 lbs
Handling tool - dry 150 lbs
- b. Dimensions: Assembly - 30 39/64-in. length, 23.756-in. OD
Beryllium - 24.00-in. length, 23.756-in. OD
- c. Material: Containment Al-6061, Reflector - beryllium

4. Removal procedure

- a. Complete the removal procedure 4.2.3 through 4.2.14.
- b. Attach the reflector handling tool to the tool carriage and lower the tool into the vessel (see Fig. 4.35).
Allow the tool to telescope over the tool guide post.
- c. The tool should be positioned so that the bottom cams do not coincide with a slot in the lower containment ring. This is accomplished by placing the tool on the reflector and rotating it until it drops into a slot approximately 1 in. deep. There are four of these slots 90° apart. Any one will position the tool properly.

- d. Engage the bottom cams of the tool with the beryllium containment ring by rotating the drive counterclockwise approximately 6 turns (see Fig. 4.36).
 - e. Raise the reflector assembly very slowly approximately 3 in. while closely observing the scales. A lifting force greater than approximately 500 lbs should not be required.
 - f. Remove the assembly from the vessel and store it on the storage stand either in the reactor or clean pool (see Fig. 4.38).
 - g. Set the removable reflector on the storage stand without regard to orientation.
5. Replacement procedure
 - a. Attach the reflector handling tool to the tool carriage assembly and then to the reflector assembly.
 - b. Transfer the tool and reflector assembly to the vessel and lower into position.
 - c. The operator handling the reflector assembly must orient it such that the N (north) arrow stamped on the top of the containment ring will be point north. This allows the four 1/2-in. positioning slots in the lower containment ring to position over the four 1/2-in. locators on the lower track assembly.
 - d. Continue lowering the assembly until it is seated on the reflector container and pedestal assembly.
 - e. Check the elevation markings on the tool and when the proper elevation has been obtained, disengage the handling tool by rotating the drive clockwise approximately 6 turns.



f. Slowly remove the tool and return it to storage.

Semipermanent Reflector

1. References

Drawings:

E-42017	Permanent and Semipermanent Reflector Assembly
E-42081	Reactor Assembly - Vertical Section Z-Z, 817 ft, 10 in. to 822 ft, 6 1/2 in.
E-42310	Reactor Assembly - Plan Section Above Reflector, 821 ft, 6 1/2 in.
E-42323	Semipermanent Reflector Machining Details
E-49164	Semipermanent Reflector Plenum and Holddown Assembly
M-10070-ØB-925-E	Semipermanent Reflector Plenum and Holddown Handling Tool Assembly

2. Tools required

a. Handling tool (four total - one for each Be segment)

3. Data

- a. Weight of each segment - dry 28 lbs
- b. Size of each segment - 63° arc length at 13.125 in. R x 24 in. long x 1.118 in. thick
- c. Material: Reflector - beryllium, holddown assembly - Al 6061-T6

4. Work conditions

- a. Reactor pool water level at the grating.
- b. Prior to removal place a protective screen in the bottom of the inner stack.

5. Removal procedure

- a. Complete the removal procedures 4.2.3 through 4.2.5.
- b. Attach a handling tool to the spring guide handle of one semipermanent beryllium reflector segment holddown assembly. NOTE: The semipermanent segment assemblies (4 total) are identified by position (north, south, east, and west) (see Fig. 4. 28). It is imperative that the relative location of each piece be retained.
- c. Depress with the handling tool the compression spring and move the tool toward the reactor centerline until the segment assembly is free of its outer shroud latch; then lift free of the reflector container and pedestal.
- d. Temporarily hang the tool and removed segment assembly on a piece of nylon cord and suspend in the inner stack area.
- e. Repeat steps 2, 3, and 4 for each of the other assemblies. Retain the identity of each as to location in core.
- f. Transfer the four assemblies to storage.

6. Replacement procedure

- a. Transfer the segment assemblies from storage and suspend in the inner stack area.
- b. Install all four into their original positions.
NOTE: To seat each assembly properly, it must fit over its locating plate and into the tapered edge of the reflector container and pedestal. After being seated depress the spring, move the segment assembly into a vertical plane and latch.

c. Remove the four handling tools and store.

d. Remove the screen from the bottom of the stack.

4.2.16 Lower track assembly

1. References

Drawings:

E-49724	Bolt Tensioner, Lower Track Holddown Bolt
E-49800	Lower Track and Bearing Assembly (see Fig. 4.39)
M-10070- ~~0~~ A-800-E	Track Handling Tool Assembly
M-10070- ~~0~~ A-810-E	Track Handling Tool Guide Post
M-10070- ~~0~~ A-820-E	Removable Reflector and Track Handling Tool Arrangement
M-10070- ~~0~~ A-830-E	Lower Track and Bearing Assembly Storage Stand

2. Tool required

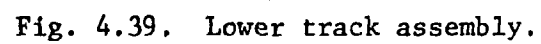
- a. Track handling tool
- b. Track handling tool guide post
- c. Bolt tensioner
- d. 15/16-in. nut removal tool

3. Data

- a. Weights: Track assembly - dry 262 lbs
Handling tool - dry 150 lbs
- b. Dimensions: Assembly - 39-31/32-in. length, 22,820-in. OD
Track - 32-6/8-in. length, 6-in. nominal width.

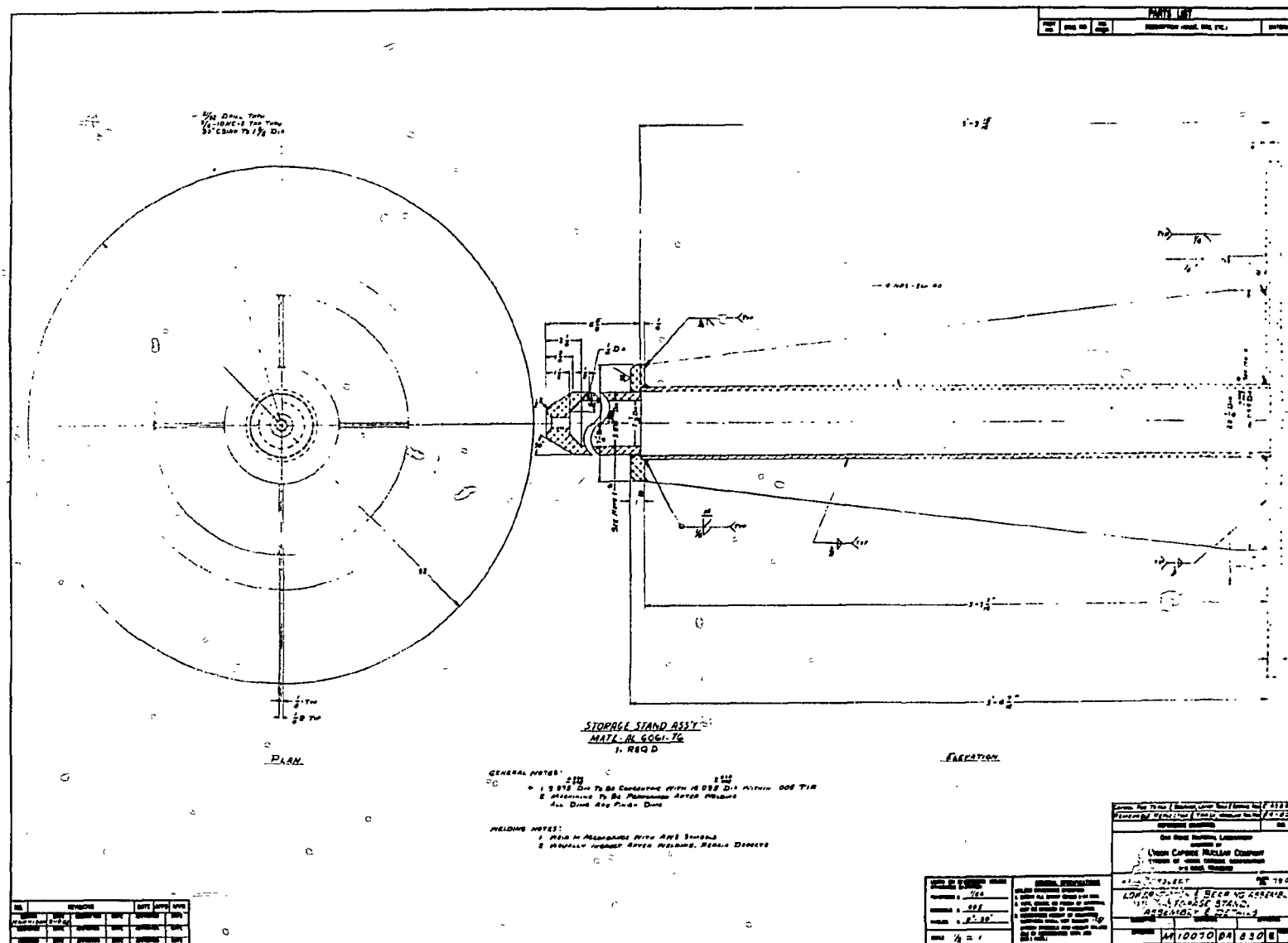
4. Removal Procedure

- a. Complete the removal procedures 4.2.3 through 4.2.15.
- b. Lower the bolt tensioner into the reactor pool. The compressor remains at poolside.



- c. Connect the water line to the bottom of the bolt tensioner tool (see Fig. 4.40). Before tightening the water line fitting, bleed air from the line by pumping water through it.
- d. Position the bolt tensioner onto the holddown bolts, each time pointing the trailing end of the tool toward the adjacent control-plate extension tube.
- e. Engage the bolt tensioner stud (T-handle operator) in the track holddown bolt. Support the weight of the tensioner so as to lessen the danger of galling; approximately nine clockwise turns are required; tighten finger tight.
- f. Set the nitrogen or air regulator to supply 70 psig to the compressor.
- g. Close the pressure release valve and pressurize the tensioner to 4500 psig.
- h. Loosen the holddown nut by turning the 3/8-in. hex head operator clockwise approximately 3 turns (Item 22, Dwg. E-49727).
- i. Release the bolt tensioner pressure and loosen the T-handle stud operator; remove the tensioner.
- j. Remove the track holddown nut using the 1 1/4-in. nut removal tool.
- k. Repeat steps e through j for each of the three holddown nuts.

- l. Attach the track handling tool to the tool carriage and lower the tool into the vessel. Allow the tool to telescope over the guide post (see Fig. 4.36).
 - m. The tool should be positioned so the tool cams will not coincide with any of the control-rod bearings. The tool can then be set all the way down onto the guide.
 - n. Engage the bottom cams of the tool with the upper ring of the lower track assembly by rotating the drive counter-clockwise approximately 8 turns.
 - o. Lift the assembly very slowly while observing the scale. A lifting force of approximately 350 lbs is necessary.
 - p. Continue slowly raising the assembly for approximately 7 ft until the track assembly has cleared the outer shroud assembly.
 - q. Remove the assembly and store it on the storage stand in the reactor or clean pool (see Fig. 4.41).
5. Replacement Procedure
- a. Attach the track handling tool to the tool carriage and then to the track assembly.
 - b. Transfer the tool and track assembly to the vessel and lower into position.
 - c. The proper orientation of the track assembly must be obtained by rotating the assembly until the N arrow is pointed in the north direction.
 - d. Continue lowering the assembly and allow the locating pins on the lower track assembly to position into the slots in the alignment blocks on the lower track support.



- e. When the assembly is seated onto the holddown studs as determined by the elevation markings on the tool handle, remove the handling tool.
- f. Insert all three holddown nuts and tighten hand tight.
- g. Insert the bolt tensioner stud into the track holddown stud and tighten finger tight.
- h. Stretch the bolt by applying 4500 psig pressure.
- i. Tighten the track holddown nut by turning the 3/8-in. hex head operator counterclockwise. Apply 30-in.-lbs force while releasing the bolt tensioner pressure.
- j. Loosen the T-handle operator and remove the bolt tensioner.
- k. Repeat Items g through j for the other two holddown nuts.
- l. Remove all tools.

4.2.17 Piston and coupling subassembly

1. References

Drawings:

F-42325	Outer Control Rod, General Assembly
E-42330	Engagement Mechanism
E-42337-22	Piston and Coupling Subassembly
M-10070-ØB-600	Outer Control Rod Piston Handling Tool Assembly

2. Tools Required

a. Piston Handling Tool

3. Data

- a. Weights: Piston Assembly - dry 50 lbs
underwater 35 lbs
Piston Handling tool - dry 80 lbs

4. Removal Procedure

- a. Complete removal procedures 4.2.3 through 4.2.16.
- b. Complete steps 4.3.3.1 through 4.3.3.2.3.4 and 4.3.3.2.3.15.e of the control plate drive engagement mechanism assembly replacement procedure (see Fig. 4.42).
- c. Attach the piston handling tool to the carriage assembly (see Fig. 4.43).
- d. Position the tool and slowly lower the nose of the tool into the piston adaptor until the housing shoulder of the tool rests on top of the piston (see Fig. 4.44). This can be determined by the mark on the tool handle and a decrease on the tool carriage scale indicator.
- e. Connect the tool to the adaptor by rotating the drive tube clockwise approximately 30 turns. This extends the balls of the tool into recess of the piston adaptor.
- f. Lift the tool 2 or 3 in. slowly and test to determine if the piston is securely attached. Check the scales to assure the piston is attached.
- g. Continue slowly raising the tool and piston assembly out of the vessel while observing the scales for signs of binding.
- h. Remove the assembly to storage. Remove the tool to storage.

5. Replacement procedure

- a. Reverse the removal procedure.

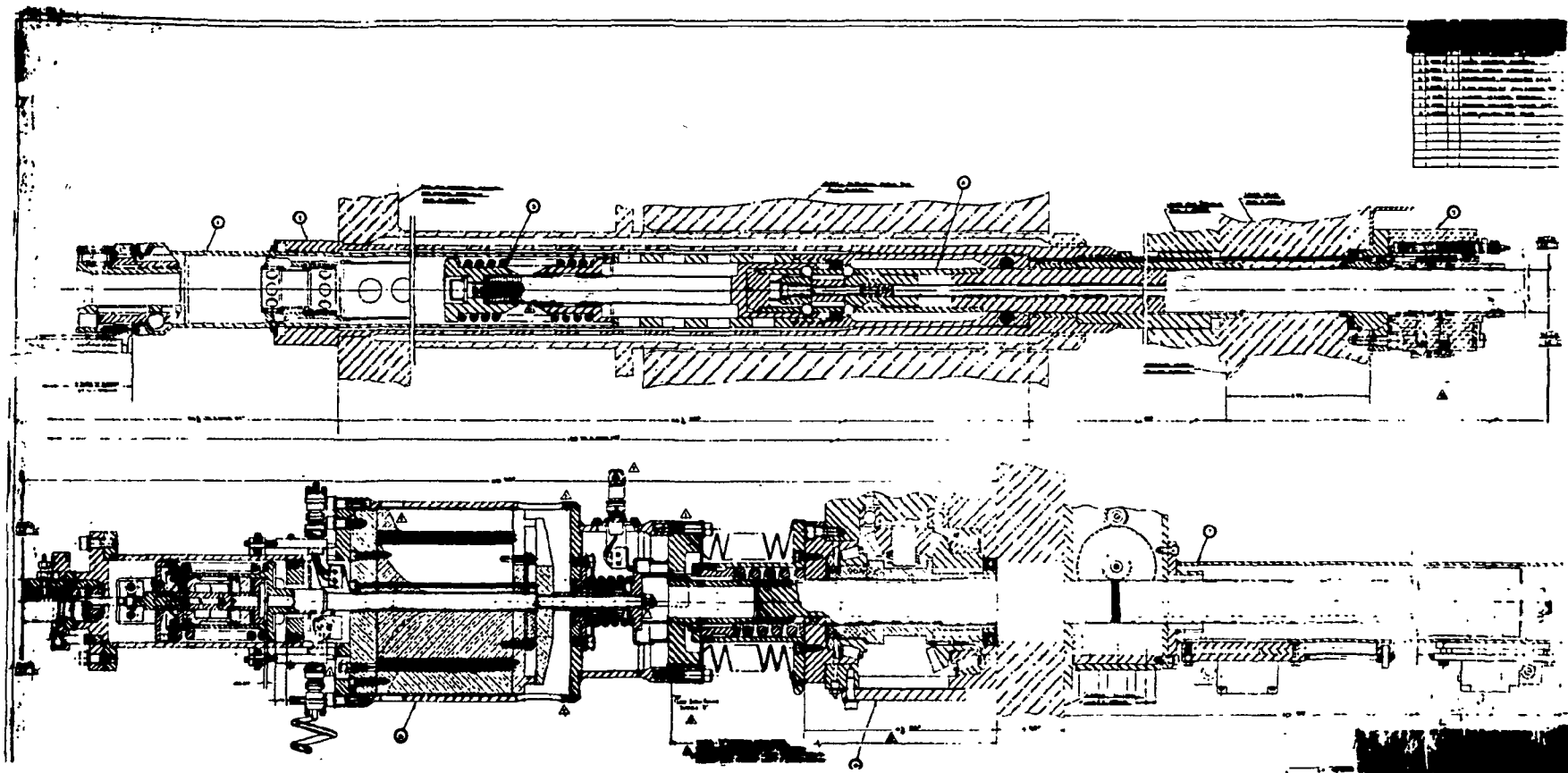


Fig. 4.42. Control rod general assembly.





4.2.18 Shock absorber assembly

1. References

Drawings:

F-42325	Outer Control Rod Drive, General Assembly
E-42335-14	Shock Absorber Assembly

2. Tools Required

- a. 1 1/2-in. Socket Head Tool (M-10070-ØB-655).
- b. Lifting Tool (M-10070-ØB-650).

3. Data

- a. Weights: Shock Absorber and Guide Assembly - dry 146 lbs

4. Removal Procedure

- a. Complete the removal procedures 4.2.3 through 4.17.
- b. Pull the seat switch actuating rod down to 69 in. $\pm$ 1/2 in. from the seal housing spool piece flange to the bottom of the actuating rod. Do not pull the actuating rod completely out of the assembly. Support the actuating rod in this position by taping the drive rod or other appropriate means.
- c. Loosen the two 1 1/2-in. bolts coupling the shock absorber to the fuel and reflector support assembly (see Figs. 4.42 and 4.45). These bolts will be retained in the shock absorber assembly but must be turned until they are free of the fuel and reflector support assembly.
- d. Lower the shock absorber lifting tool into the shock absorber and tighten until the tool is firmly attached.
- e. Slowly raise the assembly out of the core region. If any weight increase is observed, stop and make sure the drive rod pushrod has been pulled completely down and is not restricting its' movement.

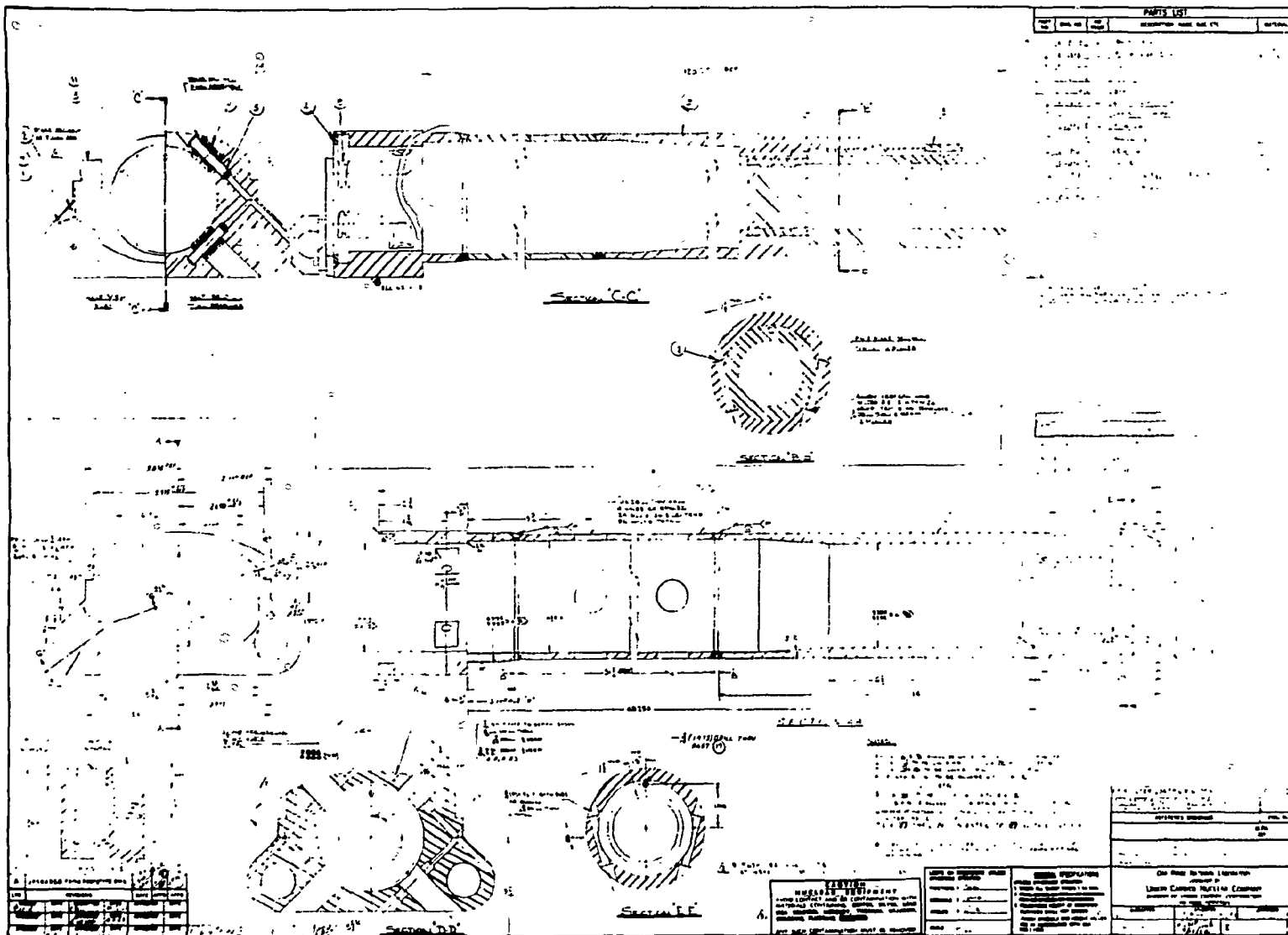


Fig. 4.45. Shock absorber assembly.

f. Remove the assembly to storage.

5. Replacement Procedure

a. Reverse the removal procedure.

b. The required torque on the 1 1/2-in. bolts is 60 to 70 ft-lbs.

4.2.19 Three-inch vertical experiment facility plug

1. References

Drawings:

E-42311 Plan Section at Reflector Midplane

E-42384 Upper Plenum and Outer Shroud Assembly

E-42349-8 Three-Inch Vertical Experiment Facility Plug

2. Tools Required

a. 33-ft Hook Tool

3. Data

a. Plug weight - dry 13 1/6 lbs.

b. Plug length - 36 in.

c. Plug OD - nominal 2.7 in.

4. Removal Procedure

a. The shift engineer and one operator must first verify the plug location (see Fig. 4.46).

b. Manually lower the hook and insert it into either of the two 1-in. diameter holes of the support (E-42349-9) (see Fig. 4.47).

c. Slowly raise the plug until it is clear of the vessel.

d. Remove the plug to pool storage.

5. Replacement Procedure

a. Reverse the removal procedure.

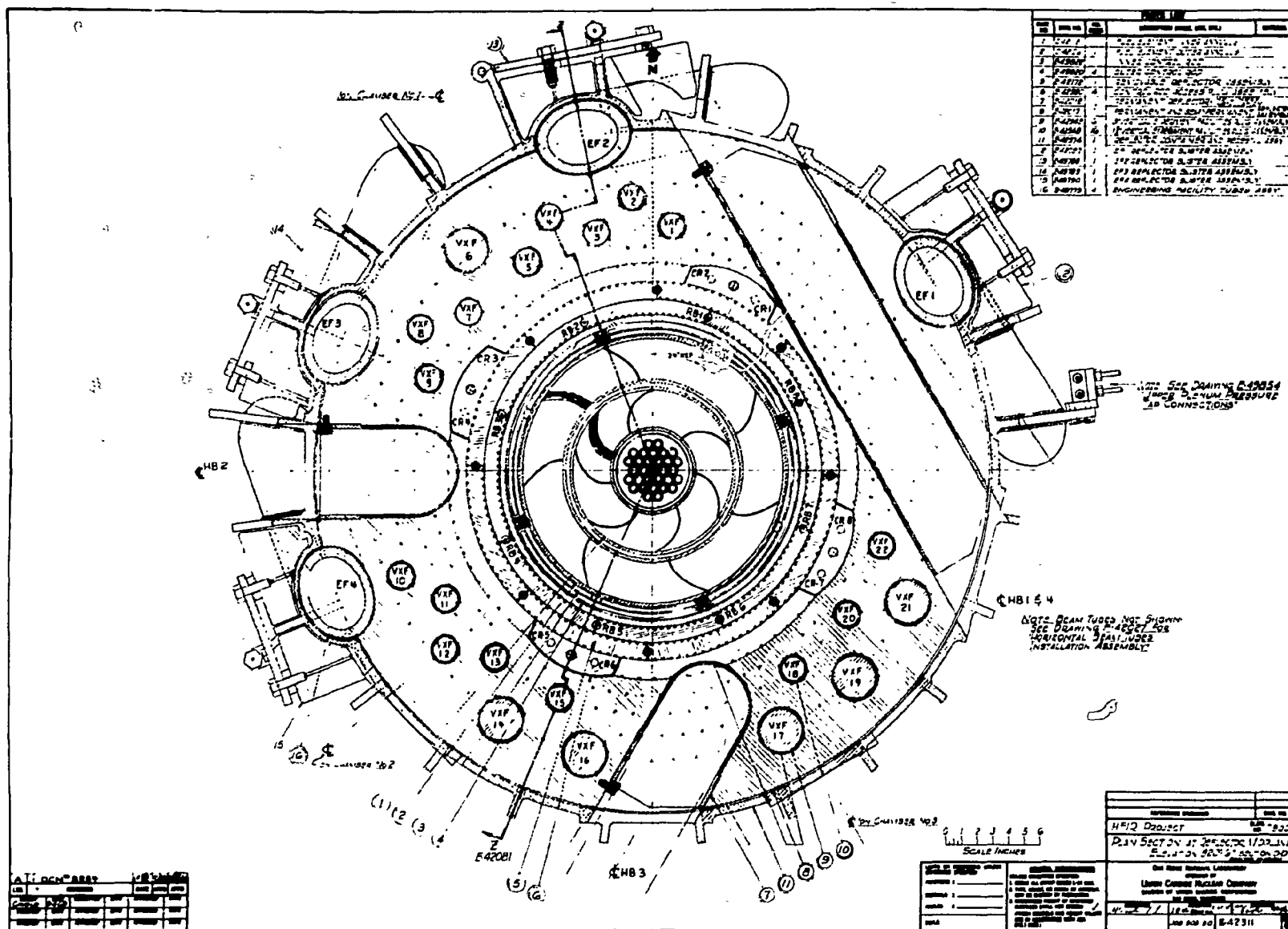


Fig. 4.46. Vertical experiment location,

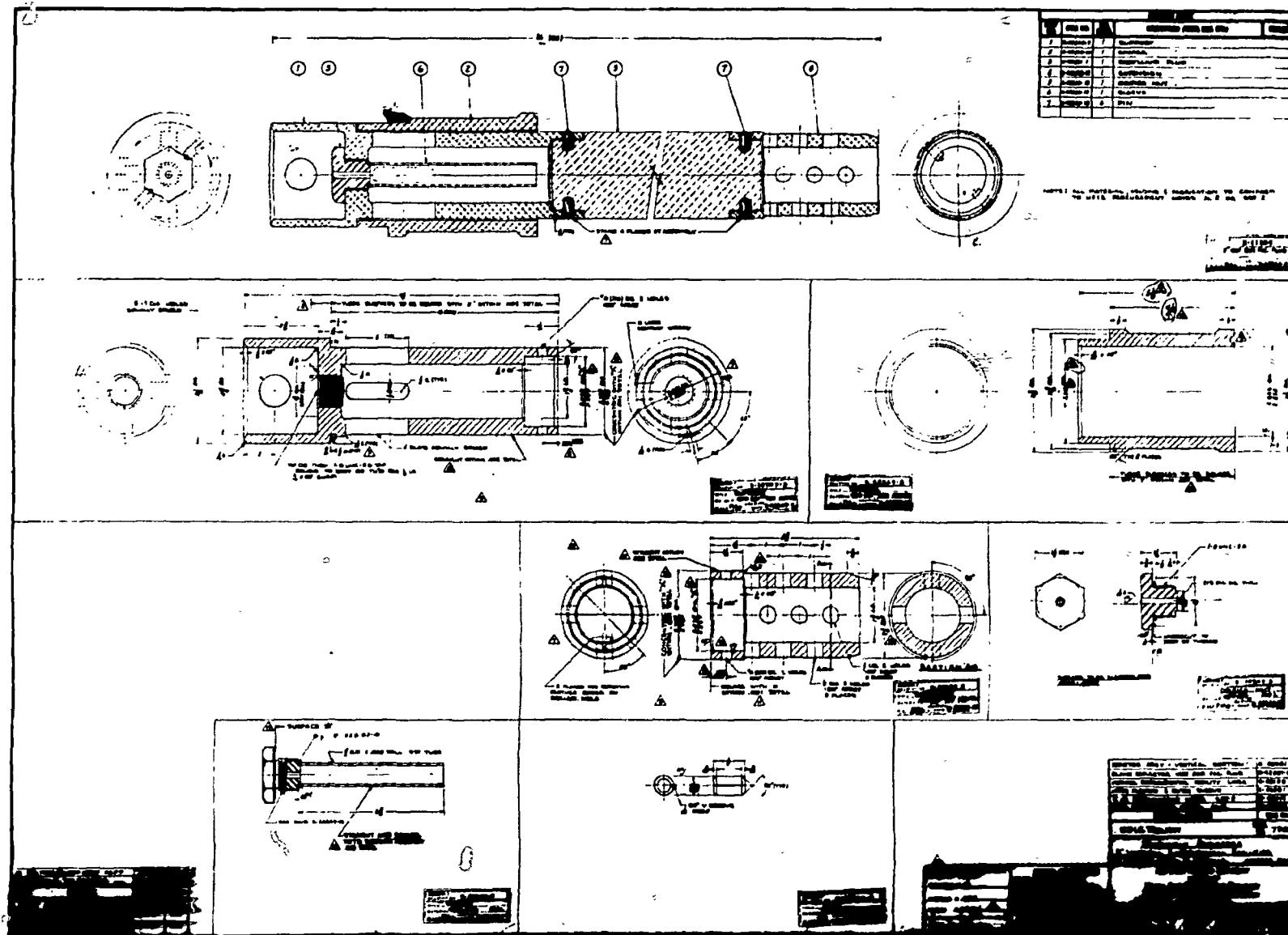


Fig. 4.47. Three-inch vertical experiment facility plug.

4.2.20 One and three-fourths-inch vertical experiment facility plug**1. References****Drawings:**

E-42311	Plan Section at Reflector Midplane
E-42384	Upper Plenum and Outer Shroud Assembly
E-42348-8	1 3/4-in. Vertical Experiment Facility Plug

2. Tools Required

a. 33-ft Hook Tool.

3. Data

- a. Plug weight - dry 4 1/4 lbs.
- b. Plug length - 36 in.
- c. Plug OD - nominal 1.5 in.

4. Removal Procedure

- a. The shift engineer and one operator must verify the plug location (see Fig. 4.46).
- b. Manually lower the hook and insert it into either of the two 1-in.-diam holes of the support (see Fig. 4.48).
- c. Slowly raise the plug until it is clear of the vessel.
- d. Remove the plug to storage. Detach the hook and remove to tool storage.

5. Replacement Procedure

- a. Reverse the removal procedure.

4.2.21 Control rod access plug - one-half-inch experiment facilities**1. References****Drawings:**

E-42081	Reactor Assembly - Vertical Section Z-Z, 817 ft 10 in., to 822 ft 3 in.
E-42380	Control Rod Access Plug Assembly and Details

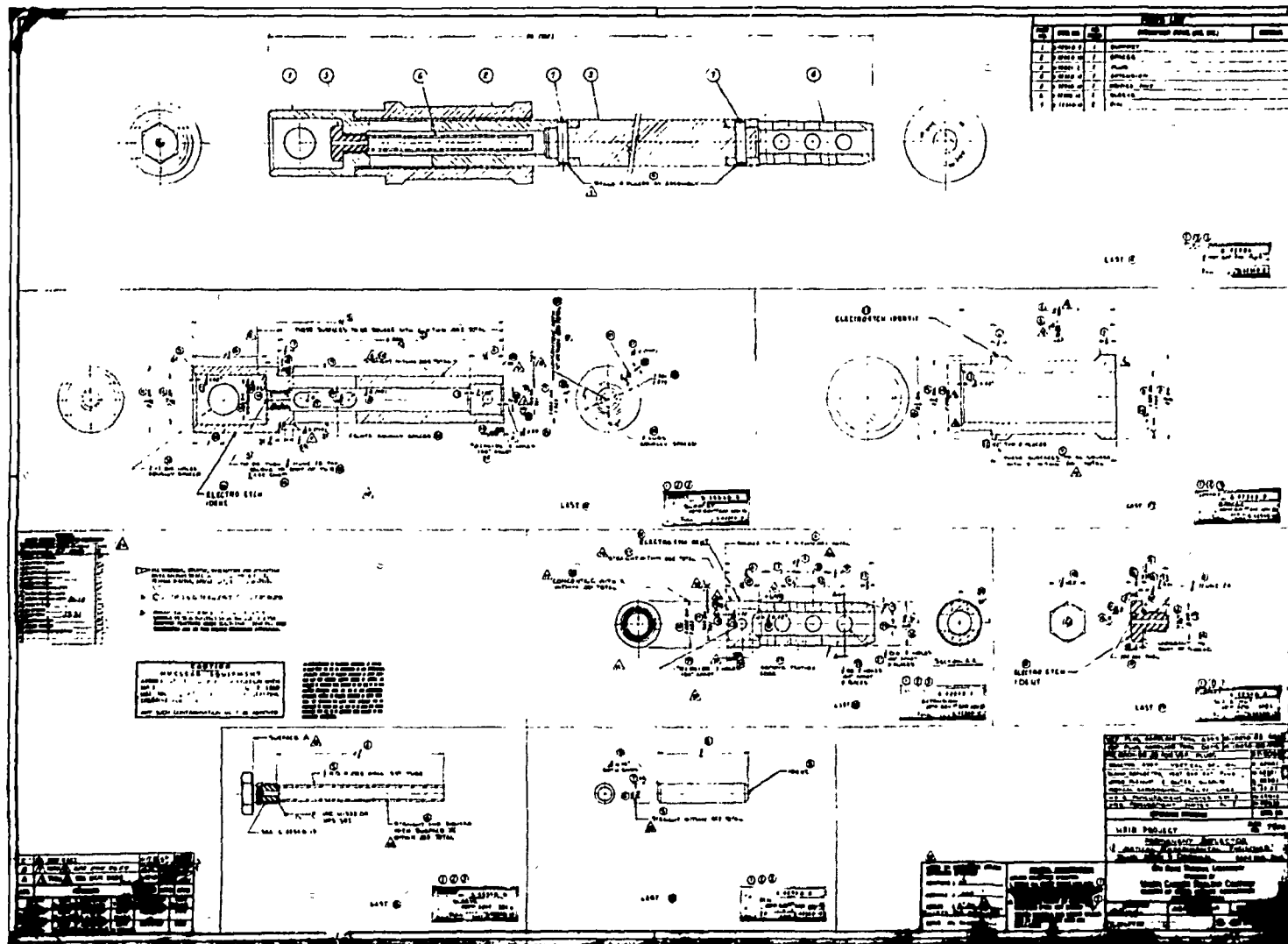


Fig. 4.48. One and three-fourth-in. vertical experiment facility plug.

D-49187 Control Rod Access Plug Aluminum Dummy
 10070-OB-995-E Control Rod Access Plug Storage Rack
 Assembly
 10070-OC-265-E Target Picker Tool, Model "B"

2. Data

NOTE: To distinguish between an experiment and an aluminum dummy, the support flange is made differently. It is round on an experiment and square with clipped corners on a dummy.

3. Work conditions

a. Reactor pool water level at the grating.

4. Removal procedure

- a. Complete the removal procedures 4.2.3 through 4.2.10 except 4.2.9.
- b. Hang the C.R.A.P. storage rack from the pool bridge and suspend in the inner stack area. Using a target picker tool, remove the designated rod from its 1/2-in. facility and store in the storage rack.

5. Replacement procedure

- a. Install an experiment or an aluminum dummy which is located in the storage rack.
- b. Raise reactor pool water level and remove C.R.A.P. storage rack.

4.2.22 RB beryllium plug

1. References

Drawings:

E-42311 Plan Section at Reflector Midplane
 E-49717 Shroud Flange Assembly

E-49716-6	Shroud Flange Plug
E-49445	Removable Reflector Assembly
E-49652	Removable Reflector Facilities
E-42132	1/2-in. RB Plug and 1 1/2-in. RB Plug Assembly
E-42132-21	Handling Tool Adaptor

2. Tools required

- a. Shroud flange plug handling tool (M-10070-OB-915)
- b. RB beryllium plug handling tool, 1/2 in. (M-10070-OB-960)
- c. Four-place assembly tool (M-10070-OB-970)
- d. Single-place plug tool (M-10070-OB-950)

3. Data

- a. RB plug assembly: weight <5 lbs.
- b. RB plug dimensions: 0.450 in. x 25.656 in.; 1.365 in.
x 24.938 in.

4. One-half-inch plug or experiment removal procedure

- a. The shift supervisor and one operator must verify the location (see Fig. 4.46).
- b. Position the shroud flange plug handling tool over the plug and fit it onto the cone of the plug (see Figs. 4.49 and 4.50) by turning the latch to the lock position.
- c. Rotate the tool handle counterclockwise approximately 6 turns until the plug can be removed from the shroud flange. Remove the tool with the plug attached out of the vessel and store temporarily.



Fig. 4.49. CR beryllium plug.

- d. Lower the 1/2-in. RB plug handling tool through the shroud flange plug hole and allow the tool to rest lightly on top of the plug end adapter. Rotate the handling tool until it drops into the orientation slot (see Fig. 4.52.) Remove the pin from the upper end of the tool and tighten approximately 4 turns or until tight.
- e. Slowly raise the tool with the plug attached and remove to the circular storage rack. CAUTION: The plug is very fragile and should be handled with extreme care. Record the storage location.
- f. Detach the handling tool and observe that the plug (or experiment) comes free from the tool and is stored properly. Remove the tool to storage. CAUTION: Do not remove the tool without verifying that the plug (or experiment) is free from it. Verification can be assured by lifting the tool approximately 6 in., then moving it horizontally. This operation must be observed by one person other than the one manipulating the tool.

5. Replacement procedure

- a. Cold 1/2-in. beryllium plugs or experiments should be loaded into the "cold" storage rack and lowered into the pool to grating level prior to their insertion into the reactor.

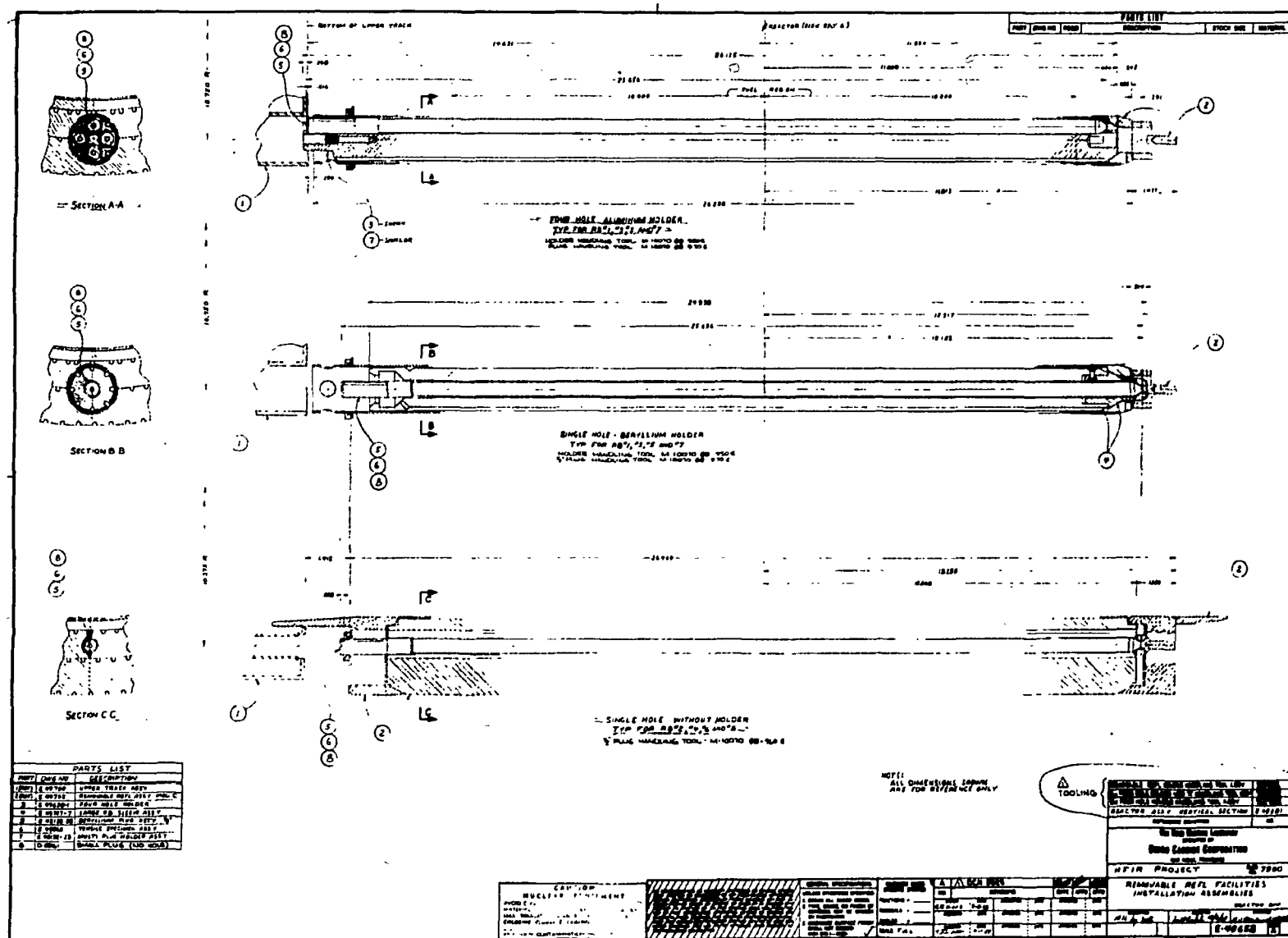


Fig. 4.51. RB plug assemblies.

- b. Place the 1/2-in. RB plug handling tool onto the correct plug in the cold storage rack and allow it to rest lightly. Rotate the handling tool until it drops into the orientation slot. Remove the pin from the upper end of the tool and tighten approximately 4 turns or until tight.
 - c. Lift the plug from the "cold" storage rack and insert it into its orientation slot. (This applies only to positions RB-2, -4, -6, and -8. Positions RB-1, -3, -5, and -7 do not have orientation slots.)
 - d. Loosen the tool from the 1/2-in. plug. Make sure the plug is free from the tool before removing it. (This must be verified by one person other than the one manipulating the tool.) Remove the tool to storage.
 - e. The shroud flange plug installation requires only that it be hand tight.
6. One and one-half inch plug removal procedure.
- a. The shift engineer and one operator must verify the location (see Fig. 4.46).
 - b. Position the shroud flange plug handling tool over the plug and fit it onto the cone of the plug (see Fig. 4.51). Lock the tool to the plug by turning the operator to the locked position.
 - c. Rotate the tool handle counterclockwise approximately 6 turns until the plug can be removed from the shroud flange. Remove the tool with the plug attached out of the vessel and store temporarily.

- d. Remove the 1 1/2-in. single plug assembly as follows:
- (1) Remove the one-half inch plug from the single plug assembly as outlined in step 4 above.
 - (2) Lower the single-plug assembly tool (see Fig. 4.50) into the upper track access tube and allow it to rest on the 1 1/2-in. plug. Rotate the tool actuator clockwise approximately 7 turns or until it is hand tight.
 - (3) Remove the tool with plug attached and store the plug in the circular storage rack. Record the location.
- e. Remove the 1 1/2-in. four-place plug assembly as follows:
- (1) Lower the quad holder handling tool into the vessel and carefully insert it into the exposed guide tube of the upper track assembly. When the tool touches the quad holder, slowly rotate until the key on the bottom of the tool fits into the quad holder slot (the tool will drop approximately 1/16 in.). Release the inner threaded rod of the tool by rotating the knurled knob 180° and guiding the retaining pin through the open groove of the support hub. This permits the rod to touch the quad holder. To lock turn clockwise approximately 6 turns (finger tight only). Remove the tool and quad holder from the vessel and store the quad holder in the RB plug storage rack. Loosen the rod and raise it through the groove, turn 180° and let the retaining pin rest in its storage position.

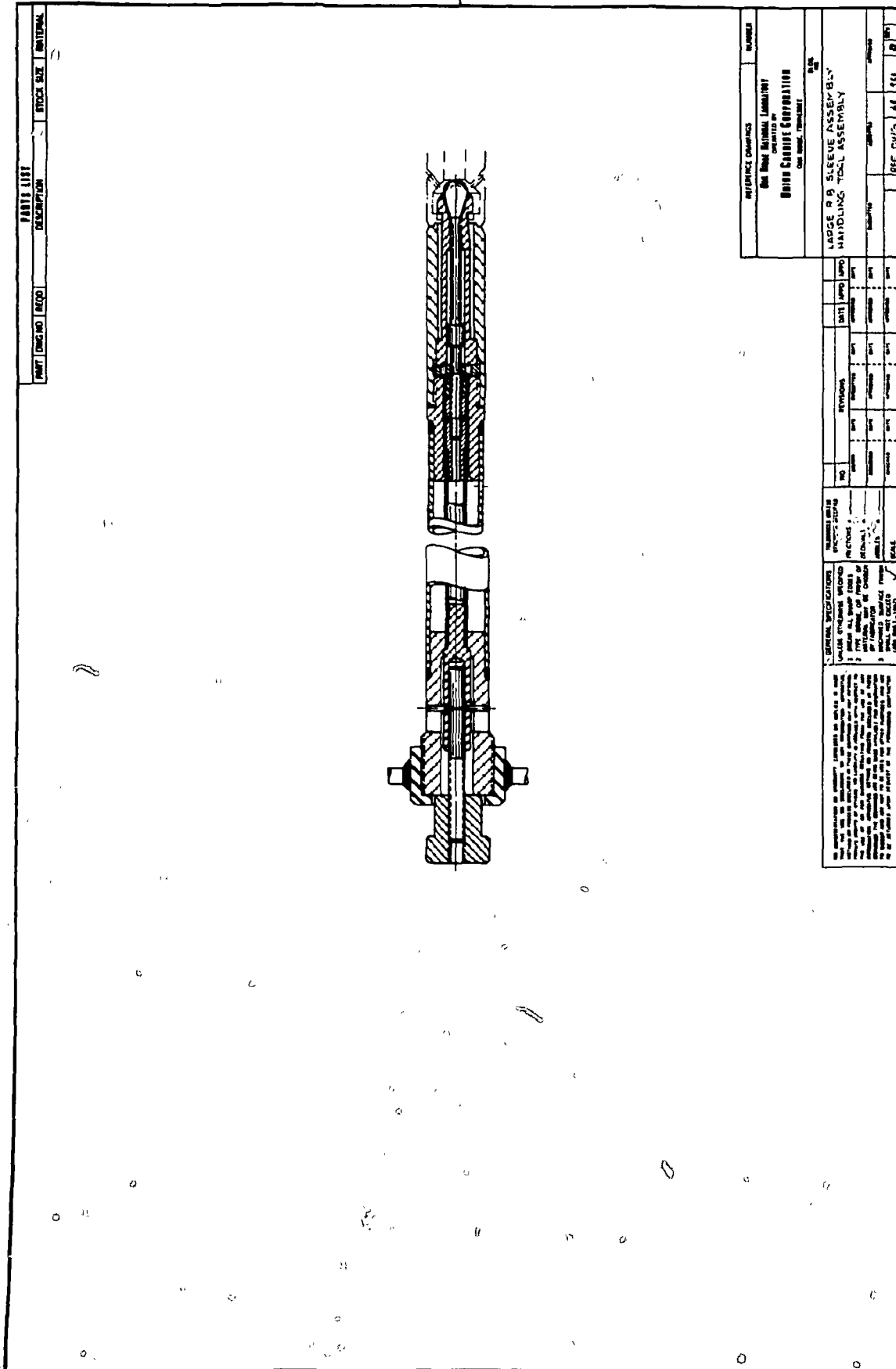


Fig. 4.52. Single-plug assembly tool.

- (2) Transfer the RB plug storage rack from the reactor pool to the center pool and set it on the target work platform.
- (3) Using the 1/4-in. threaded rod remove the designated 1/2-in. experiment by screwing into its top approximately 3-4 turns clockwise. Remove, identify and store in the RB plug storage rack being sure the key of the experiment fits the keyway of the storage rack position.
- (4) Attach the 1/4-in. rod to the new experiment and install in the quad holder. Align the plug key with the quad holder key slot.
- (5) After the experiment work is complete, transfer the storage rack back to the reactor pool grating.

f. Replacement procedure

- (1) Reverse the removal procedure.
- (2) The location should be verified by the shift engineer and one operator.
- (3) Re-install the shroud flange plug.

4.2.23 Inner control cylinder drive rod

1. References

Drawing:

E-42209

Inner Control Cylinder Drive Rod Assembly

2. Tools Required

a. Drive Rod Handling tool

3. Data

a. Weights: Drive Rod - dry 150 lbs.
Tool - dry 25 lbs.

b. Length: Drive Rod - 16 ft, 8 1/2 in.

c. Material: Drive Rod - 304L

4. Removal Procedure

a. Complete removal procedures 4.2.3 through 4.2.11.

b. The drive rod unit should be at its insert limit and the motor locked at this position.

c. Close all valves on the inlet and outlet flush lines to the seal housing. These are HV-306 and -310, high pressure water supply; HV-2360, pool water supply; and HV-2367, pool water drain.

d. Attach the drive rod handling tool to the tool carriage and position the tool over the drive rod (see Fig. 4.53).

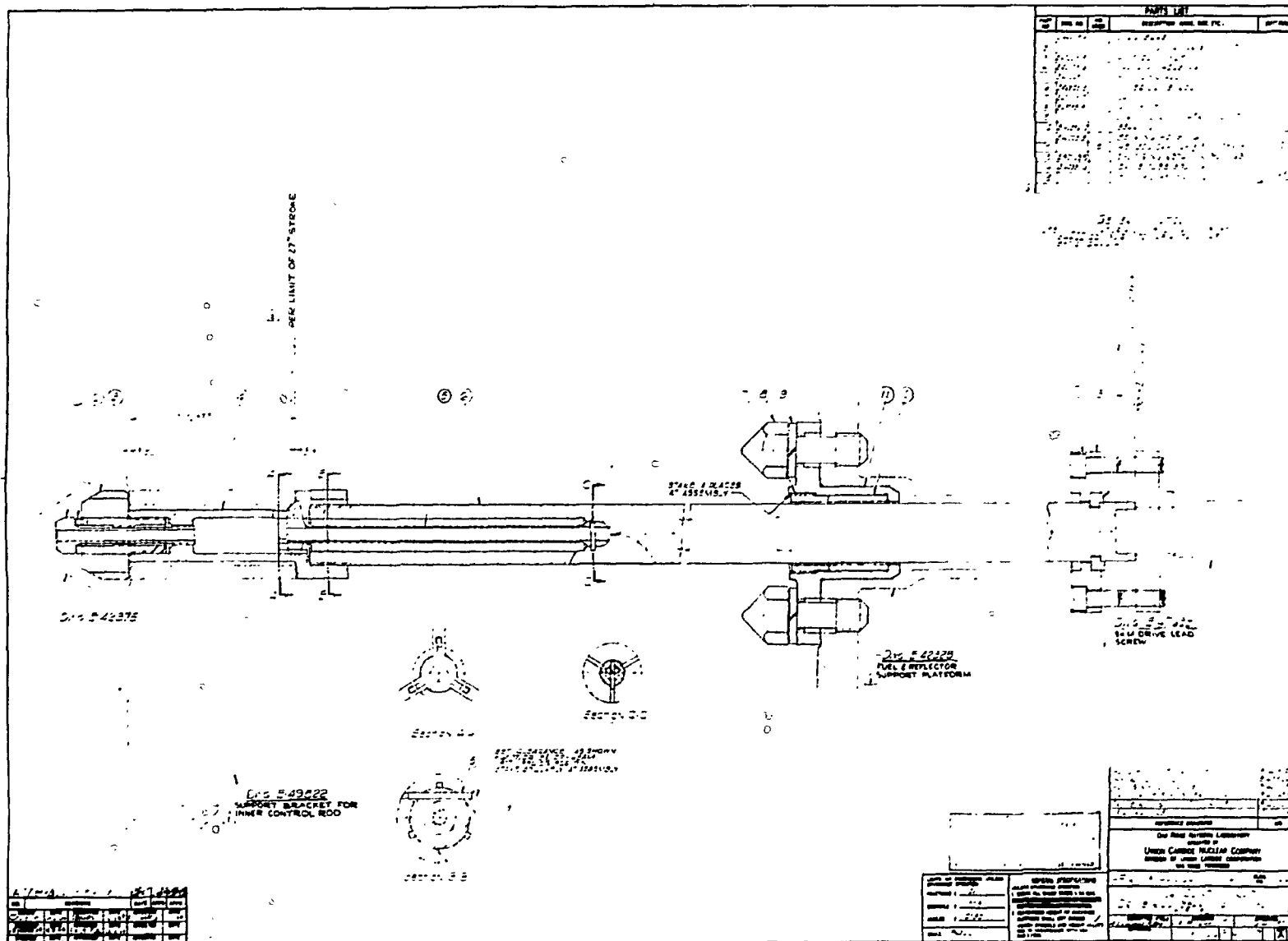
e. Attach the handling tool to the drive rod and lower the locking rod down through the center of the drive rod.

f. Communication should now be established between the operator at the tool and the subpile room using the sound-powered phone system or other communication equipment.

g. Remove the eight 1/2-in. hex socket head capscrews (E-42209-12) on the split ring retainer flange.

h. Remove the split rings (E-42209-14) and lower the split ring retainer flange onto the lead screw flange.

i. The subpile room operator should now direct the operator at the tool to raise the inner drive rod very slowly until the bottom of the drive rod is 1/8 in. below the bottom of the seal housing threaded section. (A breaking



force greater than 400 lbs should not be required.) The tool operator should mark this position on the tool for reference during installation of the drive rod and refer to this as elevation A.

- j. Install, close, lock, and tag the ball valve with a "Do Not Operate" tag.
 - k. Install a drainage line onto the drain plug connection on the bottom of the ball valve and run it to the floor drain.
 - l. Remove the bottom plug connector on the seal housing and connect the pool water supply to the housing.
 - m. Pressurize to at least 20 psig and check for leaks in the ball valve assembly.
 - n. After checking for leaks, remove the pool water line and replace the plug connector into the seal housing.
 - o. With close communication between the tool operator and the subpile room, slowly raise the inner drive rod. Continuously monitor the spring scales for indications of binding.
 - p. As the drive rod is withdrawn from the vessel, radiation surveillance is required. The coupling end of the rod may be extremely radioactive.
 - q. Transfer the drive rod to storage.
5. Replacement Procedure
- a. Reverse the removal procedure.
 - b. When the coupling end of the drive rod is approximately 1 ft above the quick-opening hatch, the insertion of the

drive rod should be made very slowly. In approximately 6 in. more of insertion, the drive rod will start to enter the bearing assembly (E-42209-10). If any binding is indicated by the spring scales, retrieve the drive rod and try again.

c. As the drive rod is lowered further into the vessel, stop at a position 6 in. above elevation A obtained in step 4.h. of the removal procedure. Open the ball valve slightly to allow a small leakage to drain. Continue to lower the drive rod slowly to elevation A. The leakage to drain should stop. Remove the ball valve assembly and continue lowering the drive rod.

d. After complete reassembly, re-establish flow to the seals by opening valves HV-306, HV-310, HV-2360, and HV-2367.

4.2.24 Inner control cylinder drive rod bearing assembly

1. References

Drawing:

E-42209 Inner Control Cylinder Drive Rod Assembly

2. Tools Requires

- a. 1 1/2-in. socket head tool
- b. Bearing handling tool (M-10070-08B-530)

3. Data

- a. Weights: Bearing - <15 lbs
- b. Material: 304 L and Stellite 6

4. Removal Procedure

- a. Complete removal procedure 4.2.23.
- b. Disengage the two 1 1/2-in. hex head bolts (E-42209-8) by

rotating the socket head tool counterclockwise. A breaking torque of approximately 80 ft-lbs may be required.

The bolts will be retained in the bearing assembly (see Fig. 4.53).

c. Insert the bearing handling tool and engage the bearing assembly.

d. Slowly withdraw the tool and bearing assembly. A force of approximately 30 lbs may be required. A force greater than 300 lbs should not be required.

e. Remove the bearing assembly to storage.

5. Replacement Procedure

a. Reverse the removal procedure.

b. The two 1 1/2-in. bolts should be torqued to approximately 100 ft-lbs.

4.2.25 Xenon production facility

1. References

Drawings:

M-11461-DH-001-E	Xenon Production Facility
T-11461-DH-005-D	Transfer Rack Assembly
T-11461-DH-007-D	Stripper and Target Rod Holder
T-11461-DH-009-E	Xenon Target Picker Tool
T-11461-DH-013-D	Fuel Ring Loading Tool

2. Precautions

a. The xenon fuel rings contain enriched ^{235}U with only 0.010-in. cladding. Care must be exercised to prevent damage to the cladding, thereby preventing exposing the fuel to the primary water.

- b. In the event no fuel rings are to be irradiated in the reactor, the facility may be left empty since a flow orifice is built into it. As an alternate, the xenon production facility itself may be removed from the VXF-9 position and replaced with a beryllium plug.

3. Working the Facility

- a. Using the long xenon target picker tool (Fig. 4.54), remove the target holder from the VXF-9 facility (Fig. 4.55) and store temporarily in the section of the transfer rack assembly (Fig. 4.56) which is painted red. Remove the picker tool.
- b. Use a medium length staff hook tool to move the transfer rack to the target work platform.
- c. With a short target picker tool, move the target to the stripper section (this is the side which has the longest tube) of the stripper and target rod holder (Fig. 4.57). Remove the picker tool.
- d. Insert the fuel ring stripping from the target rod tool down over the mushroom head of the target and push down until one fuel ring comes off the target holder and onto the tool.
- e. Use the right angle tongs to remove the fuel ring from the stripper tool. Store the fuel ring in the target work platform.
- f. To remove the second fuel ring from the target holder, repeat steps d and e.
- g. Move the target holder to the short section of the fuel ring stripper and target rod holder.



Fig. 4.54. Xenon target picker tool.



Fig. 4.55. Xenon production facility.

- h. Install a new fuel ring onto the fuel ring loading tool (Fig. 4.58).
- i. Place the fuel ring loading tool over the mushroom head of the target holder and seat it. Push down on the outside handle of the loading tool until the fuel ring comes off the tool and onto the target holder. Repeat this step for a second fuel ring.

4.2.26 Track bearing replacement

1. References

Drawings:

- E-49800 Lower Tracks and Bearing Assembly
- E-49700 Upper Tracks and Bearing Assembly

2. Tools Required

- a. Upper and lower track bearing installation and removal tools (M-10070-ØB-855-E).

3. Upper tracks

- a. Move the upper tracks to the work platform, and, using hooks and a rope, invert them so the bearings are turned upward. Monitor this operation to prevent bringing them too near the surface of the water.
- b. Using the spring compressor tool, push downward to release the old bearing (see Fig. 4.59).
- c. Remove the old bearing using the horizontal tongs.
- d. Install the new bearing using the same tongs. Be careful to orient the bearing properly. The pentagon-shaped shaft end goes to the pentagon-shaped bearing holder side; the round shaft end to the round shaft holder side.

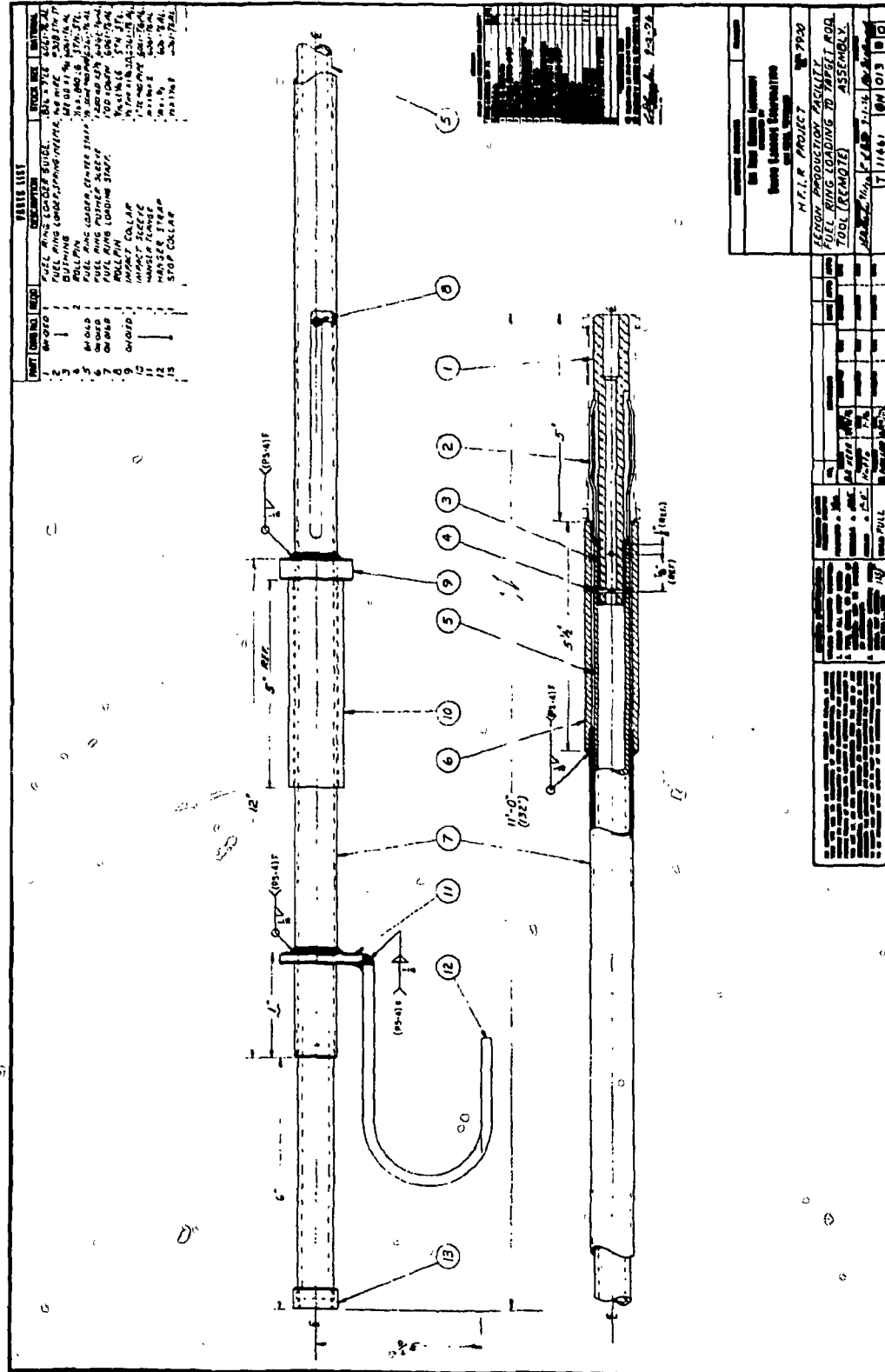


Fig. 4.58. Fuel ring loading tool.

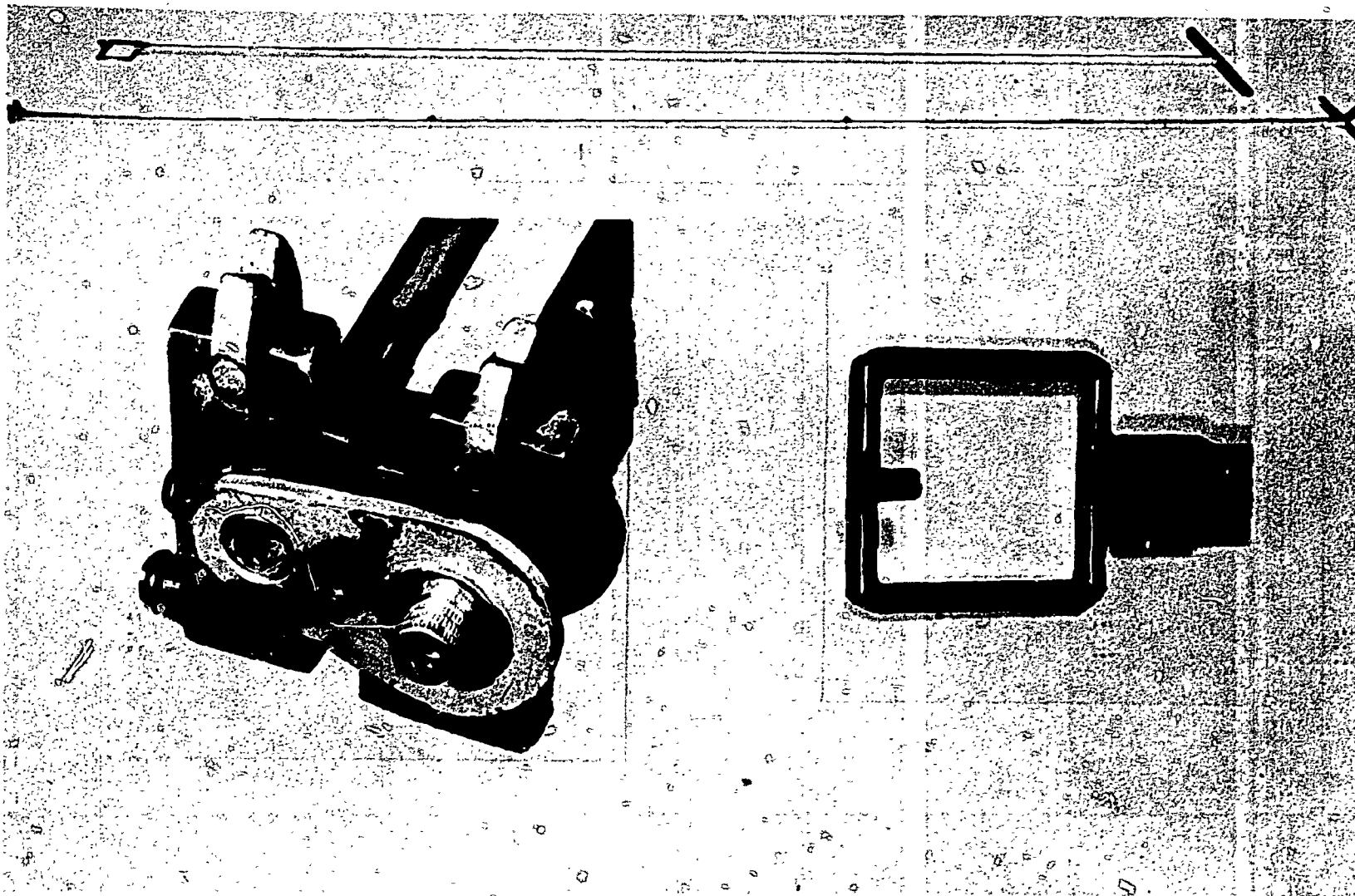


Fig. 4.59. Upper and lower track bearing removal and installation tool.

- e. Release the spring loaded bearing holder.
 - f. Inspect the bearing installation with the periscope or a mirror to make sure the bearing is securely in place and clamped properly.
 - g. Repeat steps b through f for the remaining three bearings.
 - h. Turn the track upright and store them in this storage stand.
4. Lower tracks
- a. Move the tracks to the work platform and place them in the upright position. They do not have to be inverted.
 - b. Repeat steps 3b through 3f for each of the 12 bearings on the lower tracks.
 - c. Return the tracks to storage or to the reactor for installation.

4.3. Miscellaneous Maintenance Procedures

4.3.1 Fission chamber replacement

4.3.1.1 References

Drawings:

E-49765	Fission Chamber Drive Assembly
E-49766	Thimble and Rack Details
E-49767	Gear Housing and Gear Details
RC-11-13-4A	Fission Chamber and Preamp Housing Assembly
RC-11-13-4B	Details
RC-11-13-4C	Details

4.3.1.2 Introduction. The replacement of fission chamber assemblies may be performed during reactor operation, since radiation levels encountered are not prohibitively excessive. However, in order to minimize the radiation levels, the chamber should be completely withdrawn as soon as it is found defective.

4.3.1.3 Precautions

- a. When the fission chamber assembly is pulled out, a γ -radiation beam up to 2 r/h may be expected. Precautionary measures should be taken to prevent personnel overexposure from this beam.
- b. The fission chamber itself may be emitting β - γ radiation up to 2 r/h intensity. Necessary precautions should be taken to shield the chamber as soon as it is removed.
- c. Some radioactive contamination may be present on the chamber. During its removal, the chamber should be enclosed in plastic bags to prevent the spread of this contamination.

4.3.1.4 Fission chamber removal

- a. With the fission chamber at its withdraw limit, measure the voltage between the wiper on the position potentiometer (wire No. 125N) and ground (wire No. 125P). Record this voltage for later reference when setting the position potentiometer on the replacement assembly.
- b. The replacement fission chamber and preamp should be assembled and ready for installation (see Fig. 4.60). Check the fittings to assure that all parts do not exceed the maximum allowable outer dimensions.



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- c. Unplug the fission chamber and preamp cable, located below the rod drive platform, and remove the connector plug.
- d. Uncouple the electrical connectors to the vernistat, the motor and position potentiometer, the insert limit switch, and the withdraw limit switch. These four connectors are located above the rod drive platform.
- e. Remove the insert limit switch (E-49765-39) and the switch mount (E-49765-31) as a unit by removing the four screws and separating the switch mount clamp (E-49765-32) and switch mount.
- f. Remove the withdraw limit switch (E-49765-39) from the switch mount by removing the four screws (E-49765-17).
- g. Remove the two cable brackets attached to the sleeve assembly (E-49765-5).
- h. Remove the vernistat (E-49765-28) and bracket (E-49765-38) as a unit by removing the two screws (E-49765-13).
- i. Remove the position potentiometer (E-49765-29) by removing the four screws (E-49765-16) and synchro mounting clamps (E-49765-30).
- j. Remove the motor (E-49765-26) by removing the four screws (E-49765-12).
- k. Remove the sleeve subassembly (E-49765-5) by removing the two screws (E-49765-11), then slowly lower the sleeve down through the platform.
- l. Remove the gear housing (E-49765-3) by removing the 5/8-in. screw (E-49765-8) and the 3/8-in. screw

(E-49765-9). Slowly lower the gear housing to the platform. CAUTION: It is necessary to push the rack up so the gear housing can be slipped off the lower end of the rack. If this replacement is made while the reactor is operating, use the position of the other fission chambers as a guide. DO NOT insert the fission chamber more than either of the other two. When the rack is inserted, slip the gear housing over the end of the rack and remove it to temporary storage.

- m. Position plastic bagging over the fission chamber and preamp cable and pull it up to the flange (E-49765-35). Position a constant air monitor and off-gas hose and have the Health Physics representative standing by.
- n. Lower the rack assembly (E-49765-4) only until the roll pins are visible. Remove the two roll pins to allow a flexible joint.
- o. Before the rack assembly is lowered any further, alert personnel involved that the fission chamber may be radioactive (3 mr/h to 2 r/h) and that the radiation beam from the thimble may be intense (200 mr/h to 2 r/h).
- p. Slowly lower the assembly while pulling the plastic bag up over the flexible portion of the assembly. The health physicist should monitor the assembly continuously during its removal. When the chamber is finally removed, tape the plastic tubing over the end of the chamber and remove the assembly to storage.

4.3.1.5 Fission chamber installation

- a. Insert the fission chamber and rack assembly until the roll pins (Item 6 of E-49766-5) can be installed to make a rigid joint. Install the roll pins.
- b. Raise the rack assembly until the gear housing can be fitted under the bottom of the rack. CAUTION: Do not insert the fission chamber more than either of the other two chambers that are in operation.
- c. Raise the gear housing to the flange and install the two holding screws.
- d. Allow the rack to lower until it bottoms in the gear housing.
- e. Install the motor by raising the rack 2 in. from the bottom position and engaging the motor gears to the rack. Install the four motor-holding screws.
- f. Set the position potentiometer by rotating the shaft of the potentiometer until the voltage between the wiper and ground is the same as that measured in Step 4.3.1.4a of the removal procedure. This setting is equivalent to a rack position 2 in. from the "bottom" position in the gear housing, as described in step e above.
- g. While maintaining the coupling shaft in this position, install the position potentiometer by installing the four holding screws and clamps.
- h. Install the vernistat and bracket by meshing the coupling and installing the two bracket-holding screws.
- i. Install the sleeve subassembly by fitting it into the gear housing and installing the two holding screws.

- j. Install the insert limit switch assembly and switch mount as a unit by coupling them to the switch mount clamp with the four holding screws.
- k. Adjust the insert limit switch position so that the center of the roller is $77 \frac{1}{4}$ in. from the top of the platform. (This setting allows for approximately $1 \frac{1}{2}$ in. coastdown after actuation of the switch).
- l. Install the withdraw limit switch assembly with the four holding screws. Adjustment of the withdraw limit switch is made after completing the fission chamber installation procedure.
- m. Attach the cable bracket to the sleeve assembly.
- n. Install all connectors except for the motor. Check the position indicator on the console and the chamber position meter in drawer W-1 for proper position indication.
- o. Install the motor connector. Momentarily actuate the insert position on the fission chamber actuate switch and check that the position indicator on the console moves in the insert direction. Check for proper function of the position meter in drawer W-1.
- p. The withdraw limit switch is set while the reactor is operating. It is set so that it is actuated at full operating power level. To set the switch, perform the following step.
 - 1. With the reactor operating at full power, place the fission chamber actuate switch in "manual" and move.

the fission chamber until its log count rate meter indication is the same as the log count rate meters of the other two wide range counting channels. Set the withdraw limit switch to actuate at this position. Return the actuate switch to the automatic mode.

- q. Check the operation of the withdraw limit switch to make sure it is functioning properly. A check on the operation of the insert limit switch can be made only while the reactor is shutdown.
- r. I & C personnel should establish and check the PHS setting.

4.3.2 Ionization chamber and drive assemblies

4.3.2.1 References

Drawings:

D-47747	Plan and Elevation
D-47748	Vessel Penetration and Travel Mechanism
D-47749	Travel Indicator and Drive Mechanism
D-47750	Mast Assembly

4.3.2.2 Introduction. The ion chamber assemblies are held in the reactor vessel thimbles with remotely adjustable positioners (see Fig. 4.61). The drive assembly is supported from the pool wall by a vertical mast which is also used to protect and bring electrical leads above the surface of the pool for routing to the junction box. A flexible shaft permits manual operation of the drive mechanism from above water level to position the ion chambers as required over a range of 12 in.

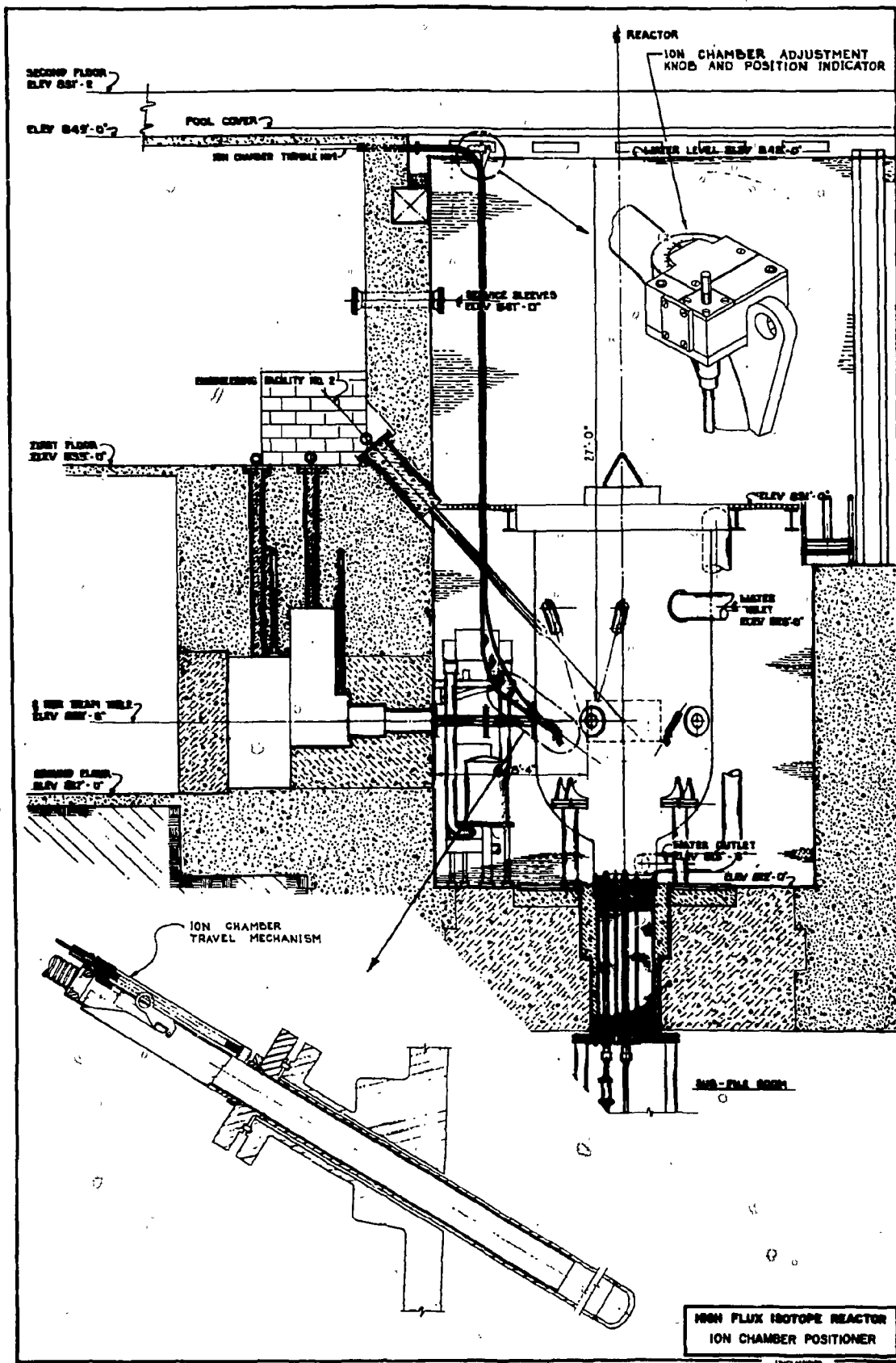


Fig. 4.61. Ion chamber positioning mechanism.

4.3.2.3 Precautions

- a. The ion chamber and support tube is located in a region where the neutron flux will be very high and, consequently, may become very highly radioactive. The dose rate at the end of the chamber is expected to be from 1 to 3 r/h at 1 ft. Thus, removal of the chamber and support tube should be under the surveillance of the area Health Physics representative.
- b. During the removal of the assembly, it is possible to raise the assembly before the support tube is completely removed from the thimble. If too great a force is exerted, it is possible to bend the support tube and ion chamber, which might cause considerable damage to the chamber.

4.3.2.4 Replacement procedure

- a. Pull the voltage supply module in the control room to the unit to be replaced. The assembly identified as No. 1 is located on the north side of the pool; No. 2 is on the west; and No. 3 is on the south.
- b. Disconnect the coupling in the junction box (located in the experiment room) and remove the cable from the support bracket.
- c. Withdraw the chamber fully to the 12-in. position by rotating the drive shaft (D-47749-29) in the counter-clockwise direction.
- d. Loosen the two flange connector bolts (D-47750-6). These are retained.

- e. Attach the bridge crane (with scales) to the handle of the mast (E-47757-8) and support the weight of the assembly.
- f. Using a hook, lift the two latches (D-47748-17) up and pivot backwards until they rest in the unlocked position.
- g. Using the tool which is cupped at the end, push downward against the flexible hose (D-47751-18), thus pulling the support tube (D-47748-3) and ion chamber out of the pressure vessel thimble. The end of the support tube should remain in the entrance guide assembly (D-47748-2).
- h. Using a short hook (1 to 2 in.), hook the lower end of the support tube. Lift the support tube out of the entrance guide and lower carefully until the tube is supported by the flexible hose. Remove the hook.
- i. Raise the assembly slowly 3 to 4 in. and at the same time pull the cable from the conduit. The cables should not be bent to a radius less than 14 in.
- j. Continue to slowly raise the assembly away from the grating and remove to appropriate storage.
- k. The installation of the replacement assembly is accomplished by reversing the removal procedure.
- l. When the assembly is fully reinstalled, withdraw the chamber to the full withdrawn position by rotating the drive shaft in the counterclockwise direction to the 12-in. position.

4.3.3 Control plate drives

4.3.3.1 Introduction. Each control plate drive (four total) is composed of a number of separate subassemblies which make up a complete control plate drive system. These subassemblies are interchangeable between drive systems and are designed to facilitate maintenance replacement and minimize reactor downtime. Spare subassemblies are kept available at all times.

It is the responsibility of the shift supervisor or a designated alternate to supervise disassembly and reassembly of the control plate drives. This will require that he thoroughly familiarize himself with the design and function of the assemblies which make up the control plate drive systems.

4.3.3.2 Control plate drive rod assembly replacement

4.3.3.2.1 References

Drawings:

F-42325	Outer Control Plate Drive - General Assembly
E-42151	Magnet Actuator Assembly
E-42342	Position Indicator Assembly
E-47909	Outer Control Rod Drive Gear Box Assembly
E-42330	Drive Rod and Engagement Mechanism Assembly

4.3.3.2.2 Precautions

1. All fuel must be removed from the reactor.
2. The primary system must be at atmospheric pressure and at zero flow.
3. Cover all equipment with plastic to protect it from any water which might be spilled.
4. The raise test switch must be placed in the "test" position.

5. Health Physicist coverage is required for removal of the drive rod.

4.3.3.2.3 Removal procedure

1. Have the control room operator withdraw the drive to approximately 18 in. Disconnect the electrical leads and the air line going to the motors.
2. Loosen the push rod coupling bolts until they seat against the nuts. Spread the coupling halves to make sure they are free from the push rod.
3. Uncouple the drive rod from the magnet actuator assembly as follows:
 - a. Unbolt the drive rod connection flange from the magnet actuator assembly top flange.
 - b. Unbolt the split ring retainer flange from the drive rod connection flange.
 - c. Raise the split ring retainer flange and remove the split rings.
 - d. Attach the drive rod support clamp assembly to the adjacent platform support post. Attach the upper arm of the assembly to the drive rod just below the seal housing. The seat switch must be removed to make room for the clamp arm.
4. Reconnect the electrical end and have the control room operator slowly insert the drive down to approximately 3 in. withdrawn. This leaves the drive rod suspended and supported by the clamp. Disconnect the motor leads in this position.

5. Unbolt the magnet actuator assembly from the lead screw.
6. Install the lifting flange on top of the magnet actuator assembly (see Fig. 4. 62), and then manually lift the assembly up and remove it to the support platform. NOTE: This assembly weighs approximately 150 lbs and should be handled carefully to protect the flange surfaces. Set the magnet actuator assembly down on a padded surface to prevent damage. If necessary, disconnect the electrical leads and transfer the actuator assembly from the platform to the storage can located on the subpile room floor by using the equipment lift provided for this purpose. Be sure to keep the actuator assembly upright during its removal and transfer.
7. Reconnect the motor leads and have the control room operator withdraw the lead screw to approximately 8 in. Disconnect the motor leads. A small magnet must be used to actuate the seat switch for withdrawal.
8. Prepare for the lead screw removal as follows:
 - a. Disconnect the boot from the lead screw flange.
 - b. Remove the roll pin from the lead screw flange and then remove the flange, lockwasher, and boot retainer from the lead screw.
 - c. Temporarily de-energize the appropriate SB switch (S-10 through S-40) and disconnect the asymmetry potentiometer from the position indicator to avoid possible damage to the potentiometer.

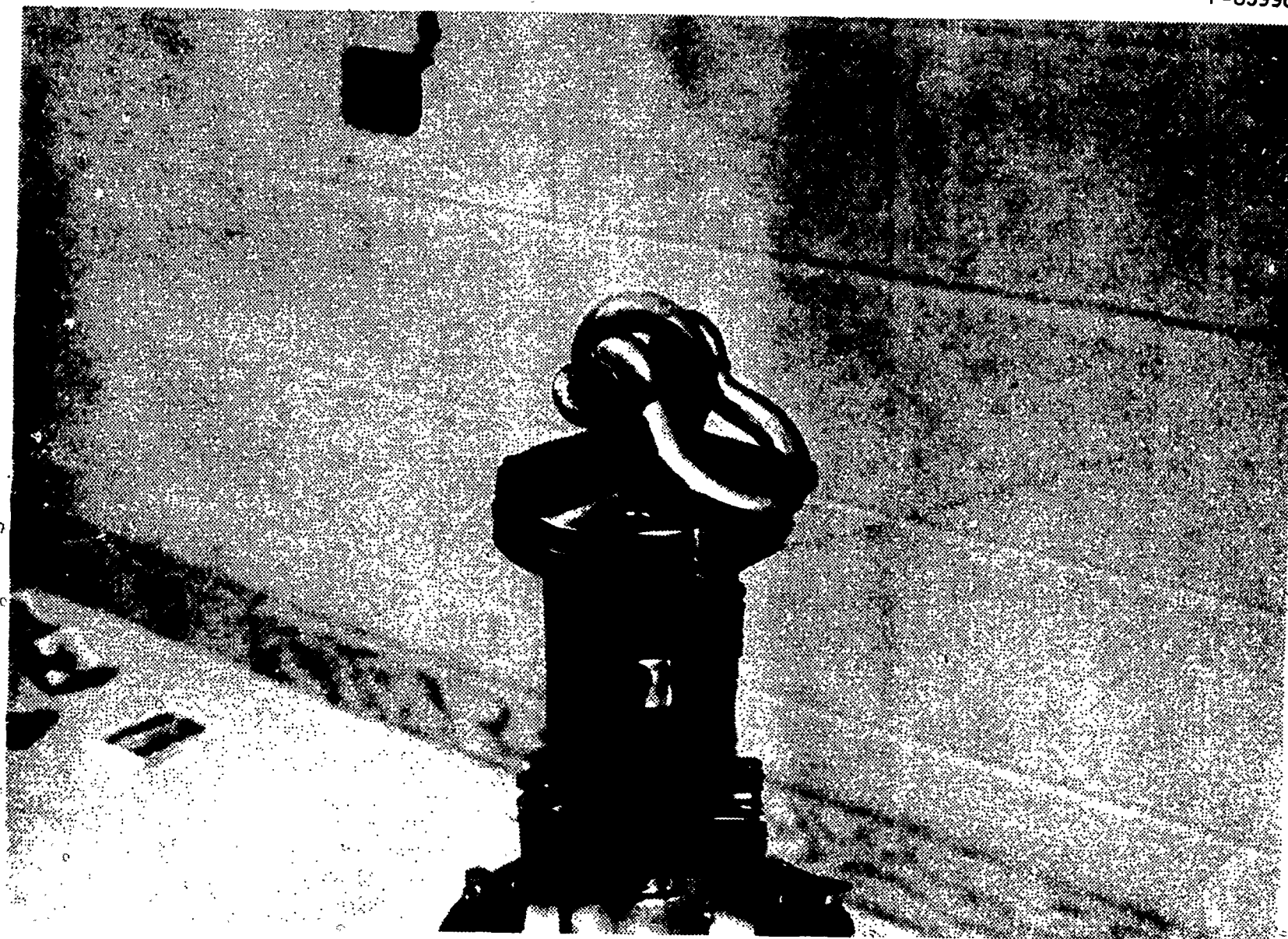


Fig. 4.62. Magnet actuator lifting flange.

- d. Loosen the set screws on the position indicator antibacklash spring and allow the spring to unwind slowly to its free position.
 - e. Loosen all screws attaching the position indicator to the support platform and slide the position indicator back away from the lead screw to the back of the slots provided. Retighten at least two screws to hold the position indicator in place.
- 9. Reconnect the motor leads and run the lead screw down to the insert limit.
 - 10. Loosen the actuator arm on the electric motor shim insert limit switch and allow the arm to swing down out of the way of the lead screw.
 - 11. Engage the castle nut on the bottom of the lead screw with the special T-handle tool (see Fig. 4.63) to prevent the lead screw from turning while running the lead screw out of the gear with the shim motor.
CAUTION: Do not drop the lead screw when it disengages. Store the lead screw in a plastic bag.
 - 12. Remove the position indicator and limit switch assembly as follows:
 - a. De-energize the appropriate SB switch (S-10 through S-40).
 - b. Disconnect the electrical connectors to the position indicator and limit switches.

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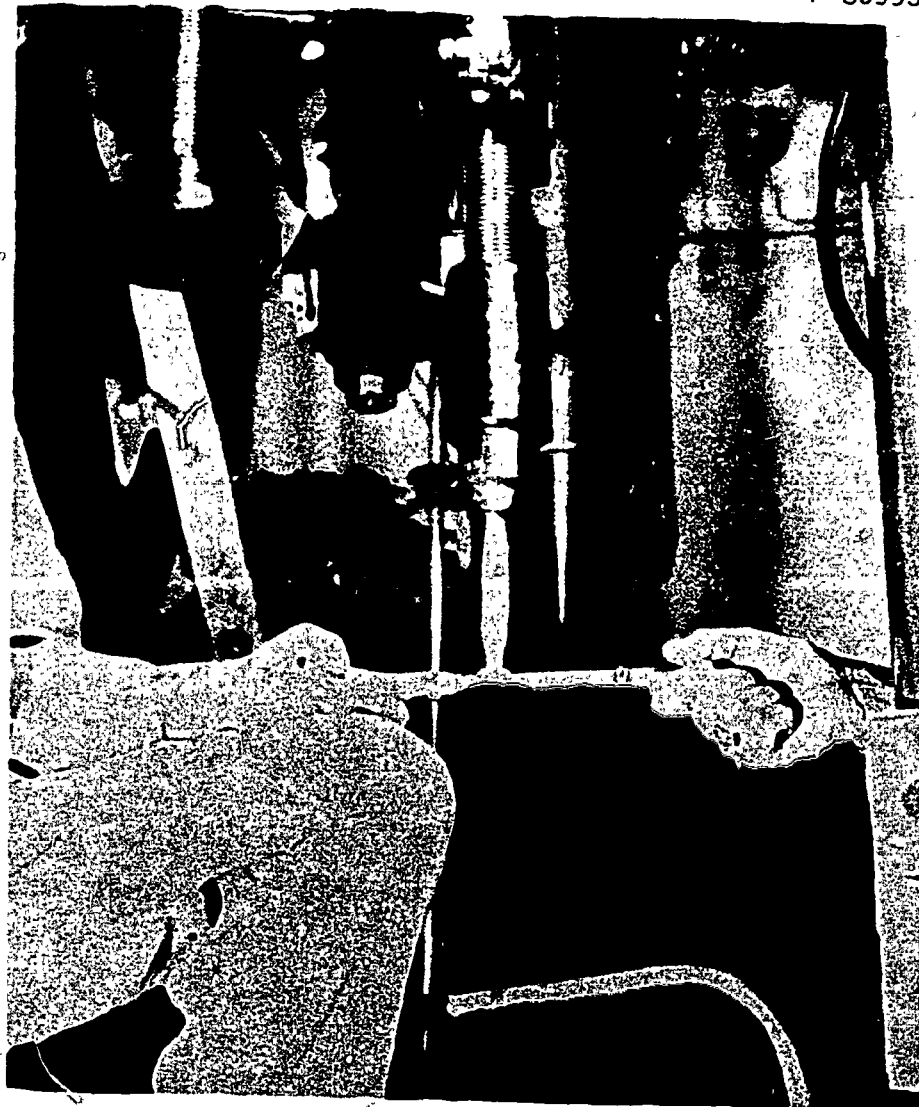


Fig. 4.63. Special T-handle tool holding lead screw.

- c. Remove all screws which attach the assembly to the support platform and carefully remove the assembly.
 - d. Store the position indicator and limit switch assembly in a safe location.
13. It is not necessary to remove the electric shim motor and the air motor from the gear box. NOTE: The shim motor flange must be used with its matching numbered gear box if either the shim motor or the gear box is replaced.
14. Remove the gear box as follows (see Fig. 4.64):
- a. Unbolt the gear box from beneath the support platform.
 - b. Install the lifting bar.
 - c. Using the equipment lift, raise the gear box straight up 1 in. off the dowel pins and remove the gear box to a safe location.
 - d. Cover the gear box openings for protection from dust and water.
15. Remove the drive rod as follows:
- a. Install a plastic protective liner in the slotted hole in the support platform.
 - b. Slide the ball valve and secondary seal housing assembly (see Fig. 4.65) on the drive rod. Attach the lower arm of the drive rod support clamp assembly beneath the ball valve. Loosen the upper arm and swing out of the way.

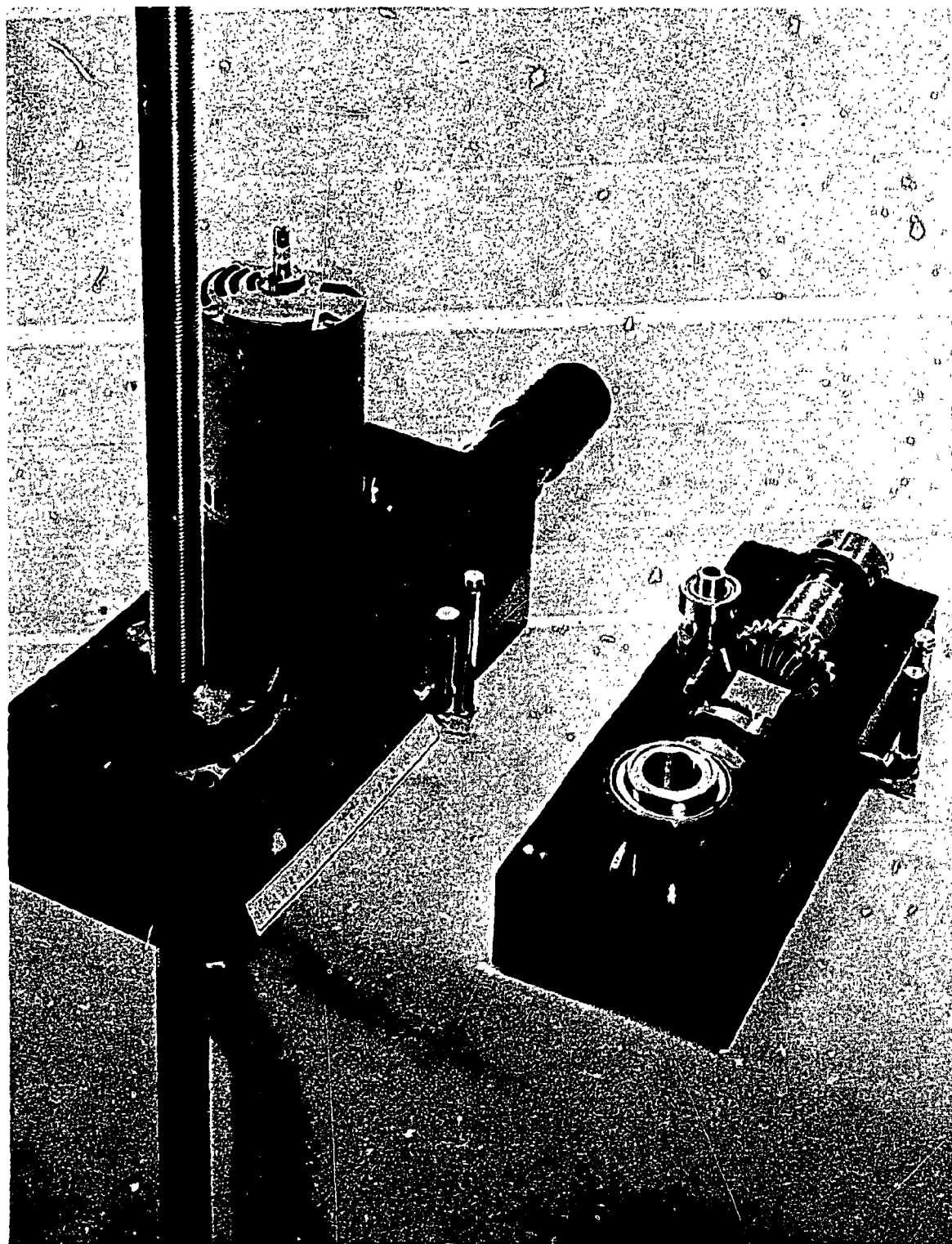


Fig. 4.64. c Outer control plate drive gear box.

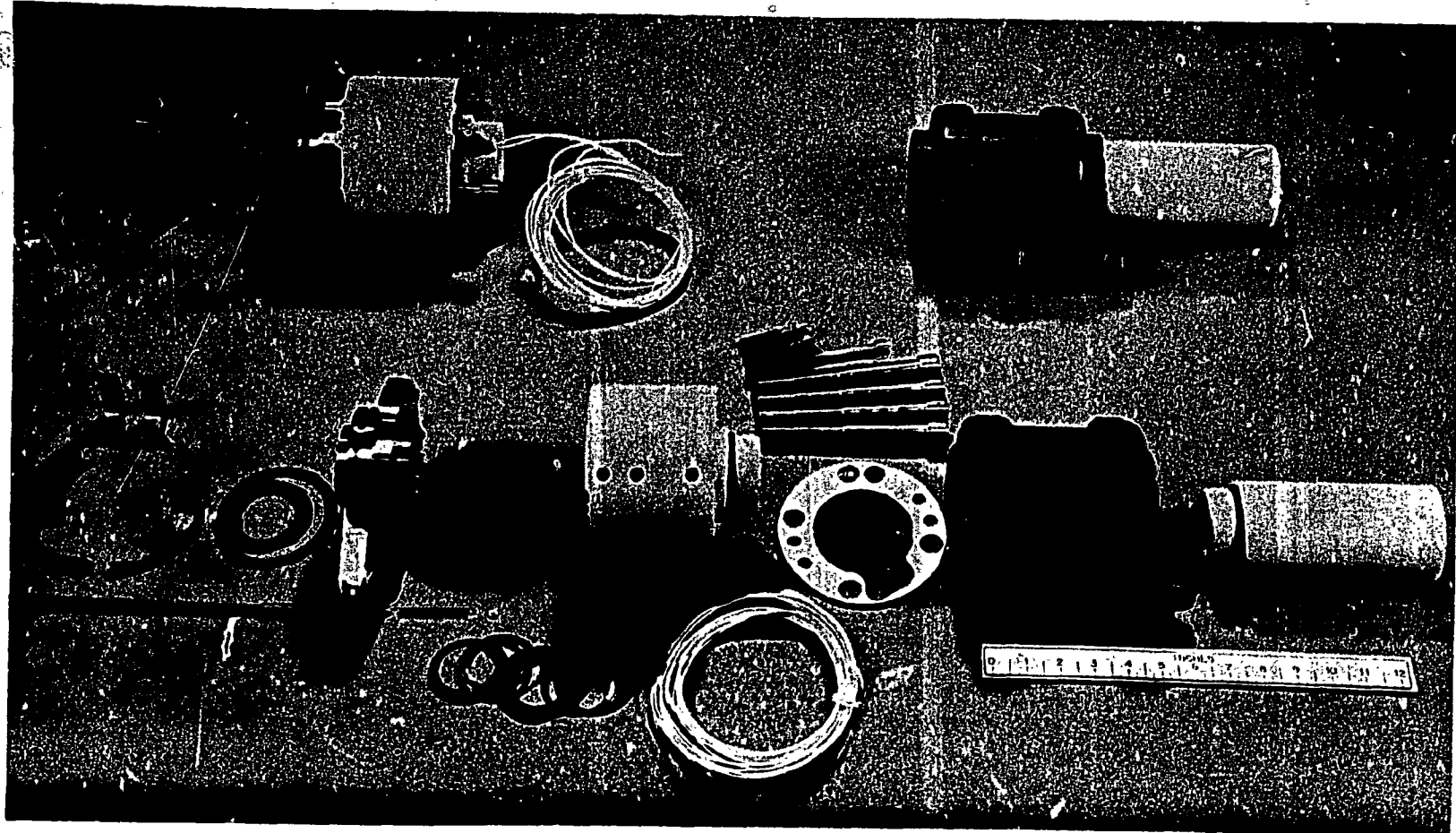


Fig. 4.65. Seal housing and ball valve assemblies.

- c. Screw the ball valve and secondary seal housing assembly onto the primary seal housing. Use strap wrenches to tighten.
- d. Install the maintenance stand (see Fig. 4.66) on the floor below the slotted hole and lock it in position to support the drive rod at an elevation such that the top of the drive rod will be just below the ball valve ball and still in the secondary seal housing.
- e. Pull the push rod to its bottom position (2 7/8 in. from the bottom of the drive rod).
- f. Using micarta clamp wrenches, support the drive rod and loosen the drive rod support clamp arm. Slowly lower the drive rod by hand until it rests on the maintenance stand. The top of the rod should be above the secondary seal, but below the ball valve. Slide a 12-ft-long plastic bag over the bottom of the drive rod as it is lowered to the maintenance stand.
- g. Close the ball valve and lock the valve operator in the closed position. Place a "DO NOT OPERATE" tag on the valve.
- h. Lower the maintenance stand and drive rod from secondary seal. NOTE: There is approximately one cup of contaminated water trapped below the ball valve. Absorb this water with rags as the drive rod is being removed. Seal off both ends of the plastic bag on the drive rod.

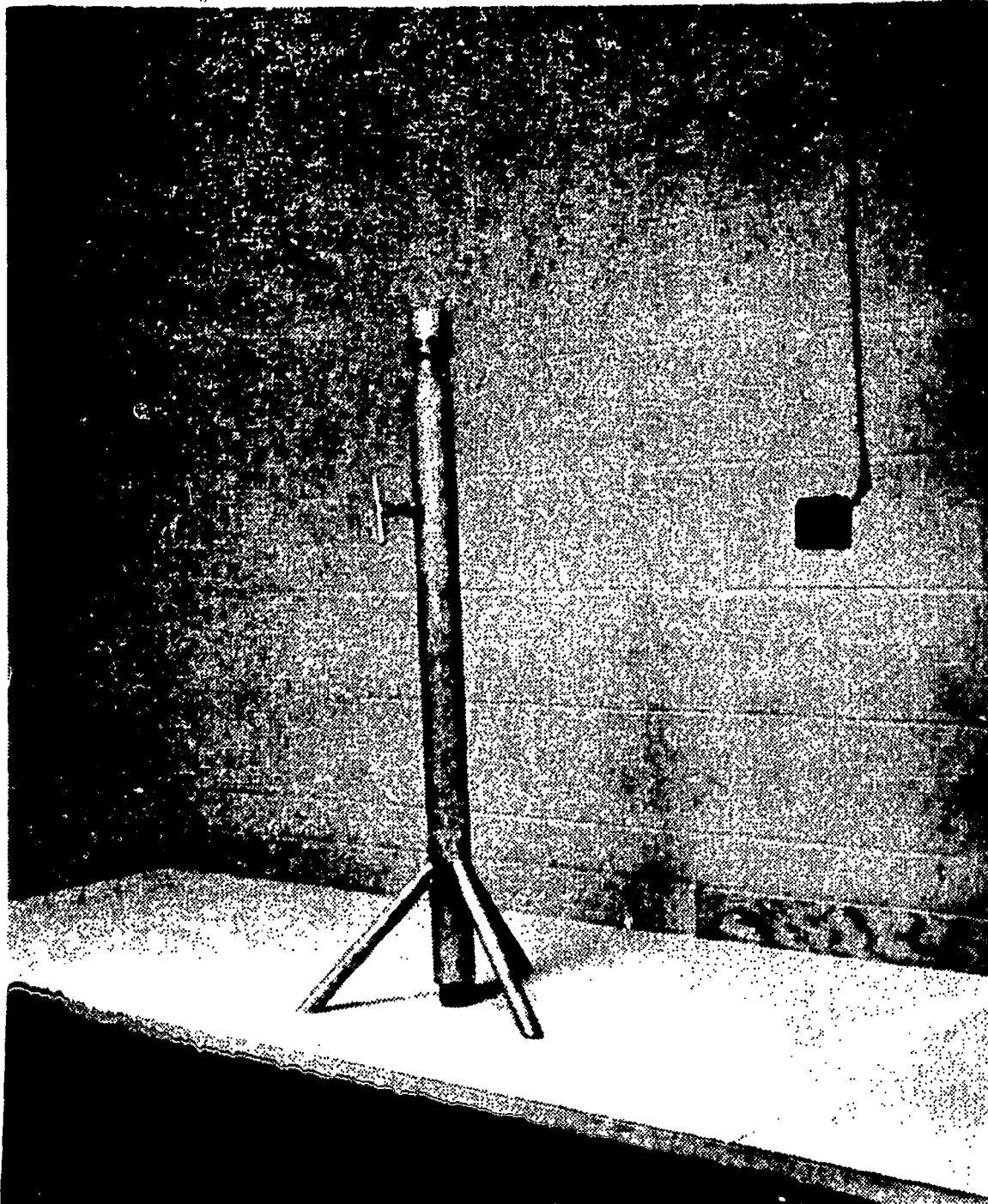


Fig. 4.66. Maintenance stand.

- i. Turn the drive rod to approximately a 30° angle to vertical along the direction of the slot in the support platform and very carefully remove the drive rod down through the support platform. CAUTION: Do not scrape or dent the surface of the drive rod, since this will cause future seal leakage.
- j. In order to remove the drive rod from below the support platform, it is necessary to remove one section of grating and extend one end of the drive rod through the opening while the other end is carried toward the steps leading from the subpile room. The section of grating which must be removed depends upon which drive rod is being removed.
- k. Place the drive rod in its carrier and use the stairwell hoist to lift it out of the subpile room. Do not carry the drive rod up the stairs.

4.3.3.2.4 Replacement Procedure. Reassemble the control plate-drive rod in the reverse order of the removal procedure and in accordance with the following:

1. Pull the push rod down to its bottom position (2 7/8 in. from the bottom of the drive rod) before installing the drive rod assembly.
2. Reconnect the asymmetry potentiometer to the position indicator with the drive in its insert limit. Turn

the potentiometer housing fully counterclockwise to its limit as viewed from its back and back off 1/4 to 1/2 revolution and lock in place. NOTE: It is important that the potentiometer be turned in the proper direction to avoid damaging it when moving the drive rod.

3. Rewind the position indicator antibacklash spring 3 1/2 revolutions clockwise with the drive in its insert limit and then lock in place.
4. Carefully guide the push rod into the snubber when coupling the magnet actuator to the drive rod mechanism.
5. Inspect the snubber assembly guide marks when the assembly is completed and with the armature against the magnet. The top of the snubber cylinder should nominally be lined with the center mark within ± 0.050 in.

4.3.3.2.5 Control Plate Drive Assembly - Switch and Position Indicator Setting:

1. Seat Switch Setting
 - a. With the raise test switch in "test" position, withdraw the control plate drive to approximately 8 in. as observed in the subpile room. A small magnet must be used to actuate the seat switch for withdrawal.
 - b. With the control plate in its seat position, screw the seat switch assembly into the seal housing until the switch makes contact. An ohm-meter must be used to determine when the switch

makes contact. Screw the switch in one turn further (approximately 0.040 in.) and lock it in place with its lock nut.

2. Response Switch Setting

- a. The control plate drive should be near the insert limit. Manually crank the drive to set the switch.
- b. Set the switch to open when the magnet armature is 0.450 ± 0.005 in. from the magnet.

3. Release Switch Setting

- a. The control plate drive should be near its insert limit. Manually crank the drive down until the armature and magnet touch. Set the zero on the indicator.
- b. Manually crank the drive up and adjust the switch to open when the magnet armature is 0.014 in. to 0.015 in. from the magnet.

4. Clutch Switch Setting

- a. The control plate drive should be near its insert limit. Manually crank the drive down until the armature and magnet touch. Set the zero on the indicator.
- b. The clutch switch is set at the same time the release switch is set. Check the setting to see that it opens and closes when the magnet armature is between 0.015 in. and 0.030 in. from the magnet.

5. Control Plate Position Indicator Setting

- a. Manually crank the drive to a point where Surface "A" of the lead screw flange is 14.750 in., ± 0.005 in., from the top of the support platform.

- b. Zero the coarse and fine synchros by loosening their adjusting screws and turning the synchros until the indication on the control plate position indicators in the control room is zero. Retighten the adjusting screws and then recheck the control plate position indicators in the control room. Both the coarse and fine pointers should indicate exactly zero.
 - c. Rotate the asymmetry potentiometer body counterclockwise to its limit; then rotate it clockwise between $1/4$ and $1/2$ revolution. The final setting on this potentiometer must be made by I&C personnel. Tighten the potentiometer attaching screws to lock it in place.
6. Shim Insert Limit Switch Setting
- Set the switch to stop the drive (including coastdown) at 0.350 in., ± 0.015 in., below the position indicator zero point as follows:
- a. Make sure the clutch switch has already been properly adjusted.
 - b. Make sure the position indicator has already been properly adjusted.
 - c. Block out the clutch switch by jumpering the switch (Pins A and C). This prevents the clutch switch from stopping the drive.
 - d. Raise the control plate drive (raise test switch in "test" position) approximately 2 in.
 - e. Adjust the insert limit switch so that it stops control plate drive insertion at 0.350 in., ± 0.015 in., (including coastdown) below the zero

point on the position indicator in the control room. CAUTION: Do not allow the drive to insert further than this setting.

f. Unblock the clutch switch.

7. Air Motor Insert Limit Switch Setting

- a. Place the raise test switch in "test" position and raise the control plate drive approximately 8 in.
- b. Block out the clutch switch by jumpering the switch (Pins A and C). This prevents the clutch switch from stopping the drive.
- c. Use the air motor control switch in the control room to insert the control plate drive.
- d. Set the air motor insert limit switch to stop the drive 0.500 ± 0.015 in. below the zero point on the position indicator located in the control room.
- e. Unblock the clutch switch.

8. Shim Withdraw Limit Switch Setting

- a. Place the raise test switch in "test" position and raise the control plate drive.
- b. Adjust the shim withdraw limit switch to stop withdrawal at 26.900 ± 0.015 in. (including coastdown) above the zero point on the position indicator in the control room.

4.3.3.3 Control plate drive seal housing replacement

4.3.3.3.1 References

Drawings:

E-42330 Drive Rod and Engagement Mechanism
Assembly

E-42346-4 Outer Control Rod Seal Housing Assembly
 E-49855 Control Rod Seal Hydraulic Lines - Flow
 Sheet

4.3.3.3.2 Precautions

1. All fuel must be removed from the reactor.
2. The primary water system must be at atmospheric pressure and at zero flow.
3. A physicist coverage is required for removal of the seal housing.
4. All equipment must be covered with plastic to protect it from water that might be spilled during the seal housing removal.
5. During replacement of the seal housing, containment of vessel water is effected by one O-ring seal. Every care must be taken to obtain this water seal and to maintain it throughout the completion of this procedure. Loss of the water seal will allow contaminated water to drain into the subpile room and possibly uncover highly radioactive components in the reactor vessel.
6. The raise test switch must be placed in the "test" position.

4.3.3.3.3 Removal procedure

1. Close the lubricating water inlet and exit valves and the high pressure flush water supply valve to the seal housing. Refer to Table 1 for the appropriate valve numbers.

Table 4.1. Valves in control plate drive seal system

Control plate No.	High pressure water supply	Lubricating water supply	Lubricating water flow control	Isolation
1	308	2358	2363	2372
2	304	2362	2366	2869
3	305	2361	2365	2370
4	307	2359	2364	2371
5	306	2360	2367	2368

High Pressure System

<u>Valve No.</u>	<u>Use</u>
301	Subpile room block in line 113 from pressurizer pumps
302	Block to PI-302
309	Manifold drain
310	Supply to pressure balance system

Lubricating Water System

<u>Valve No.</u>	<u>Use</u>
2376	Purge for the reactor vessel exten- sion
2352	Block to PI-2352
2351	Subpile room block in line 1333 from pool cleanup system supply to beam hole area

2. Complete steps 4.3.3.2.3.1 through 4.3.3.2.3.4 of the control plate drive rod assembly replacement procedure.
3. Disconnect and remove the seat switch assembly.
4. Cut and remove the lock wire from the seal housing cap screws.
5. Loosen approximately 1/16 to 1/8 in. of the cap screws that fasten the seal housing to the vessel bottom head (items 3 and 7, ORNL Dwg. E-42346). Do not loosen cap screws (item 12, ORNL Dwg. E-42346).
6. Remove the split spacer from between the seal housing and the bottom head (see Fig. 4.65).
7. Tighten the capscrews (item 7) sufficiently to fasten the spool piece against the bottom head and compress the secondary O-ring seal.
8. Drain the water from the seal housing lines through the tees at the outer edge of the bottom head.

CAUTION: Let the high pressure drain stay open at least 5 min. to determine if the secondary O-ring seal is holding. Only a small amount of leakage can be tolerated, and this leakage must be routed to the process waste sump in the corner of the subpile room.
9. If there is little or no leakage past the secondary O-ring seal, disconnect and remove the seal housing water lines. Carefully identify each of these lines to facilitate replacement in the proper location.
10. Remove capscrews (items 3 and 12) and slide the seal

housing down to the split ring retainer flange. Do not loosen or remove capscrews (item 7), since these two are compressing the secondary O-ring seal.

Leave the seat switch actuating rod in place and tape it securely to prevent it from falling out.

11. Attach the lower arm of the drive rod support clamp and remove the upper arm. Remove the split ring, retainer flange, and seal housing. CAUTION: Do not rotate the seal housing, but lower it straight down in order to prevent damage to the seat switch actuating rod. Do not lose the seat switch actuating rod spring (recessed in the seal housing). Lubricate the seals with glycerine during removal. Reattach the upper arm of the drive rod support clamp and remove the lower arm. Remove the seal housing.

4.3.3.3.4 Replacement procedure

Reassemble the seal housing in the reverse order of the removal procedure and in accordance with the following:

1. The seals should be lubricated with glycerine any time the drive rod or the seal housing is moved when the water lines are disconnected.
2. After the seal water lines are reinstalled, check for leaks both on the water line connections and through the seals. As soon as the primary system is pressurized, the seals and water line connections should again be checked for leakage.

4.3.3.4 Control plate drive magnet actuator assembly replacement

4.3.3.4.1 References

Drawings:

F-42325 Outer Control Rod Drive - General Assembly

E-42151 Magnet Actuator Assembly

4.3.3.4.2 Replacement Procedure

1. Perform steps 4.3.3.2.2 through 4.3.3.2.3.7 of the control plate drive rod assembly replacement procedure.
2. Reassemble in the reverse order and in accordance with steps 4.3.3.2.4.5 through 4.3.3.2.5.8 of the control plate drive rod assembly replacement procedure.

4.3.3.5 Control plate drive gear box assembly replacement

4.3.3.5.1 References

Drawings:

F-42325 Outer Control Rod Drive - General Assembly

E-42151 Magnet Actuator Assembly

E-47909 Outer Control Rod Drive Gear Box Assembly

4.3.3.5.2 Replacement Procedure

1. Perform steps 4.3.3.2.2 through 4.3.3.2.3.15 of the control plate drive rod assembly replacement procedure except step 4.3.3.2.3.13, which should be omitted.
2. Reassemble in the reverse order and in accordance with steps 4.3.3.2.4 through 4.3.3.2.5.8 of the control drive rod assembly replacement procedure.

4.3.3.6 Control plate drive position indicator assembly replacement

4.3.3.6.1 References

Drawings:

F-42325 Outer Control Rod Drive - General Assembly
E-42342 Position Indicator Assembly
E-47909 Outer Control Rod Drive Gear Box Assembly

4.3.3.6.2 Replace procedure

1. De-energize the appropriate SB switch (S-10 through S-40).
2. Loosen the set screws on the position indicator antibacklash spring and allow the spring to unwind slowly to its free position.
3. Disconnect the asymmetry potentiometer from the position indicator and disconnect the electrical connectors to the position indicator and limit switches.
4. Loosen all screws attaching the position indicator to the support platform and slide the position indicator back away from the lead screw to the back of the slots provided (approximately 1/4 in). Retighten at least two screws to hold the position indicator in place.
5. Remove the lock and stop nuts from the lower end of the lead screw.
6. Unbolt the position indicator assembly from the support platform and lower it, being extremely careful not to drag the position indicator worm gear against the lead screw.

7. Reassemble the position indicator assembly in the reverse order and in accordance with the items 4.3.3.2.4.3 and 4.3.3.2.4.4 of the control plate drive rod assembly replacement procedure.

4.3.3.7 Inner control cylinder regulating drive gear box replacement

4.3.3.7.1 References

Drawings:

- E-42209 Inner Control Rod Drive Rod, Bearing and Connector Assembly
- E-42290 Inner Control Rod Regulating Drive Assembly
- E-42391 Inner Control Rod Position Indicator and Limit Switch Assembly
- E-47638 Inner Control Rod Shim Drive
- E-42369 Support Platform Assembly - Top View
- E-42495 Support Platform Assembly - Bottom View

4.3.3.7.2 Precautions

1. All fuel must be removed from the reactor.
2. The primary water system must be at atmospheric pressure and at zero flow.
3. Do not drain or remove the pressure balance cylinder.

4.3.3.7.3 Removal Procedure

1. Disconnect the electrical input to each of the three servo motors.

2. Run the regulating drive to its mechanical insert limit using a hand-operated crank.
3. Run the No. 5 shim drive to its withdraw limit and disconnect the motor leads.
4. Unbolt the lead screw bottom flange from the pressure balance cylinder flange. Close and put a "DO NOT OPERATE" tag on the pressure balance system valve V-247. Do not move the pressure balance cylinder piston rod again until this valve is re-opened.
5. Reconnect the motor leads and run the shim drive to approximately 6 in. withdrawn, leaving the pressure balance piston disconnected.
6. Remove the lead screw bottom flange.
7. Remove the inner control cylinder position indicator assembly as follows:
 - a. De-energize SB switch S-50.
 - b. Disconnect the asymmetry potentiometer and disconnect the electrical connectors to the position indicator and limit switch.
 - c. Loosen the set screws on the position indicator antibacklash spring and allow the spring to unwind slowly to its free position.
 - d. Unbolt the position indicator assembly from the regulating drive and lower it while being extremely careful not to drag the position indicator worm gear against the lead screw.

8. Uncouple the drive rod from the lead screw as follows:
 - a. Unbolt the split ring retainer flange from the lead screw top flange.
 - b. Install the drive rod support clamp and attach it to the drive rod.
9. Energize the SB switch S-50 and withdraw the lead screw down 12 in. - leaving the drive rod supported by the clamp.
10. Unbolt the shim drive gear box from the regulating drive gear box (item 15, ORNL Dwg. E-42290).
11. Remove the lead screw top flange.
12. Run the lead screw down to 1 in. from the pressure balance cylinder flange. CAUTION: Since there is no limit switch protection, extreme care should be taken when performing this step.
13. De-energize SB switch S-50 and temporarily support the shim drive gear box and lead screw assembly by hand. Then turn the motor drive shaft with the hand crank and remove the shim drive gear box and motor subassembly from the lead screw.
14. Raise the lead screw as high as possible and tie off or support with other appropriate means.
15. Remove the lock screws and slowly unwind the anti-backlash spring of the regulating drive position indicator.
16. Disconnect the potentiometer from the regulating drive position indicator.

17. Remove the following couplings:
 - a. Regulating drive gear box and servo input mechanism assembly.
 - b. Regulating drive gear box and regulating drive position indicator assembly.
18. Place the equipment lift with special regulating drive gear box support beneath the gear box, then unbolt, and lower the gear box. When it is low enough to clear the lead screw, remove it from below the support platform.
19. The lead screw may now be removed if replacement is necessary.

4.3.3.7.4 Replacement procedure

1. Reassemble in the reverse order of the removal procedure and in accordance with the steps below.
 - a. Open valve V-247 on the pressure balance system after the pressure balance cylinder piston rod is reconnected to the lead screw flange.
 - b. Rewind the control plate position indicator antibacklash spring approximately 3 1/2 revolutions clockwise and lock with the shim drive at its withdraw limit.
 - c. Rewind the regulating drive position indicator antibacklash spring approximately 3 1/2 revolutions clockwise and lock with the regulating drive at its withdraw limit.

4.3.3.8 Inner control cylinder drive assembly - switch and position indicator setting (see Fig. 4.67).

4.3.3.8.1 Control plate position indicator setting

1. Position the top of the lead screw flange 51.125 ± 0.010 in. from the support platform using the manual crank provided. Do not run the drive above this point (insert limit).
2. Zero the coarse and fine synchros by loosening their adjusting screws and turning the synchros until the indication on the position indicator in the control room reads zero. (The regulating drive portion of No. 5 control cylinder must be fully inserted.) Retighten the adjusting screws.

4.3.3.8.2 Inner control cylinder shim insert limit switch setting

1. Withdraw the control cylinder approximately 2 in.
2. Adjust the insert limit so that it stops control cylinder insertion at 1.100 ± 0.015 in. (including coastdown) above the zero point on the position indicator in the control room. This position should correspond to a measured 50.025 ± 0.015 in. from the support platform to the top of the lead screw flange.

4.3.3.8.3 Inner control cylinder shim withdraw limit switch setting

1. Withdraw the control cylinder approximately 24 in.
2. Adjust the withdraw limit switch to stop the drive

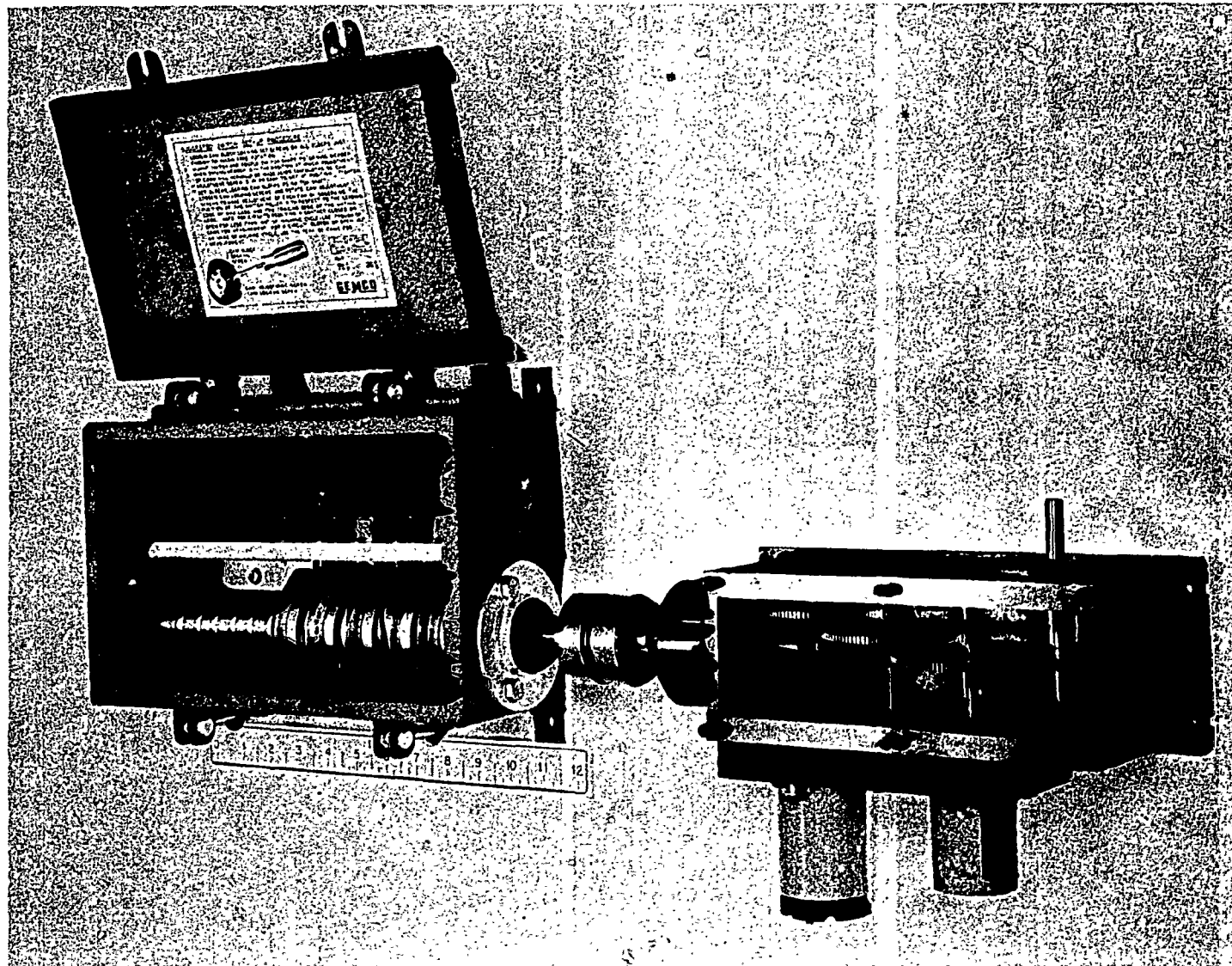


Fig. 4.67. Inner control cylinder regulating drive switch assembly and position transmitter.

(including coastdown) at 25.900 ± 0.015 in., as read out on the console position indicator or when the lead screw flange is 25.225 ± 0.015 in. above the support platform.

4.3.3.8.4 Regulating drive position indicator setting

1. Using a hand crank on one of the servo motors, manually run the regulating drive against its mechanical insert limit. Do not use the electric motors. The three servo motors will have to be disconnected electrically.
2. Loosen the potentiometer locking screws.
3. Rotate the position potentiometer clockwise to its limit, then counterclockwise approximately $1/4$ to $1/2$ revolution.
4. Tighten the locking screws to lock the potentiometer in place.

4.3.3.8.5 Regulating drive insert limit switch setting (No. 1)

1. Disconnect the three servo motor electrical leads.
2. Using a hand crank on one of the servo motors, manually run the regulating drive 0.100 ± 0.005 in. from its mechanical insert limit.
3. Set one cam so that the switch will actuate coming off the cam shoulder. Set the other cam such that the switch is off the cam shoulder from zero position (insert mechanical limit) to 0.100 ± 0.005 in. and on the cam shoulder from 0.100 in to 1.000 in. The cams should be adjusted to actuate the switch with the regulating drive traveling toward its mechanical insert limit.

4.3.3.8.6 Regulating drive automatic shim insert switch setting (No. 2)

1. Disconnect the three servo motor electrical leads.
2. Using a hand crank on one of the servo motors, manually run the regulating drive 0.200 ± 0.005 in. from its mechanical insert limit.
3. Set one cam so that the switch will actuate coming off the cam shoulder. Set the other cam such that the switch is off the cam shoulder from zero position (insert mechanical limit) to 0.200 ± 0.005 in. and on the cam shoulder from 0.200 to 1.000 in. The cams should be adjusted to actuate the switch with the regulating drive traveling toward its mechanical insert limit.

4.3.3.8.7 Regulating drive intermediate switch setting (No. 3)

1. Disconnect the three servo motor electrical leads.
2. Using a hand crank on one of the servo motors, manually run the regulating drive 0.600 ± 0.005 in. from its mechanical insert limit.
3. Set one cam so that the switch will actuate coming off the cam shoulder. Set the other cam such that the switch is off the cam shoulder from zero position (insert mechanical limit) to 0.600 ± 0.005 in. and on the cam shoulder from 0.600 to 1.000 in. The cams should be adjusted to actuate the switch with the regulating drive traveling toward its mechanical insert limit.

4.3.3.8.8 Regulating drive automatic shim insert switch setting (No. 4)

1. Disconnect the three servo motor electrical leads.
2. Using a hand crank on one of the servo motors, manually run the regulating drive 0.800 ± 0.005 in. from its mechanical insert limit.
3. Set one cam so that the switch will actuate coming off the cam shoulder. Set the other cam such that the switch is off the cam shoulder from zero position (insert mechanical limit) to 0.800 ± 0.005 in. and on the cam shoulder from 0.800 to 1.000 in. The cams should be adjusted to actuate the switch with the regulating drive traveling toward its mechanical insert limit.

4.3.3.8.9 Regulating drive intermediate switch setting (No. 5)

1. Disconnect the three servo motor electrical leads.
2. Using a hand crank on one of the servo motors, manually run the regulating drive 0.900 ± 0.005 in. from its mechanical insert limit.
3. Set one cam so that the switch will actuate coming off the cam shoulder. Set the other cam such that the switch is off the cam shoulder from zero position (insert mechanical limit) to 0.900 ± 0.005 in. and on the cam shoulder from 0.900 to 1.000 in. The cams should be adjusted to actuate the switch with the regulating drive traveling toward its mechanical insert limit.

4.3.3.9 Inner control cylinder shim drive gear box replacement

4.3.3.9.1 References

Drawings:

E-47638 Inner Control Rod Shim Drive Assembly
E-42290 Inner Control Rod Regulating Drive
Assembly
E-42391 Inner Control Rod Position Indicator
and Limit Switch Assembly

4.3.3.9.2 Precautions

1. All fuel must be removed from the reactor.
2. The primary water system must be at atmospheric pressure and at zero flow.
3. Do not drain or remove the pressure balance cylinder.

4.3.3.9.3 Removal procedure

Complete steps 4.3.3.7.3.1 through 4.3.3.7.3.14 of the inner control cylinder regulating drive gear box replacement procedure.

4.3.3.9.4 Reassembly procedure

Reassemble in the reverse order and in accordance with steps 4.3.3.7.4 through 4.3.3.8 of the inner control cylinder regulating drive gear box replacement procedure.

4.3.3.10 Inner control cylinder servo input mechanism gear box replacement

4.3.3.10.1 References

Drawings:

E-42300 Servo Input Mechanism for Inner Control
Rod Regulating Drive

E-42495 Control Rod Drives - Support Platform
Bottom View Subassembly

4.3.3.10.2 Precautions

1. The servo system must be de-energized.
2. The primary water system must be at atmospheric pressure and at zero flow.

4.3.3.10.3 Removal procedure (see Fig. 4.68)

1. Disconnect the coupling between the servo input mechanism gear box and the regulating drive gear box.
2. Disconnect the electrical leads to the three servo motors.
3. Remove the holddown bolts from the support channel.
4. Manually move the gear box out approximately half-way or until the lifting bar can be installed in the top. CAUTION: Be careful not to damage the oil level sightglass while moving the gear box.
5. Using the equipment lift, pick up and remove the assembly to a safe place.

4.3.3.10.4 Reassembly procedure

Reassemble in the reverse order.

4.3.3.11 Inner control cylinder position indicator assembly replacement

4.3.3.11.1 References

Drawings:

E-42391 Inner Control Rod Position Indicator
and Limit Switch Assembly

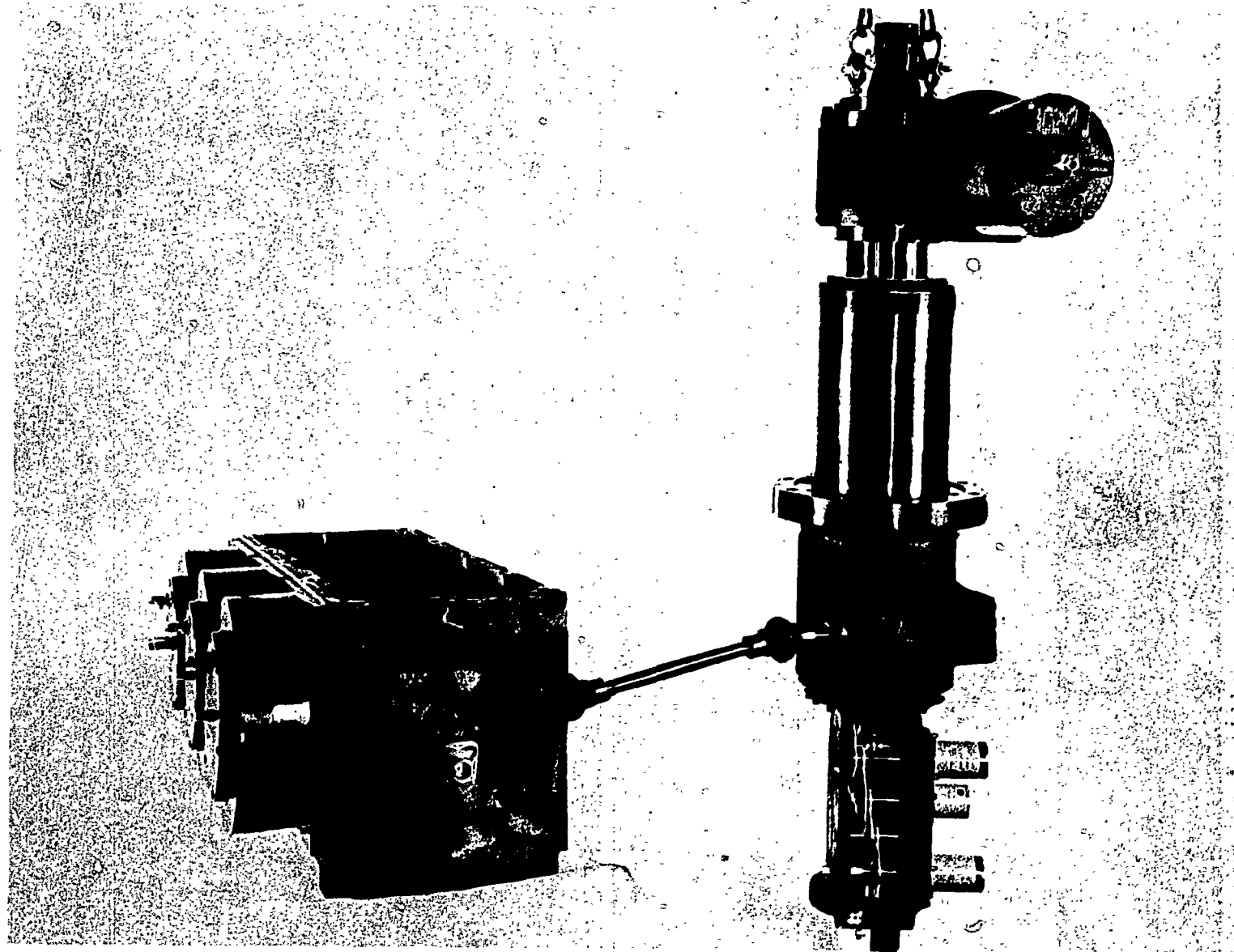


Fig. 4.68. Inner control cylinder servo input mechanism gear box.

4.3.3.11.2 Precautions

1. The servo system must be de-energized.
2. The primary water system must be at atmospheric pressure and at zero flow.
3. Do not drain or remove the pressure balance cylinder.

4.3.3.11.3 Replacement procedure

1. Complete steps 4.3.3.7.3.1 through 4.3.3.7.3.8 of the inner control cylinder regulating drive gear box replacement procedure.
2. Reassemble in the reverse order.
3. Rewind the control cylinder position indicator antibacklash spring approximately 3 1/2 revolutions with the shim drive at its withdrawal limit. Lock it in place.
4. Complete steps 4.3.3.8.1 through 4.3.3.8.9 of the inner control cylinder regulating drive gear box replacement procedure.

4.3.3.12 Inner control cylinder drive seal housing replacement

4.3.3.12.1 References

Drawings:

E-42346-4 Inner Control Rod Seal Housing Assembly
E-49856 Control Rod Seal Hydraulic Lines - Flow
Sheet

1. All fuel must be removed from the reactor.
2. The primary water system must be at atmospheric pressure and at zero flow.

3. Health physicist coverage is required for removal of the seal housing.
4. All equipment must be covered with plastic to protect it from water that might be spilled during the seal housing removal.
5. During replacement of the seal housing, containment of vessel water is effected by one O-ring seal. Every care must be taken to obtain this water seal and to maintain it throughout the completion of this procedure. Loss of the water seal will allow contaminated water to drain into the subpile room and possibly uncover highly radioactive components in the reactor vessel.

4.3.3.12.3 Removal procedure

1. Withdraw the shim drive 6 in. from its insert limit and disconnect the motor leads.
2. Close lubricating water valves V-2360 and V-2367 and high-pressure water supply valve V-306.
3. Uncouple the drive rod from the lead screw as follows:
 - a. Remove the capscrews from the split ring retainer flange and remove the split rings and flange.
 - b. Install the drive rod support clamp and tighten.
4. Reconnect the motor leads and run the lead screw down out of the way. This leaves the drive rod supported by the support clamp.

5. Cut and remove the lock wire from the seal housing capscrews.
6. Loosen approximately 1/16 to 1/8 in. of the capscrews that fasten the seal housing to the vessel bottom head (items 3 and 7, ORNL Dwg. E-42346). Do not loosen cap screws (item 12, ORNL Dwg. E-42346).
7. Remove the split spacer from between the seal housing and the bottom head.
8. Tighten the capscrews (item 7) sufficiently to fasten the spool piece against the bottom head and compress the secondary O-ring seal.
9. Drain the water from the seal housing lines through the tees at the outer edge of the bottom head.
CAUTION: Let the high pressure drain stay open at least 5 min to determine if the secondary O-ring seal is holding. Only a small amount of leakage should be tolerated, and this leakage must be routed to the subpile room sump.
10. If there is little or no leakage past the secondary O-ring seal, disconnect and remove the seal housing water lines. Carefully identify each of these lines to facilitate replacement in the proper location.
11. Remove capscrews (items 3 and 12) and slide the seal housing down to the support clamp arm. Do not loosen or remove capscrews (item 7), since these two are compressing the secondary O-ring seal.
12. Install the upper arm of the support clamp and remove the lower arm and seal housing.

4.3.3.12.4 Reassembly procedure

Reassemble the seal housing in the reverse order of the removal procedure and in accordance with the following:

1. The seals should be lubricated with glycerine any time the drive rod or the seal housing is moved when the water lines are disconnected.
2. After the seal water lines are reinstalled, check for leaks both on the water line connections and through the seals. As soon as the primary system is pressurized, the seals and water line connections should again be checked for leakage.

4.3.3.13 Inner control cylinder regulating drive position indicator and/or cam switch assembly replacement

4.3.3.13.1 References

Drawings:

D-42168 Rotating Cam Switch and Coupling Detail

D-42394 Inner Control Rod Regulating Drive
Position Indicator Assembly

E-42495 Control Rod Drives Support Platform Bottom
View Subassembly

4.3.3.13.2 Removal procedure

1. De-energize switch SB-50.
2. Disconnect the servo motors. **NOTE:** For cam switch assembly replacement only, uncouple the cam switch from the position indicator and replace the assembly. Omit steps 4, 5, 6, and 7 of the following.

3. Disconnect the electrical connectors to the regulating drive position indicator and cam switch housings.
4. Loosen the setscrews on the regulating drive position indicator antibacklash spring and allow the spring to unwind slowly to its free position.
5. Disconnect the potentiometer from the regulating drive position indicator.
6. Disconnect the coupling between the regulating drive gear box and the regulating drive position indicator assembly.
7. Disconnect the coupling between the regulating drive position indicator and the cam switch housing.
8. Unbolt from the bottom of the mounting bracket and remove as required the regulating drive position indicator and/or the cam switch housing.

4.3.3.13.3 Reassembly procedure

Reassemble in the reverse order and in accordance with the following.

1. Rewind the regulating drive position indicator antibacklash spring 3 1/2 revolutions clockwise and lock in this position with the regulating drive at its withdraw limit.
2. Set the regulating drive position indicator and cam switches by completing procedure 4.3.3.8.

4.3.3.14 Inner control cylinder pressure balance cylinder replacement

4.3.3.14.1 References

Drawings:

E-49857 Inner Control Rod Pressure Balance
System - Flow Sheet
E-50182 Inner Control Rod Pressure Balance System
E-42367 Control Rod Drives - Support Platform and
Secondary Support Columns

4.3.3.14.2 Removal procedure

1. Run the inner control cylinder shim drive to its withdraw limit and lock the drive motor with the key interlock.
2. Close and attach a "DO NOT OPERATE" tag to valves V-247 and V-257.
3. Make sure valves V-244 and V-245 are closed. Place a "DO NOT OPERATE" tag on these valves. (These valves are closed during normal operation and should remain closed.) Open HV-310 and drain the line.
4. Remove the plug from line 01-127 and drain oil from the line into a pan.
5. Disconnect lines 01-127 and 01-135 from the pressure balance cylinder and plug the holes. Plug or cover the line ends to protect them from dirt and dust.
6. Unbolt the pressure balance cylinder flange from the lead screw flange.
7. Unbolt the pressure balance cylinder flange from the mounting brackets and remove the cylinder.

8. Mount the spare cylinder on the mounting brackets and couple it to the lead screw flange.
9. Completely fill the new pressure balance cylinder with hydraulic fluid and plug the fill holes before connecting it to the piping.
10. Remove the plugs and couple lines 01-127 and 01-135 to the cylinder.
11. Add oil as required to fill tank No. 2 and pressurize to 20 psig. Open valves V-244 and V-245. Vent lines 01-135, 01-134, and 01-127 at the following points to eliminate entrained air and completely fill with oil.
 - Top and bottom of PdI-1313
 - V-285
 - V-256
 - V-264 (remove pressure gauge)
 - V-262
 - V-270 (remove plug)
12. After completely venting the system so that no air pockets can be found, attach a vacuum pump to the fill tank and alternately pull a vacuum and pressurize the fill tank until no air bubbles are pulled into the fill tank when evacuating.
13. When the filling is complete and all entrained air is removed, close valves V-244 and V-245 and open valves V-247 and V-257.
14. Insert the No. 5 shim drive while observing pressure

gauges and ΔP gauges. PdI-1313 should read 4 to 5 psi; PdI-1311 and PdI-1312 should read less than 1 psi; pressure gauges should read head pressure.

15. Withdraw the No. 5 shim drive and observe the same pressure and ΔP gauges.
16. When the primary system can be pressurized, check for leaks and repeat steps 14 and 15.
17. Accumulator draining and filling is performed as follows:
 - a. If one, or both accumulators, is drained, remove the accumulator and fill the top end with 2 1/2 gal of demineralized water. Pressurize the bottom end of the accumulator slightly to push out air pockets.
 - b. Close the valve on top of the accumulator, turn the accumulator over and completely fill the bottom end with the appropriate fluid. Close the valve on the bottom end.
 - c. Install the accumulator with its valves closed and leave them closed until all lines are filled according to steps 1 through 12 of this procedure.
 - d. The same technique may be used to fill the intermediate lines between accumulators through fill tank No. 1.

4.3.3.15 Upper O-ring seal replacement (outer)

PRESSURE BALANCE SYSTEM VALVE TABULATION

Number	System	Valve Description	Normal Operating
			Position Closed (NC) Open (NO)
V-234	Air	Fill Tank No. 1 Supply (buffer water)	NC
V-235	---	Fill Tank No. 1 Vacuum Pump Connection	NC
V-236	---	Fill Tank No. 1 Relief	Rel. at 30 psi
V-237	Buffer H ₂ O	Fill Tank No. 1 Block	NC
V-238	Buffer H ₂ O	Buffer H ₂ O System Block	NC
V-239	Buffer H ₂ O	Fill Tank No. 1 Drain	NC
V-240	Buffer H ₂ O	Buffer H ₂ O System Sample	
V-241	Air	Fill Tank No. 2 Supply (oil)	NC
V-242	---	Fill Tank No. 2 Vacuum Pump Connection	NC
V-243	---	Fill Tank No. 2 Relief	Rel. at 30 psi
V-244	Oil	Fill Tank No. 2 Block	NC
V-245	Oil	Oil System Block	NC
V-246	Oil	Fill Tank No. 2 Drain	NC
V-247*	Oil	Accumulator No. 2 Bottom	NO
V-248*	Oil	Accumulator No. 2 Top Block	NO
V-249	Buffer H ₂ O	Buffer H ₂ O to PI-1311 and 1312 Block	NO

(CONTINUED)

<u>Number</u>	<u>System</u>	<u>Valve Description</u>	Normal Operating
			Position Closed (NC) Open (NO)
V-250*	Buffer H ₂ O	Accumulator No. 1 Bottom Block	NO
V-251*	Reactor H ₂ O	Accumulator No. 1 Top Block	NO
V-252	Reactor H ₂ O	Reactor H ₂ O to ΔPI-1311 Block	NO
V-253	Reactor H ₂ O	ΔPI-1311 Vent	NC
V-254	Buffer H ₂ O	ΔPI-1311 Vent	NC
V-255	Buffer H ₂ O	ΔPI-1312 Vent	NC
V-256	Oil	ΔPI-1312 Vent	NC
V-257	Oil	Oil to ΔPI-1312 Block	NO
V-258	Reactor H ₂ O	PI-1314 Block	NO
V-259	Reactor H ₂ O	Reactor H ₂ O System Vent	NC
V-260	Reactor H ₂ O	ΔP Pressure Switch - 1316 Block	NO
V-261	Reactor H ₂ O	ΔP Pressure Switch - 1316 Vent	NC
V-262	Oil	ΔP Pressure Switch - 1316 Vent	NC
V-263	Oil	ΔP Pressure Switch - 1316 Block	NO
V-264	Oil	PI-1315 Block	NO
V-265	Oil	ΔPI-1313 Top Block	NO
V-266	Oil	ΔPI-1313 Top Vent (above Cyl. Piston)	NC
V-267	Oil	ΔPI-1313 Bottom Vent (above Cyl. Piston)	NC
V-268	Oil	ΔPI-1313 Bottom Block	NO
V-269	Oil	PI-1317 Block	NO

(CONTINUED)

<u>Number</u>	<u>System</u>	<u>Valve Description</u>	Normal Operating Position
			Closed (NC) Open (NO)
V-270	Oil	Oil System Drain	NC
V-285	Oil	Cylinder Vent	NC
HV-310*	Reactor H ₂ O	Reactor H ₂ O System Main Block	NO

***CAUTION:** During any period, operating or shutdown, when it is possible for the No. 5 shim-regulating cylinder to be moved, there are five valves that must never be closed. These valves are V-247, V-248, V-250, V-251, and HV-310. When one or more of these valves are closed, lock (MI) and tag the inner rod shim motor such that any person unlocking the motor will know that these valves must be opened. If any one of the valves were to be closed and the No. 5 shim-regulating cylinder operated through its full stroke, it is possible to exert approximately 6,000 psi on certain parts of the pressure balance system.