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To HAZARDS, TI

VESR

Acc. 1183.4

AMENDMENT NO. 4

TO

LICENSE APPLICATION

FOR

VALLECITOS EXPERIMENTAL SUPERHEAT REACTOR

Re: Docket 50-183

GENERAL ELECTRIC COMPANY

ATOMIC POWER EQUIPMENT DEPARTMENT

2151 South First Street

San Jose, California

AMENDMENT NO. 4

TO

LICENSE APPLICATION

FOR

VALLECITOS EXPERIMENTAL SUPERHEAT REACTOR

General Electric submitted an application dated February 1, 1961, to construct and operate the Vallecitos Experimental Superheat Reactor. General Electric now desires to amend its application to submit additional information regarding the control rod drives and physics calculational methods. We hereby add to the Preliminary Hazards Summary Report, GEAP-3643, a Part V. B, attached hereto and made a part hereof.

All other conditions remain the same.

To the best of my knowledge and belief, the information contained herein is accurate.

GENERAL ELECTRIC COMPANY
ATOMIC POWER EQUIPMENT DEPARTMENT

/s/ J. R. Wolcott
for George White
General Manager

ATTEST:

Charles W. Wilder
Attesting Secretary

Subscribed and sworn to before me this 2nd day of May, 1961.

Everett H. Layne
Notary Public in and for the County of Santa Clara, State of California

My Commision expires December 30, 1964

ap

PART V — SUPPLEMENTARY INFORMATION

TO

PRELIMINARY HAZARDS SUMMARY REPORT

FOR

VALLECITOS EXPERIMENTAL SUPERHEAT REACTOR

SECTION B: SUPPLEMENTARY INFORMATION ON CONTROL ROD DRIVES AND PHYSICS CALCULATIONAL METHODS

Engineering Section
Atomic Power Equipment Department
General Electric Company

May 1, 1961

SECTION B — SUPPLEMENTARY INFORMATION ON CONTROL ROD DRIVES AND PHYSICS CALCULATIONAL METHODS

1. Control Rod Drive Description

1.1 General

A summary description of the control rod drives is presented in Section II. B. 4 of the hazards report. Figures II. 8 and II. 9, presented therein, are pertinent to the more detailed description presented here.

Each control rod drive assembly is hung from a seal housing which, in turn, is bolted to a thimble which protrudes from the bottom head of the reactor pressure vessel. A seal shaft running through a linear seal connects the lead screw section of the drive to the extension shaft which extends up through the thimble into the pressure vessel proper. The extension shaft is attached to the lower end of the control rod. Operation of the control rod drive moves the seal shaft, extension shaft, and the control rod up or down.

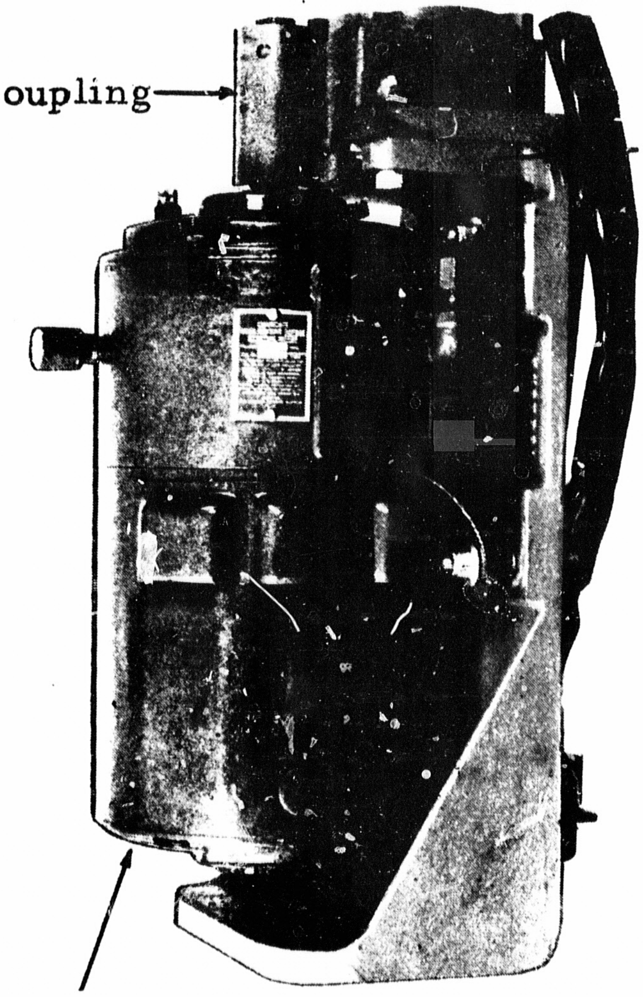
The drives are capable of SHIM (selective actuation and positioning at normal speed) or SCRAM (all rods fully inserted pneumatically) action. The drives are operated from the control panel of the main reactor control station.

Each control rod drive assembly (refer to Figure II. 8) is made up of the following six major sections:

a. Gear Motor Section
b. Pneumatic Cylinder
c. Position Indicator Assembly
d. Lead Screw Section
e. Seal Assembly
f. Extension Shaft Assembly.

1.2 Gear Motor Section

The gear motor section consists of the 3-phase reversible motor, the motor mounting bracket, and attaching hardware. The gear box shaft is coupled with a drive shaft which connects to the chain drive mechanism in the lead screw section.



During normal operation (normal shim speed) of the control rod drive assembly, the insertion and withdrawal action is achieved by the operation of the gear motor. The output shaft of the motor gearbox drives the sprocket on the end of the drive shaft in the lead screw section. The roller chain transmits the motor torque to the sprockets on the bottom of each lead screw. The nut carriage assembly, being restricted of rotation, moves up or down the lead screw during the controlled rotation of the motor.

1.3 Pneumatic Cylinder (Figure II. 9)

The air cylinder of each drive assembly provides the movement for scram action of the reactor control rods. It is also used during normal operation of the drives to balance the load on the drive nut. The cylinder has a built in adjustable cushion, and during operation has an applied back pressure at the rod end for cushioning assistance and to force the control rod to follow the carriage nut at low reactor pressure. The restricting orifice at the rod end of the cylinder serves as a meter to control the velocity of the piston at the end of a scram stroke. The piston rod extends upward into the lead screw section where it is coupled with the seal shaft.

An interlocking valve and switch circuit adjusts the input air pressures for normal drive operation to correct for pressure changes inside the reactor vessel. The input pressures for balance and back air each have one value for reactor pressures below 600 psi (40 psig back pressure and 25 psig balance pressure) and are step-changed automatically to a different value (20 psig back pressure and 50 psig balance pressure) for reactor pressures above 600 psi as indicated on Figure II. 9. These pressures are so chosen that at low reactor pressures the greater back pressure than balance pressure will ensure that the control rod follows the nut carriage assembly on withdrawal; and at high reactor pressures the lower back pressure than balance pressure will reduce the load on the drive nut.

For scram operation (fast control rod insertion), full scram tank pressure (about 245 psi) is directed to the lower end of the cylinder to extend the piston rod and a relief valve vents the back pressure through a restricting orifice. When the cylinder is energized for a scram stroke, the piston rod lifts the latch assembly off the carriage nut, where it rests unattached, and forces it upward. A hole in the nut channel allows the piston rod to pass through, leaving the carriage nut assembly in its original position. When the latch assembly separates from the carriage nut assembly, the separation indication switch mounted on the nut channel is actuated. This actuation lights a yellow light on the control panel, starts the drive motor in the up stroke rotation, and allows the carriage to bypass the upper limit switch in order for the carriage to be driven up sufficiently far to again close the separation switch.

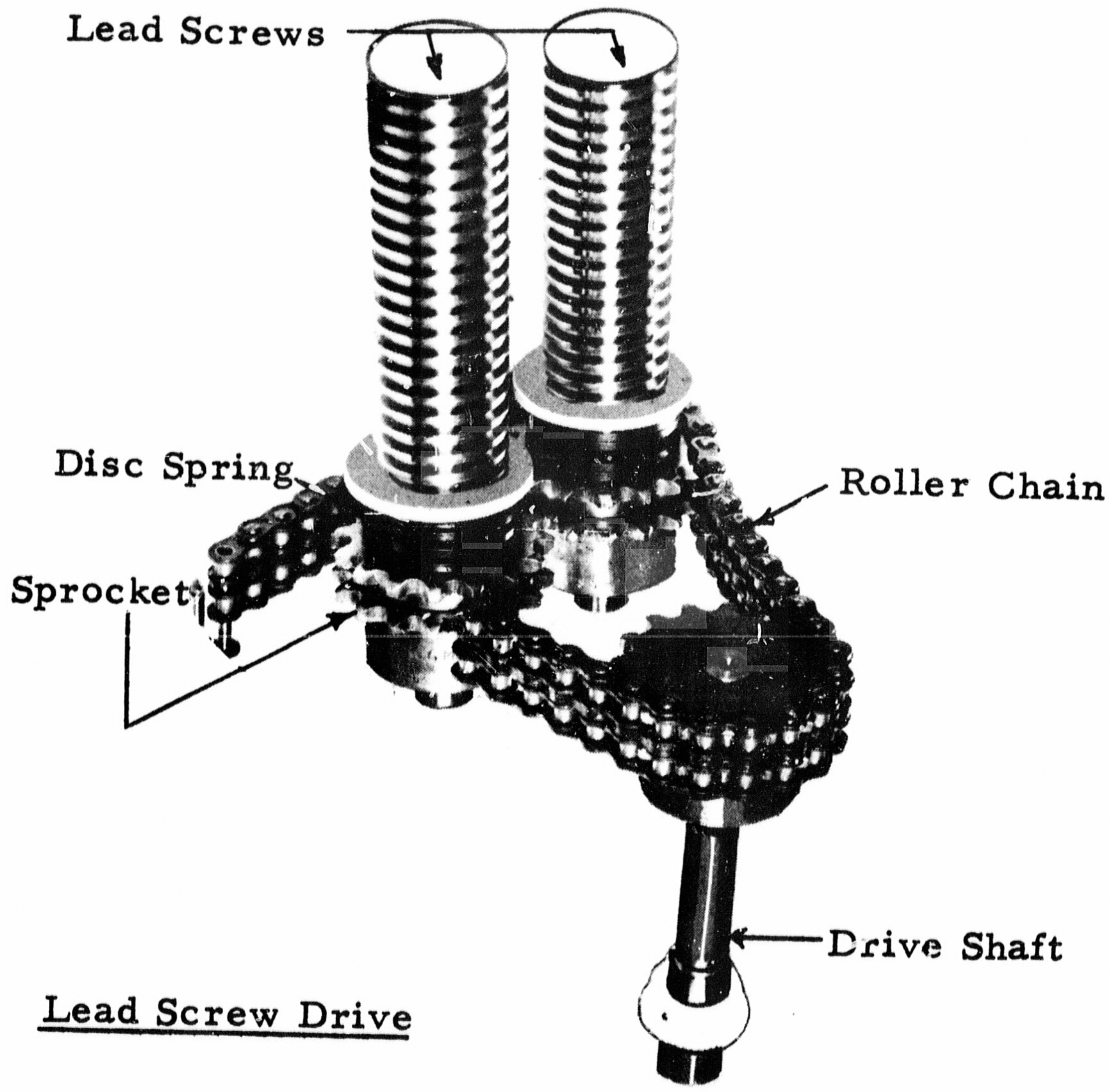
1.4 Position Indicator Assembly

The position indicator functions to transmit signals to the control panel to indicate the vertical position of the individual rods. This is accomplished by the rotation of the drive shaft that drives a speed changer which reduces the drive shaft speed. The output shaft of the speed changer drives the torque transmitter which transmits an electrical signal to a torque receiver mounted on the remote position indicator in the control room.

1.5 Lead Screw Section

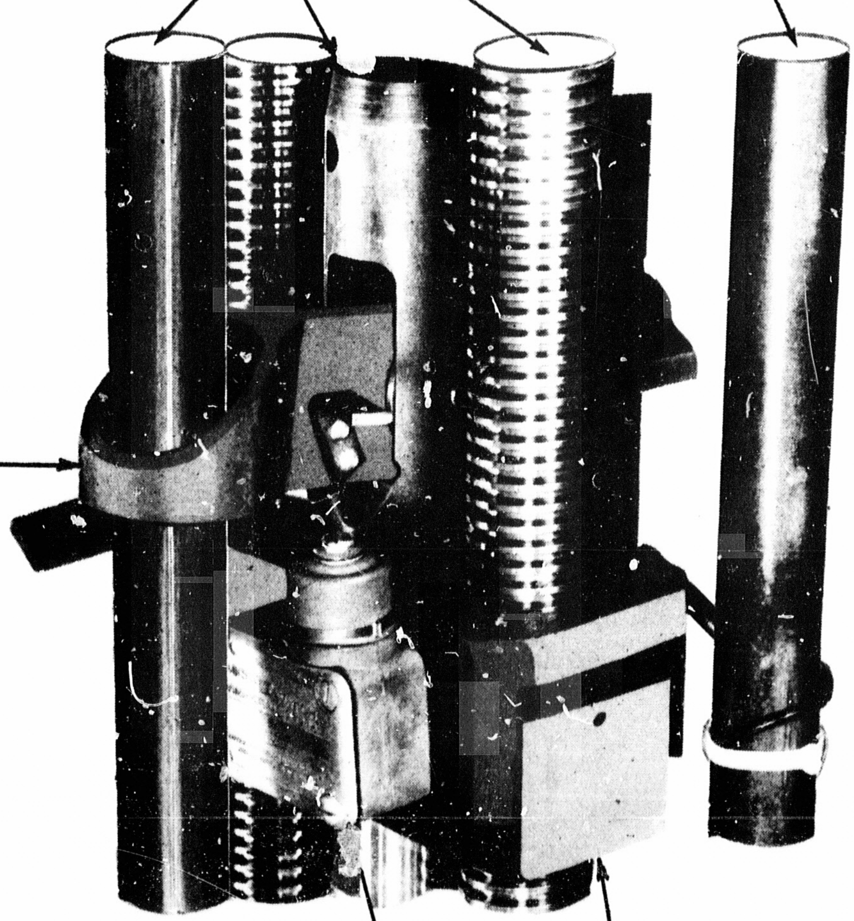
The lead screw section of the drive (refer to Figure II. 8) contains the mechanical and electrical equipment required for normal shim speed operation, plus scram speed indicating equipment.

The lead screws are driven by the double roller chain which transmits the torque from the gear motor to the sprocket of each screw. The lead screws are driven at the same speed as the gear motor. Two pairs of disc springs serve to cushion the impact of the nuts if the drive is operated to excessive over-travel when seating the valve plug.

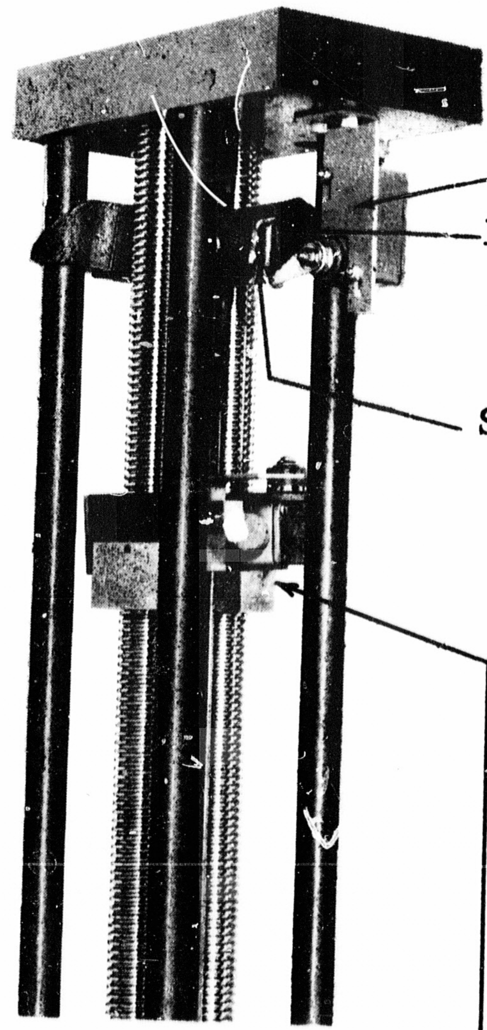


Lead Screw Drive

The latch arms of the latch assembly function only when they are separated from the nut carriage. The latch arms pivot from a hinge pin in the connection tube, and the hole in each outboard end surrounds a tie rod. The two tension springs pull the pivot end of the arms down and the outboard ends up, bringing the bottom and inboard edge of the hole in contact with the tie rod. With the latch arms in this position, a subsequent loss of pressure in the cylinder will allow the downward forces on the extension shaft to be applied to the latch arms. This force is further transmitted outwardly through the latch arms to the tie rods, providing a gripping force which prevents the control rod from withdrawing.



Closeup of Latch and
Nut Carriage Assembly



Latch Assembly in
Scram Position

After a scram stroke, the gear motor operates to drive the carriage nut upward. Since the carriage is permitted to by-pass the upper limit switch after a scram stroke, it moves up against the latch arms forcing them to a horizontal position. With the latch arms released from the tie rods and the separation indication switch reset, the drives are capable of normal operation.

The two traveling nuts are assembled on the lead screws at the same vertical level, and are restrained from rotation by a nut channel. With the lead screw rotating, the nuts are driven vertically. A bracket fastened to the nut channel actuates the upper and lower limit switches.

The electrical equipment on each drive consists of limit switches, a separation switch, and scram speed indicating equipment.

The upper and lower limit switches provide the electrical control for opening the gear motor contacts when the carriage nut assembly has reached a prescribed vertical position. When the limit switches are actuated to stop the gear motor, they also energize indicator lights at the main control panel. Both switches are adjustable for a required amount of over-travel. The upper limit switch is electrically interlocked with the separation indicator switch on the carriage nut assembly to permit bypassing the upper limit switch after a scram stroke.

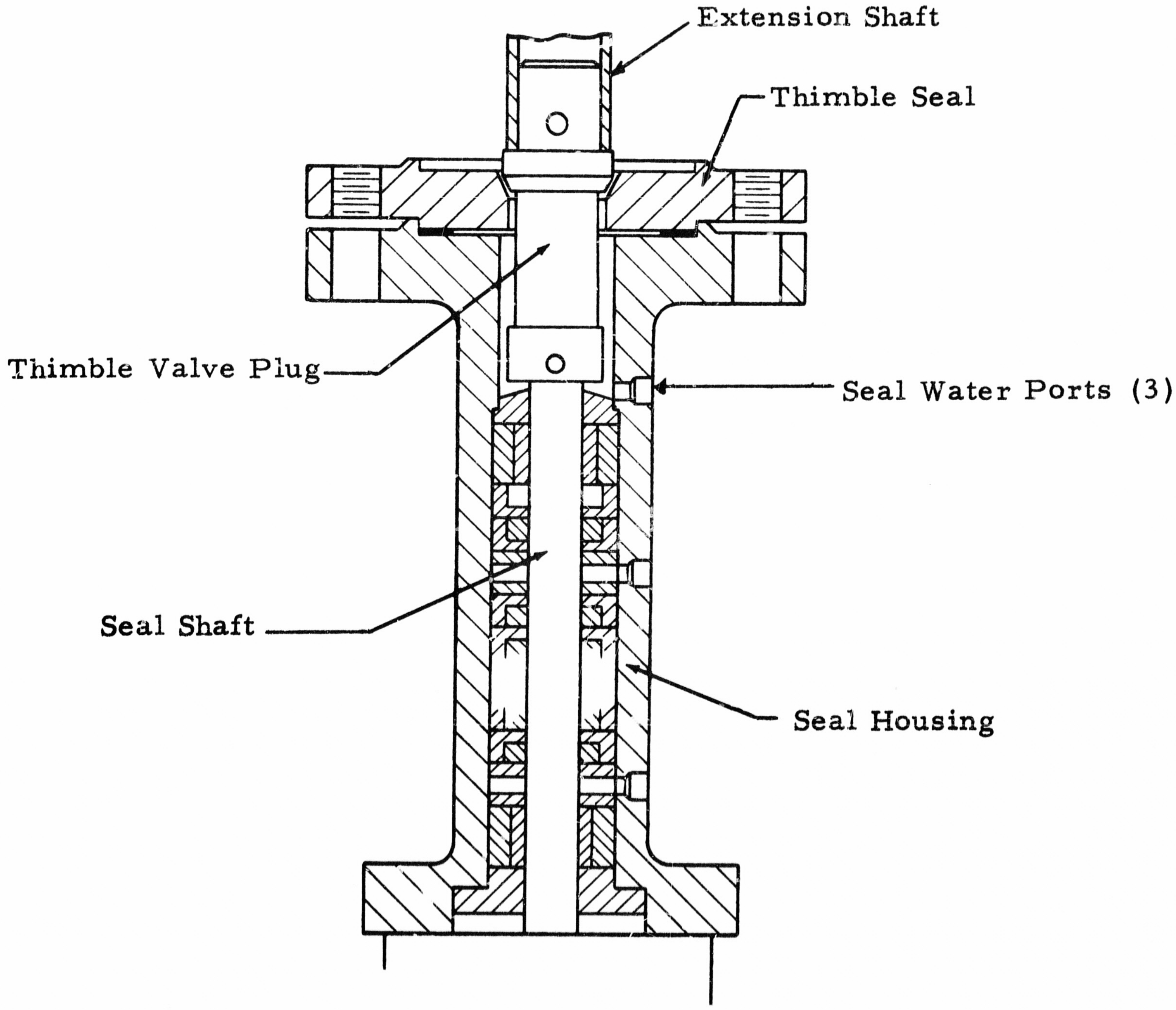
The separation indicator switch is mounted on the channel of the carriage nut assembly. The cord from the switch runs downward and into the position indicator housing.

The scram speed indicators are used as checkout equipment to determine the efficiency of the pneumatic system while making a fast insertion. The indicators are coil springs which are attached to the tie rod at measured intervals. The springs extend outward from the tie rod and are positioned in the path of the latch arms.

The purpose of the indicators is to provide an electrical signal to be used in remote recording or indicating devices. To produce this signal, it is necessary to connect a lead from a source of electrical power to a lead which is connected to the springs, and a ground lead from the source connected to the drive assembly. The signal is provided when the latch arms contact the springs and close the ground-to-power circuit. The instruments will indicate the length of time between signals as the latch arms move upward and make contact with the four springs. The contact springs are also used for checking the accuracy of position indicators.

1.6 Seal Assembly

The seal assembly includes the linear shaft seal and, because of its close relationship, the thimble valve seat.



Seal Assembly

The shaft seal consists of a seal housing, seal internals, and a seal shaft. Three ports are provided to permit flow of seal water to seal internals.

The shaft seal serves to restrict reactor water from leaking around the shaft but allows the shaft to move vertically. The seal accomplishes this service by admission of high pressure water to the central port. The water admitted to this port also serves to cool the seal. The top port is used for back flushing the upper area of the seal, while the bottom port serves as a drain. The seal is designed to always give leakage into the reactor. This prevents radioactive particles from entering the seal drain line and also helps keep foreign matter out of the seal.

The seal shaft is a chrome plated, one inch diameter shaft approximately one stroke length long. The top end of the seal shaft is pinned to the thimble valve plug which is the lower end of the extension shaft. The bottom of the seal shaft is pinned to a connection tube which is joined to the piston rod of the air cylinder.

The joint between the connection tube and piston rod is purposely made the weakest point to provide "safe failure" if excessive forces are exerted due to gross failure in the back pressure system. The term "safe failure" means that if the pin in the joint does shear, a full control rod insertion can be made and maintained.

The thimble seal prevents the leakage of reactor water when the drive assembly is removed from the vessel. This is accomplished by seating the thimble valve plug of the extension shaft in the sealing seat of the thimble valve. A holddown tool is used on the extension shaft to maintain an efficient sealing condition.

1.7 Extension Shaft Assembly

The extension shaft assembly consists of a locking device, an extension tube, and a thimble valve plug.

The locking device connects the extension shaft to the control rod. The VESR design utilizes an interrupted lug-type connector which requires 45° rotation of the control blade to couple or uncouple the blade from the extension shaft. This provides the safety feature that the four fuel assemblies and channels which are adjacent to a control blade must be removed before it is possible to uncouple and remove a control blade from the core.

The extension shaft is approximately six feet long and is the link between the control rod and the drive mechanism. The shaft is connected to the seal shaft and to the control rod inside the vessel.

2. Test and Operating Experience on Twin Screw Control Rod Drives

The first APED design for twin-screw-type drives was started in 1955. Since then, APED has maintained a continuing program of design, manufacture, test and operation on twin screw control rod drives. The first APED twin screw drive was manufactured for the VBWR, with the drive design following closely the concepts of the twin screw EBWR drives. However, to provide first hand performance information on this twin screw mechanism, a prototype drive was built and tested.

After the satisfactory completion of the VBWR drive program, a decision was made to redesign and as nearly as possible standardize the design of the twin screw drive. A model drive was manufactured and readied for an extensive testing program. The tests included evaluations of various critical components, such as the thimble seal, lead screws and nuts, and drive chain, as well as thorough testing of the completed drive mechanism. A summary of the tests and results follows.

2.1 Component Tests

Thimble Seal and Valve Tests

During these tests 47,000 feet of seal shaft travel was accumulated at approximately 1 inch/sec under vessel pressure from atmospheric to 1250 psig and vessel temperatures of 70 to 200°F. In addition, the seal was subjected to 985 scrams under the same range of vessel conditions. The conclusions of these tests were:

a. A seal shaft can be run successfully without excessive wear for more than 25,000 feet of travel at pressures of 1000 psig and temperatures of 200°F.

b. Maximum leakage rate during 25,000 feet of shaft travel was 2 gals/hr.

c. Scram speeds of 4 ft/sec average may be obtained without appreciable increase in the seal leakage or material wear rates.

d. A blow-down port on the top of the shaft seal is successful in removing accumulated foreign particles.

e. The control rod seal shaft will not expand and seize when withdrawn into the seal if the water temperature just above the seal is kept below 250°F.

f. A thimble valve for sealing off a vessel thimble during control rod drive removal is practical. A leakage rate ranging from 2 to 20 ml/min was found to be adequate for the application.

g. With proper preparation and the necessary equipment, a control rod drive may be disassembled and reassembled within the pattern at the bottom of a reactor.

Lead Screw and Nut Tests

The conclusions to these life and friction tests were:

a. A bronze or phenolic nut can be run successfully without excessive wear for more than 50,000 feet of stroke at greater than design loads with proper lubrication from an oil wick.

b. A bronze nut or a steel screw has a low frictional measurement and a low tendency to "stick-slip" in running.

c. At temperatures of 130 to 165°F ambient, oil wicks will lubricate properly for approximately 10,000 feet of stroke, at which time they should be replaced.

d. A lubricating oil of proper viscosity with a mild EP (fatty acid) additive is satisfactory.

Drive Chain Test

A life test was performed on a twin screw drive chain to determine the chain lubrication, the chain elongation under load, and the chain wear rate during operation. The chains were tested by driving under load for 1026 hrs in one direction and then for 1307 hrs in the opposite direction. The conclusions were :

a. The chain should be lubricated by first cleaning and then dipping into a Tonna No. 72 lubricant which is at approximately 150°F.

b. For 14 years of operation at an assumed drive nut travel of 9000 ft/yr, chain wear would be approximately 0.043 inch.

c. Elongation of chain after initial run-in is insignificant.

2.2 Prototype Operational Tests

Operational testing of the new twin screw drive components had just gotten underway when a twin screw drive was selected for use on the RWE Kahl reactor to be built in Germany. Therefore, the remainder of the operational testing on the drive was done under RWE control rod and reactor vessel conditions. The prototype control rod was installed in the APED test building and an engineering evaluation of the drive begun. The tests of the prototype drive included the following:

Shimming Speed Tests

The normal operating speed of the control rod drive was investigated both in the insertion and withdrawal directions at zero and 1000 psig reactor pressure. There was no measurable change in velocity with change in vessel pressure.

Coast Test

The coast of the control rod drive after shut-off of gear motor power was measured at maximum vessel pressure. The coast was $3/16 \pm 1/32$ inch while inserting and $13/32 \pm 1/16$ inch while withdrawing.

Motor Stall Test

Limit switches were deactivated and the gear motor was made to run the drive into the mechanical stops at both ends of stroke to assure that nothing in the drive would break before the motor stalled out.

Air Cylinder Test

The adjustable air cushion built into the pneumatic air cylinder was tested for proper adjustment. It was determined that the air cylinder cushion alone was sufficient to decelerate the control rod properly during scram, but controlled back pressure was continued in the design as the primary means of deceleration.

Position Indication Test

The accuracy of the position indicator was tested repeatedly while running in both directions and found to be within $\pm 3/8$ inch of the indicated position.

Limit Switch Test

The limit switches and separation switch were actuated over 30,000 times during testing prior to the first failure.

Nuts and Twin Screw Tests

Problems developed with nut and drive shaft vibration during prototype tests. The problems were eliminated by changing the material of the nut, increasing the diameter of the lead screw, increasing the diameter of the drive shaft and improving drive shaft alignment.

Latch Test

The latches were tested over 100 times by scramming the drive and then releasing the scram air pressure from the bottom of the air cylinder. When the scram pressure was released, the latches locked onto the tie-rods and prevented the control rods from being forced out due to vessel pressure and their own weight.

Servo System Test

The servo control system was tested using the prototype control rod drive and the engineering test model of the RWE automatic control system position controller. These tests included adjustment of position controller gain and dead-band width. The accuracy of the system was $\pm$ 0.25 inch for both the withdrawal and insertion directions. (VESR will not utilize an automatic control system.)

Drive Removal Demonstration

The control rod drive and seal assemblies were removed from the test vessel under simulated reactor conditions. This was done to evaluate the feasibility of this removal operation without draining the reactor vessel.

Scram Tests

The scram tests were performed with various vessel environmental conditions: temperature 80 to 550°F; pressure zero to 1250 psig. Under these conditions the normal back, balance, and scram pressures produced scrams which met specifications with a safety factor of greater than 1.5.

The maximum deceleration scram conditions of zero vessel pressure with full stroke and zero vessel pressure with 1/4 stroke were investigated to assure that scrams under these conditions did not over-load the drive. Scram speed tests at 1265 psig vessel pressure with full stroke were also run to assure that drive had enough acceleration to meet the scram time specifications.

2.3 RWE Production Drive Tests

The tests described above were performed on the prototype drive. In addition, all 22 RWE control rod drives were tested in a mock-up assembly for proper operation of the various components. Four of these drives were further tested in the test facility under reactor conditions of pressure and temperature to ensure proper operation and agreement with scram time specifications. These production tests were run under 0, 600, 1000, and 1265 psig reactor pressure; strokes of 17-1/2, 32-1/2, 47-1/2 and 55-1/4 inches; using normal back, balance, and scram pressures. All drives met scram specifications.

2.4 RWE Spare Drive Engineering Tests

A spare RWE twin screw control rod drive was used with the original prototype test seal assembly, extension shaft and control rod to perform a series of engineering tests in the control rod drive test facility. These tests were performed in an attempt to evaluate completely the effect of changing various operating conditions in the pneumatic system on scram time acceleration and deceleration and on component loading. Major consideration was given to operating conditions which could have a detrimental effect on the drive mechanism during scram. Factors such as high scram pressure coincident with low back pressure at zero reactor pressure could greatly affect the loading on the drive due to high acceleration and deceleration forces. Tests were performed at zero, 600, 1000, and 1250 psig reactor pressures varying scram, back, and balance pressures. Results of a typical test for a vessel pressure of 1000 psig and scram air pressures from 240 to 280 psig are shown on Figure V.3. Tests were also performed with and without make-up to the scram air tank from the compressor receiver. At 1000 psig, the scram tank volume was varied to determine what effect this would have on the drive scram performance. After testing, the drive was disassembled so that the control rod drive coupling and all the pins could be inspected for wear and deformation. The conclusions of these series of tests on the spare RWE control rod drive were:

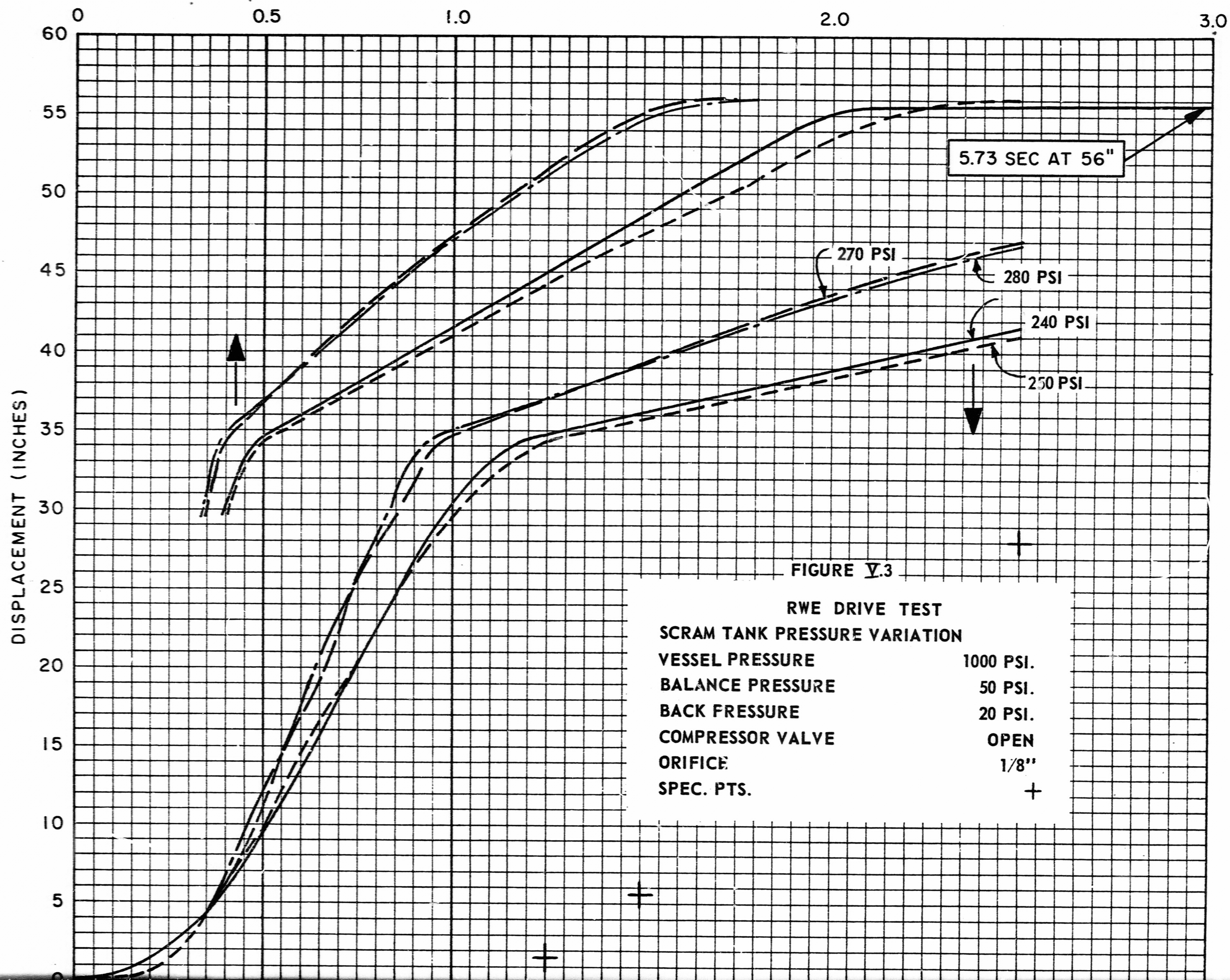
a. Operating the mechanism under the prescribed design conditions met the scram time specifications at the 50% travel point by a factor of two; and at the 3%, 10% and 100% travel points by a factor greater than two. (Scram time specifications for RWE were the same as for VESR. Refer to paragraph IV. J. 1. 3 of the Preliminary Hazards Summary Report.)

b. Balance pressure does not have an appreciable effect on the scram characteristics of the drive.

c. The scram tank has an adequate volume at 1000 psi reactor vessel pressure for full stroke scrams.

d. Closing the valve to the compressor does not substantially affect the scram time during the first 50% of the stroke on full stroke scrams. At short strokes closing the compressor valve had a very slight effect.

e. Back pressure should not be decreased at zero reactor pressure below 30 psi; it should not be increased at 1250 psi higher than 25 psi. At the other reactor pressures the back pressure can be between 20 and 40 psi.



5.73 SEC AT 56"
270 PSI
280 PSI
240 PSI
250 PSI
DISPLACEMENT (INCHES)
0
0.5
1.0
2.0
3.0
60
55
50
45
40
35
30
25
20
15
10
5
RWE DRIVE TEST
SCRAM TANK PRESSURE VARIATION
VESSEL PRESSURE 1000 PSI.
BALANCE PRESSURE 50 PSI.
BACK FRESSURE 20 PSI.
COMPRESSOR VALVE OPEN
ORIFICE 1/8"
SPEC. PTS. +

FIGURE V.3

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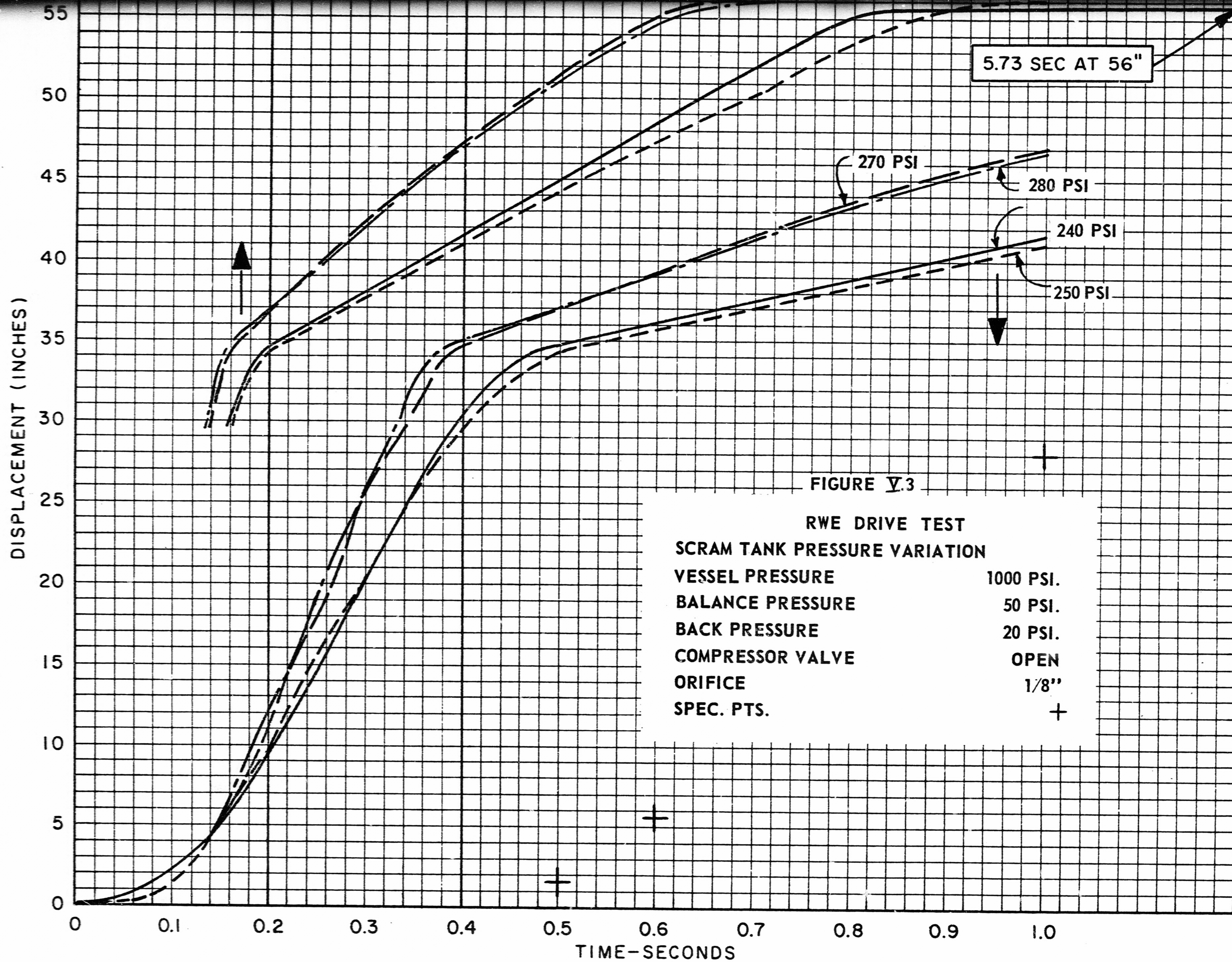
5.73 SEC AT 56"
270 PSI
280 PSI
240 PSI
250 PSI
FIGURE V.3
RWE DRIVE TEST
SCRAM TANK PRESSURE VARIATION
VESSEL PRESSURE 1000 PSI.
BALANCE PRESSURE 50 PSI.
BACK PRESSURE 20 PSI.
COMPRESSOR VALVE OPEN
ORIFICE 1/8"
SPEC. PTS. +
DISPLACEMENT (INCHES)
0
5
10
15
20
25
30
35
40
45
50
55
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
TIME-SECONDS

2

f. The mechanism can be operated at the prescribed design conditions without exceeding the design g load. The maximum acceleration or deceleration obtained was 6.5 g's.

g. The 1/8 inch orifice in the back pressure line keeps bounce to a minimum.

2.5 RWE Pre-Operational Tests

After the production tests were performed at San Jose, the control rod drives were shipped to Kahl, Germany and mounted beneath the reactor vessel where they were subjected to a series of pre-operational tests by GE personnel. These tests were intended to check drive operation with the actual plant pneumatic system against expected and specified operation. The seal cooling water system and the pneumatic system were checked out before the drive tests were begun. The seal system tests included seal flow tests, pressure regulating valve tests, and orifice flow tests. The pneumatic system tests consisted of checking all pressure regulating valves, relief valves, solenoid valves, the compressor, and all instruments.

Each drive underwent installation inspections and testing in accordance with individual check-off and record sheets. Each drive was scrammed individually at zero, 600, and 1000 psig reactor pressure with varying scram pressures from 240 to 280 psig and with varying balance and back pressures. (The reactor was pressurized with gas.) The drives were also scrammed in groups of 4, 11, and all 21, at zero, 600, and 1000 psig reactor pressure. The particularly critical tests of high scram pressure and low back pressure were run with all drives scrammed simultaneously. During these pre-operational tests, a total of over 1500 scrams were made to check out proper operation of the control rod drive system under a wide range of system conditions.

The results of this extensive test program showed that all of the drives were well within the specified range of performance.

3. VESR Twin-Screw Control Rod Drives

The information from all the indicated tests made at the various stages of a control rod drive's life on several different drives of the twin-screw type that APED has produced, plus field observation from APED's personnel, make up our expanding experience with the drive planned for use on the VESR. The demonstrated performance of the VBWR drives, RWE drives, N. S. Savannah drives, and Consolidated Edison drives (the N. S. Savannah drives and Consolidated Edison drives received tests comparable to and in some instances exceeding those described for the RWE drives) ensures that the nearly identical VESR drives can be manufactured and tested to demonstrate performance that is within specifications.

The extensive testing program on the afore-mentioned drives have shown the need for some slight modifications which will be included in the VESR drives. Some of the typical items which will be revised are: the addition of filters before all critical components of the pneumatic system, a change in the location and arrangement of the position indicator housing, a modification in the travel of drive chain take-up, the use of 17-4 PH stainless steel heat treated to the H-1100 condition in seal internals and seal shafts, rearrangement of air piping to the air cylinders, and the use of a stronger cable clamp holding the limit switch wire. These typical changes indicate that, in general, no major modifications are planned in the twin-screw type drive design for its satisfactory adaption to the VESR.

4. VESR Control Rod Drive Tests

The VESR drives will receive production functional tests, pre-operational tests, and operational tests.

The functional tests will consist of running each drive at shim speed under no load to overload conditions, checking the position indicator for accuracy, testing latches, measuring air cylinder friction, and checking the separation switches.

The pre-operational tests will be performed on the control rod drive system during and after installation on the reactor vessel and prior to loading fuel. These tests will include a check of the seal water system and the pneumatic system, as well as shimming and scramming each drive at zero to full reactor pressures.

During operation of the reactor, in-service operating tests will be performed to assure the continued normal operation of the drives, the seal water system, and pneumatic system. These continuing tests will add directly to the reliability of the installed drives, since any detected deterioration can be repaired due to the accessible nature of this type drive.

5. Control Rod Drive Nozzles

The control rod drive nozzles penetrate the bottom head of the reactor vessel and extend below and above the head for mounting and guiding of the associated drive mechanism. The discussion which follows describes the design and attachment of the control rod nozzles in the vessel head to produce the high integrity unit which is required. The attachment has been specifically designed to:

a. Reduce stress concentration and thermal stresses at location "J" (Figure V.4) by moving the dissimilar metal joints as far as possible from the vessel head and by providing a generous radius at "J".

b. Obtain the best quality of welding by allowing as many as possible of the joints to be made where preheat temperatures are low and where visibility and accessibility are most favorable.

c. Reduce thermal stresses at weld "K" by using filler metal which has a similar coefficient of expansion to ferritic steel.

d. Provide a very ductile weld at "K", where there is a maximum difference in thermal expansion between dissimilar base metals.

e. Provide a "bench" weld at "K" for the utmost in integrity of the joint.

The fabrication steps in installing the nozzle are as follows (refer to Figure V.4):

a. Piece "A" (ferritic steel) is preheated, weld overlayed, joined to Piece "E" (austenitic stainless steel), welded with Inconel-type electrode, and given an intermediate tempering treatment. This becomes a bench-welded sub-assembly.

b. Pieces "G" and "F" (both austenitic stainless steel) are bench-welded to become a sub-assembly.

c. The cladding is stripped back from the vessel head and nozzle at "D", followed by making the weld "C", and re-applying the cladding at "D" -- all performed in a confined area under 250°F minimum preheat temperature.

d. The vessel head is given an interstage tempering treatment and cooled to room temperature where the inside diameter of Part "A" can be bored to final dimensions, if necessary.

GENERAL ELECTRIC

UNLESS OTHERWISE SPECIFIED USE THE FOLLOWING:–				
APPLIED PRACTICES	SURFACES	TOLERANCES ON MACHINED DIMENSIONS		
		FRACTIONS	DECIMALS	ANGLES
	✓	+ –	+ –	+ –

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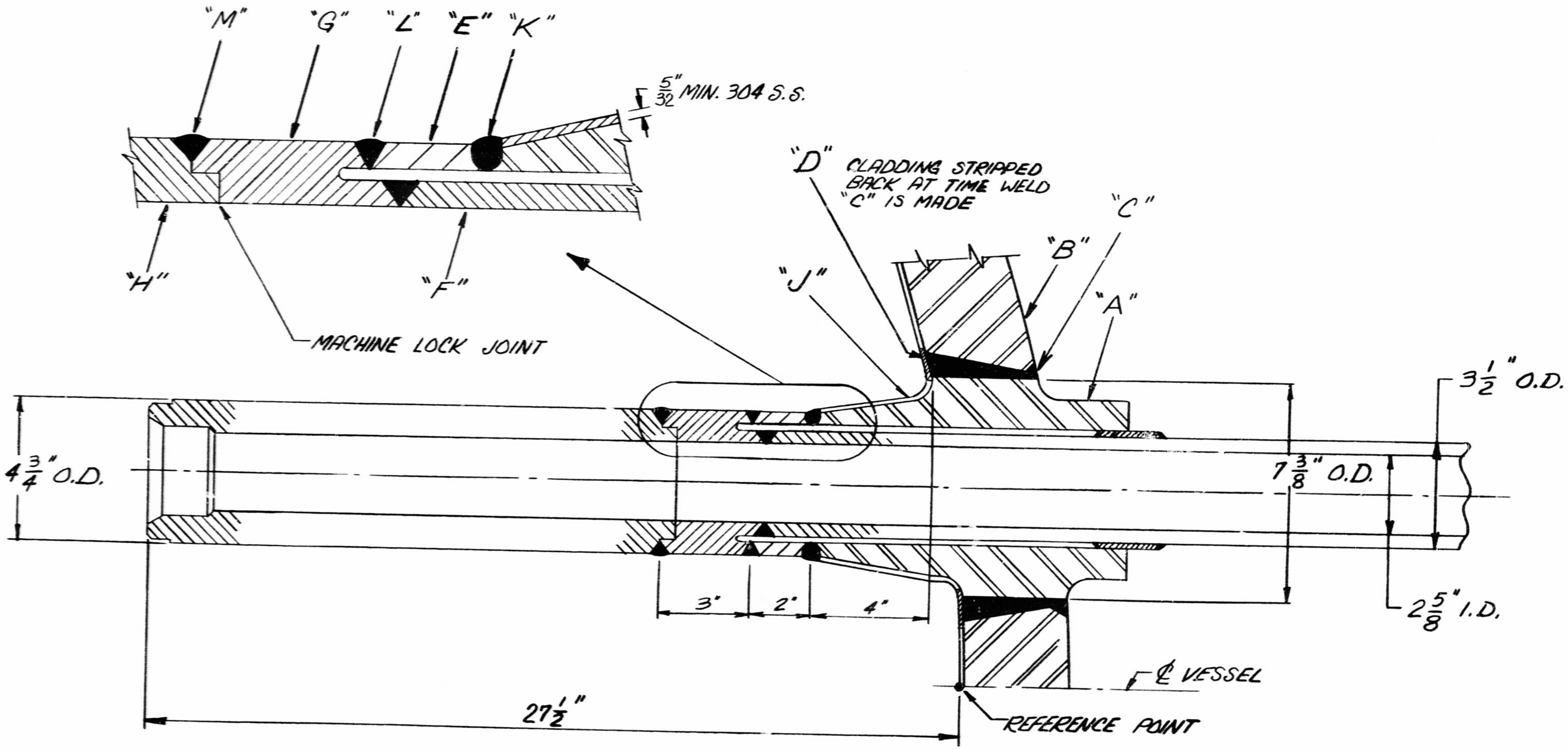
TITLE

FIRST MADE FOR

CONT ON SHEET SH NO. 1



CONTROL ROD DRIVE NOZZLE
FIGURE V.4

REVISIONS

PRINTS TO

MADE	APPROVALS	DIV OR DEPT	
ISSUED		LOCATION	CONT ON SHEET SH NO.

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e. The work from this point on can be performed without preheat or stress relief. The sub-assembly of parts "G" and "F" can be welded at "L" with austenitic electrodes, and, finally, Piece "H" can be welded at "M" with a partial penetration joint, since it is not a pressure-containing weld. The weld at "M" is necessary to provide visibility and accessibility to weld "L", which is a pressure-containing joint and must, therefore, be radiographed, the same as all other full penetration pressure-containing welds.

Dye penetrant, magnetic particle, and radiographic tests are all used as part of the procedure. The weld clad is ultrasonically inspected for proper bonding.

6. Physics Calculational Methods

The physics calculational model used in the VESR analysis was the synthesis of several individual models. First, the "L Factor", which is the ratio of the heterogeneous to homogeneous resonance integral for U-238, was calculated for an equivalent rod, where the equivalent rod was defined as one having the same effective surface to mass ratio. The "L Factor" and the smeared atomic concentrations were then used as input to the MUFT-IV code(1). MUFT calculates the fast and epithermal group parameters. The MUFT parameters were corrected for the Behren's(2) enhanced leakage effect of voids and used for group one and two of a three-group diffusion model. The thermal parameters were obtained by using the Wilkins' heavy gas model to determine the thermal spectrum weighting of the microscopic cross sections and by using the P-3 geometric flux weighting for the thermal flux depression in the fuel. A Behren's correction was also applied to the thermal group parameters. The presence of structural materials, controls, or other discontinuities was next taken into account by a two-dimensional diffusion flux weighting calculation. Finally, either a one or two-dimensional diffusion calculation for the core and reflector was performed to yield the gross reactivity and flux distributions.

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(1) Bohl, H. J., Gelbard, E. M., Ryan, G. H., "MUFT-4 – Fast Neutron Spectrum Code for the IBM-704", WAPD-TM-72, (July, 1957).

(2) Behren, D. J., "The Effect of Holes in Reacting Materials on the Passage of Neutrons", Proc. Physical Society (London), A62, 607 (1949).

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