ENGINEERING DIVISION
U.S. ARMY ENGINEER REACTORS GROUP
CORPS OF ENGINEERS
FT. BELVOIR, VA. 22060

AD

AD 701906

ED-6923
MH-1A REFUELING
17-25 OCTOBER 1969

C. FREDERICK SEARS, CPT, C. E.

DECEMBER 20, 1969

Distribution of this document is unlimited.

39

ED-6923
MH-1A REFUELING
17-25 October 1969

C. FREDERICK SEARS, CPT, C. E.

December 20, 1969

ENGINEERING DIVISION
U. S. ARMY ENGINEER REACTORS GROUP
CORPS OF ENGINEERS

SUMMARY

The initial refueling of the MH-1A (STURGIS) took place in October 1969. This report discusses the nuclear behavior of the reactor during refueling, and explains how the monitoring of this behavior was affected by orientation and locations of core components with respect to the source range instrumentation. Various figures and tables are used to illustrate the measured nuclear behavior.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

I. INTRODUCTION

The first refueling of the MH-1A was accomplished during the period 17-23 October 1969. The refueling was conducted in accordance with Section I, Chapter 2 of the TM-MH-1A Maintenance Manual including changes thru 1 September 1969. The sequence of movement for core components was specified in "Special Refueling Instructions for MH-1A Initial Core Shuffle" dated September 1969 (Appendix A). The following sections discuss the actual refueling and point out or explain the behavior of the criticality monitoring of the core during the refueling.

II. DISCUSSION

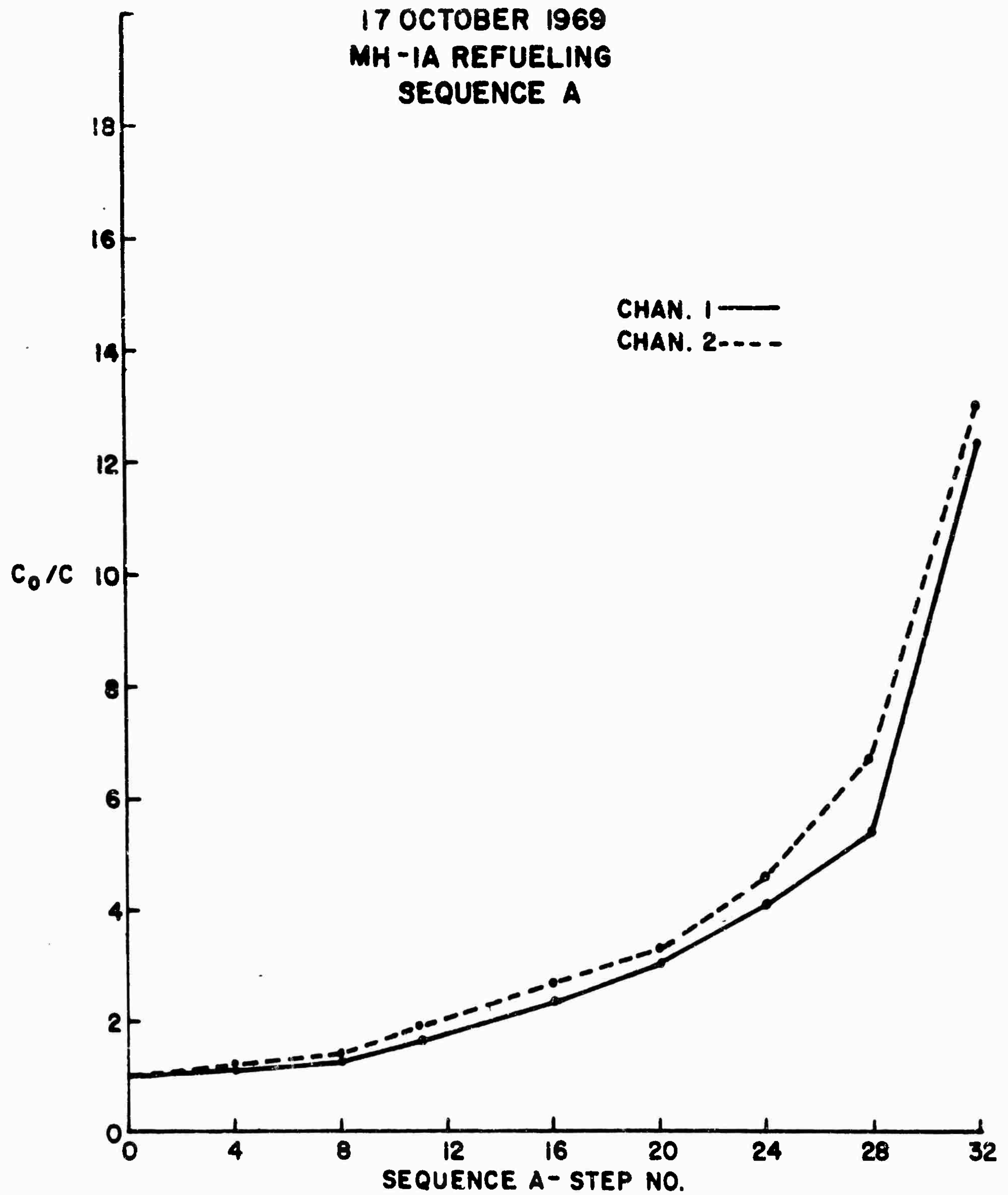
A. Finger Poison Rod Assembly Insertion

The sequence of finger poison rod assembly insertions was designed to provide a symmetric core configuration after every four assembly insertions. The coupling of the source range detectors and the secondary neutron sources was also a major factor in the sequence design. Although the source range instrumentation was monitored at all times, the plot of initial count rate, Co, divided by the count rate at a given step in the sequence, C, was made after every four insertions. This provided a smooth plot and enabled the response of the two source range channels to be compared. A plot at every step does not permit a straightforward comparison of the channels due to the small size of the core, the locations of the source range detectors, and the location of the secondary sources. During the assembly insertion sequence, it was determined that source range channels 1 and 2 were reversed, i.e., source range 1 detector was in the port-aft position, and source range 2 detector was in the forward-starboard position. This reversal was easily noticed during the portions of the sequence when the core was nonsymmetric. It should be noted that the Co/C plot shows both channels behaving in a similar manner. During the intermediate steps, the two channels performed similarly when the appropriate sequence steps were compared. Table I and Figure 1 show the sequence recorded count rates and the plot of Co/C for each source range channel. The data at step A11 instead of A12 was taken during a work stoppage so as to permit a smoother loading in the following steps since each four steps brought about a break in a smooth work routine.

TABLE I

FINGER POISON ROD ASSEMBLY INSERTION

Sequence Step No.	Source Range Channel 1 (cpm)	Source Range Channel 2 (cpm)
A0	7241	7063
A4	6372	6162
A8	5534	5063
A11	4389	3747
A16	3075	2650
A20	2381	2168
A24	1759	1553
A28	1344	1156
A32	586	542



FINGER POISON ROD ASSEMBLY INSERTION
FIGURE 1

B. Dummy Core Rod and Primary Source Rod Removal.

As expected, the removal of the twelve dummy core rods and the primary source rod produced no detectable changes in the criticality status of the reactor. As in sequence A, data for criticality check was recorded after every four steps. Data was also taken after the removal of the primary source rod. Since the data varies by less than two standard deviations for both channels, no plot is shown. Table II gives the count rates which were recorded.

TABLE II

DUMMY CORE ROD AND PRIMARY SOURCE ROD REMOVAL

Sequence Step No.	Source Range Channel 1 (cpm)	Source Range Channel 2 (cpm)
B0	533	495
B4	535	460
B8	548	447
B12	550	418
B13	526	452

C. Control Rod Removal.

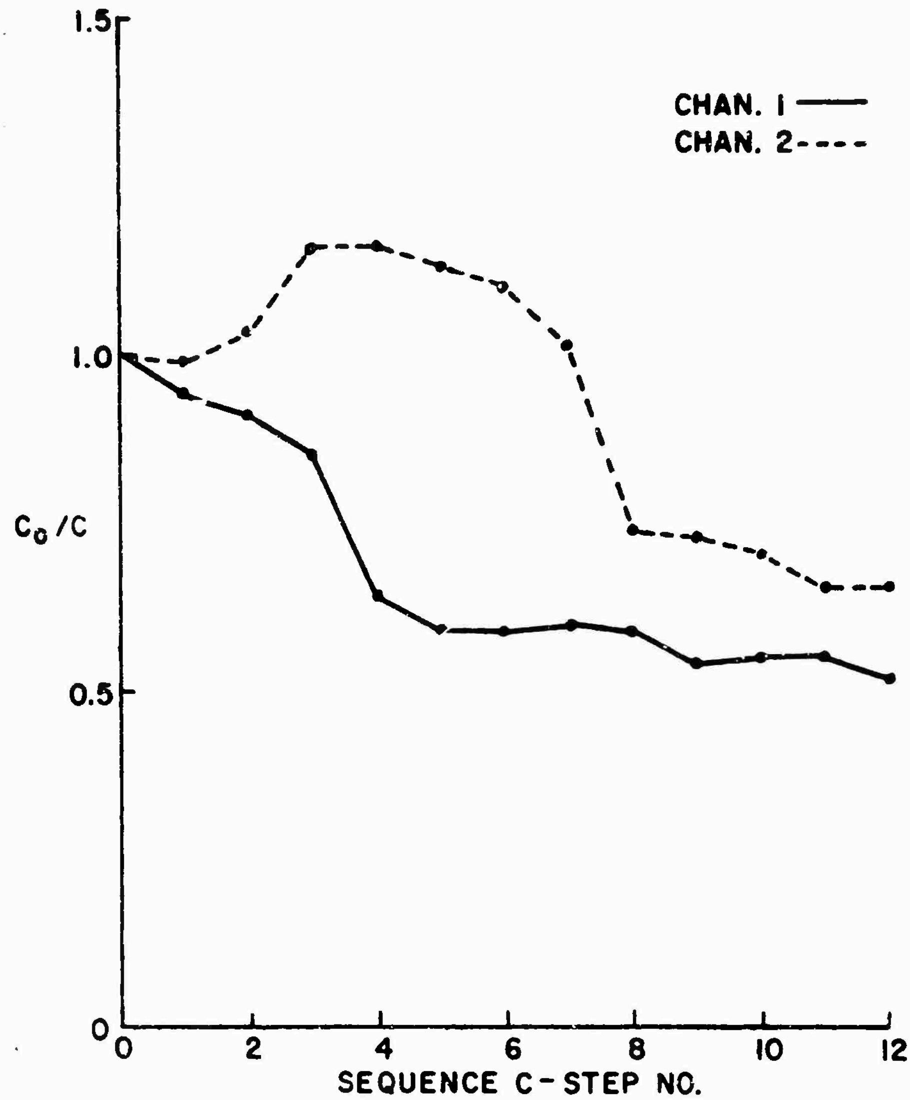
The plot of Co/C was maintained for the removal of each control rod. The spatial changes in the flux shape and subsequent source range channel response are readily noticable in the plot. It should be noted that the changes are predictable solely from observation of the spatial positions of the control rods and the source range detectors. The removal of the control rods in a symmetric manner was not necessary since the finger poison rod assemblies provide the necessary reactivity shutdown. In fact, the nonsymmetric removal of the control rods provide an excellent indication of the spatial behavior of the core under nonsymmetric conditions. Table III lists the recorded data, Figure 2 provides a Co/C plot for each source range channel, and Figure 3 provides a view of the locations of the detectors.

TABLE III

CONTROL ROD REMOVAL

Sequence Step No.	Source Range Channel 1 (cpm)	Source Range Channel 2 (cpm)
C0	484	361
C1	515	366
C2	531	349
C3	567	310
C4	753	311
C5	826	318
C6	819	329
C7	807	357
C8	825	492
C9	894	498
C10	878	516
C11	888	556
C12	937	551

18-19 OCTOBER 1969
MH-1A REFUELING
SEQUENCE C



CONTROL ROD REMOVAL
FIGURE 2

15 DEC 69

RE-1466

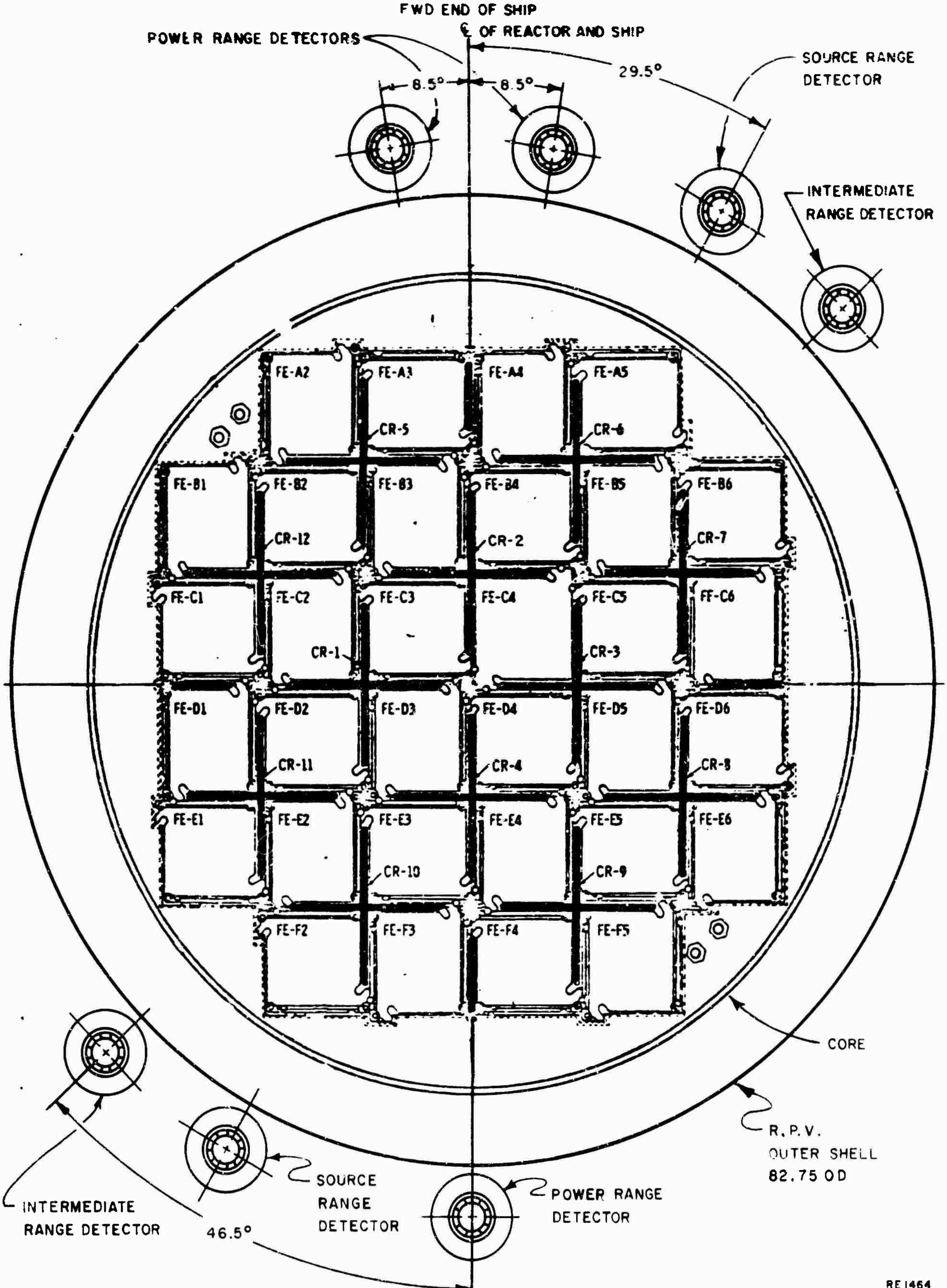


FIGURE 3, CORE - DETECTOR ORIENTATION

15 DEC 69

The dramatic differences in the responses of the two source range channels is a result of source-detector coupling and flux profile changes. The removal of control rods 12, 11, 10, and 9 produced an increase in the source-detector coupling for the port-aft detector (channel 1). Their removal also produced a change from a symmetrical flux profile to a profile with a maximum skew toward the port-aft detector. This skewing produces a decrease in neutron population near the starboard-forward detector (channel 2). The reversal of this behavior is observed with the removal of control rods 8, 7, 6, and 5. The removal of control rods 4, 3, 2, and 1 also produces observable space-dependent behavior of the same type, but of less magnitude as the outer rods.

D. Fuel Element Removal, Shuffle, and Insertion.

Movement of old fuel elements on a quadrant basis was done in an effort to provide a compact coupled core with a predictable behavior. During the movement of the old fuel elements it was found that the rotation of four of the outer elements for movement to the inside of the core was incorrect. The rotation for sequence steps D15, D16, D31, and D32 was incorrect since the locating slots in the lower grid plate was 180 degrees out from the location necessary for the Martin Co. specified rotation.

During the movement of fuel both scalers gave erratic behavior at times. The sensitivity of the scaler for channel 1 appeared to be drifting. During this apparent drift, the log count rate meter for that channel behaved normally. This apparent drift was probably due to the high control room temperature at that time (control room air conditioning unit had malfunctioned and was being repaired). Later this same scaler gave count rates which were off by a factor of two for about a thirty minute period. It then stabilized, and no further scaler problems were encountered for that channel.

The scaler for the other channel (channel 2) picked up spurious counts in bursts of 10-40 counts during the later stages of old fuel element movement. These bursts were not apparent on the log count rate instrumentation. The MH-1A instrumentation personnel say the burst is due to the leading edge of the 1000 cps power to the instrument drawers being seen by the scaler. The behavior of both channels was closely observed and every attempt was made to record valid information; however, even with this effort some of the data is in error. At no time though were fuel movements made without adequate nuclear monitoring of the core status.

It should be noted that at the beginning of fuel movements the two channels differed by a factor of two while at the completion of movement they differed by a factor of three. This change is unexplainable since at the start and at the finish, the flux shape should have been similar. At this time it is also appropriate to note that at sequence step AO the count rates of the two channel differed by less than 3 percent; however, at step G-32, when the core was in a similar configuration to step AO the channels still differed by a factor of three. No cause for this can be found, but a slight drift of amplifier gain in either channel could produce this effect. If this is the case, it is more probable that the gain on channel 2 had decreased.

Table IV gives the sequence recorded count rates for both channels. For the elements which were shuffled, a count rate was recorded after removal and after insertion. During the actual refueling, both count rates were used in maintaining the multiplication plot, however in this report only the values after insertion are plotted. Figures 4, 5 and 6 show the plots of C_0/C, C_{16}/C, and C_{32}/C respectively. This was done to provide a more understandable 1/M plot for the fuel movements. The same spatial nuclear behavior explained for control rod removal in the previous section occurs for fuel element movements.

TABLE IV

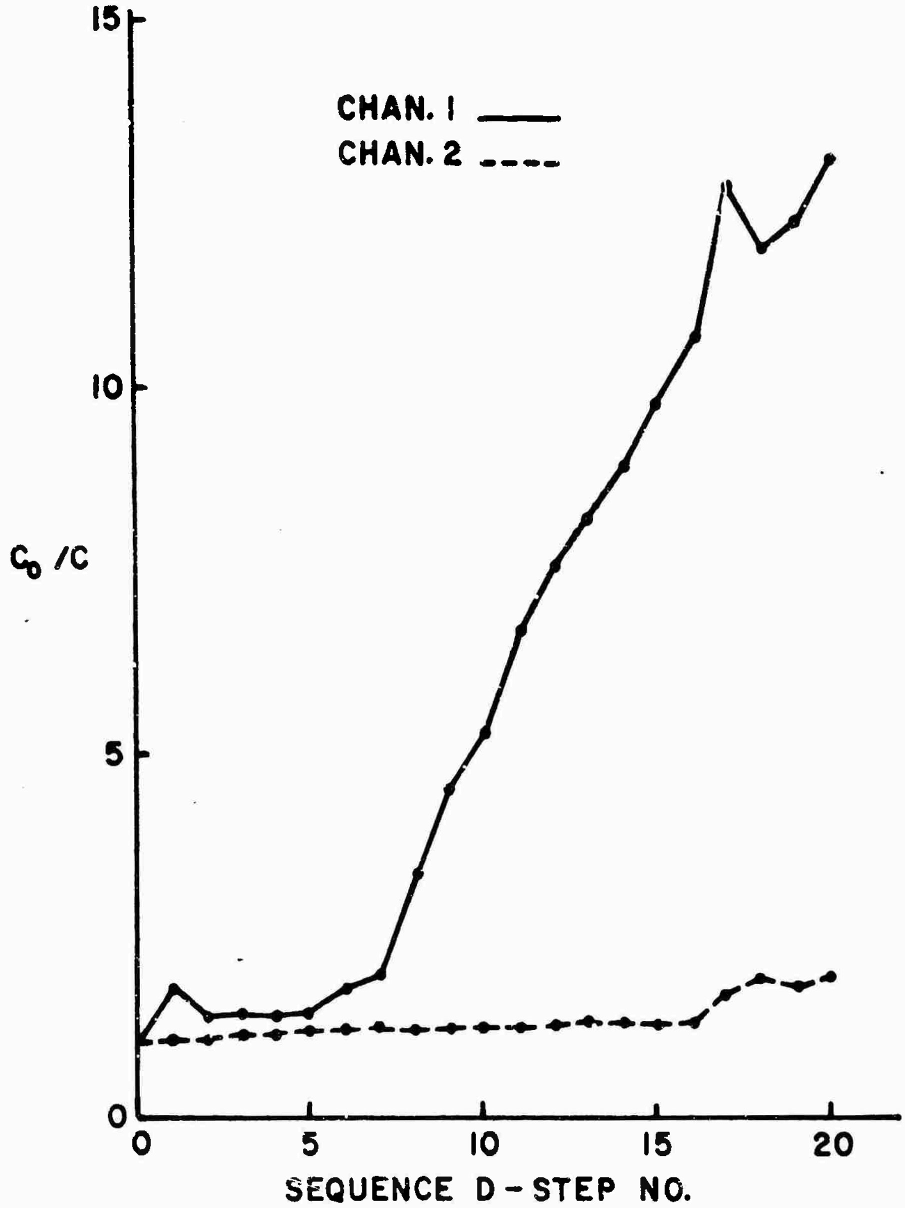
FUEL ELEMENT REMOVAL, SHUFFLE, AND INSERTION

Sequence Step No.	Source Range Channel 1 (cpm)	Source Range Channel 2 (cpm)
D0	943	554
D1	520	513
D2	679	502
D3	664	480
D4	674	473
D5	656/662	462/468
D6	544/540	430/460
D7	458/482	447/452
D8	232/282	218/459
D9	207	443
D10	179	448
D11	144	450
D12	126	432
D13	101/115	436/424
D14	92/106	409/429
D15	84/96	412/427
D16	74/89	422/430
D17	74	324

TABLE IV (continued)

Sequence Step No.	Source Range Channel 1 (cpm)	Source Range Channel 2 (cpm)
D18	79	290
D19	76	306
D20	72	286
D21	58/58	289/296
D22	35/36	245/231
D23	31/36	172/212
D24	27/42	54/84
D25	29	70
D26	33	73
D27	42	70
D28	40	75
D29	29/29	59/58
D30	29/29	59/41
D31	28/30	/41
D32	27/30	/40
D33	67	183
D34	72	294
D35	70	291
D36	69	392
D37	65	386
D38	66	397
D39	66	415
D40	152	469
D41	606	519
D42	810	532
D43	1098	524
D44	1498	510
D45	1596	522
D46	1707	533
D47	1669	514
D48	1936	664

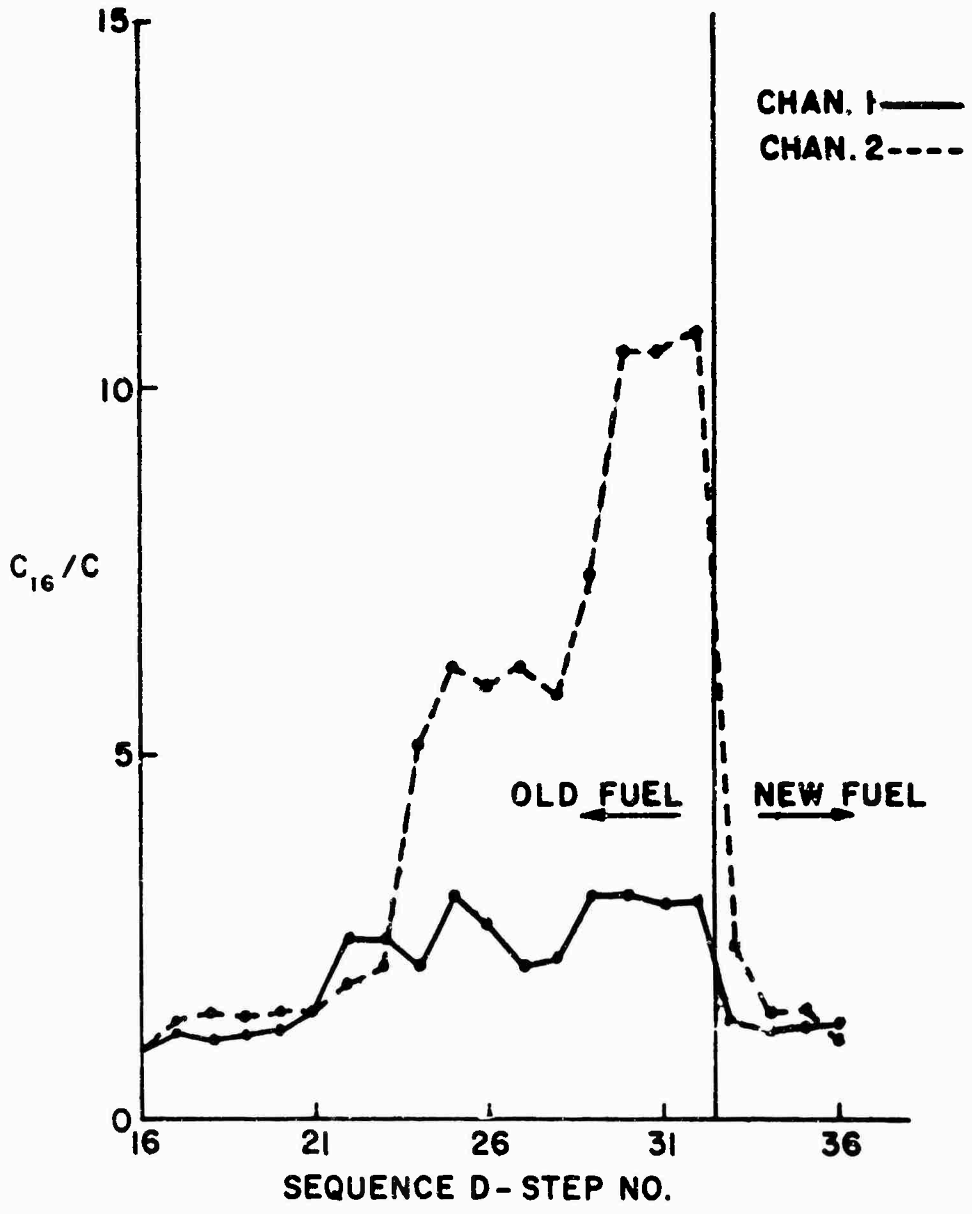
20-21 OCTOBER 1969
MH-1A REFUELING
SEQUENCE D



OLD FUEL REMOVAL AND SHUFFLE
FIGURE 4

15 DEC 69
RE-1467

20-21, 23 OCTOBER 1969
MH-1A REFUELING
SEQUENCE D

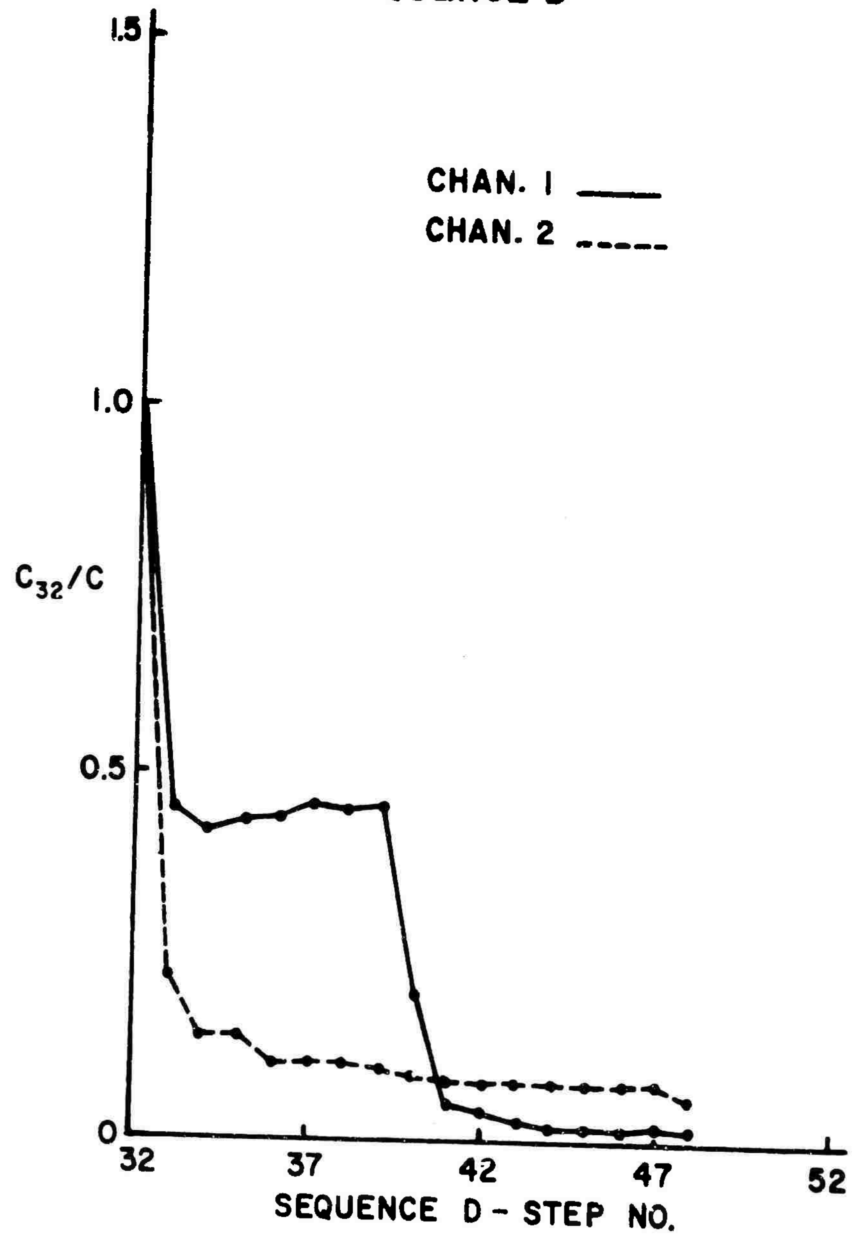


OLD FUEL REMOVAL AND SHUFFLE AND NEW FUEL INSERTION
FIGURE 5

15 DEC 69

RE-1468

23 - 24 OCTOBER 1969
MH-1A REFUELING
SEQUENCE D



NEW FUEL INSERTION
FIGURE 6

15 DEC 69
RE-1489

E. Poison Core Rod and Dummy Source Rod Installation.

The installation of the poison core rods and the dummy source rod were done prior to the installation of the control rods. The installation was performed while awaiting the decision on which set of control rods would be used. Table V gives the recorded count rates for the installation. The effect of adding a poison to the core and causing a decrease in K_{eff} is observable in the decrease in count rate.

TABLE V

POISON CORE ROD AND DUMMY SOURCE ROD INSTALLATION

Sequence Step No.	Source Range Channel 1 (cpm)	Source Range Channel 2 (cpm)
F0	1920	639
F1	1786	630
F5	1831	618
F9	1825	612
F13	1707	568

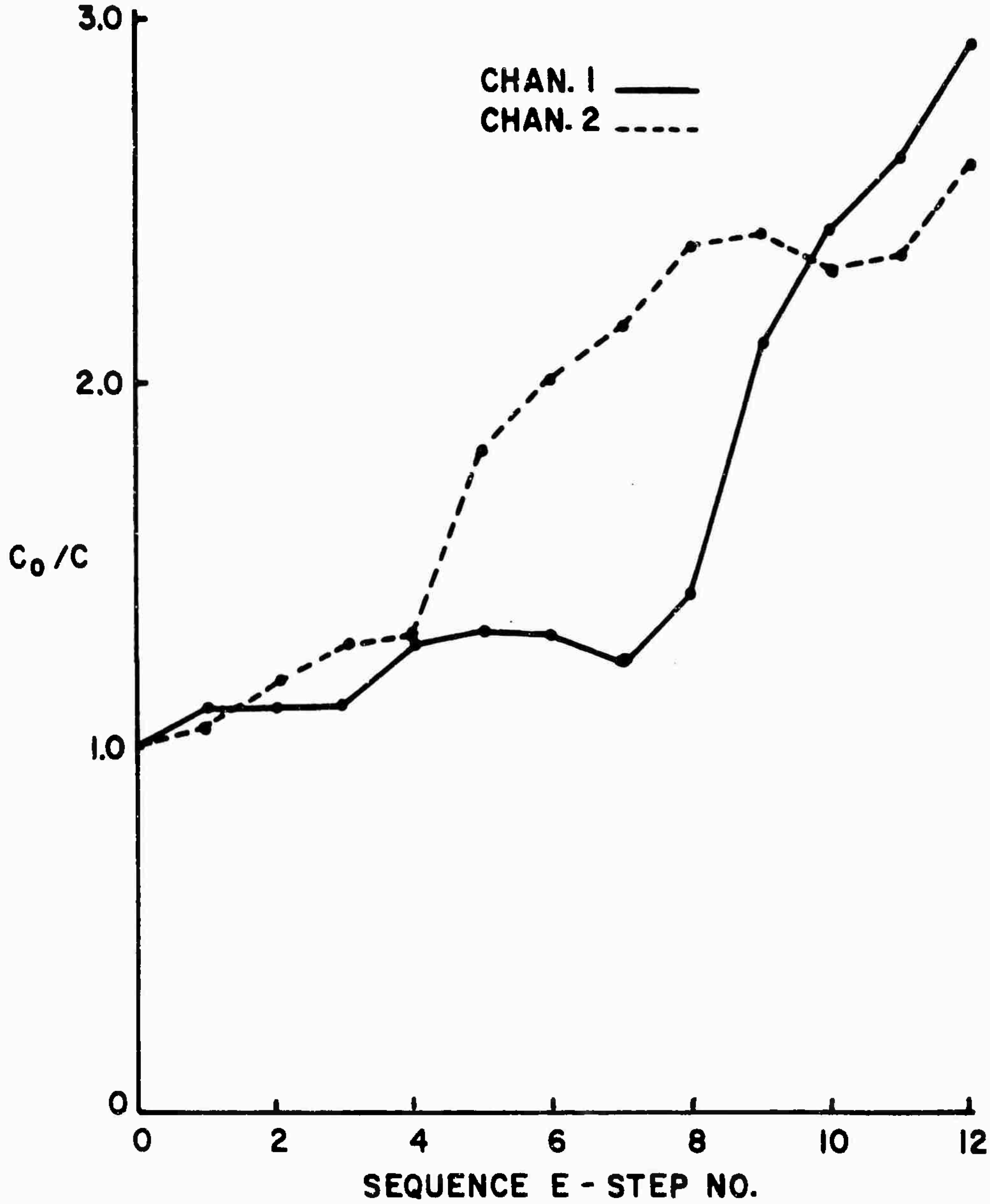
F. Control Rod Installation

The initial refueling plans were to reuse the original control rods for a second fullpower year. The visual inspection of the original control rod disclosed several cracks in the facial welds at the tips of the cruciforms. These welds are not structural welds, but a detailed metallurgical and physical examination needs to be performed to verify the reuse of the initial control rods with these minor cracks; therefore, the new control rods were installed in the core. Their orientation is such that the serial numbers are on the port side of the forward blade of each rod. Measurements and visual inspections of each rod were made prior to loading.

During the installation of the control rods, the source range channels behaved as expected with good examples of spatial behavior in evidence. The overall change in count rate was much greater than that shown during the control rod removal. No explantion for this is available.

Table VI gives the recorded count rates during this sequence, and Figure 7, the 1/M plot.

24 - 25 OCTOBER 1969
MH-1A REFUELING
SEQUENCE E



CONTROL ROD INSERTION

FIGURE 7

TABLE VI

CONTROL ROD INSTALLATION

Sequence Step No.	Source Range Channel 1 (cpm)	Source Range Channel 2 (cpm)
E0	1649	567
E1	1497	533
E2	1484	479
E3	1477	443
E4	1289	434
E5	1250	313
E6	1263	282
E7	1329	264
E8	1150	239
E9	784	236
E10	680	246
E11	629	242
E12	564	218

G. Finger Poison Rod Assembly Removal.

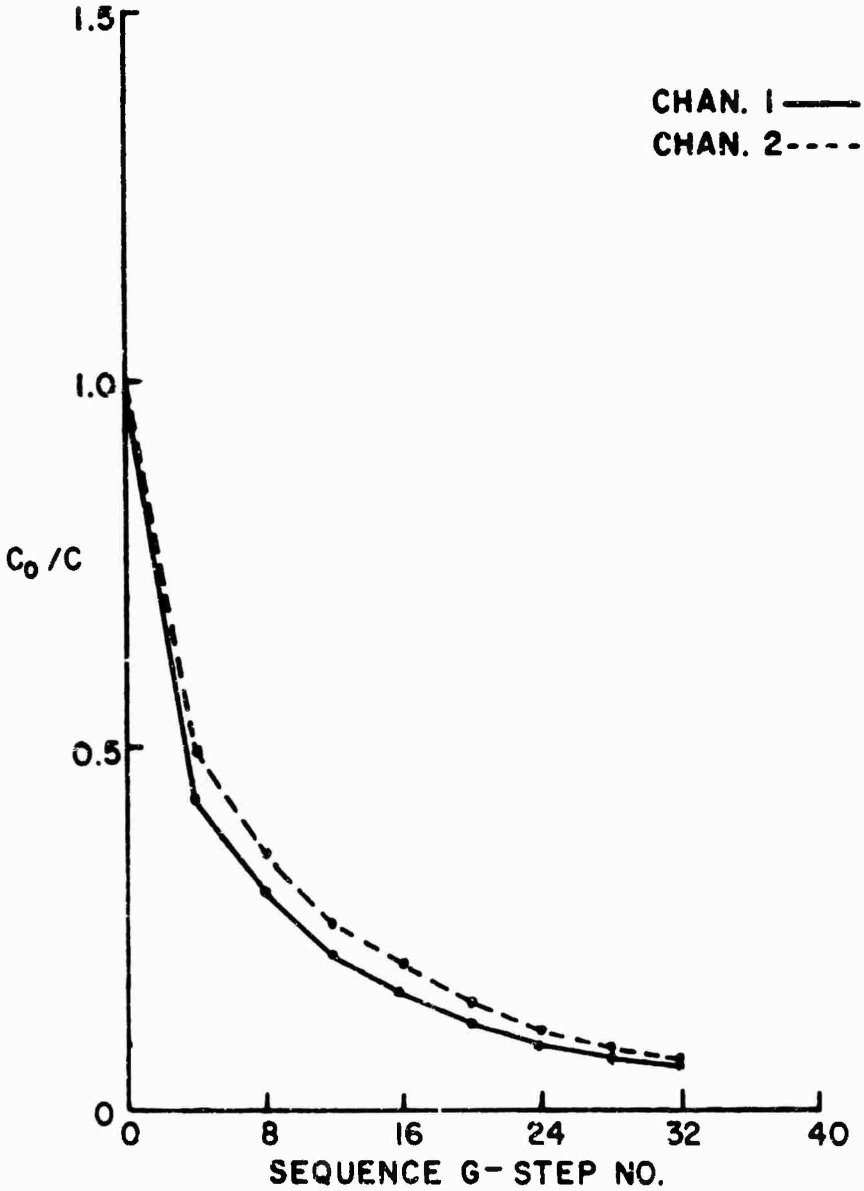
The final phase of the actual refueling core component movement was the removal of the finger poison rod assemblies. Since this was a removal of negative reactivity, the source range channels were recorded at every removal and a 1/M plot maintained. In this report the data and plot are given for every fourth removal. This provides much smoother data and a more meaningful plot.

Prior to the removal of the assemblies, a 1/M plot was made using the data from sequence A, Finger Poison Rod Assembly Insertion. This plot predicted what should occur during the removal. The agreement between the plot as predicted by sequence A and that actually measured was outstanding.

The control room 1/M plot made at each removal exhibited the expected spatial behavior differences between the two channels, with the two plots crossing and recrossing several times.

The count rate data and the 1/M plots are given in Table VII and Figure 8 respectively.

25 OCTOBER 1969
MH-1A REFUELING
SEQUENCE G



FINGER POISON ROD ASSEMBLY REMOVAL
FIGURE 8

15 DEC 69

RE-1471

TABLE VII

FINGER POISON ROD ASSEMBLY REMOVAL

Sequence Step No.	Source Range Channel 1 (cpm)	Source Range Channel 2 (cpm)
G0	590	228
G4	1376	464
G8	1963	646
G12	2601	902
G16	3685	1168
G20	4823	1487
G24	6898	2131
G28	8270	2578
G32	9922	3192

III. CONCLUSIONS

Initial refueling of the MH-1A was accomplished smoothly and with predictable results. The movement sequence of core components specified in the special refueling instructions was instrumental in providing good monitoring of changes in the reactivity status of the reactor.

The expected tight fits for the fuel elements did not materialize during the refueling. Based on this fact, the movement of fuel elements for the next refueling can be changed to a one-for-one exchange sequence. (i.e. Remove an inner element, shuffle the appropriate outer element into the center, and then insert a new element into the vacated outer space). This one-for-one sequence will provide a significant increase in core-detector coupling and will give a much better monitoring of the core's criticality status.

APPENDIX A

SPECIAL REFUELING INSTRUCTIONS
FOR MH-1A INITIAL CORE SHUFFLE

REFUELING SEQUENCE

09 SEP 1969

1. INTRODUCTION:

This supplement is written to provide an unloading and loading sequence for all movements of the nuclear core components for the initial MH-1A refueling. The sequence of movements is designed to provide a safe and observable unloading and loading of those core components which affect the reactivity status of the reactor.

The sequence in some instances is different from that outlined in the Maintenance Manual but the procedures used will be those given in the Maintenance Manual. The sequence allows a significant amount of shutdown information to be gleaned during the unloading and therefore points to a better understanding of the shutdown conditions as the core is made more reactive.

2. GENERAL MOVEMENT SEQUENCE:

All movement of core components, including the surveillance samples and core hold down structure, shall be monitored by observation of the source range instrumentation in the control room. The movement of any core component shall be done slowly so that the neutron level and consequently the source range instrumentation will reflect any reactivity changes. This movement sequence commences after the removal of the hold down structure (page 2-26) and ends before the replacement of the surveillance samples (page 2-67).

The finger poison rod assemblies will be loaded in the 32 fuel elements prior to the removal of the core dummy rods and the source rod. They will be loaded from the inside to the outside so as to provide the maximum coupling between the core and the source range instrumentation. The 1/M graph will be started prior to the insertion of the finger rods. A point will be plotted after every four assemblies have been inserted. A minimum of 300 counts will be used for each 1/M graph throughout the refueling if at all possible.

Following the insertion of the 32 poison finger rod assemblies the dummy core rods (12) and the primary source rod will be removed. A new 1/M graph will be used for the removal of the thirteen rods. A point will be plotted after every four rod removals and after the source rod removal.

Item Destination	Full Item Name
FPRA	Finger Poison Rod Assembly
FE-zn	Fuel Element in Core Location zn
DCR	Dummy Core Rod
SR	Source Rod
CR-n	Control Rod Number n
SFST	Spent Fuel Storage Tank
FE	Fuel Element (Original)
FEN	Fuel Element (New)
NFSV	New Fuel Storage Vault
PCR	Poison Core Rod

The next removals involve the twelve control rods. A 1/M graph will be kept with points plotted after complete removal of each control rod. The rods will be withdrawn in reverse order of their numerical designations (Tech. Manual Chap. 2, Section 1, Figure 2-32).

The fuel elements presently in the core will then be removed or shuffled by quadrants. This will permit a better method of monitoring the core than the sequence outlined in the manual. The four inner elements in a quadrant are removed and then the four outer elements are moved in. The 1/M graph for movement of the fuel elements will be maintained with a point being plotted after every element has been removed, shuffled, or inserted. After the sixteen inner elements have been removed and the sixteen outer elements shuffled in, the sixteen new fuel elements along with the poison finger rods assemblies from the inner sixteen elements will be inserted in the core.

The original control rods will be inserted in numerical order with a 1/M graph maintained and points plotted after each control rod insertion.

Following this the source rod and the twelve poison core rods will be inserted. The 1/M graph will be plotted after the source rod insertion and after every four poison rods have been inserted.

The final portion of the sequence is the removal of the thirty-two finger poison rod assemblies and the plotting of the 1/M graph after removal of every four assemblies. If anomalies occur during the removal of the assemblies, the 1/M graph should be plotted after every withdrawal.

The above set of movement sequences will generate seven separate 1/M graphs. Prior to taking counts for any of the 1/M graphs, the reactor must be allowed to stabilize its neutron population for a minimum of five minutes after movement of a core component from or to the core.

3. SPECIFIC MOVEMENT SEQUENCE:

The core locations for the various core components will be designated through the use of the alphanumeric system of core locations shown in Figures 2-23 and 2-24 of the Refueling Procedures. For items located at the corners of the fuel elements their location will be designated by a double alphanumeric location defining the rows above and below the point and the columns to the left and right of the point (i.e. Control Rod No. 1 is located at CD23). The following are a list of item designations which will be used in the tabular loading sequence.

Seq. No.	Item	From	To	Remarks
A0	----	----	----	Take initial count C_{A0} and commence first 1/M graph
A1	FPRA	Storage	FE-C3	
A2	FPRA	Storage	FE-C4	
A3	FPRA	Storage	FE-D4	
A4	FPRA	Storage	FE-D3	Take count C_{A4} and plot C_{A0}/C_{A4} on graph
A5	FPRA	Storage	FE-D2	
A6	FPRA	Storage	FE-C2	
A7	FPRA	Storage	FE-C5	
A8	FPRA	Storage	FE-D5	Take count C_{A8} and plot C_{A0}/C_{A8} on graph
A9	FPRA	Storage	FE-B3	
A10	FPRA	Storage	FE-B4	
A11	FPRA	Storage	FE-E4	
A12	FPRA	Storage	FE-E3	Take count C_{A12} and plot C_{A0}/C_{A12} on graph
A13	FPRA	Storage	FE-E2	
A14	FPRA	Storage	FE-B2	
A15	FPRA	Storage	FE-B5	
A16	FPRA	Storage	FE-E5	Take count C_{A16} and plot C_{A0}/C_{A16} on graph
A17	FPRA	Storage	FE-A5	
A18	FPRA	Storage	FE-B6	
A19	FPRA	Storage	FE-F2	
A20	FPRA	Storage	FE-E1	Take count C_{A20} and plot C_{A0}/C_{A20} on graph
A21	FPRA	Storage	FE-F3	

11 SEP 1969

Seq. No.	Item	From	To	Remarks
A22	FPRA	Storage	FE-D1	
A23	FPRA	Storage	FE-A4	
A24	FPRA	Storage	FE-C6	Take count C_{A24} and plot C_{A0}/C_{A24} on graph
A25	FPRA	Storage	FE-D6	
A26	FPRA	Storage	FE-F4	
A27	FPRA	Storage	FE-C1	
A28	FPRA	Storage	FE-A3	Take count C_{A28} and plot C_{A0}/C_{A28} on graph
A29	FPRA	Storage	FE-B1	
A30	FPRA	Storage	FE-A2	
A31	FPRA	Storage	FE-E6	
A32	FPRA	Storage	FE-F5	Take count C_{A32} and plot C_{A0}/C_{A32} on graph

Seq. No.	Item	From	To	Remarks
B0	----	----	----	Take initial count C_{B0} and commence second 1/M graph
B1	DCR	AB12	Storage	
B2	DCR	AB56	Storage	
B3	DCR	EF56	Storage	
B4	DCR	EF12	Storage	Take count C_{B4} and plot C_{B0}/C_{B4} on graph
B5	DCR	AB34	Storage	
B6	DCR	CD56	Storage	
B7	DCR	EF34	Storage	
B8	DCR	CD12	Storage	Take count C_{B8} and plot C_{B0}/C_{B8} on graph
B9	DCR	BC23	Storage	
B10	DCR	BC45	Storage	
B11	DCR	DE45	Storage	
B12	DCR	DE23	Storage	Take count C_{B12} and plot C_{B0}/C_{B12} on graph
B13	SR	CD34	Storage	Take count C_{B13} and plot C_{B0}/C_{B13} on graph

Seq. No.	Item	From	To	Remarks
C0	----	----	----	Take initial count C_{CO} and commence third 1/M graph
C1	CR-12	BC12	SFST	For each sequence number take count C and plot C_{CO}/C on graph
C2	CR-11	DE12	SFST	
C3	CR-10	EF23	SFST	
C4	CR-9	EF45	SFST	
C5	CR-8	DE56	SFST	
C6	CR-7	BC56	SFST	
C7	CR-6	AB45	SFST	
C8	CR-5	AB23	SFST	
C9	CR-4	DE34	SFST	
C10	CR-3	CD45	SFST	
C11	CR-2	BC34	SFST	
C12	CR-1	CD23	SFST	

Seq. No.	Item	From	To	Remarks
D0	----	----	----	Take initial count C_{D0} and commence fourth 1/M graph
D1	FE-E5	E5	SFST	For each sequence number take count C and plot C_{D0}/C on graph
D2	FE-E4	E4	SFST	
D3	FE-D5	D5	SFST	
D4	FE-D4	D4	SFST	
D5	FE-D6	D6	D4	
D6	FE-E6	E6	D5	
D7	FE-F4	F4	E4 90° CW	
D8	FE-F5	F5	E5 90° CCW	
D9	FE-E2	E2	SFST	
D10	FE-D2	D2	SFST	
D11	FE-E3	E3	SFST	
D12	FE-D3	D3	SFST	
D13	FE-F3	F3	D3	
D14	FE-F2	F2	E3	
D15	FE-D1	D1	D2 90° CW	
D16	FE-E1	E1	E2 90° CCW	
D17	FE-B2	B2	SFST	
D18	FE-B3	B3	SFST	
D19	FE-C2	C2	SFST	
D20	FE-C3	C3	SFST	
D21	FE-C1	C1	C3	

Seq. No.	Item	From	To	Remarks
D22	FE-B1	B1	C2	
D23	FE-A3	A3	B3 90° CW	
D24	FE-A2	A2	B2 90° CCW	
D25	FE-B5	B5	SFST	
D26	FE-C5	C5	SFST	
D27	FE-B4	B4	SFST	
D28	FE-C4	C4	SFST	
D29	FE-A4	A4	C4	
D30	FE-A5	A5	B4	
D31	FE-C6	C6	C5 90° CW	
D32	FE-B6	B6	B5 90° CCW	
D33	FEN	NFSV	A2	
D34	FEN	NFSV	A3	
D35	FEN	NFSV	A4	
D36	FEN	NFSV	A5	
D37	FEN	NFSV	B6	
D38	FEN	NFSV	C6	
D39	FEN	NFSV	D6	
D40	FEN	NFSV	E6	
D41	FEN	NFSV	F5	
D42	FEN	NFSV	F4	
D43	FEN	NFSV	F3	
D44	FEN	NFSV	F2	

Seq. No.	Item	From	To	Remarks
D45	FEN	NFSV	E1	
D46	FEN	NFSV	D1	
D47	FEN	NFSV	C1	
D48	FEN	NFSV	B1	

Seq. No.	Item	From	To	Remarks
E0	----	----	----	Take initial count C_{E0} and commence fifth 1/M graph
E1	CR-1	SFST	CD23	For each sequence number take count C and plot C_{E0}/C on graph
E2	CR-2	SFST	BC34	
E3	CR-3	SFST	CD45	
E4	CR-4	SFST	DE34	
E5	CR-5	SFST	AB23	
E6	CR-6	SFST	AB45	
E7	CR-7	SFST	BC56	
E8	CR-8	SFST	DE56	
E9	CR-9	SFST	EF45	
E10	CR-10	SFST	EF23	
E11	CR-11	SFST	DE12	
E12	CR-12	SFST	BC12	

Seq. No.	Item	From	To	Remarks
F0	----	----	----	Take initial count C_{F0} and commence sixth 1/M graph
F1	SR	Storage	CD34	Take count C_{F1} and plot C_{F0}/C_{F1} on graph
F2	PCR	Storage	DE23	
F3	PCR	Storage	DE45	
F4	PCR	Storage	BC45	
F5	PCR	Storage	BC23	Take count C_{F5} and plot C_{F0}/C_{F5} on graph
F6	PCR	Storage	CD12	
F7	PCR	Storage	EF34	
F8	PCR	Storage	CD56	
F9	PCR	Storage	AB34	Take count C_{F9} and plot C_{F0}/C_{F9} on graph
F10	Pcr	Storage	EF12	
F11	PCR	Storage	EF56	
F12	PCR	Storage	AB56	
F13	PCR	Storage	AB12	Take count C_{F13} and plot C_{FC}/C_{F13} on graph

Seq. No.	Item	From	To	Remarks
G0	----	----	----	Take initial count C_{G0} and commence seventh 1/M graph
G1	FPRA	FE-F5	Storage	
G2	FPRA	FE-E6	Storage	
G3	FPRA	FE-A2	Storage	
G4	FPRA	FE-B1	Storage	Take count C_{G4} and plot C_{G0}/C_{G4} on graph
G5	FPRA	FE-A3	Storage	
G6	FPRA	FE-C1	Storage	
G7	FPRA	FE-F4	Storage	
G8	FPRA	FE-D6	Storage	Take count C_{G8} and plot C_{G0}/C_{G8} on graph
G9	FPRA	FE-C6	Storage	
G10	FPRA	FE-A4	Storage	
G11	FPRA	FE-D1	Storage	
G12	FPRA	FE-F3	Storage	Take count C_{G12} and plot C_{G0}/C_{G12} on graph
G13	FPRA	FE-E1	Storage	
G14	FPRA	FE-F2	Storage	
G15	FPRA	FE-B6	Storage	
G16	FPRA	FE-A5	Storage	Take count C_{G16} and plot C_{G0}/C_{G16} on graph
G17	FPRA	FE-E5	Storage	
G18	FPRA	FE-B5	Storage	
G19	FPRA	FE-B2	Storage	
G20	FPRA	FE-E2	Storage	Take count C_{G20} and plot C_{Go}/C_{G20} on graph
G21	FPRA	FE-E3	Storage	

Seq. No.	Item	From	To	Remarks
G22	FPRA	FE-E4	Storage	
G23	FPRA	FE-B4	Storage	
G24	FPRA	FE-B3	Storage	Take count C_{G24} and plot C_{G0}/C_{G24} on graph
G25	FPRA	FE-D5	Storage	
G26	FPRA	FE-C5	Storage	
G27	FPRA	FE-C2	Storage	
G28	FPRA	FE-D2	Storage	Take count C_{G28} and plot C_{G0}/C_{G28} on graph
G29	FPRA	FE-D3	Storage	
G30	FPRA	FE-D4	Storage	
G31	FPRA	FE-C4	Storage	
G32	FPRA	FE-C3	Storage	Take count C_{G32} and plot C_{G0}/C_{G32} on graph

Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author)

U. S. Army Engineer Reactors Group

2a. REPORT SECURITY CLASSIFICATION

None

2b. GROUP

3. REPORT TITLE

MH-1A Refueling

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final

5. AUTHOR(S) (First name, middle initial, last name)

C. Frederick Sears, CPT, CE

6. REPORT DATE

20 December 1969

7a. TOTAL NO. OF PAGES

33

7b. NO. OF REFS

none

8a. CONTRACT OR GRANT NO

In-house

b. PROJECT NO

c.

d.

9a. ORIGINATOR'S REPORT NUMBER(S)

ED-6923

9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

10. DISTRIBUTION STATEMENT

Distribution of this document is unlimited.

11. SUPPLEMENTARY NOTES

12. SPONSORING MILITARY ACTIVITY

United States Army Engineer Reactors Group

13. ABSTRACT

The initial refueling of the MH-1A (STURGIS) took place in October 1969. This report discusses the nuclear behavior of the reactor during refueling, and explains how the monitoring of this behavior was affected by orientation and locations of core components with respect to the source range instrumentation. Various figures and tables are used to illustrate the measured nuclear behavior.

DD FORM 1 NOV 65 1473 REPLACES DD FORM 1473, 1 JAN 64, WHICH IS OBSOLETE FOR ARMY USE.

Security Classification

Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
0 Nuclear Reactor, (Army, Refueling)						
0 Reactor, Nuclear						
3 Refueling (of Nuclear Reactor MH-1A)						
3 MH-1A Refueling						