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ASSURANCE OF ACCEPTABLE SCRAM THROUGH CONTROL ROD DRIVE SPEED ANALYSIS

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ABSTRACT

This study presents a new method for determining the existence of an acceptable scram through a simple analysis of the control rod drive insertion performance, a measured plant parameter. The approach defines limiting control rod velocity distributions as a function of the number of inoperable and "slow clump" control rods, and in doing so, provides methods by which one may determine if a particular distribution of fast, slow, and inoperable control rods does not violate the limiting distributions and thereby assures the occurrence of an acceptable scram. The separation requirements of slow and inoperable control rods remain constant in the approach, and the speeds of control rod insertion are allowed to vary in a free manner as long as local and global restrictions placed on the performances of all operable control drives are met.

1. INTRODUCTION

The existence of slow scramming and inoperable control rods in reactor cores, and the accompanying loss of scram reactivity, lead to operational problems for all nuclear reactors. As a result, technical specifications must allow the existence of these control rods as well as provide a checking method to assure an acceptable scram reactivity response. An analysis of the current specification showed that it could be employed, however it would be difficult to satisfy from a mechanical performance standpoint and would adversely affect plant availability. Therefore, a new approach for the technical specification was developed to solve this problem. The new approach adequately provides for an acceptable scram reactivity response by imposing local and global restrictions on control rod performance. However, attempts to provide for maximum availability have also been incorporated.

2. PRELIMINARY WORK

2.1 EVALUATION OF CURRENT SPECIFICATION

Current technical specifications impose two restrictions on control rod performance to assure an acceptable scram:

a. A limiting core average scram insertion schedule (notches inserted versus time) is specified for all of the operable control rods.

b. The fastest three-out-of-four control rods in each 2x2 array must meet another average insertion schedule, which is currently less restrictive than the core average insertion schedule.

This was an acceptable approach when the specification was generated due to the large design margin in scram reactivity calculations. However, with the reduction of this design margin, the three-out-of-four specification would require for the fast scram system that the three fastest control rods in each 2x2 array be inserted to 75% insertion in 1.53 seconds (fast scram 1.62 sec to 75%

insertion). This very fast scram response will be very difficult to meet from a mechanical response standpoint, so the current three-out-of-four specification was not judged adequate for the fast scram application. In addition, it was realized that it was not sufficient to specify an average scram insertion schedule for the core. (If the core average is maintained for a case with slow rods in the central core region and fast rods in the peripheral region, an acceptable scram may not result due to low peripheral and high central control rod worths.)

To assure an acceptable scram, it is necessary to localize and restrict the variations in control rod performance. (This is also desirable in order to minimize hot spots around slow or withdrawn inoperable rods during a scram due to the power redistribution during the scram. However, it was not the intent of this study to investigate or minimize this effect.)

2.2 TECHNICAL BASIS FOR NEW APPROACH

As a basis for the new approach, the limiting velocity distribution was determined for a 2x2 array of four fast (F) and slow (S) control rods. Four configurations were investigated.

1.)	F	F	2.)	F	S	3.)	F	F	4.)	F	S
	F	S		S	F		S	S		S	S

Each configuration was investigated using the GEBSCRAM model on Fermi-2, Cycle 1 (764 bundles, 80 mil channels) at end-of-cycle with all rods out using a Haling burn. The effects of non-Haling burns are discussed later. The configurations were repeated for each 2x2 cell in the core with no special edge patterns. (See Figure 1.) Using the constraint that the average insertion speed of the four control rods remained constant, it was found that the minimum scram reactivity insertion occurred when all four control rods in each cell were inserted at the same rate. (This is not surprising due to the monotonically increasing nature of the 1st derivative of control rod worth versus insertion in the lower BWR core. Since an acceptable scram is required through just the first second of the scram (rods inserted approximately half of core height in 1.0 sec), control rods going faster more than compensate for slow rods in this time and reactivity worth domain.) This result is shown graphically for one particular situation in Figure 2.

Figure 1.

Typical Core Configuration With Fast and Slow Control Rods

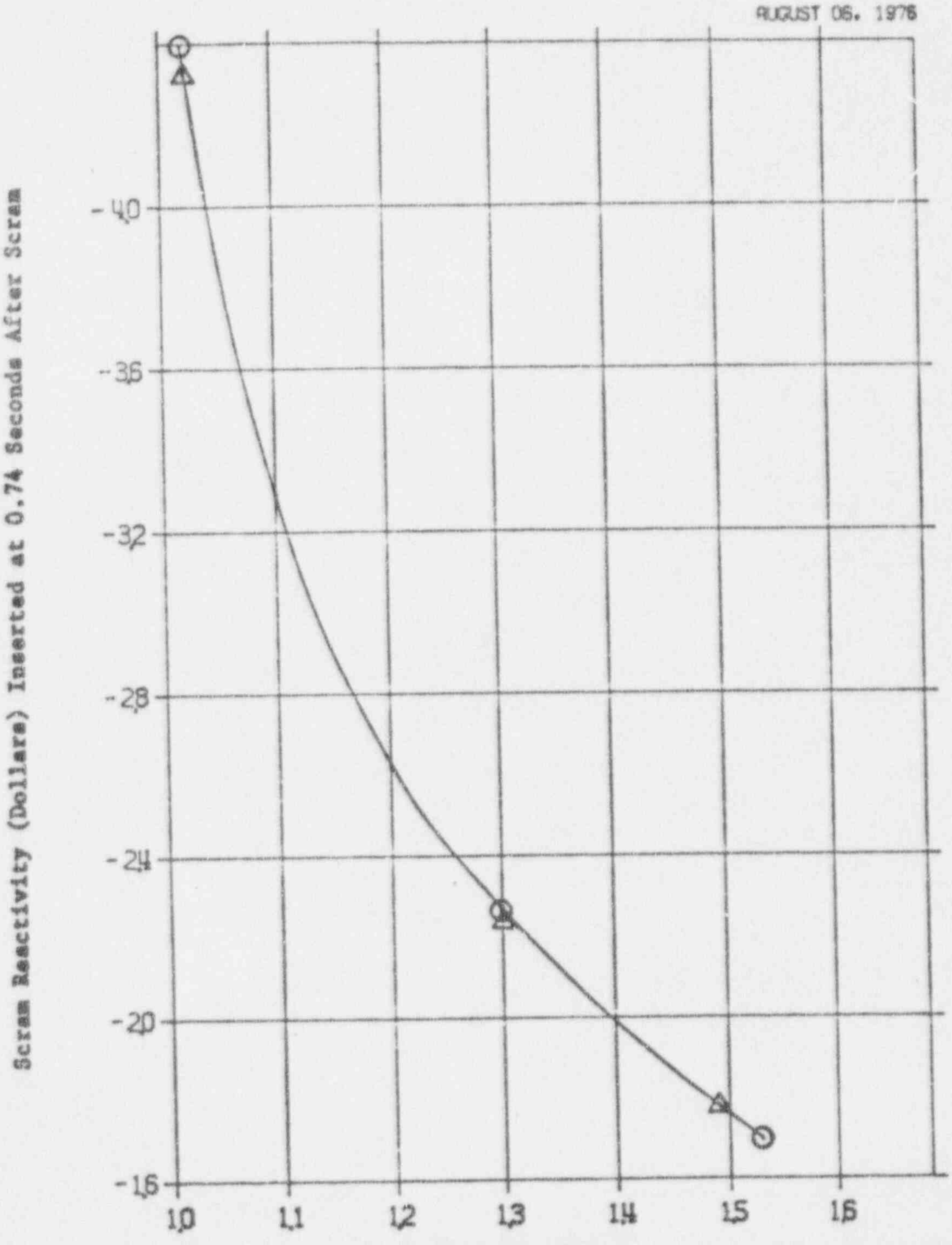
				F	F	F	F
			F	S	F	S	F
		F	F	F	F	F	F
	F	S	F	S	F	S	F
F	F	F	F	F	F	F	F
S	F	S	F	S	F	S	F
F	F	F	F	F	F	F	F
S	F	S	F	S	F	S	F

F = Fast -- 1.55 sec. to 75% Insertion

S = Slow -- 1.80 sec. to 75% Insertion

Figure 2.

Reactivity Insertion at 0.74 Seconds as a Function of the Scram Speed of the Two Fastest Control Rods in a 2x2 Control Rod Array Under the Constraint that the Average Inverse Scram Speed Remains Constant



2.3 BASIS FOR ACCEPTABLE SCRAM

The minimum values of required scram reactivity versus time which define an "acceptable" scram were documented in Reference 1, a letter from L. R. Huang of the Transient Analysis group. The requirements were simplified by L. R. Huang for the scram analysis to include only the two points shown in Table 1. The values are taken directly from the D-scram curve.

TABLE 1

Required Scram Reactivity Response

Time (seconds)	Scram Reactivity $(\frac{\Delta K}{B})$ (Dollars)
0.74	- 1.00
1.001	- 2.00

While the values in Table 1 specify the limiting values of scram reactivity required for an acceptable scram (with no multipliers), these values were not used directly in this approach. Instead, since the current fast scram system is being designed for a 75% control rod insertion time of 1.62 seconds, the limiting values for an acceptable scram were defined from a scram reactivity calculation for Fermi-2 at EOC1 from an all rods out condition with all control rods scramming to the fast scram system rate noted above. The new limiting values of scram reactivity were calculated via STARPATH and are shown in Table 1A. As seen in Table 1A, the predicted values of scram reactivity are greater than the values in Table 1 by about 70%. Therefore, by using these new limiting values, additional design margin of 70% has been introduced. However, since this study was undertaken to define a new methodology to accommmodate slow and inoperable control rods, this change is not of great concern. When the new methodology has been defined, the limiting scram speed may be redefined to reflect the values of scram reactivity in Table 1, or some other values with a desired design margin. (It may be noted that Table 1A specifies a scram reactivity at 1.00 seconds while Table 1 specifies a scram reactivity at 1.001 seconds. Although this change is

small, it is still inconsistent. However, it is not significant since it was found that if the required scram reactivity is provided at 0.74 seconds, then more than the required scram reactivity is consistently provided at 1.00 seconds).

TABLE 1A

Required Scram Reactivity Response Assuming Fast Scram Insertion Rate

(75% insertion in 1.62 seconds)

Time (seconds)	Scram Reactivity $(\frac{\Delta K}{B})$ (Dollars)
0.74	- 1.70
1.00	- 3.44

3. GENERAL CONSIDERATIONS FOR NEW APPROACH

3.1 REQUIREMENTS

A specification that will assure an acceptable scram response has the following requirements:

a. Define the limiting control rod velocity distributions for the core.

b. Define the allowable number and distribution of slow scramming and inoperable control rods.

c. The above two requirements should be satisfied to provide maximum potential availability and minimize the complexity and applicability of the specification.

To minimize the complexity of the new approach only three control rod velocity domains are considered:

a. Normal Control Rods
b. Slow Control Rods
c. Inoperable Control Rods

Normal control rods are defined as having Effective Insertion Times (EIT's) that do not exceed the Maximum Allowable Effective Insertion Time (MAEIT). Slow control rods are defined as having EIT's that exceed the MAEIT. Inoperable control rods are those control rods that have been electrically disarmed and do not scram.

The new approach recognizes two basic methods to make up lost scram reactivity due to slow scramming and inoperable control rods:

a. Can make up lost scram reactivity "locally" by requiring the control rods surrounding a slow or inoperable control rod to meet a "tighter than average" specification, or

b. Can make up lost scram reactivity on a "global" basis by requiring all normal control rods to meet a "tighter" specification than normally required.

3.2 EFFECTIVE INSERTION TIMES

To simplify the approach and the analysis, the control rod insertion profile (% insertion versus time) was characterized by a single number - the time required for a control rod to reach 75% insertion from a fully withdrawn initial condition. This time is denoted as the Effective Insertion Time (EIT). This assumes that the insertion profiles for different EIT's are all geometrically similar. For lack of operational data on fast scram control drives, this is a reasonable assumption, and the proposed insertion profile for the fast scram system (1.62 sec to 75%) was used to calculate similar insertion profiles at different scram speeds for use in the analysis.

4. GENERAL METHODOLOGY OF APPROACH

Basically, the approach generates (from a table) a value for the Maximum Allowable Effective Insertion Time (MAEIT). This value has two functions:

a. The MAEIT sets a control rod performance limit which defines the boundary between normal and slow scramming control rods.

b. By specifying a MAEIT, one requires that all control rods except a small known set of degenerate* control rods scram with EIT's which do not exceed the MAEIT.

With the degenerate control rods properly accounted for in the value of the MAEIT, and if all other control rods have EIT's which do not exceed the MAEIT, then it is known that the amount of scram reactivity which is inserted is at least equal to that amount which would be inserted if all non-degenerate control rods scrammed at a rate equal to that defined by the MAEIT. This is the first level at which the approach addresses the determination of the limiting velocity distribution. By specifying an appropriate MAEIT value, adequate scram reactivity may be provided.

The second level of the approach assumes that there exist some "barely" slow control rods (i.e., control rods with EIT's that just exceed the MAEIT). In this case, the limiting velocity distribution is determined by requiring additional local restrictions around the control rods which are slow with respect to the value of the MAEIT.

The third level of the approach considers the moderately slow control rods whose EIT's exceed the range of the second level of the approach. These control rods are denoted as "slow clump" rods and are treated as degenerate rods. In this case, the limiting velocity distribution is determined by requiring a tighter global restriction on the operable control rods in proportion to the number of slow clump rods (i.e., the value of the MAEIT is adjusted in accordance with the number of degenerate slow clump rods).

The fourth level of the approach addresses the alternatives for very slow control rods. These control rods may be handled as "slow clump" rods, or they may be considered as inoperable control rods, whichever is more convenient or allows more flexibility from an operational point of view. This is the last level at which the approach handles slow control rods.

*Degenerate implies inoperable from a scram reactivity standpoint.

Inoperable control rods are considered to be degenerate rods. The limiting velocity distribution with fully inserted or fully withdrawn inoperable rods present is determined by requiring a tighter global restriction on the operable control rods (i.e., the value of the MAEIT is adjusted in accordance with the number of inoperable control rods). Partially inserted inoperable rods are treated in a more restrictive manner due to their especially large effect on scram reactivity. In addition to requiring an even tighter global restriction on operable control rod performance, the number of partially inserted inoperable control rods is limited to one or two.

From the above discussion, it is realized that the value of the MAEIT is dependent on the number of slow clump and inoperable control rods. The value of the MAEIT is also dependent upon the distribution of the degenerate control rods. For the fast scram analysis, the distribution effects were found to cause only small changes in the value of the MAEIT (<0.01 sec), so distribution was considered as a relatively insensitive parameter. As a result, specific separation requirements are imposed on degenerate control rods in order to eliminate variations in the analysis due to this second order effect.

In summary, for a specific number of slow clump and inoperable control rods obeying a particular distribution criteria, a value of the MAEIT parameter may be found such that if all of the remaining operable control rods are scrammed at the rate defined by the MAEIT, an acceptable scram will result. Furthermore, barely slow scramming control rods may also be tolerated as long as the loss of scram reactivity accompanying the slow rod is made up for locally.

5. SPECIFIC METHODOLOGY

The following specific methodology is set forth by the new approach to accommodate the existence of degenerate control rods while still assuring an acceptable scram reactivity response.

In the approach, all three control rod types (normal, slow, and inoperable) are treated separately, with slow and inoperable rods further categorized. By determining the number of degenerate control rods (inoperable and slow clump), corresponding value for the MAEIT may be defined from Table 2. Then, with the EIT's of the normal rods not exceeding the MAEIT, and with the remaining slow rods meeting the special provisions set forth by the approach, an acceptable scram reactivity response is assured.

Each type of control rod is handled in the following manner:

5.1 NORMAL CONTROL RODS

By definition, a normal control rod has an EIT which does not exceed the MAEIT. No restrictions are directly placed on these control rods since they do not pose problems in meeting the scram reactivity implied by all operable rods scramming at the MAEIT rate.

5.2 SLOW CONTROL RODS

Lost scram reactivity due to a slow control rod is made up locally or globally, depending on how slow the control rod is inserted. Therefore, slow control rods grouped into three categories - barely slow, moderately slow, and very slow. The approach makes up the lost scram reactivity for each case in different manners, which become increasingly stricter as the rod becomes slower.

5.2.1 Barely Slow Control Rod

When the EIT of a slow control rod just exceeds the MAEIT, it is easiest to replace the lost scram reactivity locally. (From preliminary work, it is known that if a slow control rod is surrounded by faster control rods, then the minimum amount of reactivity inserted is bounded by the amount that would be inserted if the rods all scrammed at the average speed. (This is shown graphically in Figure 2.) So, if the local average EIT does not exceed the MAEIT, then no degradation of scram reactivity will occur due to the slow rod, relative to all

TABLE 2

Maximum Allowable Effective Insertion Times (MAEIT)

for Fast Scram (75% insertion in 1.62 sec)

Number of Inoperable Rods	Number of Slow Clump Rods	MAEIT (sec) No Partially Inserted Stuck Rods	MAEIT (sec) 1 Partially Inserted Stuck Rod
0	0	1.62	---
0	1-4	1.60	---
0	5-9	1.59	---
1-2	0	1.61	1.57
1-2	1-4	1.59	1.56
1-2	5-8	1.58	1.55
3-5	0	1.60	1.56
3-5	1-4	1.58	1.56
3-5	5-8	1.57	1.55
6-9	0	1.59	1.56
6-9	1-4	1.57	1.55
6-9	5-8	1.56	1.54

operable rods scramming at the MAEIT rate.) Therefore, any number of barely slow control rods may be accommodated when separation requirements (discussed later) and the following condition is met:

> "The average EIT of a barely slow control rod and the eight surrounding control rods shall not exceed the MAEIT."

5.2.2 Moderately Slow Control Rod

When the average EIT of a slow control rod and its eight surrounding control rods exceeds the MAEIT, it may not be considered a barely slow rod and there may be a loss of scram reactivity due to the slow rod which is not made up locally by the faster surrounding rods. To handle this case, the slow control rod is denoted as a "slow clump" rod, and the lost scram reactivity is made up on a global basis by specifying a faster (lower) value for the MAEIT. (This places a tighter restriction on the performance of all of the normal control rods to make up the lost scram reactivity on a core-wide basis.) The restriction on the MAEIT varies proportionally with the number of slow clump rods, and is detailed in Table 2. A maximum of nine slow clump rods are allowed (limited only by depth of analysis).

The restriction on the MAEIT above is not a function of how slow a slow clump rod may scram. This allows a control rod which scrams so slow that it looks like it does not scram at all to be considered an operable control rod rather than an inoperable control rod. This will be advantageous from an availability standpoint.

5.2.3 Very Slow Control Rods

In some cases it may be advantageous to declare a very slow control rod inoperable rather than classify it as a slow clump rod. This is the final option provided by the approach to accommodate slow control rods.

5.2.4 Separation of Slow Control Rods

To simplify the distribution effects of the slow control rods, the approach requires slow control rods to be separated from other slow or inoperable control rods by at least one operable control rod in each direction (including diagonal rods). This allows slow control rods to be packed together with a minimum of one control rod cell separation.

5.2.5 Adjacent Slow Control Rods

Although separation of slow control rods by one control rod cell is required, it is reasonable to assume that two slow control rods may occur in directly or diagonally adjacent positions. In this special case, the slow control rods may be considered barely slow control rods when the following condition is met:

> "The average EIT for each array of four control rods, arranged in a 2x2 cell, containing an adjacent slow control rod shall not exceed the MAEIT."

When the above criteria is not met, no assurance of an acceptable scram is provided. Appropriate action must then be taken, either by repairing the slow drives or by performing a special calculation or demonstration to assure that an acceptable scram will occur.

5.3 INOPERABLE CONTROL RODS

In analyzing the different types of inoperable control rods, it was found that some types had adverse effects on scram reactivity while others had propitious effects. The following types of inoperable control rods were categorized as shown below to evaluate their impact on scram reactivity:

a. Drifting Rods
b. Loss of Rod Position Indicator System (RPIS)
c. Decoupled Rod
d. Very Slow Rod

e. Failed Accummulator Rod

f. Stuck Rods

(1) Fully Withdrawn

(2) Partially Inserted

(3) Fully Inserted

Drifting control rods and those which have experienced a loss of the RPIS are required by technical specifications to resolve their associated problems within a specified time period or be fully inserted, electrically disarmed and declared inoperable. Until valved out of service, however, these control rods will still scram, so no loss of scram reactivity due to these two conditions will occur. Furthermore, when a control rod is fully inserted, the core power is redistributed toward the bottom of the core which increases scram reactivity during the early part of the scram (first second). Therefore, no additional loss of scram reactivity may be attributed to these inoperable control rods.

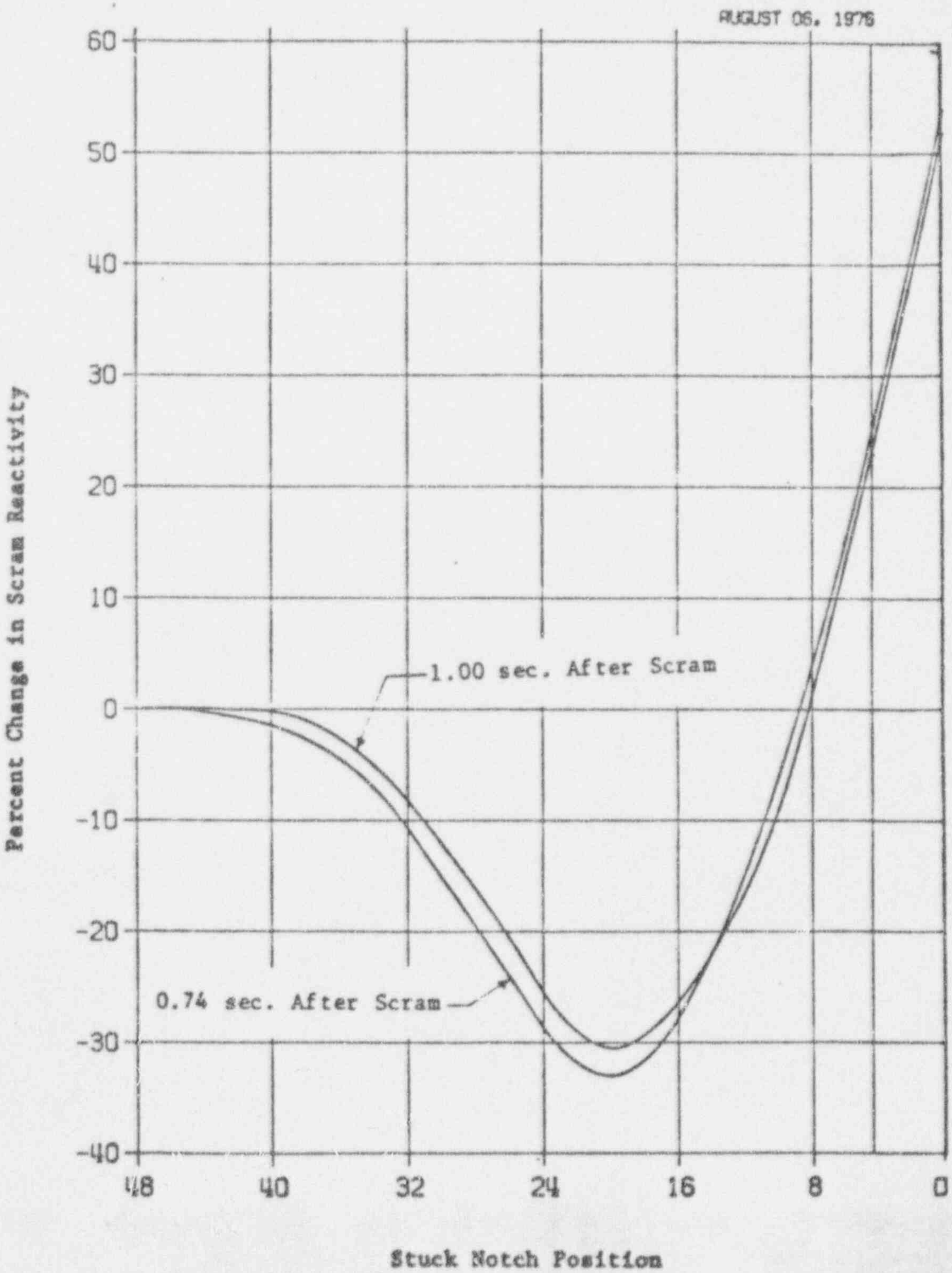
Decoupled control rods are required by technical specifications to be fully inserted, electrically disarmed and declared inoperable. Again, no loss of scram reactivity will be realized by decoupled control rods.

Very slow control rods and those with failed accummulators do affect scram reactivity adversely. These control rods are normally handled in the approach as barely slow or slow clump rods, however, those which are declared inoperable must meet the separation criteria for inoperable rods.

Stuck control rods have the largest adverse effects on scram reactivity of all the inoperable rod types. Analysis shows that when control rods are stuck at notch position 20, the core power is redistributed in a manner that minimizes scram reactivity. This may be seen in Figure 3. Figure 3 shows the change in scram reactivity at 1.00 second with nine inoperable control rods stuck at various notch positions in the core with all of the remaining control rods scramming at the same speed. Maximum degradation in scram reactivity is seen to occur when the stuck inoperable control rods are stuck at notch position 20 (10 notches withdrawn from full insertion). In addition, a severe penalty exists for even a

Figure 3.

Change in Scram Reactivity for Nine Inoperable Control Rods Stuck at Various Axial Positions (Fermi-2, 80 mil channel)



few control rods stuck at notch 20. Therefore, only one partially inserted stuck control rod will be allowed. Fully withdrawn stuck control rods affect scram reactivity just like a very slow control rod. Conversely, fully inserted stuck control rods have a propitious effect on scram reactivity as noted before.

In summary, the approach handles inoperable control rods in the following manner:

Lost scram reactivity due to fully withdrawn inoperable control rods is made up globally by requiring a faster (lower) MAEIT in proportion to the number of inoperable control rods (see Table 2). Fully inserted control rods do not degrade scram reactivity and are not counted as inoperable rods in Table 2.

A maximum on one partially inserted stuck control rod is allowed.

A maximum of nine fully and partially withdrawn inoperable control rods are allowed (limited only by depth of analysis determining Table 2). More than nine inoperable rods could be justified by additional analysis; however, based on operating experience and engineering judgment the selection of nine inoperable rods is adequate to ensure sufficient plant availability. If the case should arise where there are more than nine inoperable rods, a specific case-by-case analysis can be performed to justify continued operation.

5.3.1 Separation Requirements for Inoperable Control Rods

The separation of inoperable control rods seems restricted by simple reasoning to zero, one, or two control rods. (Greater separation would lead to availability problems.) Zero control rod separation may be eliminated by noting that if many fully withdrawn inoperable control rods were adjacent, gross radial power profile distortion would occur affecting operational flexibility, as well as possible problems associated with the subsequent cold shutdown margin due to changes in control rod worths. This is not desirable and leaves one or two control rod separations to be considered. Since it is required to assume the failure of the highest worth control rod in the core, the additional failure of

a control rod to insert in the proximity (center) of four or more fully withdrawn inoperable control rods with a one-cell separation may cause an excessive loss of scram reactivity as well as possible cold shutdown problems. Therefore, it seems reasonable to require inoperable control rods to be separated by at least two control rods (cells) in all directions. This actually limits the maximum number of inoperable control rods due to limited core size. Note that for simplicity, all inoperable control rod types are specified with this same separation requirement.

5.4 APPROACH ALTERNATIVES

In some cases, it may be advantageous or necessary to perform a special calculation to verify an acceptable scram condition in order to justify further operation. This is the alternative when the approach is not applicable or when separation or required scram speed response are not met.

5.5 FLOW DIAGRAM

A flow diagram outlining the use of the approach is shown in Figure 4. The approach is initiated by measuring the effective insertion times (EIT) for the control rods in the reactor core. The number of inoperable control rods is then determined directly. The maximum allowable number of inoperable and partially inserted stuck rods are checked along with separation requirements, and a value for the MAEIT is determined from Table 2 based on the number of inoperable control rods. If some slow clump rods are known to exist, they may be accounted for in the determination of the initial MAEIT value.

With a value for the MAEIT defined, the EIT's of the operable control rods may be compared with the MAEIT to determine the number of slow control rods. These may immediately be categorized into adjacent and isolated slow control rods. The adjacent slow control rods are checked to be sure that they meet the appropriate criteria. Next, the average EIT for each isolated slow control rod and its eight surrounding control rods is calculated. For those slow control rods with average EIT's (of the nine-rod group) that do not exceed the MAEIT, no further action is

Figure 4. Flow Diagram for the Proposed New Approach for Determining an Acceptable Scram

MEASURE EFFECTIVE INSERTION
TIMES FOR CONTROL RODS

DETERMINE THE NUMBER OF
A. INOPERABLE CONTROL RODS, AND
B. PARTIALLY INSERTED STUCK CONTROL RODS

CHECK MAXIMUM NUMBER OF
A. INOPERABLE TYPE CONTROL RODS
B. PARTIALLY INSERTED STUCK CONTROL RODS

DETERMINE MAXIMUM ALLOWABLE EFFECTIVE
INSERTION TIME FROM TABLE 2 BASED ON
NUMBER OF INOPERABLE RODS

DETERMINE THE NUMBER OF SLOW CONTROL RODS
(EIT>MAEIT)
AND CATEGORIZE SLOW CONTROL RODS

<u>ADJACENT SLOW CONTROL RODS</u>
AVERAGE EIT FOR EACH 2X2
CONTROL ROD CELL INCLUDING
AN ADJACENT SLOW ROD < MAEIT

<u>ISOLATED SLOW CONTROL RODS</u>
A. AVERAGE EIT FOR SLOW ROD AND 8 SURROUNDING RODS <MAEIT
B. CLASSIFY AS A "SLOW CLUMP"

CHECK MAXIMUM NUMBER OF
SLOW CLUMPS

DETERMINE NEW MAEIT FROM
TABLES

IF $MAEIT_{NEW} < MAEIT_{OLD}$

RE-EVALUATE SLOW CONTROL
RODS

EIT - EFFECTIVE INSERTION TIME - TIME REQUIRED FOR CONTROL BLADE TO BE INSERTED 75%.

MAEIT - MAXIMUM ALLOWABLE EFFECTIVE INSERTION TIME

required. If the average EIT of one or more of the slow control rod groups exceeds the MAEIT, then the slow control rod becomes classified as "slow clump" rod. With the new number of slow clump rods determined and not exceeding the maximum allowable number, a new value for the MAEIT is redefined from Table 2.

If the new MAEIT is less than the old MAEIT, then the slow control rods must be reevaluated using the new MAEIT value. Otherwise, the procedure is finished and an acceptable scram is assured.

If the situation arises that the specification criteria cannot be met, a special calculation to determine the scram reactivity, or other appropriate action, such as repairing faulty control drives, must be performed.

5.6 MAEIT TABLE

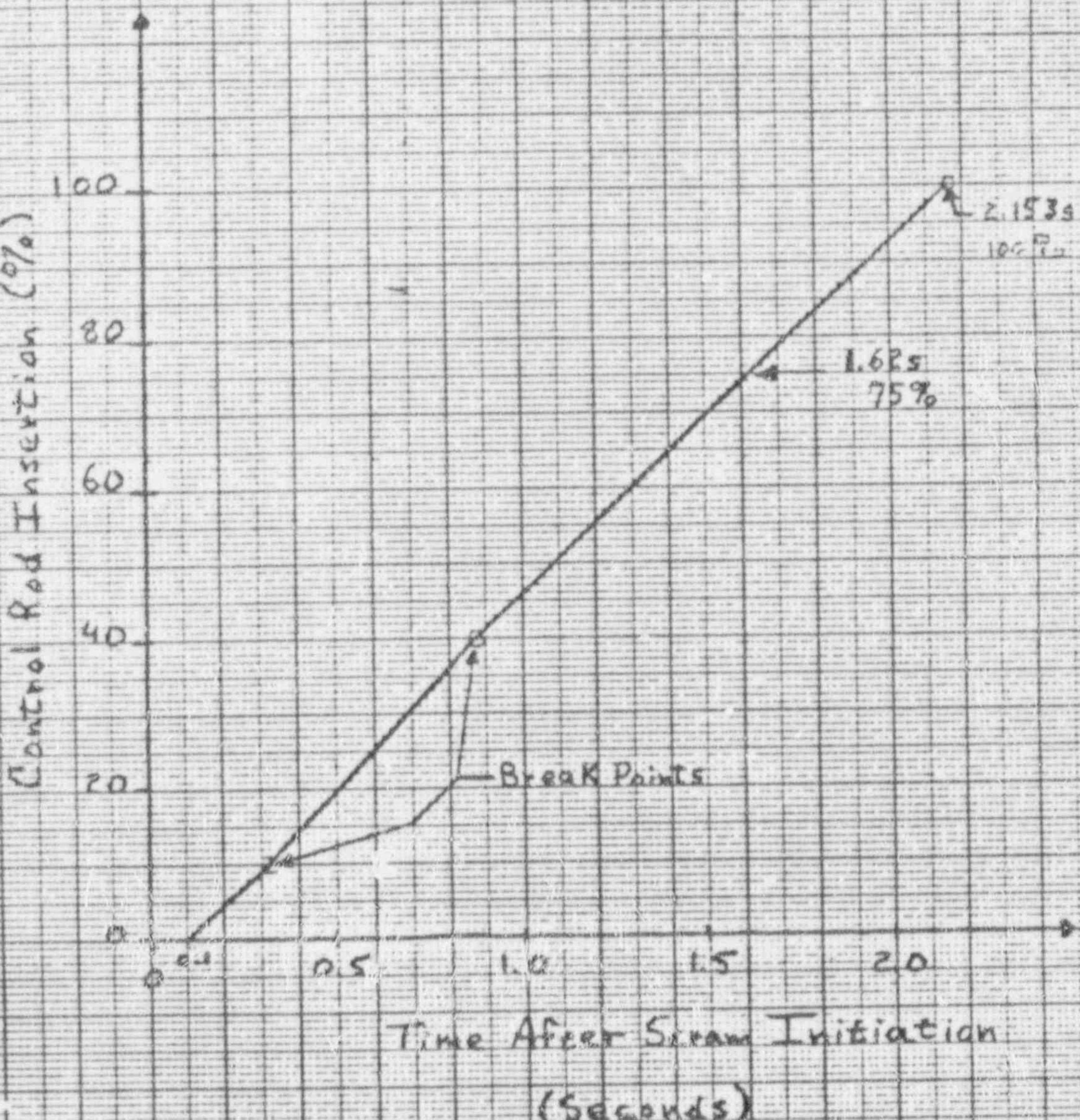
Table 2 defines the Maximum Allowable Effective Insertion Times (MAEIT) for various numbers of slow clump and inoperable control rods. The numbers represent an analysis for the current fast scram system (75% insertion in 1.62 seconds). The values of the MAEIT were evaluated using the limiting distribution of slow clump, inoperable, and partially inserted stuck control rods. This is detailed in Appendix I. The MAEIT values account for the additional failure of the highest worth control rod to insert, except for the case with no slow or inoperable control rods. In this case, only a 0.45% loss of scram reactivity was discovered at 1.00 second when the highest worth rod failed to insert while all other rods scrammed. This is a very small degradation in scram reactivity, and is adequately compensated for by the 20% margin in required scram reactivity.

5.7 SCRAM INSERTION SCHEDULE RESTRICTIONS

Since the approach bases control rod performance on the Effective Insertion Time (EIT, time to 75% insertion), the shape of the control rod insertion schedule must be specified such that insertion requirements at 0.74 sec and 1.00 sec are met as well as at the 75% insertion time (1.62 seconds). For the fast scram analysis, all of the scram insertion schedules were calculated to be geometrically similar to the base insertion schedule in Figure 5. A 0.1 sec delay was assumed for all scram schedules.

Figure 5.

Scram Insertion Profile



Breakpoints

Time	Insertion
0.00 sec	0.0 %
0.10	0.0
0.32	10.0
0.87	40.0
2.16	100.0

6. ADDITIONAL ANALYSIS

6.1 STARPATH VERIFICATION

Although GEBSCRAM is a level 2R code, it is not yet recognized as a current design method to calculate transient scram reactivity. The currently accepted design code is STARPATH. For this study, however, GEBSCRAM was used in a consistent manner to take advantage of the much simpler input scheme. In order to apply the GEBSCRAM predicted reactivity to the acceptability criteria, a set of normalization multipliers were obtained to apply to the GEBSCRAM results to simulate STARPATH results. These correction factors were obtained by running two identical cases, one with each code. The normalization cases were run with all control rods scramming at the fast scram system rate defined by 1.62 seconds to 75% insertion. Values of scram reactivity predicted by GEBSCRAM and STARPATH were tabulated at 0.1 second intervals up to 1.0 seconds, and a multiplier factor was then determined at each time step which would correct the GEBSCRAM value to yield the STARPATH value of scram reactivity. The normalization factors are shown in Table 3. To investigate the effects on the normalization of control rods not scramming at the same rate, comparison cases were run with each code for a case when three out of each four control rods in each 2x2 array were scrammed at 1.53 seconds to 75% insertion with the fourth control rod in each array not scramming. (The 1.53 second-3/4 case yields a scram reactivity comparable to the 1.62 second-4/4 case.) A comparison of the results during the first second of the scram is shown in Figure 6. A large difference between the results at 0.2 second is noted in Figure 6. This is due to early GEBSCRAM convergence problems. However, after 0.3 second the differences are small (<4.3%). This consistency in the results indicates that the normalization multipliers are not largely affected by the control rod velocity distribution.

As a further test, the 4/4 normalization factors were applied to the 3/4 GEBSCRAM results and compared to the 3/4 STARPATH results. This comparison is shown graphically in Figure 7. Again, after the first 0.2 second, the normalized 3/4 GEBSCRAM results only vary a maximum of -4% up to the first second of the scram,

Figure 6.

Difference Between Normalized GEBSCRAM and STARPATH for 3 Out of Each 4 Control Rods Scramming

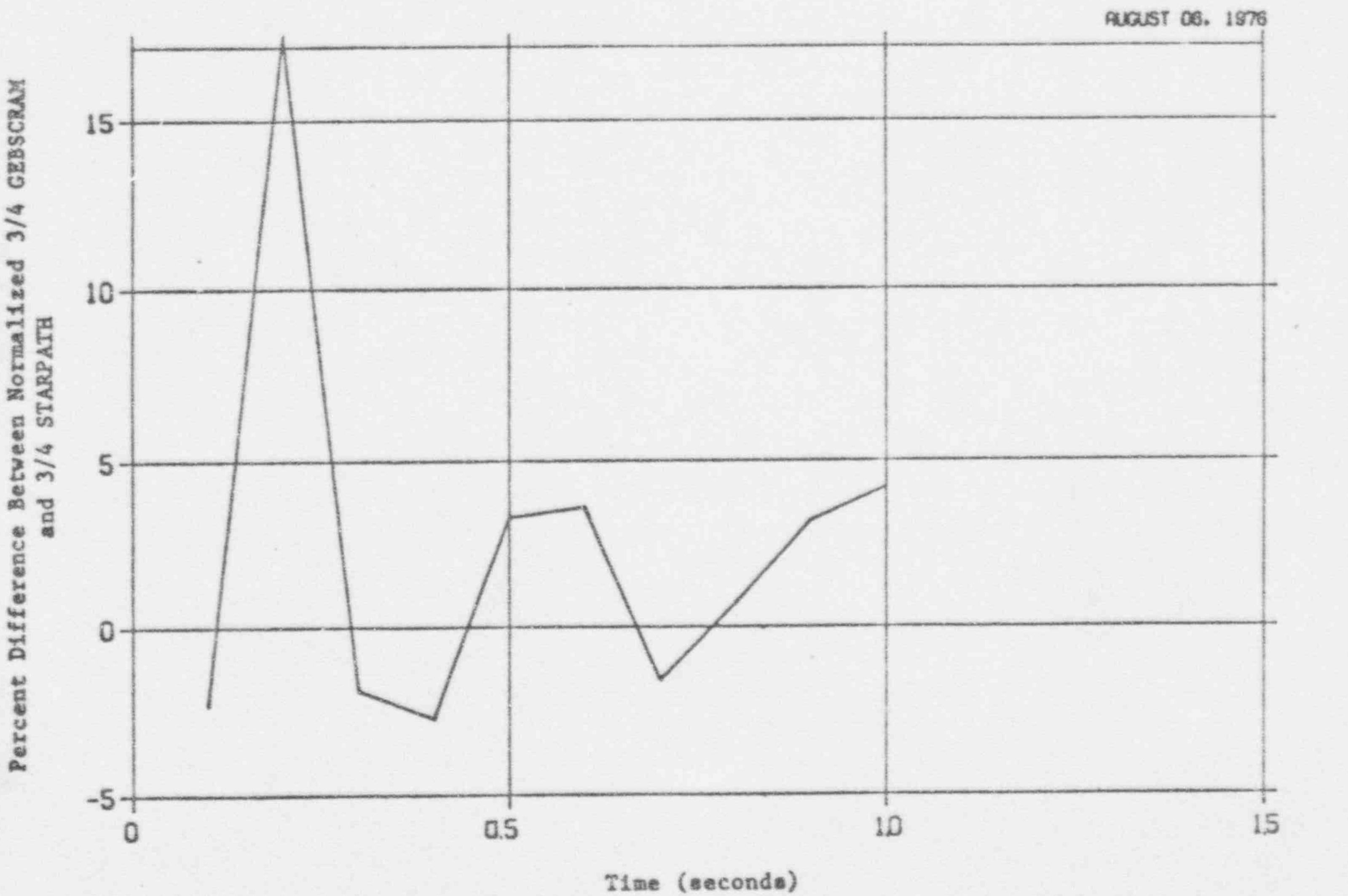
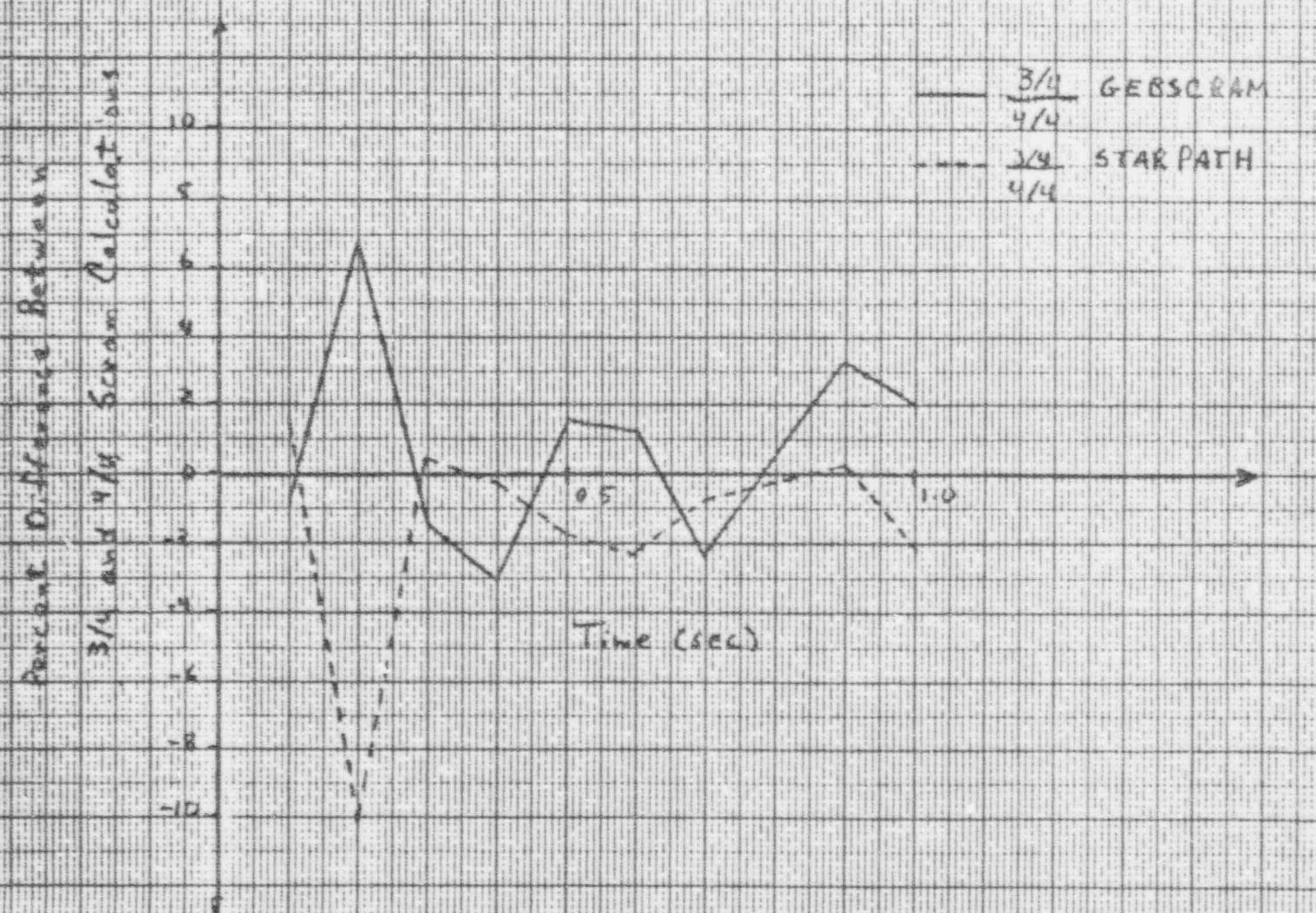


Figure 7.

Comparison of GEBSCRAM And STARPATH

For Two Equivalent Control Rod Velocity Distributions



which is the range over which the scram calculation is important. It was therefore assumed that the normalization factors could be applied to GEBSCRAM results with differing control rod speeds with only a small amount of error during the first second of the scram.

TABLE 3

GEBSCRAM Normalization Factors

Time (sec)	Multiplier
0.1	20.612
0.2	1.127
0.3	1.031
0.4	0.997
0.5	1.014
0.6	0.977
0.7	0.934
0.8	0.922
0.9	0.911
1.0	0.881

6.2 EFFECT OF TOP PEAKED POWER SHAPES

To investigate the effect of a top peaked power shape, a full scram (four out of every four control rods) at a 1.62 second EIT and a partial scram (three out of four) at a 1.53 second EIT were evaluated for a top peaked power shape. From the Haling power shape analysis, it is known that the 3/4 case yields a slightly better scram than the 4/4 case. For the top peaked power shape, the 3/4 case also yielded a slightly better scram than the 4/4 case. The results are presented in Table 4. Since the reference "D" scram curve lies between a Haling and a top

peaked scram curve, the above relationship between the scrams is assumed to hold for the "D" scram curve as well. Therefore, the approach presented may be applied with confidence in reference to the "D" scram curve. (The top peaked power distribution is the worst case for a scram calculation.)

TABLE 4

Comparison of 3/4 and 4/4 Cases for Haling and Top Peaked Power Shapes

	GEBSCRAM Predicted Scram Reactivity (Not Normalized)	
Haling	0.74 sec	1.00 sec
3/4 Case	\$ - 1.84	\$ - 4.04
4/4 Case	\$ - 1.83	\$ - 3.90
Top Peaked		
3/4 Case	\$ - 0.46	\$ - 1.39
4/4 Case	\$ - 0.43	\$ - 1.23

6.3 SCRAM BANK FAILURE

An analysis was performed in order to evaluate the effects of the failure of one of the four scram banks to insert. Both the present and a new proposed scram bank assignment were investigated. The present system (applied to plants without solid-state reactor manual control systems) is illustrated in Figure 8 and the new system is illustrated in Figure 9. The changes in scram reactivity due to one scram bank failure for the two systems is shown in Table 5. The present system was found to be slightly worse. The results for the present system are graphed in Figures 10 and 11. The loss of scram reactivity at the end of the scram is -26%, nearly proportional to the 25% rod failure. However, in the earlier, more important part of the scram, less loss of reactivity occurs as noted in Figures 10 and 11. These results will require further transient analysis in order to completely evaluate the effects of failing one scram bank.

Figure 8.

Control Rod Assignment to Scram Groups
Currently Being Employed

	2	6	10	14	18	22	26	30	34	38	42	46	50	54	58
59					2	1	3	4	2	1	3				
55				3	4	2	1	3	4	2	1	3			
51			1	3	4	2	1	3	4	2	1	3	4		
47		1	3	4	2	1	3	4	2	1	3	4	2	1	
43	2	1	3	4	2	1	3	4	2	1	3	4	2	1	3
39	4	2	1	3	4	2	1	3	4	2	1	3	4	2	1
35	4	2	1	3	4	2	1	3	4	2	1	3	4	2	1
31	2	1	3	4	2	1	3	4	2	1	3	4	2	1	3
27	2	1	3	4	2	1	3	4	2	1	3	4	2	1	3
23	4	2	1	3	4	2	1	3	4	2	1	3	4	2	1
19	4	2	1	3	4	2	1	3	4	2	1	3	4	2	1
15		1	3	4	2	1	3	4	2	1	3	4	2	1	
11			3	4	2	1	3	4	2	1	3	4	2		
7				3	4	2	1	3	4	2	1	3			
3					4	2	1	3	4	2	1				

Figure 9.

Proposed Control Rod Assignment to Scram Groups

	2	6	10	14	18	22	26	30	34	38	42	46	50	54	58
59					2	4	1	3	4	2	3				
55				4	1	3	4	2	3	1	2	4			
51			1	3	4	2	3	1	2	4	1	3	4		
47		3	4	2	3	1	2	4	1	3	4	2	3	1	
43	4	2	3	1	2	4	1	3	4	2	3	1	2	4	1
39	3	1	2	4	1	3	4	2	3	1	2	4	1	3	4
35	2	4	1	3	4	2	3	1	2	4	1	3	4	2	3
31	1	3	4	2	3	1	2	4	1	3	4	2	3	1	2
27	4	2	3	1	2	4	1	3	4	2	3	1	2	4	1
23	3	1	2	4	1	3	4	2	3	1	2	4	1	2	4
19	2	4	1	3	4	2	3	1	2	4	1	3	4	2	3
15		3	4	2	3	1	2	4	1	3	4	2	3	1	
11			3	1	2	4	1	3	4	2	3	1	2		
7				4	1	3	4	2	3	1	2	4			
3					4	2	3	1	2	4	1				

Figure 10.

Effect of One Scram Bank Failure for Current Scram Bank Assignments During the First Second of Scram

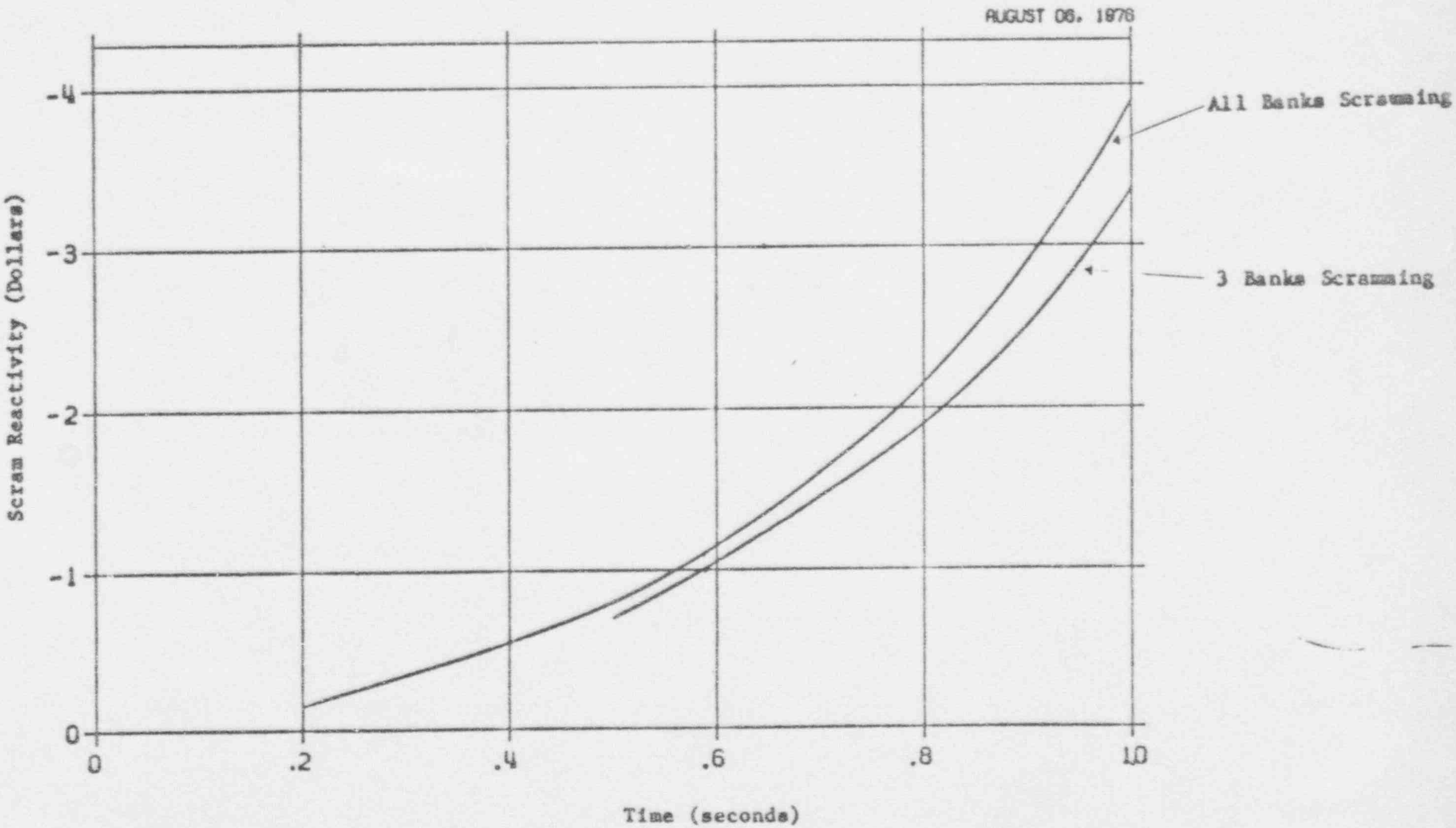


Figure 11.

Effect of One Scram Bank Failure for Current Scram Bank Assignments During the Entire Scram

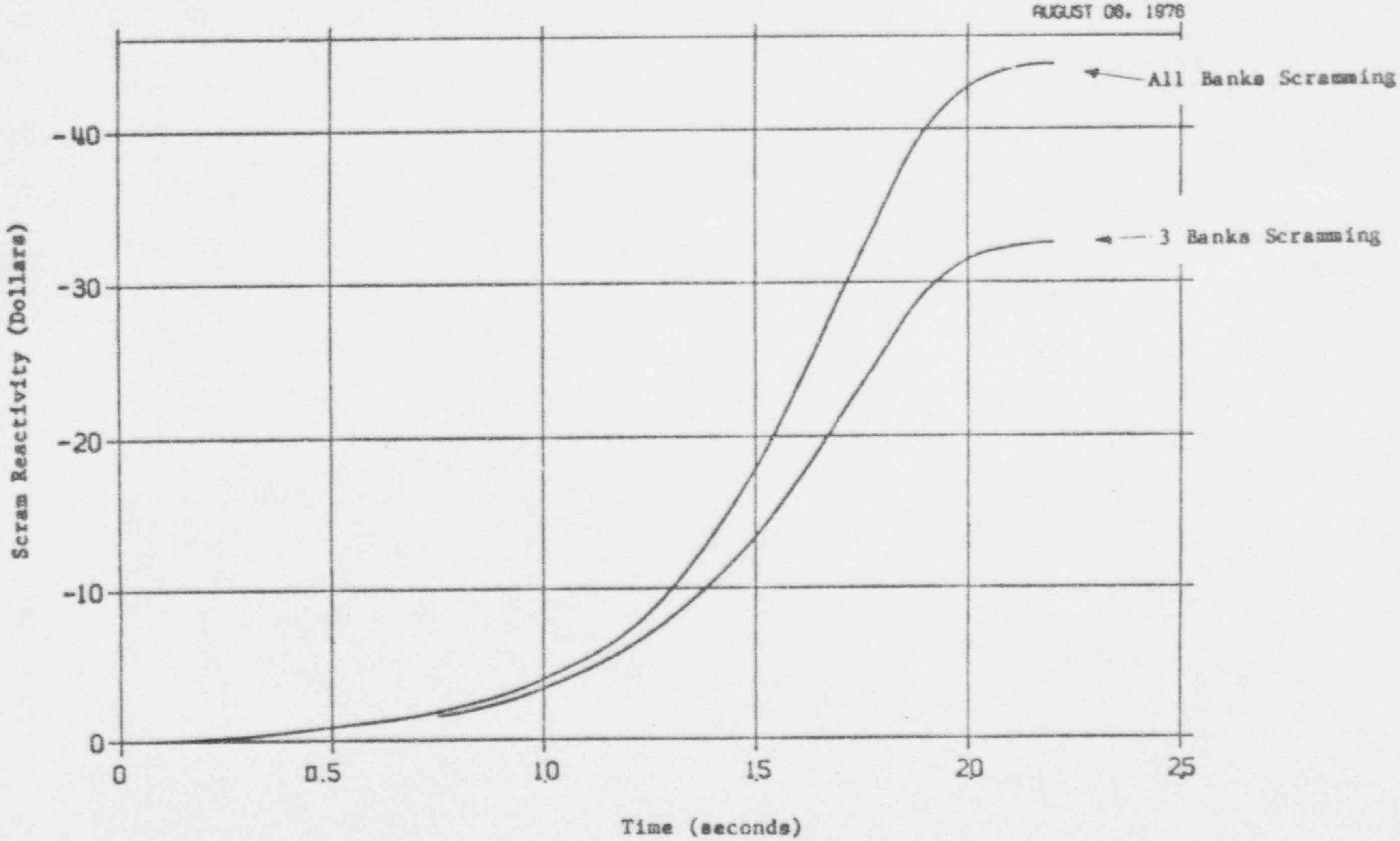


TABLE 5

Scram Bank Failure Results

System	Loss of Scram Reactivity (%) 0.74 sec	1.00 sec
Present	-11.0%	-13.7%
Proposed	-10.8%	-13.4%

6.4 PROPOSED ADDITIONAL ANALYSIS

Several additional analyses of interest were recognized, however lack of time has not yet permitted their investigation.

The effects of core size are expected to have some impact on the approach. This is due to the higher relative worths of control rods in smaller size cores. It is expected that the results of the preliminary work will not change (i.e. small groups of control rods insert minimum reactivity when the control rods are inserted at the same rate and a constant average rate is maintained). The values of the MAEIT may change, however, reflecting core size differences.

The results shown in Table 2 reflect an analysis performed for the BWR/6 fast scram rate of 75% insertion in 1.62 seconds. Currently, it is not expected that this scram speed will be met due to mechanical limitations. Therefore, an analysis should be performed reflecting an updated, more realistic fast scram speed when it becomes available. An analysis may also be performed for the '67 B scram speed to update the scram specification for currently operating plants.

A proposed method to increase the scram speed which was not considered by the approach is to partially insert some control rods so that they reach 75% insertion quicker than if they were fully withdrawn. This would seem particularly useful to increase the effective speed of a slow control rod. However, the required

amount of insertion and the subsequent effects on operating strategy and fuel cycle economics must be evaluated to assure satisfactory results from this method. A quick calculation showed that a control rod with an EIT of 1.62 seconds could have its EIT reduced to 1.42 seconds by being inserted four notches before initiation of the scram. However, the scram performance must be evaluated as opposed to changes in the EIT in order to get a good estimate of the changes in scram reactivity.

REFERENCES

1. Letter, L. R. Huang to R. C. Stirn, "BWR/6 Fastest 3 Out of 4 Scram Speed," May 28, 1975.

APPENDIX I

EVALUATION OF MAEIT VALUES

The new proposed approach defines the limiting velocity distribution of operable control rods by specifying a limiting value for the Maximum Allowable Effective Insertion Time (MAEIT) as a function of the number of inoperable and slow clump control rods. An acceptable scram is assured as long as the local and global restrictions on the operable control rods are met with respect to the value of the MAEIT and the distribution or separation requirements are also satisfied. Therefore, for a given minimum required scram reactivity response, the MAEIT values of Table 2 must be determined. The following procedure describes the required computations. Computations are performed for an all rods out case at end of cycle (the limiting case).

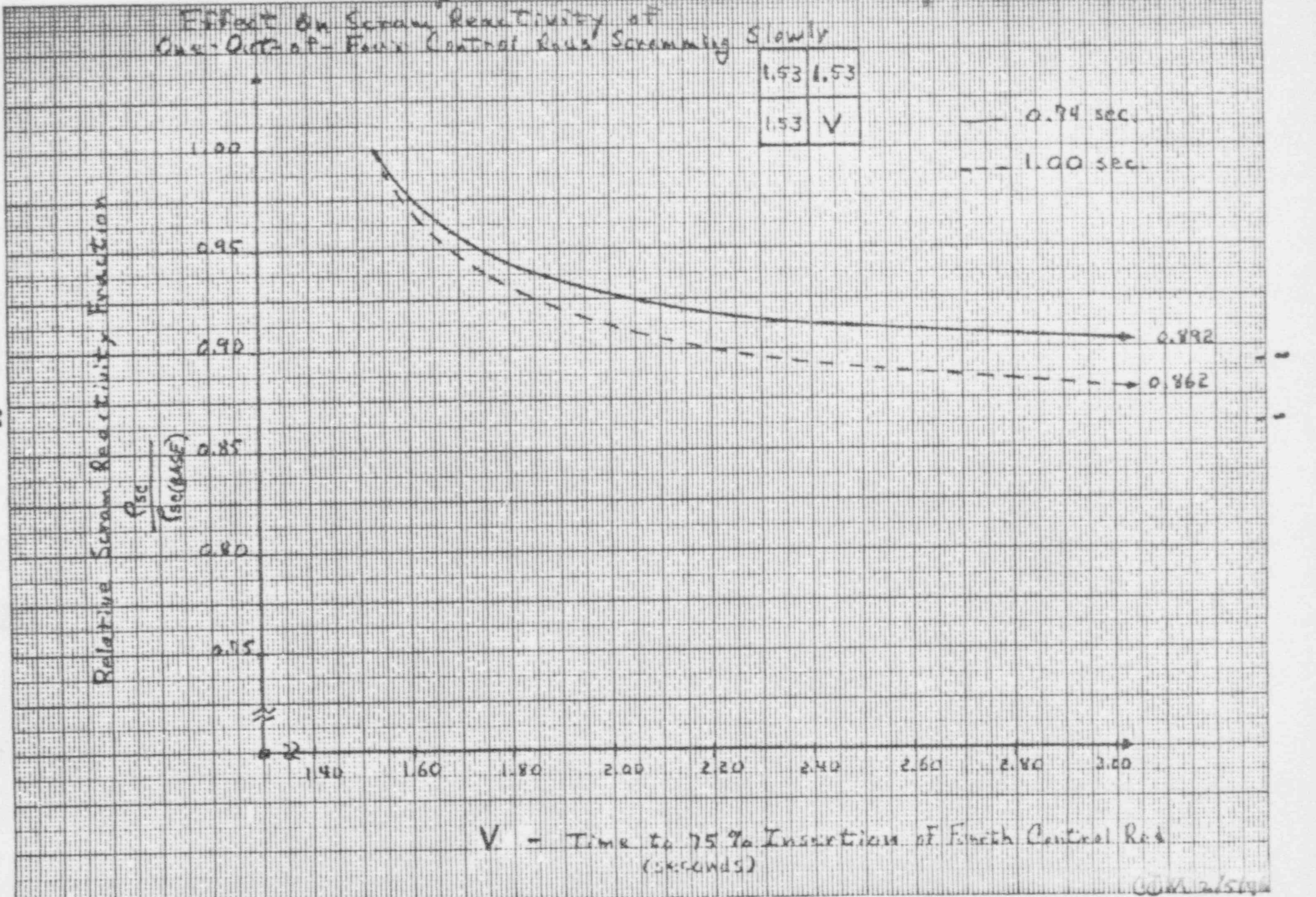
First, the limiting control rod velocity distribution must be determined if no slow or inoperable control rods are present. For this case, all of the control rods in the core are scrammed at the same speed. (This was previously determined as the velocity distribution which inserts minimum reactivity while maintaining the average control rod speed in the core.) Since the NRC requires that the highest worth control rod is assumed to fail, the highest worth control rod (generally the center control rod) should not be scrammed in this calculation. By iterating on control rod speed, the limiting value of the MAEIT which just provides the required scram reactivity response may be found. Figure 13 illustrates the control rod speed distribution in a 764 size core for this case. All blank control rods scram at same rate defined by the MAEIT. The failed rod, F, does not scram at all.

The next step is to determine MAEIT values for various numbers of slow clump and inoperable control rods. This requires placing the slow clump and inoperable control rods in the closest packed, limiting distribution while still satisfying the separation requirements. The slow clump and inoperable control rods are not allowed to scram at all, as well as the additional failed control rod. The other normal control rods all scram at the same speed defined by the MAEIT value. Figures 14-33 illustrate the limiting distributions for a 764 size core. Both zero

and one partially inserted stuck inoperable rod cases are shown since the existence of a stuck rod changes the limiting distribution of slow clump and inoperable rods. Scram calculations are run for each case shown in Figures 14-33 to determine the limiting values of the MAEIT's. Sample GEBSCRAM input files for several of the calculations are shown in Figures 34-36.

Some additional conservatism is introduced into the MAEIT values by assuming that the slow clump control rods do not scram at all. To determine the amount of conservatism, an investigation of how slow control rod scram speed affected scram reactivity was performed. A core of uniform 2x2 control rod cells was set up with three of each four control rods scramming at the same constant speed. The speed of the fourth control rod was then varied from the same speed of the other control rods until the slow rod did not insert at all. The resulting changes in scram reactivity at 0.74 and 1.0 seconds are shown in Figure 12. The results show that the amount of scram reactivity decreases rapidly as the fourth control rod just becomes slower than the other three control rods. For example, 50% of the scram worth of the fourth control rod is lost if the control rod slowed down by ~ 0.20 seconds with respect to the EIT of the other three control rods (EIT's = 1.53 seconds). This rapid decrease means that a slow control rod does not have to slow down very much to have a major effect on the resultant scram reactivity in the time frame of interest (i.e., less than 1 second). Therefore, little conservatism is actually added by assuming that the slow clump control rods do not scram since slow clump control rods will already have a relatively slow insertion speed.

Figure 12



Effect On Scram Reactivity of
One-Out-of-Four Control Rods Scramming Slowly
1.53
1.53
1.53
V
0.74 sec.
1.00 sec.
1.00
0.95
0.90
0.85
0.80
0.75
Relative Scram Reactivity Fraction
1.40
1.60
1.80
2.00
2.20
2.40
2.60
2.80
3.00
0.892
0.862
V - Time to 75 % Insertion of Fourth Control Rod
(seconds)

Figure 13

No Inop. or Slow Rods
1 Extra Failed Rod

(Reference Configuration)

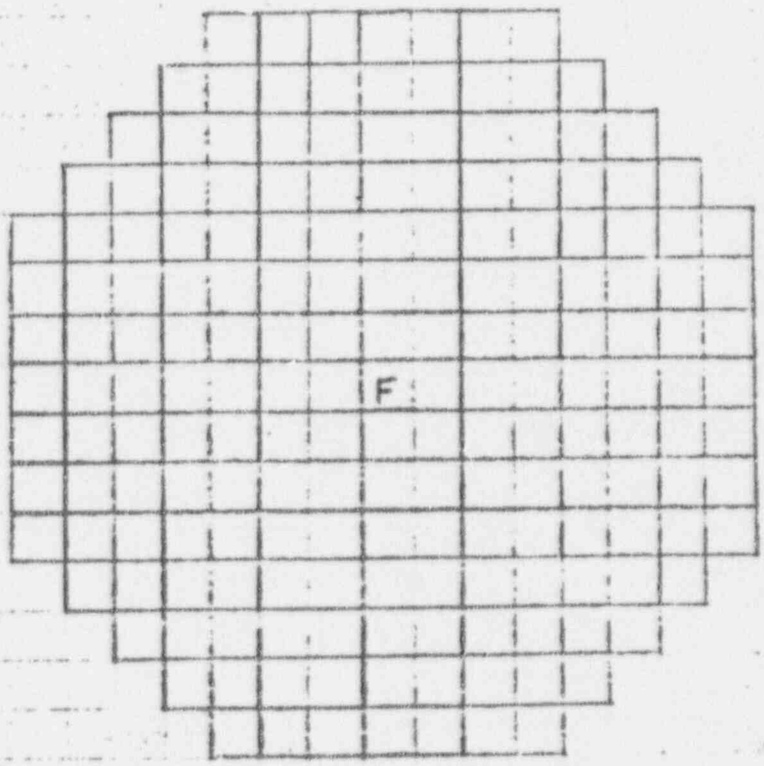
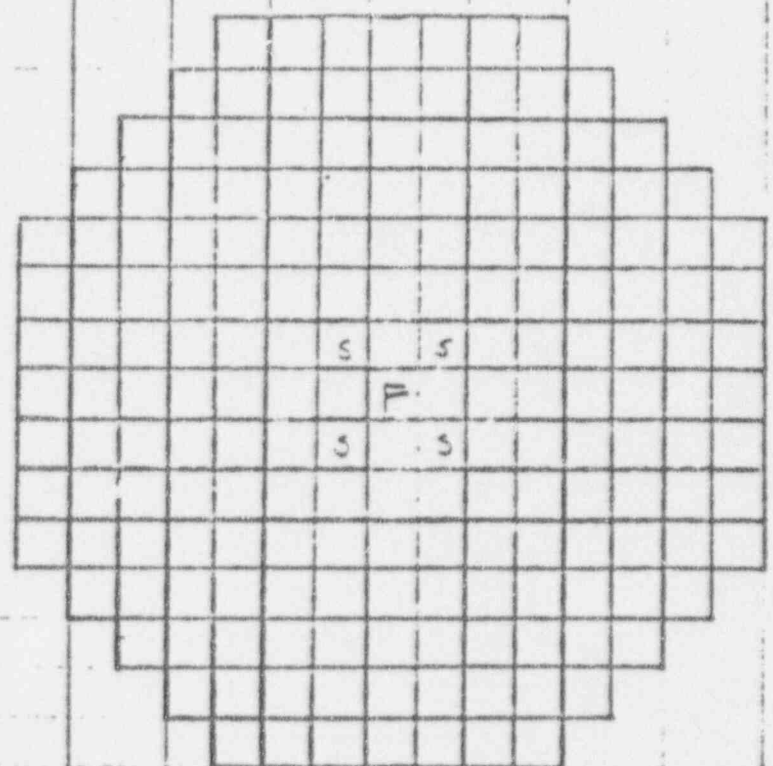


Figure 14

No Inop Rods - 1 Extra Failed Rod
4 Slow Rods - 1 Cell Separation

Configuration 1



S ⇒ Slow Clump Rod
F ⇒ Additional Failed Rod (Highest Worth)
I ⇒ Inoperable Rod Stuck Fully Withdrawn
I^{20} ⇒ Inoperable Rod Stuck at Notch 20

Figure 15

No Inop Rods - 1 Extra Failed Rod
8 Slow Rods - 1 Cell Separation

Configuration 1

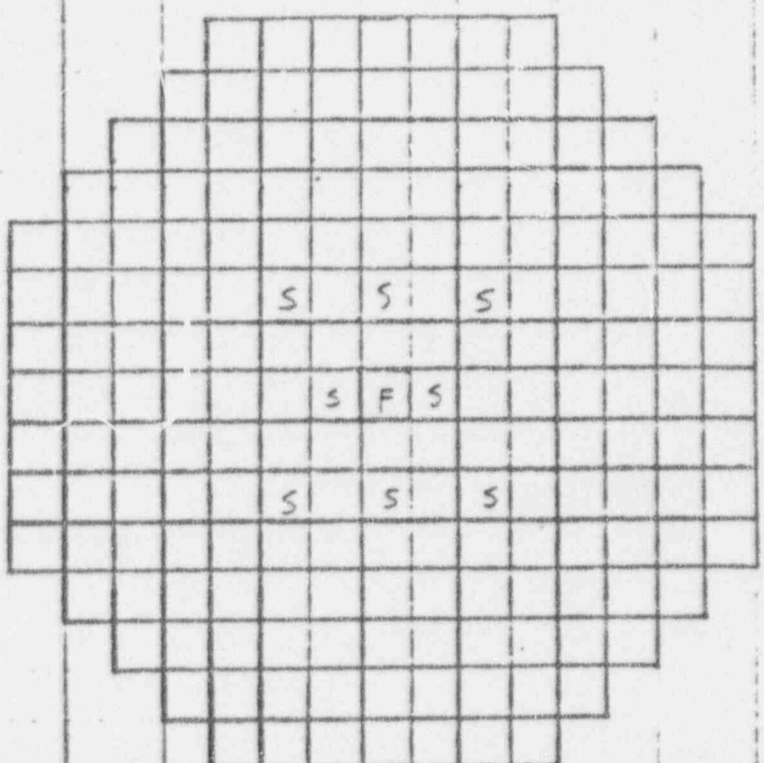


Figure 16

2 Inop. Rods
1 Extra Failed Rod

Configuration 1

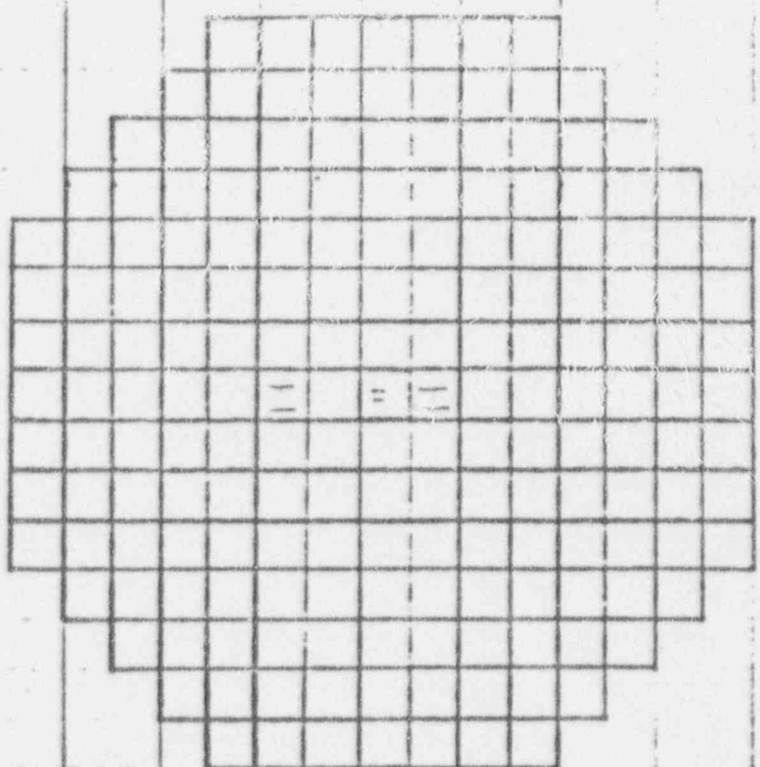


Figure 17

2 Inop. Rods
1 Extra Failed Rod
4 Slow Rods (1 Cell Sep.)

Configuration 2

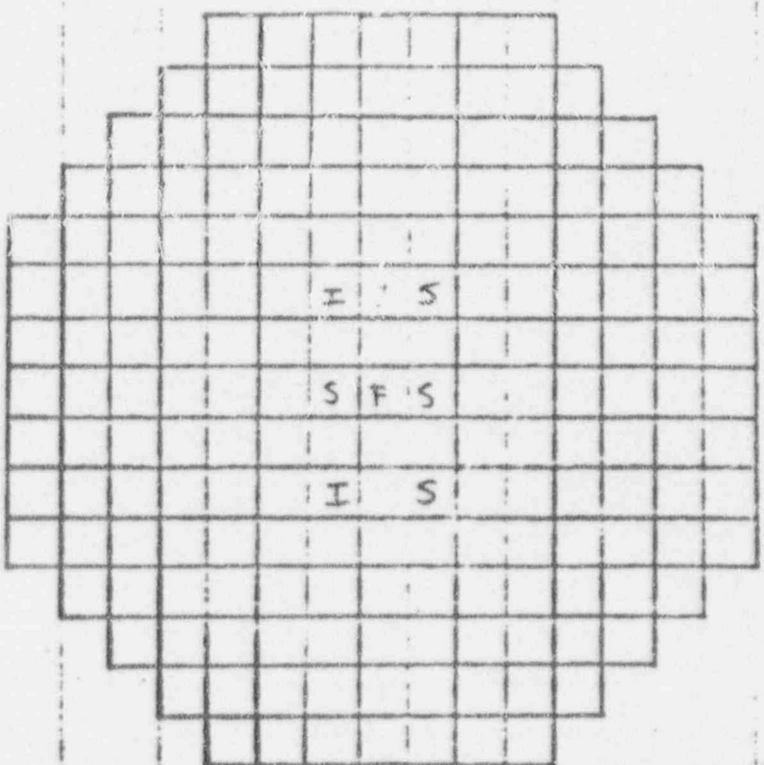


Figure 18

2 Inop. Rods
1 Extra Failed Rod
8 Slow Rods - (1 Cell Sep.)

Configuration 1

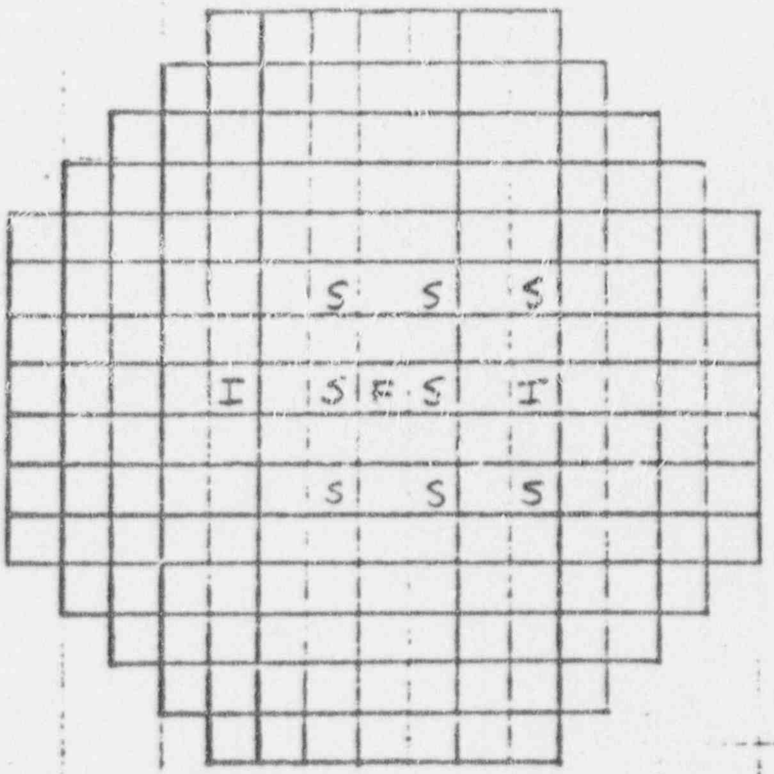


FIGURE 19

2 Inop. Rods - 1 Stuck at Notch 20
1 Extra Failed Rod

Configuration 4

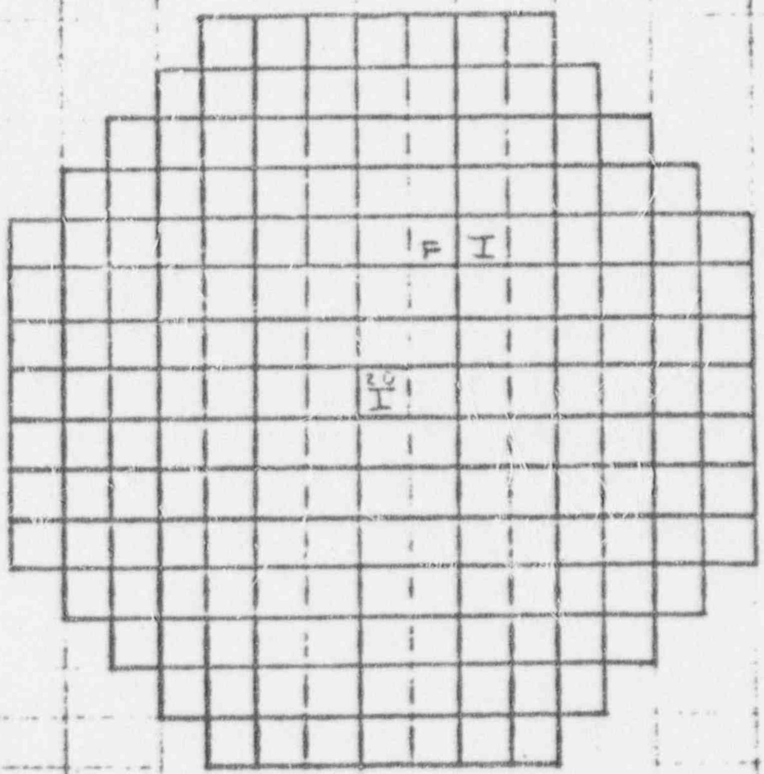


FIGURE 20

2 Inop Rods - 1 Stuck at Notch 20
1 Extra Failed Rod - 4 Slow (1 Cell Rep)

Configuration 2

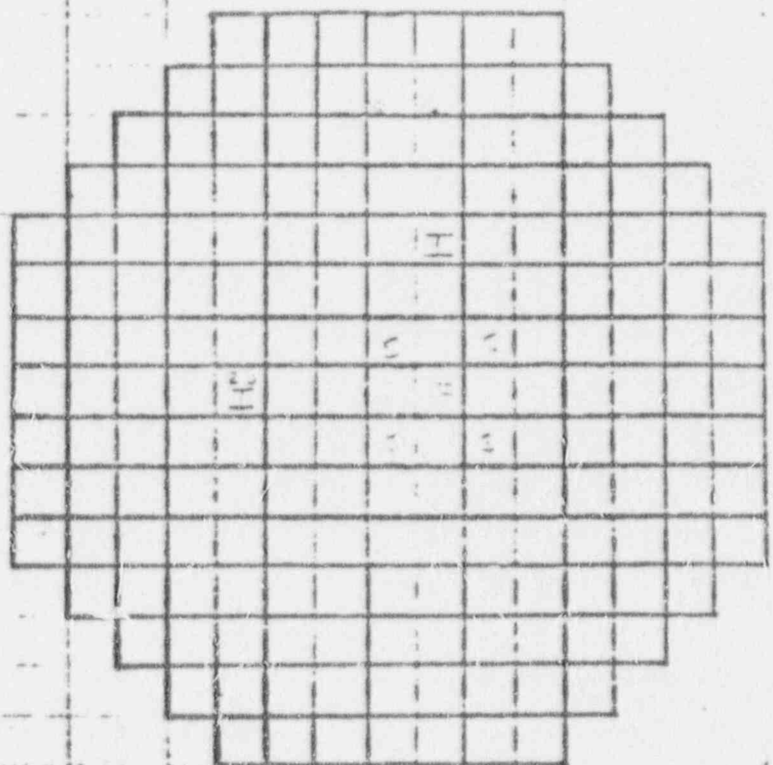


Figure 21

2 Inop. Rods - 1 Stuck at Notch 20
1 Extra Failed Rod - 8 Slow (1 Cell Sep.)

Configuration 1

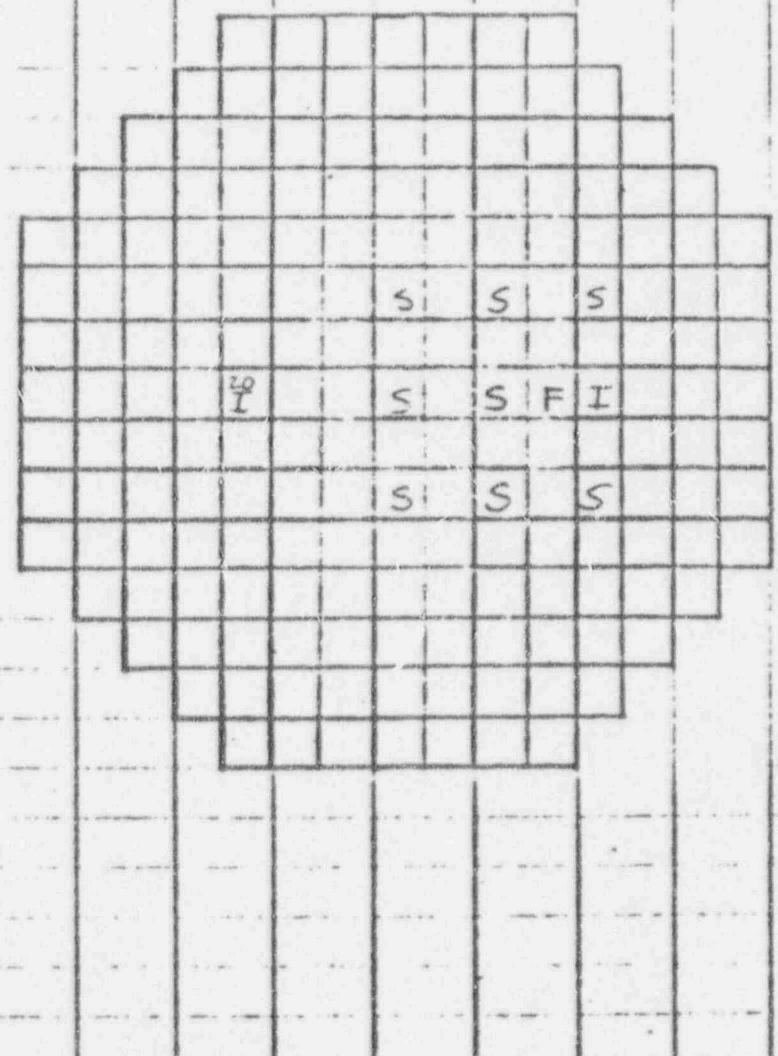


FIGURE 22

5 Inop.
1 Extra Failed

Configuration 1

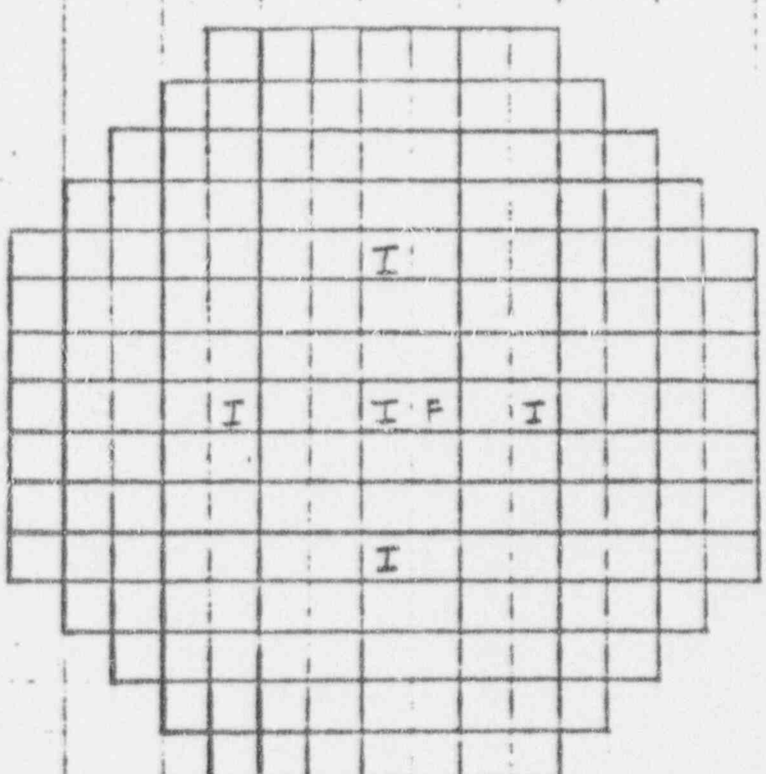


FIGURE 23

5 Inop. Rods
1 Extra Failed
4 Slow (1 Cell Sep.)

Configuration 2

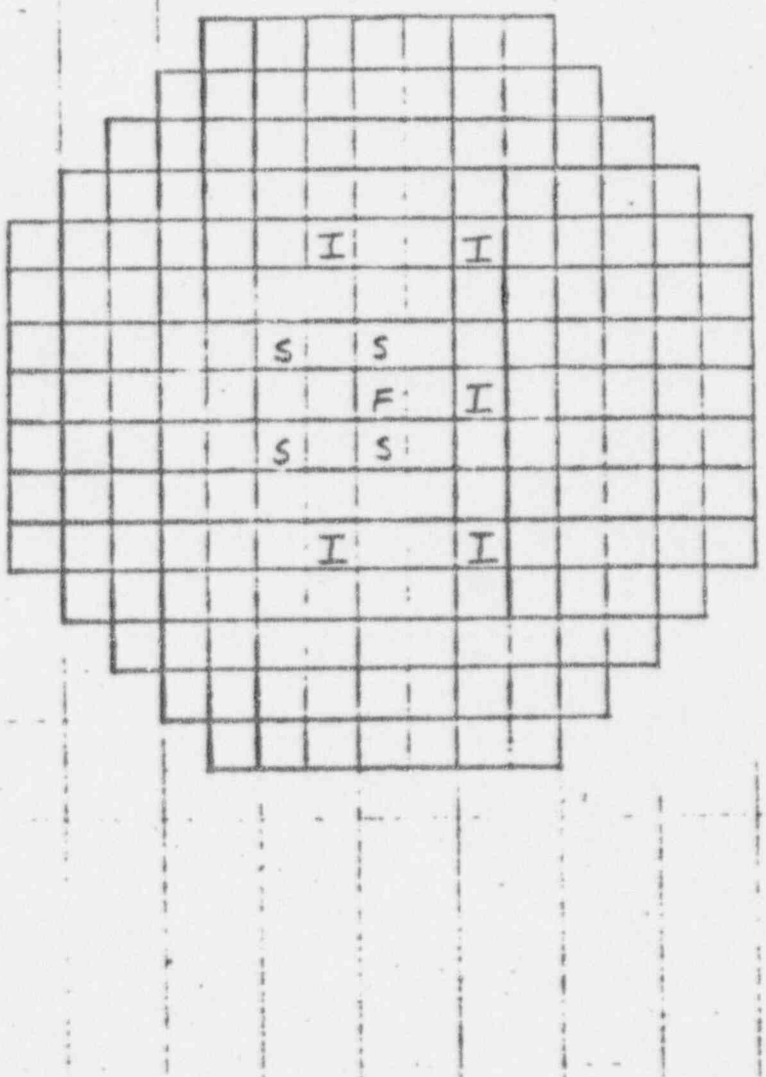


FIGURE 24

5 Inop.
1 Extra Failed
8 Slow (1 Cell Sep.)

Configuration 1

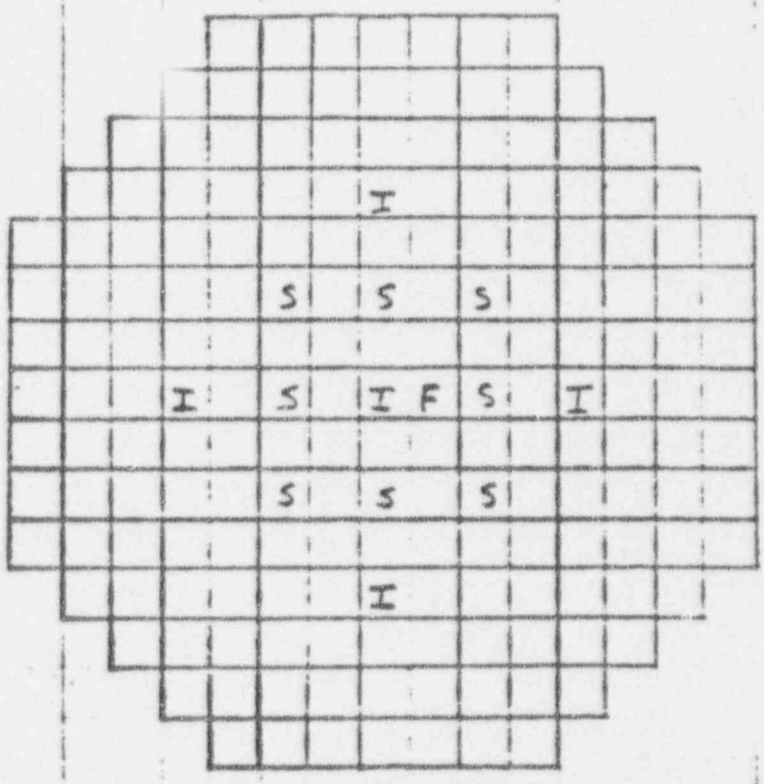


FIGURE 25

5 Inop Rods - 1 Stuck at Notch 20
1 Extra Failed Rod

Configuration 3

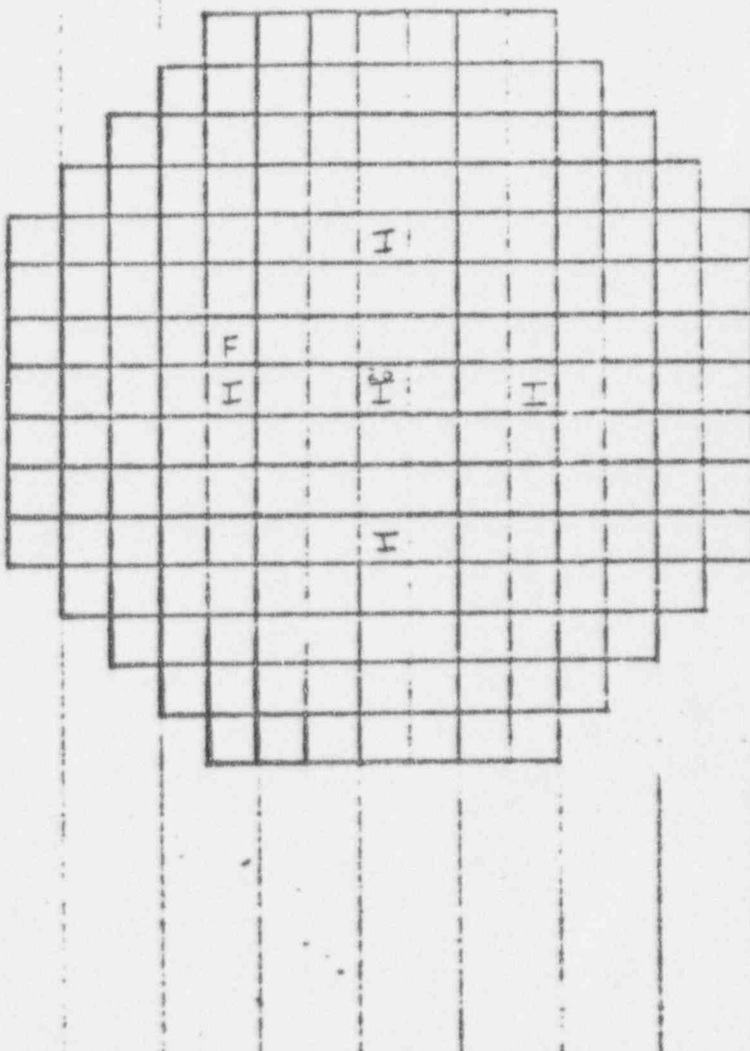


FIGURE 26

5 (6) Inop Rods - 1 Stuck at Notch 20
1 Extra Rod Failed - 4 Slow - 1 Cell Sep.

Configuration 1

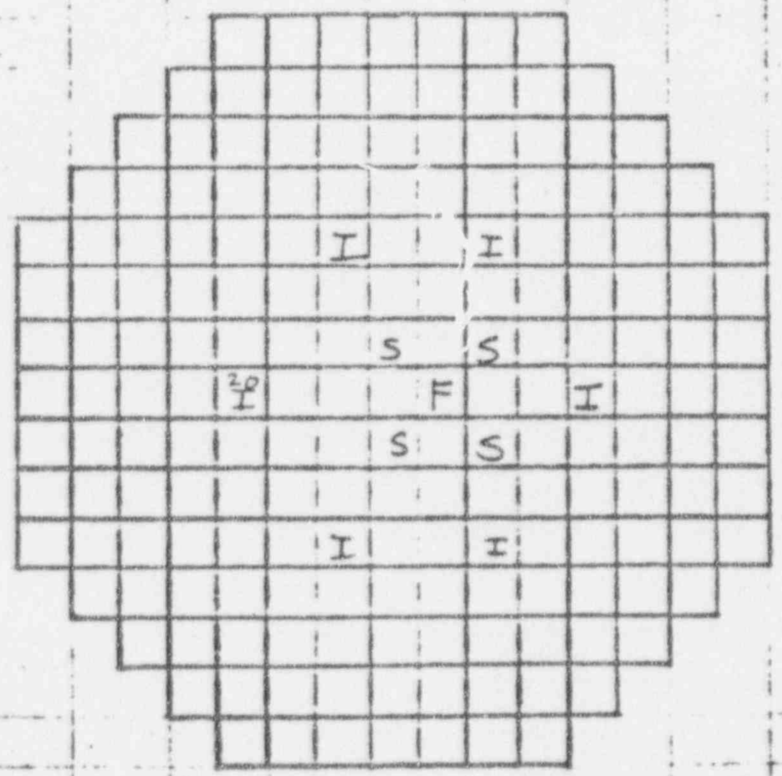


FIGURE 27

5 Inop. Rods - 1 Stuck at Notch 20
1 Extra Failed Rod - 8 Slow Rods (1 Fail Sep)

Configuration 1

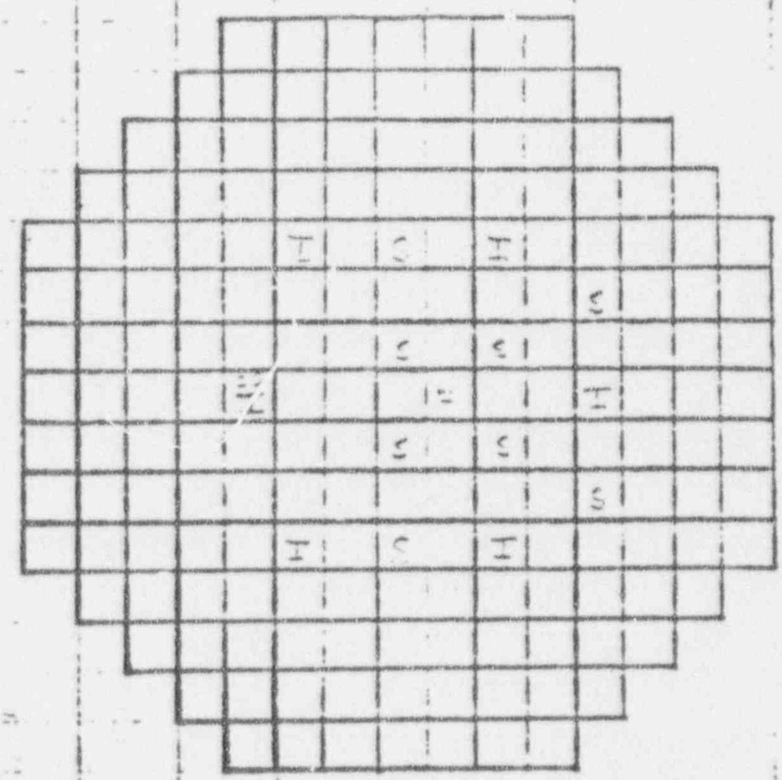


FIGURE 28

9 Inop. Rods
1 Extra Failed

Configuration 1

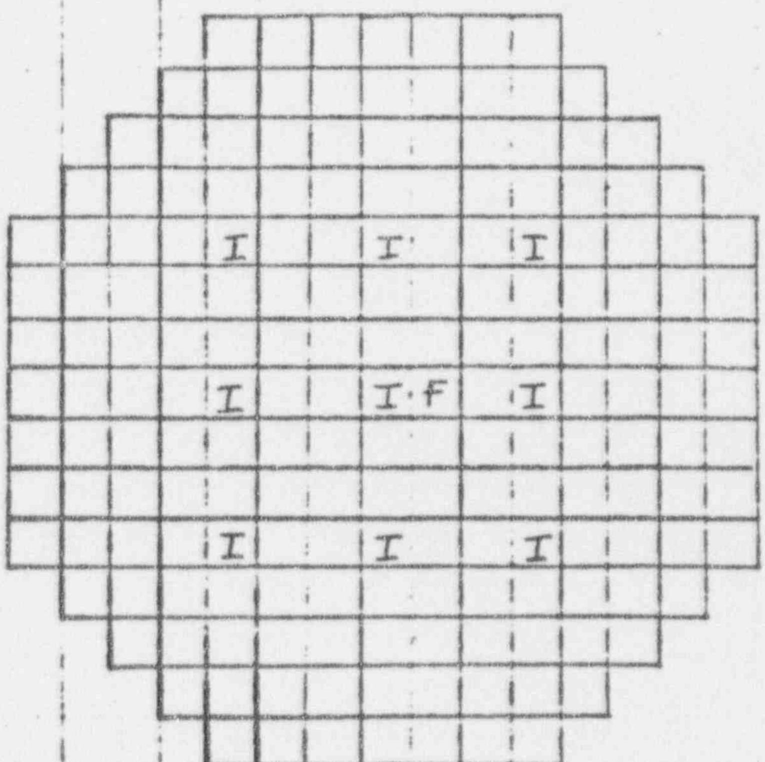


Figure 29

9 Inop.
1 Extra Failed
4 Slow (1 Cell Sep.)

Configuration 1

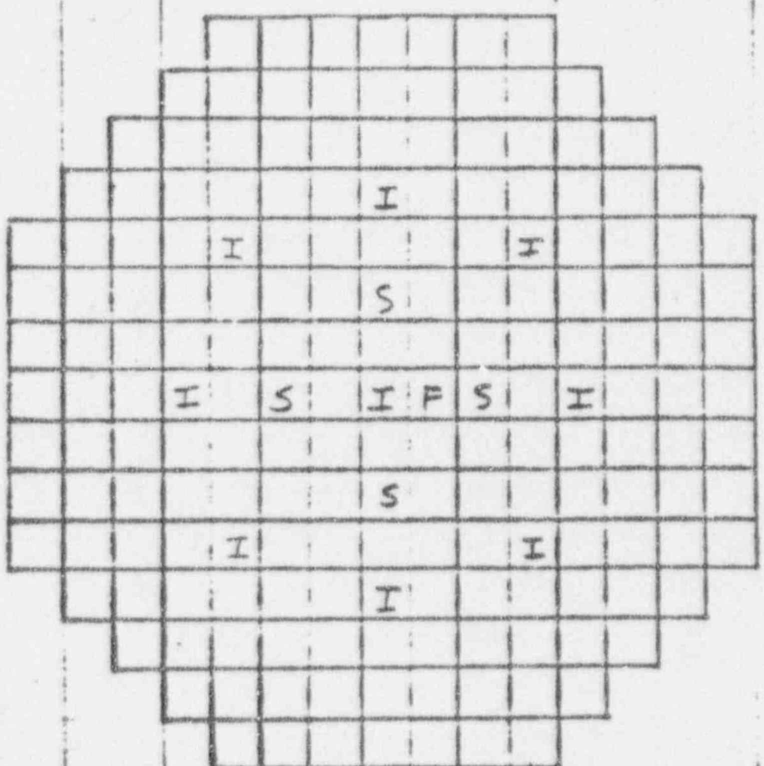


Figure 30

9 Inop.
1 Extra Failed
8 Slow (1 Cell Sep.)

Configuration 1

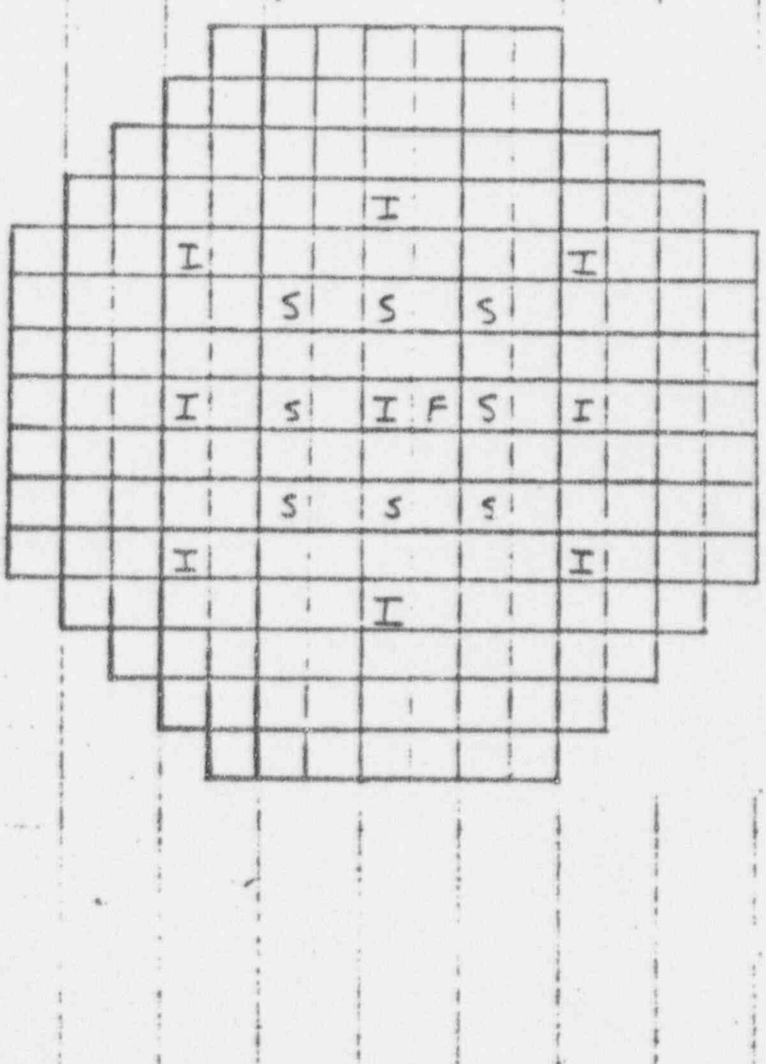


FIGURE 31

9 Inop Rods - 1 Stuck at Notch 20
1 Extra Failed Rod

Configuration 3

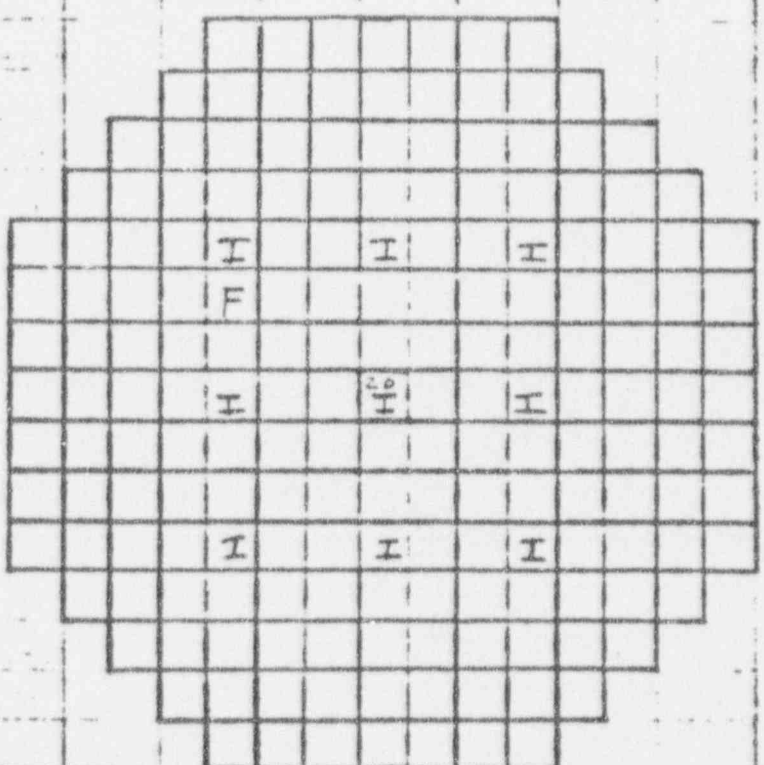


Figure 32

9 Inop Rods - 1 Stuck at Notch 20
1 Extra Failed Rod - 4 Slow Rods (1 Cell Separation)

Configuration 1

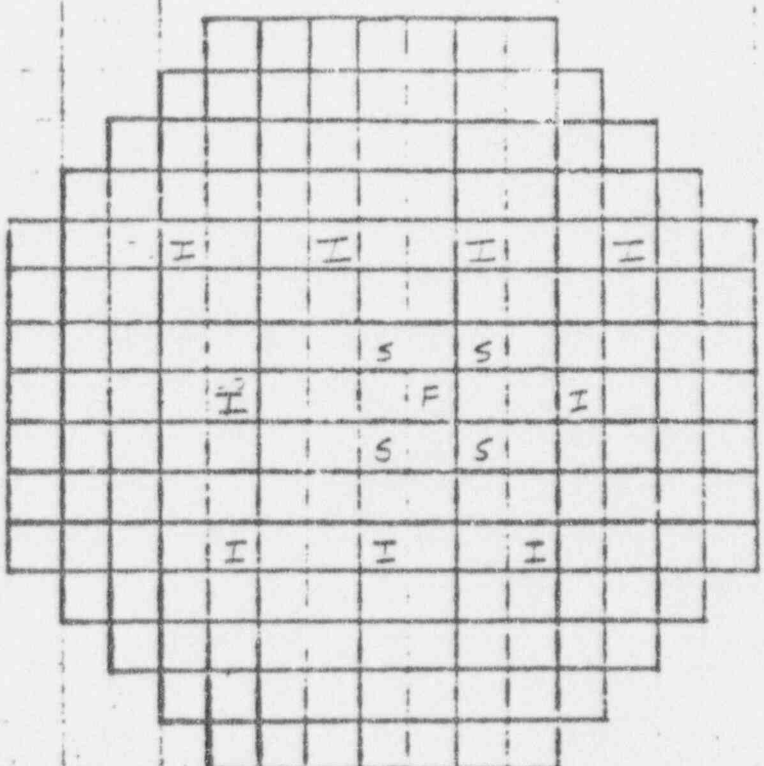
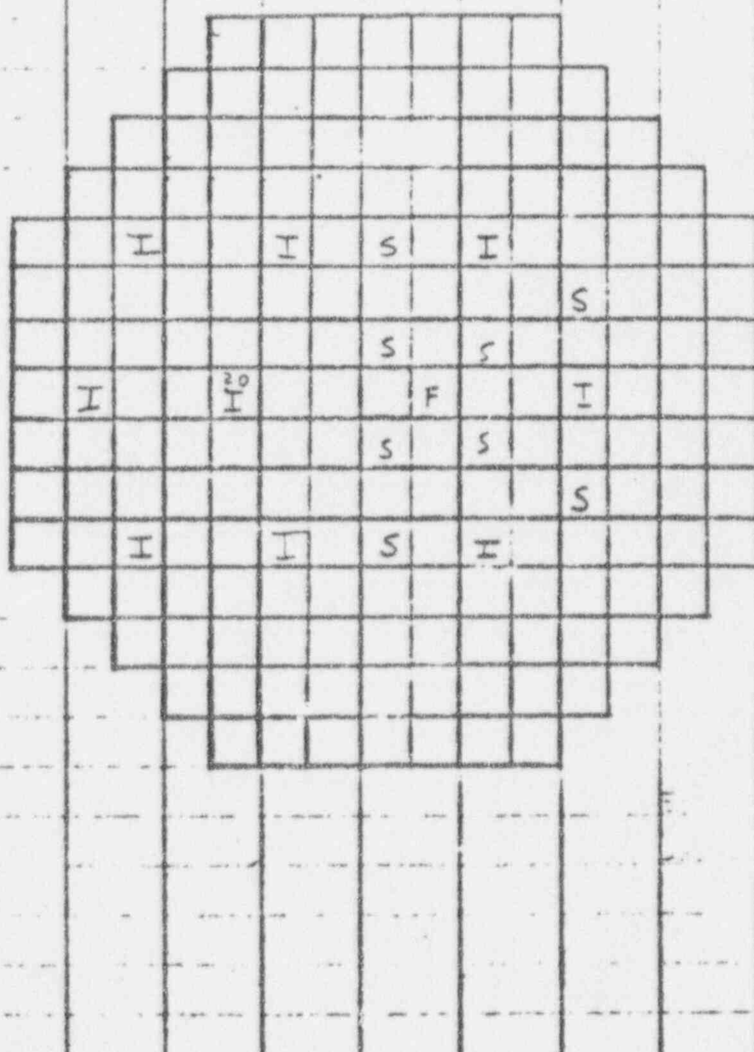


Figure 33

9 Inop Rods - 1 Stuck at Notch 20
1 Extra Failed Rod - 8 Slow Rods (1 Cell Separatio)

Configuration I



03/30/76   16.83

GEBSCRAM Input For Figure 16

```
10##STRIP,POUT(29) %,8,16,79
20$%IDENT%N958,CCM-TTT13,GEBSCRAM% 2
25$%USERID%FS0263$SIUYA
3  :SELECT%PANAC02
40$%LIMITS%50,43K
70$%PRMFL%20,R/W,R,FS0263/FEM2WRP
80)FERMI-2(80)HALING SCRAM*2 INOP/0SLOW(1)/1 EXTRA FAILED C.A.=1.61  C.1
81   IBOUN=2  IRN=1    (HALF CORE:MIRROR SYMMETRY)
81     RESTFC=20
90  IDREST="FEM2HALOKDV"
100  NITER=9
110  $$
120  NOTL=0  EDIT(35)=0
130  NSMAX=100  RSTART=1
140  LMAX=999
150  EPS5=.001
160  EPSI=.004
170  EDIT(90)=1
180  TLCON(17,1*)=1.0831 R6
190  DELTE=0.0  NCYOPT=1
200  IEXFLX=2  NDLAYS=6  OMEG=0.75
210  TIMEOS=0.0
220  TSTOPS=0.99
540  IFT(1,3)=2 R24
550  IFT(1,4)=5 R4 6 R7 5 R11 2 R2
570   IFRODS(1,1)=1 7
580   IFRODS(1,2)=3 5
590   IFRODS(1,3)=5 3
600   IFRODS(1,4)=7 1
6    IFRODS(1,5)=11 15
62   IFRODS(1,6)=15 15
630  IFRODS(1,7)=17 15
660  IFRODS(1,8)=23 1
670  IFRODS(1,9)=25 3
680  IFRODS(1,10)=27 5
690  IFRODS(1,11)=29 7
700  SIFT(1,1)=0.0 0.1 0.1371 0.2097 0.3150 0.4919 0.6768 0.8686
710  SIFT(9,1)=1.0684 1.2781 1.4967 1.6100 2.1397 1000.0
720  SIFT(1,2)=0.0 0.0 0.01 0.05 .1 .2 .3 .4 .5 .6 .7 .75 1.0 1.0
730  SIFT(1,3)=0.0 1000.0
740  SIFT(1,4)=0.0 0.0
560$%SELECTA%FS0263/FERLBNC2
1695$       SELECTA FS0263/FERLBNC3
1700  $$
1708)LAST
1709$%ENDJOB

READY

*RUN
  SNUMB # 8170T
LINE TRUNCATED, PROCESSING CONTINUED-20$%IDENT%N958,CCM-TTT13,GEBSCRAM% 2
```

03/24/76   16.10   Figure 38

GEBSCRAM Input For Figure 21

```
*
10##STRIP,ROUT(25) ",3,16,72
20$%IDENT%495%,CC -TTT13,GEBSCRAM% W
25$%USERID%FS0263$SIUYA
26$%SELECT%BOSK-02
27$%TAPE9%IN,XID,,22730
28$%FILE%OT,X20S,150R
29 22730: FE"2R0D9+15
30$%SELECT%PA.AC02
40$%LIMITS%80,48K
70$%FILE%20,20R
80)FERMI-2(30)*2 INOP/1 STUCK(20)/1 EXTRA FAILED/8 SLOW(1) CA=1.56 CONF.1
81  ISOUN=2  IMD=1  (0=FULL,1=1/4,2=1/2 ;  0=0,1=MIRROR,2=ROTAT.)
81      RESTRC=20
90  IDRRST="FE"2R0D9+15"
100  NITER=9
110  SS
120  NOTL=0  EDIT(35)=0
130  NSTAX=100  NSTART=1
140  LMAX=999
150  EPSS=.001
160  EPSI=.004
170  EDIT(99)=1
180  TLCON(17,1*)=1.0831 R6
190  DELTE=0.0  NCYOPT=1
200  IEXFLX=2  NDLAYS=6  OMEG=0.75
210  TIMEOS=0.0
220  TSTOPS=0.99
540  IFI(1,3)=2 R24
550  IFI(1,4)=5 R4 6 R7 5 R11 2 R2
570   IFRODS(1,1)=1 7
580   IFRODS(1,2)=3 5
590   IFRODS(1,3)=5 3
600   IFRODS(1,4)=7 1
610  IFRODS(1,5)=23 1
620  IFRODS(1,6)=25 3
630  IFRODS(1,7)=27 5
640  IFRODS(1,8)=29 7
650  IFRODS(1,9)=15 11
660  IFRODS(1,10)=19 11
670  IFRODS(1,11)=23 11
680  IFRODS(1,12)=9 15
690  IFRODS(1,13)=15 15
691  IFRODS(1,14)=19 15
692  IFRODS(1,15)=21 15
693  IFRODS(1,16)=23 15
700  SIFI(1,1)=0.0 0.0 0.1329 0.2032 0.3953 0.4757 0.5558 0.8416
710  SIFI(9,1)=1.0352 1.2384 1.4502 1.5000 2.0733 1000.0
720  SIFI(1,2)=0.0 0.0 0.01 0.05 .1 .2 .3 .4 .5 .6 .7 .75 1.0 1.0
730  SIFI(1,3)=0.0 1000.0
740  SIFI(1,4)=0.0 0.7
900$%SELECTA%FS0263/FERLBNC2
1095$        SELECTA FS0263/FERLBNC3
1700  SS
1708)LAST
1709$%ENDJOB

ready

*RYMO.. # 302/t
```

GEBSCRAM Input for Figure 33

```
10##STRIP.ROUT.20) %.8.16.79
20$*.IDENT*.N958.CCM-TTT13.GEBSCRAM% 2
25$%USERID*.FS0263$SIUYA
26$*.SELECT*.BOIK-02
27$*.TAPE9*.IN.X1D..22730
  *.FILE*.OT.X20S.150R
2? 22730: FEM2ROD9+15
30$*.SELECT*.RANAC02
40$*.LIMITS*.80.43K
70$*.FILE*.20.X20R
80)FERMI-2(90)+9 INOP/1 STUCK(20)/1 EXTRA FAILED/8 SLOW(1) CA=1.55 CONF.1
81  IBOUN=2  IRN=1  (0=FULL.1=1/4.2=1/2 ;  0=0.1=MIRROR.2=ROTAT.)
81      RESTRC=20
90  IDRESIT="FEM2ROD9+15"
100  NITER=9
110  $$
120  NOTL=0  EDIT(35)=0
130  NSMAX=100  RSTART=1
140  LMAX=999
150  EPS5=.001
160  EPSI=.004
170  EDIT(90)=1
180  TLCON(17.1*)=1.0831 R6
190  DELTE=0.0  NCYOPT=1
200  IFXFLX=2  NDLAYS=6  OMEG=0.75
210  TIMEOS=0.0
220  TSTOPS=0.99
540  IFT(1.3)=2 R24
550  IFT(1.4)=5 R4 6 R7 5 R11 2 R2
570   IFRODS(1.1)=1 7
580   IFRODS(1.2)=3 5
5     IFRODS(1.3)=5 3
      IFRODS(1.4)=7 1
610  IFRODS(1.5)=23 1
620  IFRODS(1.6)=25 3
630  IFRODS(1.7)=27 5
640  IFRODS(1.8)=29 7
650  IFRODS(1.9)=5 9
660  IFRODS(1.10)=11 9
670  IFRODS(1.11)=15 9
680  IFRODS(1.12)=19 9
690  IFRODS(1.13)=23 11
691  IFRODS(1.14)=15 13
692  IFRODS(1.15)=19 13
693  IFRODS(1.16)=3 15
694  IFRODS(1.17)=9 15
695  IFRODS(1.18)=17 15
696  IFRODS(1.19)=23 15
700  SIFT(1.1)=0.0 0.1 0.1320 0.2019 0.3033 0.4736 0.6516 0.8362
710  SIFT(9.1)=1.0285 1.2304 1.4409 1.5500 2.0600 1000.0
720  SIFT(1.2)=0.0 0.0 0.01 0.05/.1 .2 .3 .4 .5 .6 .7 .75 1.0 1.0
730  SIFT(1.3)=0.0 1000.0
740  SIFT(1.4)=0.0 0.0
560$%SELECTA%FS0263/FERLBNC2
1695$        SELECTA FS0263/FERLBNC3
1700  $$
1708)LAST
17??$%ENDJOB

READY 7999 T

*EDIT
READY
VERI
----
```

ENCLOSURE 3

BRUNSWICK STEAM ELECTRIC PLANT, UNIT 1 AND 2
NRC DOCKETS 50-325 & 50-324
OPERATING LICENSES DPR-71 & DPR-62
REQUEST FOR LICENSE AMENDMENTS
CONTROL ROD DRIVE SCRAM ACCUMULATORS

LIST OF REGULATORY COMMITMENTS

The following table identifies those actions committed to by Carolina Power & Light Company in this document. Any other actions discussed in the submittal represent intended or planned actions by Carolina Power & Light Company. They are described to the NRC for the NRC's information and are not regulatory commitments. Please notify the Manager-Regulatory Affairs at the Brunswick Nuclear Plant of any questions regarding this document or any associated regulatory commitments.

Commitment	Committed date or outage
NONE	NA