U. of Md. DRAFT REPORT ON 1969-1979 BWR PRECURSOR EVENT RE-EVALUATION USING BWR PLANT CLASS SPECIFIC EVENT TREES

DRAFT
11/18/83

1.0 Introduction

In the Accident Sequence Precursor (ASP) study it was assumed that a specific precursor event, mitigating system failure, or initiating event was applicable to all nuclear power plants. Further, two generic sets of standard event trees for PWR and BWR plants were developed and used in the analysis process. Finally, for each precursor, the conditional probability of subsequent core damage (Pscd) was calculated from the analysis of these generic trees and averaged by dividing it by the total number of reactor years.

Much concern has risen because of the generic approach taken in the ASP study, mainly due to the fact that not all precursors that occured in a specific plant can apply to every plant of the same type. Even it an event does apply to many plants the probability of subsequent core damage may vary in plants of the same type. Because of this concern, the study presented in this report was initiated. The objective of this study was to estimate the impact of using a more plant specific approach versus the ASP generic approach.

This study started with the calculation of more plant specific evaluations for the BWR's simply because there are fewer BWR's and a lesser number of precursors that occured in them. The next part of this study will, however, perform similar calculations for the PWR plants.

Ideally, the most appropriate approach would be to employ specific event trees for each of the BWR power plants, because there are no two plants that are similar in design, operation, or maintenance. Precursors that have happened in a plant which can potentially happen to other plants should then be identified and applied on the plant specific event trees. Finally, the frequency of the subsequent core damage for each percursor and for the specific

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factor of as high as 2 if the generic approach is used. Certain precursor events were, however, observed to have an over-estimation of more than an order of magnitude. In a few instances an underestimation of as high as an order of 4 by using the generic approach were seen.

The plant specific approach used in this study is a very straight forward one which models and estimates a more accurate representation of the precursor analysis than the generic approach used in the ASP report. We strongly recommend to implement this approach for further analysis of the precursors.

plants that they apply to, should be calculated. Summation of all of these frequencies would yield the estimate of average industry-wide frequency of core damage. The problem with this approach is first, that the development of plant specific event trees is a prohibitive task and is out of the scope of this study. Secondly, application of complete plant specific approach will severely limit the use of LER data in estimating probability of loss of safety systems and frequency of initiating events. The use of complete plant specific approach is also not necessary, because it was observed that there are groups of plants that respond closely to an initiating event or precursor. Therefore, one can group the plants into categories with close response.

To deal with the difficulty just stated above, in this study the BWR plants were grouped into categories that respond similarly to an initiating event. The methodology to categorize the plants are dicussed in detail in the next chapter. For each category a set of event trees for Loss of Offsite Power (LOOP), Loss of Feed Water Events (LOFW), Loss of Coolant Accidents (LOCA) and Main Steam Line Breaks (MSLB) initiating events were developed. The trees developed were based on the available PRA's of a specific plant in each category. A total of five categories were defined and one of the categories was divided into three subcategories.

In a review of all of the BWR precursors identified in the ASP study, applicability of each category or subcategory to these individual precursor was determined. Then, the loss of function probabilities and frequency of initiating events were calculated. Finally, frequency of core damage for individual precursors and for each category was calculated and the total frequency of core damage was obtained.

The results of this more plant specific calculation showed that the frequency of core damage can be over-estimated by a

2.0 BWR Categorization

2.1 Review of Procedure

A three step procedure has been used to divide the BWR plants into specific categories. In the first two steps, the major plant categories were generated. In the third step sub-categories for specific event situations were identified.

In step 1, each plant was examined to determine what systems it utilizes to perform the various generic plant functions which must be performed in response to any initiating event. These generic functions have been identified in many probabilistic risk assessment studies and methodology documents and referred to by many different names. In general, they can be summarized as follows:

- reactor subcriticality
- vessel water inventory
- short-term core heat removal
- containment overpressure protection
- long-term core heat removal
- containment heat removal
- radioactivity removal

Step 1 identified for each plant, those systems that the plant has to perform each of these functions. The initial plant categories were selected so that the plants whose systems are nominally identical were grouped. The plants with systems of the same type and function, without accounting for the differences in the design of those systems, were thus grouped.

In Step 2 these categories were refined by taking into account major differences in the design and operation of the plant systems identified in Step 1. There was a certain amount of subjectivity in this process, and the analyst must have the knowledge and experience to be able to judge what a major design difference is. This judgement is based not so much on the mechanical concept of difference in design, but rather is intended to be based on a probabilistic concept. A major design difference is one which would greatly affect the availability a system to perform its intended function. A great amount of insight is required to make this judgement, since all facets of a system's operation must be considered. The effect of system differences must consider recoverability and other human interactions as well as base unreliability. There is obviously no set rule which can be utilized for Step 2. By way of example however, such things as three pumps rather than two, or three-out-of-four as opposed to two-out-of-four operation are generally considered not major. However, such things as turbine pumps rather than motor driven pumps, or shutoff head greater than reactor operating pressure as opposed to less than reactor operating pressure are generally considered major. Even those examples cannot be used as hard and fast rules.

At the conclusion of Step 2, the major plant categories were established. These categories served to allow construction of event trees that were reasonable representations of the response to various initiators of the plants within each category and the evaluation of event sequences for most observed precursor events. There were, however, some specific events for which these groupings were not sufficiently unique. Since only a small number of events require this additional detail, it is not reasonable to further break up the categories for all cases. This would only serve to further dilute the available data base.

Step 3 is intended to develop sub-categories within each category which will be utilized only for those events which do not apply equally to all plants in a category. This development

PLANT NAME	BWR TYPE	FW PUMP TYPE	HPCI	RCIC	IC	FWCI	LPCI	RHR	SDC	EM.P	PLANT CATEGORY	REACTOR YEARS
Oyster Creek	2	M			X				X	D		
Big Rock Point	1	M			X				X	D	A1	21.5
Dresden 1	1	M			X	X			X	D		
Nine Mile Point	2	M			X	X			X	D	A2	21.0
Milestone 1	3	M			X	X	X		X	D/G		
Humbolt Bay 3	1	M			X	X	X		X	P	A3	20.5
Dresden 2	3	M	X		X		X		X	D	D	18.9
Dresden 3	3	M	X		X		X		X	D		
Pilgrim	3	M	X	X				X		D		
Monticello	3	M	X	X				X		D		
Quad Cities 1	3	M	X	X				X		D	C	46.02
Quad Cities 2	3	M	X	X				X		D		
Duane Arnold	4	M	X	X				X		D		
Vermont Yankee	4	M	X	X				X		D		
Cooper	4	T	X	X				X		D		
Browns Ferry 1	4	T	X	X				X		D		
Browns Ferry 2	4	T	X	X				X		D		
Browns Ferry 3	4	T	X	X				X		D		
Hatch 1	4	T	X	X				X		D	B	46.83
Hatch 2	4	T	X	X				X		D		
Fitzpatrick	4	T	X	X				X		D		
Brunswick 1	4	T	X	X				X		D		
Brunswick 2	4	T	X	X				X		D		
Peach Bottom 2	4	T	X	X				X		D		
Peach Bottom 3	4	T	X	X				X		D		
La Crosse										D	E	11.0

M = Motor Driven
T = Turbine Driven
D = Diesel Generator
G = Gas Turbine Generator
P = Propane Generator

Table 1
Summary of BWR Categories

is carried out by determining the plant specific applicability and response characteristics for each precursor event and each plant. In most cases, every plant in a category will be essentially identical in its response to a particular precursor. For those few precursors for which this is not true, sub-categories are created which are used only when evaluating sequences which include that particular event. For the evaluation of all other events, the major categories are left intact.

It is important to note that this categorization applies only to the deterministic aspects of event tree development. In many cases, data which may be used to quantify the event tree sequences must be applied in a different manner. Data for specific systems may span more than one category, whereas data for other systems may apply only to the plants in a specific category or subcategory.

2.2 Summary of Categories Identified

Table 1 summarizes the results of the categorization phase of the work. Twenty-six plants were considered and seven plant categories (A1, A2, A3, B, C, D, and E) were selected based upon presence or absence of the system functions as identified in the table.

In figures 1 to 6, the generic event trees for LOCA are presented for each category. Figures 7 to 11 and 12 to 17 present analogous trees for the LOFW and LOOP initiating events respectively. Figures 18 to 22 are loss of PCS initiating event.

In the remainder of this section major reasons for this categorization and a brief summary of specifications of each category or subcategory is discussed. In the next chapter the procedure in which the category generic event trees (shown in figures 1 through 17 in this chapter) are constructed from PRA plant specific event trees are discussed.

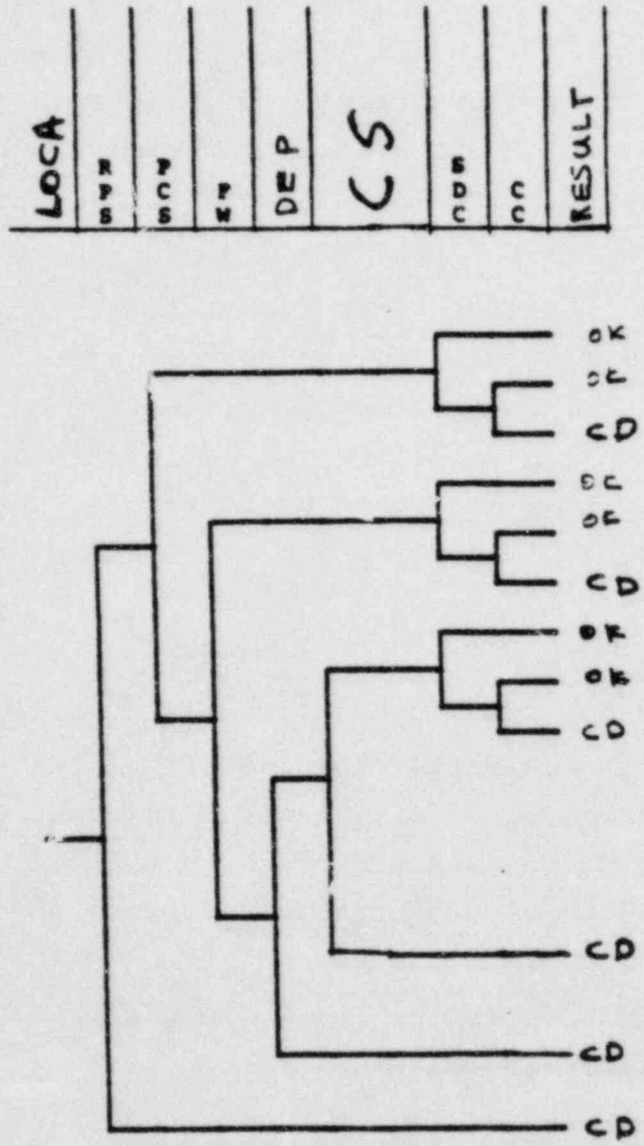

Figure 1 LOCA Event Tree
Categories A1 and A2

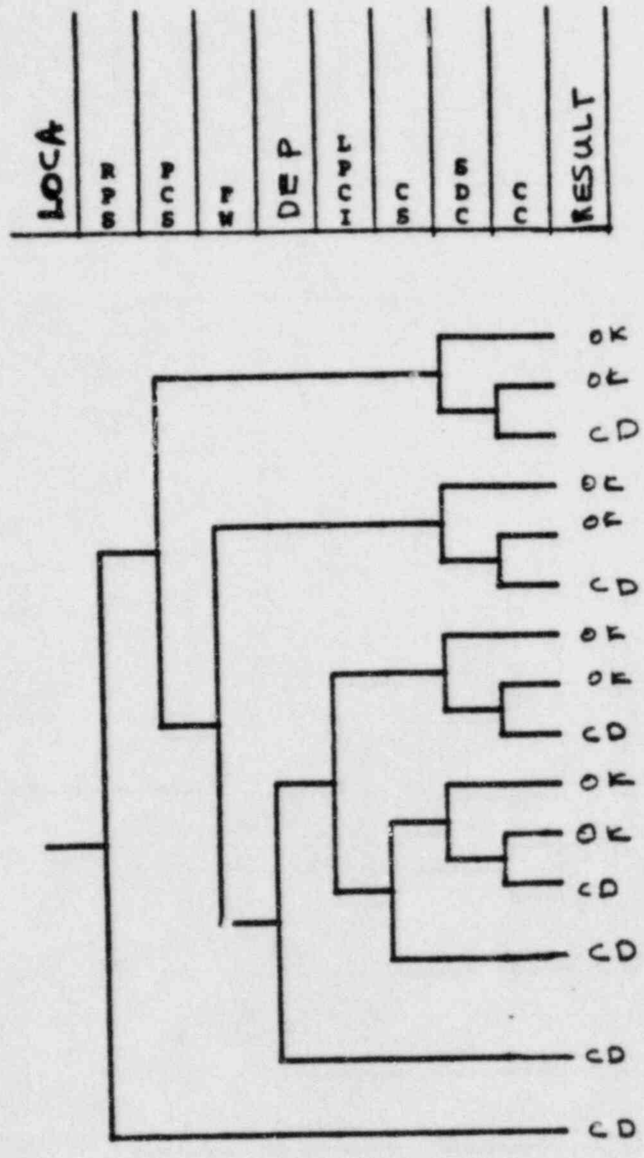

Figure 2 LOCA Event Tree
Category A3

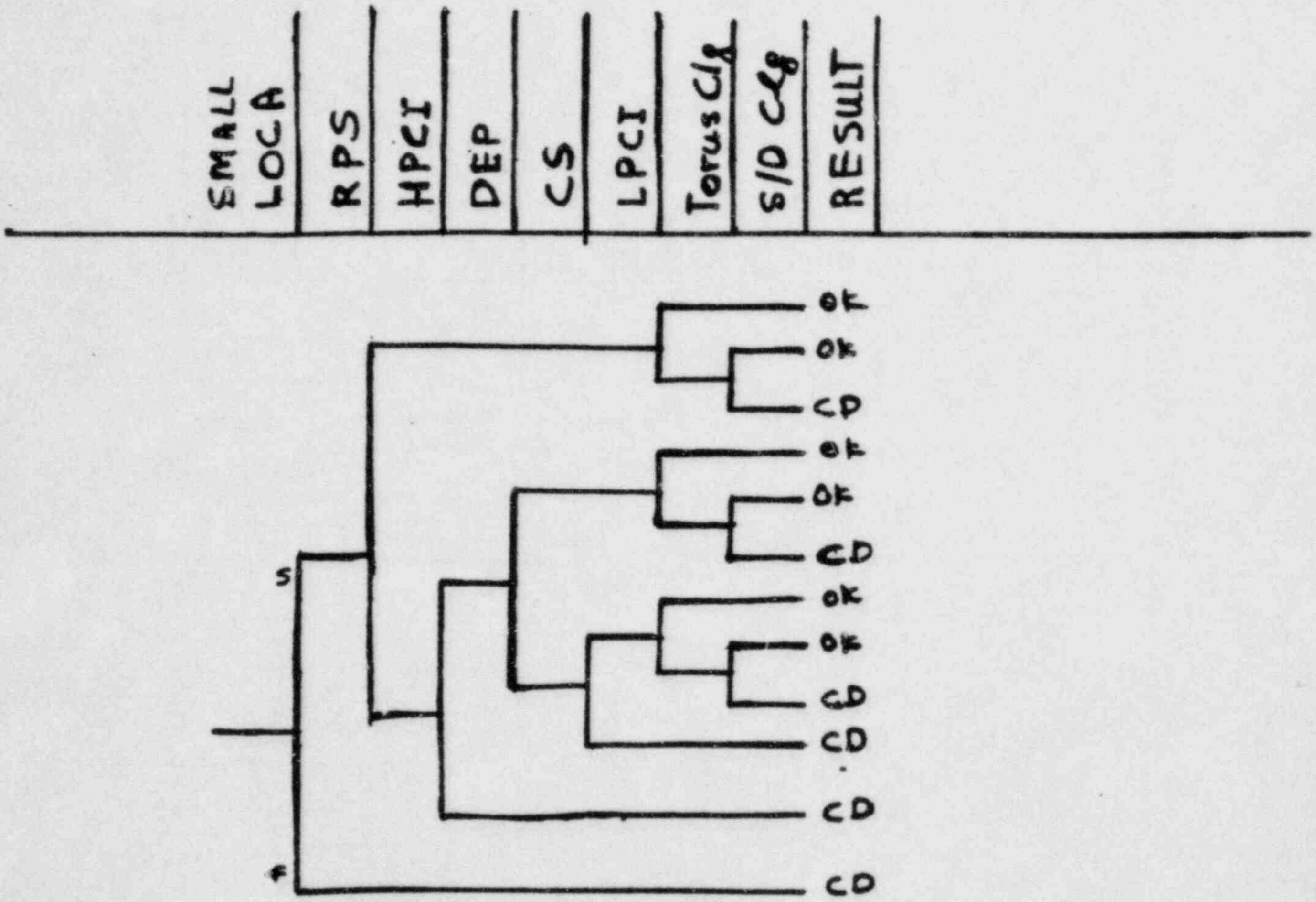

Figure 3: LOCA Event Tree

Category B

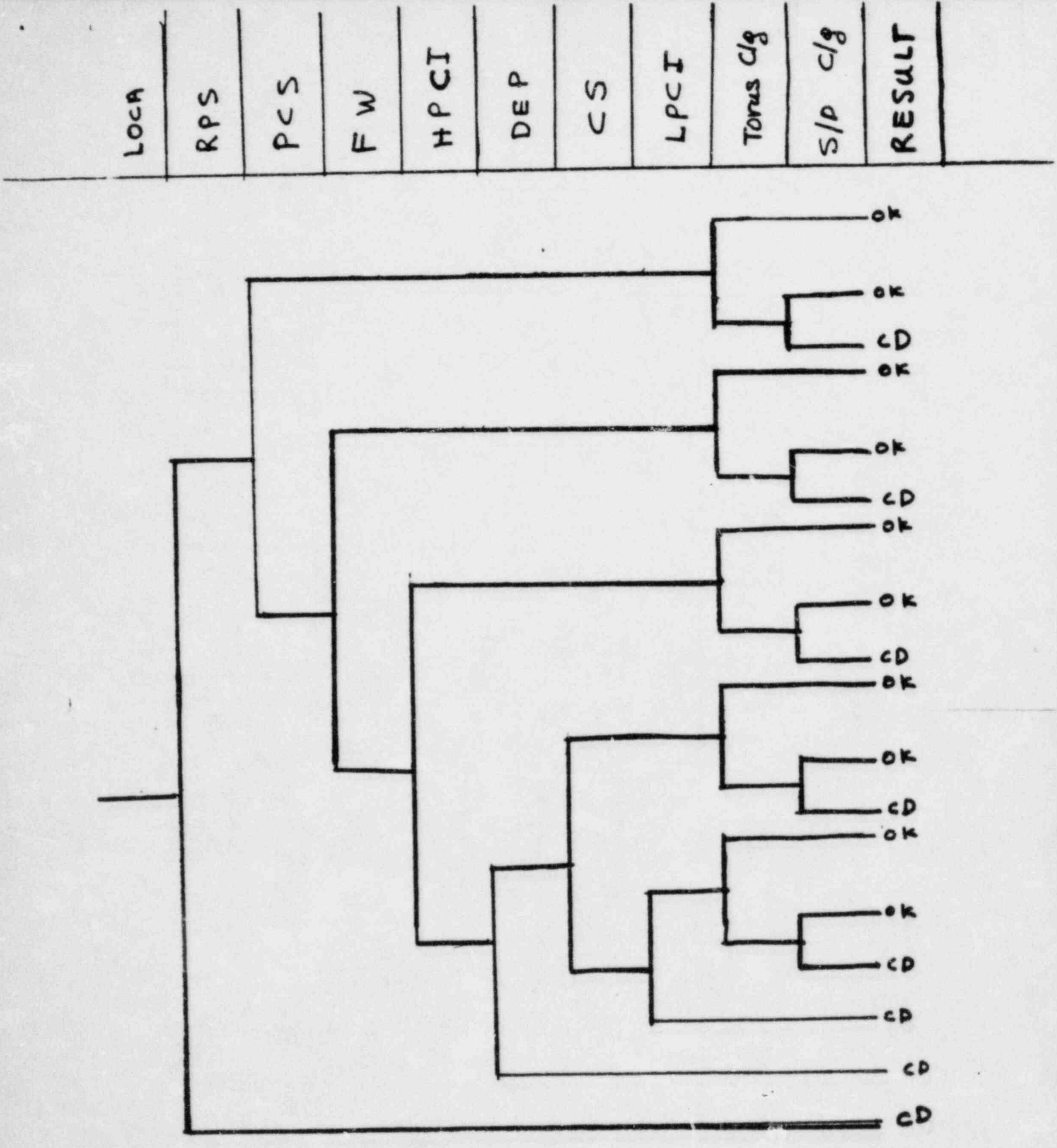

Figure 4 LOCA Event Tree
Category C

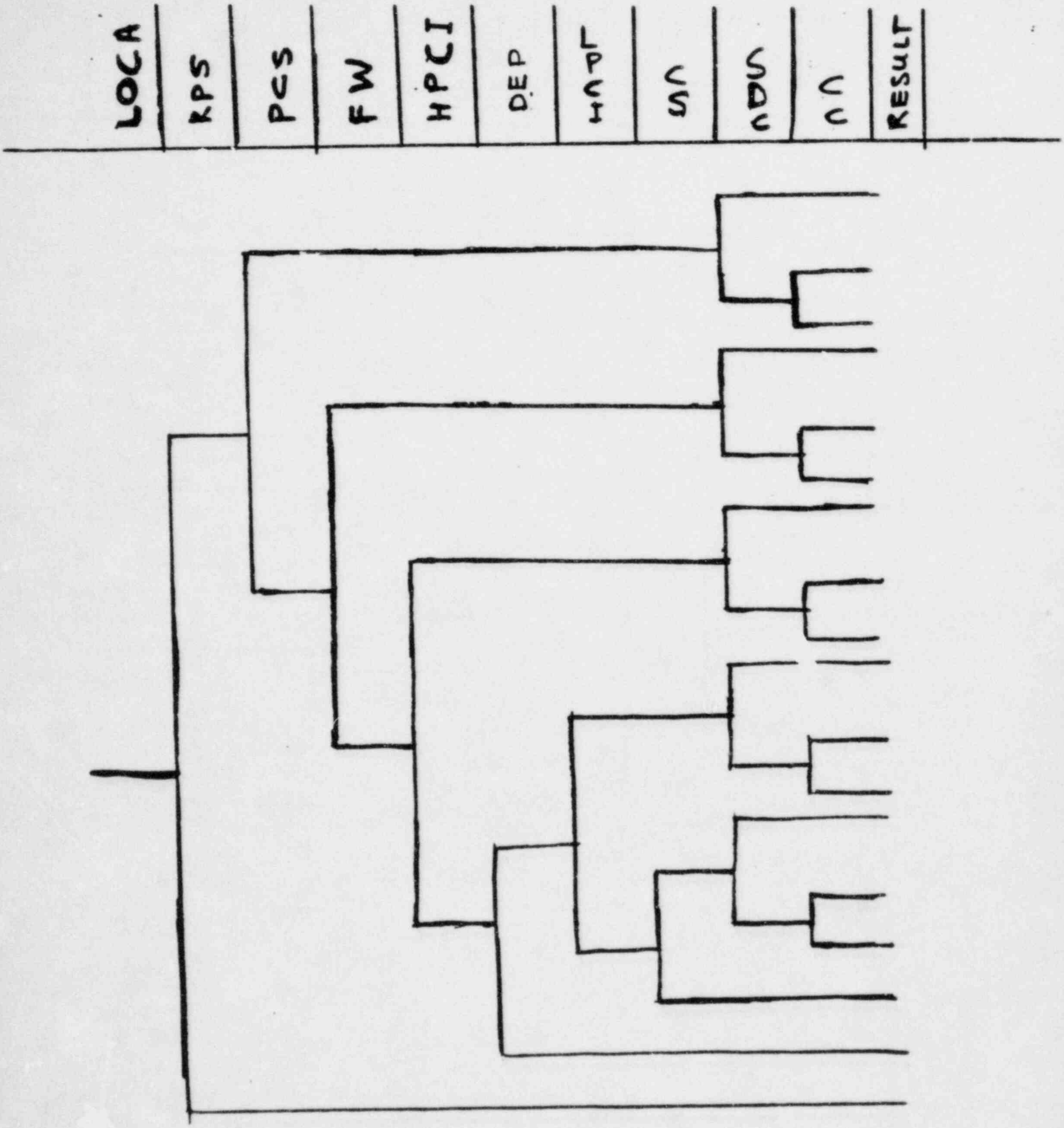

Figure 5 LOCA Event Tree
Category D

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ORNL-DWG 82-5551 ETD

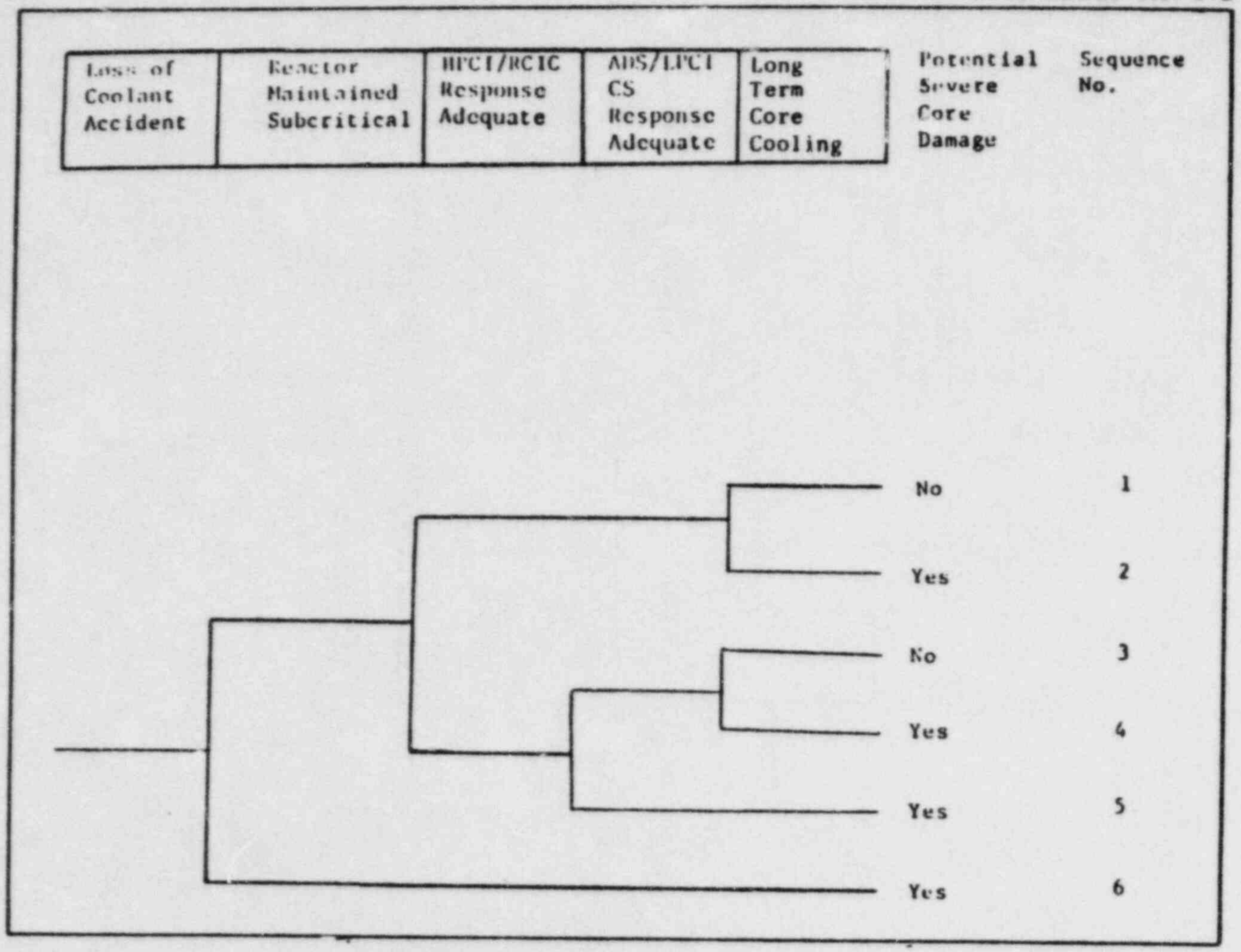


Figure 6 LOCA Event Tree
Category E

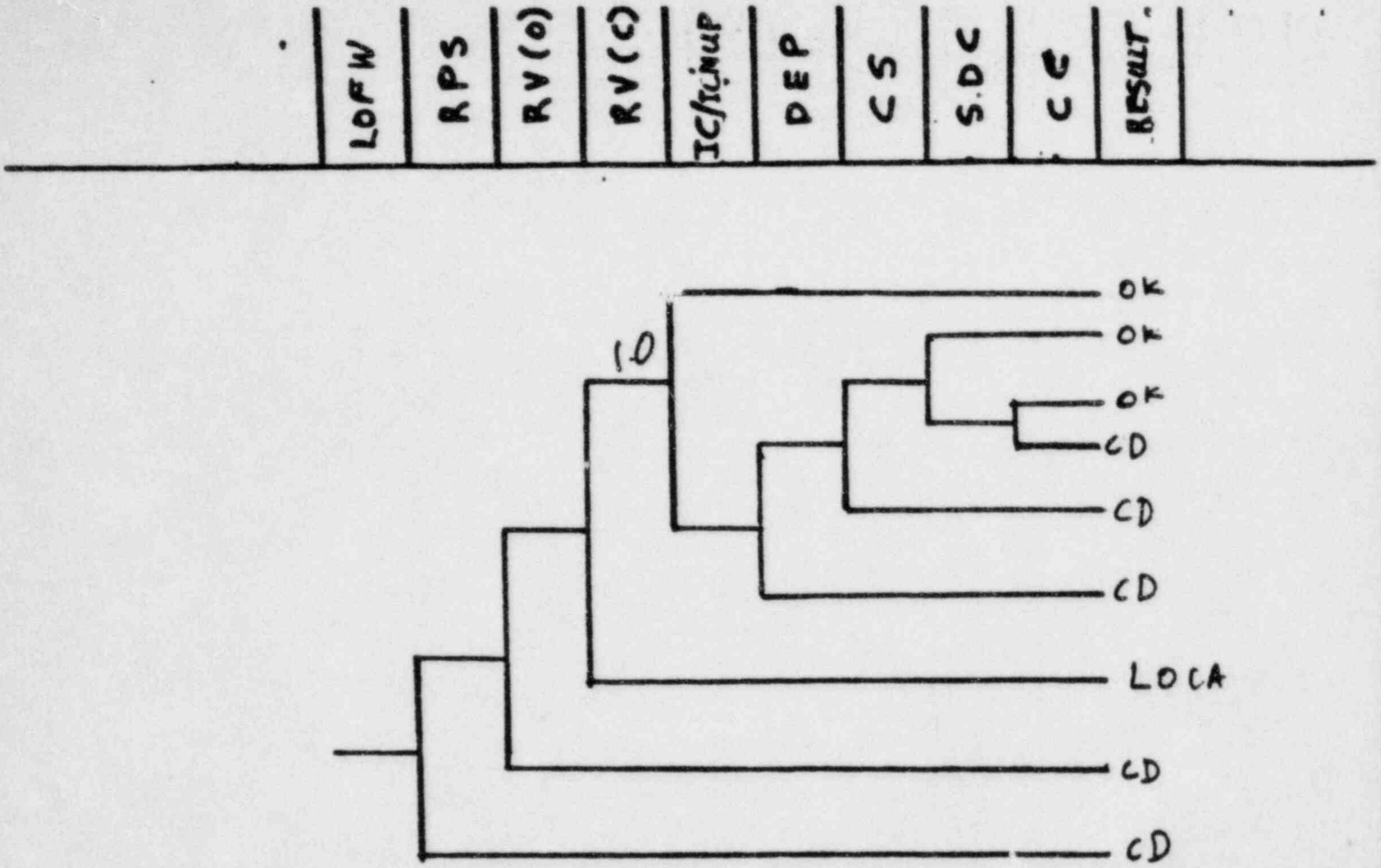


Figure 7 LOFW Event Tree
Categories A1 & A2

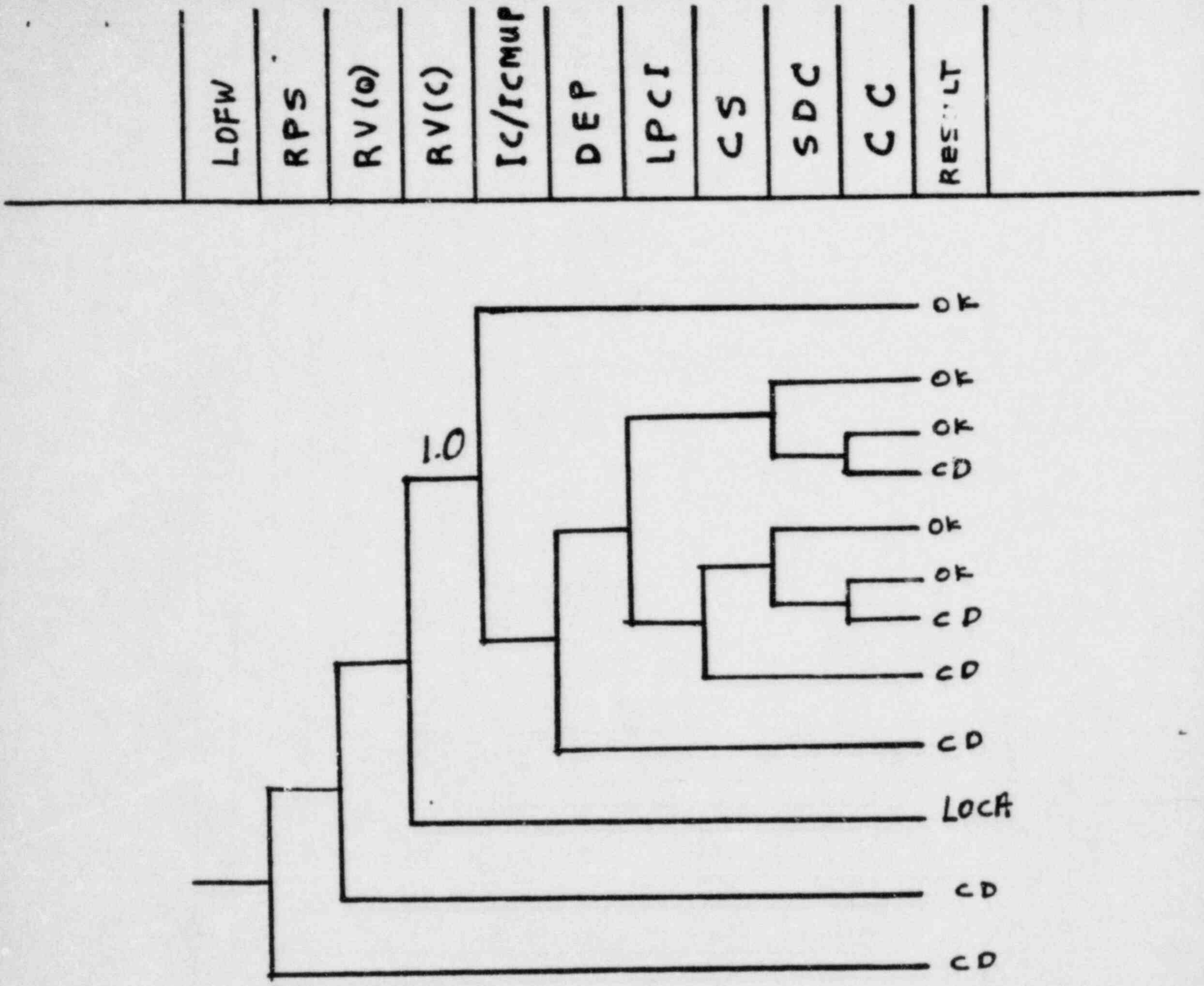


Figure 8 LOFW Event Tree
Category A3

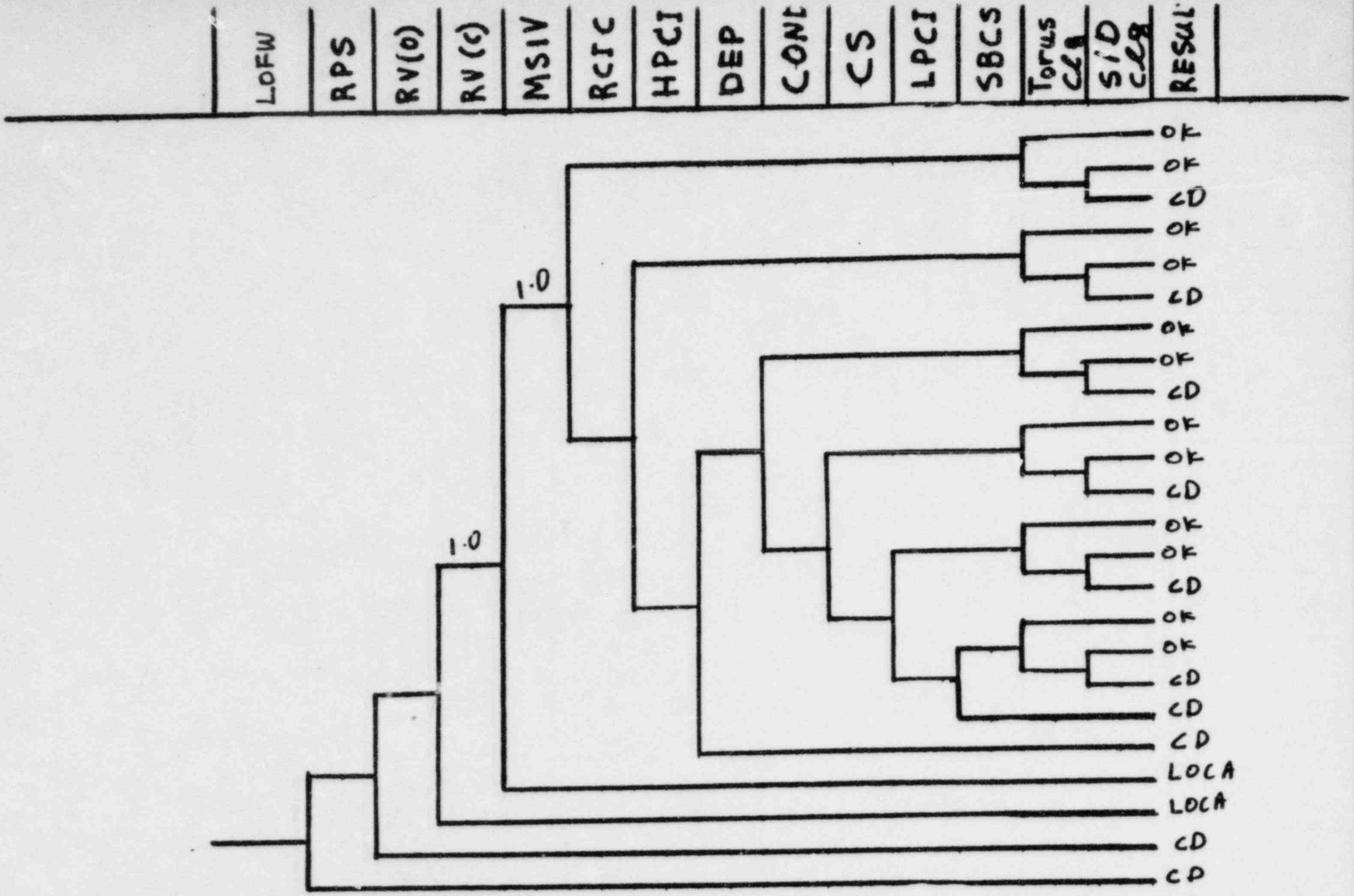


Figure 9 LOFW Event Tree

Categories B and C

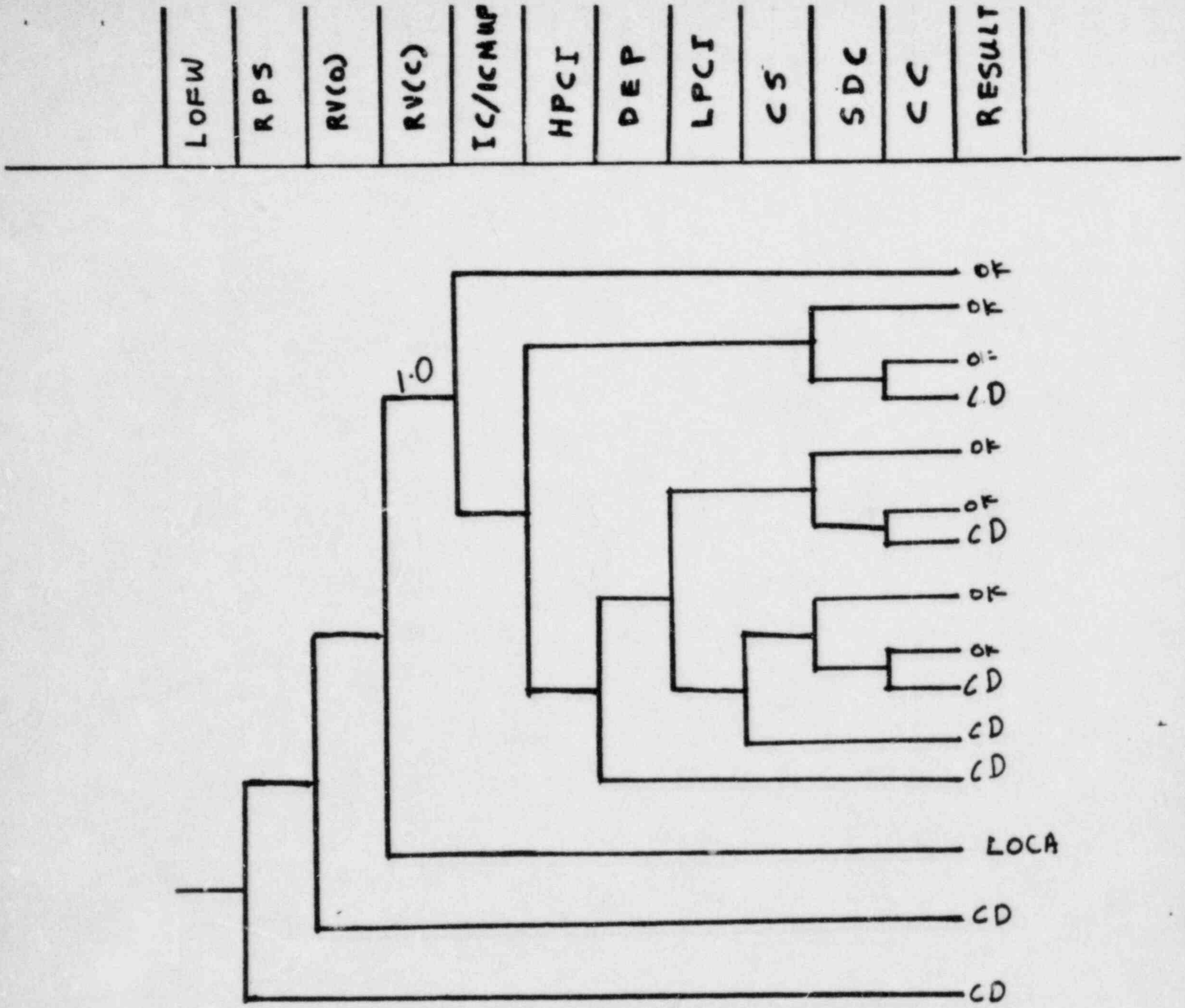


Figure 10 : LOFW Event Tree
Category D

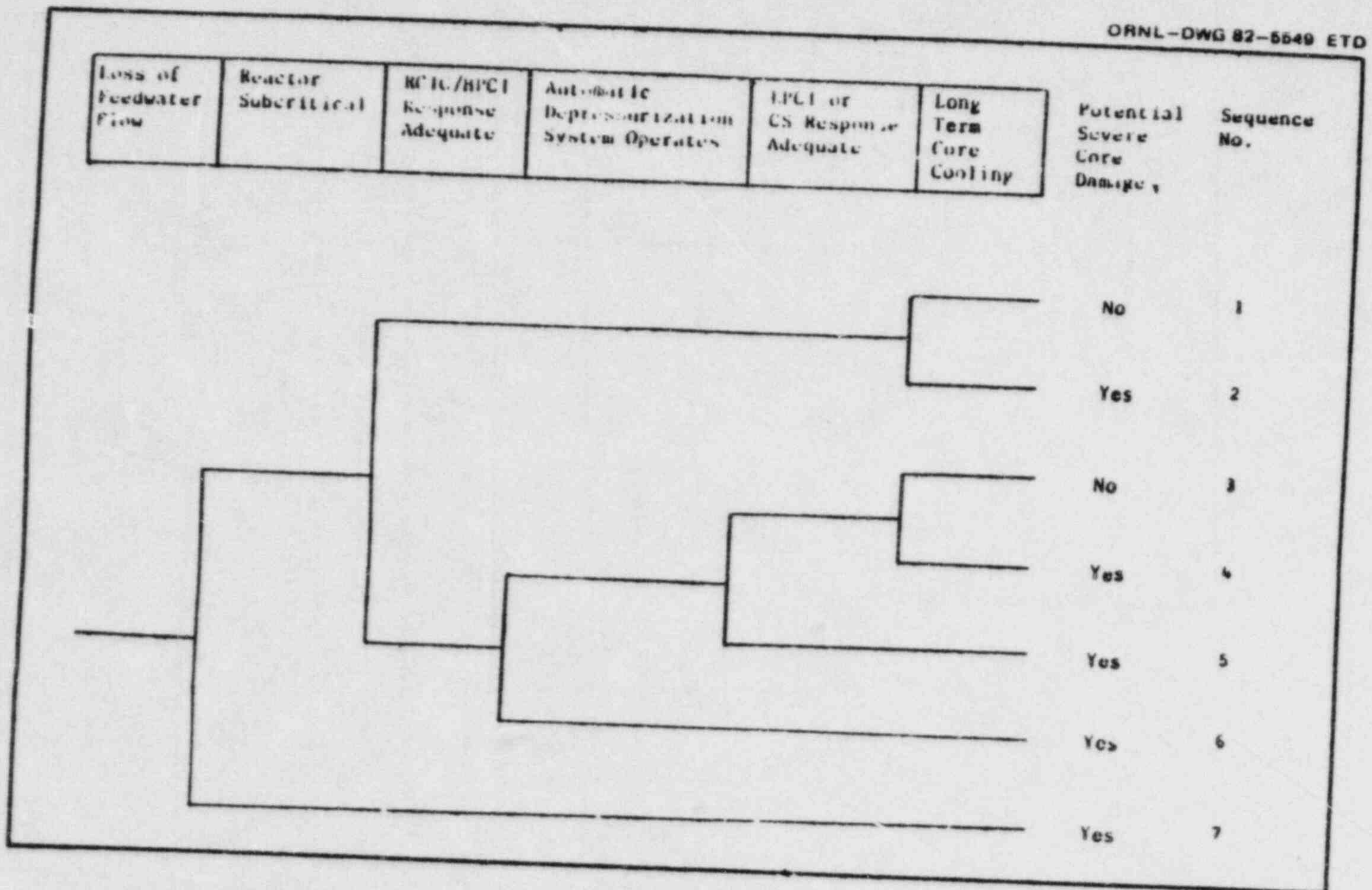


Figure 11 LOFW Event Tree

Category E

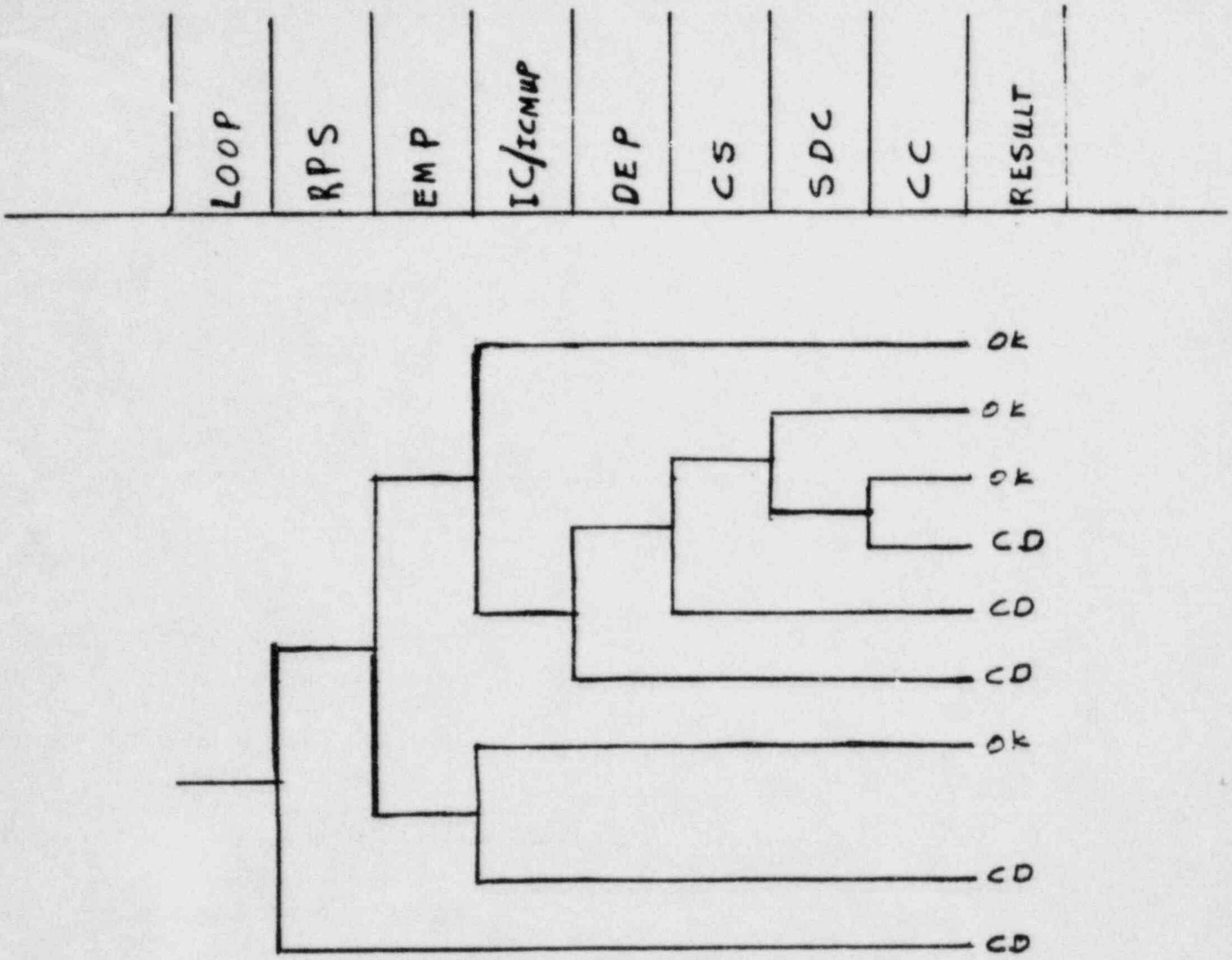


Figure 12 LOOP Event Tree
Category A1

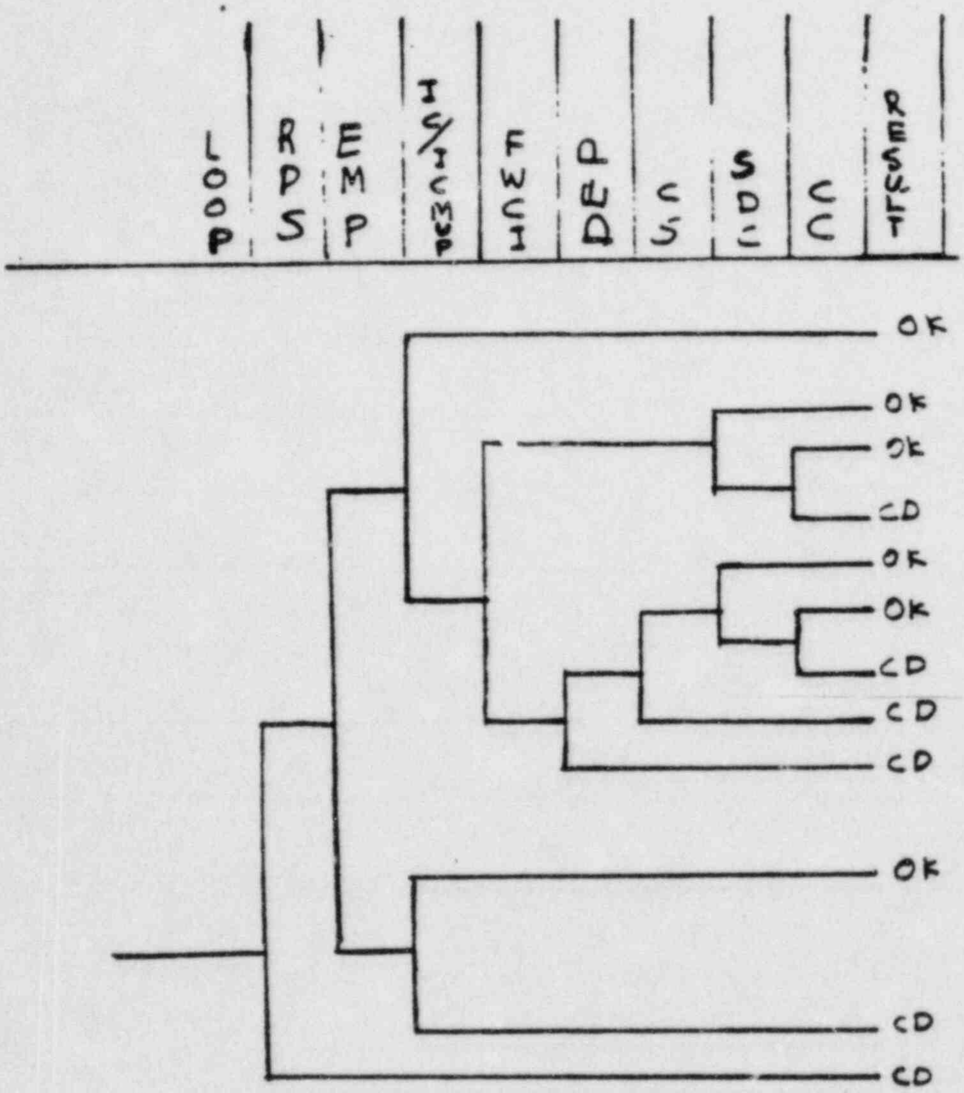


Figure ~~12~~ 13 LOOP Event Tree

Category A2

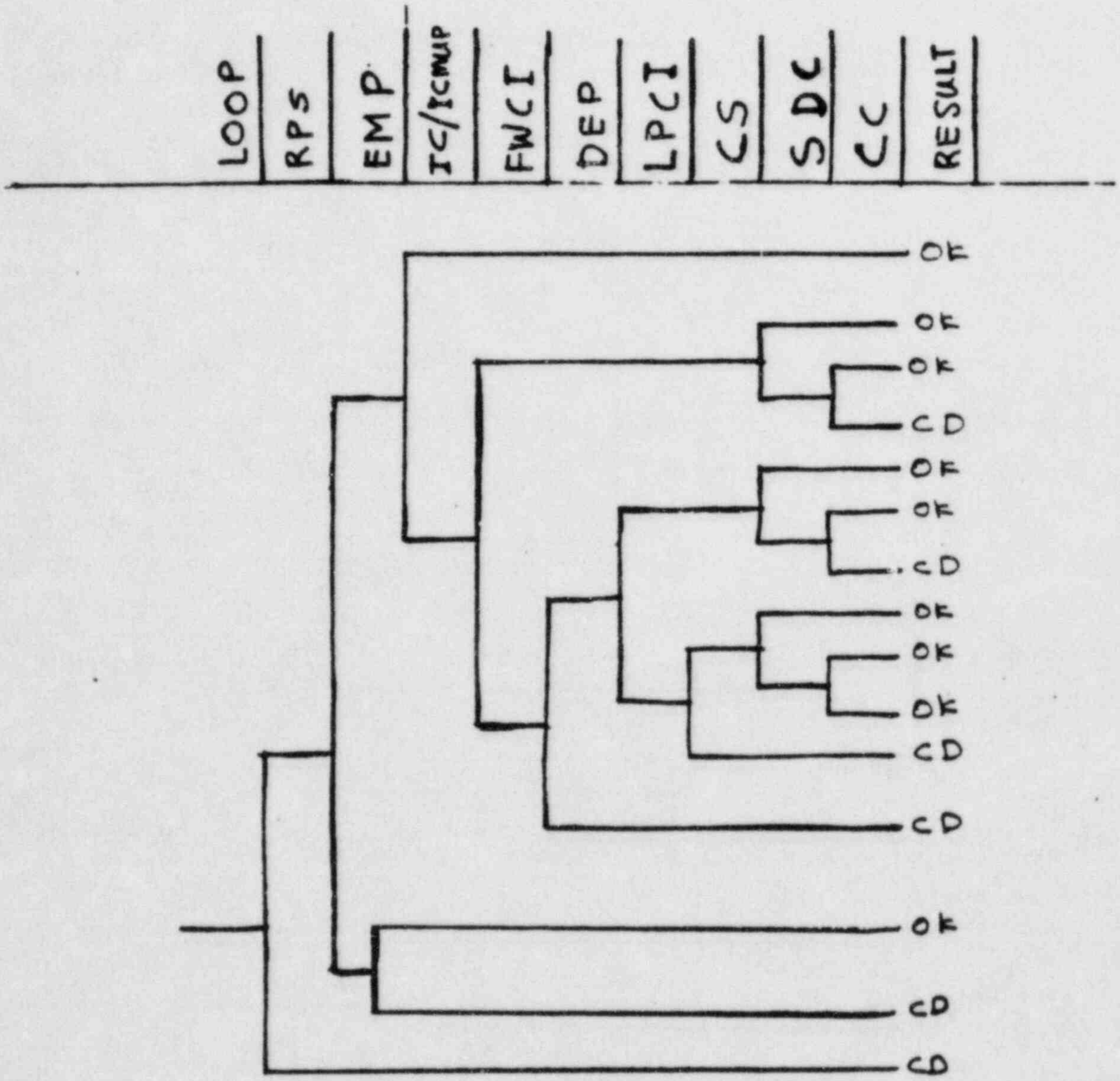


Figure 14 LOOP Event Tree
Category A3

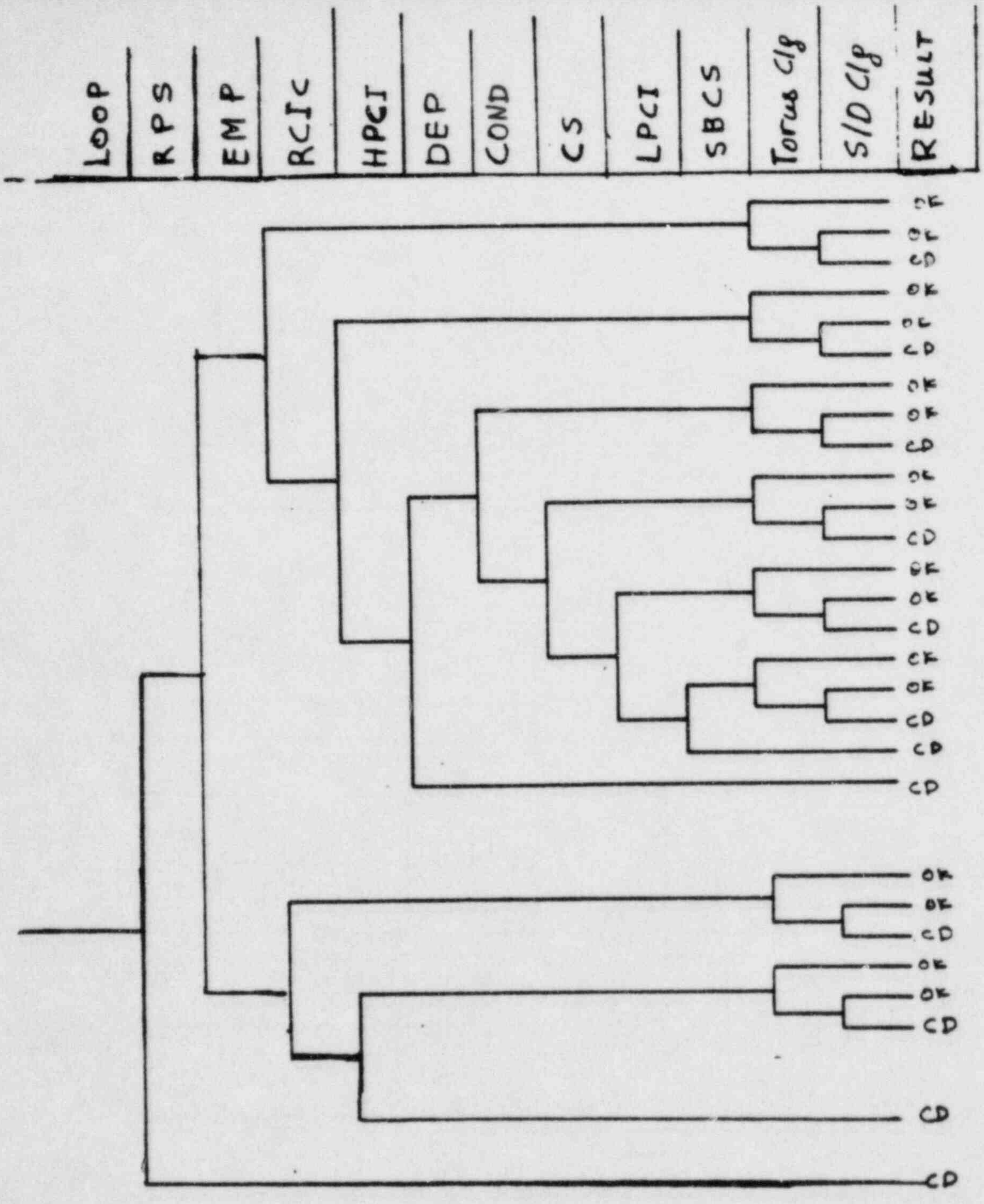


Figure 15 LOOP Event Tree
Categories B & C

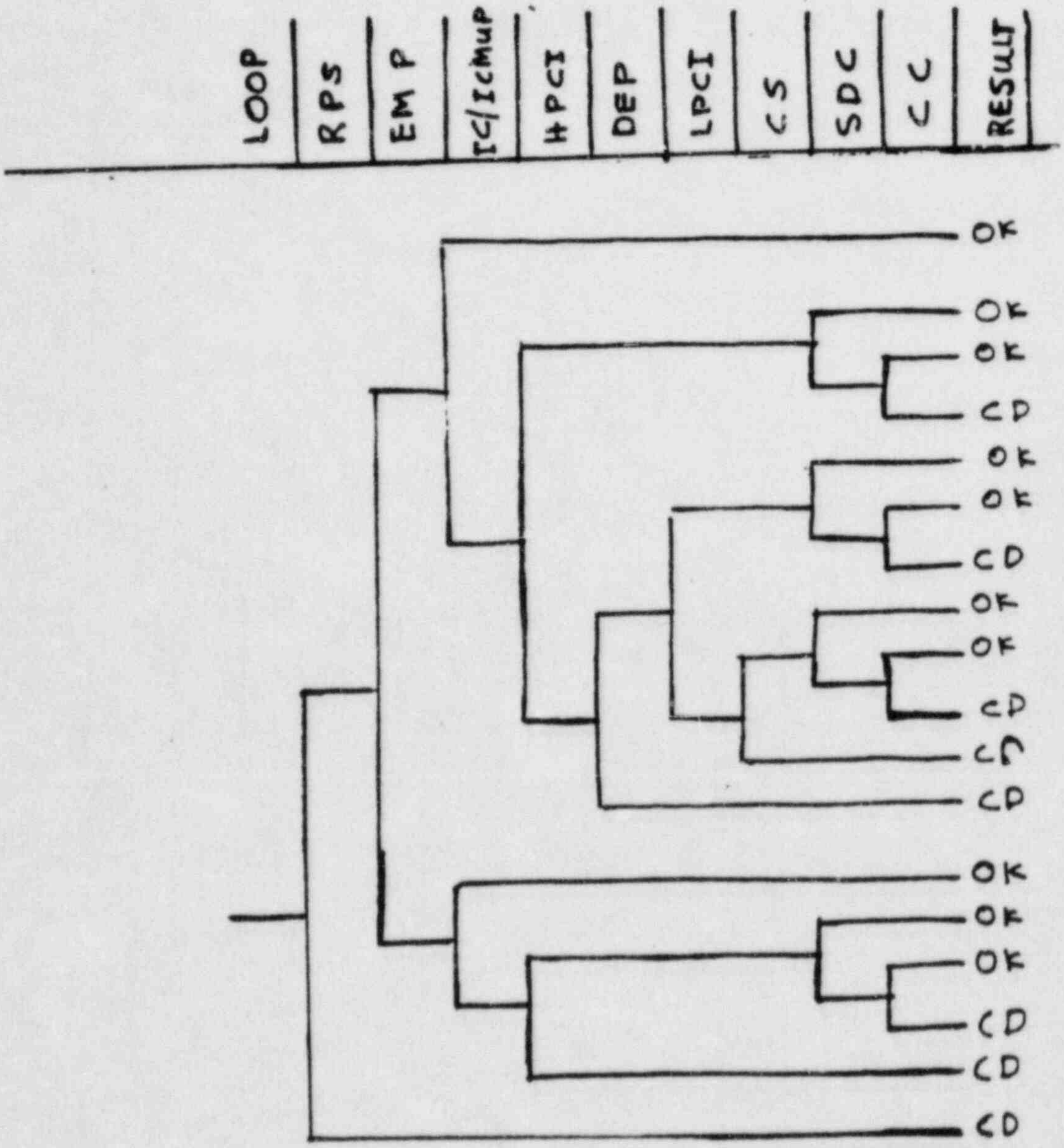


Figure 16 LOOP Event Tree
Category D

ORNL-DWG 82-5550 ETD

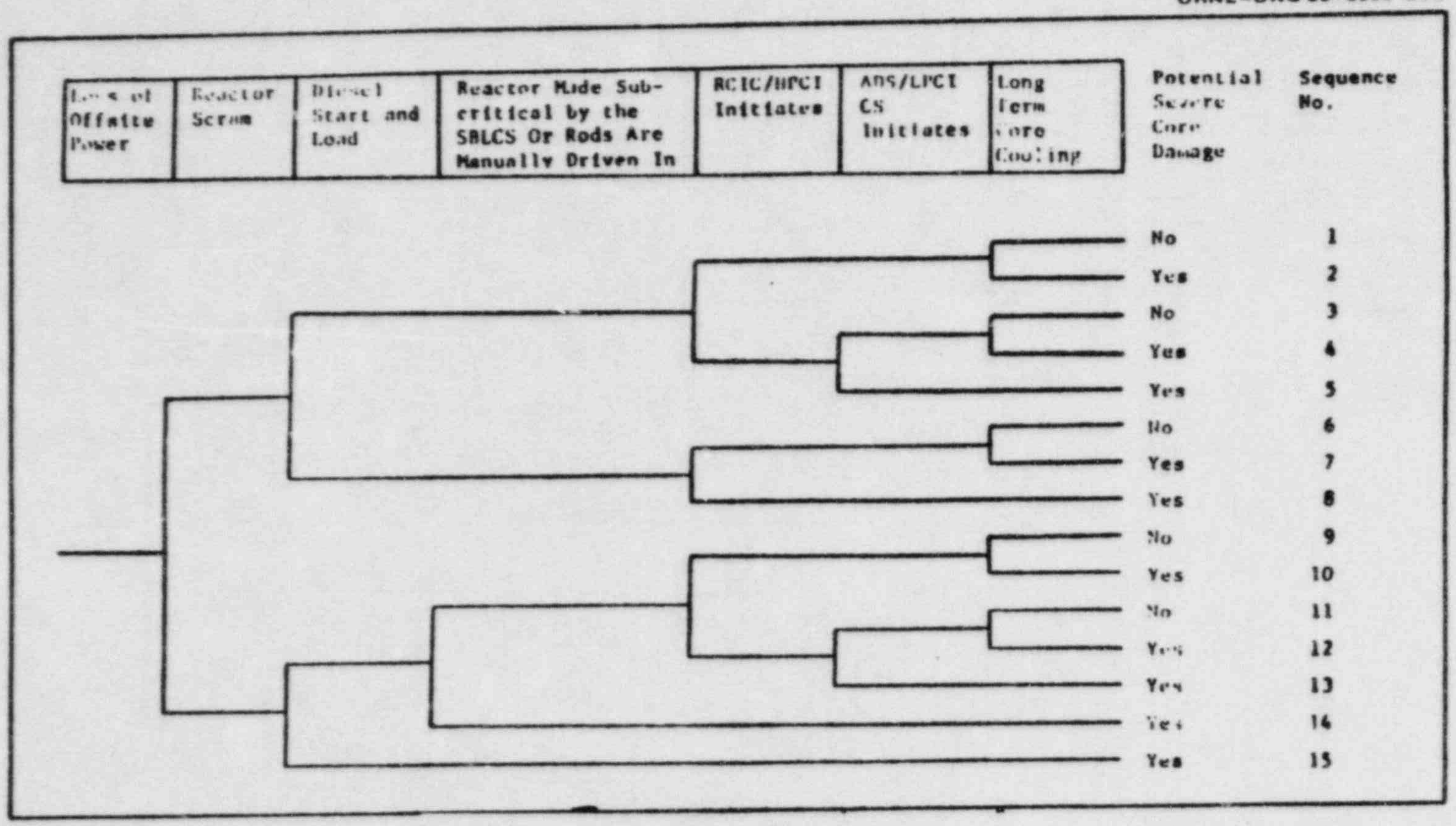


Figure 17 LOOP Event Tree

Category E

Figure 18: Loss of PCS Event Tree

Categories A1 and A2

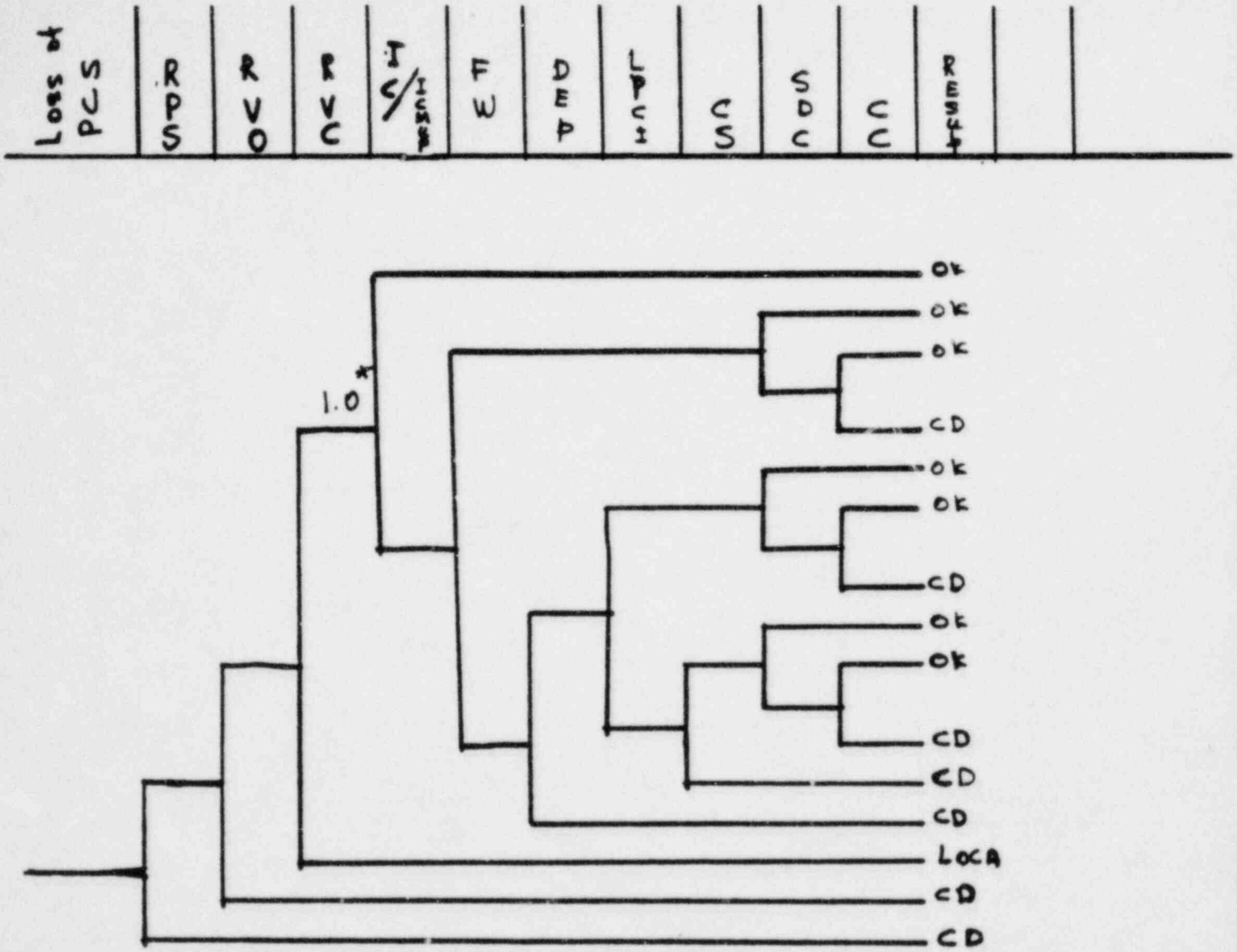


Figure 19: Loss of PCS Event Tree

Category A3

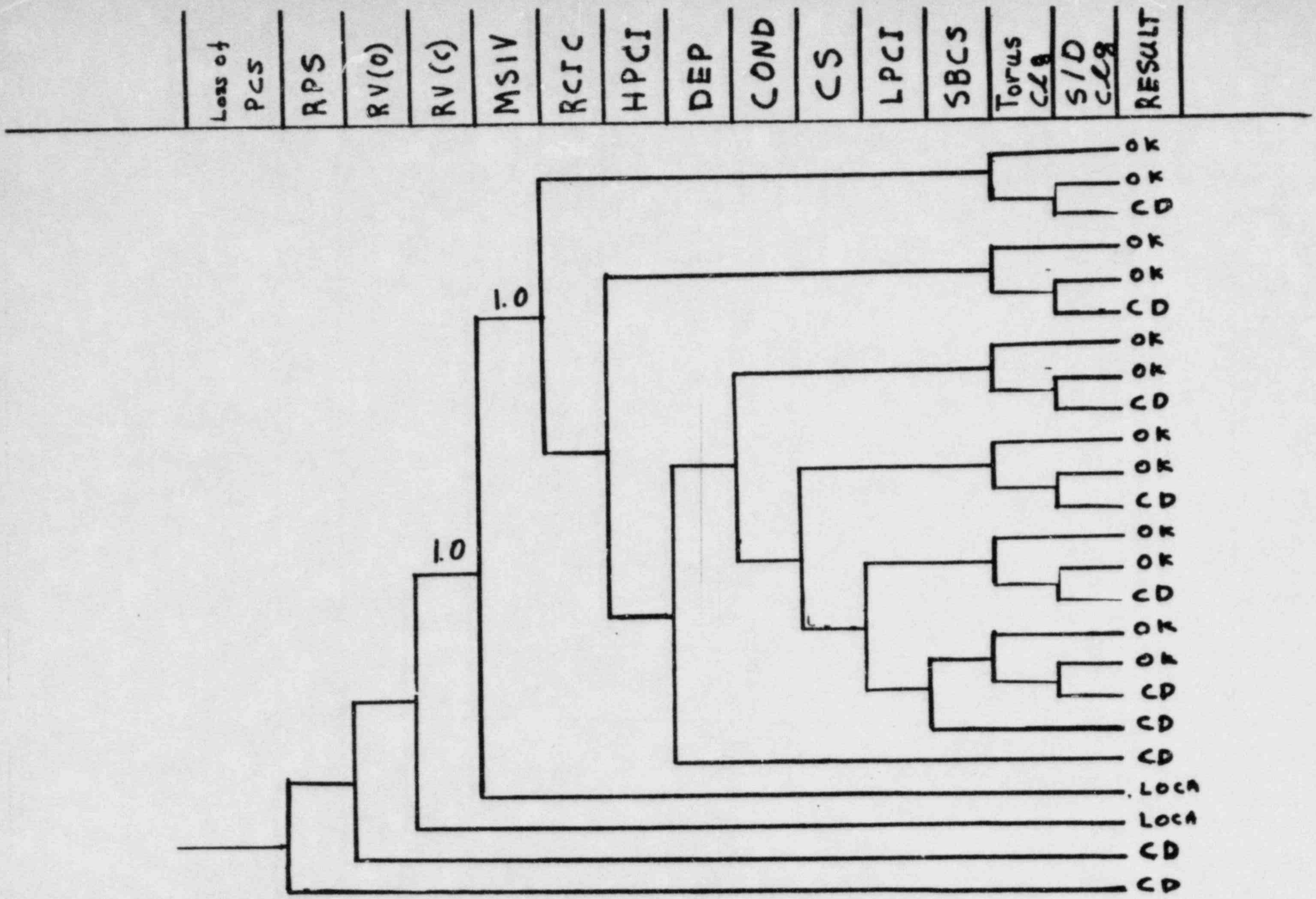
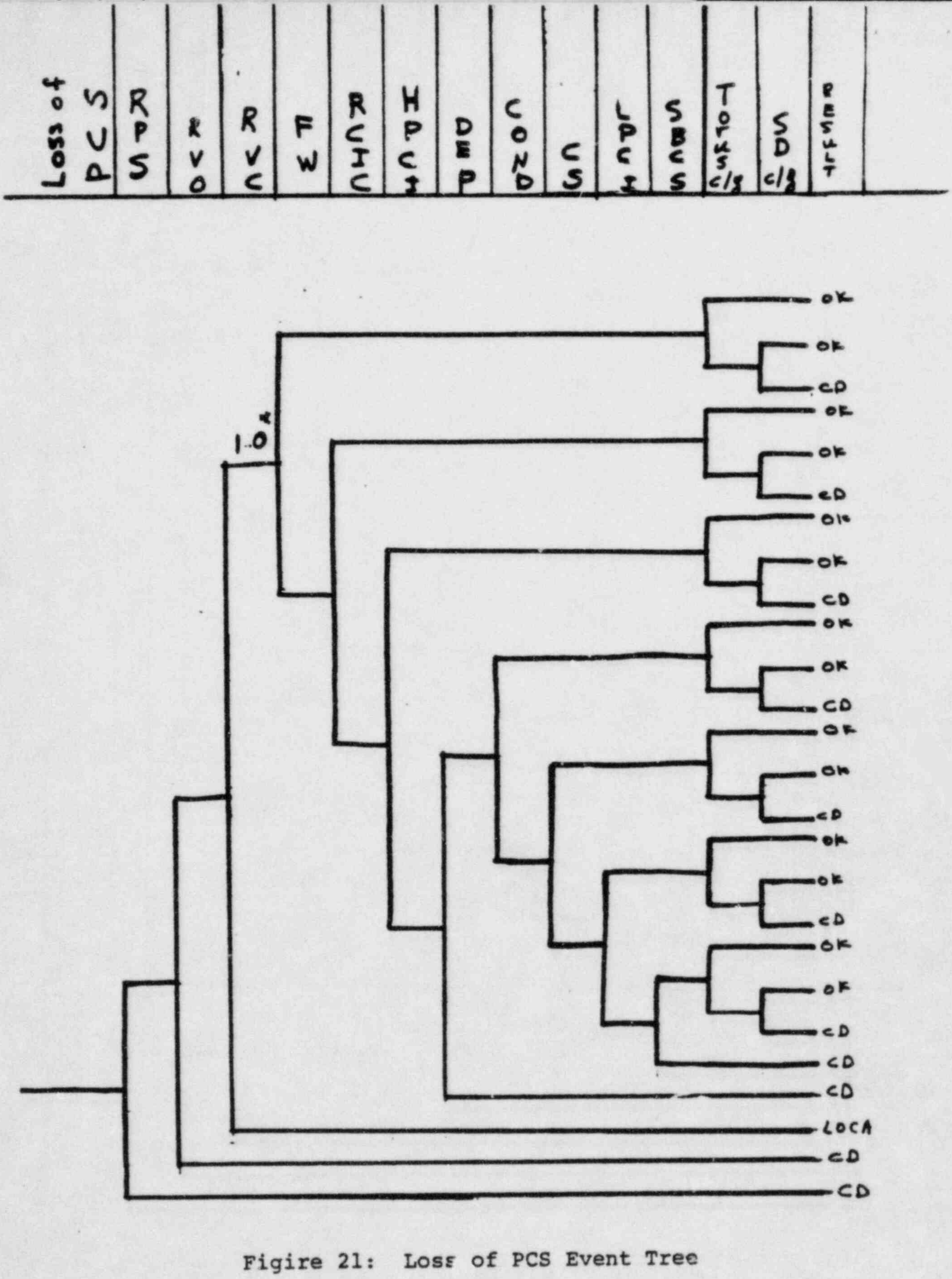


Figure 20: Loss of PCS Event Tree

Category B



Figire 21: Loss of PCS Event Tree

Category C

The BWR plants were grouped according to their engineered safety system design and feedwater pump type. (See Table 1).

Category A

This category represents the group of older BWRs. They are not a homogeneous group, but they have similarities which allow them to be evaluated as a single categroy for many of the precursors analyzed. In particular, they all have only isolation condensors as the sole means of supplying high pressure cooling when feedwater is unavailable. Also, they all utilize separate systems for containment cooling and shutdown cooling, giving them long term cooling diversity. For certain precursors, the differences between these plants become important. This requires that they be evaluated in subcategories.

Subcategroy A1- These plants would be evaluated separately for transients involving loss of offsite power. The other plants in Category A have feedwater coolant injection systems. This provides a means of utilizing the feedwater system to provide cooling flow at high pressure when only onsite AC power is available. The subcategory A1 plants do not have the capability, and thus have less diversity during these transients.

Subcategory A2- These plants would be evaluated along with Subcategory A1 for precursors which involve common mode type failures in a single low pressure injection system. Each of the plants in these two subcategories has only one low pressure safety system, the low pressure core spray. This system also provides the containment cooling function for these plants. The subcategory A3 plants have both a low pressure core spray and a low pressure coolant injection, a diversity which these plants do not have. Interstingly enough, when only random failures of the low pressure systems are evaluated the unavailability of the one system

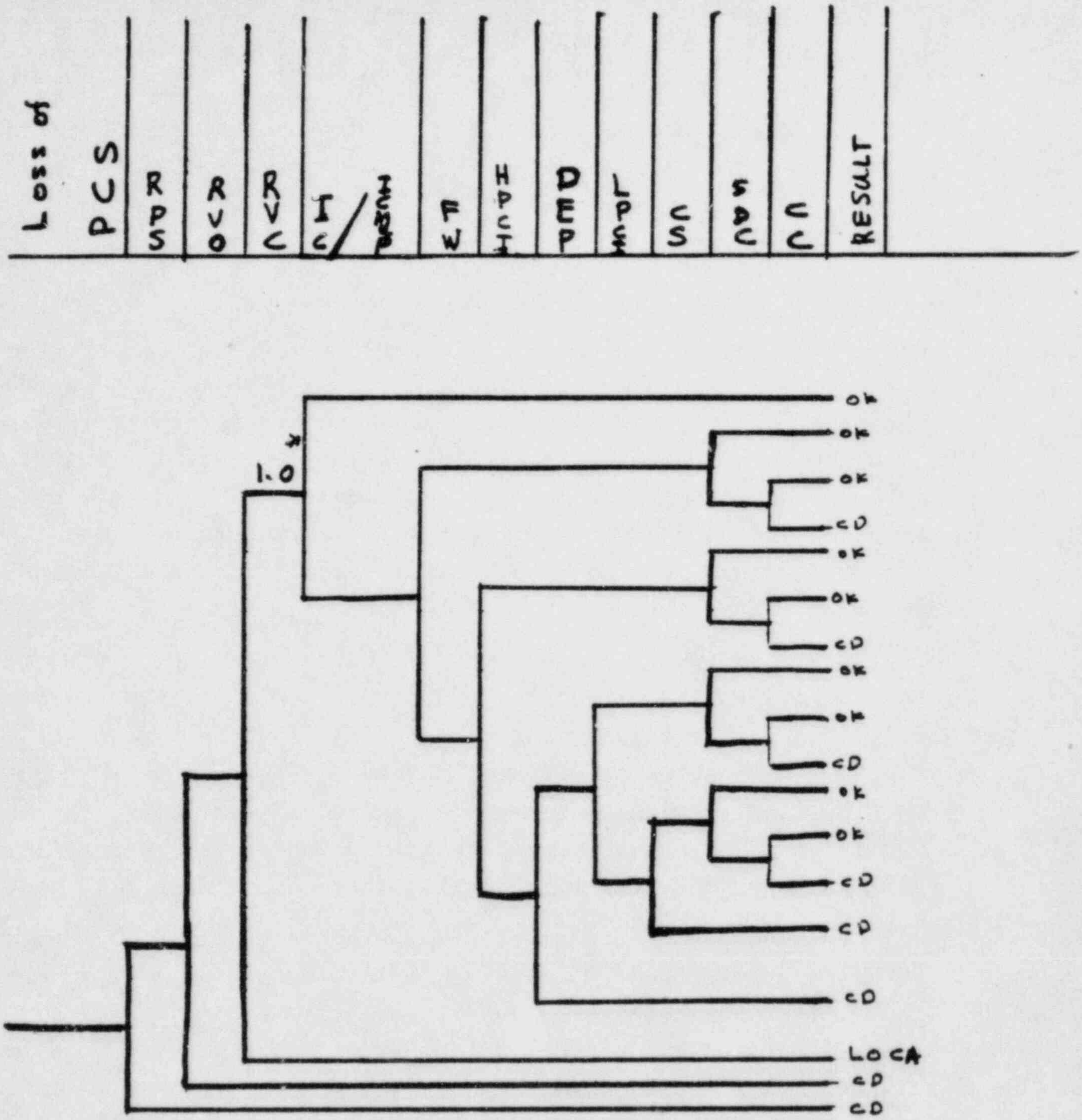


Figure 22: Loss of PCS Event Tree

Category D

These plants also saw the elimination of the isolation condenser, which was replaced by the reactor core isolation cooling (RCIC) system. This afforded additional high pressure injection for very small LOCA events, but was not as simple or reliable as the isolation condenser. Further, this also served to make additional reductions in the diversity of long term cooling. The isolation condenser actually provided a third method of long term cooling for the early plants, since it could maintain the plant in hot shutdown for extended periods of time. The RCIC operates like the other injection cooling systems, thus ultimate long terms cooling by the RHR system is still required. Thus, the category C plants reduce long term cooling diversity from three system to only one.

Category B

The category B plants continued the standardization begun with category C, and they have all of the same systems. The difference is that the category B plants replaced motor driven main feedwater pumps (which all the other plant categories have) with turbine driven main feedwater pumps. This reduces the availability of main feedwater as a source of injection water, with the turbine pumps, any event which causes any part of the secondary cycle to fail will result in a total loss of feedwater. This is because the main feedwater isolation valves will close, isolating steam to the turbine. With the motor driven pumps, this cannot occur and feedwater can continue running or be easily recovered. Thus, the category B plants have reduced diversity for high pressure injection of coolant for pressure which in older plants would result in loss of the secondary cycle without failure of the feedwater system.

Category E

This category represents only the LaCrosse BWR plant. This design versus the two system design are reasonably equivalent. Thus, for many of the precursors, it is not necessary to make the distinction.

Subcategroy A3- These plants have both the feedwater coolant injection system and the two system low pressure systems design. This group would be evaluated along with subcategory A2 for loss of offsite power and separately for loss of single low pressure system.

Category D

The category D plants are lumped together because they have a high pressure coolant injection system in addition to Category A. This gives the plant two high pressure cooling systems when feedwater is unavailable. They do not have a feedwater coolant injection system, but they do have the two low pressure systems. The major difference is in the high pressure coolant injection (HPCI). Having two high pressure systems (HPCI and isolation condenser) improves response to loss of feedwater events. Also, injection cooling is now available if a consequential LOCA occurs due to a stuck open relief valve. In plants without HPCI, it is necessary to blow down and use low pressure cooling in this situation.

Category C

This category represents the early group of plants where the BWR design became more standardized. These plants differ from the earlier plants in that low pressure cooling/containment cooling system and shutdown cooling system were combined into a single, integrated, residual heat removal (RHR) system. This reduces the number of components, but also elimantes the diversity enjoyed by the earlier plants with separate shutdown cooling systems. This plant group is more susceptible to precursors involving common mode type failures of long term cooling systems.

1) <u>LOFW Event Tree</u>

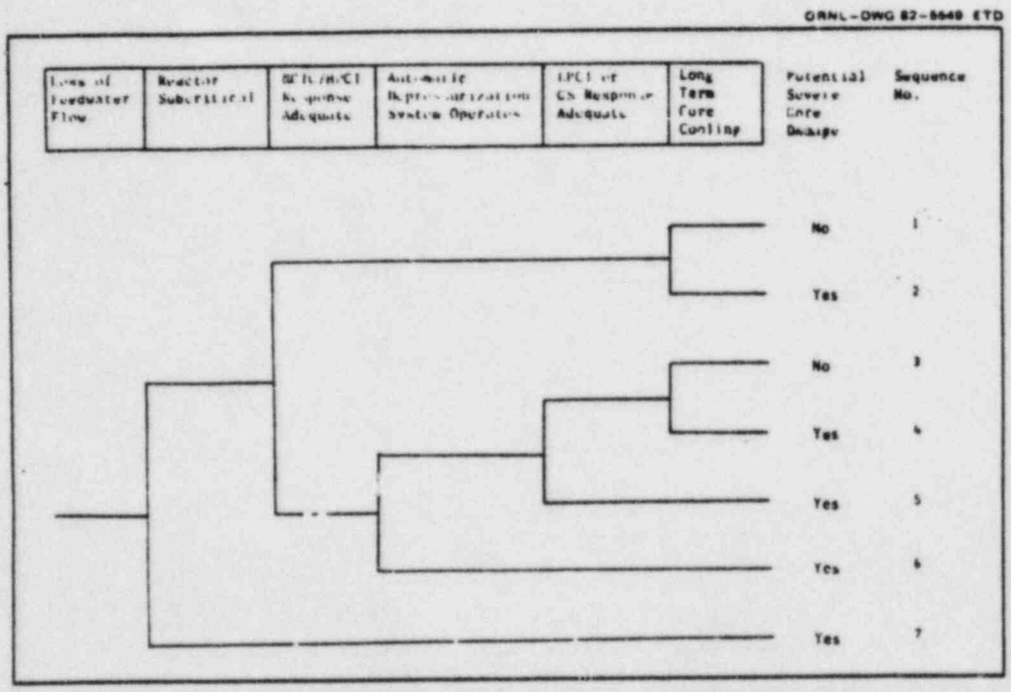


Figure 23: ASP Study Event Tree for Loss of Feedwater

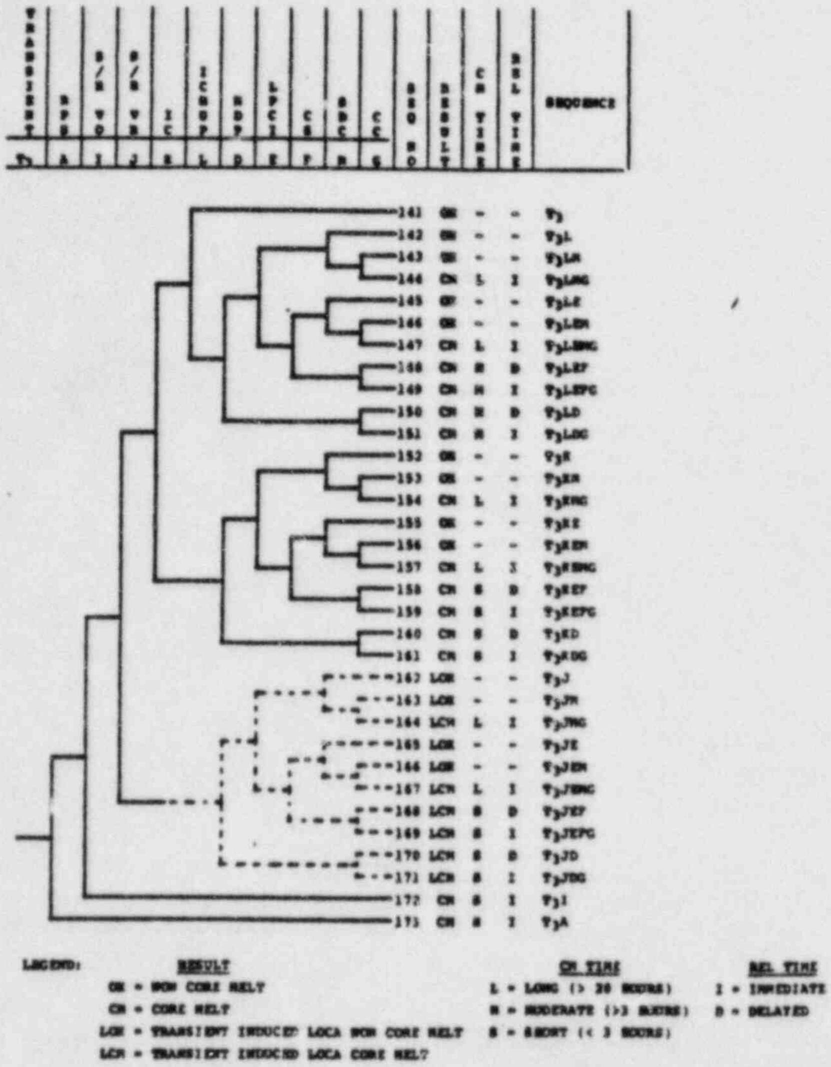


Figure 24: IREP Millstone 1 Event Tree for Loss of All Feedwater

In addition to modifications discussed in this section, the probability of success of Safety relief valve to reclose was assumed to be 1.0, thus forcing the event tree to describe only LOFW event and not transient induced LOCA's. since LOCA's are treated separately.

3.0 BWR Plant Specific Percursors Analysis

3.1 Initiating Events and Function Failures Applied

For each precursor event, the initiator and the subsequent safety system failures were reviewed individually. If the description of the actual occurence (as given in App. B of the ASP report) indicated that the event could occur at any plant, then the precursor was applied to all plant categories. On the other hand, if the conditions inducing the precursor were plant specific or could apply only to a group of plants, then the precursor was restricted to the specific plants(s). For example, a LOCA event caused by a stuck open relief valve was considered applicable to all plants, while the LOOP event caused by salt buildup on the 345kv lines and insulators at Millstone I (NSIC 116780) was considered applicable to only plants next to the ocean.

Some of LOFW initiators that occured at plants of Category B were converted to loss of PCS when applied to the other plant categories, because the use of turbine driven feedwater pumps in Category B results in a LOFW following an MSIV closure transient. In the case of the Browns Ferry Fire, the description of the event (NUREG/CR-2497 pg B-213) reveals that feedwater was lost because of the MSIV closure, while the feedwater system was not damaged by the fire. In actuality, the core was cooled through condensate booster pumps after manual depressurization. Thus if this event is applied to plants with motor-driven feedwater pumps, it would result in loss of PCS only and not loss of the feedwater system.

In a similar manner, mitigating system failures or degradations were categorized. For example, a HPCI failure was not assumed an IC failure and vice versas as is done in the ASP study. In some instances a system's failure or degradation applicability was restricted to a subcategory or even to one is required since the plant is of a different design, having been built by Allis-Chalmere rather than General Electric. It is the only Allis-Chalmere plant ever built.

plant. For example, the RCIC/HPCI failure cause by a wrong reset logic connection was considered applicable only to the Browns Ferry 1 plant at which it occured (NSIC 85566). However, if the mitigating system failure or degradation resulted as a consequence of another failure, it was credited for all plant categories in which the initiator was applicable. As an example, consider the LOOP event with the relief valve stuck open at Pilgrim 1. (NSIC #   ). Pilgrim 1 utilizes RCIC/HPCI systems which were degraded because of the stuck open relief valve. Thus, in categories B and C the RCIC/HPCI systems are assumed to be degraded in this analysis. However, when the event is applied to categories A and D which utilize isolation condensers and FWCI, the isolation condenser is considered failed and FWCI degraded, because the isolation condenser can not function with a stuck open relief valve. Appendix A summarizes all precursors as they are applied to each applicable category.

3.2 Category Specific Event Trees

This analysis used systematic event trees developed by the "Interim Reliability Evaluation Program" (IREP) as follows: In categories A and D the event-trees developed from the Millstone Point 1 Nuclear Power Plant were adopted, while for categories B and C the trees adopted were developed from the Browns Ferry 1 Nuclear Power Plant. The IREP-Millstone 1 event trees used in category A were modified to make them category specific as follows: (i) the IC and ICMP systems were merged into one event, (ii) the LPCI option was deleted for subcategories A1 and A2 (iii) the FWCI option was deleted for subcategory A2 and (iv) the Containment Cooling (CC) option was deleted after CS or MDP failure since both branches of the event tree lead to core damage. (This option was taken into consideration in the IREP-Millstone 1 study in order to account for the severity of the sequence in containment calculations).

Event trees used in Category D were obtained from the same set of trees by adding the HPCI option which is missing in the IREP-MIllstone 1 systematic event trees. For Category B, the event trees of Browns Ferry 1 were used with no modifications. For Category C the Category B event trees were applied but they were modified to include the FW and/or PCS availability where applicable.

Category E consists only of the La Crosse plant which is considerably different in design from all other BWR plants, and therefore available event trees and function failure probability data are difficult to find. Thus for this specific category, the ASP study event trees and point estimated were applied.

In the rest of this section the ASP standard event trees, the original IREP trees (Millstone and Browns Ferry) and the corresponding category specific event trees are shown. The footnotes in each figure summarizes the consideration made for any modifications.

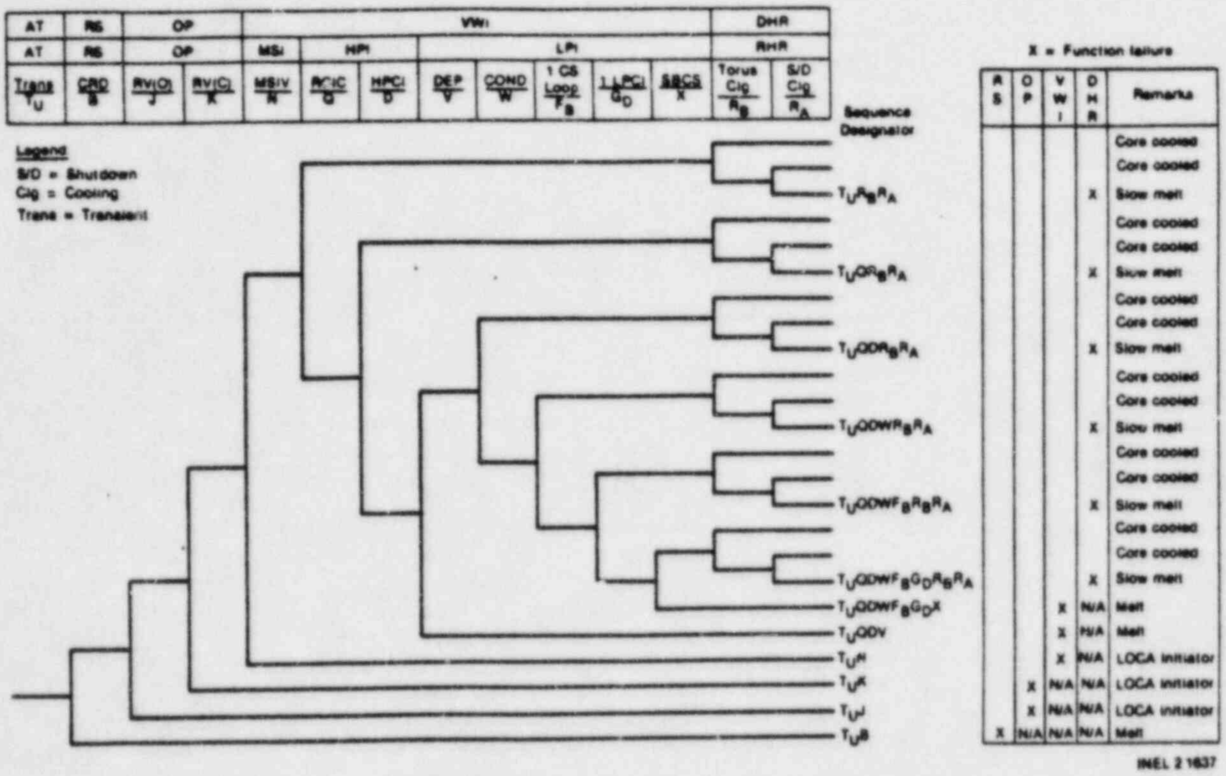


Figure 25: IRED Study Browns Ferry 1 Event Tree where PCS is unavailable (T_U).

Note that the LOFW transient in the IREP-Browns Ferry 1 study is part of "transient systematic event tree where PCS is unavailable (TU)." The tree becomes a LOFW event tree by assuming success prob. for relief valve to reclose and MSIV to close to be 1.0.

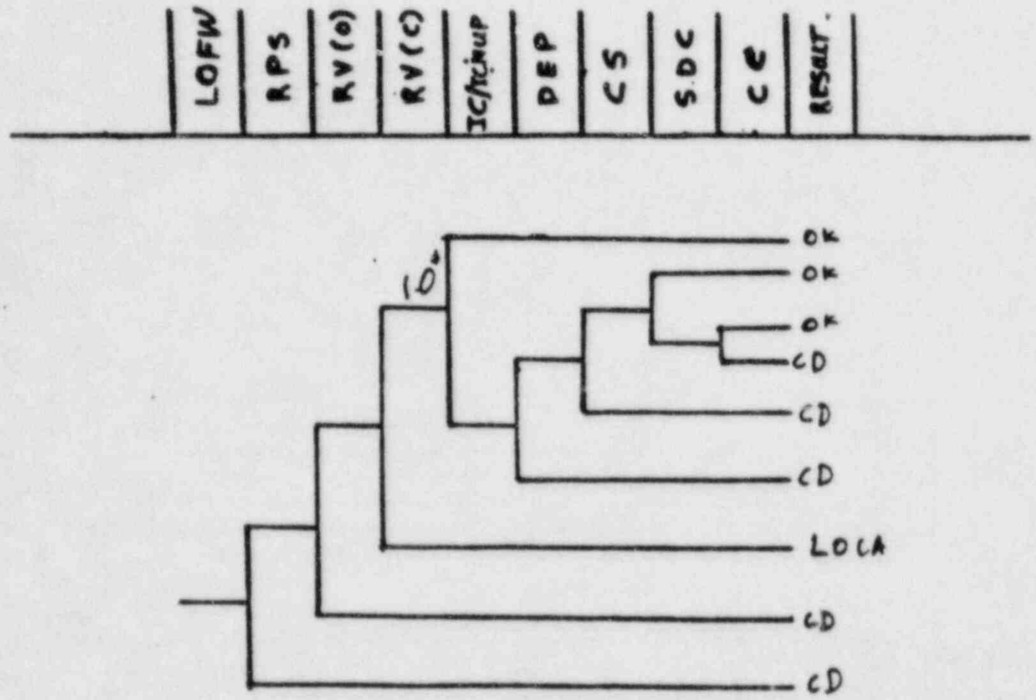


Figure 26: IREP-Study Millstone 1 for LOFW Systematic event tree modified for Categories A1 and A2

*Assumption of 1.0 for RC(C) success forces the event tree to describe a LOFW event.

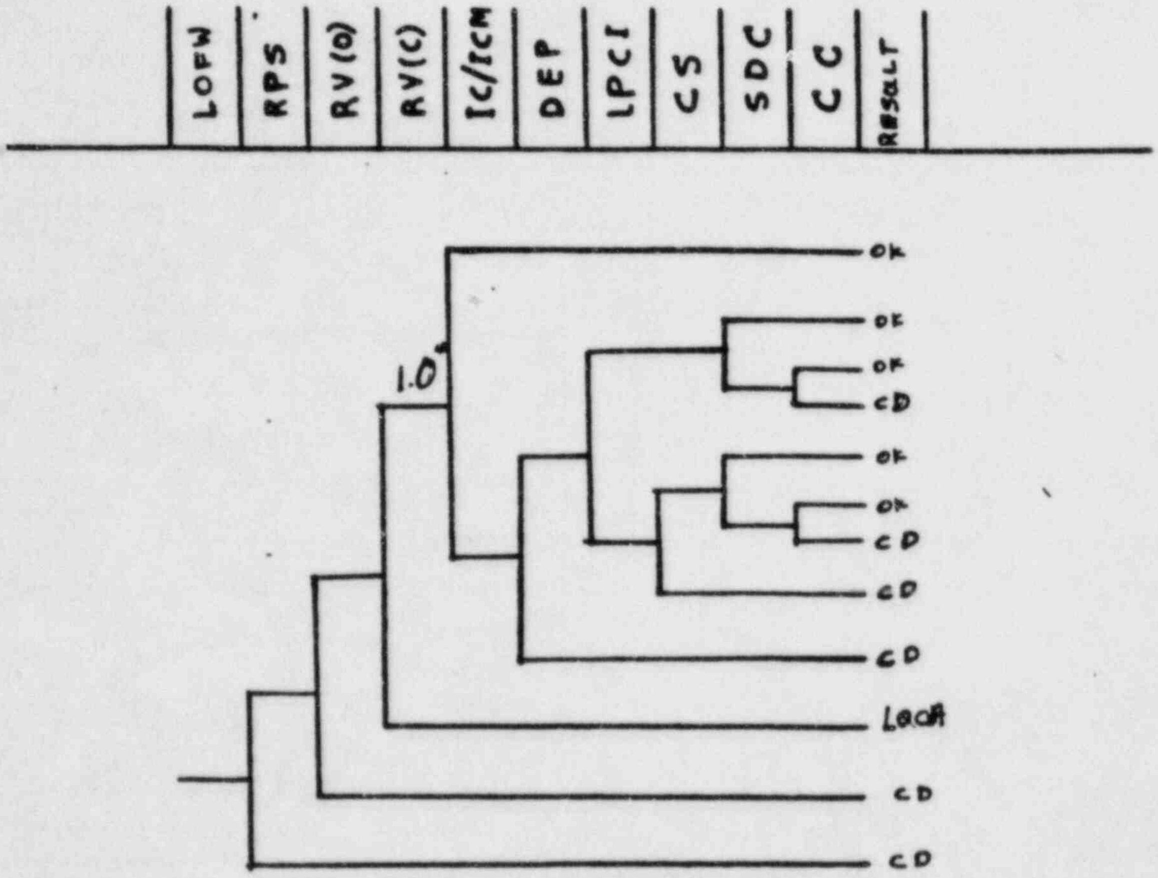


Figure 27 : IREP Study Millstone 1 for LOFW
Systematic event tree modified to apply
in Category A3

Assumption of 1.0 for RV(C) success forces the event tree to represent a LOFW event.

LOFW Event Tree for Categories B and C

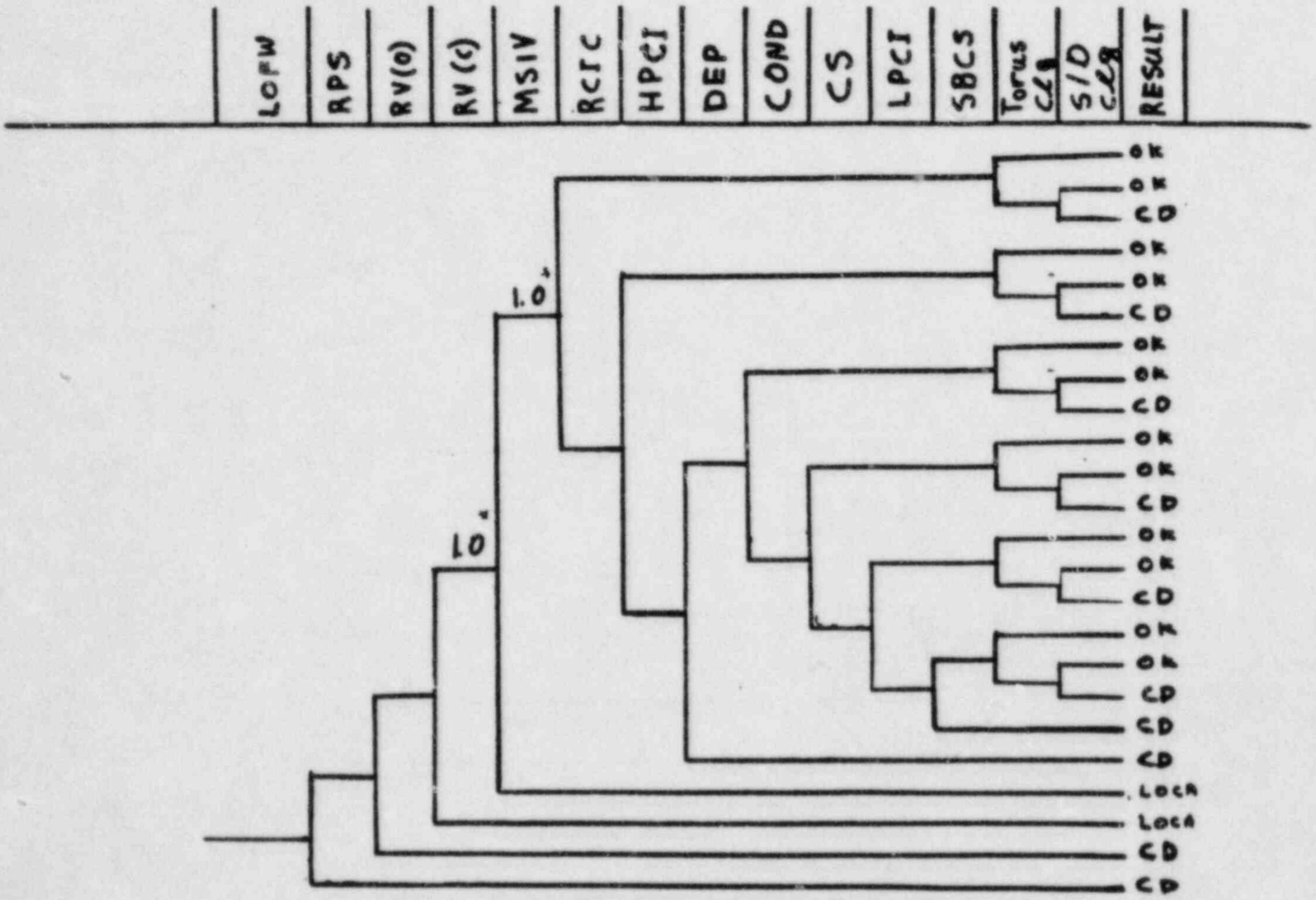


Figure 28: IREP Study Browns Ferry 1 for LOFW Event Tree Modified to apply in Categories B and C

*Assumption of 1.0 for RVCC and MSIV closure success forces the event tree to represent a LOFW event.

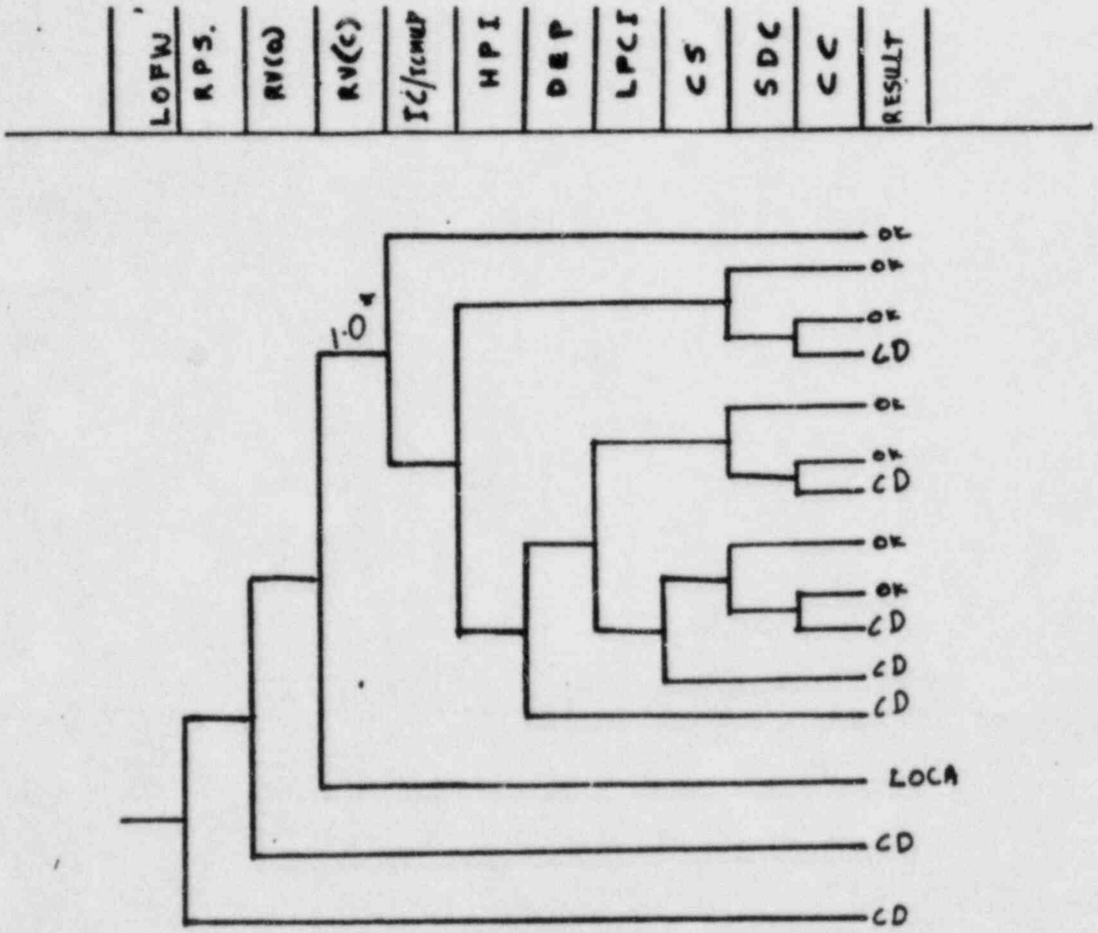


Figure 29: IREP Study Millsteon 1 for LOFW Systematic Event Tree Modified to apply in Category D.

*Assumption of 1.0 for RV(C) success forces the event tree to describe a LOFW event.

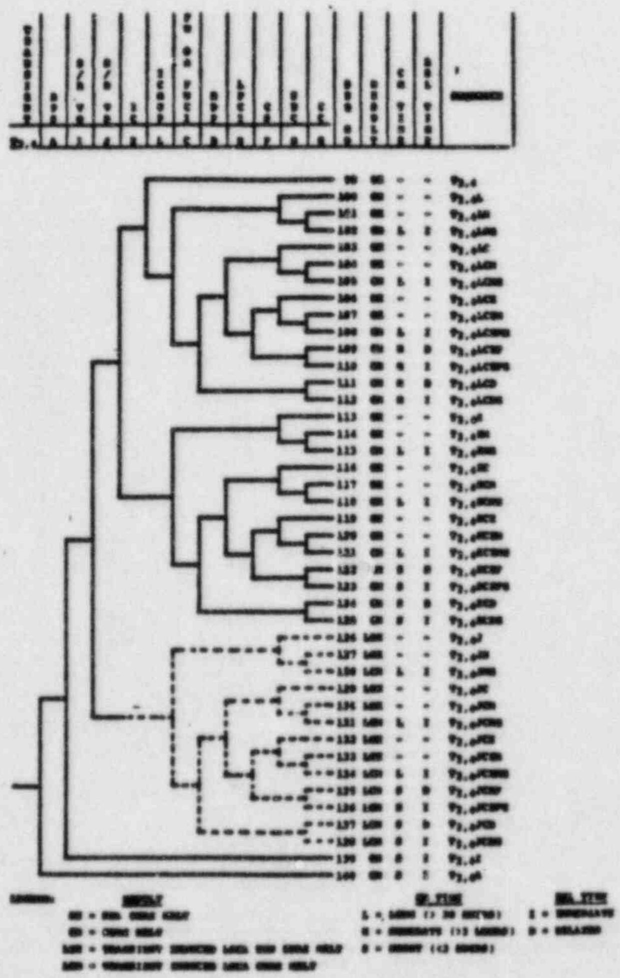


Figure 30: IREP Study Millstone 1 for Loss of PCS (Excl. Feedwater) (T_2) Loss of Normal AC Power (T_4)

The ASP Study did not include PCS failure as an initiating event in its event tree sequences.

The "Transient systemic event tree where PCS is unavailable (TU)" shown in figure 20 and used for LOFW event is the appropriate tree for loss of PCS event. This tree was used in Category B as it was and modified to include the FW availability for Category C.

Figure 31: IREP Study Millstone 1 for Loss of PCS Event Tree Modified to apply in Categories A1 and A2

* Assumption of 1.0 for RV(C) success forces the event tree to represent a loss of PCS event.

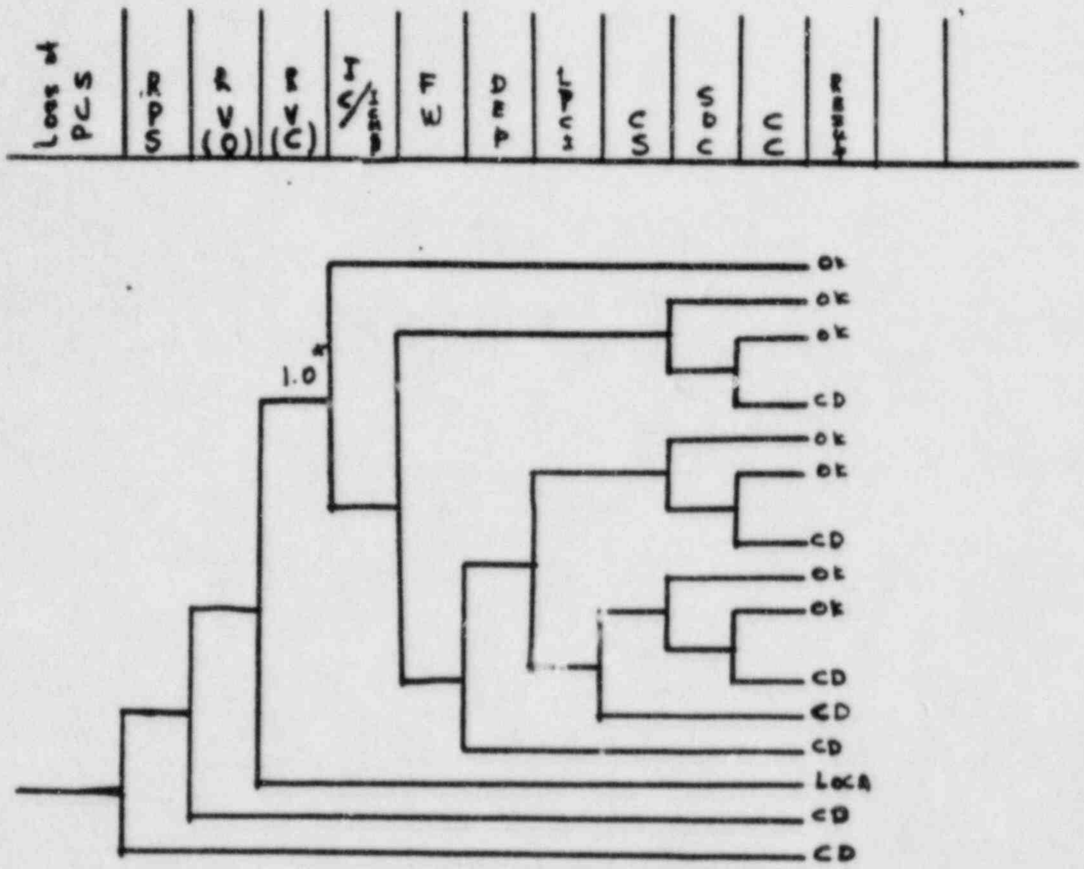


Figure 32: IREP-Study Millstone 1 Event Tree for Loss of PCS modified to apply in Category A3

* Assumption of 1.0 for RV(C) success forces the event tree to represent a loss of PCS event.

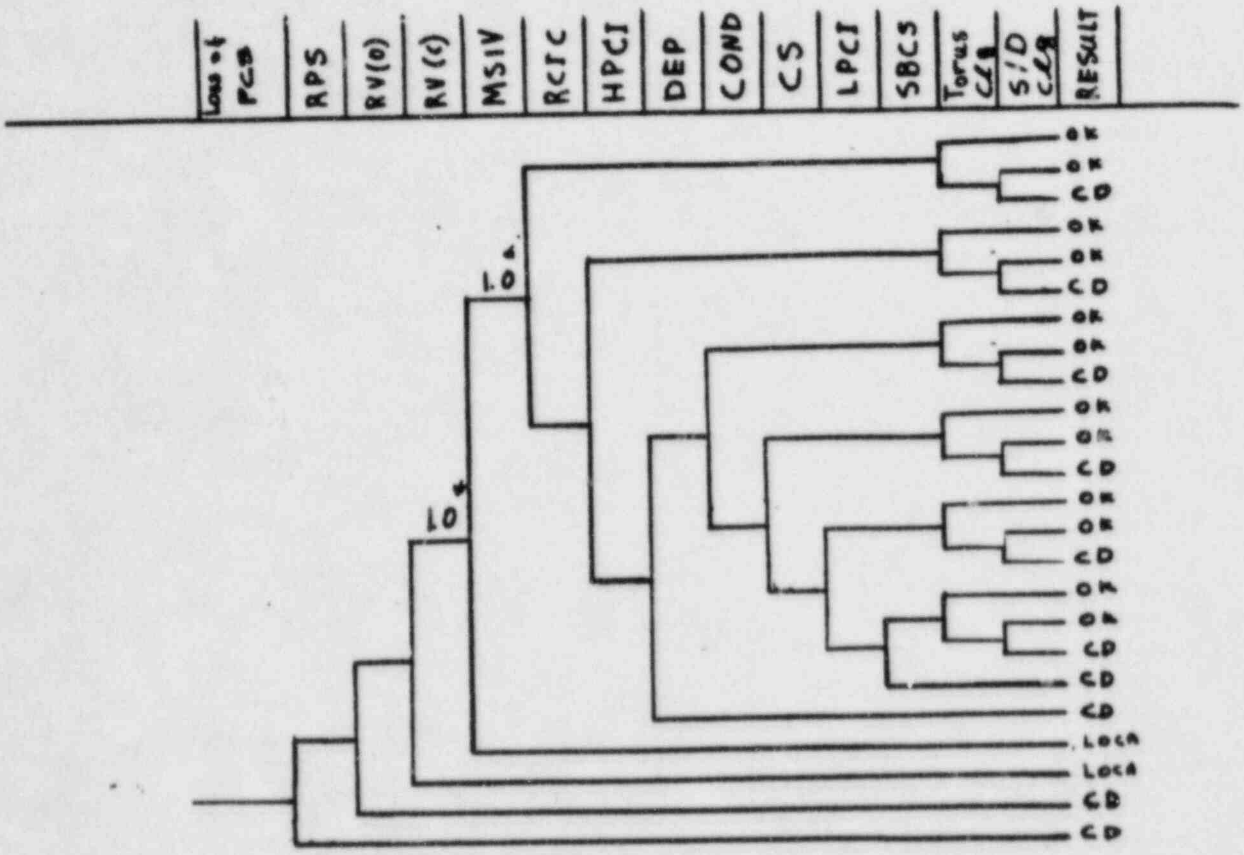


Figure 33: IREP Study Browns Ferry 1 Event Tree for Loss of PCS applied in Category B

* Assumption of 1.0 for RV(C) and MSIV closure success forces the event tree to represent a loss of PCS event.

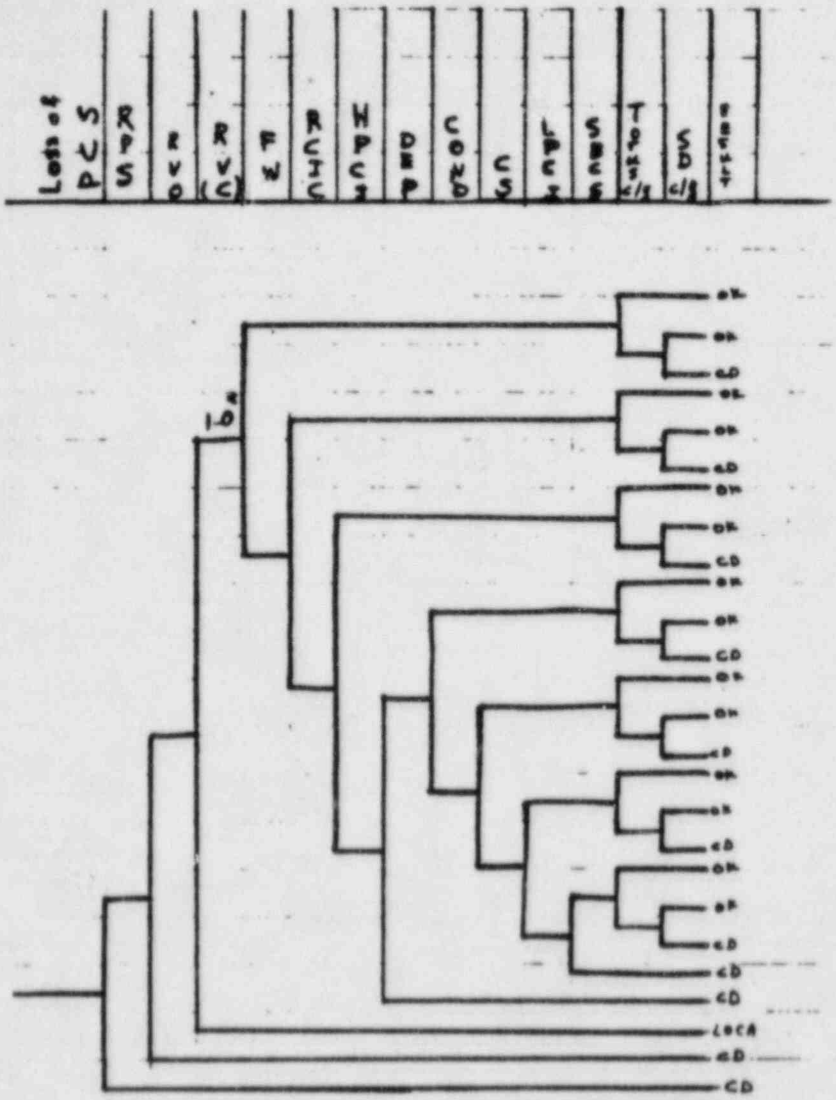


Figure 34: IREP Study Browns Ferry 1 event tree for Loss of PCS modified to apply in <u>Category C</u>

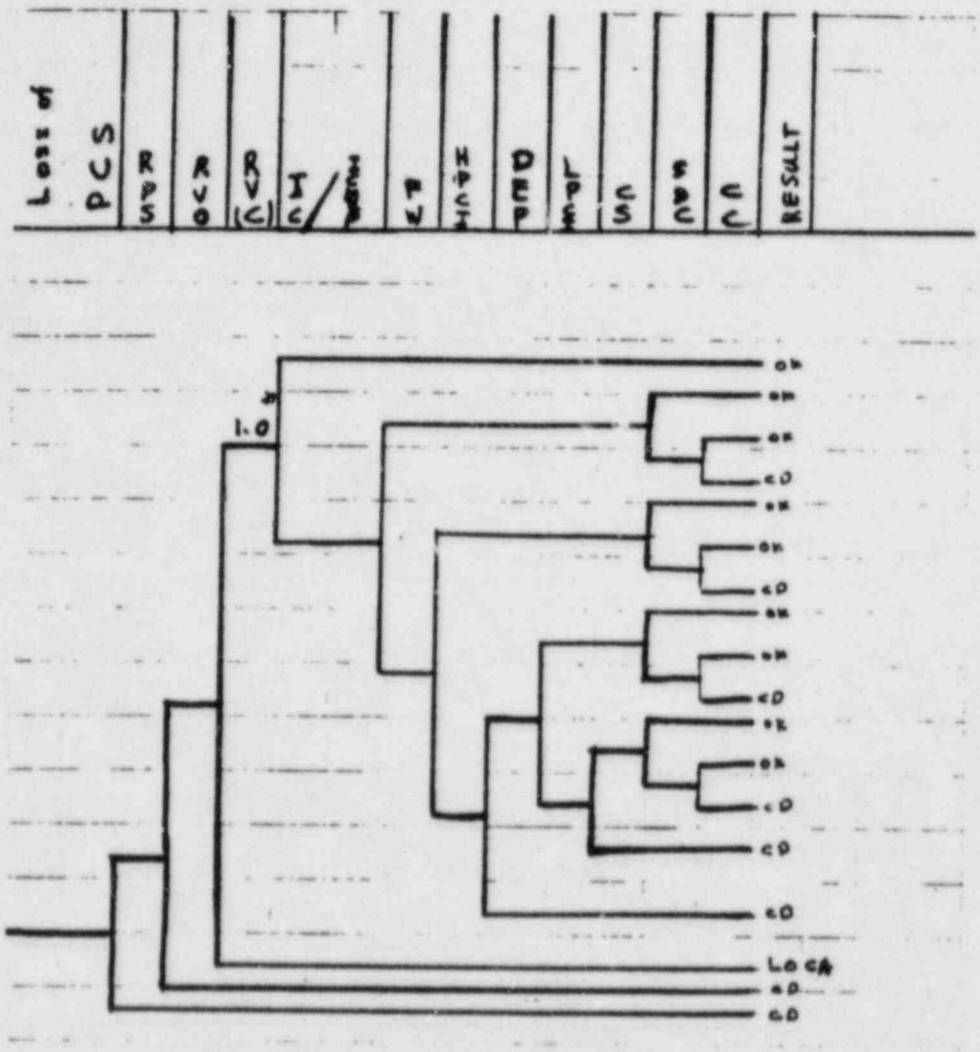


Figure 35: IREP Study Millstone 1 event tree for loss of PCS modified to apply in Category D

* Assumption of 1.0 for RV(C) success forces the event tree to represent a loss of PCS success

3) Loss of Offsite Power Event Trees

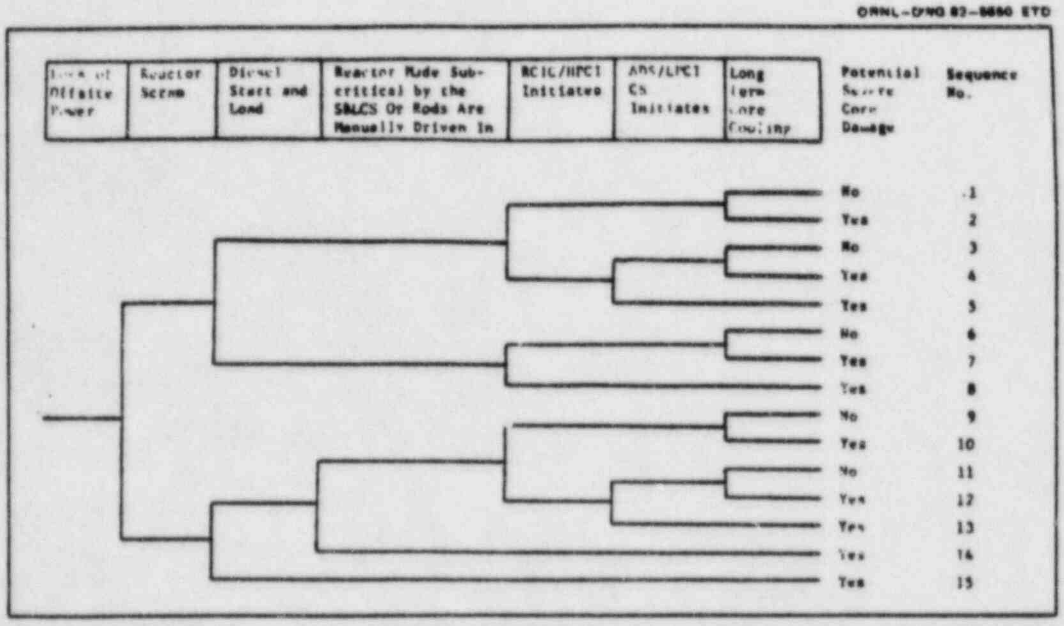


Figure 36: ASP Study Event Tree

Standard event tree for BWR loss of offsite power.

The ASP study treated the Emergency Power System as an separate system in its functional event tree for a loss of offsite power. On the contrary in the IREP Study, the function of the Emergency Power System was considered an integral part of the success or failure of the related safety systems. In this analysis we followed the ASP study approach. Thus, in addition to modifications discussed at the beginning of this section, the IREP study event trees used for the loss of offsite power events were modified further to include the Emergency Power System.

The IREP study event trees used for loss of offsite power are the event trees of figures 20 and 25.

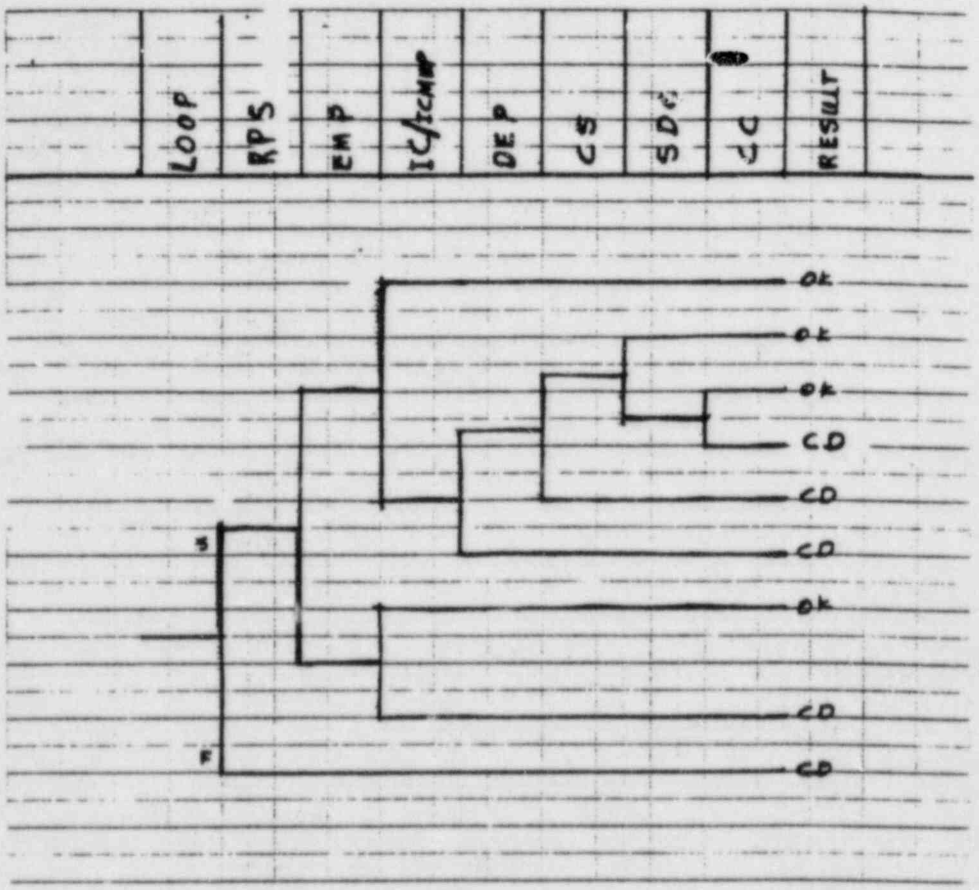


Figure 37: IREP Study Millstone 1 event tree for LOOP modified to apply in Category A1

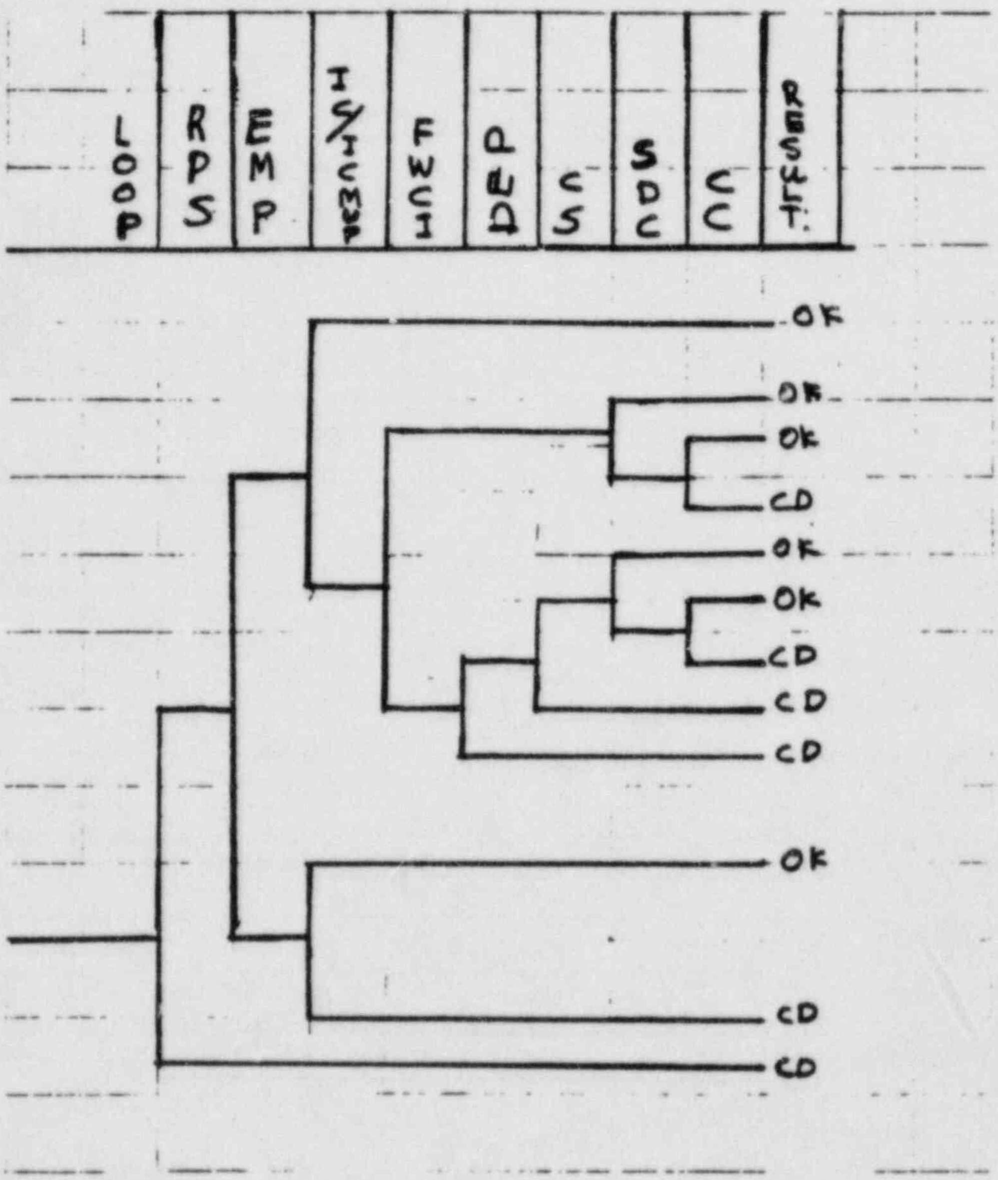


Figure 38: IREP Study Millstone 1 event tree for LOOP modified to apply in Category A2

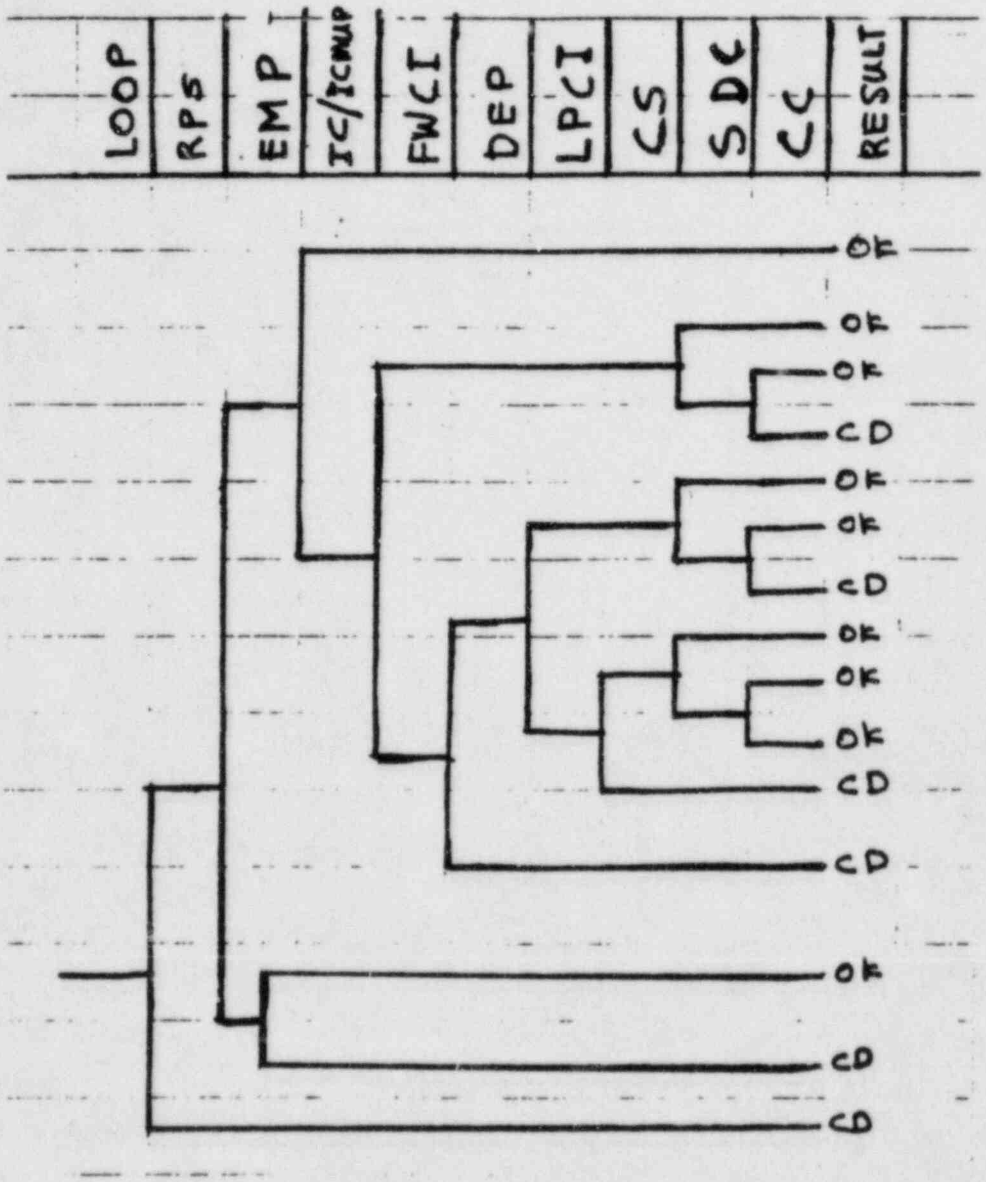


Figure 39: IREP Study Millstone 1 event tree for LOOP modified to apply in Cateogory A3

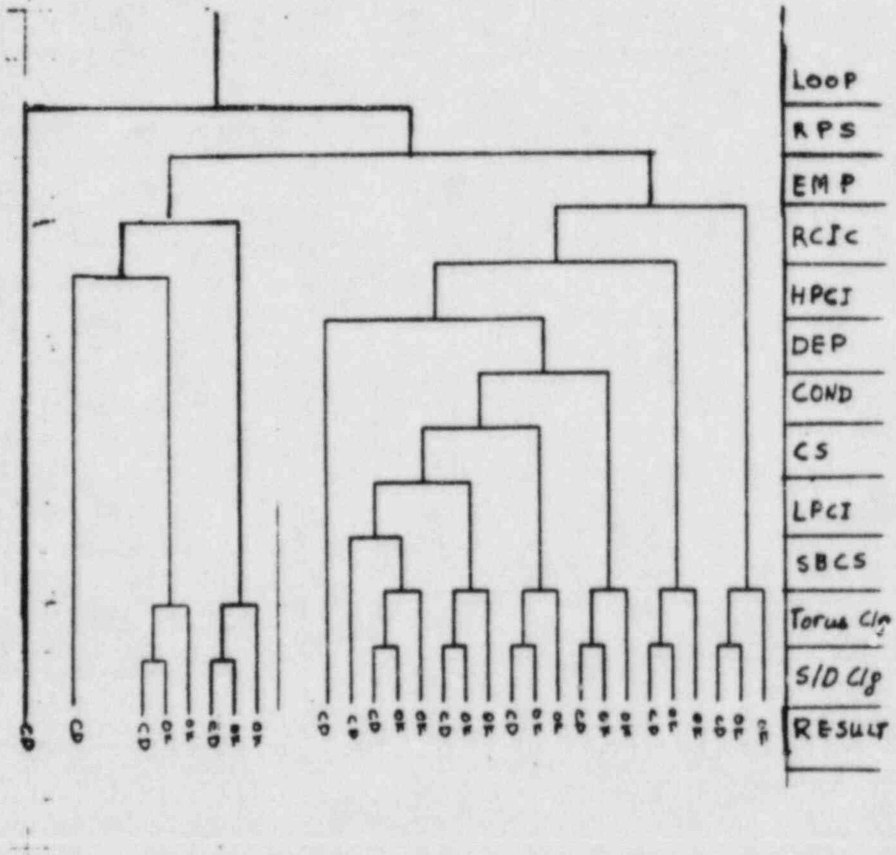


Figure 40: IREP Study Browns Ferry 1
Event Tree for LOOP modified
to apply in
Categories B and C

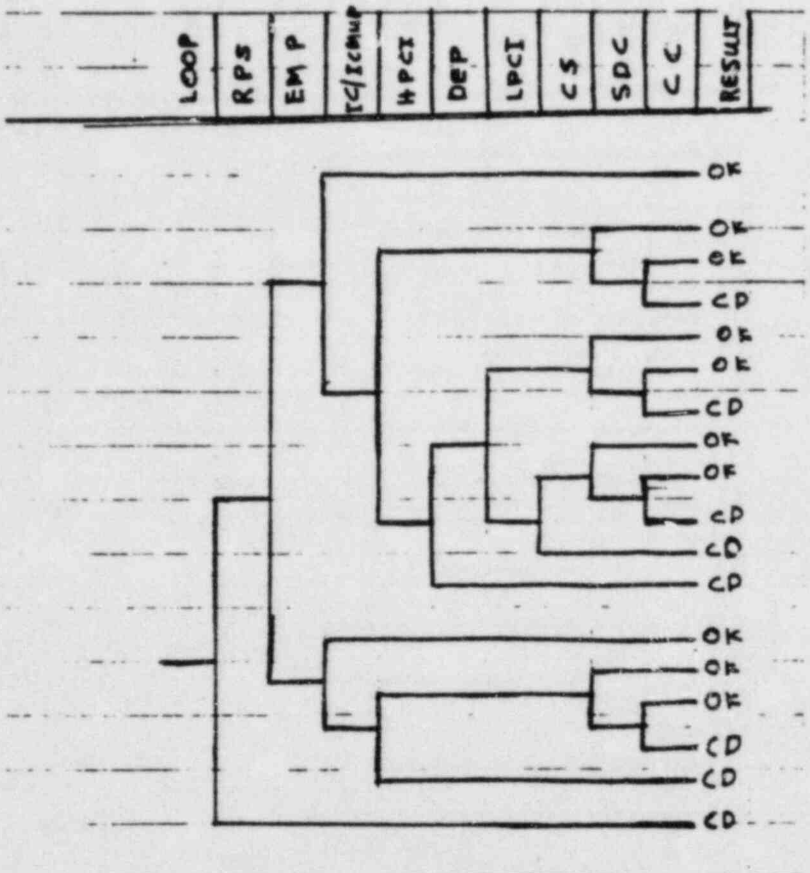


Figure 41: IREP Study Millstone 1 event tree for LOOP modified to apply in Category D

Small LOCA Event Trees

All of the BWR small LOCA events in the ASP report are stuck open relief valve events. In the IREP study for Millstone 1 plant, the stuck open relief valve event was treated separately and the corresponding event tree was used in this analysis for the small LOCA initiators at categories A and D. On the other hand, the IREP study for Browns Ferry 1 plant treated the stuck open relief valve event as part of the small steam line event. The corresponding event tree was modified in this analysis by omitting the vapor suppression system availability since this system consists of a set of relief valves.

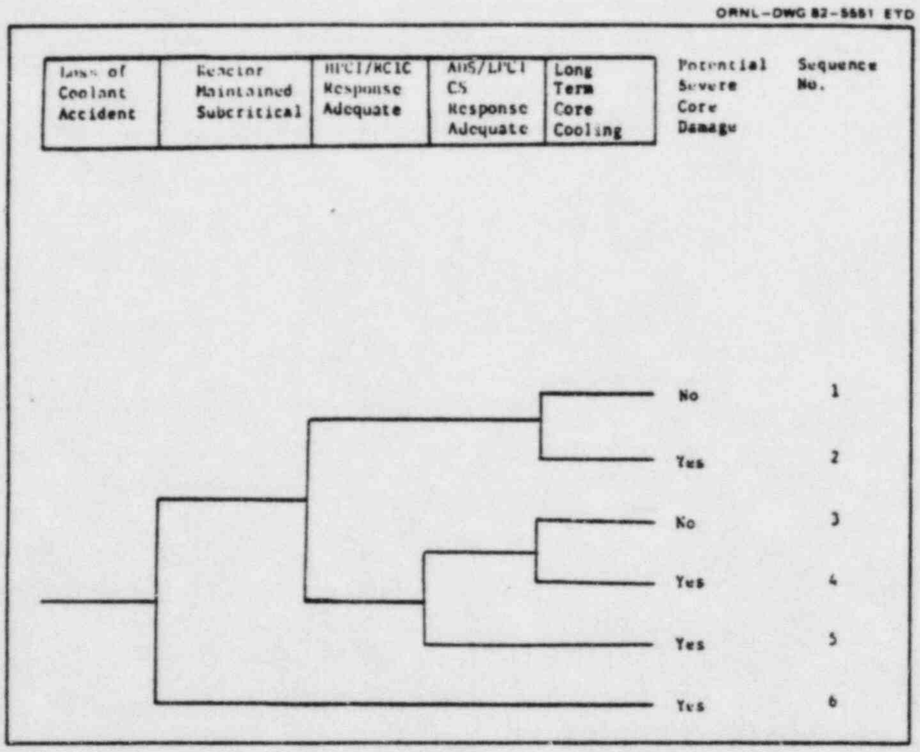
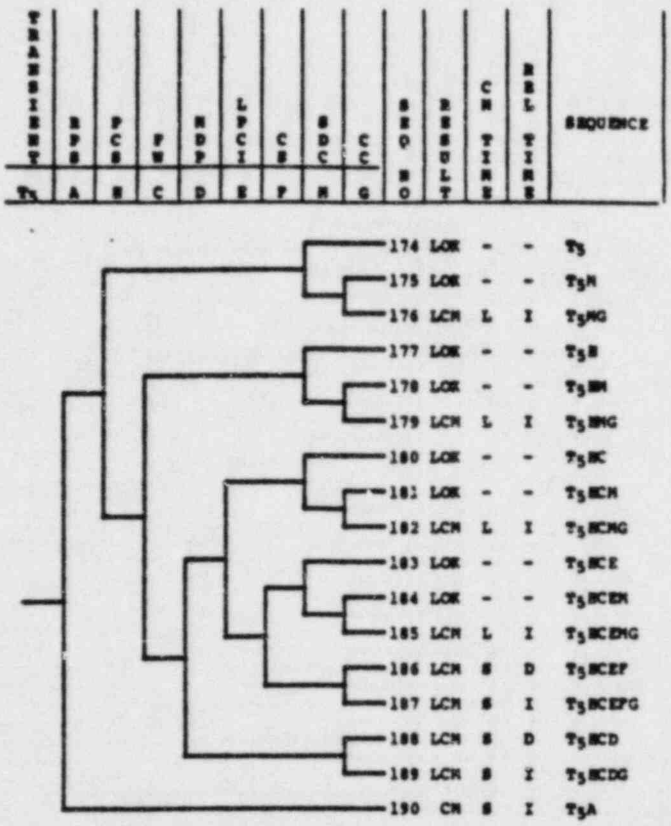


Figure 42: ASP Event Tree for Loss of Coolant Accident



LEGEND:

RESULT

OK = NON CORE MELT
CM = CORE MELT
LOK = TRANSIENT INDUCED LOCA NON CORE MELT
LCM = TRANSIENT INDUCED LOCA CORE MELT

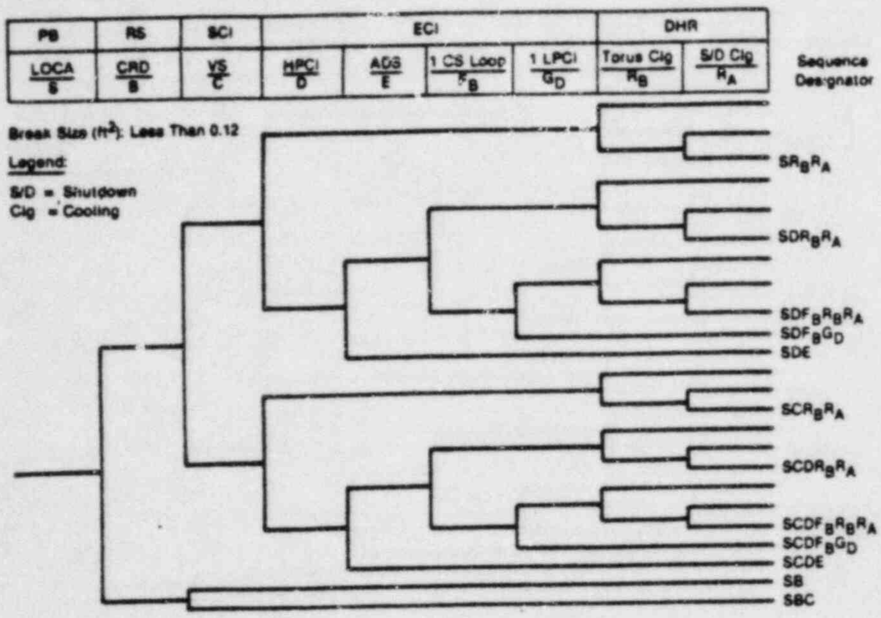
CM TIME

L = LONG (> 20 HOURS)
M = MODERATE (> 3 HOURS)
S = SHORT (< 3 HOURS)

REL TIME

I = IMMEDIATE
D = DELAYED

Figure 43: IREP Study Millstone 1 Event Tree Safety Relief Valve (Inadvertent Opening) (T_5)



X = Function failure

RS	SCI	ECI	DHR	Remarks
				Core cooled
				Core cooled
			X	Slow melt
				Core cooled
				Core cooled
			X	Slow melt
				Core cooled
				Core cooled
			X	Slow melt
		X	N/A	Melt
		X	N/A	Melt
	X			Core cooled
	X			Core cooled
	X		X	Slow melt
	X			Core cooled
	X			Core cooled
	X		X	Slow melt
	X			Core cooled
	X			Core cooled
	X		X	Slow melt
	X	X	N/A	Melt
	X	X	N/A	Melt
X		N/A	N/A	Melt
X	X	N/A	N/A	Melt

INEL 2 1636

Figure 44: IREP Study Browns Ferry 1
Event Tree for small liquid-line or steam-line break (S).

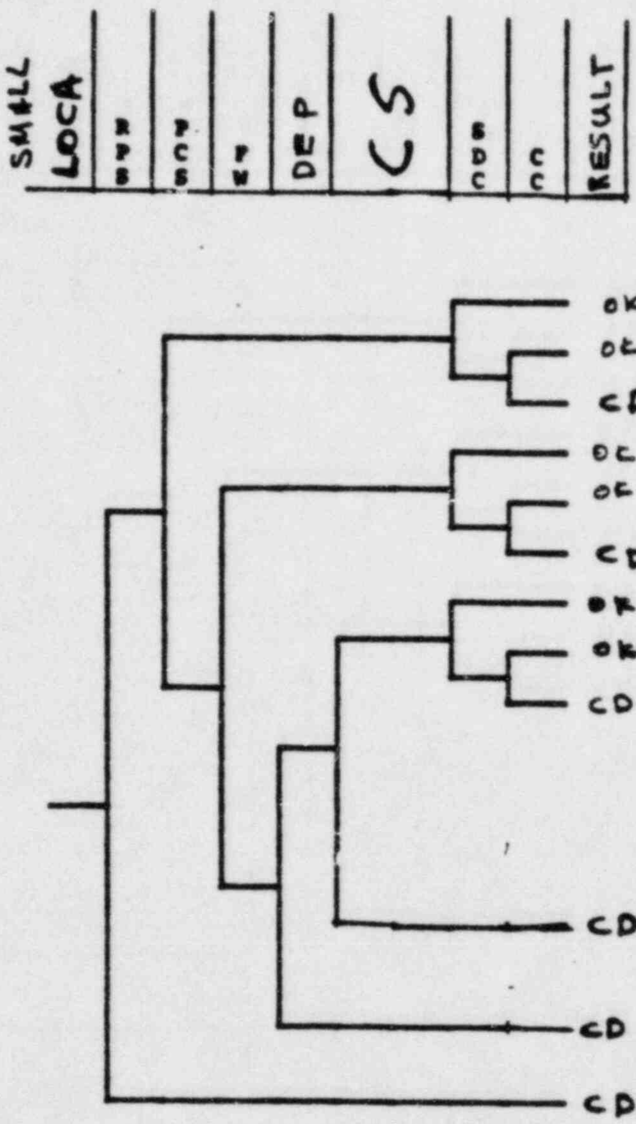


Figure 45: IREP Study Millstone 1 event tree for small LOCA modified to apply in Categories A1 and A2

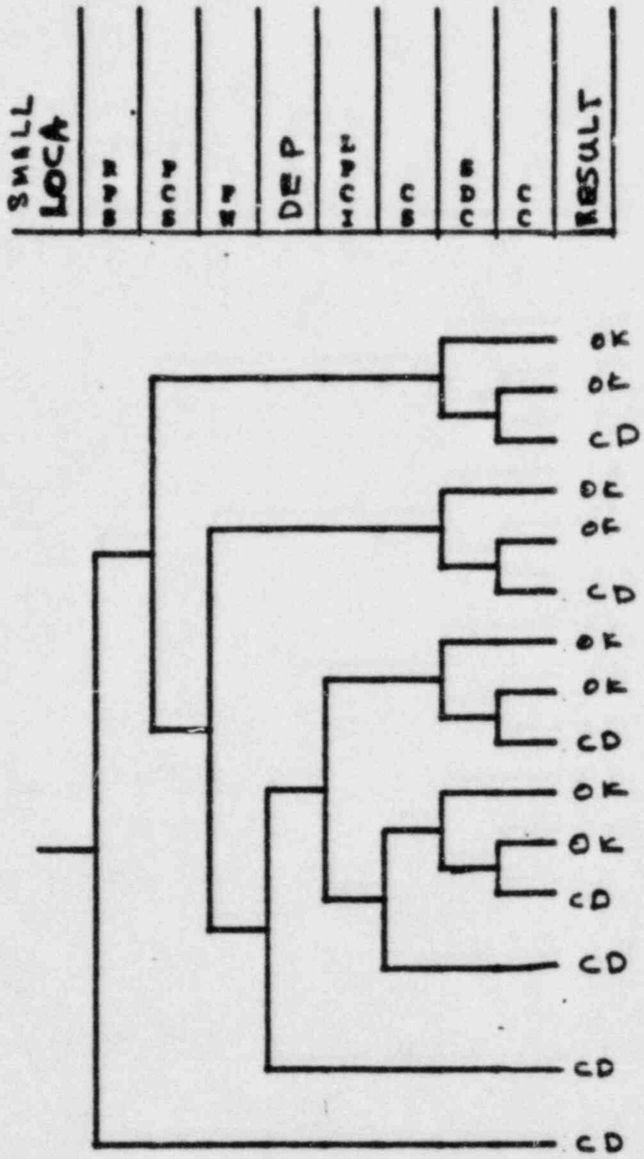


Figure 46: IREP Study Millstone 1 Event Tree for small LOCA applied in Category A3

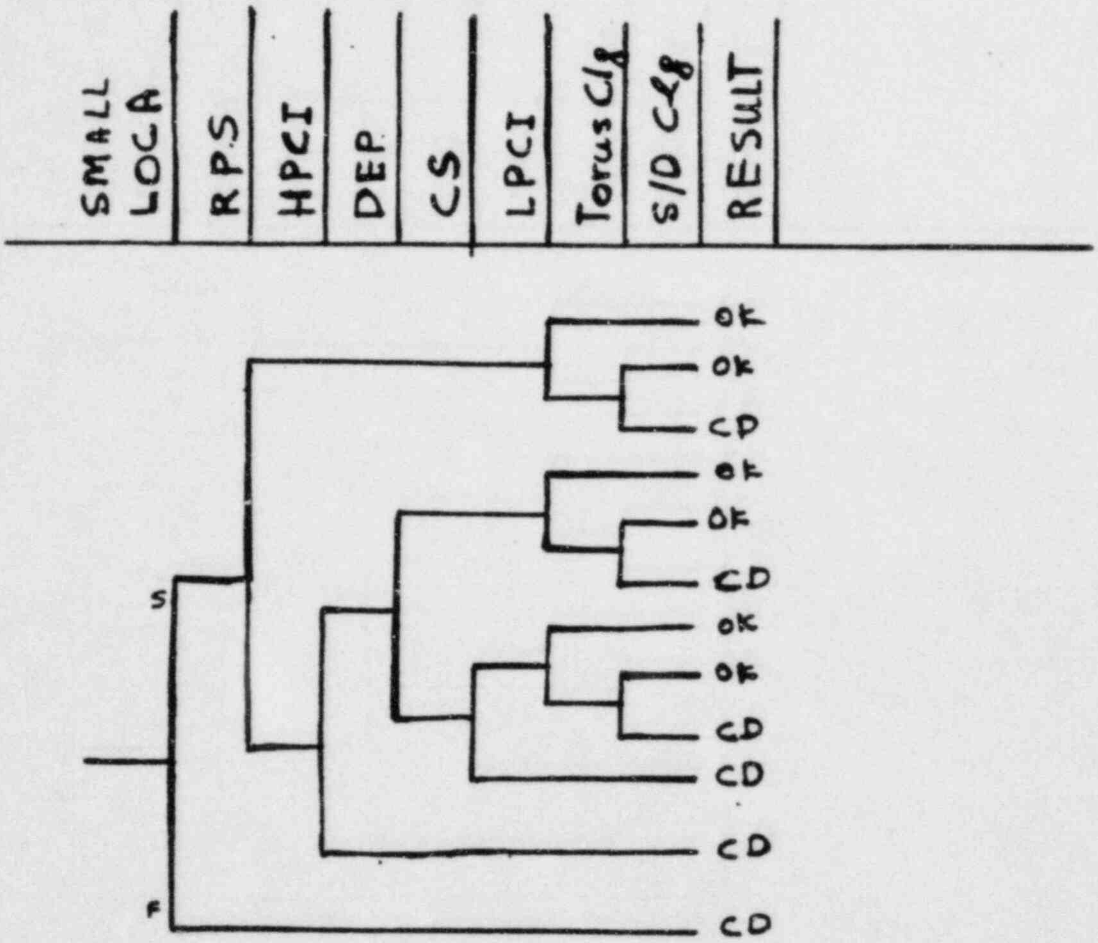


Figure 47: IREP Study Browns Ferry 1 Event Tree for small LOCA modified to apply in Category B

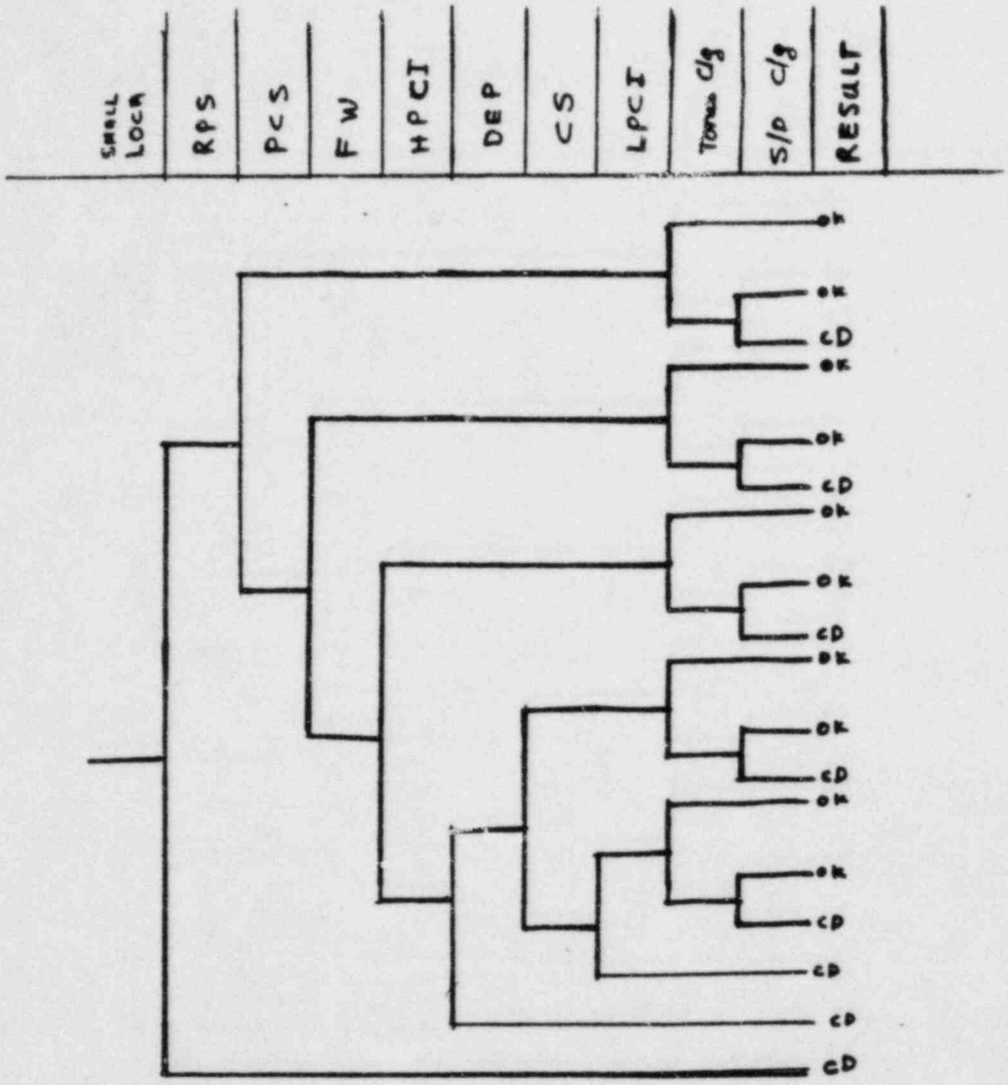


Figure 48: IREP Study Browns Ferry 1 Event Tree for small LOCA modified to apply in Category C

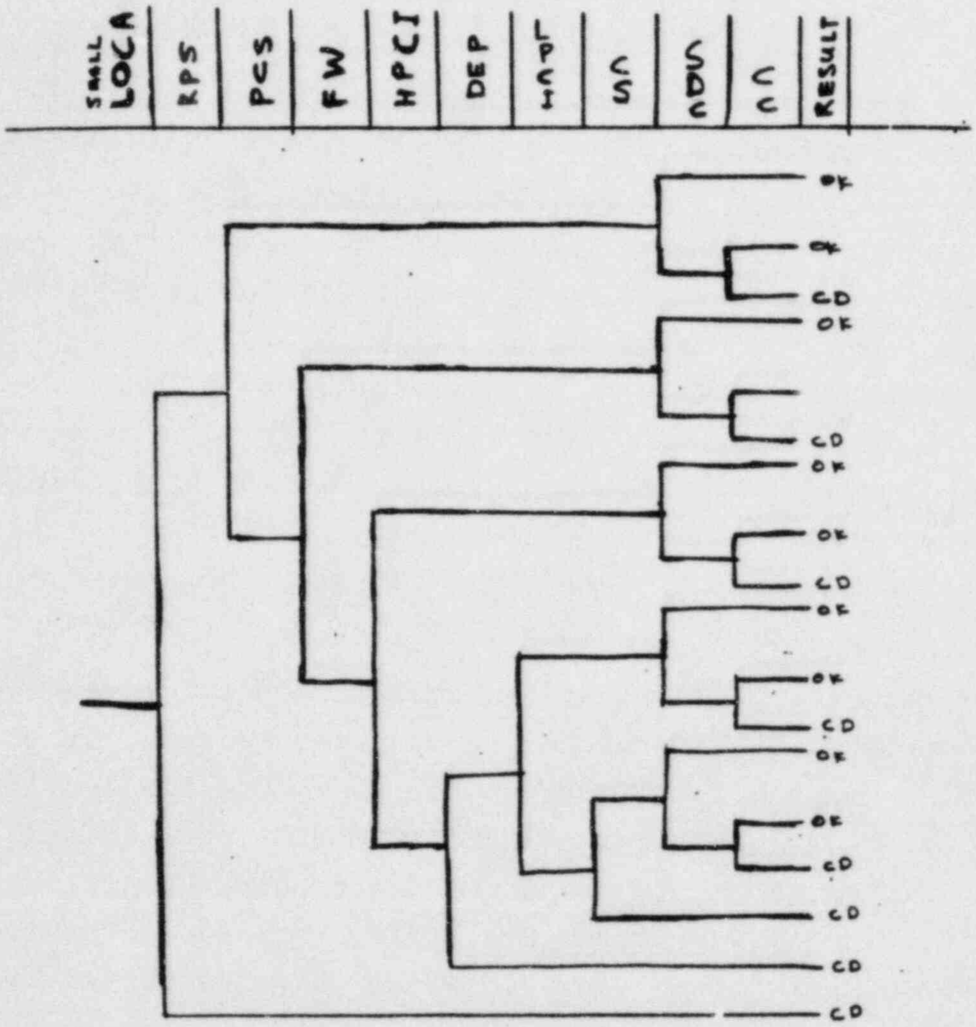


Figure 49: IREP Study Millstone 1 Event Tree for small LOCA modified to apply to in Category D

4.0 Numerical Analysis

4.1 Precursor Event Frequency and System Unavailability Data

The category specific precursor event frequencies were estimated according to the number of events and number of reactor years in each category. The ASP report data was used to calculate failure probabilities. If no system failures occured in a precursor belonging to a specific category while there were system failures in other categories, the 50% χ^2 - value for zero failures was used. Frequencies for LOFW and MSLB initiators were not categorized, the former because LOFW events are not reportable in LER and therefore the ASP study did not have complete data, and the latter because there was no MSLB initiator in the ASP data for BWR's. For both cases the ASP study point estimates were utilized for all categories.

Sufficient data was available to compute category specific unavailability for the Emergency Power System. Likewise, isolation condenser unavailability was computed from ASP data. Furthermore, it was observed that the RCIC/HPCI unavailability estimation was fitted in the categories B and C which have these systems and this estimate was used. Similarly, the ASP HPCI unavailability for LOCA estimation was used where only HPCI unavailability is needed.

All of the data for ADS unavailability estimation in the ASP report corresponds to plants of Category C. But the ASP estimate of $0.27/_D$ is close to $0.3/_D$ that both the MIllstone-1 and Browns Ferry 1 IREP studies used. Hence, the ASP estimate for ADS failure was used for all categories. For the rest of the Safety Systems, there was no data in the ASP report. The sources used for the corresponding unavailabilities are listed in Table 2.

In analyzing the precursors, no changes were made in the recovery factors of the ASP report. It is beyond the scope of this analysis to calculate more accurate recovery factors. In actuality it was not desirable to change them, since one of the objectives of this analysis is to determine the impact of the plant specific calculation on the results of the ASP study. Since the safety systems are grouped in the ASP event trees, the recovery factors were assigned to groups of systems. In applying the recovery factors per safety system, care was taken so the end result, would be the same with the corresponding ASP recovery factor. For example, in the ASP report for NSlC 153810 (Loss of feedwater event), the RCIC/HPCI system is failed with a recovery factor of .1 in the ASP report. The actual occurence was: HPCI was unavailable due to maintenance, the RCIC turbine trip was manually reset and them put into operation. This in this analysis for this event, the recovery factor .1 was assigned to RCIC and factor of 1.0 to HPCI.

4.2 Frequency Calculations

For each of the seven plant categories identified in this study, the generalized tree representing the LOCA, LOOP and LOFW events were modeled and discussed in Chapter III. The generalized trees for the 21 cases considered in this study (7 categories x 3 event types) are presented in Table 2.

Subsequently, specific NSIC events were considered and the generalized trees and function data were modified to reflect the specific events that occured.

To cite one example illustrating this procedure, consider NSIC 106616. To reflect this Category A1 LOOP event, the category specific event tree is modified as follows:

- o The initiator (the leading constant in the equation) is set to 0.5. Since the initiating events was part of the precursor.

TABLE 2

LOSS OF FUNCTION PROBABILITIES AND INITIATING EVENT FREQUENCIES

Category	A1	A2	A3	B	C	D	Source
LOFW	0.58	0.58	0.58	0.58	0.58	0.58	ASP
LOOP	$4x10^{-2}$	$4x10^{-2}$	$4x10^{-2}$	$21x10^{-2}$	$5.4x10^{-2}$	$3.66x10^{-2}$	This Study
LOCA	$3.17x10^{-2}$	$3.17x10^{-2}$	$3.17x10^{-2}$	$2.1x10^{-2}$	$2.17x10^{-3}$	$3.66x10^{-2}$	This Study
MSLB	$1.0x10^{-4}$	$1.0x10^{-4}$	$1.0x10^{-4}$	$1.0x10^{-4}$	$1.0x10^{-4}$	$1.0x10^{-4}$	ASP
RPS	$1.3x10^{-6}$	$1.3x10^{-6}$	$1.3x10^{-6}$	$1.3x10^{-6}$	$1.3x10^{-6}$	$1.3x10^{-6}$	ASP
EP	$1.98x10^{-3}$	$1.98x10^{-3}$	$1.98x10^{-3}$	$1.5x10^{-2}$	$3.6x10^{-3}$	$2.43x10^{-2}$	This Study
FW	0.02	0.02	0.02	-	0.02	0.02	Millstone-1 IREP
IC	$4.4x10^{-3}$	$4.4x10^{-3}$	$4.4x10^{-3}$	-	-	$4.4x10^{-3}$	This Study
FWCI	-	$1.3x10^{-2}$	$1.3x10^{-2}$	-	-	-	NUREG/CR-3226
HPCI	-	-	-	$5.7x10^{-2}$	$5.7x10^{-2}$	$5.7x10^{-2}$	ASP
LPCI	-	-	$7.0x10^{-3}$	-	-	$7.0x10^{-3}$	NUREG/CR-3226
CS	$6.0x10^{-4}$	$6.0x10^{-4}$	$6.0x10^{-4}$	-	-	$6.0x10^{-4}$	NUREG/CR-3226
SDC	$2.2x10^{-2}$	$2.2x10^{-2}$	$2.2x10^{-2}$	-	-	$2.2x10^{-2}$	NUREG/CR-3226
CC	$9.5x10^{-3}$	$9.5x10^{-3}$	$9.5x10^{-3}$	-	-	$9.5x10^{-3}$	NUREG/CR-3226
RCIC/HPCI	-	-	-	$3.9x10^{-3}$	$3.9x10^{-3}$	-	ASP
DEP	$2.7x10^{-2}$	$2.7x10^{-2}$	$2.7x10^{-2}$	$2.7x10^{-2}$	$2.7x10^{-2}$	$2.7x10^{-2}$	ASP
COND	-	-	-	$7.0x10^{-3}$	$7.0x10^{-3}$	-	Browns Ferry IREP
CS	-	-	-	$6.6x10^{-3}$ NP $9.6x10^{-3}$ LOOP	$6.6x10^{-3}$ NP $9.6x10^{-3}$ LOOP	-	Browns Ferry IREP
LPCI	-	-	-	$1.1x10^{-4}$ NP $2.7x10^{-4}$ LOOP	$1.1x10^{-4}$ NP $2.7x10^{-4}$ LOOP	- -	Browns Ferry IREP
SBCS	-	-	-	$4.2x10^{-2}$ NP $4.6x10^{-2}$ LOOP	$4.2x10^{-2}$ NP $4.6x10^{-2}$ LOOP	- -	Browns Ferry IREP
THRUS CLG.	-	-	-	$3.1x10^{-3}$ NP $7.2x10^{-3}$ LOOP	$3.1x10^{-3}$ NP $7.2x10^{-3}$ LOOP	- -	Browns Ferry IREP
S/D CLG.	-	-	-	$2.0x10^{-2}$ NP $4.2x10^{-2}$ LOOP	$2.0x10^{-2}$ NP $4.2x10^{-2}$ LOOP	- -	Browns Ferry IREP
PCS	0.1	0.1	0.1	-	0.1	0.1	Millstone-1 IREP

Table 4

Reactor Years by Plant Category

Category	Reactor Years	% of Total
A1	21.5	11.57
A2	21	11.31
A3	20.5	11.04
B	46.83	25.21
C	46.02	24.78
D	18.9	10.17
E	11.0	5.92
TOTAL	185.75	

- The HPCI function failure is set to 1 to represent failures, since HPCI failed in the precursor.

A total of 19 significant precursor events from the ASP study were considered, yielding a total of more than 200 specific event trees for the 7 plant categories (A1, A2, A3, B, C, D, and E) and the 3 event types (LOCA, LOOP, and LOFW).

The specific event trees were then used to estimate the conditional probability of core damage and the total frequency of core damage (per reactor year) for BWR's only. In addition, the trees were grouped to analyze the 7 plant categories separately and, as a final case, all trees were grouped to yield overall estimates of core damage.

Two techniques of weighting the core damage probability based upon the number of reactor years per plant category were examined. In the first (referred to as Method I) the core damage conditional probability for each plant category i was weighted by RY_i / RY_T where RY_i is the number of reactor years for that plant category and RY_T is the total number of reactor years for all plants for which the NSIC event would occur. The reactor years by plant category (for all plants in the category) is given in Table 4. The frequency of severe core damage was estimated by dividing the weighted conditional probability by the total of 185.75 BWR reactor years.

In the second technique, (referred to as Method II), the frequency of severe core damage was directly estimated by dividing the conditional probability for each plant category i by RY_i; the number of reactor years in that category. In this case only precursors that actually happened in each category were considered.

TABLE 5

METHOD I RESULTS

NSIC #	CAT A1	CAT A2	CAT A3	CAT B	CAT C	CAT D	CAT E	TOTAL	ASP ESTIMATE Pacd	ASP ESTIMATE FREQUENCY	DIFFERENCE
61434	4.64×10^{-6}	3.88×10^{-7}	3.78×10^{-7}	3.21×10^{-7}	2.84×10^{-7}	4.32×10^{-7}	2.58×10^{-6}	9.03×10^{-6}	8.8×10^{-3}	4.73×10^{-5}	5.24
63129	4.12×10^{-8}	3.81×10^{-9}	3.71×10^{-9}	3.21×10^{-7}	2.84×10^{-7}	4.15×10^{-9}	5.14×10^{-6}	5.80×10^{-6}	1.8×10^{-2}	9.69×10^{-5}	16.7
66996	6.08×10^{-7}	5.94×10^{-7}	5.73×10^{-7}	2.18×10^{-6}	2.10×10^{-7}	2.49×10^{-7}	5.28×10^{-7}	4.94×10^{-6}	1.8×10^{-3}	9.69×10^{-6}	1.96
77916	6.08×10^{-7}	5.94×10^{-7}	5.73×10^{-7}	2.18×10^{-6}	2.10×10^{-7}	2.49×10^{-7}	5.28×10^{-7}	4.94×10^{-6}	2.1×10^{-4}	1.13×10^{-6}	-4.37
79565	4.12×10^{-8}	3.81×10^{-9}	3.71×10^{-9}	1.33×10^{-6}	1.01×10^{-6}	3.6×10^{-8}	9.83×10^{-7}	3.41×10^{-6}	6.8×10^{-4}	3.66×10^{-6}	1.07
85566	4.12×10^{-8}	8.17×10^{-9}	7.87×10^{-9}	4.54×10^{-5}	2.84×10^{-7}	4.15×10^{-9}	9.91×10^{-7}	4.67×10^{-5}	3.1×10^{-3}	1.67×10^{-5}	-2.80
85738	7.71×10^{-8}	7.53×10^{-8}	7.19×10^{-8}	3.95×10^{-6}	3.88×10^{-6}	7.82×10^{-9}	1.08×10^{-6}	9.14×10^{-6}	3.4×10^{-3}	1.83×10^{-5}	2.00
101444	3.50×10^{-5}	3.42×10^{-5}	3.34×10^{-5}	5.63×10^{-4}	1.42×10^{-4}	3.08×10^{-5}	1.25×10^{-4}	9.63×10^{-4}	0.39	2.1×10^{-3}	2.18
103002	6.08×20^{-7}	5.94×10^{-7}	5.73×10^{-7}	3.44×10^{-5}	8.94×10^{-6}	4.02×10^{-7}	5.26×10^{-6}	5.08×10^{-5}	2.4×10^{-3}	1.29×10^{-5}	-3.94
105540	6.08×10^{-8}	5.94×10^{-8}	5.73×10^{-8}	2.18×10^{-7}	2.10×10^{-8}	2.49×10^{-8}	5.28×10^{-8}	4.94×10^{-7}	1.7×10^{-4}	9.15×10^{-7}	1.85
106616	9.26×10^{-6}	1.77×10^{-6}	1.70×10^{-6}	3.21×10^{-7}	2.84×10^{-7}	8.63×10^{-7}	2.97×10^{-7}	1.45×10^{-5}	9.3×10^{-4}	5.00×10^{-6}	-2.90
115870	9.64×10^{-7}	8.83×10^{-7}	8.61×10^{-7}	2.67×10^{-6}	1.83×10^{-6}	5.13×10^{-8}	1.99×10^{-6}	9.25×10^{-6} *	1.6×10^{-3}	1.15×10^{-5}	1.24
116780	1.06×10^{-7}	N/A	6.30×10^{-7}	5.34×10^{-7}	5.34×10^{-7}	N/A	N/A	1.80×10^{-6}	1.6×10^{-3}	8.61×10^{-6}	4.79
120443	9.64×10^{-7}	8.83×10^{-7}	8.61×10^{-7}	2.67×10^{-6}	1.83×10^{-6}	5.13×10^{-8}	1.99×10^{-6}	9.25×10^{-6} *	1.6×10^{-3}	1.15×10^{-5}	1.24
124222	9.64×10^{-7}	8.83×10^{-7}	8.61×10^{-7}	2.67×10^{-6}	1.83×10^{-6}	5.13×10^{-8}	1.99×10^{-6}	9.25×10^{-6} *	1.8×10^{-3}	1.15×10^{-5}	1.24
128569	1.79×10^{-7}	1.75×10^{-7}	1.70×10^{-7}	2.18×10^{-6}	9.70×10^{-8}	1.29×10^{-7}	5.28×10^{-7}	3.46×10^{-6}	1.4×10^{-2}	9.69×10^{-6}	2.80
128906	7.71×10^{-8}	7.53×10^{-8}	7.19×10^{-8}	1.86×10^{-5}	1.83×10^{-5}	3.42×10^{-8}	4.45×10^{-6}	4.16×10^{-5}	2.77×10^{-2}	7.54×10^{-5}	1.81
149450	1.67×10^{-5}	7.87×10^{-8}	7.18×10^{-8}	4.21×10^{-7}	4.14×10^{-7}	4.97×10^{-9}	8.84×10^{-6}	2.65×10^{-5}	1.38×10^{-2}	1.49×10^{-4}	5.62
149961	3.85×10^{-8}	3.76×20^{-8}	3.60×10^{-8}	1.85×10^{-5}	1.82×10^{-5}	3.36×10^{-8}	4.43×10^{-6}	4.13×10^{-5}	2.9×10^{-3}	7.43×10^{-5}	1.80
153810	7.71×10^{-8}	7.53×10^{-8}	7.19×10^{-8}	3.95×10^{-6}	3.88×10^{-6}	6.73×10^{-8}	9.18×10^{-7}	8.82×10^{-6}	-	1.56×10^{-5}	1.77
TOTAL	7.11×10^{-5}	4.13×10^{-5}	3.94×10^{-5}	7.05×10^{-4}	1.97×10^{-4}	3.35×10^{-5}	1.68×10^{-4}	1.25×10^{-3}	-	2.65×10^{-3}	2.12
95% Upper Bound	1.56×10^{-4}	1.02×10^{-4}	1.02×10^{-4}	1.35×10^{-3}	4.29×10^{-4}	8.45×10^{-5}	3.29×10^{-4}	2.08×10^{-3}	-	-	-
Total Excluding Browns Ferry								2.87×10^{-4}		5.53×10^{-4}	1.93

* Factor of 0.75 is not applied in this table.

5.0 Results

Table 5 summarizes the quantitative results obtained using Method I for weighting with respect to reactor years. The results for Method II are given in Table 6.

A comparison for the core damage frequency estimates by the two methods, I and II, shows that the category totals represent different types of estimates. The category totals for Method I represent fractional core damage contributions be added together to obtain an overall core damage frequency estimate. The totals for Method II, however, represent an overall core damage frequency estimate based upon the failure data for each category and thus are larger than the figures calculated in Method I. This is mainly due to small number of reactor years associated with each category.

To estimate the upper bound for the core damage frequency in Method I, the conditional core damage probabilities were summed by category A 95% binomial confidence interval was then computed for each category using the probability sum and the "N" figure for the category as determined by the Maximus reduction, Method ( ). The upper 95% confidence interval was then divided by 185.75 to yield the upper confidence interval for core damage frequency. An overall upper confidence interval was also determined by further summing all of the category probability totals and determining an overall N.

For Method II, the core damage frequency for each category was multiplied by the number of reactor years in the category to determine a conditional probability. These probabilities were then used in conjunction with the N figures from the Maximus reduction to calculate the binomial 95% upper confidence interval The upper interval figures were then divided by the number of reactor years in each category to return to a frequency estimate.

The 95% confidence interval in Method I represent approximately a factor of two increase over the base core damage contributions. Comparing the frequency estimates by category shows that Category B is the largest contributor to the overall core damage frequency estimate. The event totals indicate that the Brown's Ferry cable tray fire (NSIC 101444) is the largest contributing event. Multiplying this event's frequency by 185.75 results in a conditional probability of .179. This is approximately one-half of the .39 figure reported in the ASP study. Generally, the analysis indicates that other precursors contributions are over-estimated by an average of a factor of two.

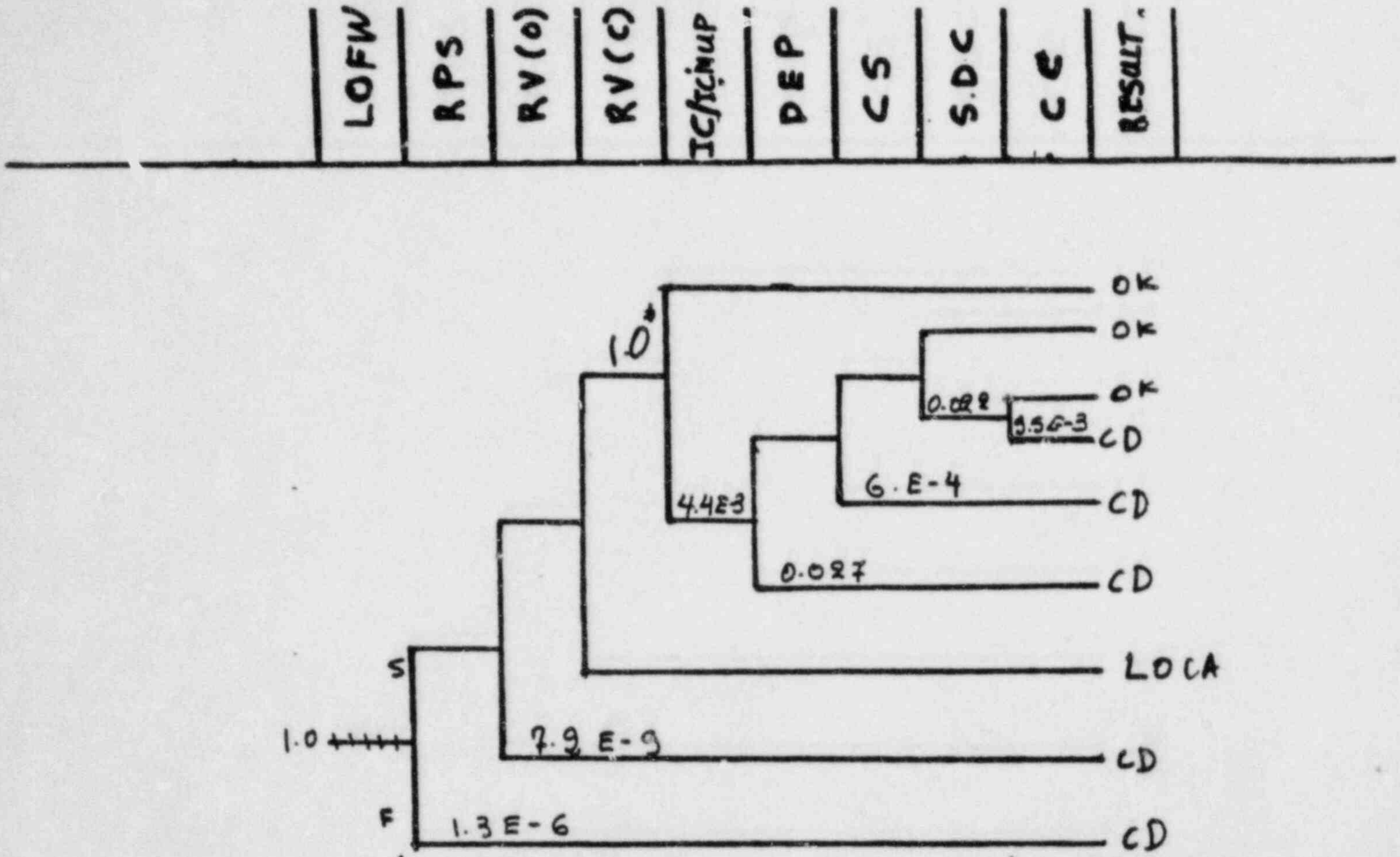
TABLE 6

METHOD II RESULTS

NSIC #	CAT A1	CAT A2	CAT A3	CAT B	CAT C	CAT D	CAT E
61434			3.10×10^{-5}				
63129							1.46×10^{-3}
69966			4.70×10^{-5}				
77916	4.54×10^{-5}						
79565					1.64×10^{-5}		
85566				7.31×10^{-3}			
85738				6.22×10^{-5}			
101444				8.86×10^{-3}			
103002				5.42×10^{-4}			
105540					3.42×10^{-7}		
106616					4.62×10^{-5}		
115870					2.98×10^{-5}		
116780			4.88×10^{-5}				
120443					2.98×10^{-5}		
124222					2.98×10^{-5}		
128569				3.43×10^{-5}			
128906				2.93×10^{-4}			
149450	1.34×10^{-3}						
149961				2.91×10^{-4}			
153810				6.22×10^{-5}			
TOTAL	1.39×10^{-3}	-0-	1.27×10^{-4}	1.15×10^{-2}	1.11×10^{-4}	-0-	1.46×10^{-3}
95% Upper Bound	1.62×10^{-3}	-0-	1.52×10^{-4}	1.18×10^{-2}	1.21×10^{-4}	-0-	1.79×10^{-3}

APPENDIX A

Precursor as they are applied on the Category Event Trees



(NSIC 85738) - Sequence of Interest for RCIC and HPCI Failures During Testing at Browns Ferry 1 Applied in CATEGORIES A1 and A2

P = 1.23 E-4

RESULT

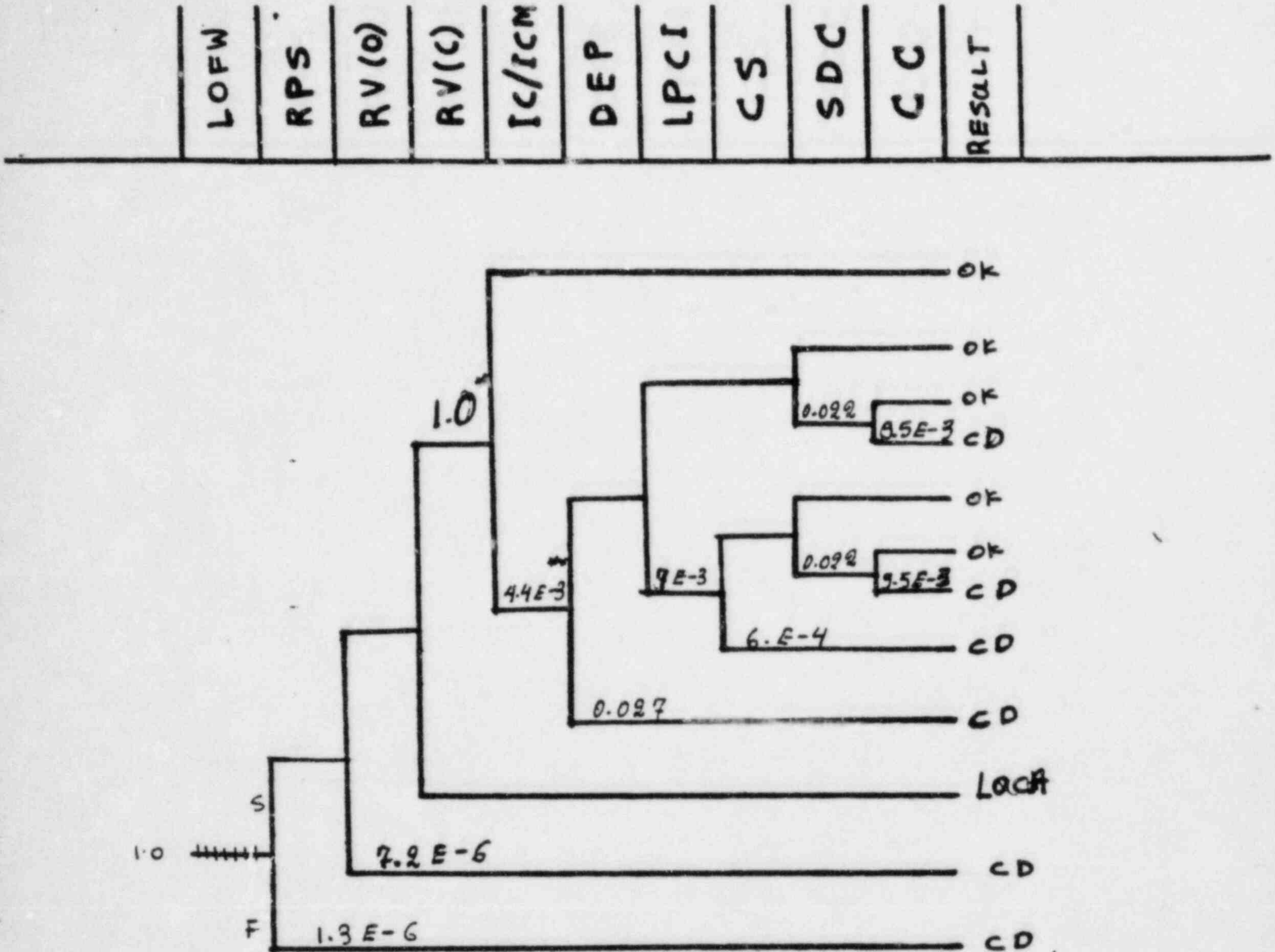
OK = NO CORE DAMAGE

CD = CORE DAMAGE

S = Success

F = Failure

* Assumption of 1.0 forces the event tree to represent a LOFW event.



(NSIC 14950) - Sequence of Interest for a Loss of Feedwater Flow at Oyester Creek applied in

CATEGORY A3

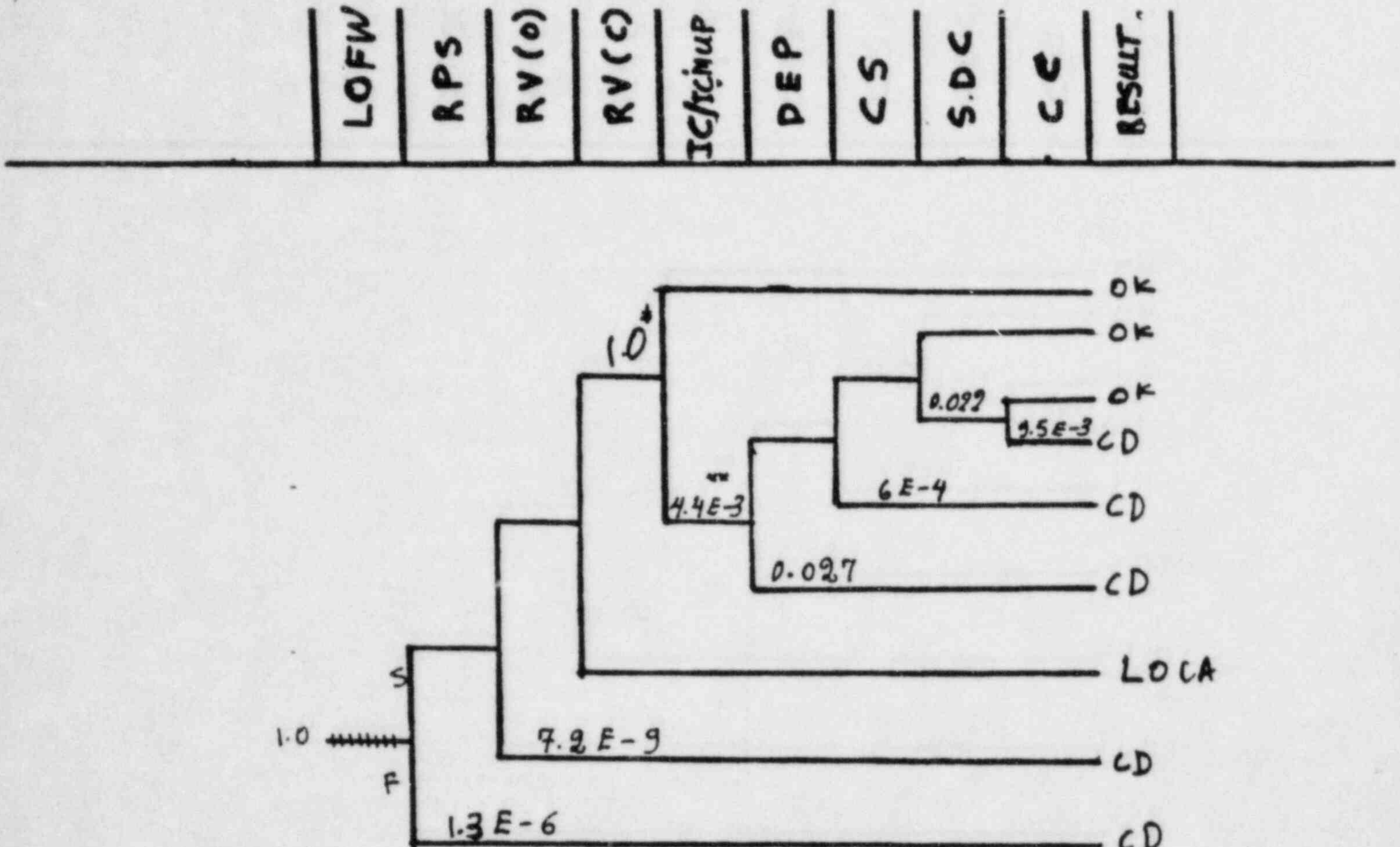
P = 1.2 E-4

RESULT
OK = NO CORE DAMAGE
CD = CORE DAMAGE

S = Success
F = Failure.

* Assumption of 1.0 forces the event tree to represent a LOFW event.

** IC failure applies at BWR plants type 2 only



(NSIC 14950) - Sequence of Interest for a Loss of Feedwater Flow at Oyster Creek applied at BIG ROCK POINT and DRESDEN I

P = 1.22 E-4

RESULT

OK = NO CORE DAMAGE

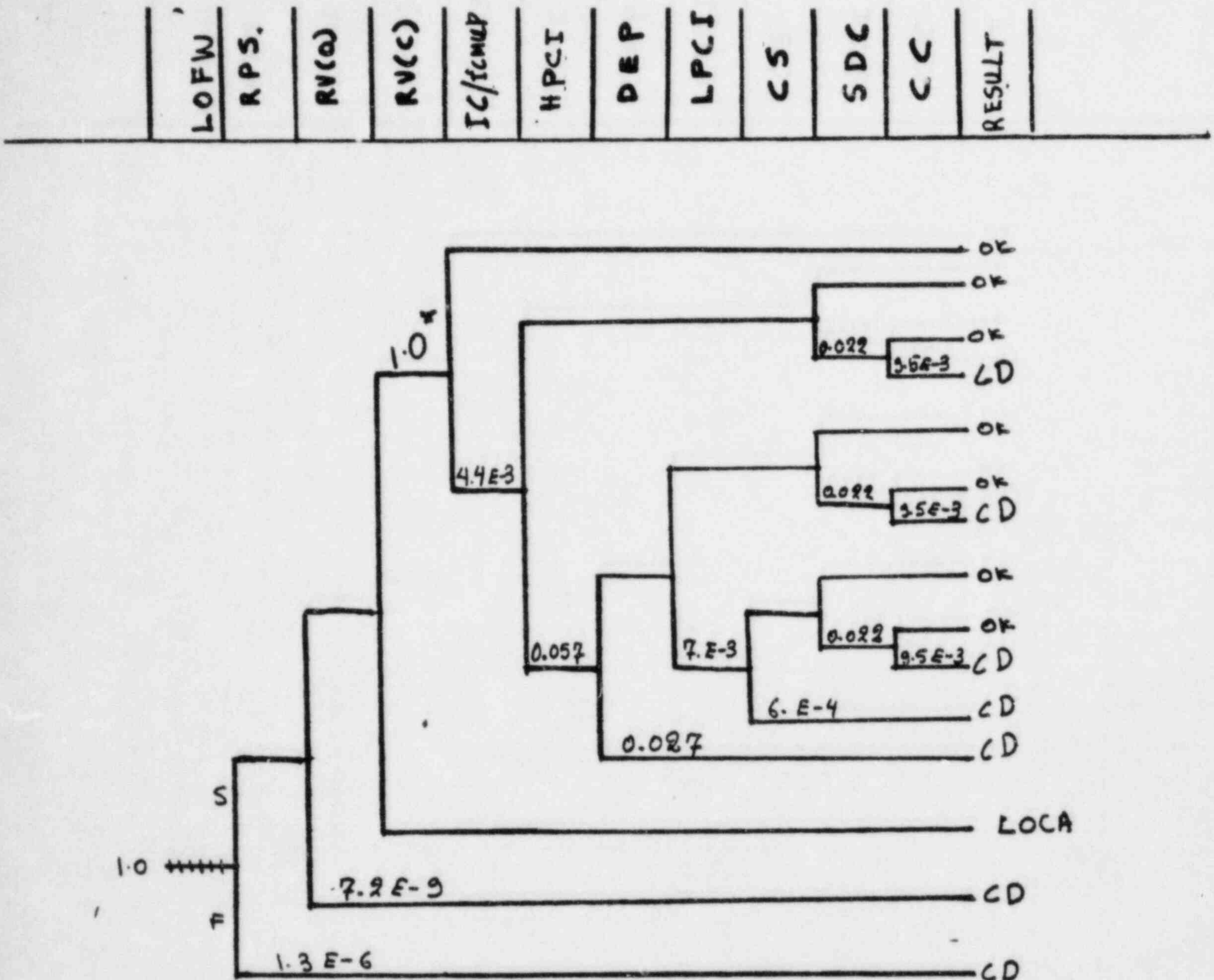
CD = CORE DAMAGE

S = Success

F = Failure

* Assumption of 1.0 forces the event tree to represent a LOFW event.

** IC failure apples only at BWR type 2 plants only



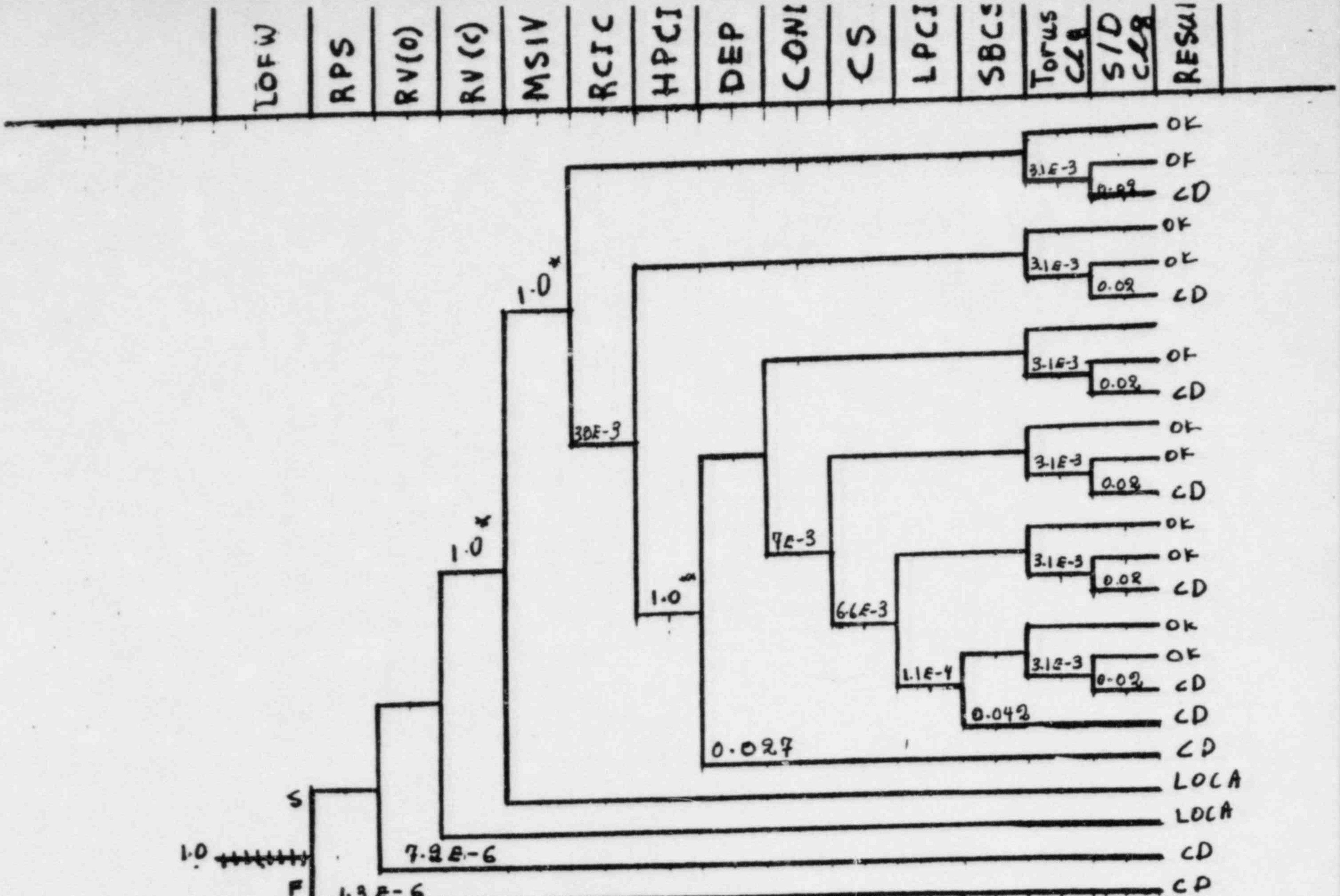
(NSIC 149450) - Sequence of Interest for a Loss of Feedwater Flow at Oyester Creek applied in <u>CATEGORY D</u>

P = 9.08E-6

<u>RESULT</u>
OK = NO CORE DAMAGE
CD = CORE DAMAGE

S = Success
F = Failure

* Assumption of 1.0 forces the event tree to represent a LOFW event.



(NSIC 149450)-Sequence of Interest for a Loss of Feedwater Flow at Oyester Creek Applied in CATEGORIES B and C

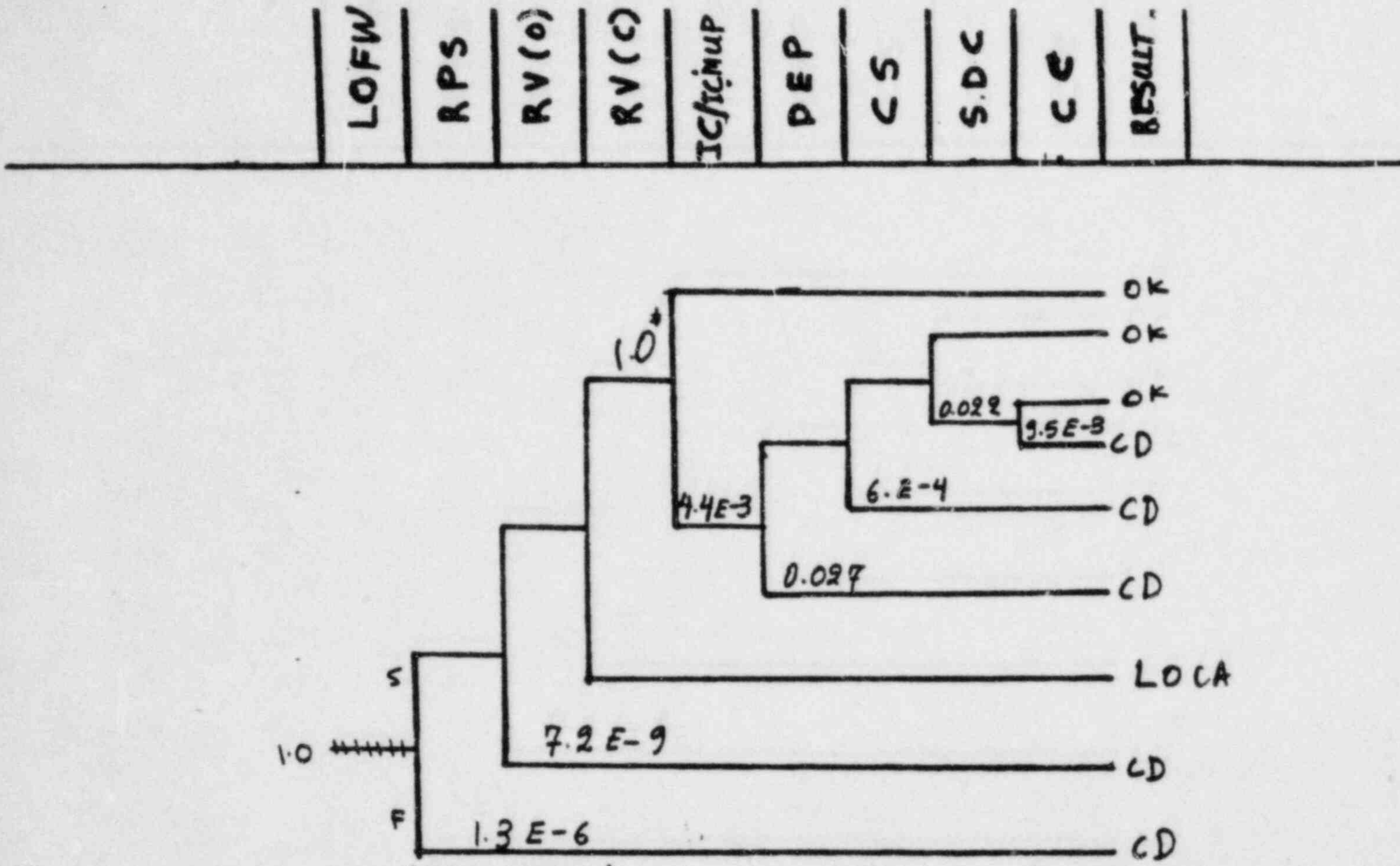
P= 3.1E-4

** Assumption of 1.0 makes the RCIC/HPCI probability equal to ASP prob.

S = Success
F = Failure

RESULT
OK = NO CORE DAMAGE
CD = CORE DAMAGE

* Assumption of 1.0 forces the event tree to represent a LOFW event



(NSIC 128906) - Sequence of Interest for No Break Power Panel De-energized at Cooper Applied in

CATEGORIES A1 and A2

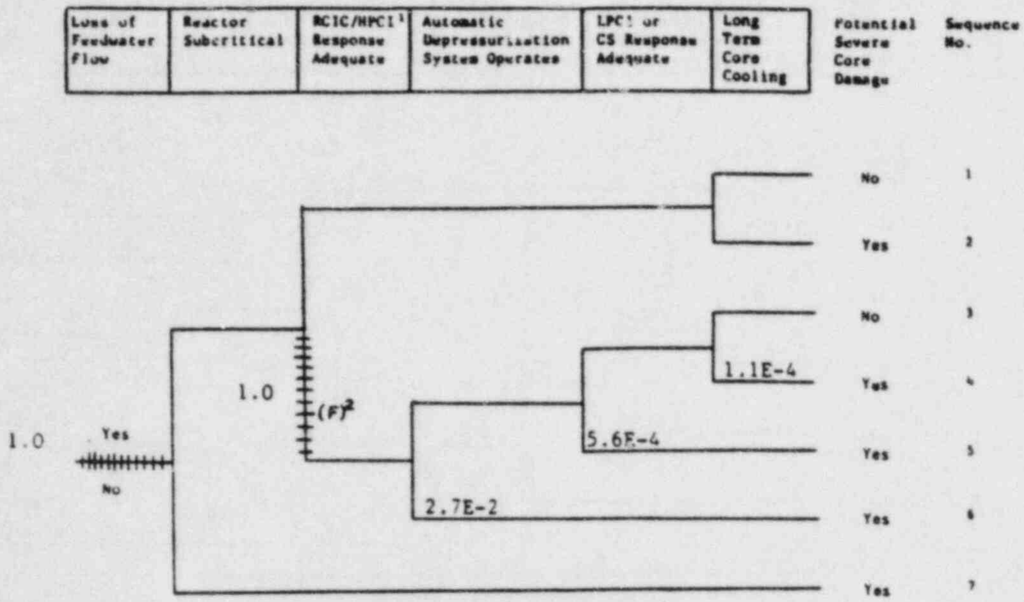
P= 1.23 E-4

RESULT

OK = NO CORE DAMAGE   S = Success

CD = CORE DAMAGE   F = Failure

* Assumption of 1.0 forces the event tree to represent a LOFW event.

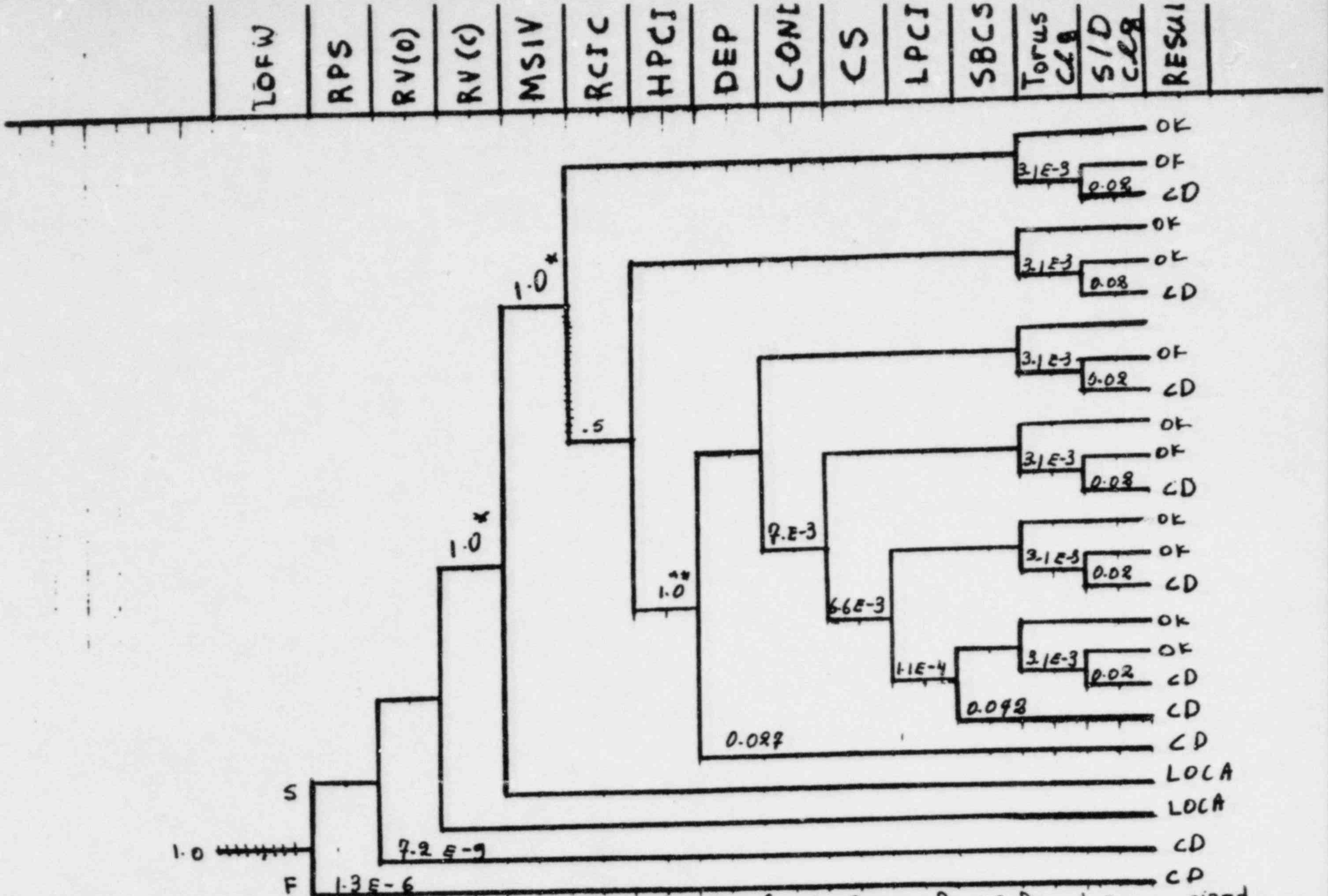


P = 2.77E-2 (SC = 16)

(NSIC 149450) Sequence of Interest for a Loss of Feedwater Flow at Oyster Creek.
applied in Category E

[1] Oyster Creek utilizes Isolation condensers rather than RCIC

[2] Success requires proper operation of either FWCT or IC.



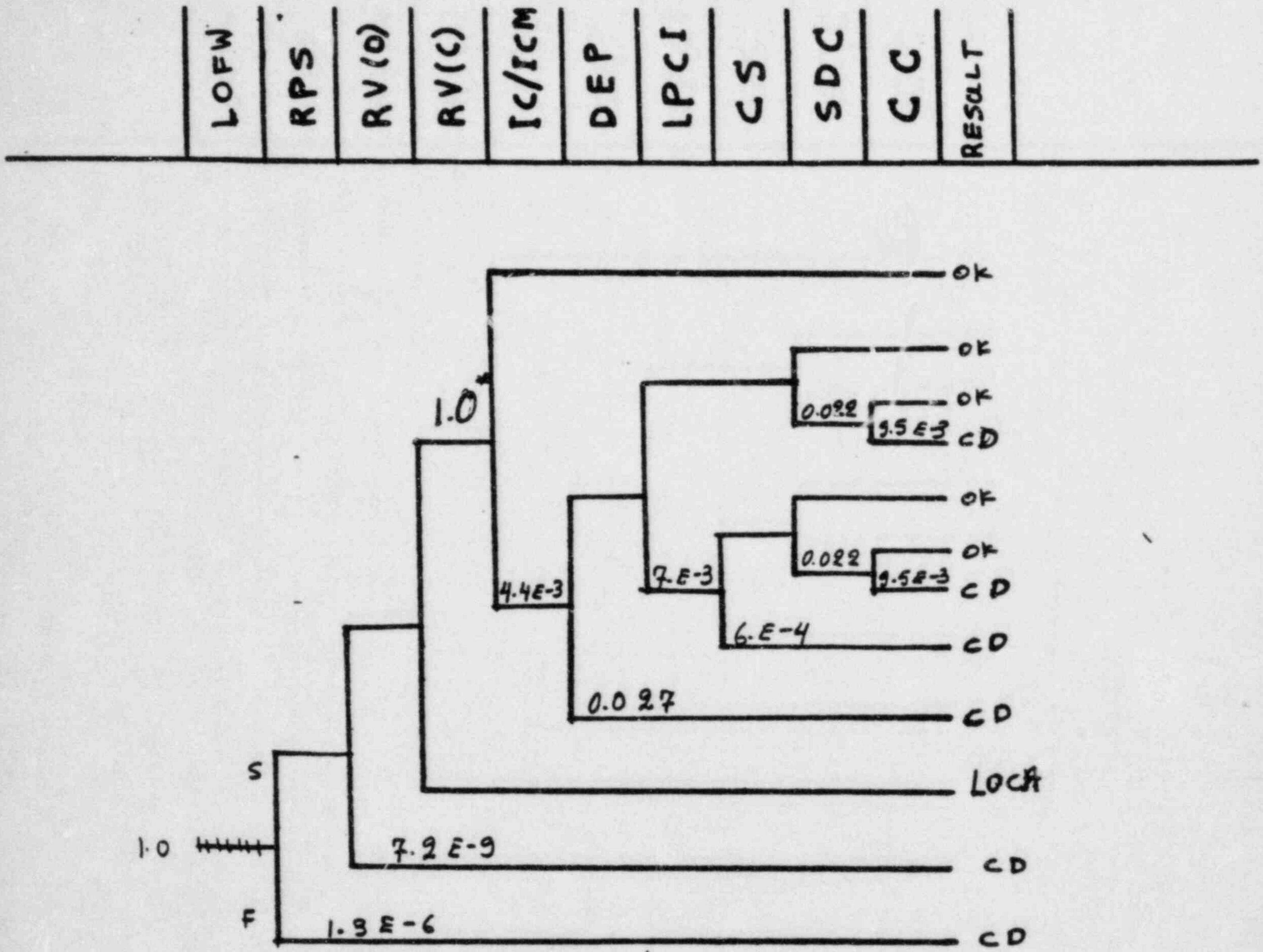
(NSIC 128906) - Sequence of Interest for No Break Power Panel De-energized at Cooper Applied in CATEGORIES B and C

P = 0.014

** Factor of 1.0 makes the recovery factor for RCIC/HPCI equal to ASP recovery factor.

* Assumption of 1.0 forces the event tree to represent a LOFW event

RESULT
OK = NO CORE DAMAGE
CD = CORE DAMAGE



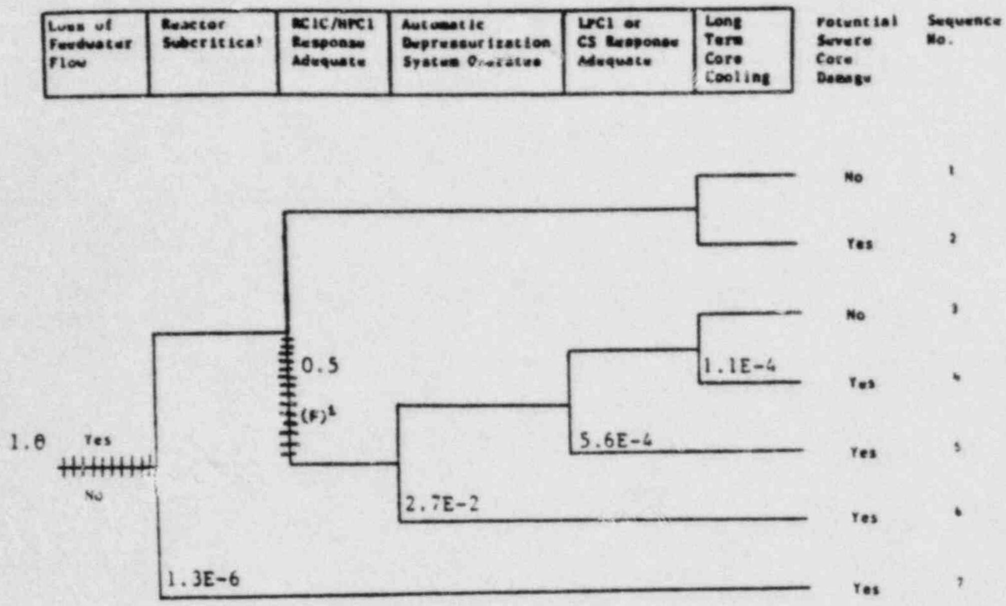
(NSIC 128906) - Sequence of Interest for No Break Power Panel De-energized at Cooper Applied in CATEGORY A3

P= 1.21 E-4

RESULT
OK= NO CORE DAMAGE
CD= CORE DAMAGE

S = Success
F = Failure

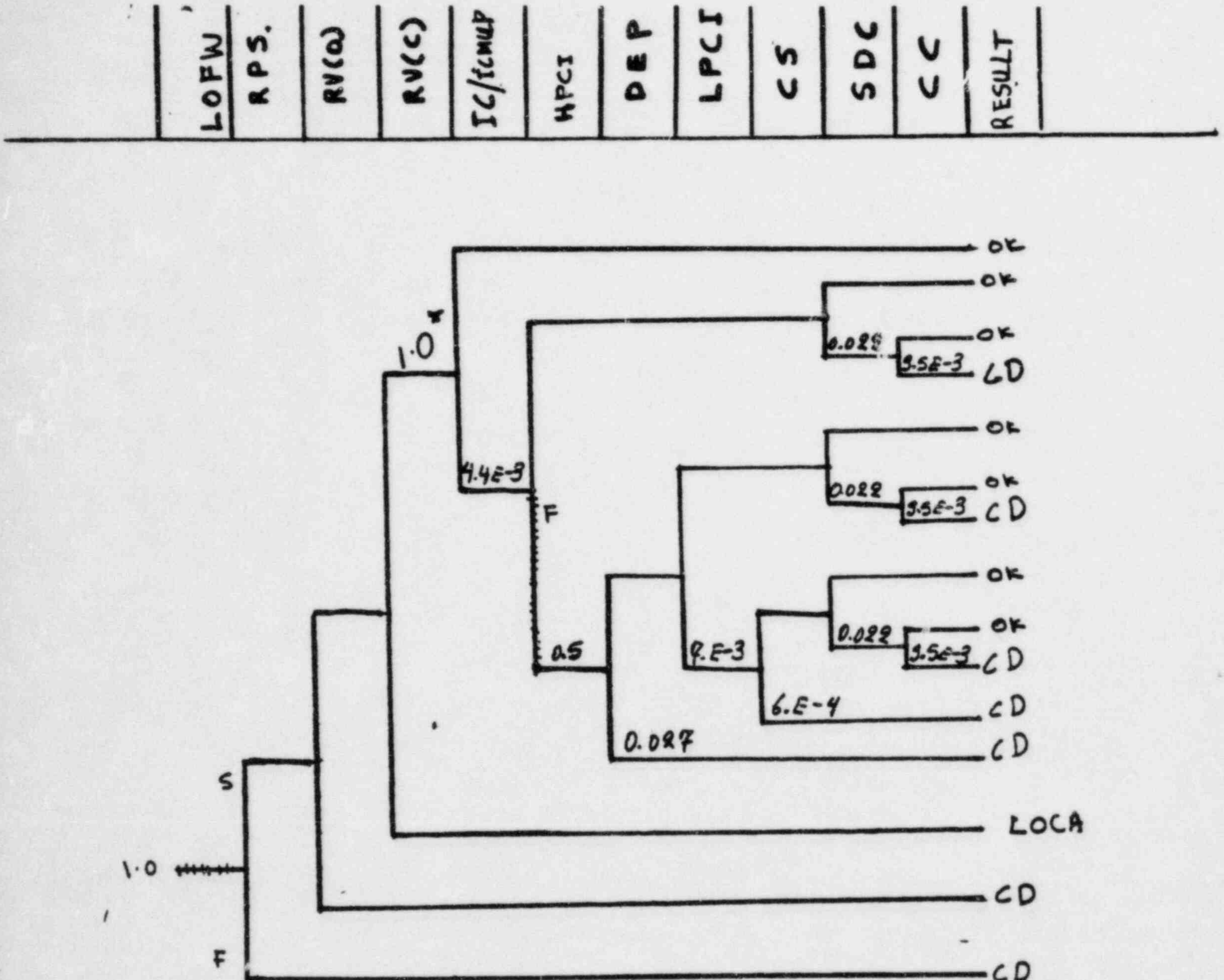
* Assumption of 1.0 forces the event tree to represent a LOFW event.



P = 1.4E-2 (SC = 19)

NSIC 128906 – Sequence of Interest for No Break Power Panel De-energized at Cooper Applied in CATEGORY E

[1]Success requires restoration of power to the NBPP.



(NSIC 128906) - Sequence of Interest for No Break Power Panel De-energized at Cooper Applied in

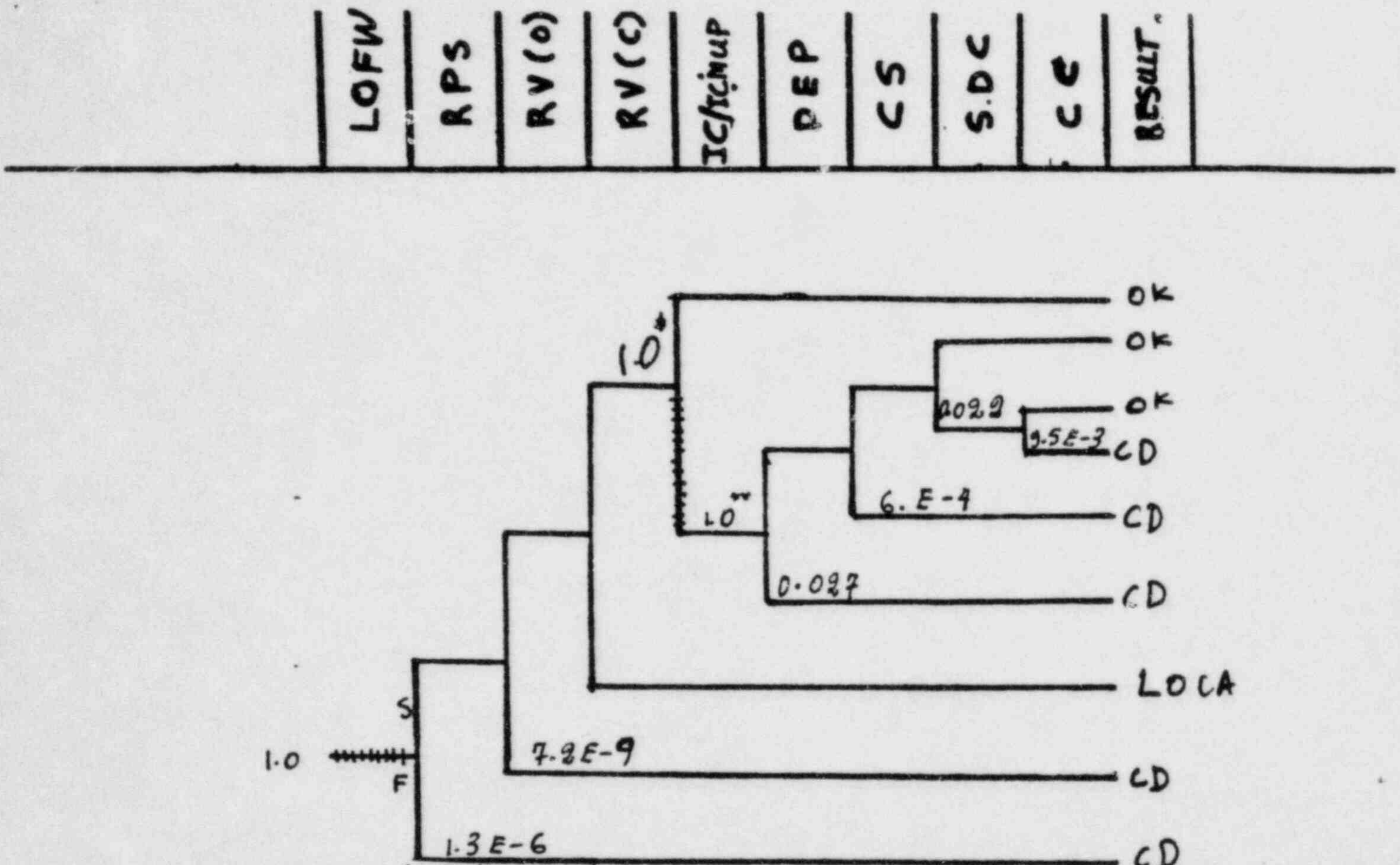
Category D

$P = 6.25\,E-5$

RESULT
OK = NO CORE DAMAGE
CD = CORE DAMAGE

S = Success
F = Failure

* Assumption of 1.0 forces the event tree to represent a LOFW event.



(NSIC 14950)-Sequence of Interest for a Loss of Feedwater Flow at Oyster Creek Applied in OYESTER CREEK and NINE MILE POINT plants.

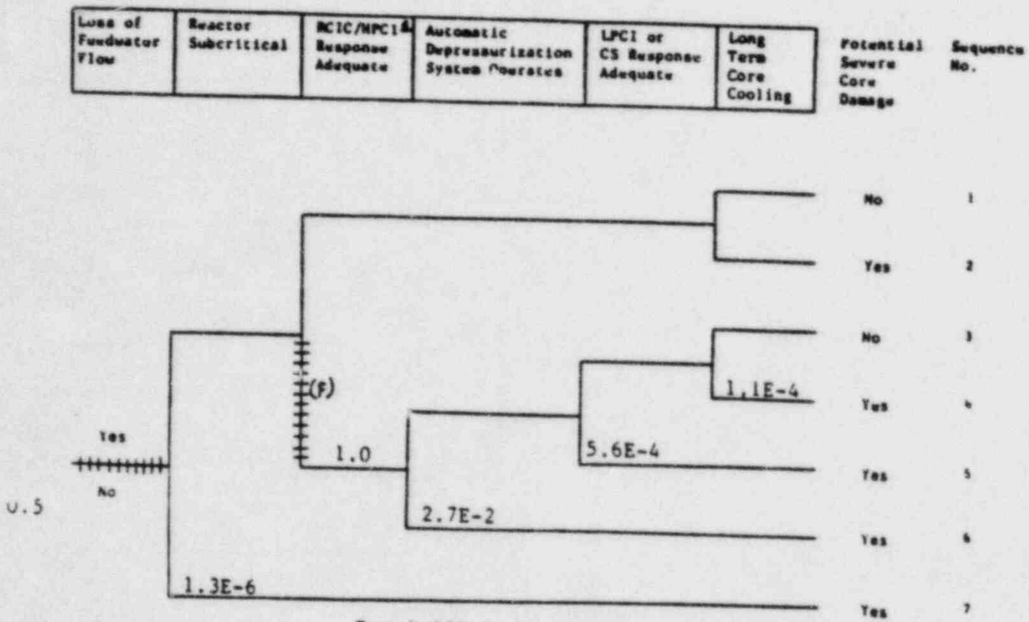
P = 0.0278

RESULT
OK = NO CORE DAMAGE
CD = CORE DAMAGE

S = Success
F = Failure

* Assumption of 1.0 forces the event tree to represent a LOFW event.

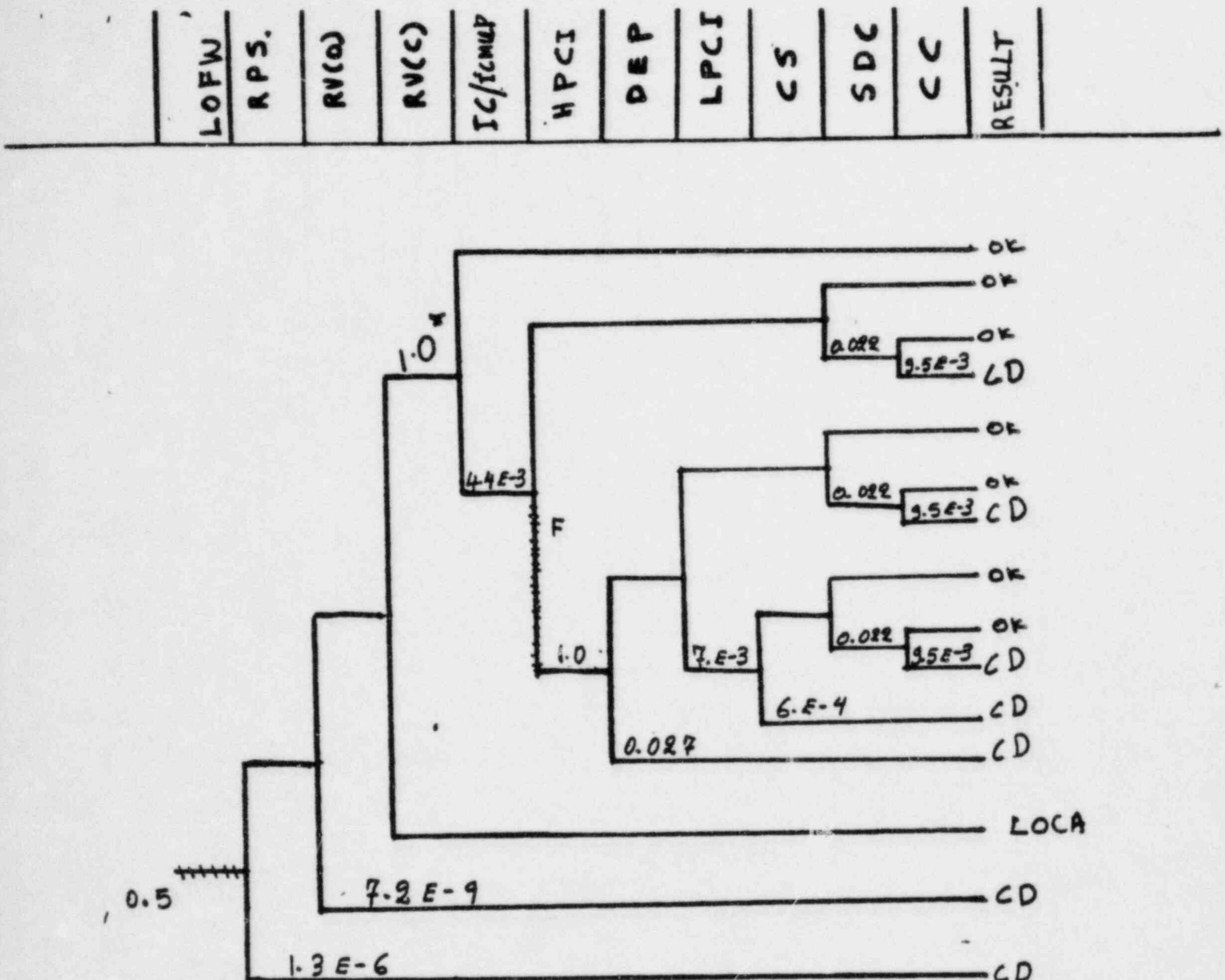
** IC failure applies only on BWR type 2 plants only i.e. Oyester creek and Nine Mile point



P = 1.38E-2 (SC = 19)

NSIC 149961 - Sequence of Interest for HPCI Fails to Start When the Turbine Stop Valve Fails to Open at Hatch 2, applied in Category 6

[1]RCIC was out of service.



(NSIC 149961)-Sequence of Interest for HPCI Fails to Start When its Turbine Stop Valve Fails to Open at Hatch 2 Applied in <u>CATEGORY D</u>

P= 6.14E-5

RESULT

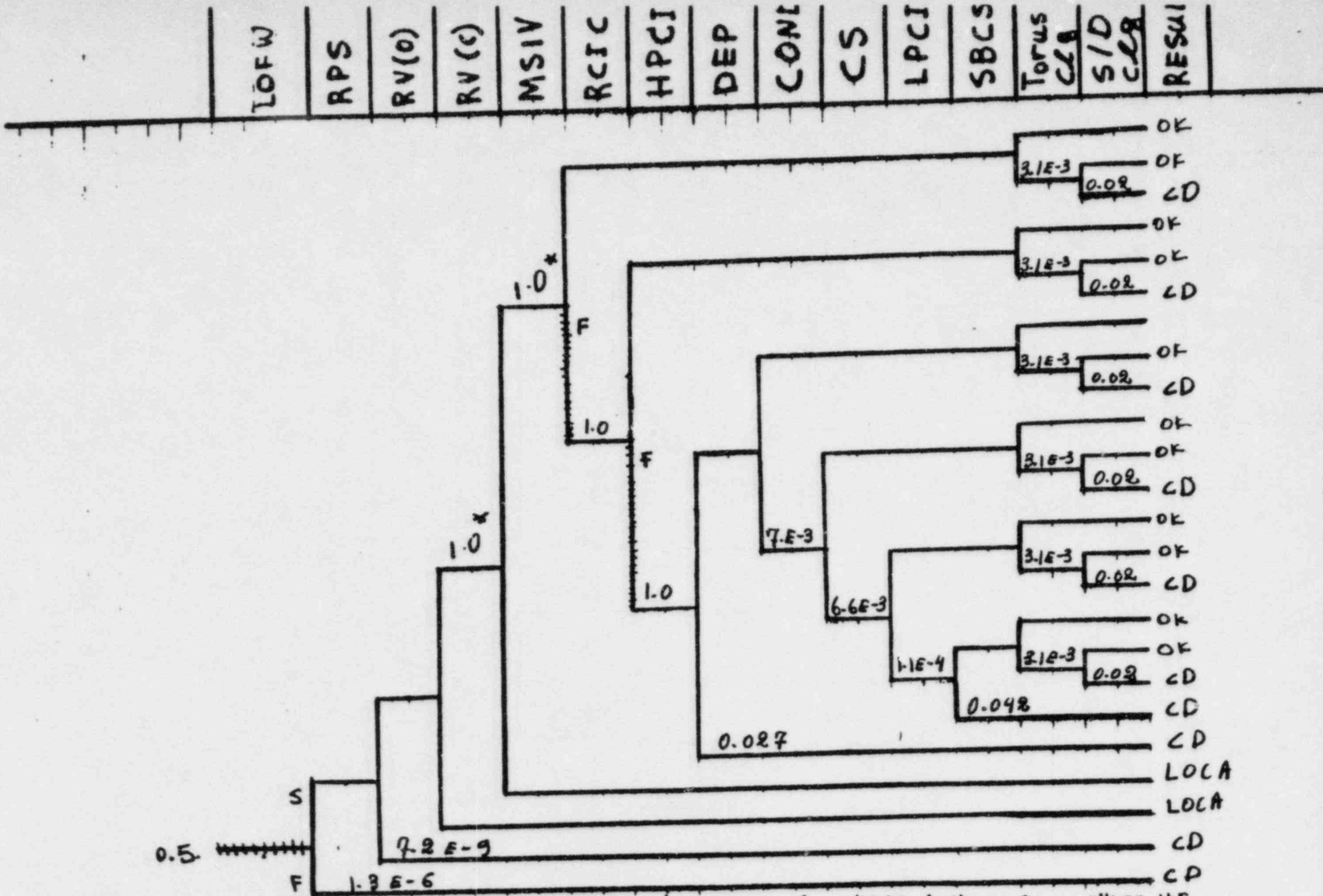
OK= NO CORE DAMAGE

CD= CORE DAMAGE

S= Success

F= Failure

* Assumption of 1.0 forces the event tree to represent a LOFW event.



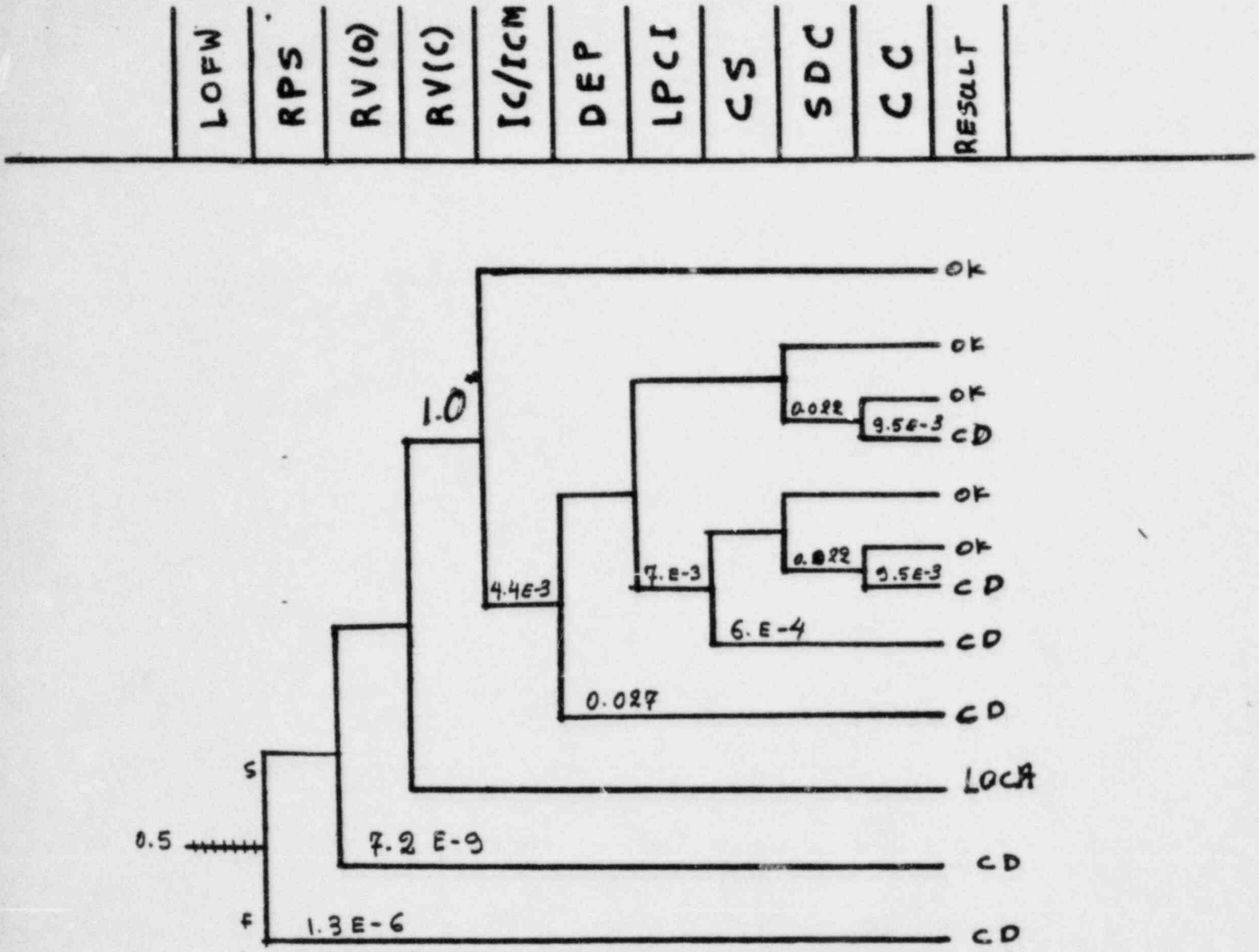
(NSIC 149961) - Sequence of Interest for HPCI fails to Start When its Turbine Stop Valve Fails to Open at Hatch 2 Applied in Categories B and C

P = 1.36 E-8

S = Success
F = Fails

RESULT
OK = NO CORE DAMAGE
CD = CORE DAMAGE

* Assumption of 1.0 forces the event tree to represent a LOFW event



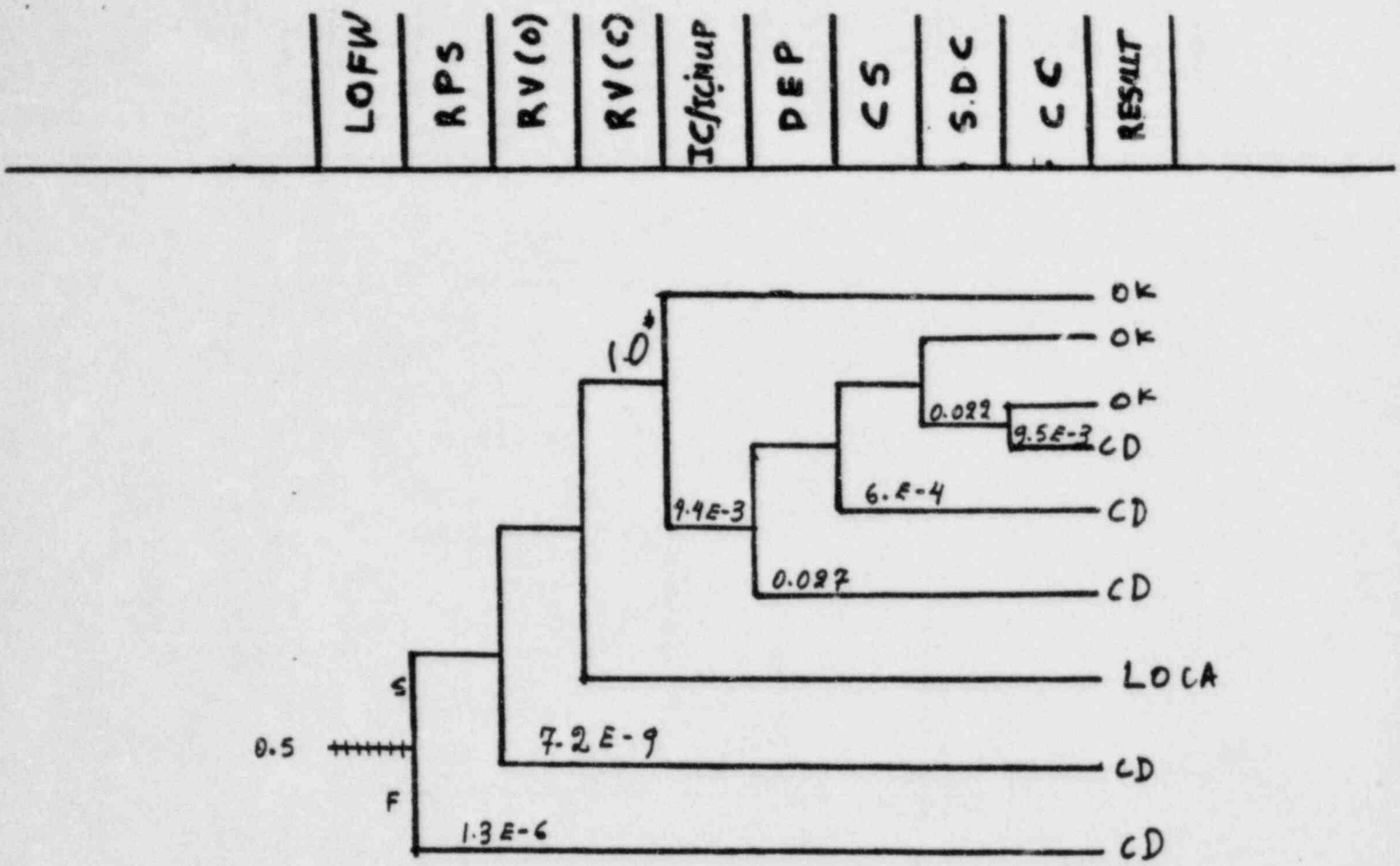
(NSIC 149961) - Sequence of Interest for HPCI fails to Start When its Turbine Stop Valve Fails to Open at [illegible]atch 2 Applied in CATEGORY A3

P= 6.05 E-5

RESULT
OK= NO CORE DAMAGE
CD= CORE DAMAGE

S = Success
F = Failure

* Assumption of 1.0 forces the event tree to represent a LOFW event.



(NSIC 149961) - Sequence of Interest for HPCI Fails to Start When its Turbine Stop Valve Fails to open at Hatch 2 Applied in CATEGORIES AI and A2

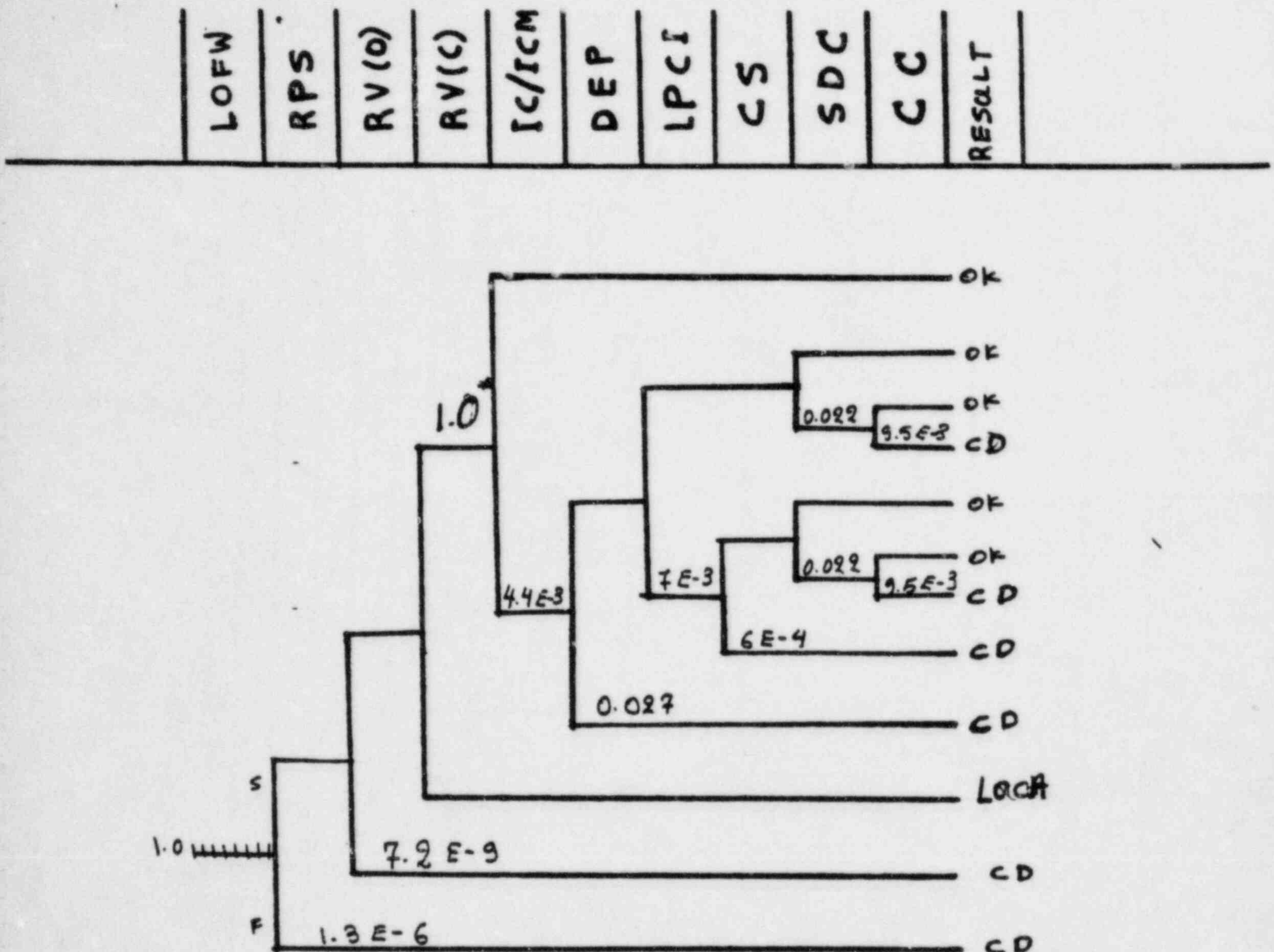
P = 6.2E-5

RESULT

OK = NO CORE DAMAGE
CD = CORE DAMAGE

S = Success
F = Failure

* Assumption of 1.0 forces the event tree to represent a LOFW event.



(NSIC 85738) - Sequence of Interest for RCIC and HPCI Failures During Testing at Browns Ferry 1 Applied in

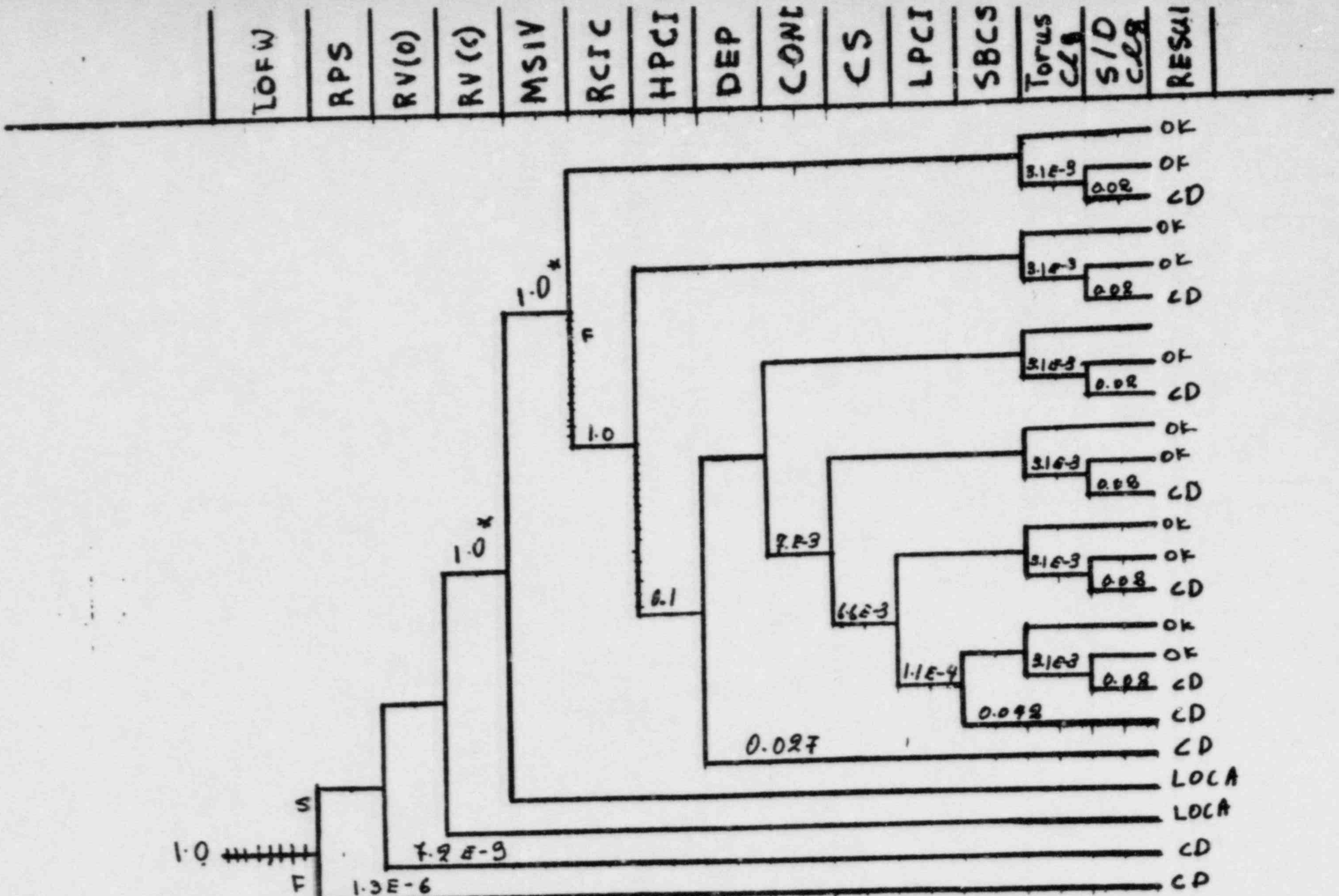
CATEGORY A3

P = 1.214 E-4

RESULT
OK = NO CORE DAMAGE
CD = CORE DAMAGE

S = Success
F = Failure

* Assumption of 1.0 forces the event tree to represent a LOFW event.

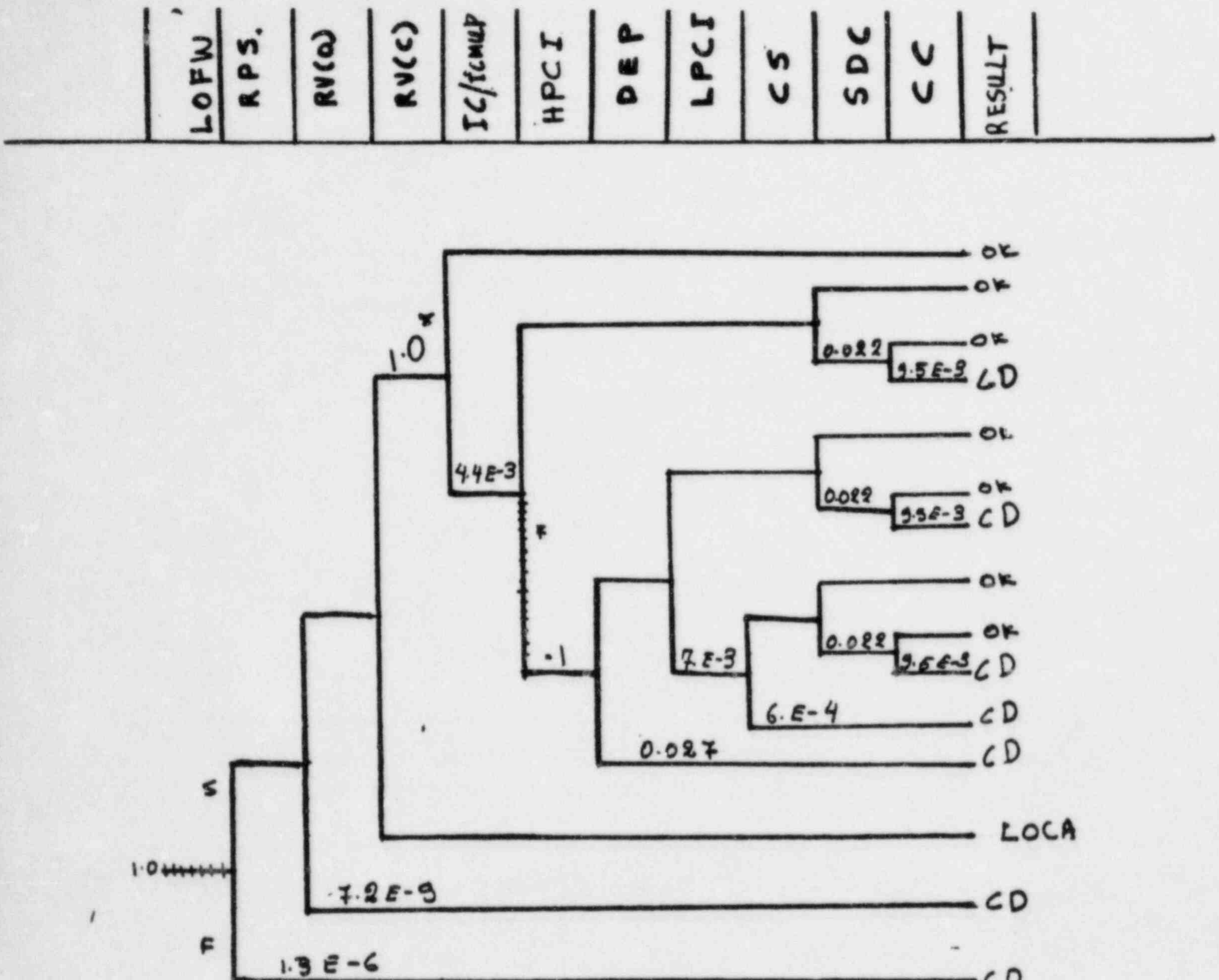


(NSIC 85938)-Sequence of Interest for RCIC and HPCI Failures During Testing at Browns Ferry 1 Applied at CATEGORIES B AND C

P= 2.96E-3

RESULT
OK = NO CORE DAMAGE
CD = CORE DAMAGE

* Assumption of 1.0 forces the event tree to represent a LOFW event



(NSIC 85938) - Sequence of Interest for RCIC and HPCI Failures During Testing at Browns Ferry I Applied in

CATEGORY D

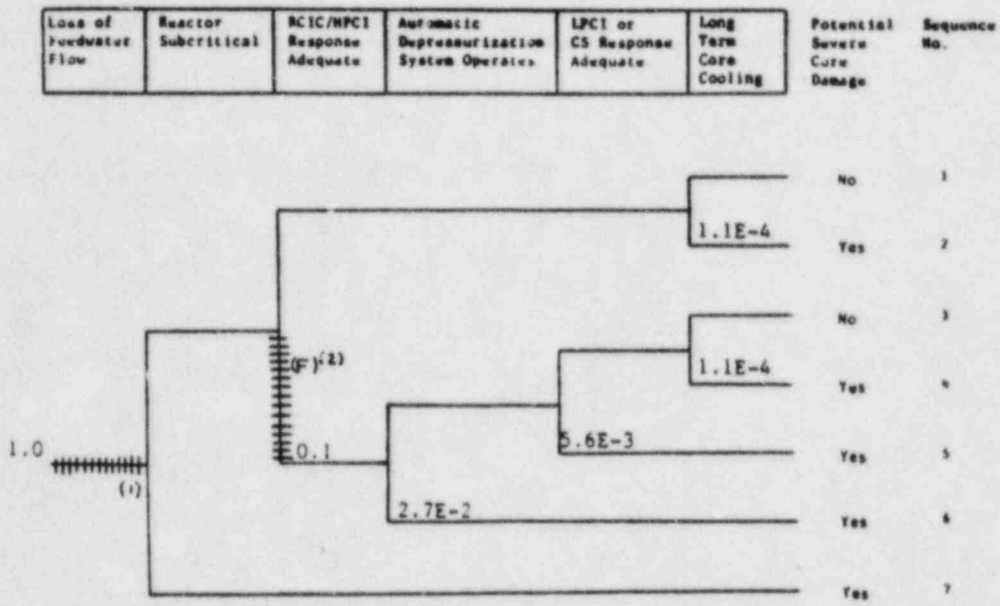
P = 1.42 E-5

RESULT

OK = NO CORE DAMAGE S = Success

CD = CORE DAMAGE F = Failures

* Assumption of 1.0 forces the event tree to represent a LOFW event.



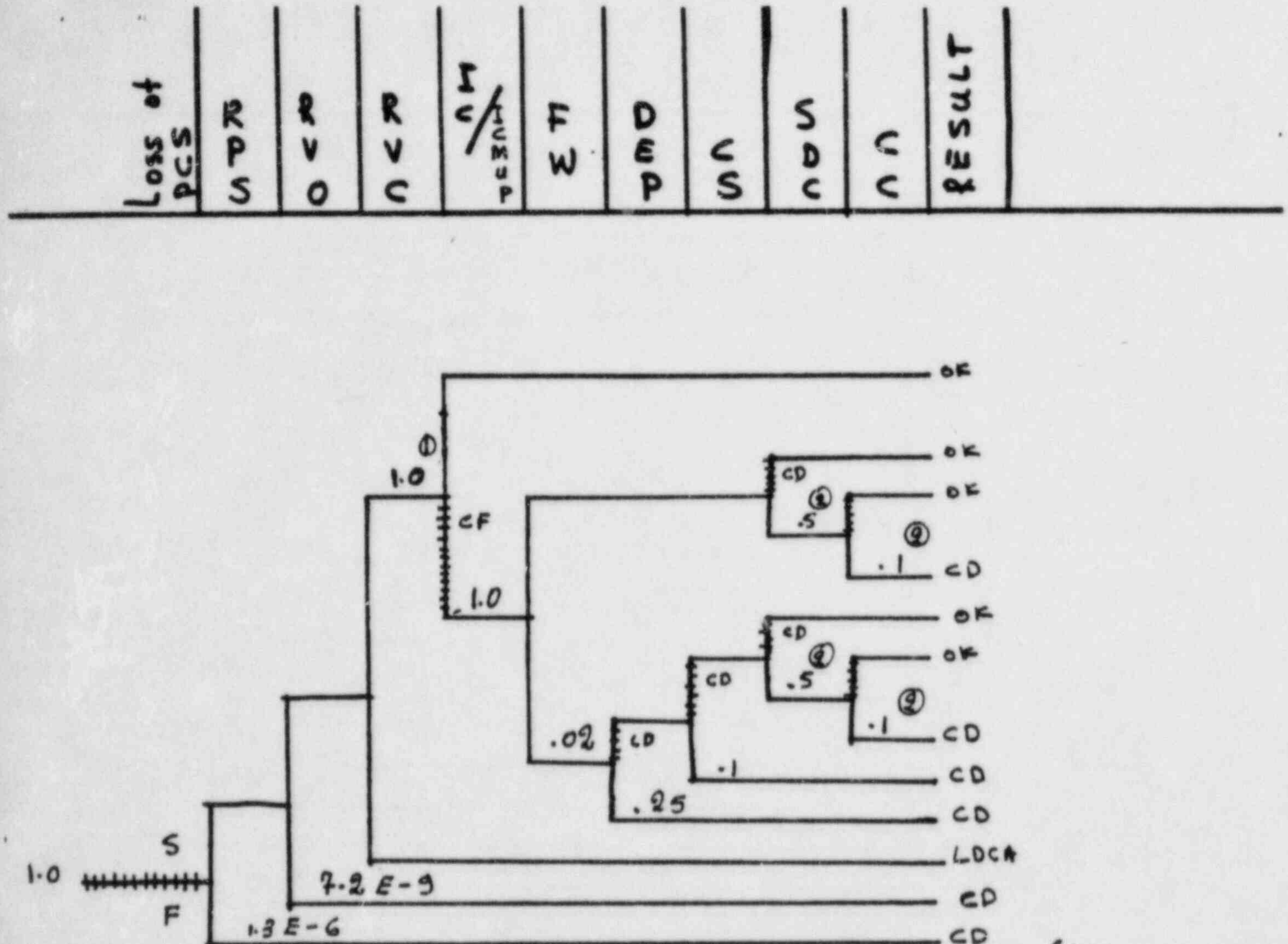
P = 3.4E-3 (SC = 25)

NSIC 85738 - Sequence of Interest for RCIC and HPCI Failures During Testing at Browns Ferry 1

[1] An apparent loss of feedwater.

[2] HPCI was manually reset and operated satisfactorily.

Applied in Category E



(NSIC 101444) Sequence of Interest of Cable Tray fire at Browns Ferry 1 applied in

<u>Categories A1 and A2</u>

P = 0.0562

<u>RESULT</u>

OK = NO CORE DAMAGE

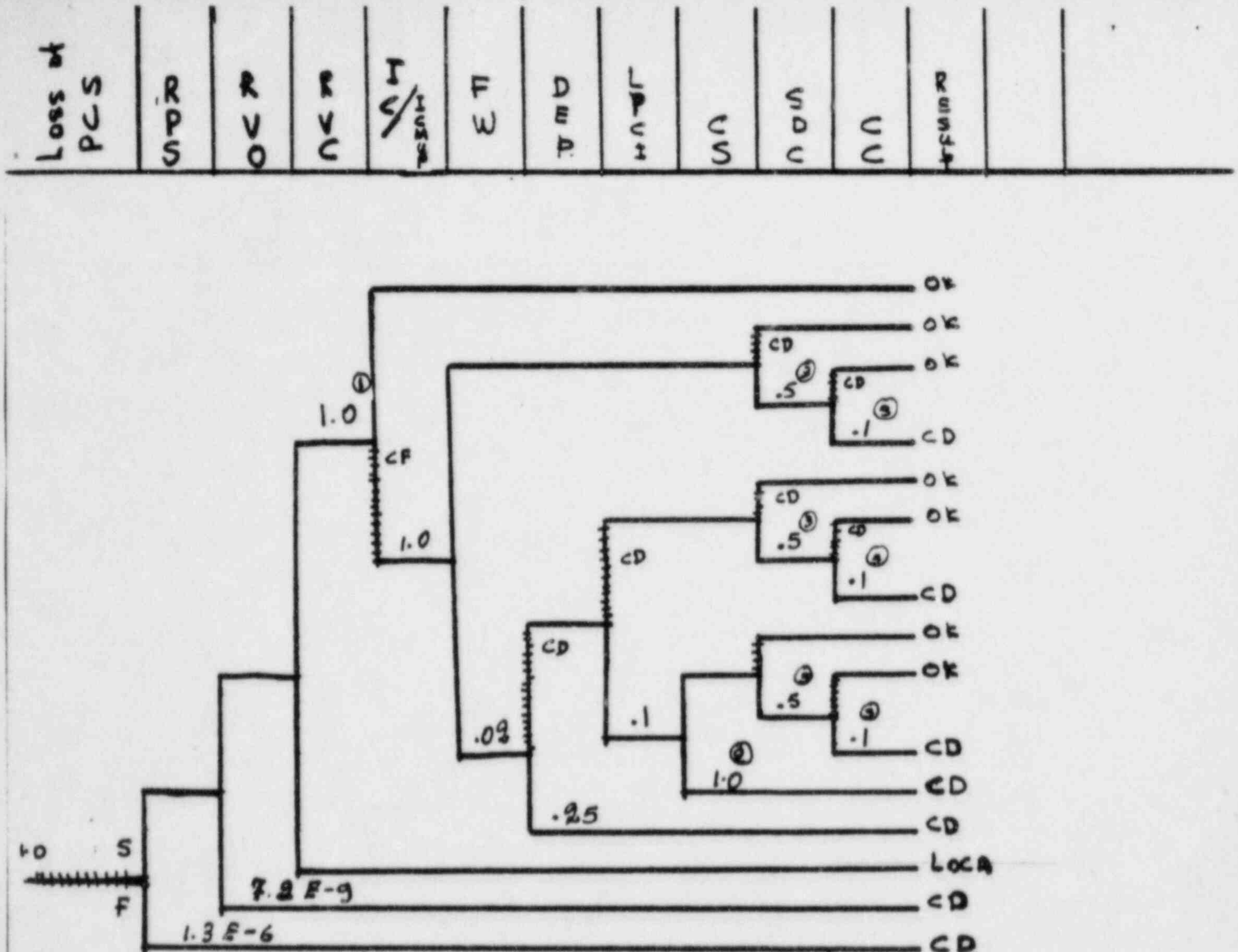
CD = CORE DAMAGE

S = Success

F = Failure

① Assumption of 1.0 forces the event tree to represent a Loss of PCS event

② Credit was given for the independence of the two systems.



(NSIC 101444) Sequence of Interest of Cable Tray fire at Browns Ferry 1 applied in

CATEGORY A3

P = 0.0562

RESULT

OK = NO CORE DAMAGE

CD = CORE DAMAGE

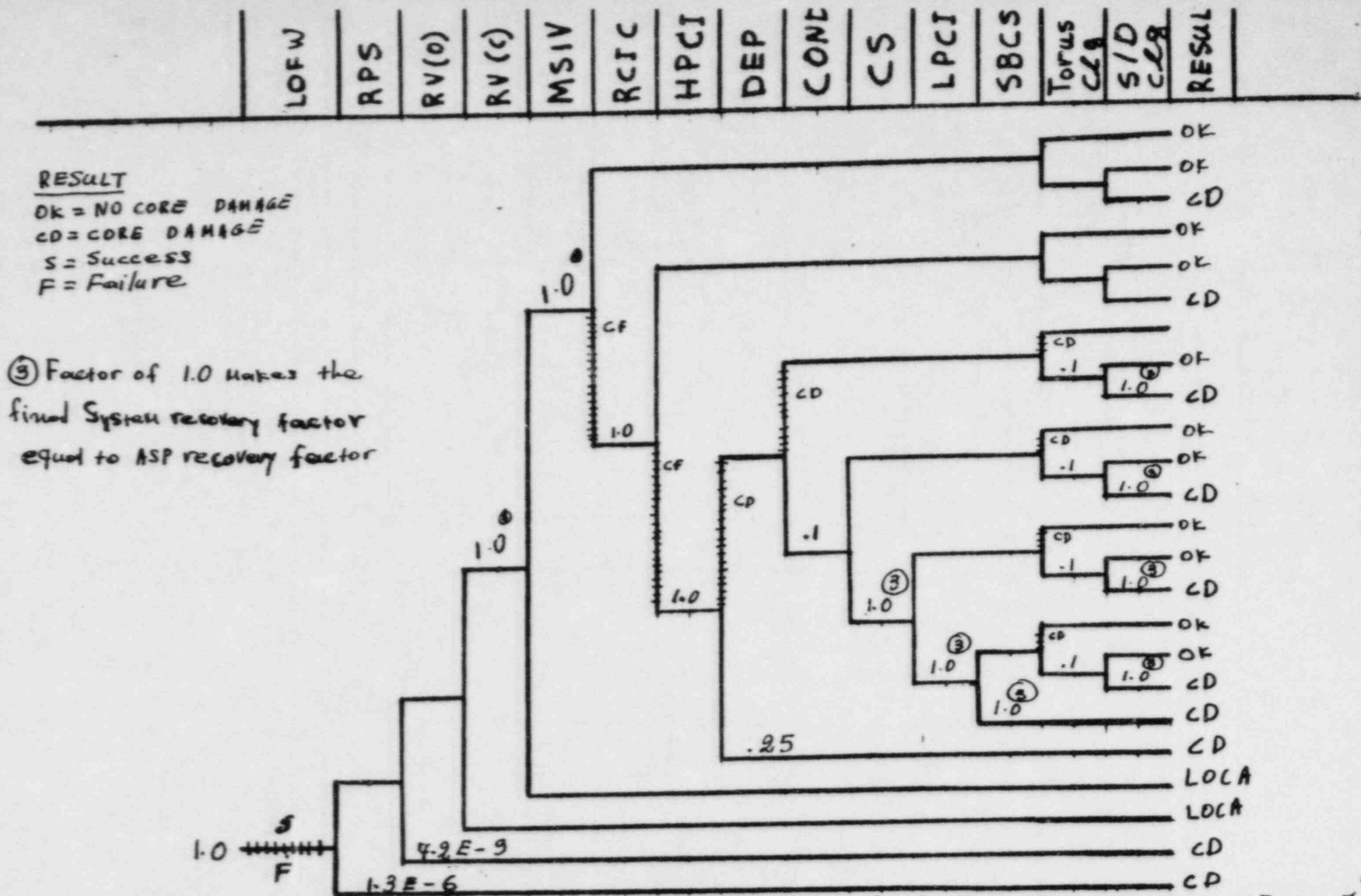
S = Success

F = Failure

① Assumption of 1.0 forces the event tree to represent a Loss of PCS event

② Factor of 1.0 makes the final system recovery factor equal to ASP factor

③ Gradit was given for the independency of the two systems.

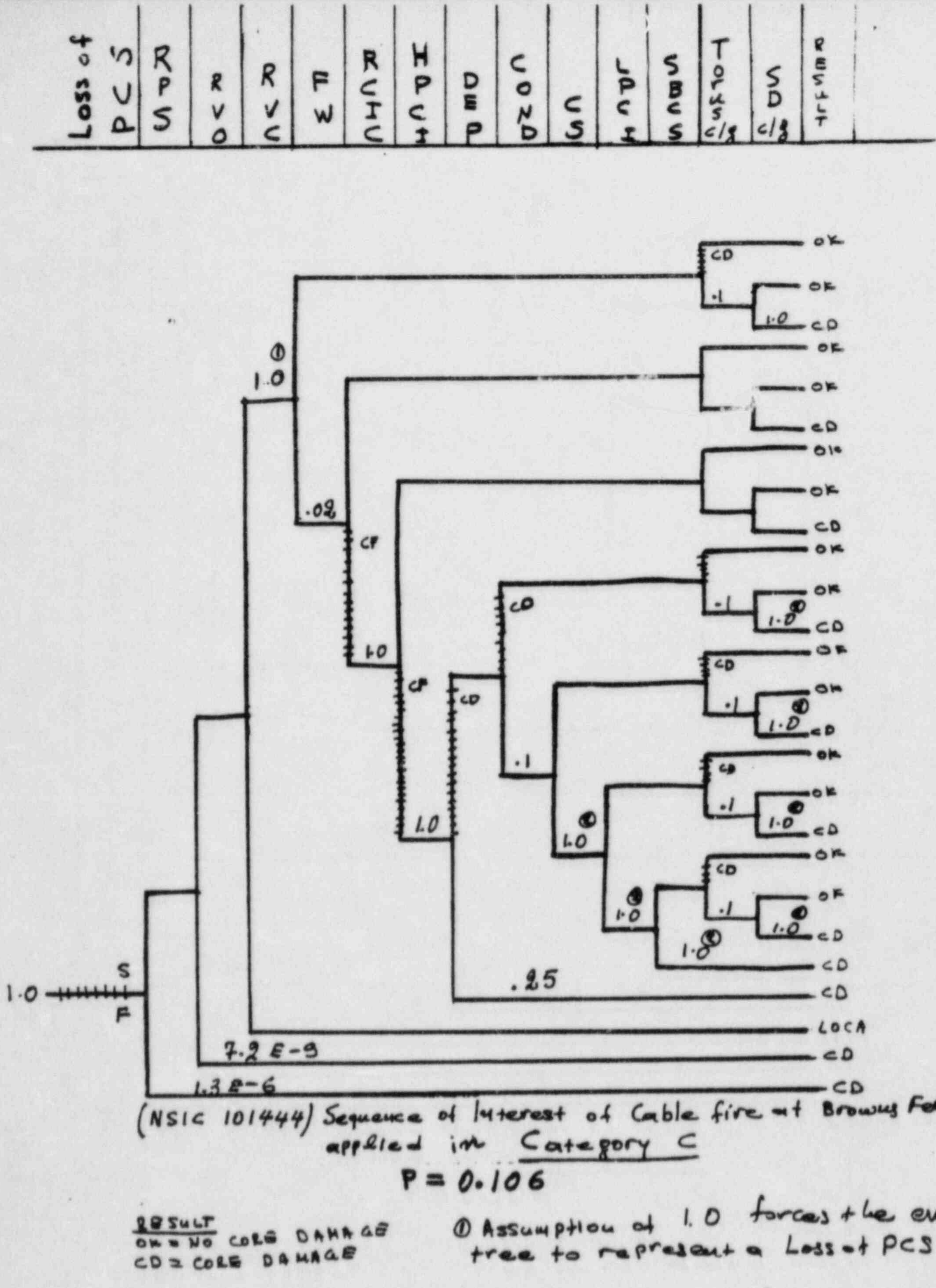


(NSIC 101444)-Sequence of Interest of Cable Tray Fire at Browns Ferry 1 ①
applied in Category B

P = 0.39

① Browns Ferry 1 belongs to Category B

② Assumption of 1.0 forces the event tree to represent a LOFW event



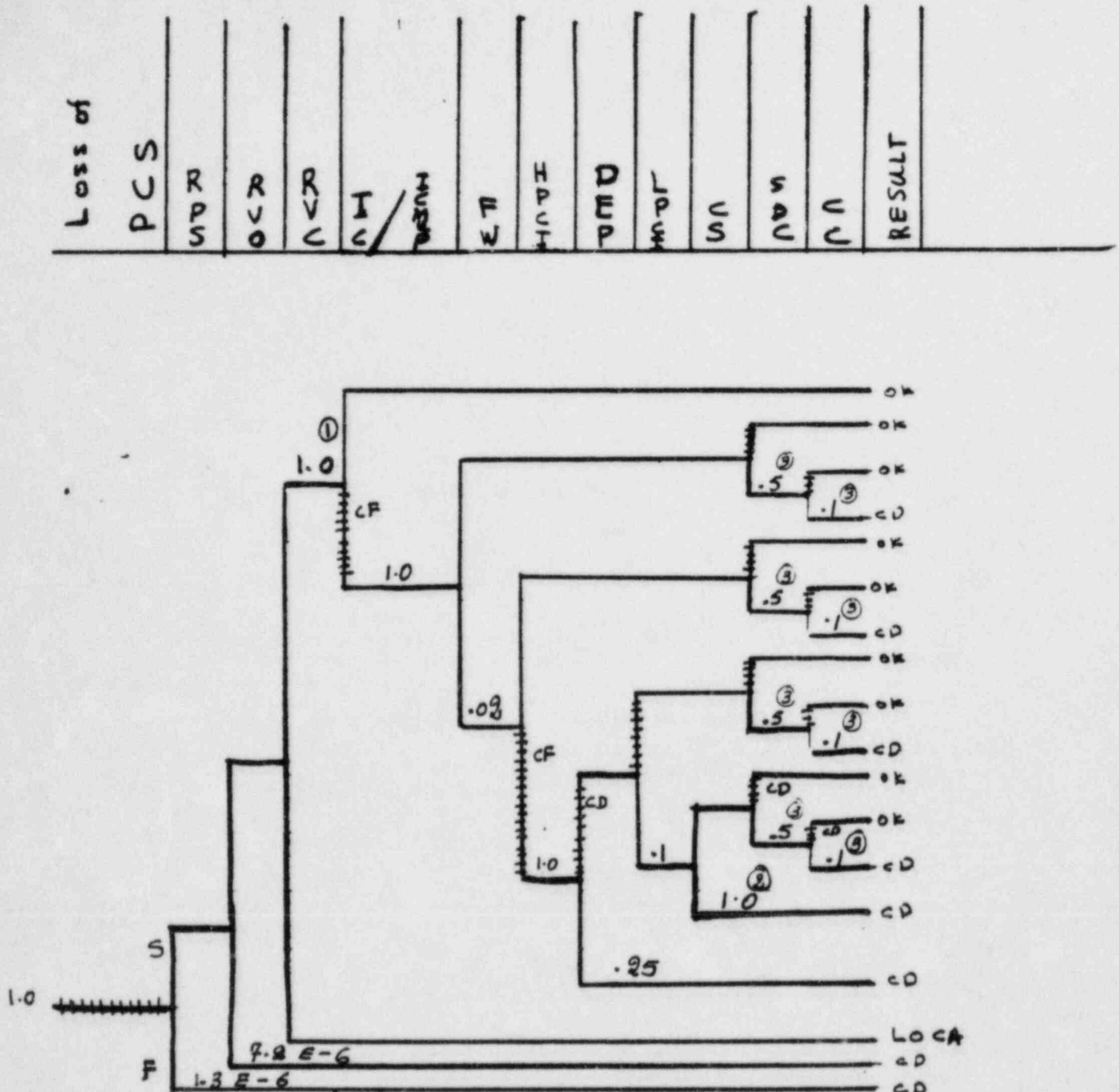
(NSIC 101444) Sequence of Interest of Cable fire at Browns Ferry 1 applied in Category C

P = 0.106

RESULT
OK = NO CORE DAMAGE
CD = CORE DAMAGE

① Assumption of 1.0 forces the event tree to represent a Loss of PCS eve

② Factor of 1.0 makes the final system recovery factor equal to ASP recovery factor.



(NSIC 10444)–Sequence of Interest of Cable Tray fire at Browns Ferry I Applied in

<u>Category D</u>

P = 0.0562

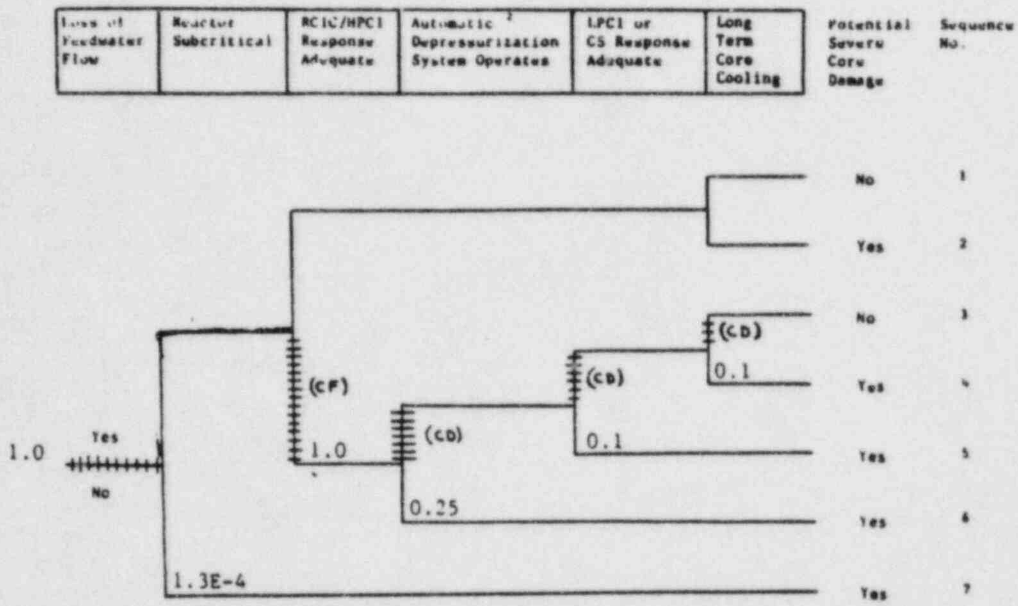
<u>RESULT</u>

OK = NO CORE DAMAGE
CD = CORE DAMAGE
S = Succes
F = Failure

① Assumption of 1.0 forces the event tree to represent a Loss of PCS event.

② Factor of 1.0 makes the final system recovery factor equal to ASP factor

③ Credit was given for the independency of the two systems.

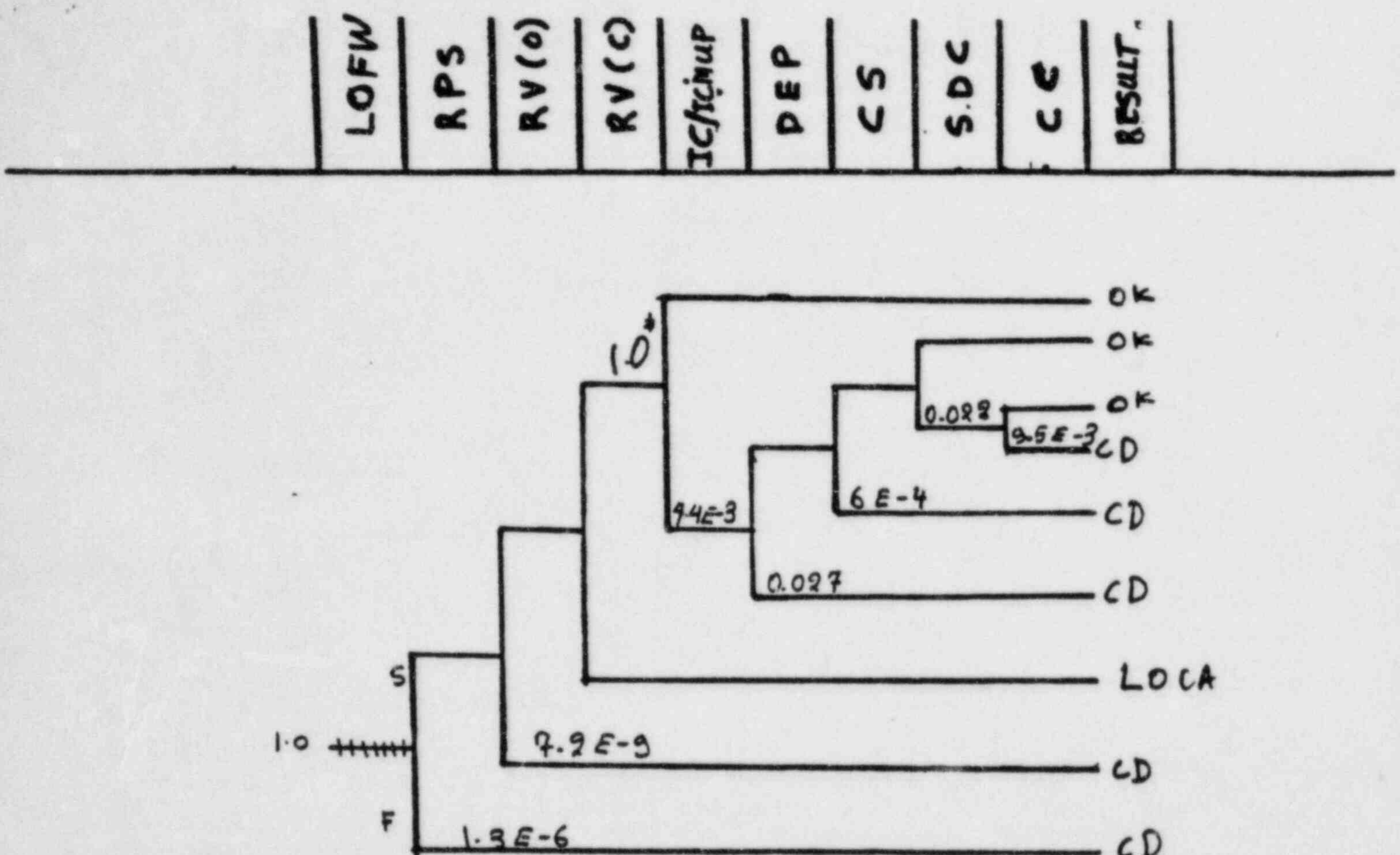


P = 0.39 (SC = 4)

NSIC 101444 - Sequence of Interest of Cable Tray Fire at Browns Ferry 1 applied in Category E

[1] Nonstandard techniques could have been used to make RCIC operable.

[2] The depressurization was manually initiated.



(NSIC 153180) - Sequence of Interest for RCIC Turbine Trip with HPCI Unavailable at Brunswic I Applied in CATEGORIES A1 AND A2

P = 1.23 E-4

RESULT

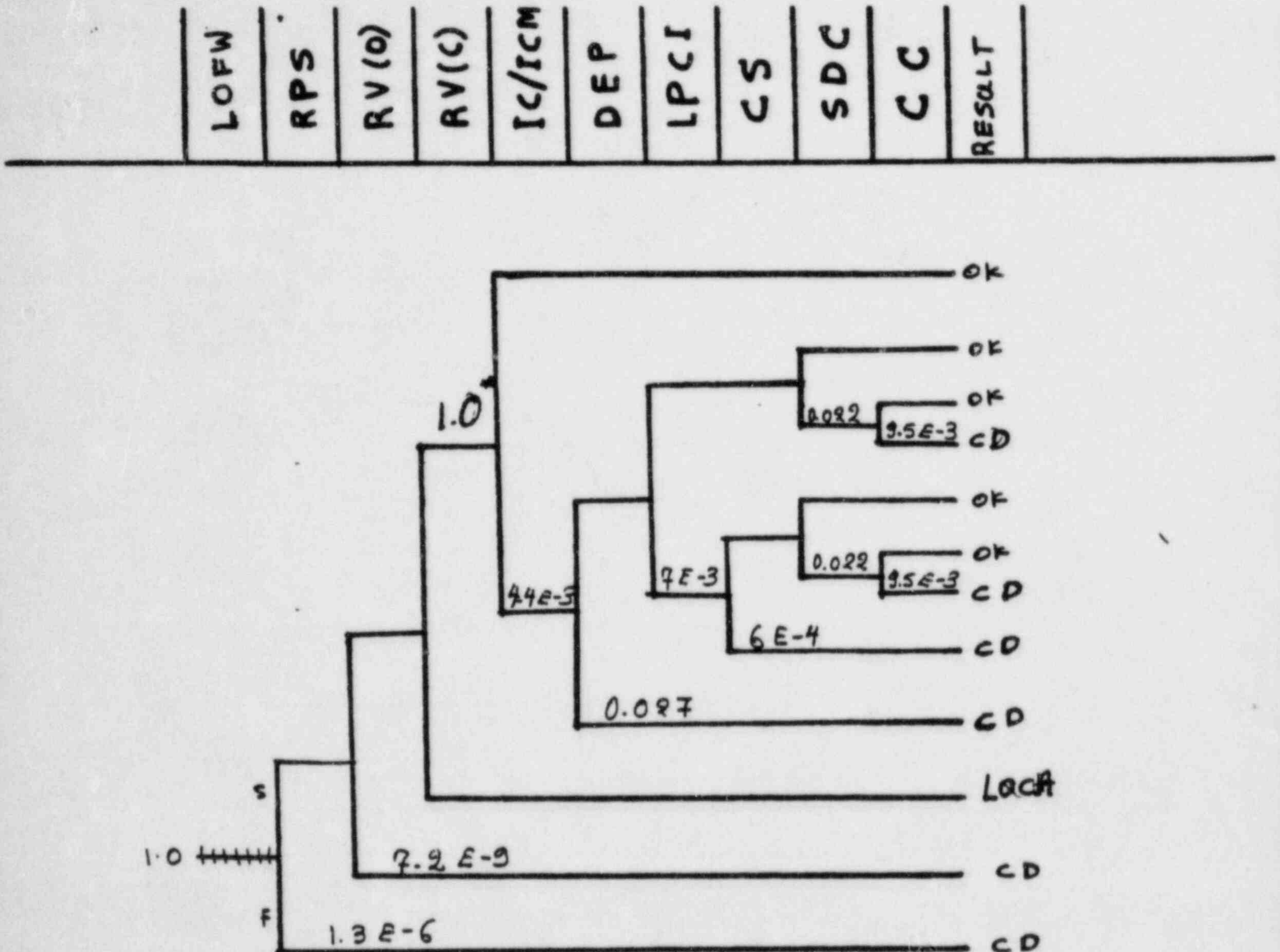
OK = NO CORE DAMAGE

CD = CORE DAMAGE

S = Success

F = Failure

* Assumption of 1.0 forces the event tree to represent a LOFW event.



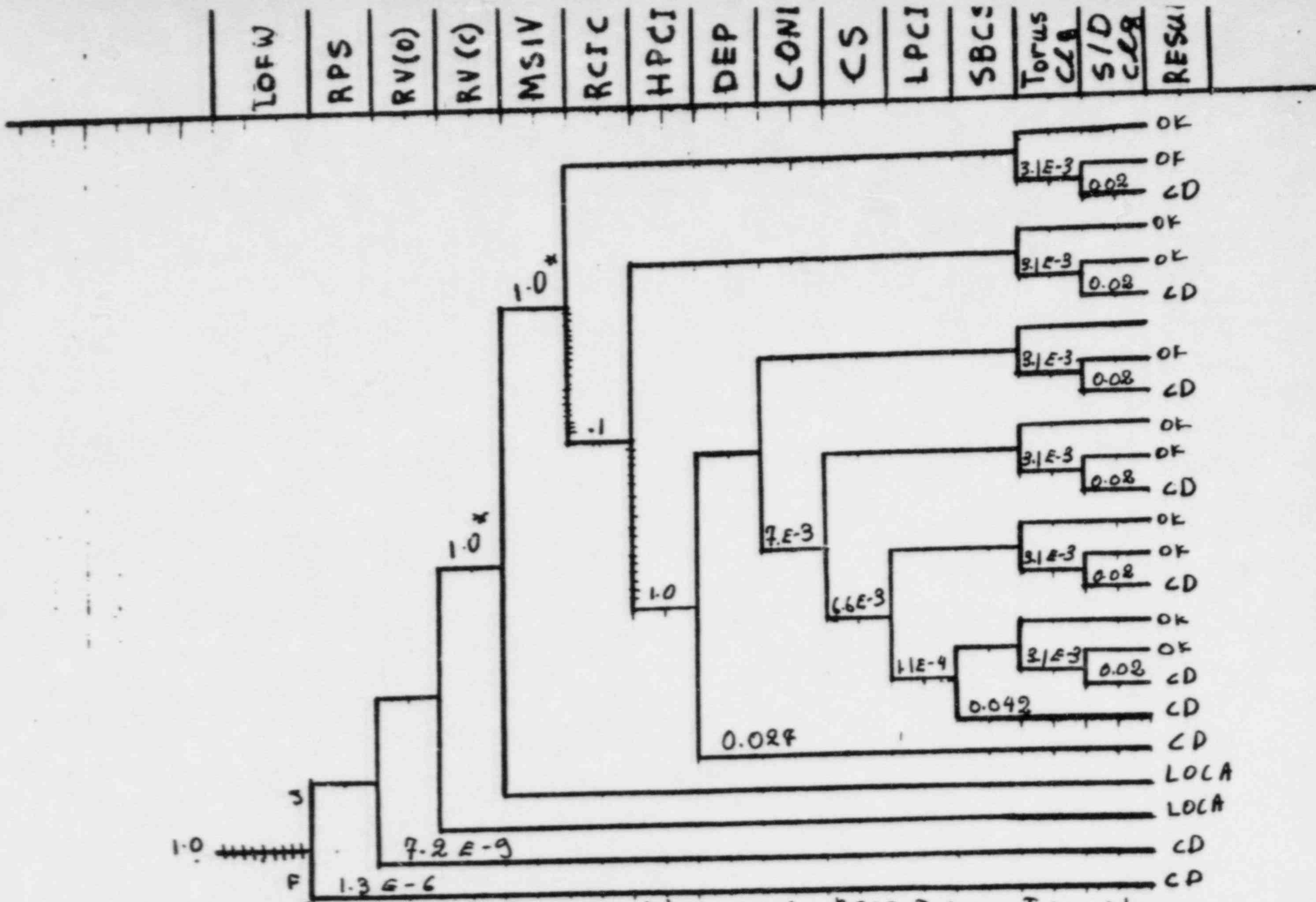
(NSIC 153810) - Sequence of Interest for RCIC Turbine Trip with HPCI Unavailable at Brunswick 1 Applied in CATEGORY A3

P = 1.21 E-4

RESULT
ok = NO CORE DAMAGE
CD = CORE DAMAGE

S = Success
F = Failure

* Assumption of 1.0 forces the event tree to represent a LOFW event.



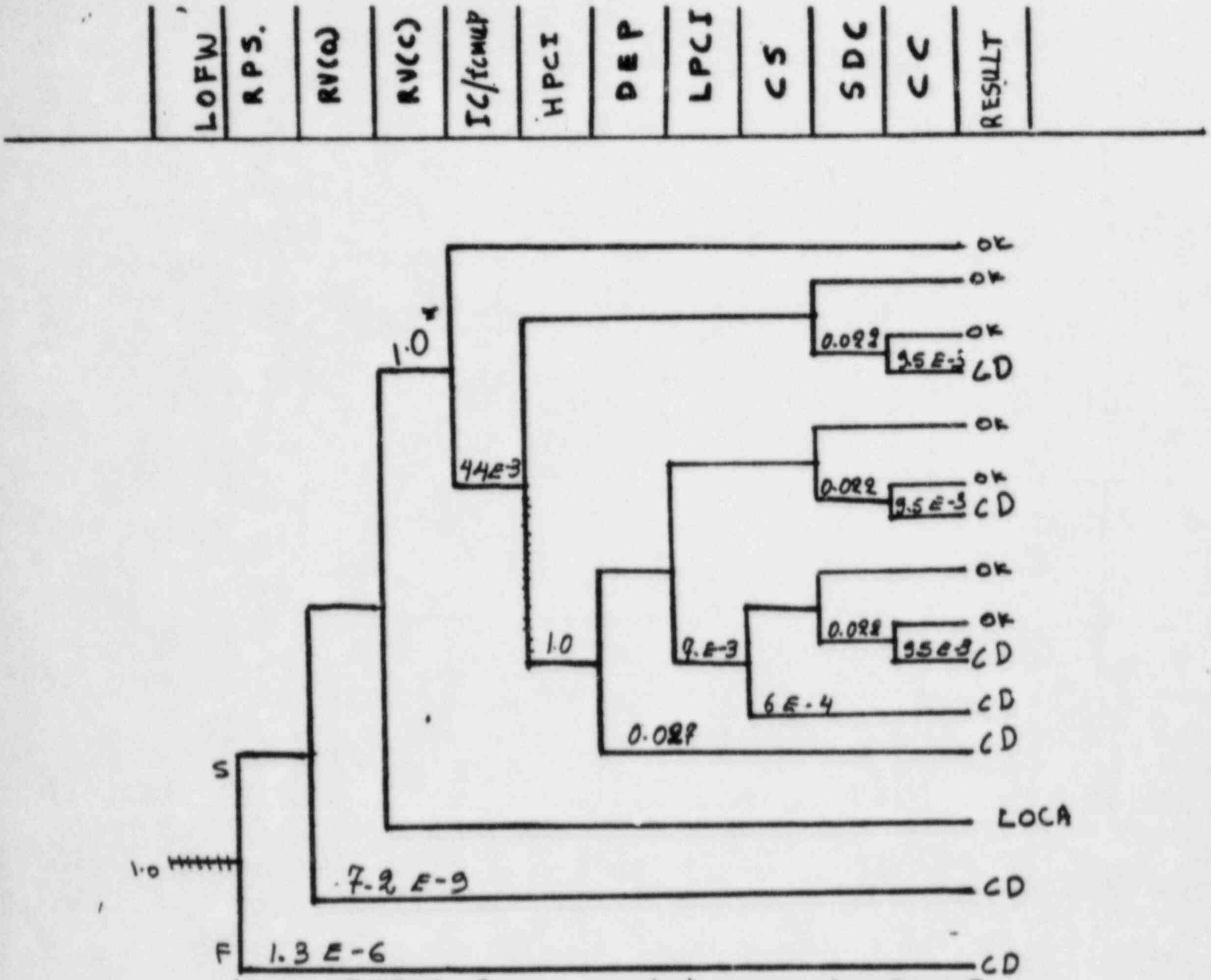
(NSIC 153810) - Sequence of Interest for RCIC Turbine Trip with HPCI Unavailable at Brunswick 1 Applied in CATEGORIES B AND C

P = 2.96 E-3

S = Success
F = Failure

RESULT
OK = NO CORE DAMAGE
CD = CORE DAMAGE

* Assumption of 1.0 forces the event tree to represent a LOFW event



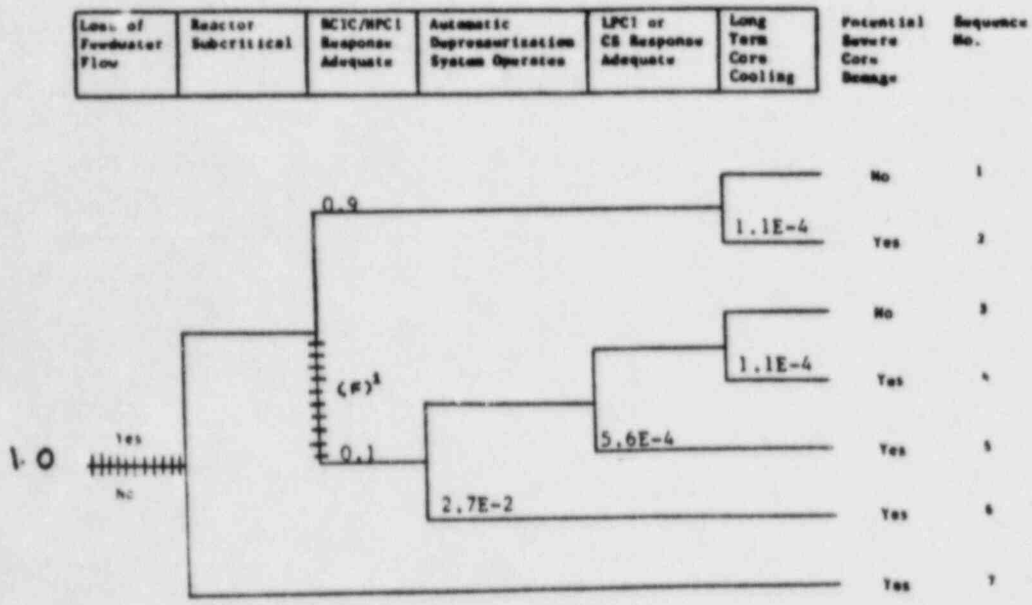
(NSIC 158810) - Sequence of Interest for RCIC Turbine Trip with HPCI Unavailable at Brunswick I Applied in <u>CATEGORY D</u>

P = 1.21E-4

<u>RESULT</u>
OK = NO CORE DAMAGE
CD = CORE DAMAGE

S = Success
F = Failure

* Assumption of 1.0 forces the event tree to represent a LOFW event.

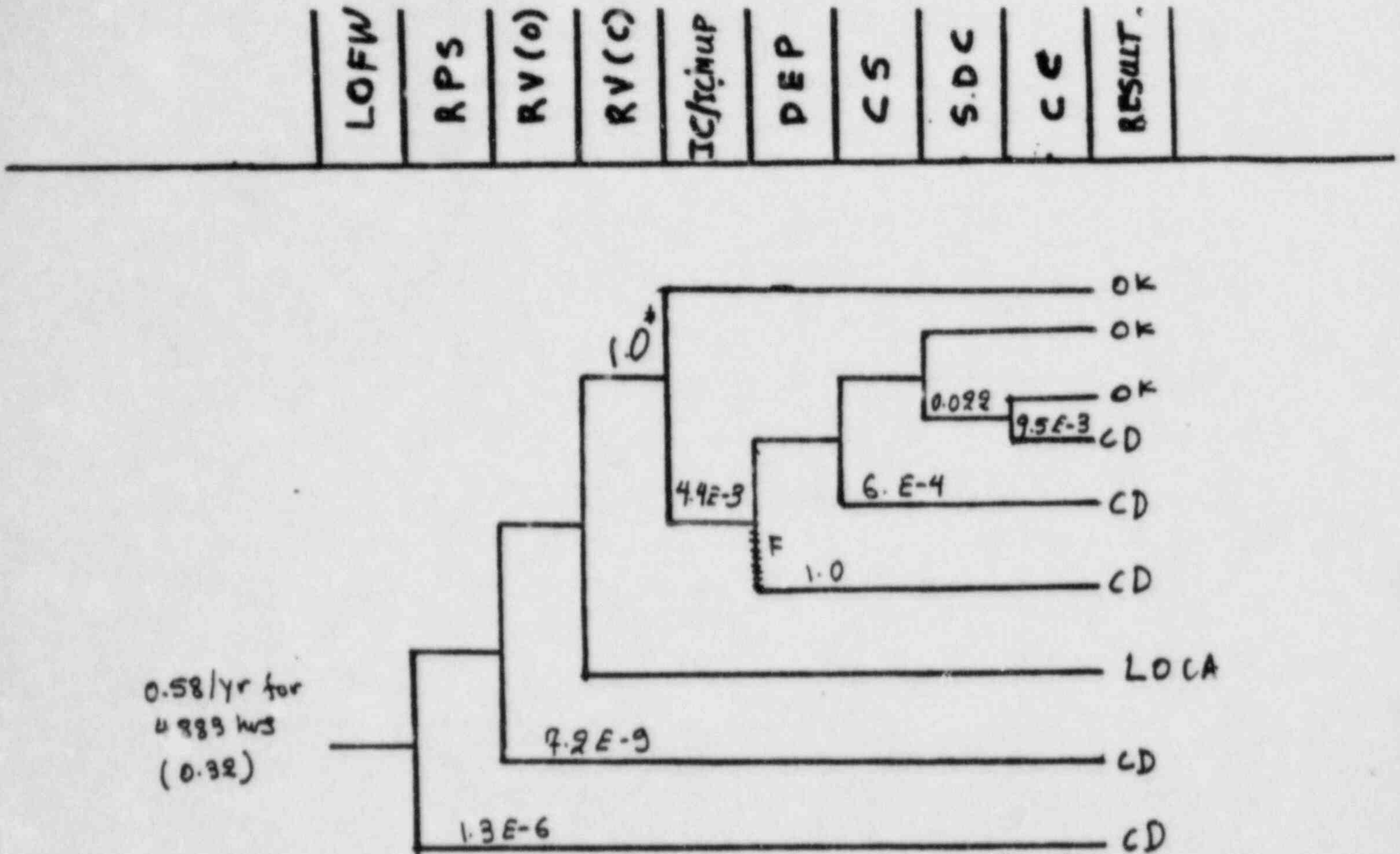


P = 2.9E-3 (SC = 25)

NSIC 153810 - Sequence of Interest for RCIC Turbine Trip with HPCI Unavailable at Brunswick 1

([1]Success requires the operator to reset and manually start RCIC.)

applied in category E



(NSIC 120443) - Sequence of Interest for Two Electromatic Relief Valves Fail at Quad Cities 2 Applied in Categories A1 and A2

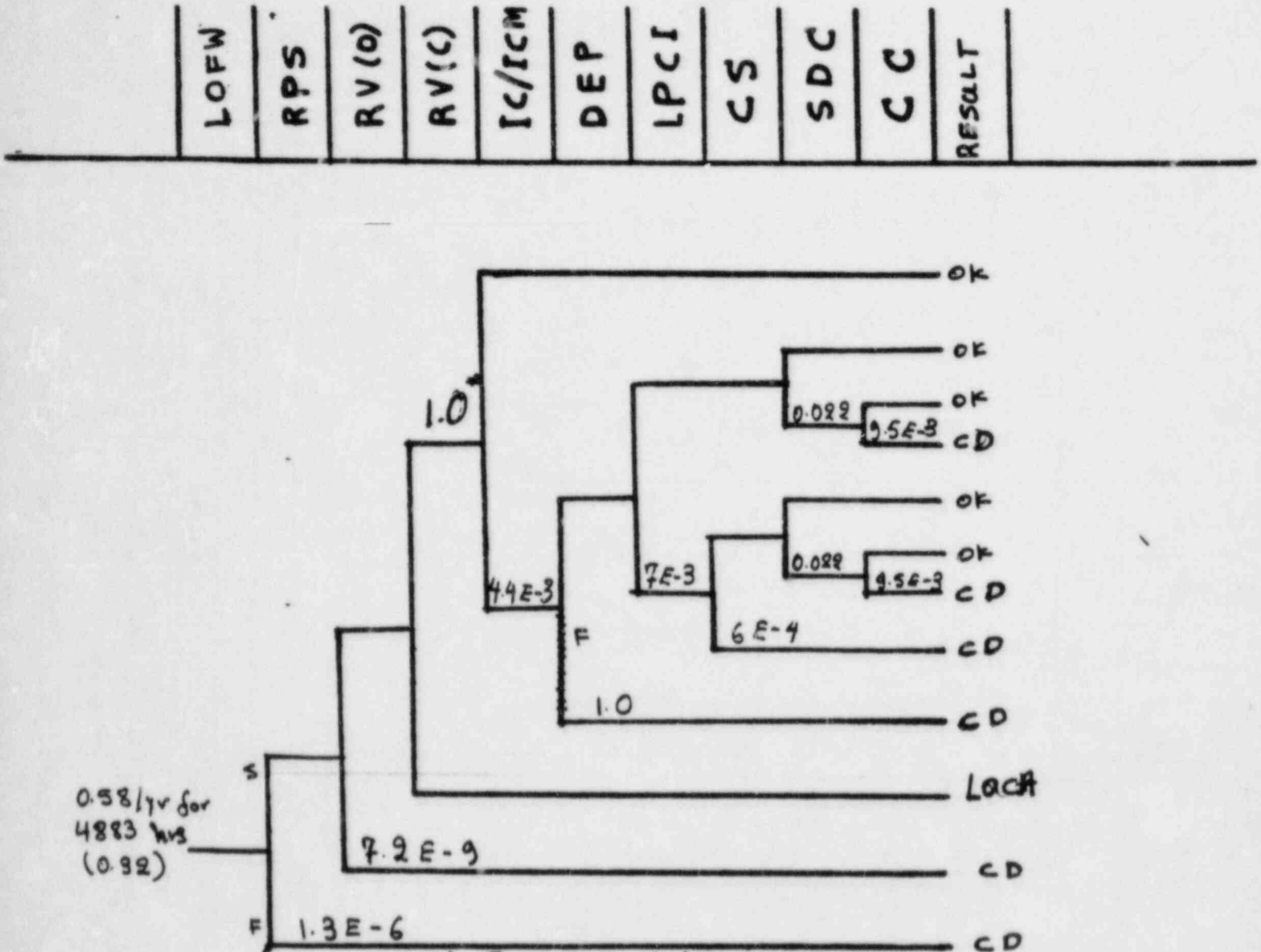
$P = 1.41E{-3} +$ addl. cont (LOOP, LOCA, MSLB). $4.1E{-4} = 1.55E{-3}$
$\times$ prob of occuring at power (0.75) $= 1.16E{-3}$

RESULT

OK = NO CORE DAMAGE

CD = CORE DAMAGE

* Assumption of 1.0 forces the event tree to represent a LOFW event.



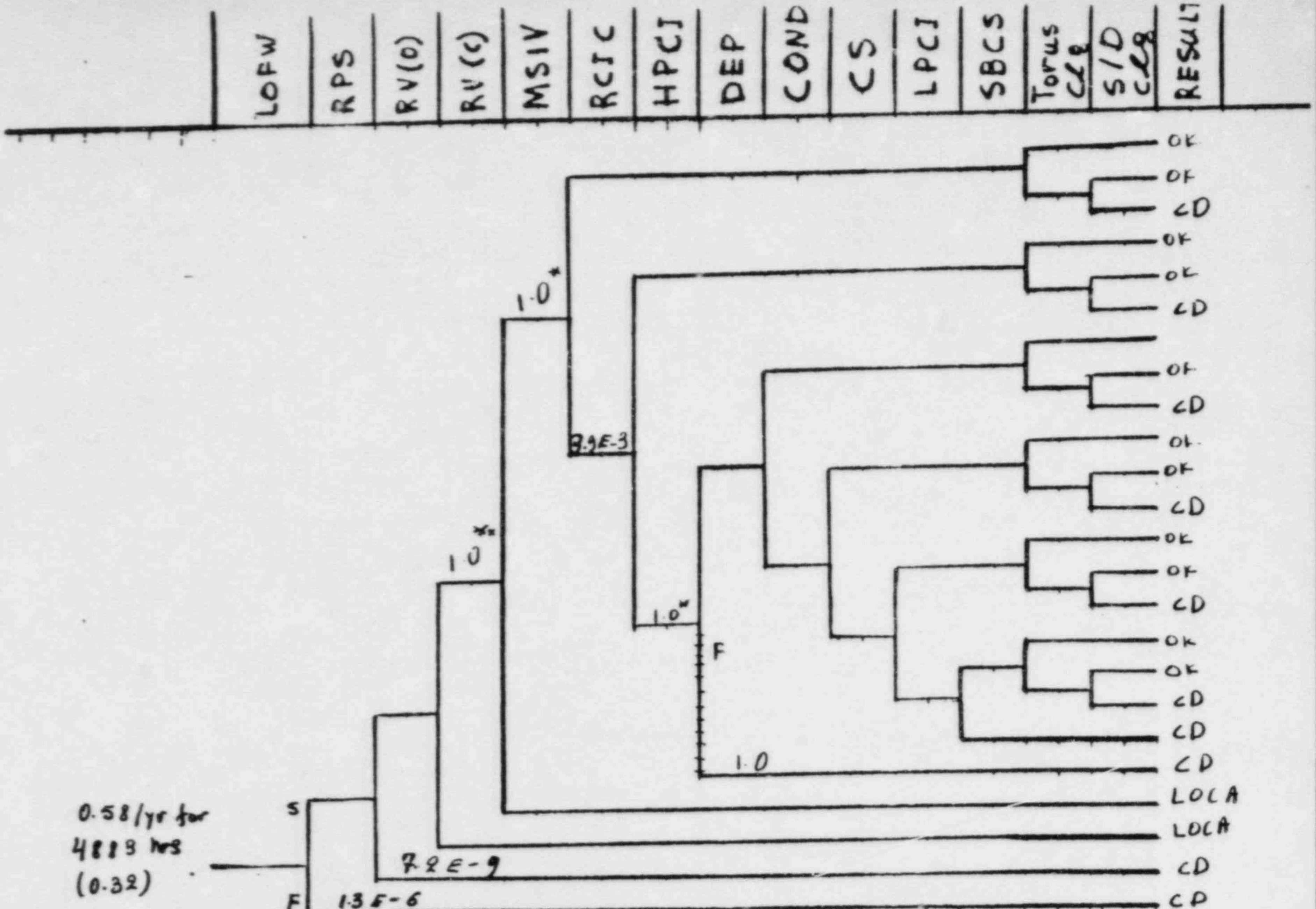
(NSIC 120443) - Sequence of Interest for Two Electromatic Relief Valves Fail at Quad Cities & Applied in

CATEGORY A3

P = 1.41E-3 + addl c. f. (LOOP, LOCA, MSLB), 4.1E-4 = 1.55E-3
× prob. of occuring at (0.75) power = 1.16E-3

RESULT
OK = NO CORE DAMAGE   S = Success
CD = CORE DAMAGE   F = Failure

* Assumption of 1.0 forces the event tree to represent a LOFW event.



(NSIC 120443)- Sequence of Interest for Two Electromatic Relief Valves Fail at Quad Cities, Applied in Category B

P=1.248 E-3 + addl. cont. (LOOP, LOCA, MSLB), 7.22E-4 = 1.97 E-3

x prob. of occuring at Power (0.75) = 1.48 E-3

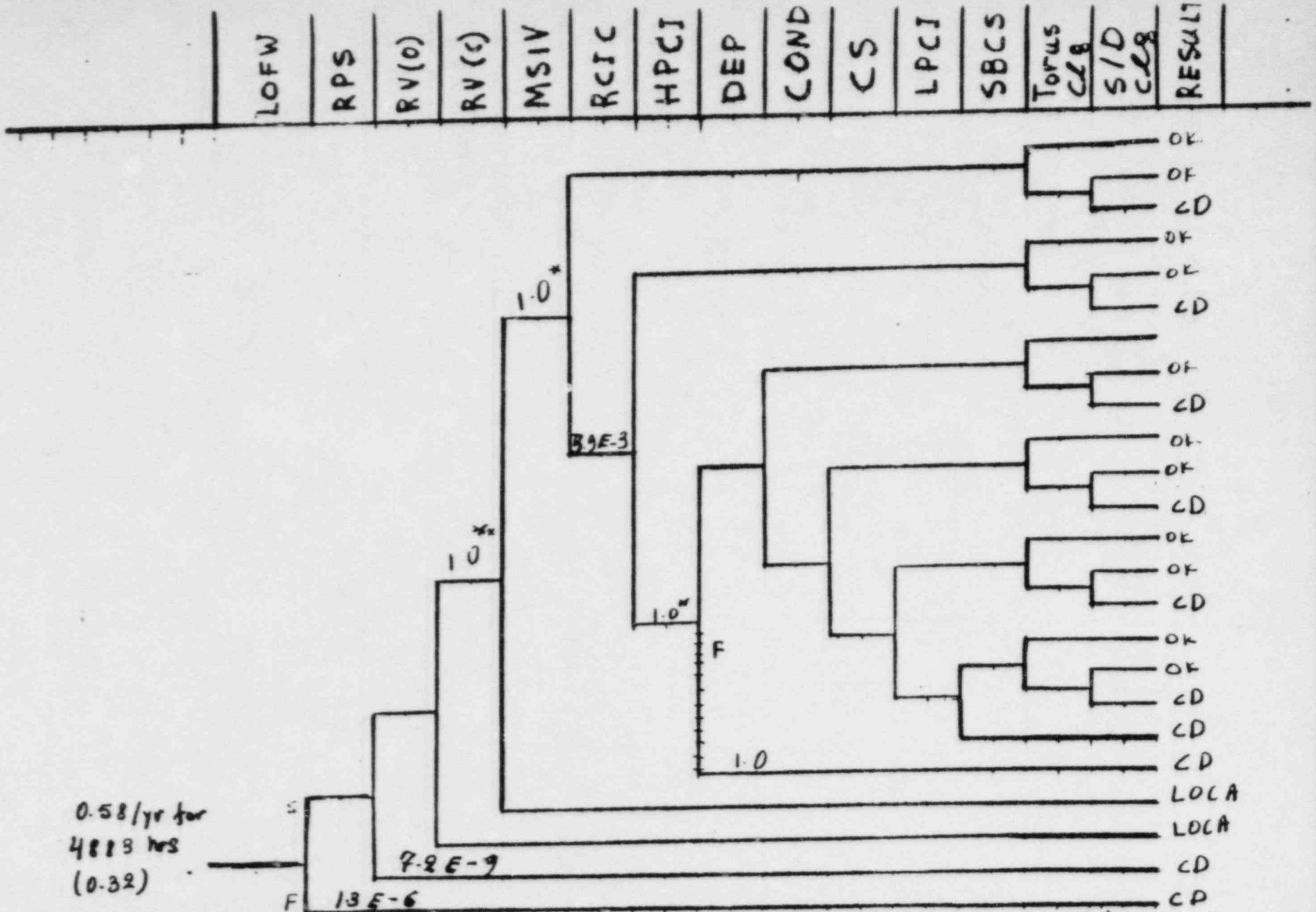
Result

OK = No Core Damage

CD = Core Damage

* Factor of 1.0 makes the RCIC/HPCI prob. equal to ASP prob.

** Assumption of 1.0 forces the event tree to represent a LOFW event.



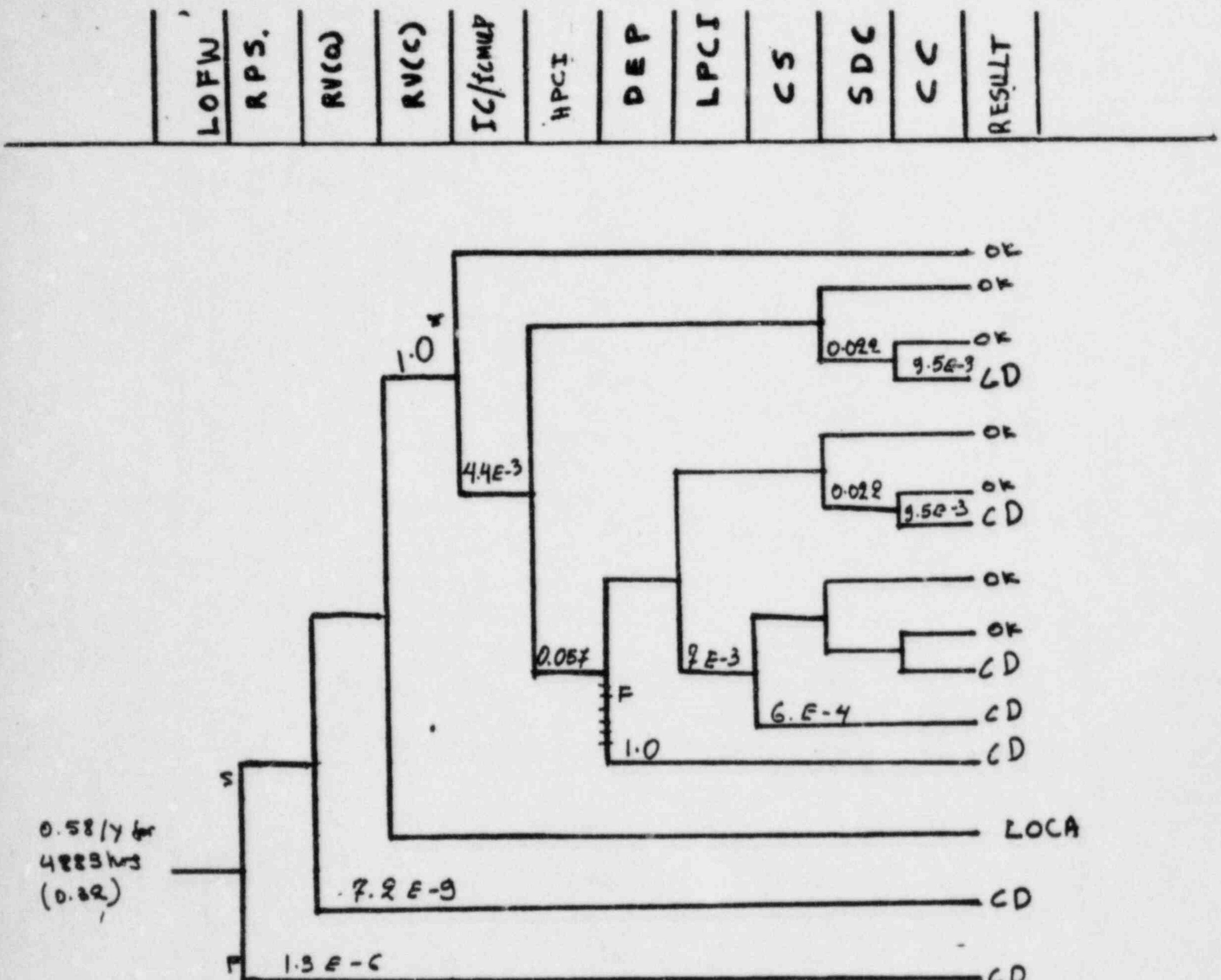
(NSIC 120443) - Sequence of Interest for Two Electromatic Relief Valves Fail at Quad Cities, Applied in Category C

P = 1.248 E-3 + add. Cont. (LOOP, LOCA, MSLB) 1.12 E-4 = 1.36 E-3

x prob. of occuring at Power (0.78) = 1.02 E-3

RESULT
OK = No CORE DAMAGE
CD = CORE DAMAGE

* Factor of 1.0 makes the RCIC/HPCI prob. equal to ASP prob.
** Assumption of 1.0 forces the event tree represent a LOFW event.

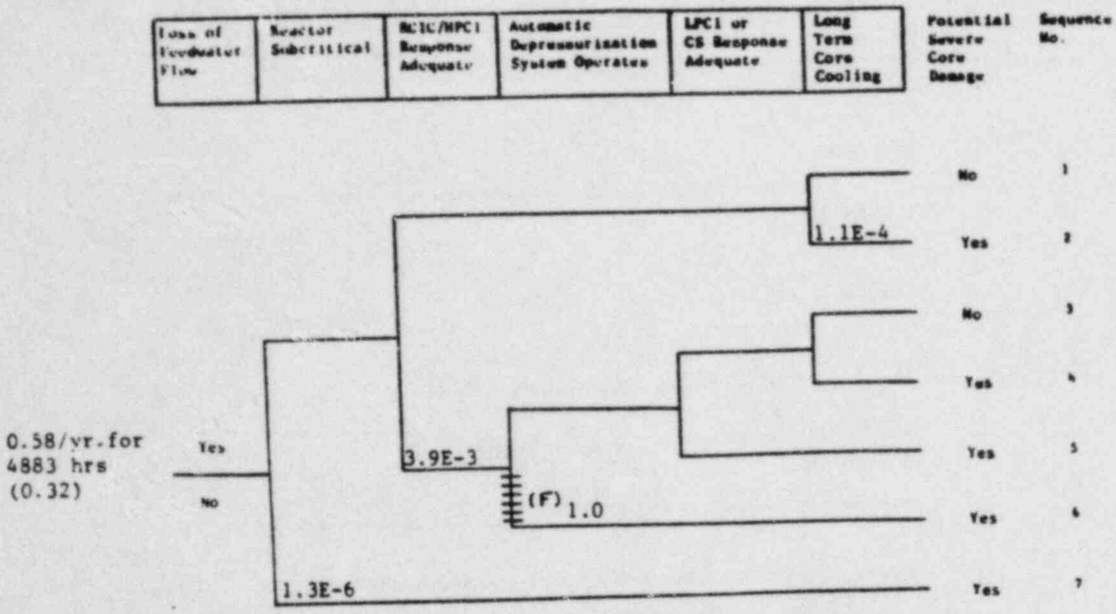


(NSIC 190449)-Sequence of Interest for Two Electromatic Relief Valves Fail at Quad Cities 2 Applied in Category D

P= 8.02 E-5 + addl cont. (LOOP, LOCA, MSLB), 1.34E-5
= 9.37E-5 × prob. of occuring at power (0.75) = 7. E-5

RESULT
OK = NO CORE DAMAGE   S = Success
CD = CORE DAMAGE   F = Failure

* Assumption of 1.0 forces the event tree to represent a LOFW event.

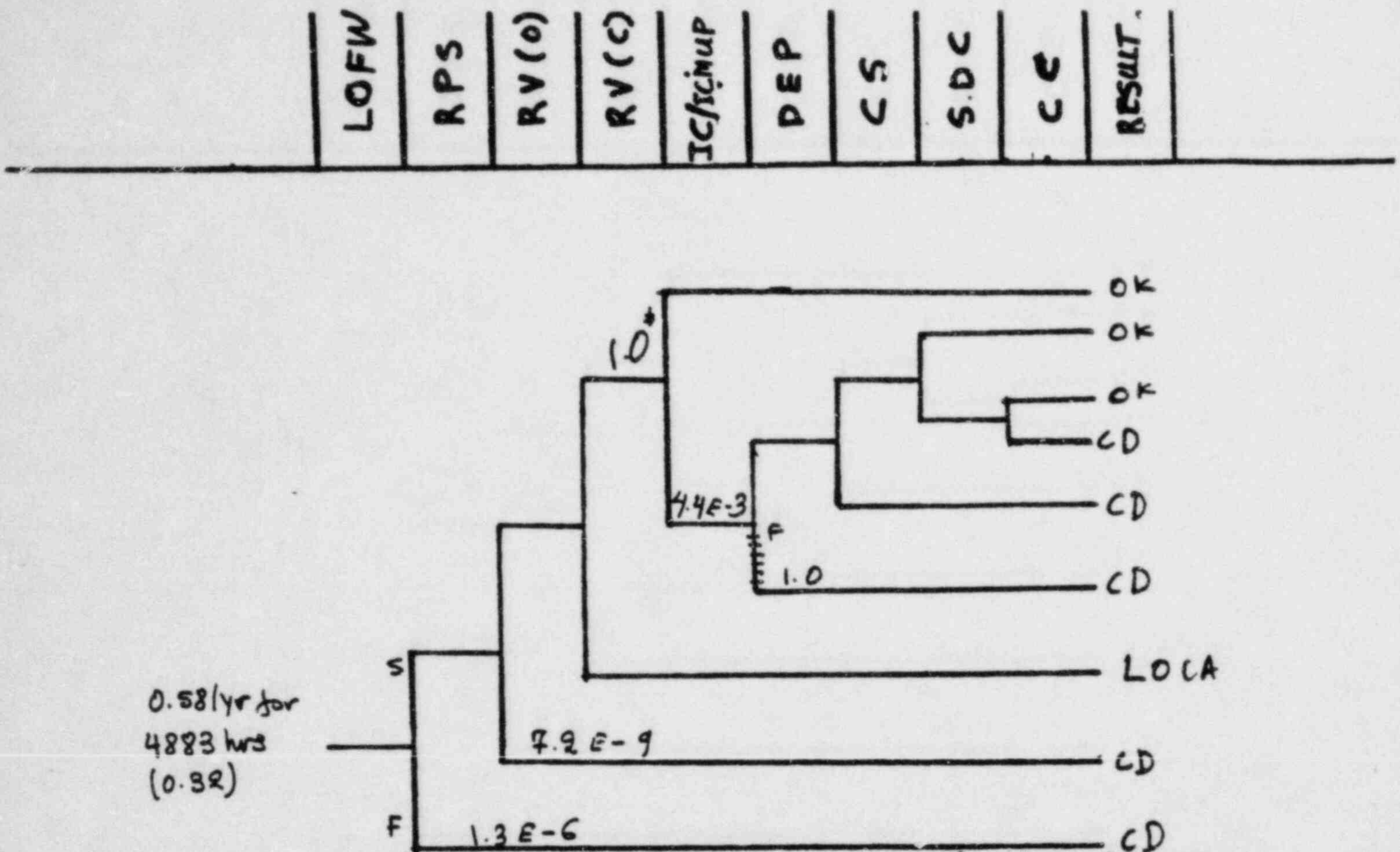


P = 1.3E-3 + addl. cont. (LOOP, LOCA, MSLB), 8E-4 = 2.1E-3

x prob. of occurring at power (0.75) = 1.6E-3 (SC = 28)

NSIC 120443 - Sequence of Interest for Two Electromatic Relief Valves Fail at Quad Cities 2

applied in Category E



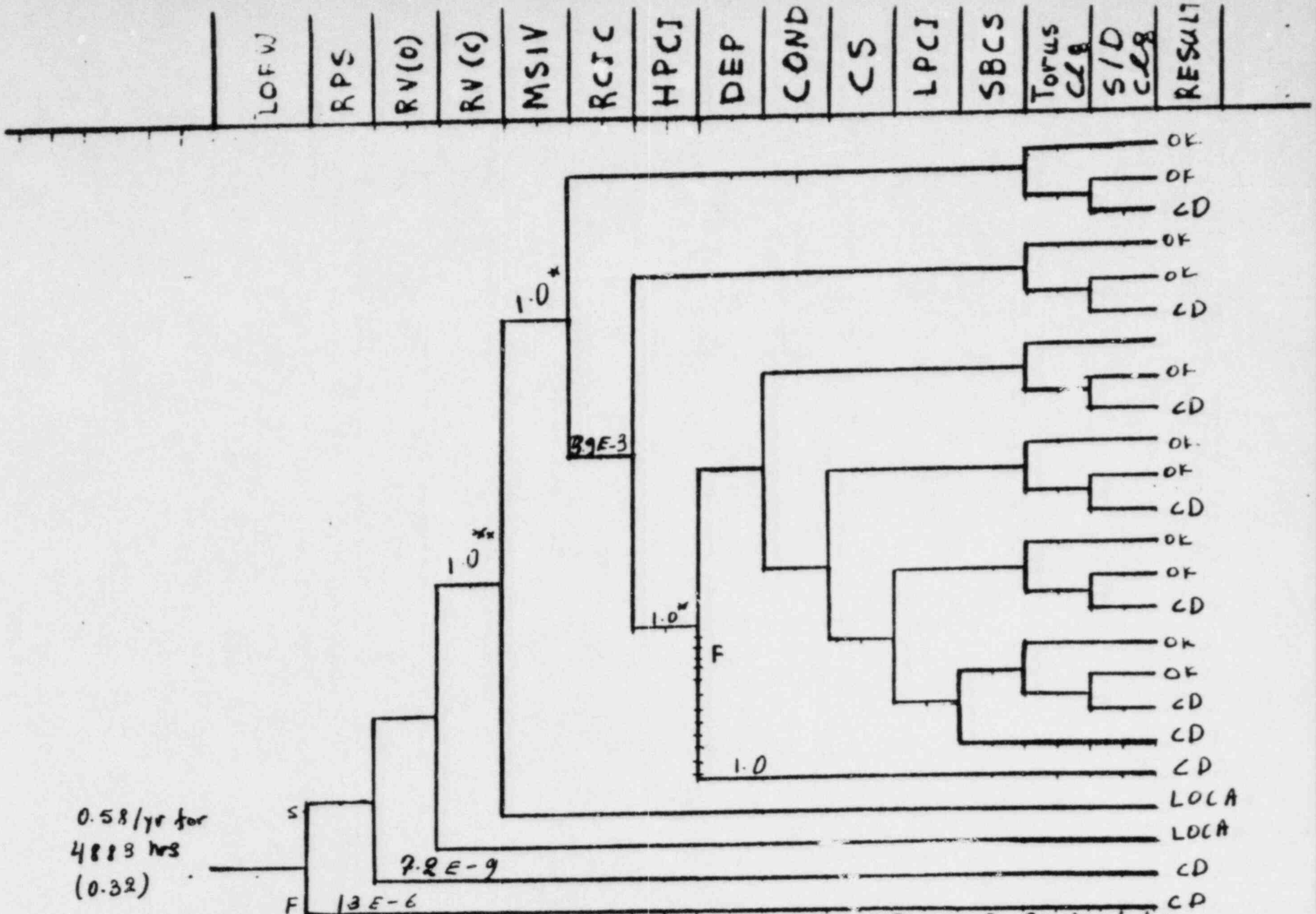
(NSIC 115870) - Sequence of Interest for Main Steam Relief Valve Fails to Operate at Vermont Yankee Applied in Categories A1 and A2

P = 1.41 E-3 + add'l. cont. (LOOP, LOCA, MSLB), 4.1 E-4
= 1.55 E-3 x prob. of occuring at power (0.75) = 1.16 E-3

RESULT

OK = NO CORE DAMAGE, S = Success
CD = CORE DAMAGE   F = Failure

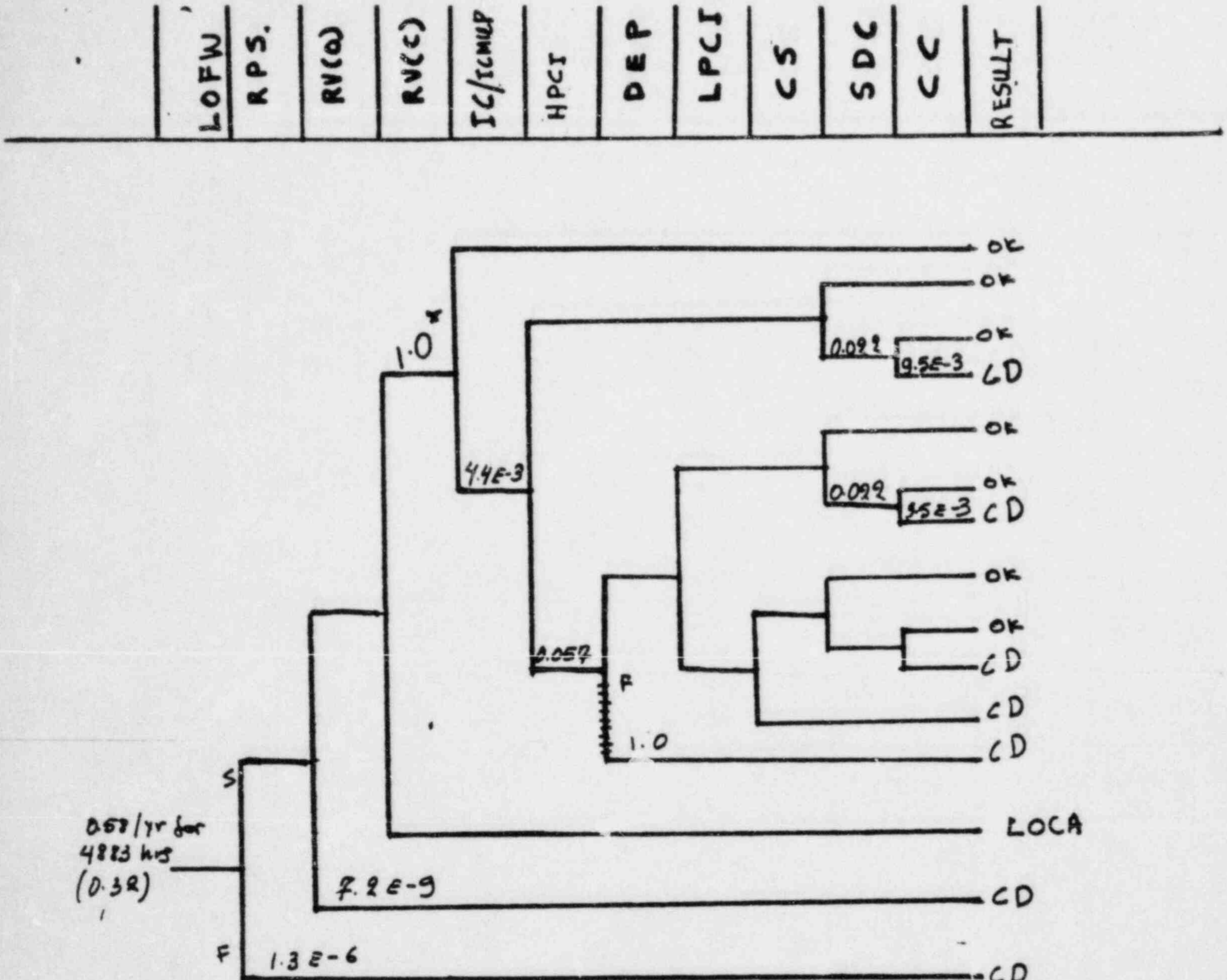
* Assumption of 1.0 forces the event tree to represent a LOFW event.



(NSIC 115870) - Sequence of Interest for Main Steam Relief Valve Fails to Operate at Vermont Yankee Applied in Category C

P = 1.248E-3 + add. cont. (LOOP, LOCA, MSLB) 1.12E-4 = 1.36E-3
x prob of occuring at Power (0.75) = 1.02E-3

* Factor of 1.0 makes the RCIC/HPCI prob. equal to ASP prob.
** Assumption of 1.0 forces the event tree to represent a LOFW event

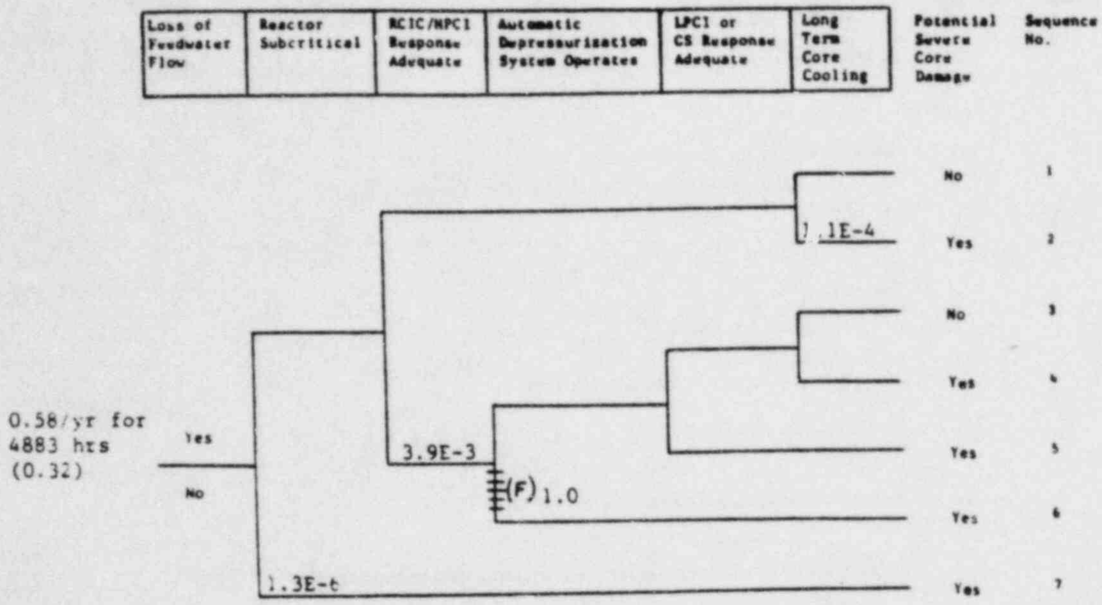


(NSIC 115870) - Sequence of Interest for Main Steam Relief Valve Fails to Operate at Vermont Yankee applied in Category D

P = 8.02 E-5 + add cont. (LOOP, LOCA, MSLB), 1.34 E-5 = 9.37 E-5
× prob of occuring on power (0.75) = 7. E-5

RESULT
OK = NO CORE DAMAGE   S = Success
CD = CORE DAMAGE   F = Failure

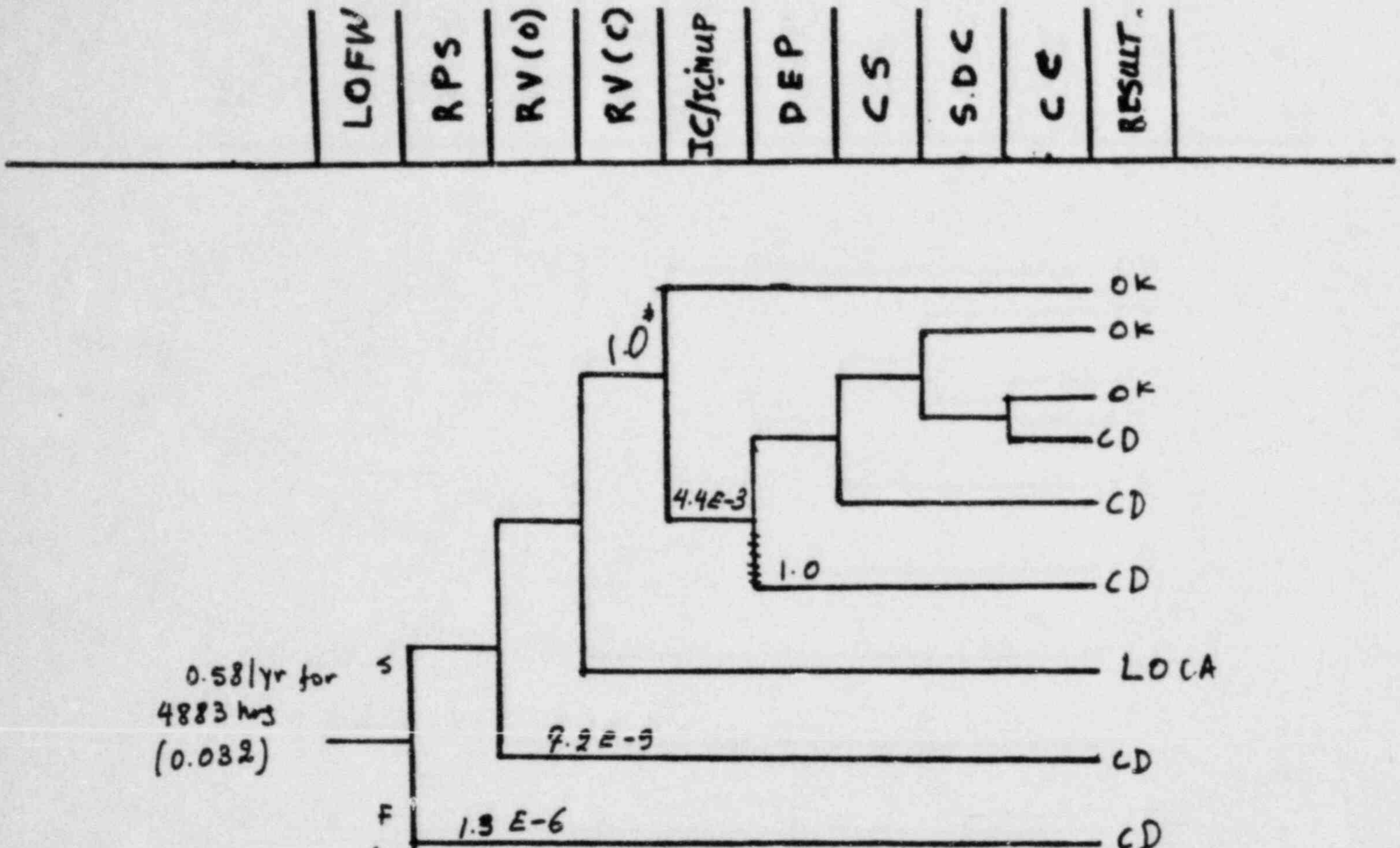
* Assumption of 1.0 forces the event tree to represent a LOFW event.



P = 1.3E-3 + addl. cont. (LOOP, LOCA, MSLB), 8E-4 = 2.1E-3

x prob. of occurring at power (0.75) = 1.5E-3 (SC = 28)

NSIC 115870 - Sequence of Interest for Main Steam Relief Valve Fails to Operate at Vermont Yankee applied in Category E



(NSIC 124222) - Sequence of Interest for Six Main Steam Relief Valves Fail to Lift Properly at Duane Arnold Applied in Categories A1 and A2

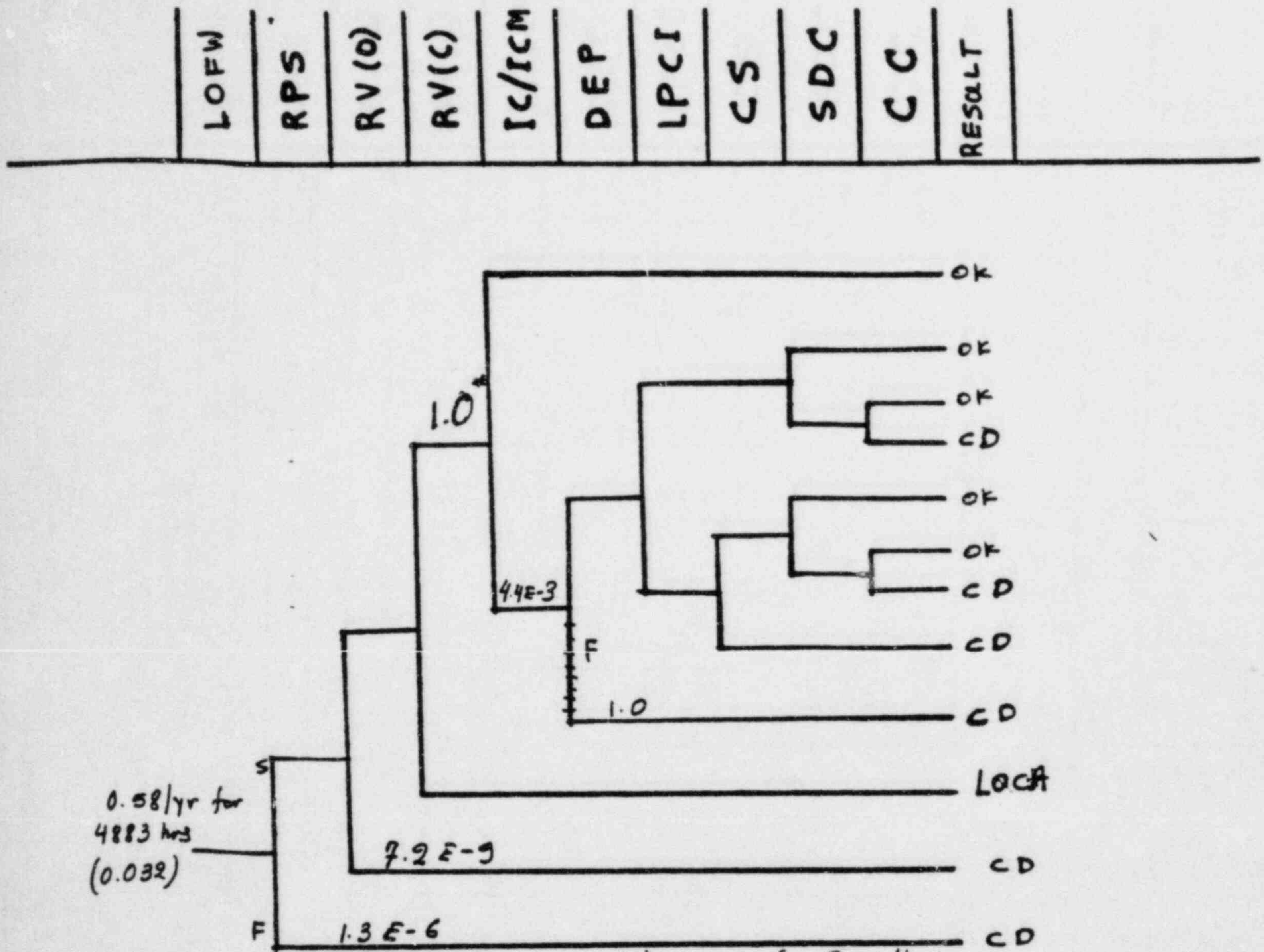
P = 1.41E-3 + addl. cont. (LOOP, LOCA, MSLB), 4.1E-4
= 1.55E-3 x prob. of occuring at power (0.75) = 1.16E-3

RESULT

OK = NO CORE DAMAGE   S = success

CD = CORE DAMAGE   F = Failure

* Assumption of 1.0 forces the event tree to represent a LOFW event.

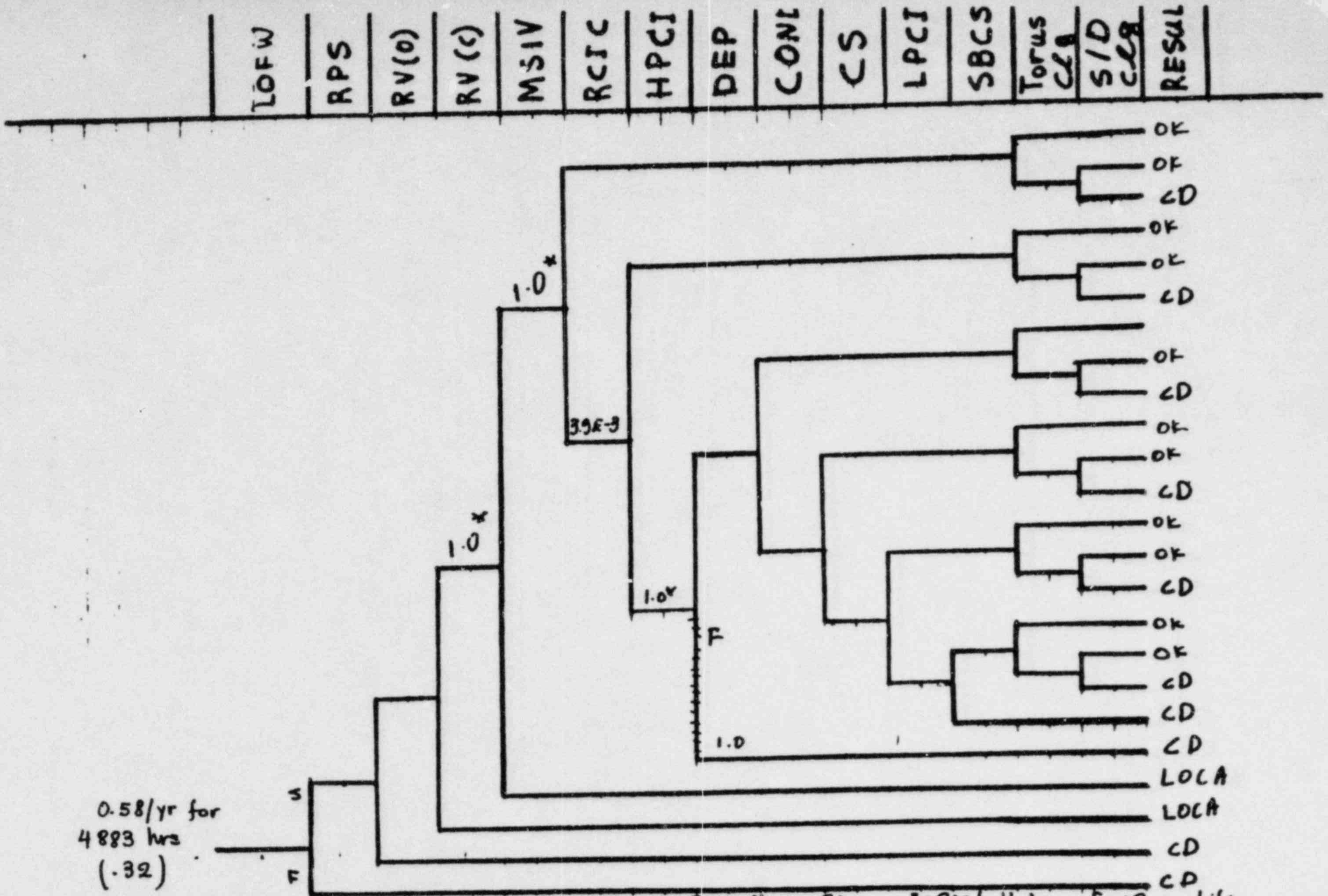


(NSIC 124222) Sequence of Interest for Six Main Steam Relief Valves Fail to Lift Properly at Duane Arnold, Applied in <u>Category A3</u>

P = 1.41 E-3 + addl. cont. (LOOP, LOCA, MSLB), 4.1E-4
= 1.55E-3 * prob. of occuring at power (0.75) = 1.16 E-3

<u>RESULT</u>
OK = NO CORE DAMAGE   S = Success
CD = CORE DAMAGE   F = Failure

* Assumption of 1.0 forces the event tree to represent a LOFW event.



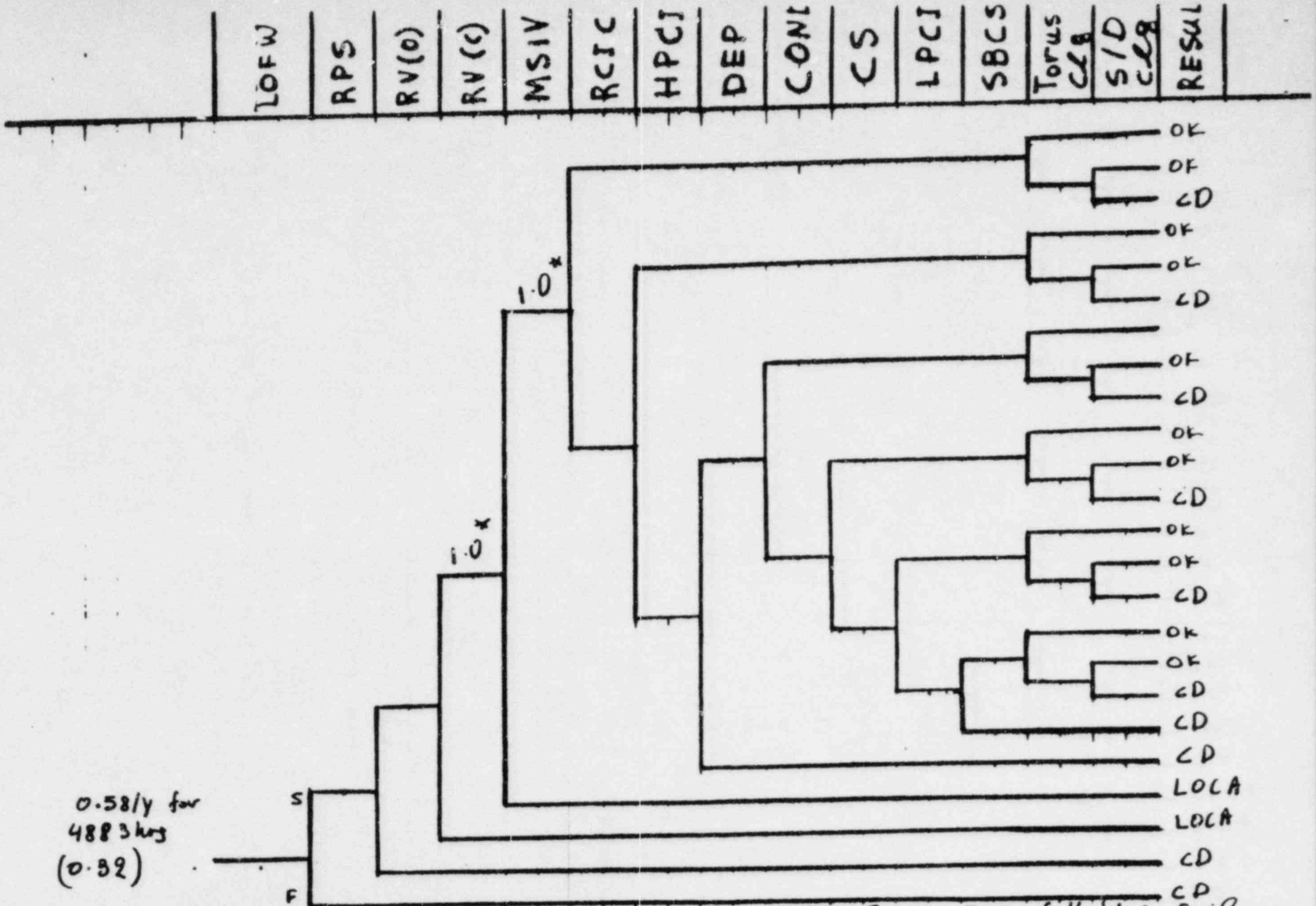
(NSIC 124222)- Sequence of Interest of Six Main Steam Relief Valves Fail to Lift Properly at Duane Arnold Applied, in Category B

P = 1.248E-3 + add. cont. (LOOP, LOCA, MSLB), 7.22E-4 = 1.97E-3

× prob. of occuring at Power (0.75) = 1.48E-3

RESULT
OK = NO CORE DAMAGE
CD = CORE DAMAGE

* Assumption of 1.0 forces the event tree to represent a LOFW event

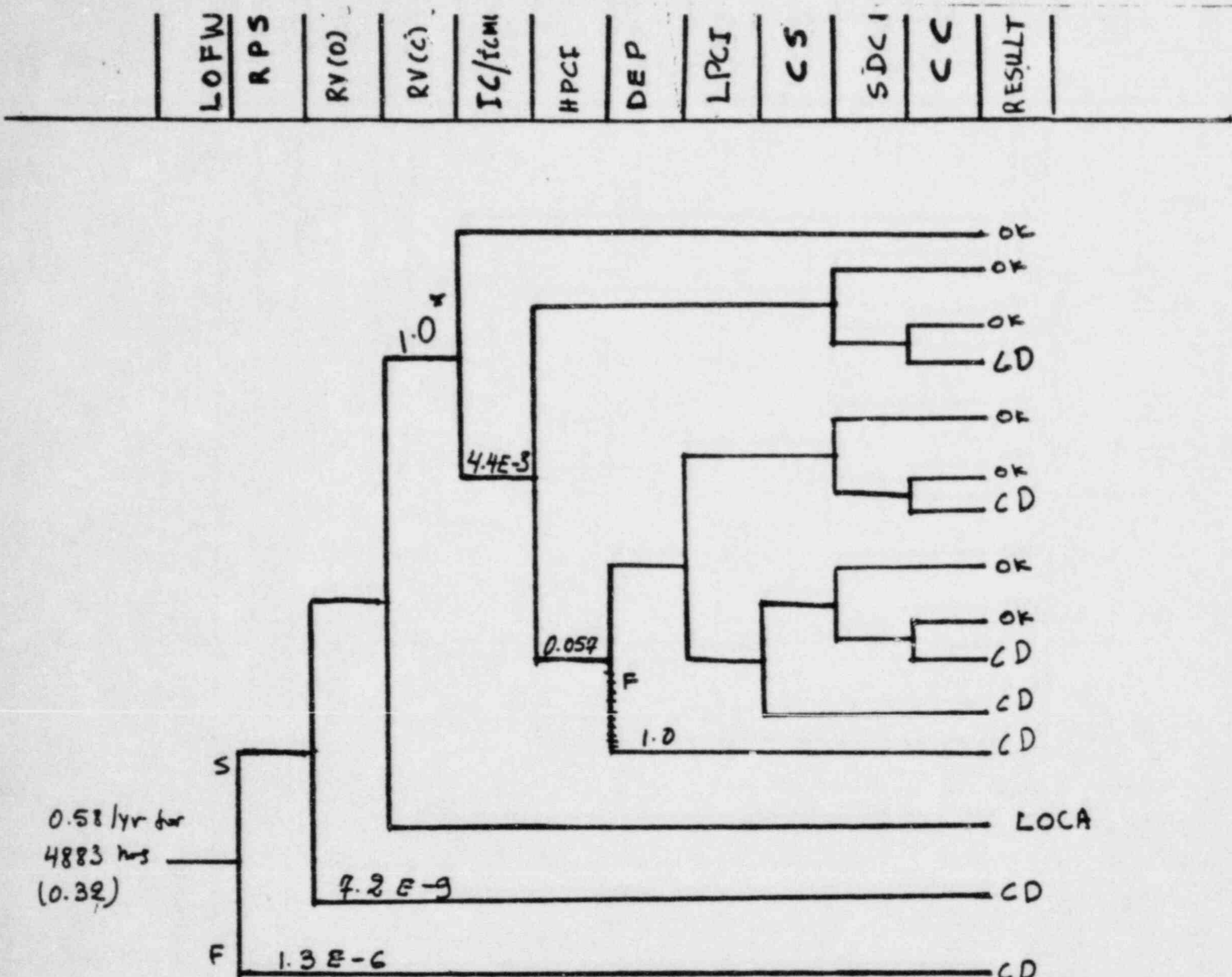


(NSIC 124222) - Sequence of Interest of Six Main Steam Relief Valves Fail to Lift Properly at Duane Arnold, Applied in Category C

P = 1.248E-3 + addl. Cont. (LOOP, LOCA, MSLB) 1.12E-4 = 1.36E-3
x Prob. of occuring at Power (.75) = 1.02E-3

RESULT
OK = NO CORE DAMAGE
CD = CORE DAMAGE

* Assumption of 1.0 forces the event tree to represent a LOFW event

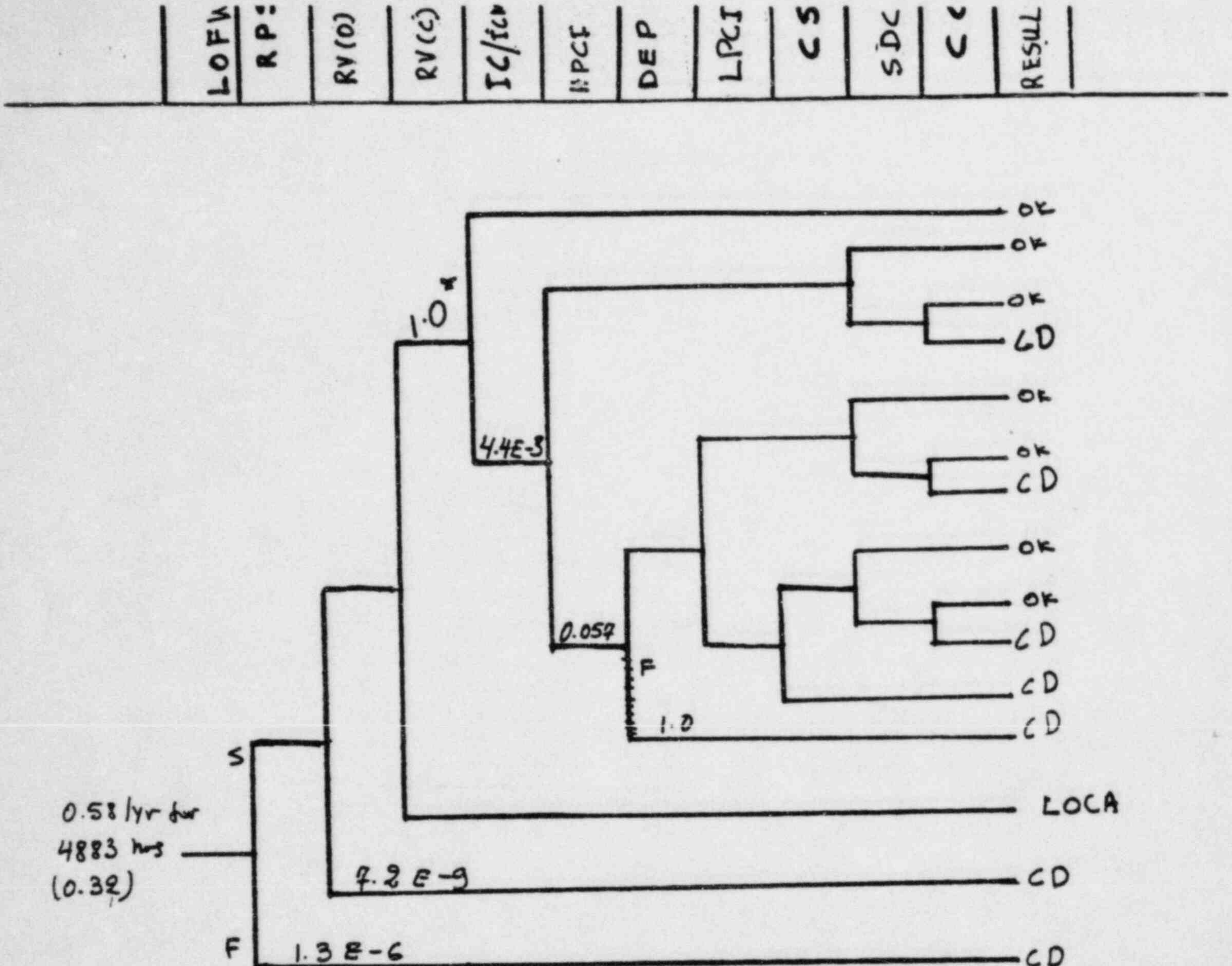


(NSIC 124222) - Sequence of Interest for Six Main Steam Relief Valve Fail to Lift Properly at Duane Arnold Applied in <u>Category D</u>

P= 8.02E-5+addl. cont. (LOOP, LOCA, MSLB), 1.34E-5
=9.37E-5 x prob. of occuring at power (0.75)
= 7.E-5

<u>RESULT</u>
OK = NO CORE DAMAGE   S = success
CD = CORE DAMAGE   F = Failure

* Assumption of 1.0 forces the event tree to represent a LOFW event.



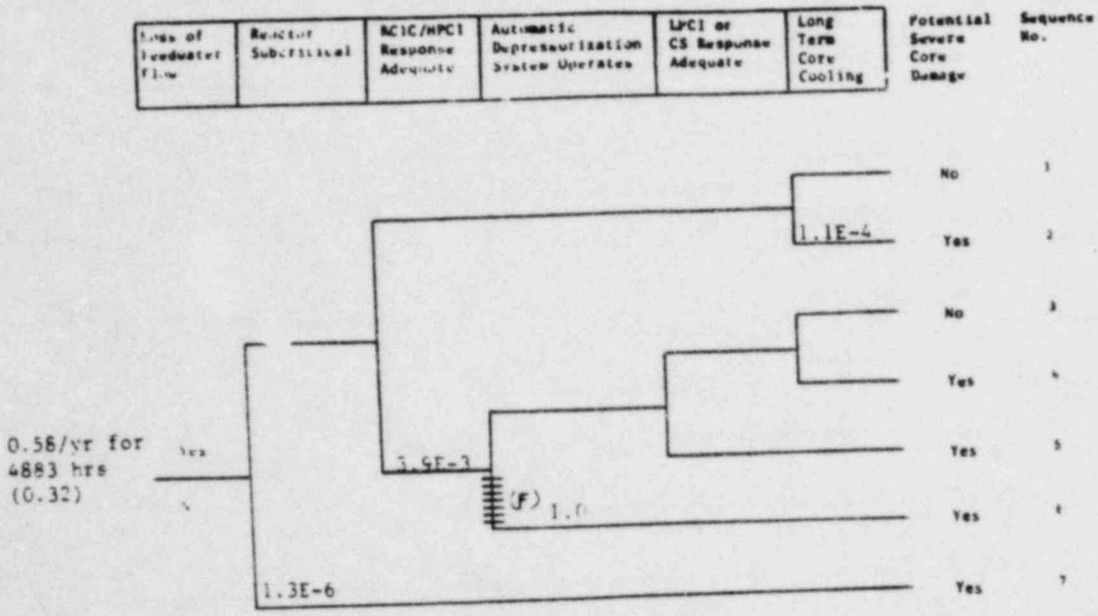
(NSIC 124222) - Sequence of Interest for Six Main Steam Relief Valves Fail to Lift Properly at Duane Arnold Applied in <u>Category D</u>

P = 8.02E-5 + addl. cont. (LOOP, LOCA, MSLB), 1.34E-5
= 9.37E-5 x prob. of occuring at power (0.75)
= 7.E-5

RESULT

OK = NO CORE DAMAGE S = success
CD = CORE DAMAGE F = Failure

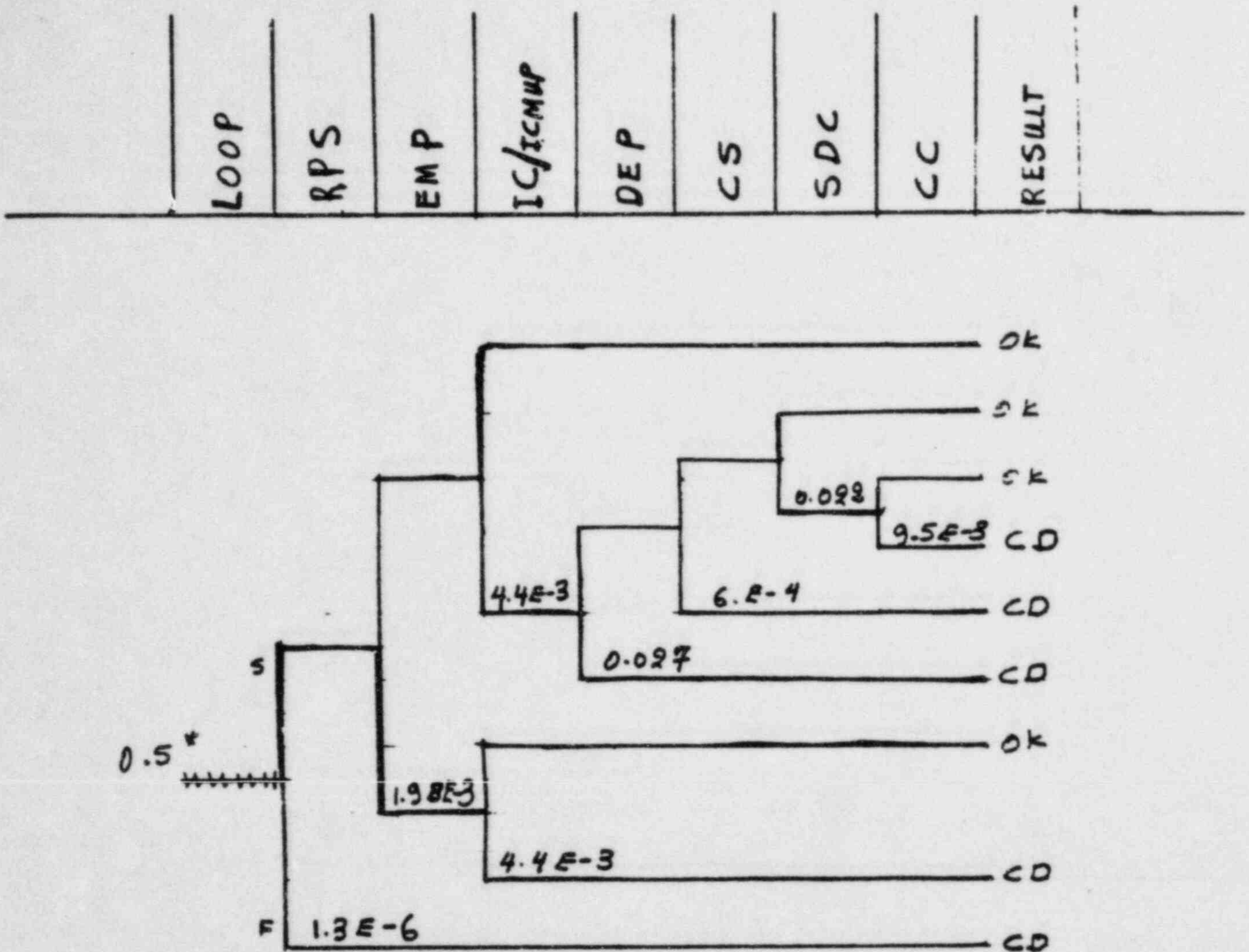
* Assumption of 1.0 forces the event tree to represent a LOFW event.



P = 1.3E-3 + addl. cont. (LOOP, LOCA, MSLB), 8E-4 = 2.1E-3

x prob. of occurring at power (0.75) = 1.6E-3 (SC = 28)

NSIC 174222 - Sequence of Interest for Six Main Steam Relief Valves Fail to Lift Properly at Duane Arnold, applied in Category E



(NSIC 116980) - Sequence of Interest of Gas Turbine Becomes Unavailable at Millstone 1, Applied in Oyester Creek Plant of Category A1.

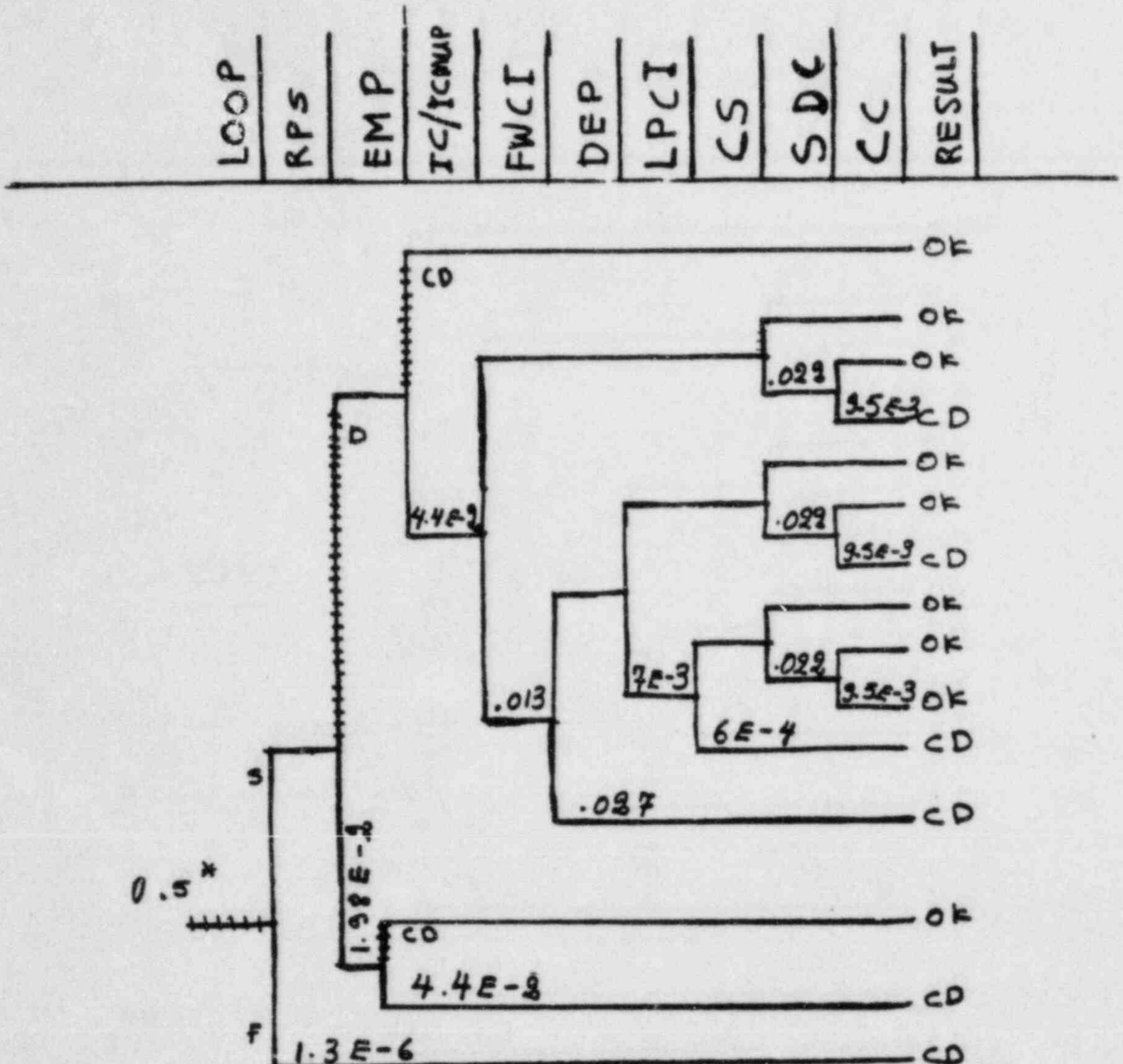
P= 6.62 E-5

RESULT

OK = NO CORE DAMAGE S = SUCCESS

CD = CORE DAMAGE F = Failure

* Applies at plants near the Ocean Only.

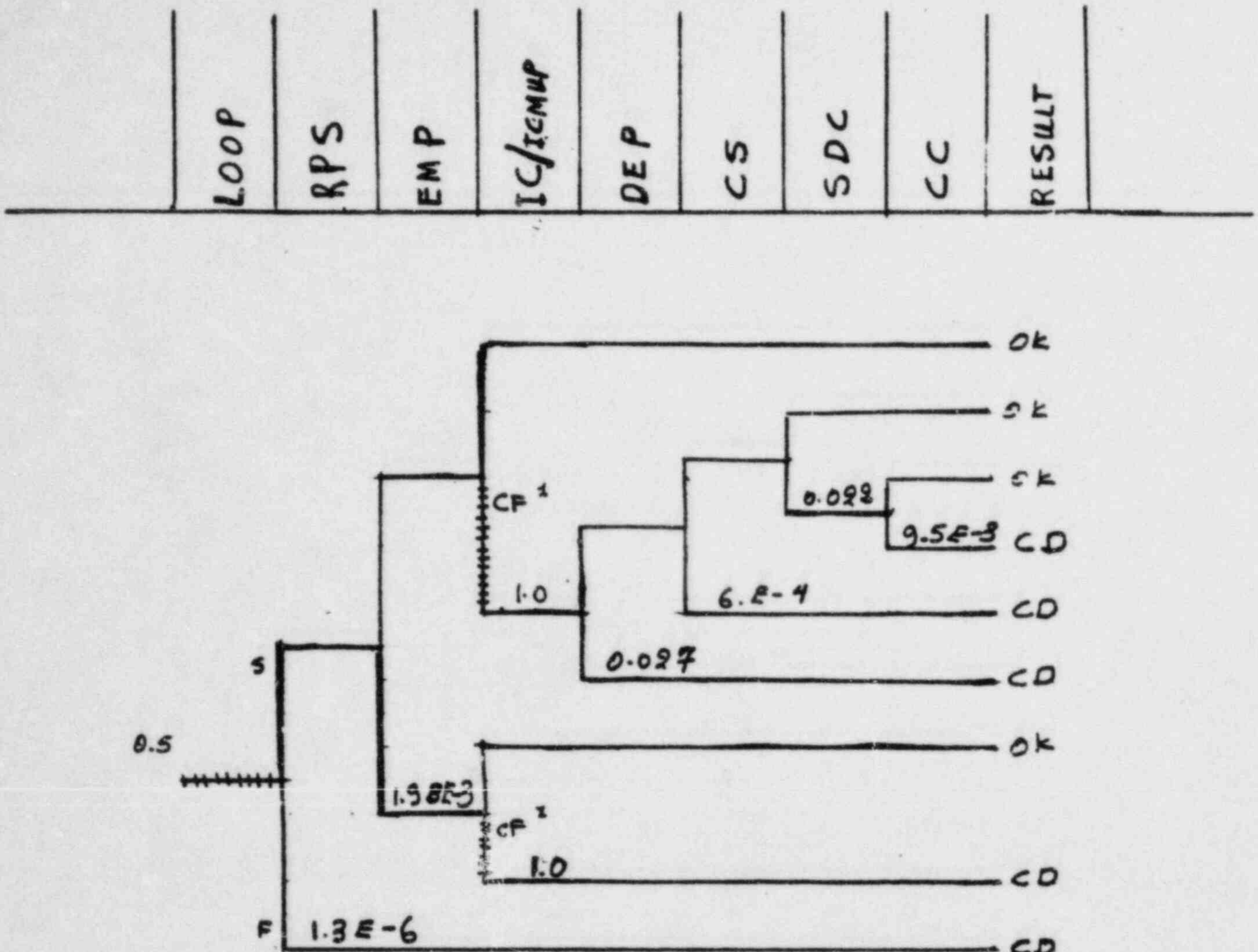


(NSIC 116980)-Sequence of Interest of Gas Turbine becomes Unavailable at Millstone 1, Applied at Millstone 1 plant o/s Category AS

P= 4.49 E-4

RESULT
OK = NO CORE DAMAGE
CD = CORE DAMAGE
S = Success
F = Failure

* Applies at plants near the Ocean only.



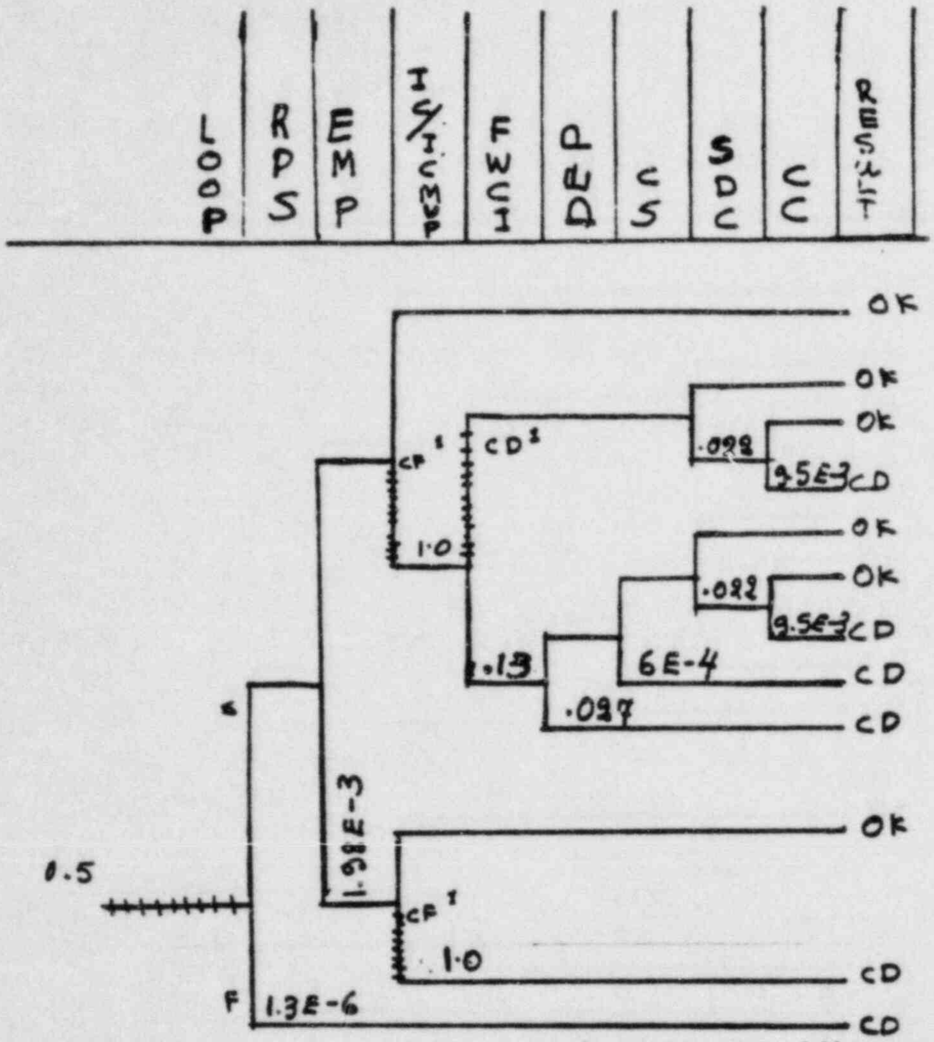
(NSIC 106616)-Sequence of Interest of Offsite Power and a Relief Valve Sticks Open at Pilgrim 1, Applied in Category A1

P=1.45E-2

RESULT

OK = NO CORE DAMAGE   S = SUCCESS
CD = CORE DAMAGE   F = Failure

1. Relief Valve stuck Open.



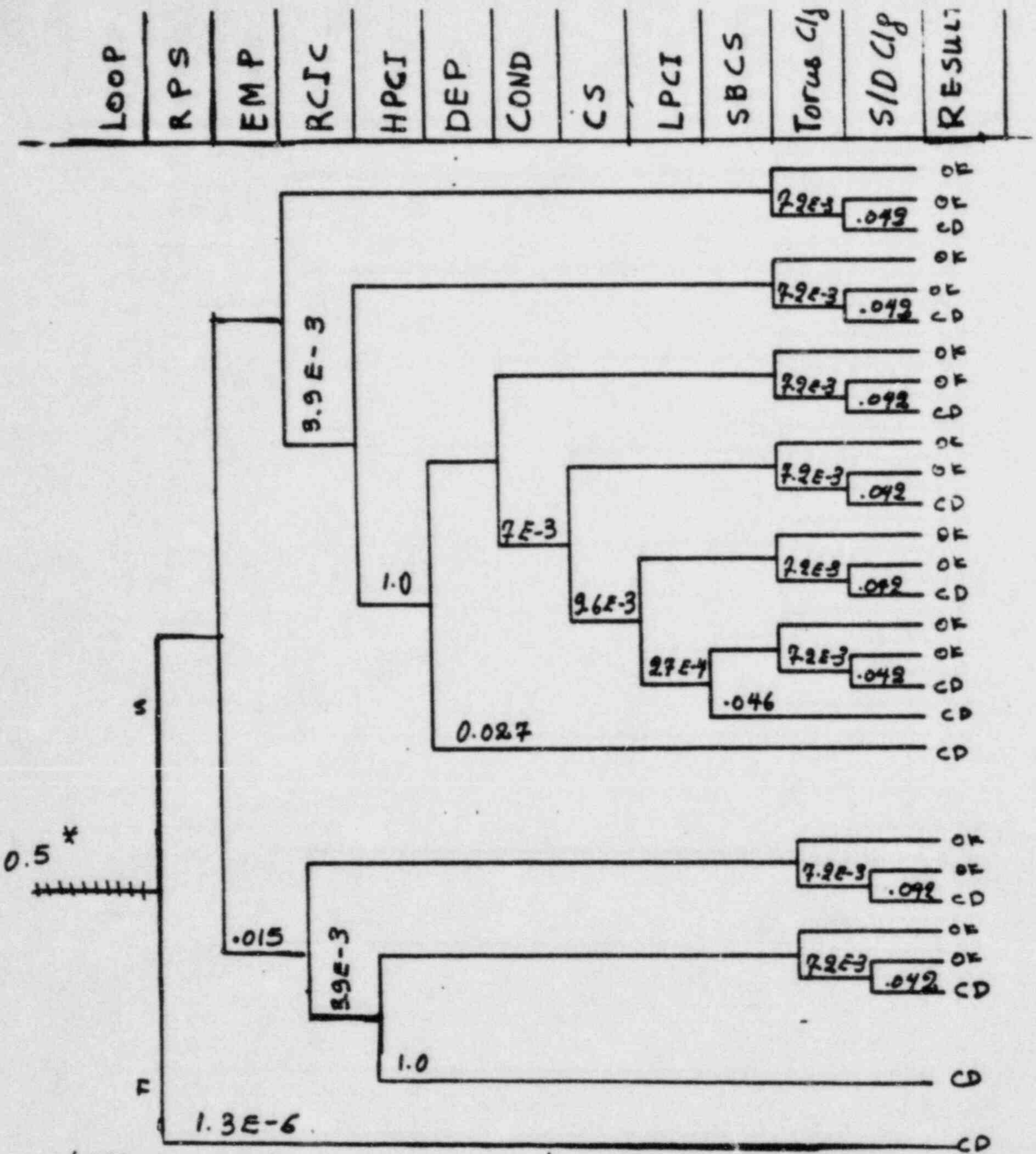
(NSIC 106616) – Sequence of Interest of Offsite Power and Relief Valve Sticks Open at Pilgrim 1.
Applied in <u>Category A2</u>

P = 2.90E-3

<u>RESULT</u>

OK = NO CORE DAMAGE
CD = CORE DAMAGE
S = Success
F = Failure

1. A relief Valve Stuck Open.



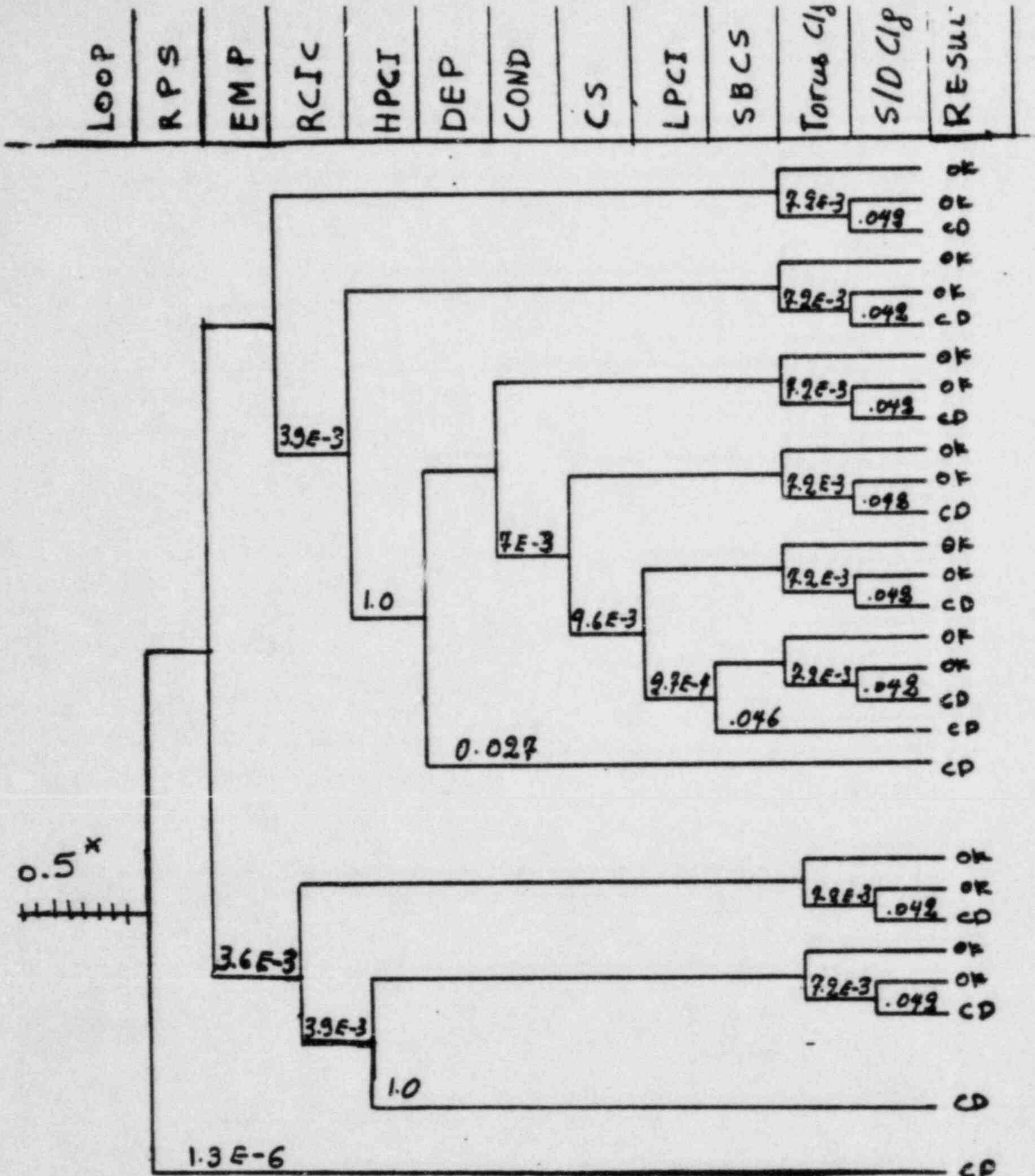
(NSIC 116700) - Sequence of Interest of Gas Turbine Becomes Unavailable at Millstone 1, Applied at Brunswick 2 plant of Category B.

P=2.37E-4

RESULT

OK = NO CORE DAMAGE
CD = CORE DAMAGE
S = Success
F = Failure

* Applies at plants near the Ocean only.



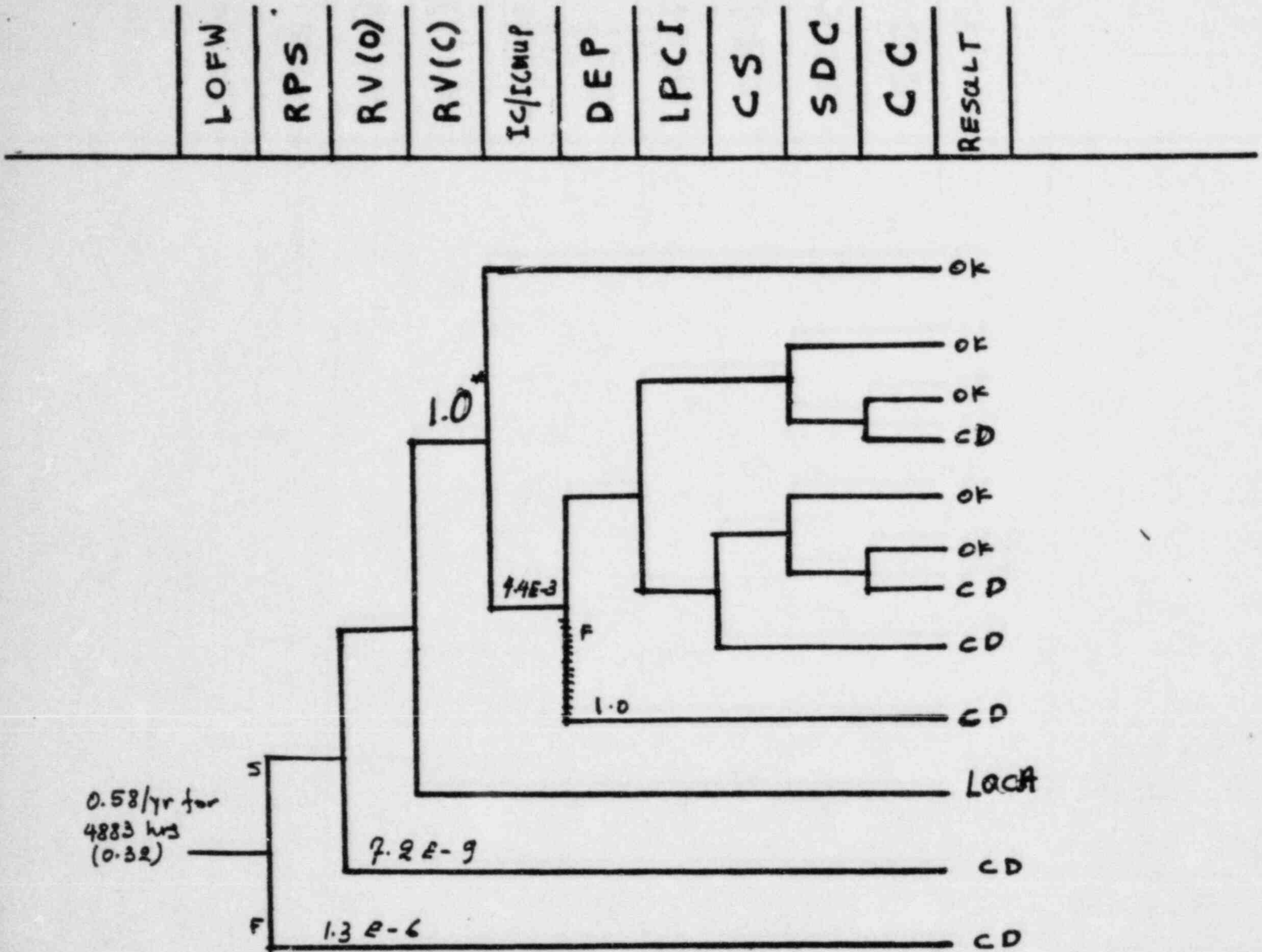
(NSIC 116780) - Sequence of Interest of Gas Turbine Becomes Unavailable at Millstone I, Applied at Pilgrim plant of Category C

P = 2.13E-4

RESULT

OK = NO CORE DAMAGE
CD = CORE DAMAGE

* Applies at plants near the Ocean only.

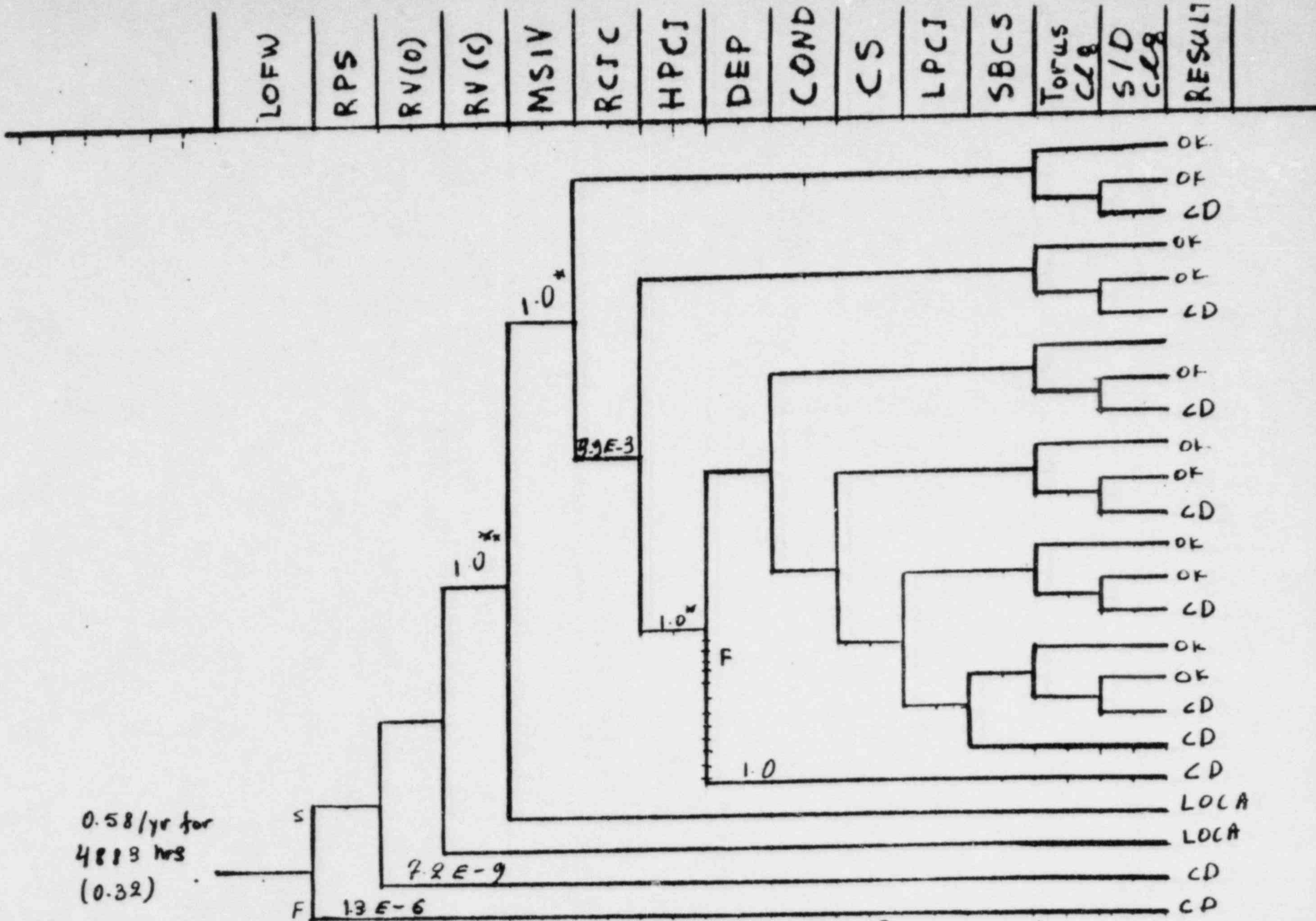


(NSIC 115780) - Sequence of Interest for Main Steam Relief Valve Fails to Operate at Vermont Yankee Applied in <u>Category A3</u>

P = 1.41E-3 + addl. cont. (LOOP, LOCA, MSLB), 4.1E-4
= 1.55E-3 × prob of occuring at (0.95) power = 1.15E-3

<u>RESULT</u>
OK = NO CORE DAMAGE   S = Success
CD = CORE DAMAGE   F = Failure

* Assumption of 1.0 forces the event tree to represent a LOFW event.



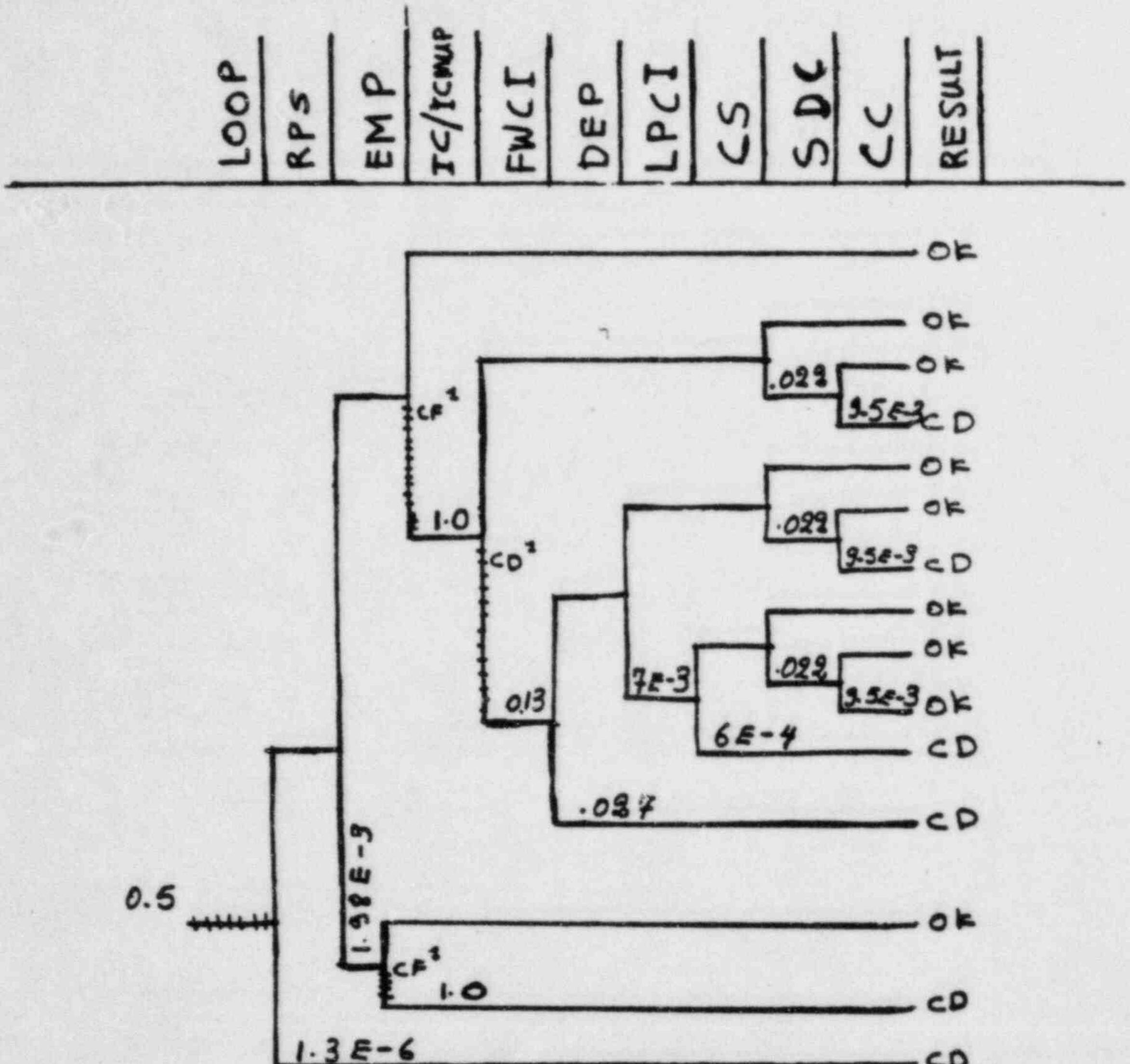
(NSIC 115880) - Sequence of Interest for Main Steam Relief Valve Fails to Operate at Vermont Yankee, Applied in Category B

P = 1.248E-3 + add. cont. (LOOP, LOCA, MSLB), 7.22E-4 = 1.97E-3

* Prob. of occuring at Power (0.75) = 1.48 E-3

* Factor of 1.0 makes the RCIC/HPCI prob. equal to ASP prob.

** Assumption of 1.0 forces the Event tree to represent a LOFW event



(NSIC 106616)- Sequence of Interest for Loss of Offsite Power and a Relief Valve Sticks Open at Pilgrim 1, Applied in Category A3

P=2.86 E-3

RESULT

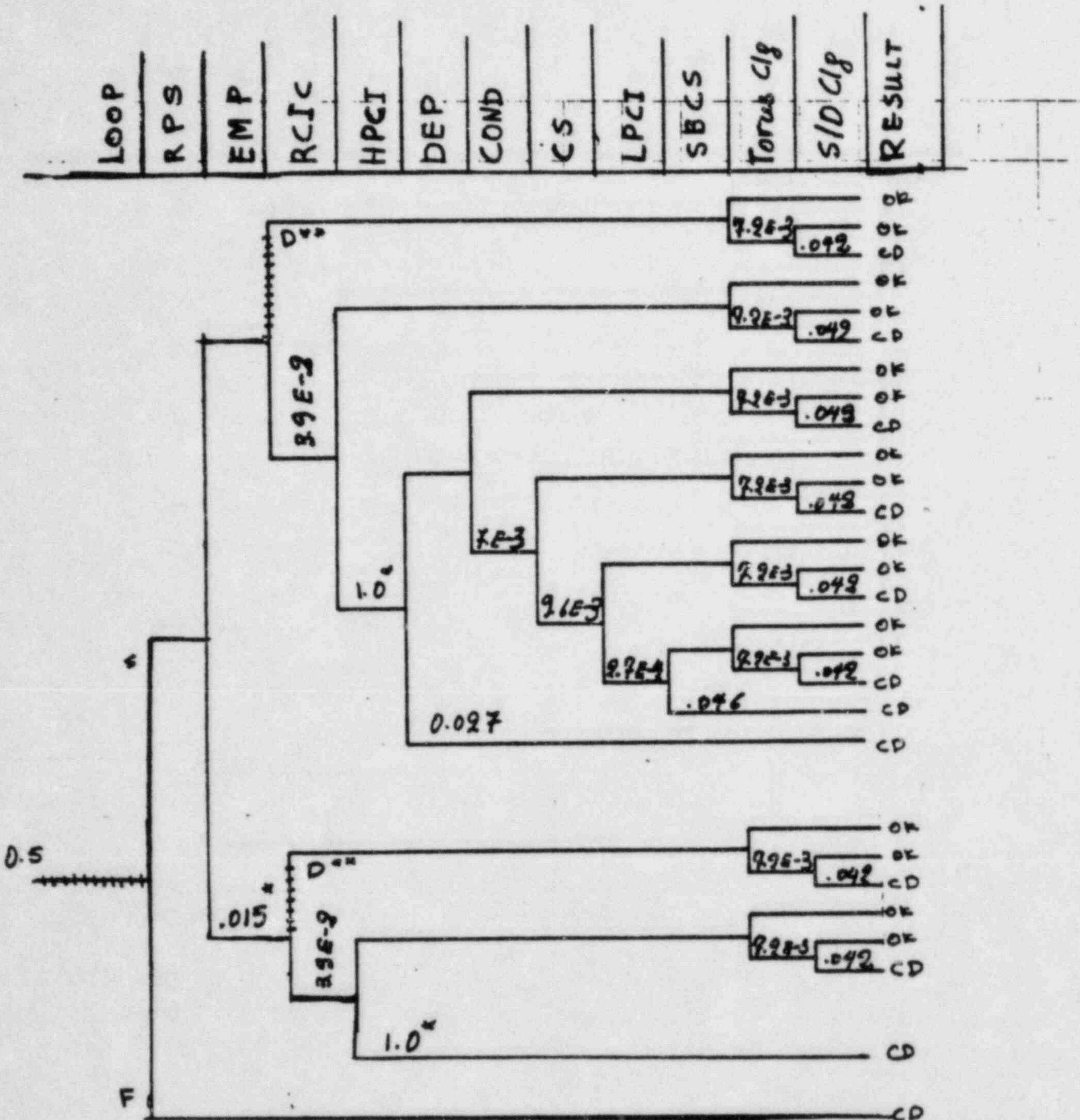
OK = NO CORE DAMAGE

CD = CORE DAMAGE

S = Success

F = Failure

1. A relief valve stuck open.



(NSIC 106616)–Sequence of Interest for Loss of Offsite Power and a Relief Valve sticks open at Pilgrim 1, Applied in Category B

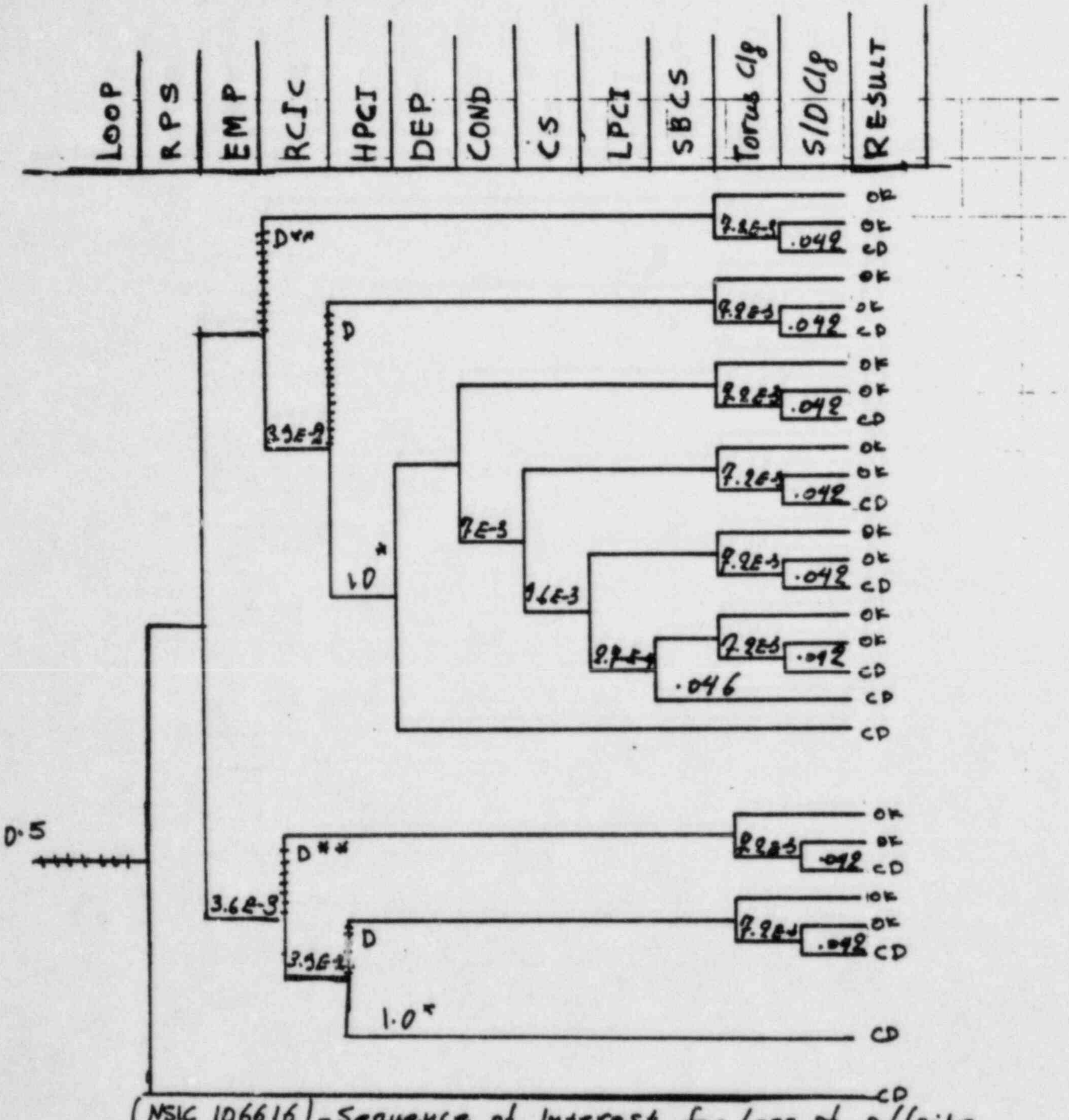
P = 2.37E-3

RESULT

OK = NO CORE DAMAGE
CD = CORE DAMAGE
S = Success
F = Failure

* Factor of 1.0 makes the RCIC/HPCI prob. equal to ASP prob.

** A relief valve stuck open.



(NSIC 106616) - Sequence of Interest for Loss of Offsite Power and a Relief Valve sticks Open at Pilgrim 1, Applied in Category C

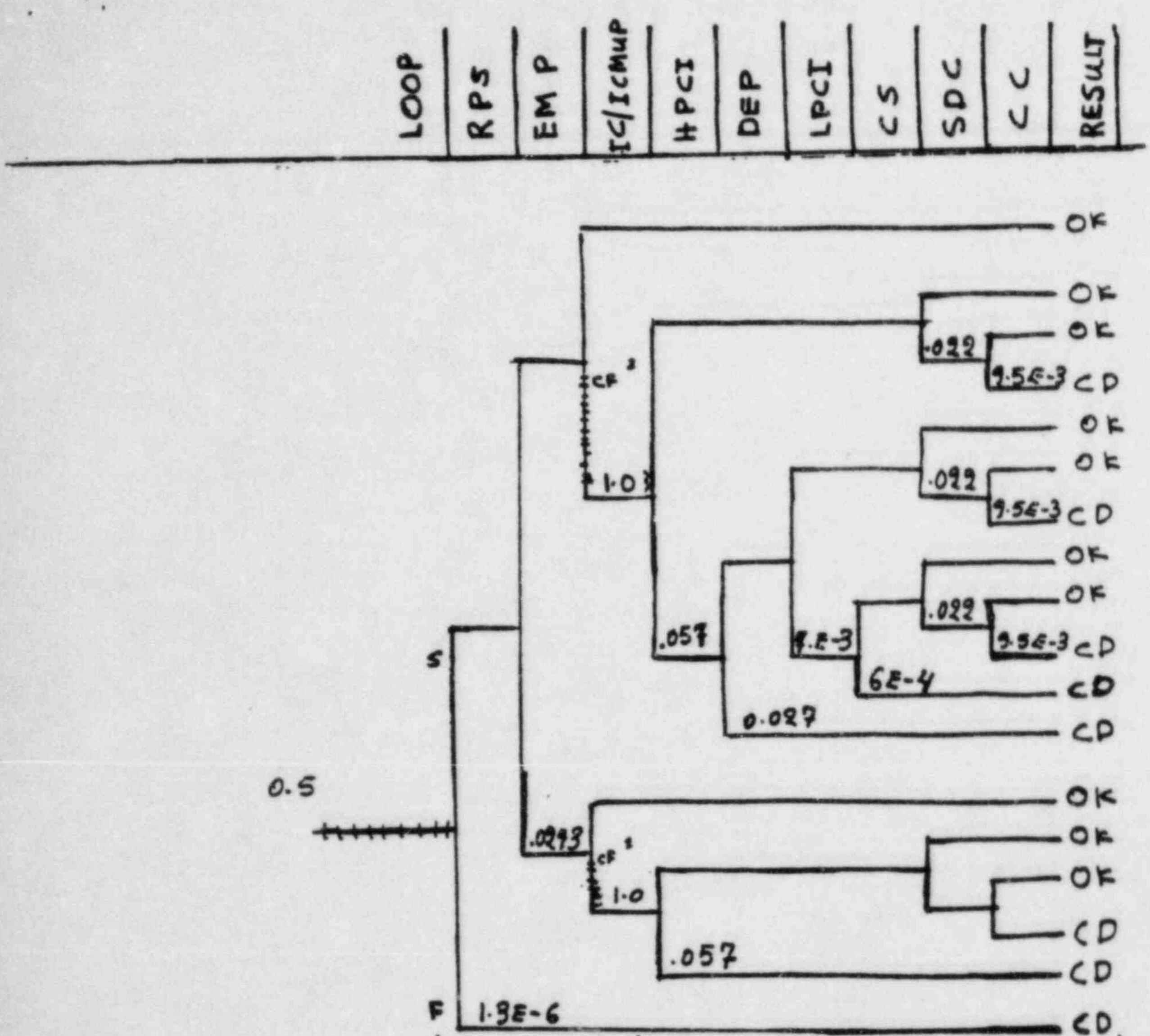
$P = 2.13E-3$

RESULT

OK = NO CORE DAMAGE
CD = CORE DAMAGE
S = Success
F = Failure

* Factor of 1.0 makes the RCIC/HPCI prob. equal to ASP prob.

** A relief valve stuck open.



(NSIC 106616)- Sequence of Interest for Loss of Offsite Power and a Relief Valve Sticks Open at Pilgrim 1, Applied at

Category D

P= 1.57 E-3

RESULT

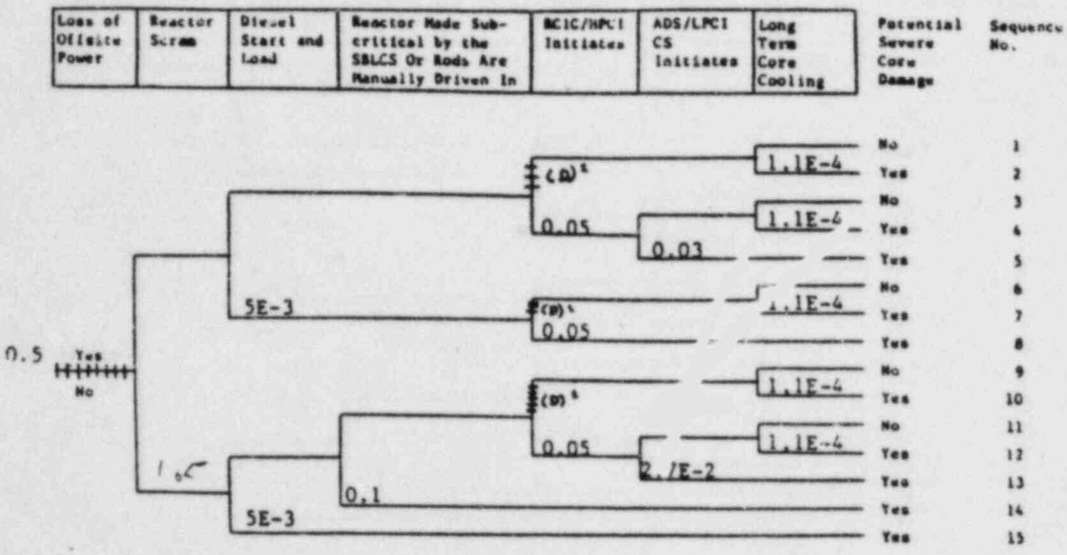
OK = NO CORE DAMAGE

CD = CORE DAMAGE

S = Success

F = Failure

1. A relief valve stuck open.

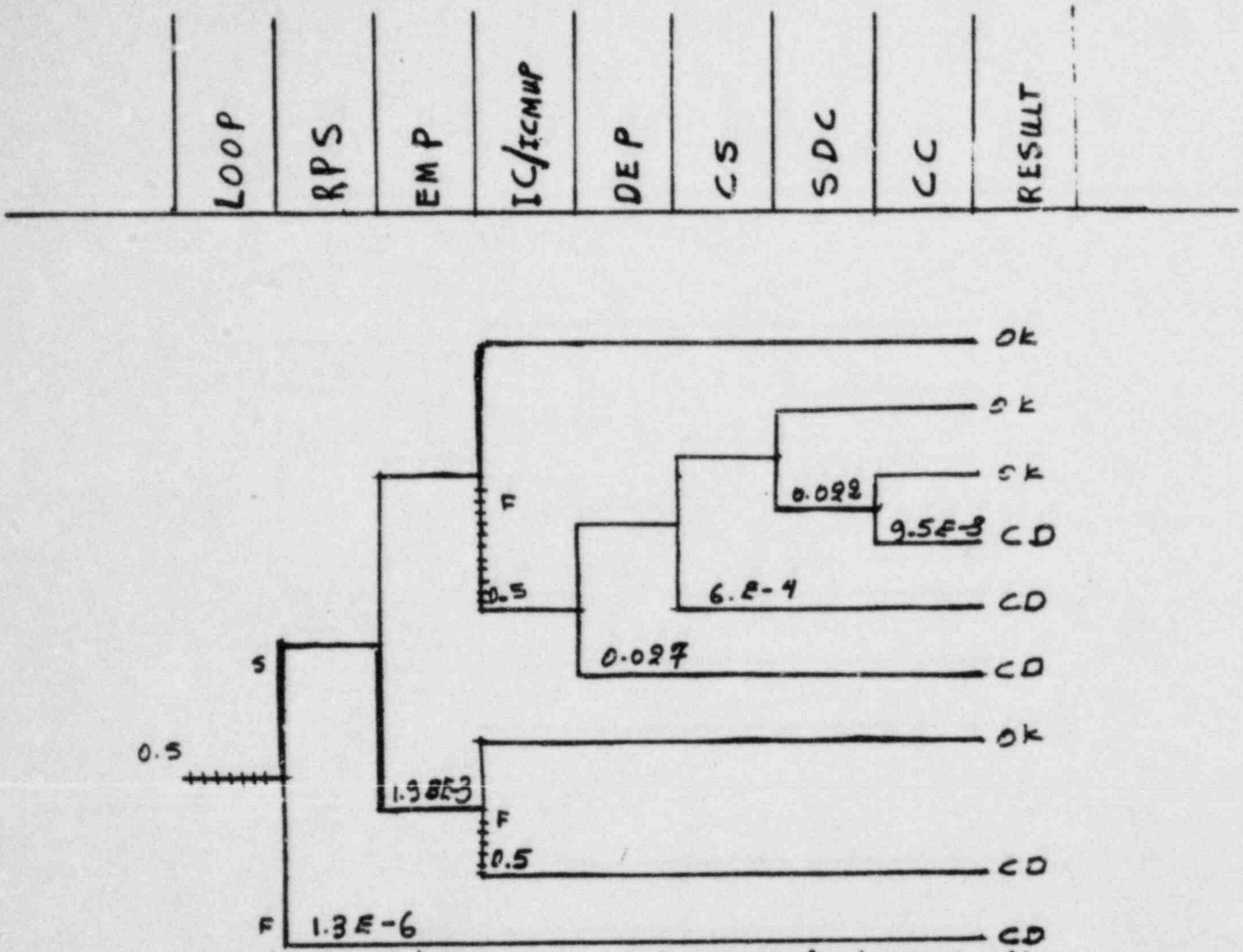


Γ = 9.3E-4 (SC = 30)

NSIC 106616 - Sequence of Interest for Loss of Offsite Power and a Relief Valve Sticks Open at Pilgrim 1

1 A relief valve stuck open.

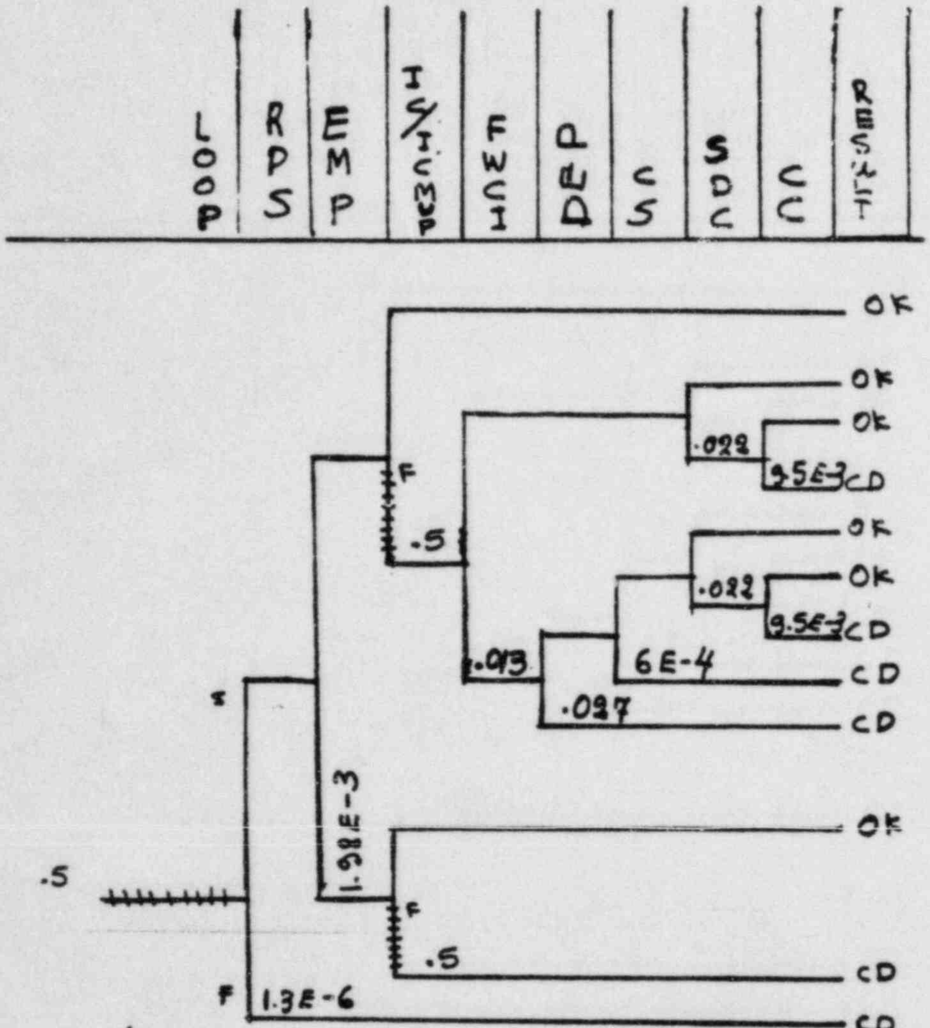
Applied in Category E



(NSIC 61434) – Sequence of Interest for Loss of Offsite Power and Failure of an Emergency Condenser Valve to open at Humbolt Bay, Applied in Category A1

P = 7.45 E-3

RESULT
OK = NO CORE DAMAGE S = SUCCESS
CD = CORE DAMAGE F = Failure

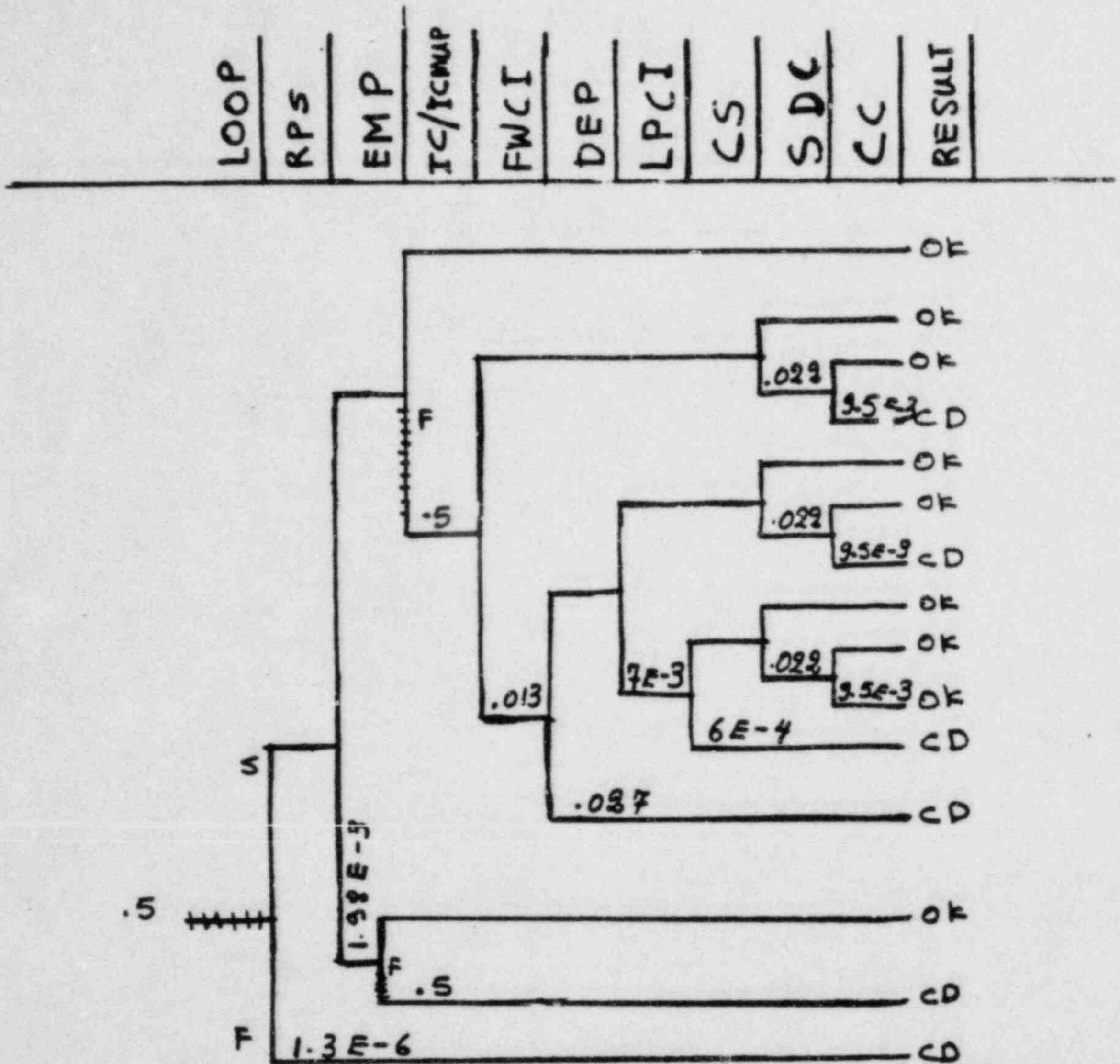


(NSIC 61434) - Sequence of Interest for Loss of Offsite Power and Failure of an Emergency Condenser Valve to Open at Humbolt bay, Applied in Category A2

P= 6.39E-4

RESULT

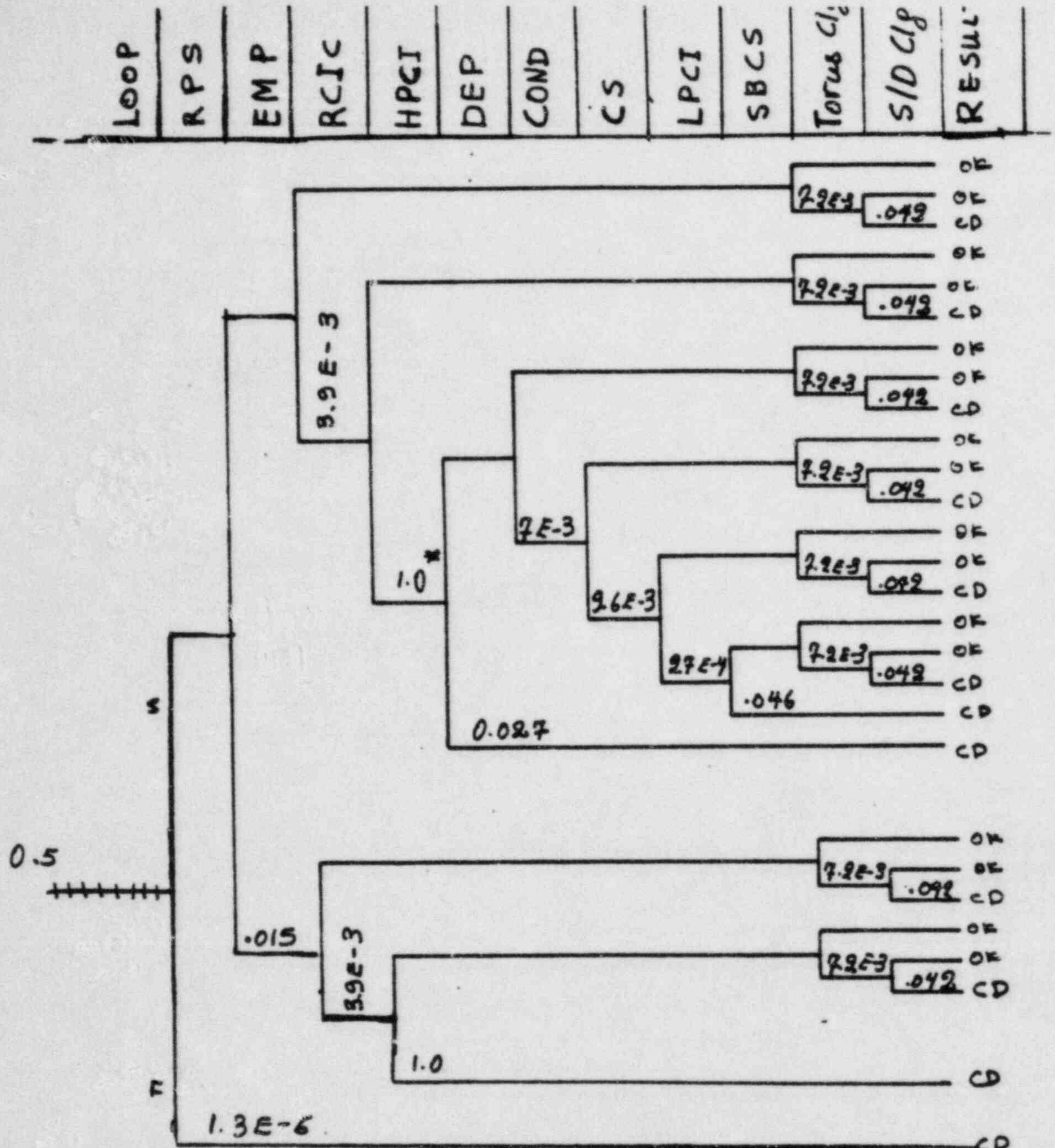
OK = NO CORE DAMAGE
CD = CORE DAMAGE
S = Success
F = Failure



(NSIC 61434)-Sequence of Interest for Loss of Offsite Power and Failure of an Emergency Condenser Valve to Open at Humbolt Bay, Applied in Category A3

P= 6.36E-4

RESULT
OK = NO CORE DAMAGE
CD = CORE DAMAGE
S = Success
F = Failure



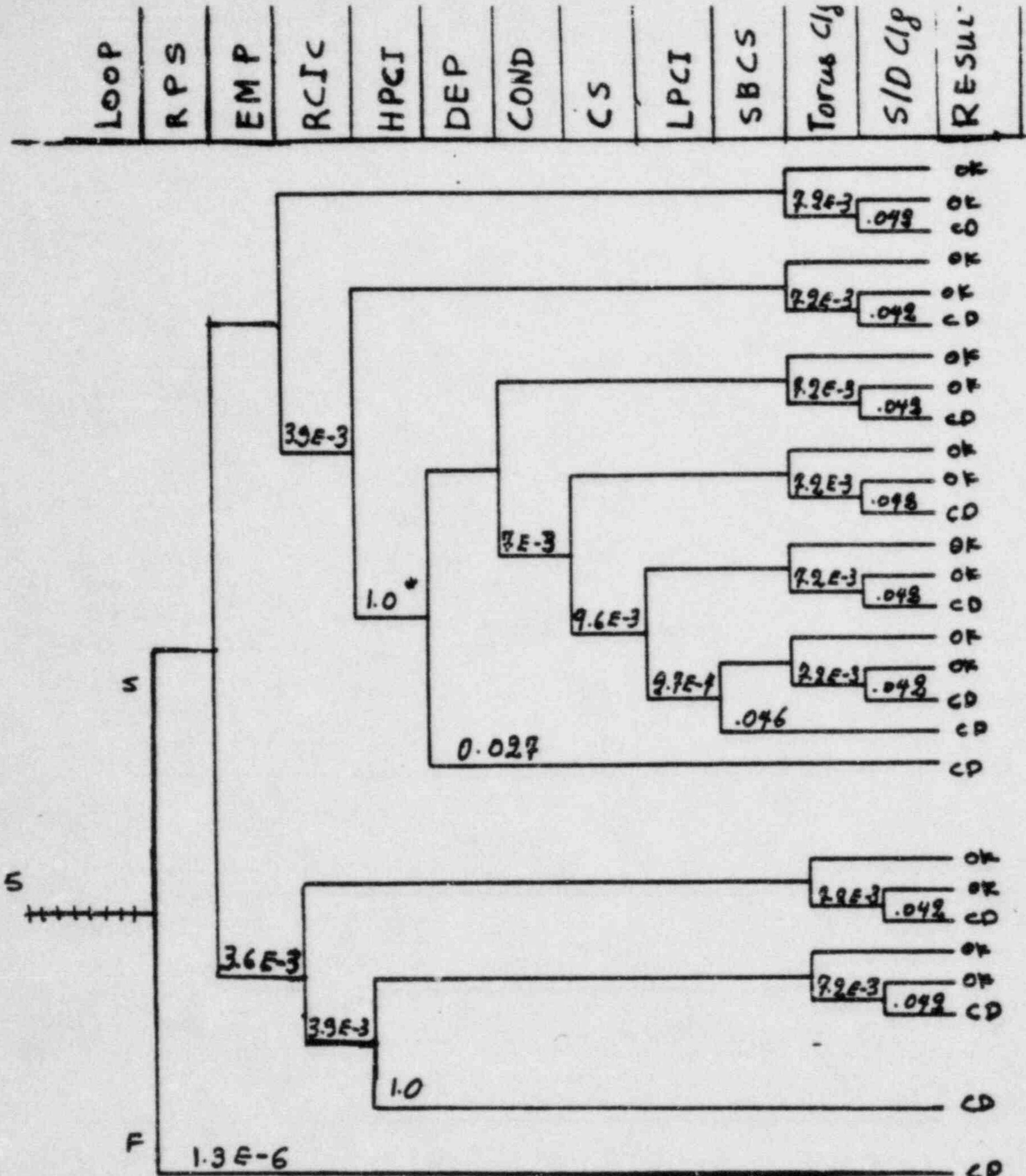
(NSIC 61434) - Sequence of Interest for Loss of Offsite Power and Failure of an Emergency Condenser Valve to Open at Humboldt Bay, Applied in Category B

P = 2.4 E-4

RESULT

OK = NO CORE DAMAGE
CD = CORE DAMAGE
S = Success
F = Failure

* Factor of 1.0 makes the RCIC/HPCI prob. equal to ASP prob.



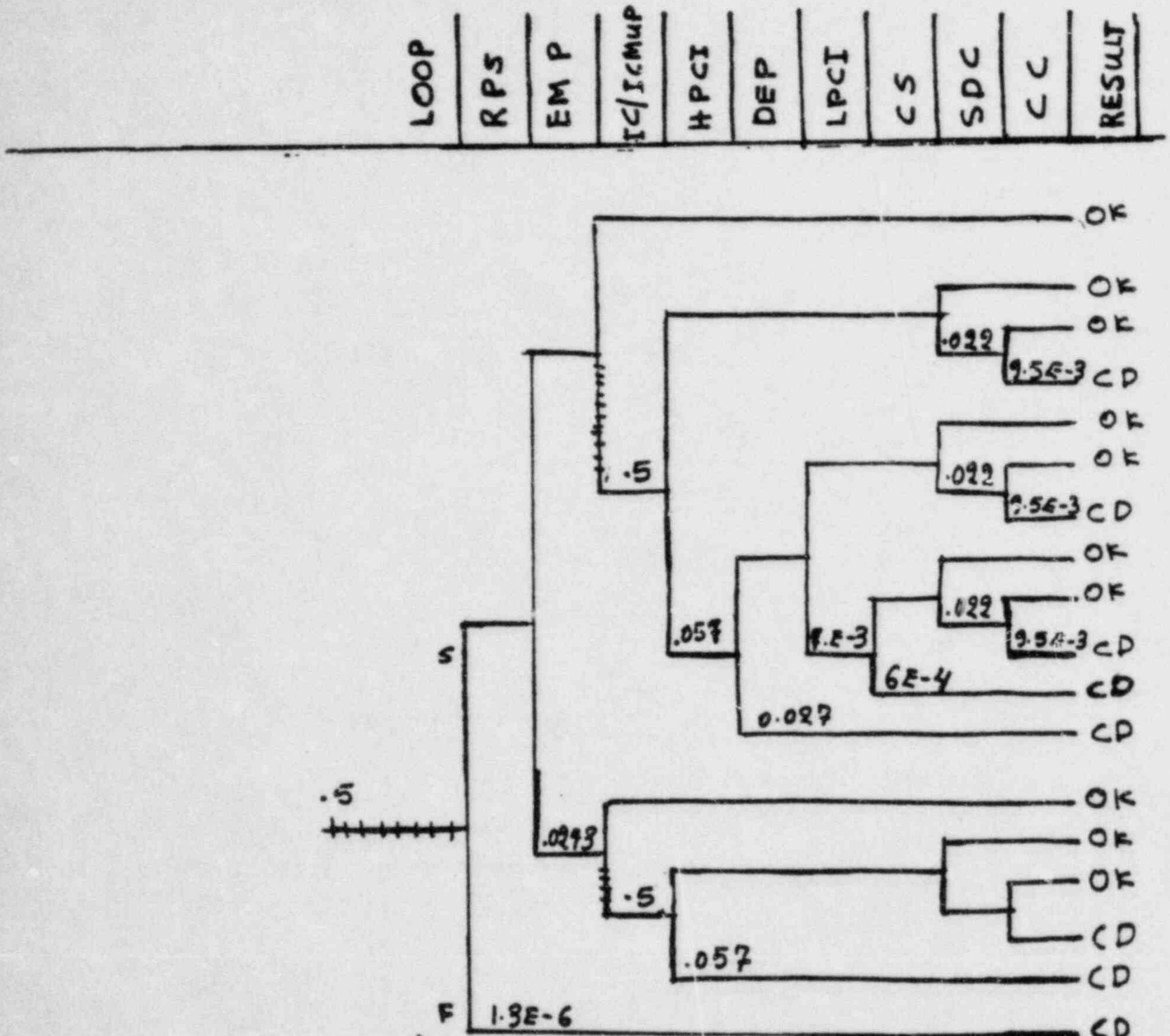
(NSIC 61434) - Sequence of Interest for Loss of Offsite Power and Failure of an Emergency Condenser Valve to Open at Humboldt Bay, Applied in Category C

P = 2.13 E-4

RESULT

OK = NO CORE DAMAGE
CD = CORE DAMAGE
S = SUCCESS
F = Failure

*Factor of 1.0 makes the RCIC/HPCI probability equal to ASP probability



(NSIC 61434) – Sequence of Interest for Loss of Offsite Power of an Emergency Condenser Valve to Open at Humboldt Bay, Applied in Category D

P = 7.9E-4

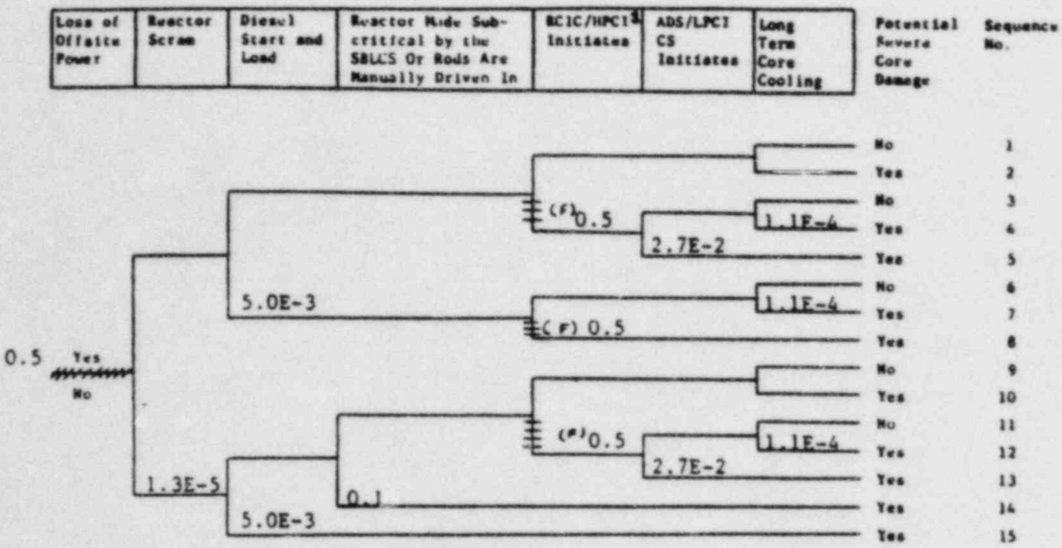
RESULT

OK = NO CORE DAMAGE

CD = CORE DAMAGE

S = Success

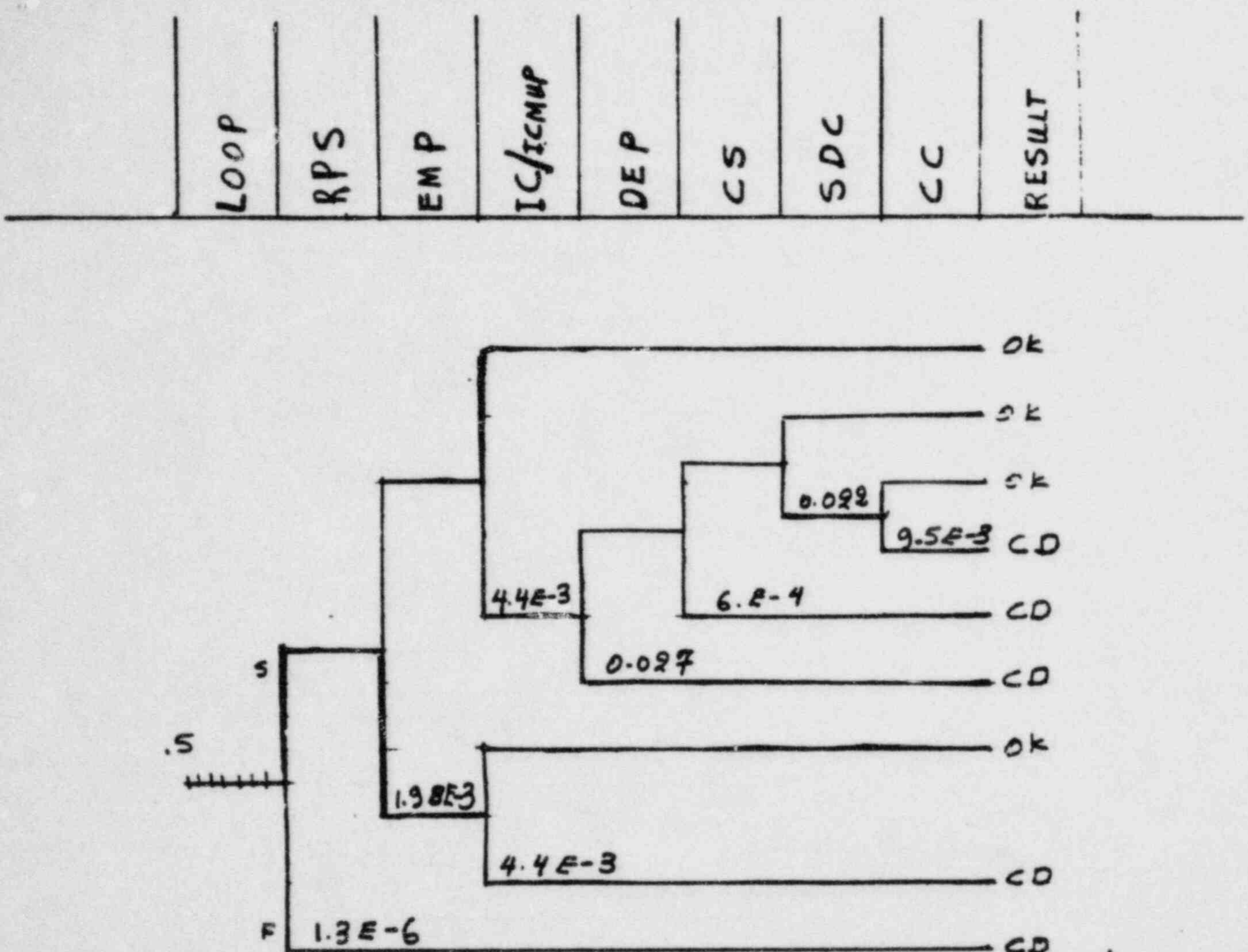
F = Failure



P = 8.8E-3 (SC = 21)

NSIC 61434 – Sequence of Interest for Loss of Offsite Power and Failure of an Emergency Condenser Valve to Open at Humboldt Bay, Applied in Category E

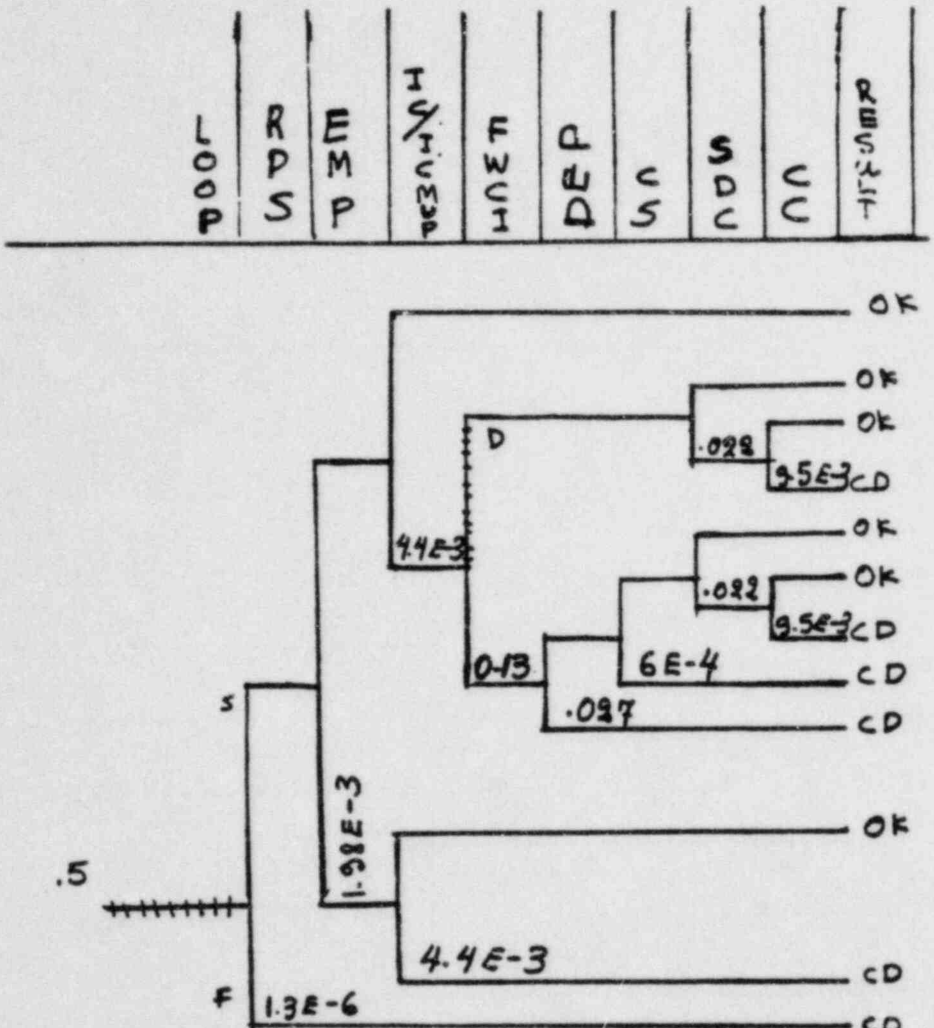
[1] Humboldt Bay utilized an emergency condenser and CRD hydraulic pumps/safety valves for decay heat removal



(NSIC 85566)-Sequence of Interest for Complete Loss of Plant A.C. Power Caused RCIC and HPCI to be Inoperable at Browns Ferry 1, Applied in Category A1

P= 6.62E-5

RESULT
OK = NO CORE DAMAGE
CD = CORE DAMAGE
S = SUCCESS
F = Failure



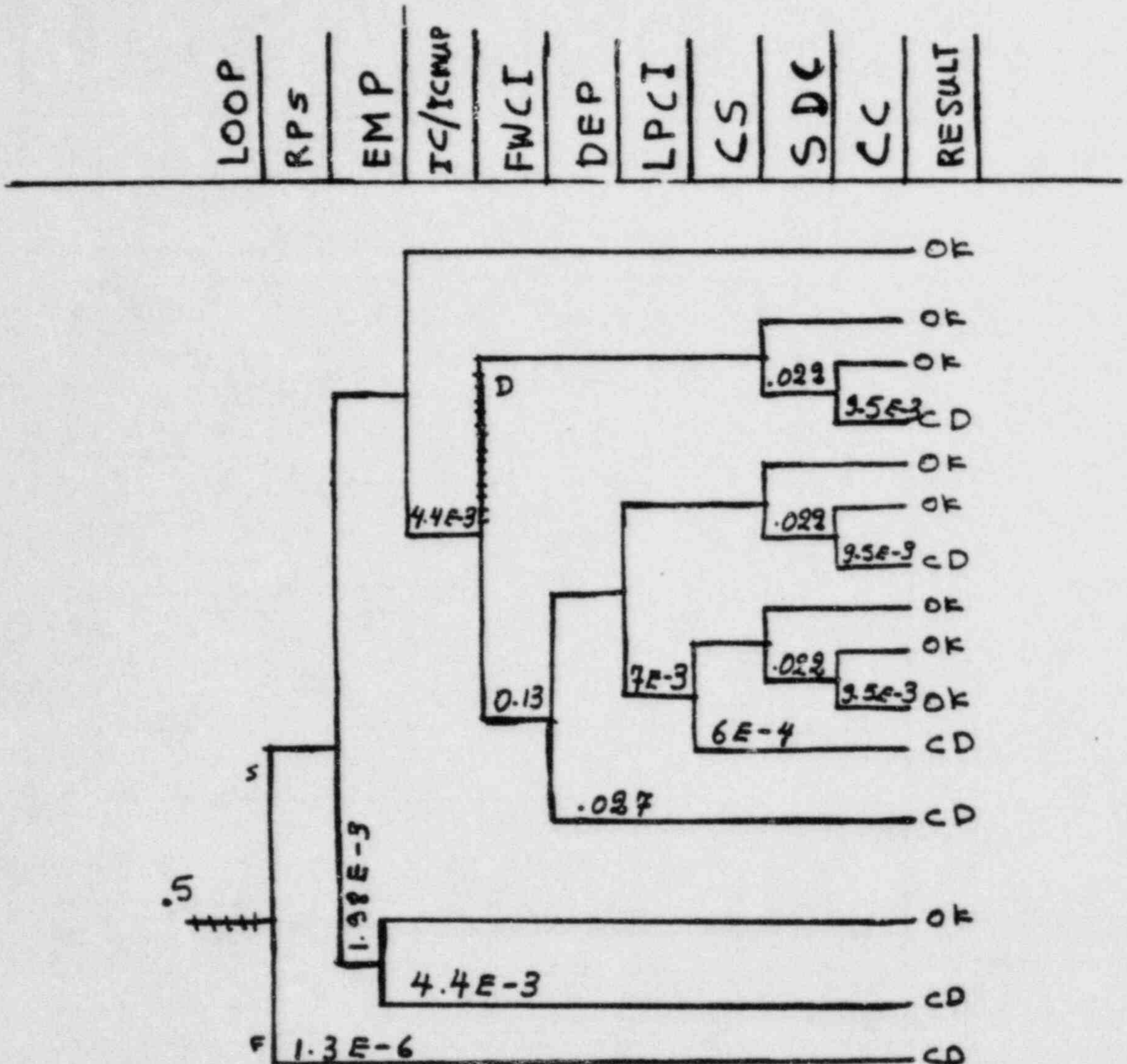
(NSIC 85566) - Sequence of Interest for Complete Loss of Plant A.C. Power Caused RCIC and HPCI to be Inoperable at Browns Ferry 1 Applied in

Category A2

P= 1.34 E-5

RESULT

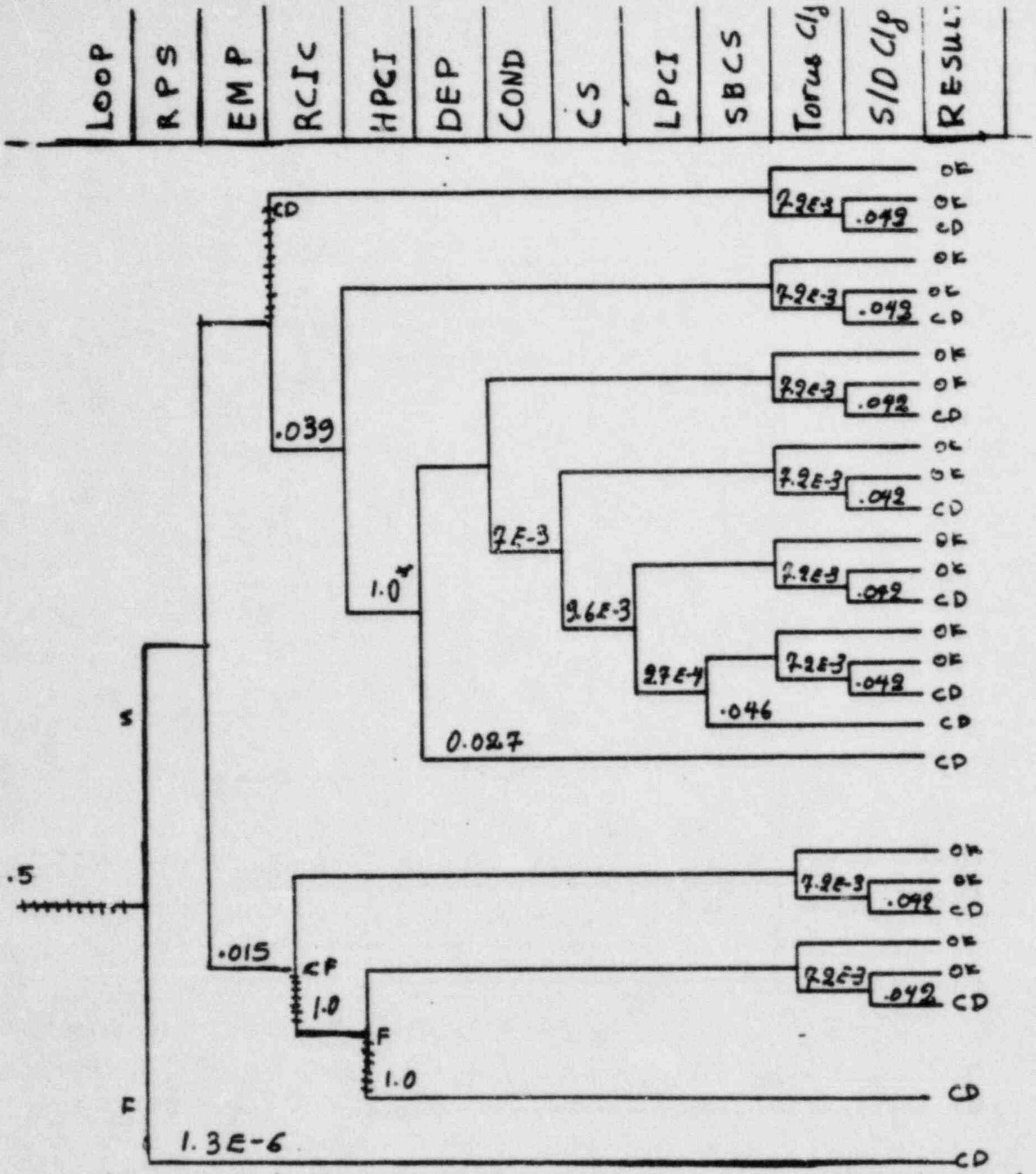
OK = NO CORE DAMAGE
CD = CORE DAMAGE
S = Success
F = Failure



(NSIC 85566) - Sequence of Interest for Complete Loss of Plant A.C. Power Caused RCIC and HPCI to be Inoperable at Browns Ferry 1, Applied in Category A3

P= 1.32 E-6

RESULT
OK = NO CORE DAMAGE
CD = CORE DAMAGE
S = Success
F = Failure



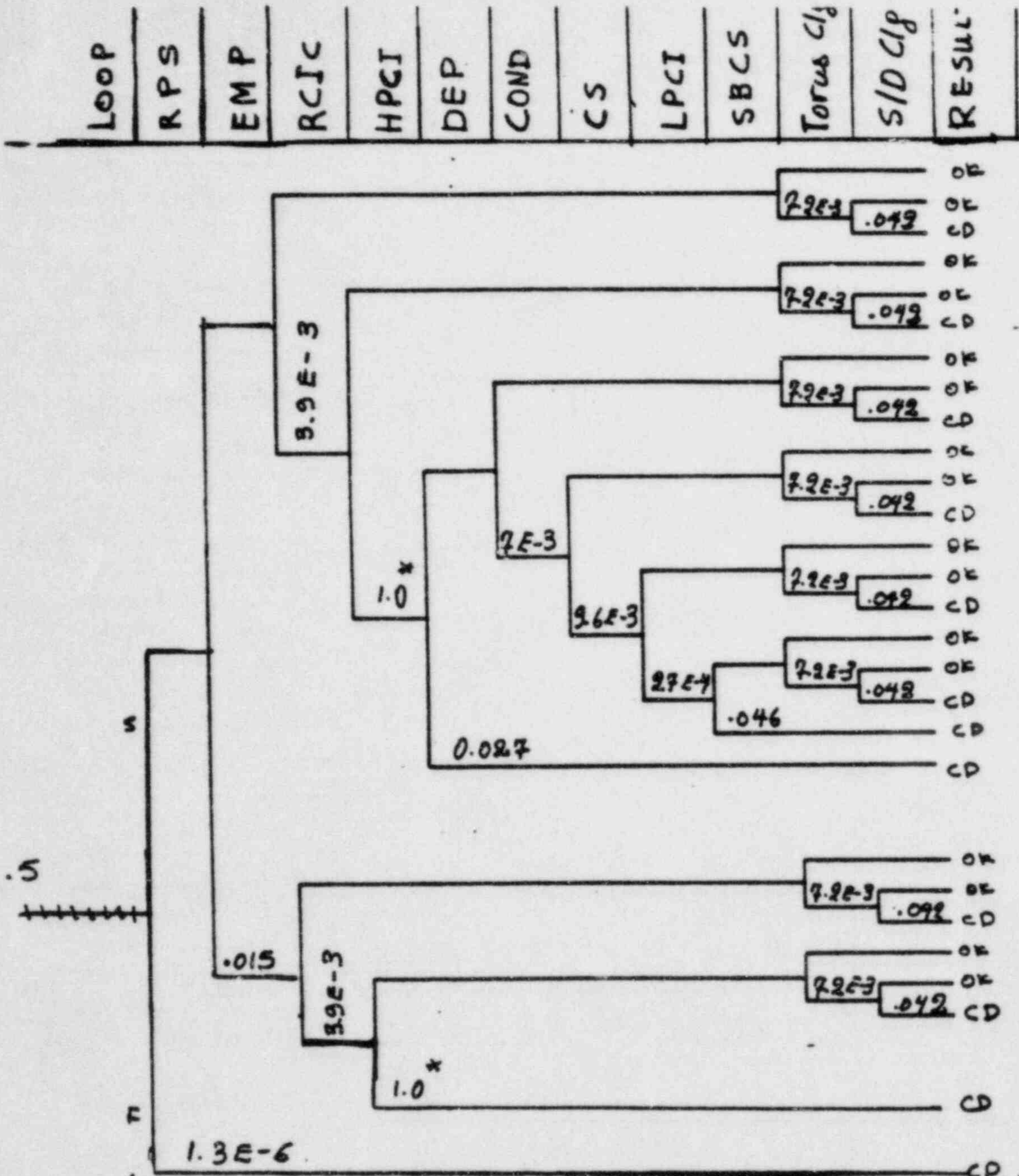
(NSIC 85566) - Sequence of Interest for Complete Loss of Plant A.C. Power Caused RCIC and HPCI to be Inoperable at Browns Ferry 1, Applied in Browns Ferry 1 plant Only.

$P = 8.2E-3$

RESULT

OK = NO CORE DAMAGE
CD = CORE DAMAGE
S = Success
F = Failure

* Factor of 1.0 makes the RCIC/HPCI prob equal to ASP prob.



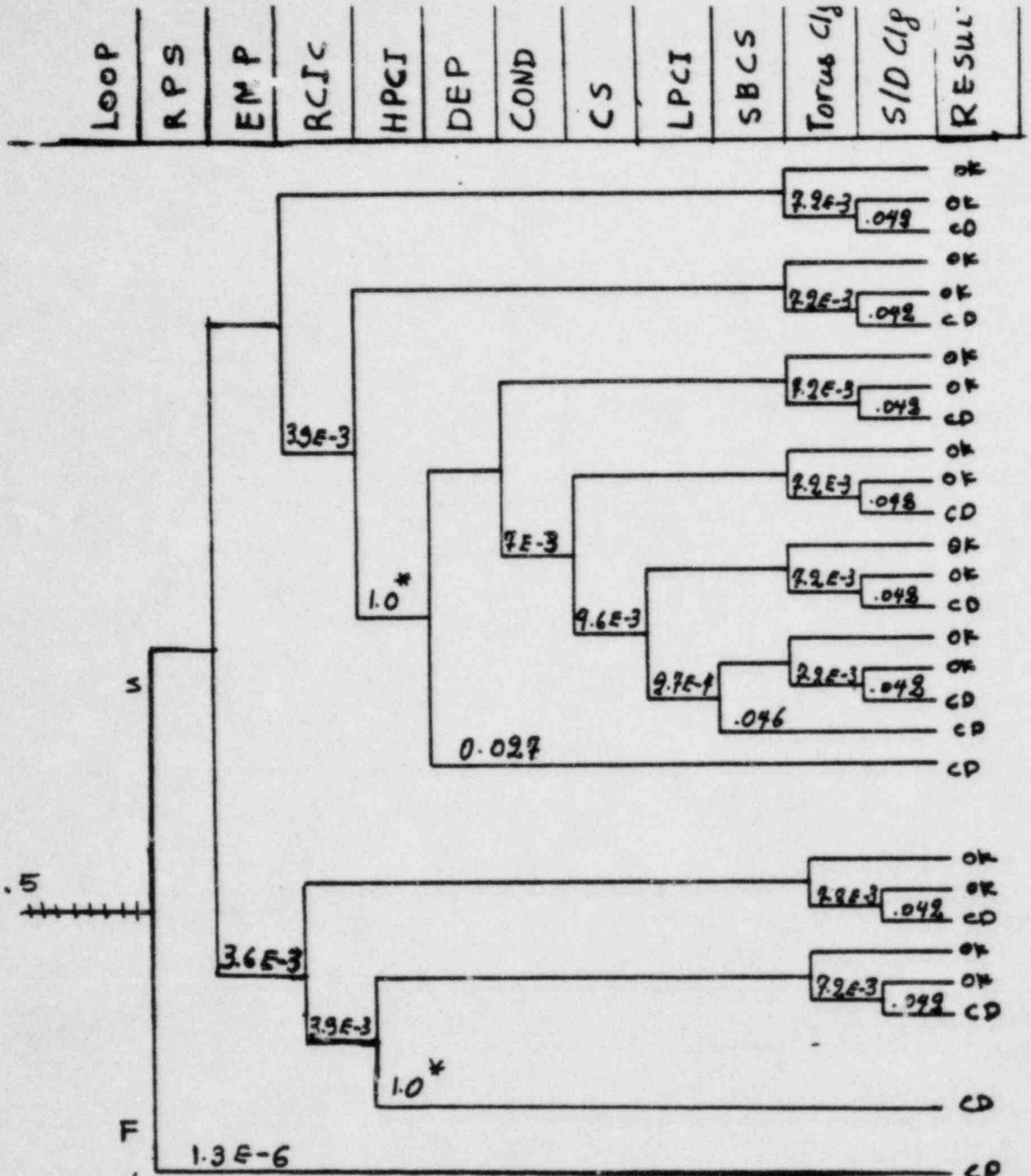
(NSIC 85566) - Sequence of Interest for Complete Loss of A.C. Power Caused RCIC and HPCI to be Inoperable, Applied in Category B minus B.R.F. plant

P=2.37E-4

RESULT

OK = NO CORE DAMAGE
CD = CORE DAMAGE
S = Success
F = Failure

* Factor of 1.0 makes the RCIC/HPCI prob. equal to ASP probability.



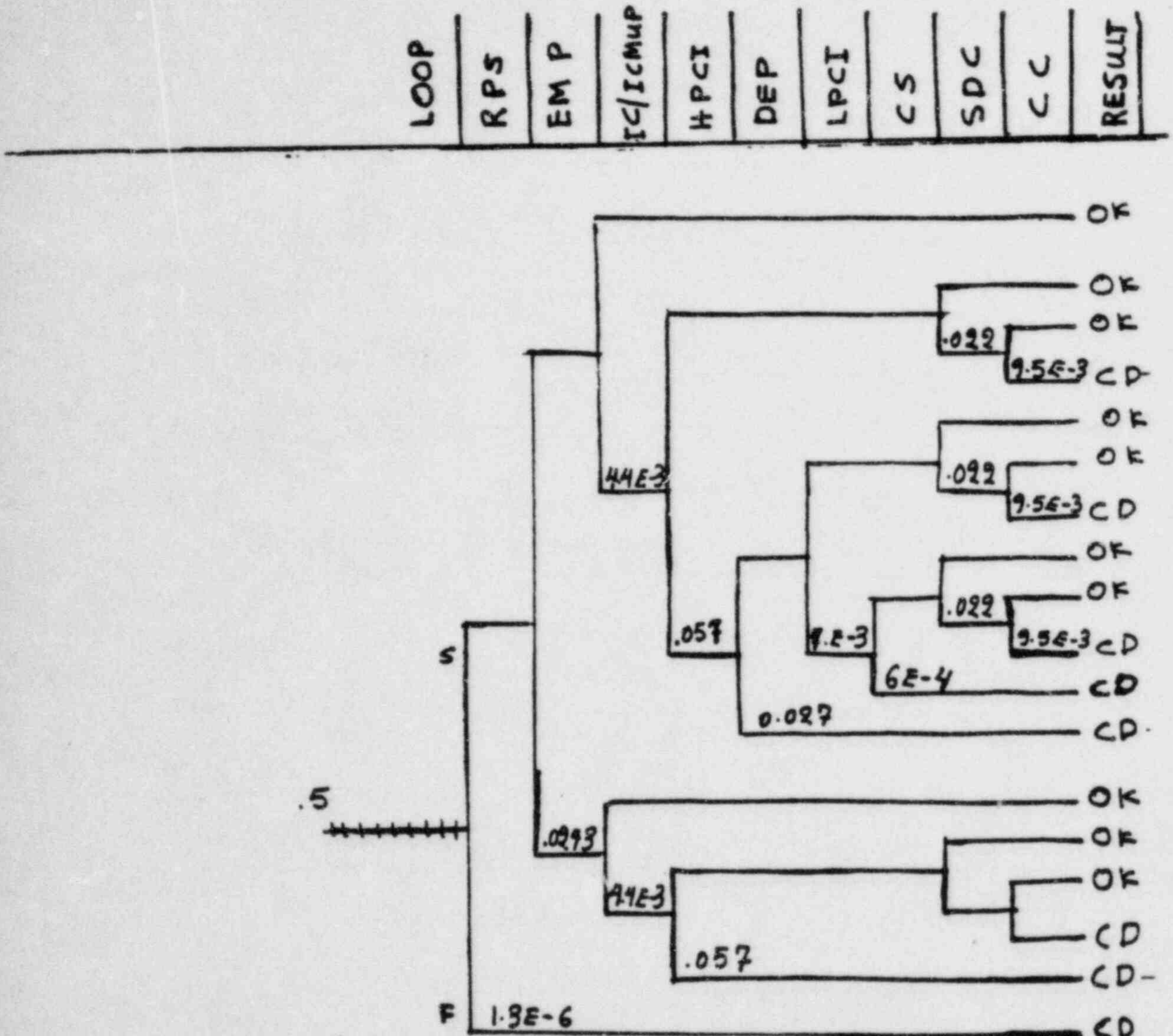
(NSIC 85566)-Sequence of Interest for Complete Loss of A.C. Power Caused RCIC and HPCI to be Inoperable at Browns Ferry 1, Applied in Category C

P=2.13E-4

RESULT

OK = NO CORE DAMAGE
CD = CORE DAMAGE
S = Success
F = Failure

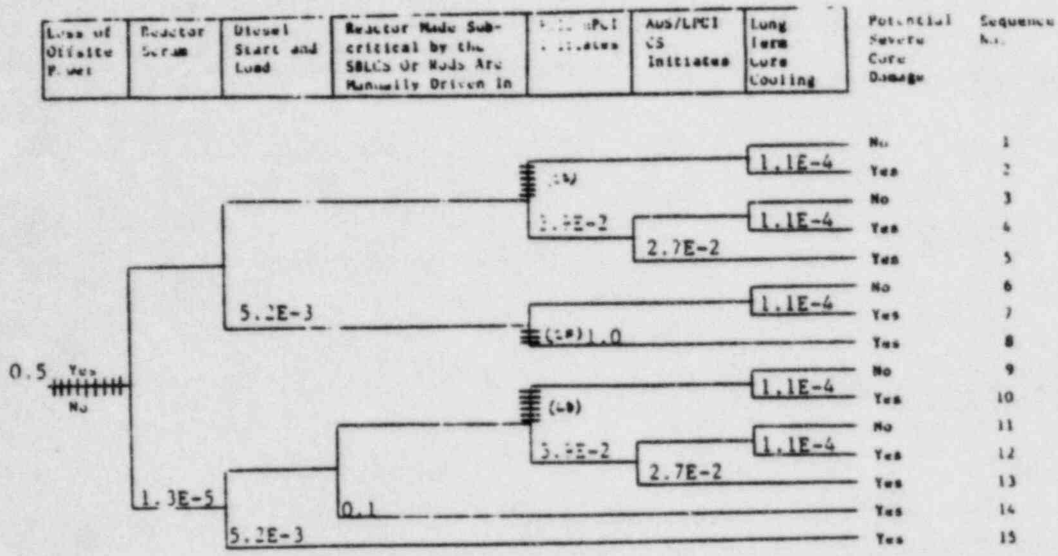
* Factor of 1.0 makes the RCIC/HPCI prob. equal to ASP prob.



(NSIC 85566) - Sequence of Interest for Complete Loss of A.C. Power Caused RCIC and HPCI to be Inoperable at Browns Ferry 1, Applied in Category D

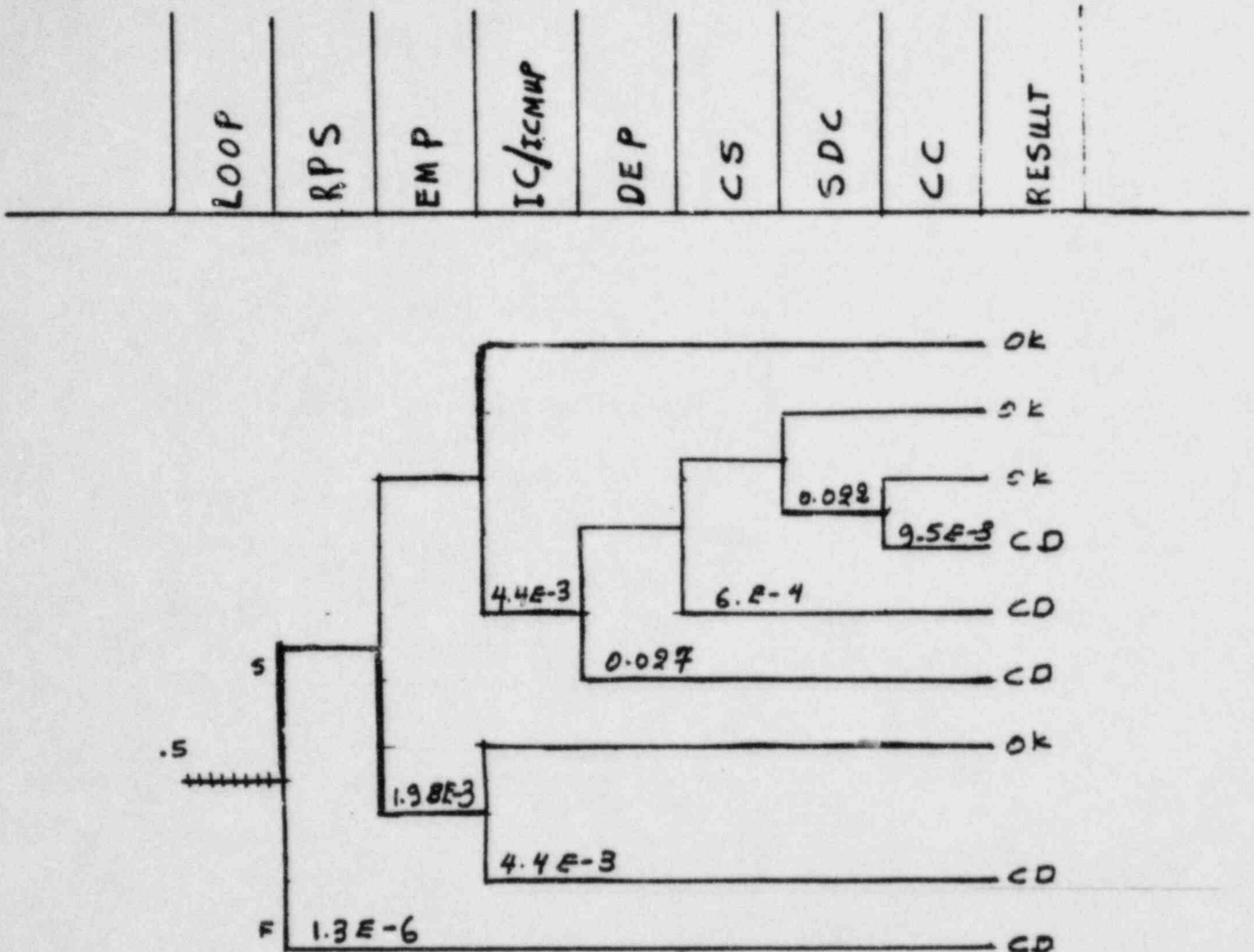
P=7.58 E-6

RESULT
OK = NO CORE DAMAGE
CD = CORE DAMAGE
S = Success
F = Failure



P = 3.1E-3 (SC = 25)

NSIC 85566 - Sequence of Interest for Complete Loss of Plant A.C. Power Caused RCIC and HPCI to be Inoperable at Browns Ferry 1, Applied in Category E

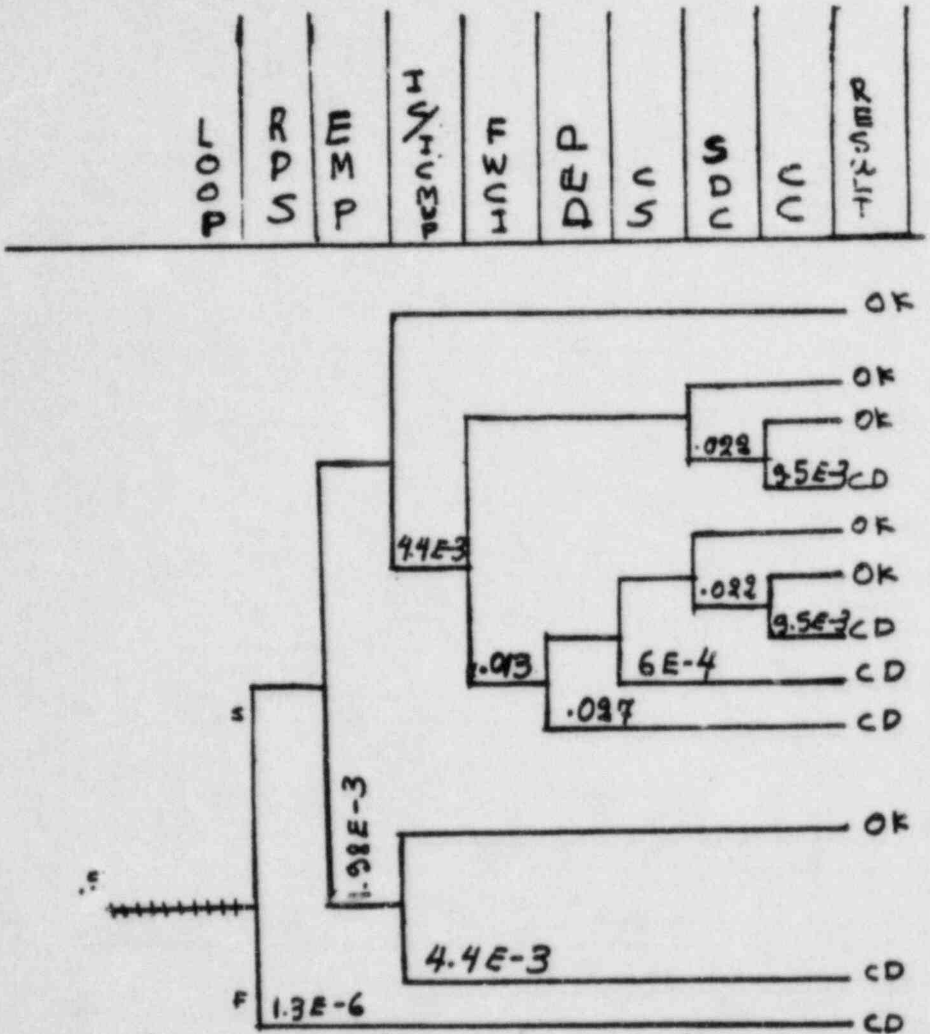


(NSIC 63129) - Sequence of Interest for a Scram Caused by Load Rejection at La Crosse, Applied in Category A1

P= 6.62E-5

RESULT

OK = NO CORE DAMAGE S = SUCCESS
CD = CORE DAMAGE F = Failure

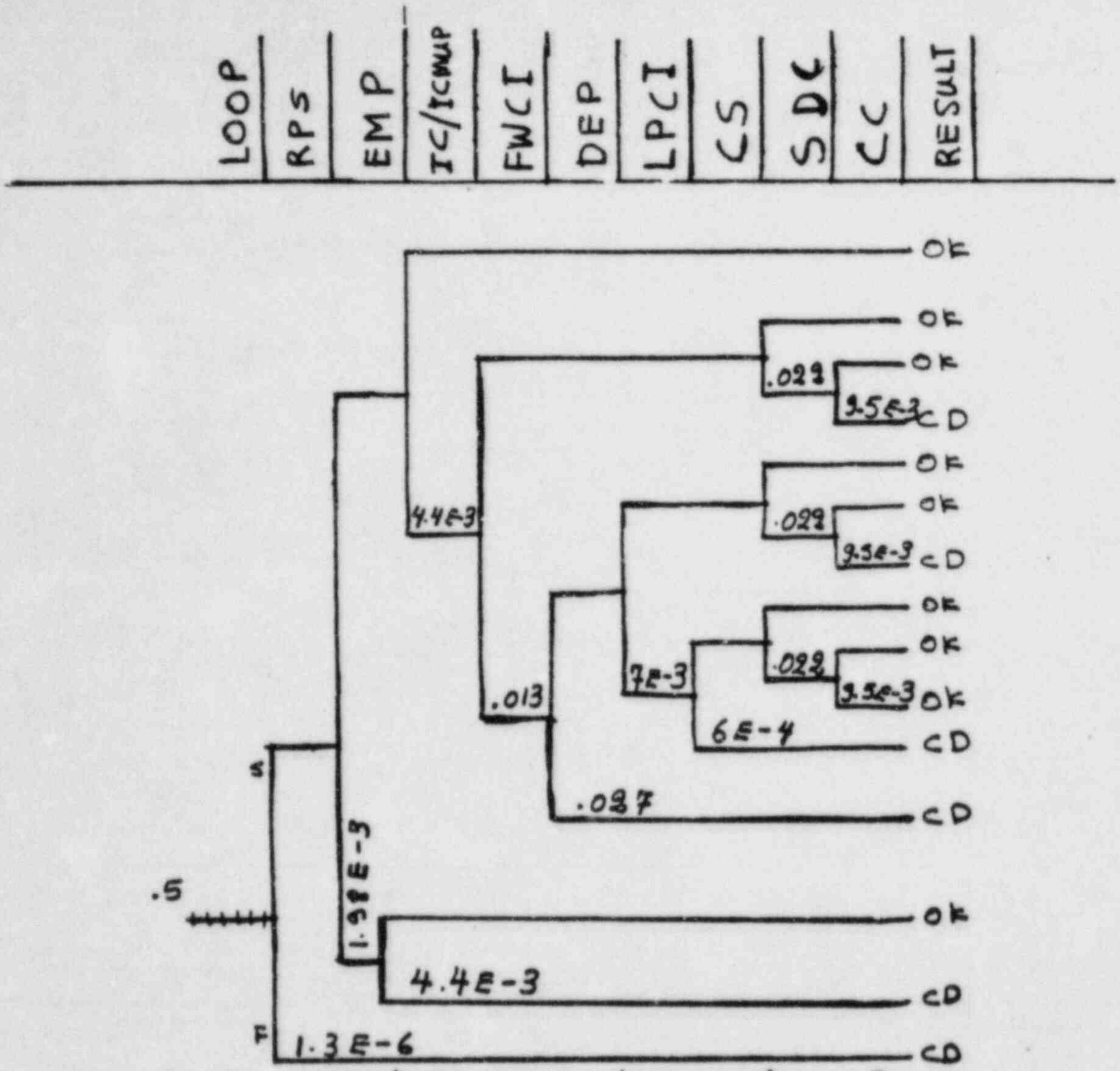


(NSIC 63129) - Sequence of Interest for a Scram Caused by Electrical Load Rejection at La Crosse, Applied in Category A2

P = 6.26 E-6

RESULT

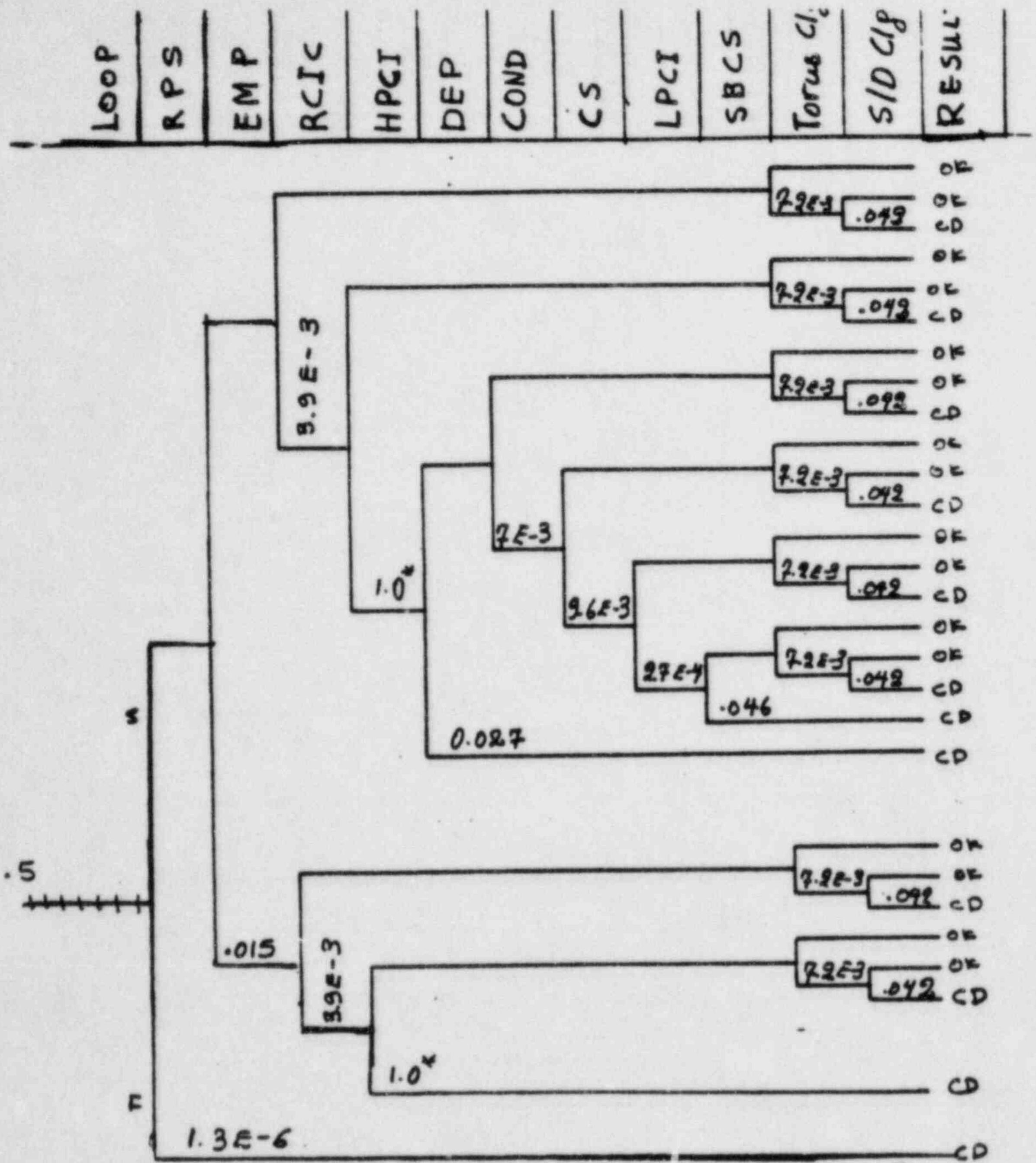
OK = NO CORE DAMAGE
CD = CORE DAMAGE
S = Success
F = Failure



(NSIC 63129) - Sequence of Interest for a Scram Caused by Electrical Load Rejection at La Crosse. Applied in Category A3

P= 6.24E-6

RESULT
OK = NO CORE DAMAGE
CD = CORE DAMAGE
S = Success
F = Failure



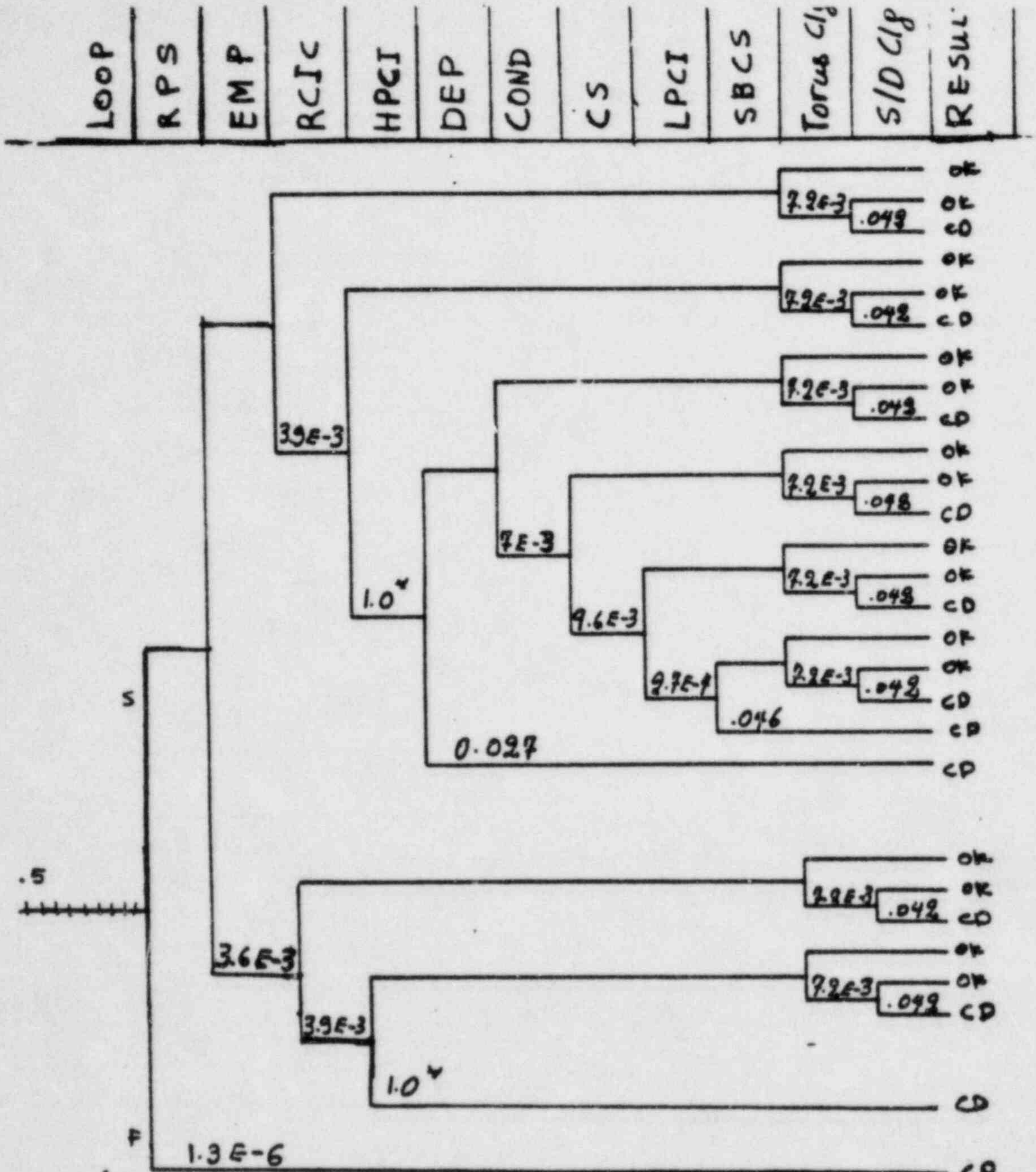
(NSIC 63129) - Sequence of Interest for a Scram Caused by Electrical Load Rejection at La Crosse, Applied in Category B

P = 2.37E-4

RESULT

OK = NO CORE DAMAGE
CD = CORE DAMAGE
S = SUCCESS
F = Failure

* Factor of 1.0 makes the RCIC/HPCI probability equal to ASP probability.



(NSIC 63129) - Sequence of Interest for A Scram Caused by Electrical Load Rejection at La Crosse, Applied in

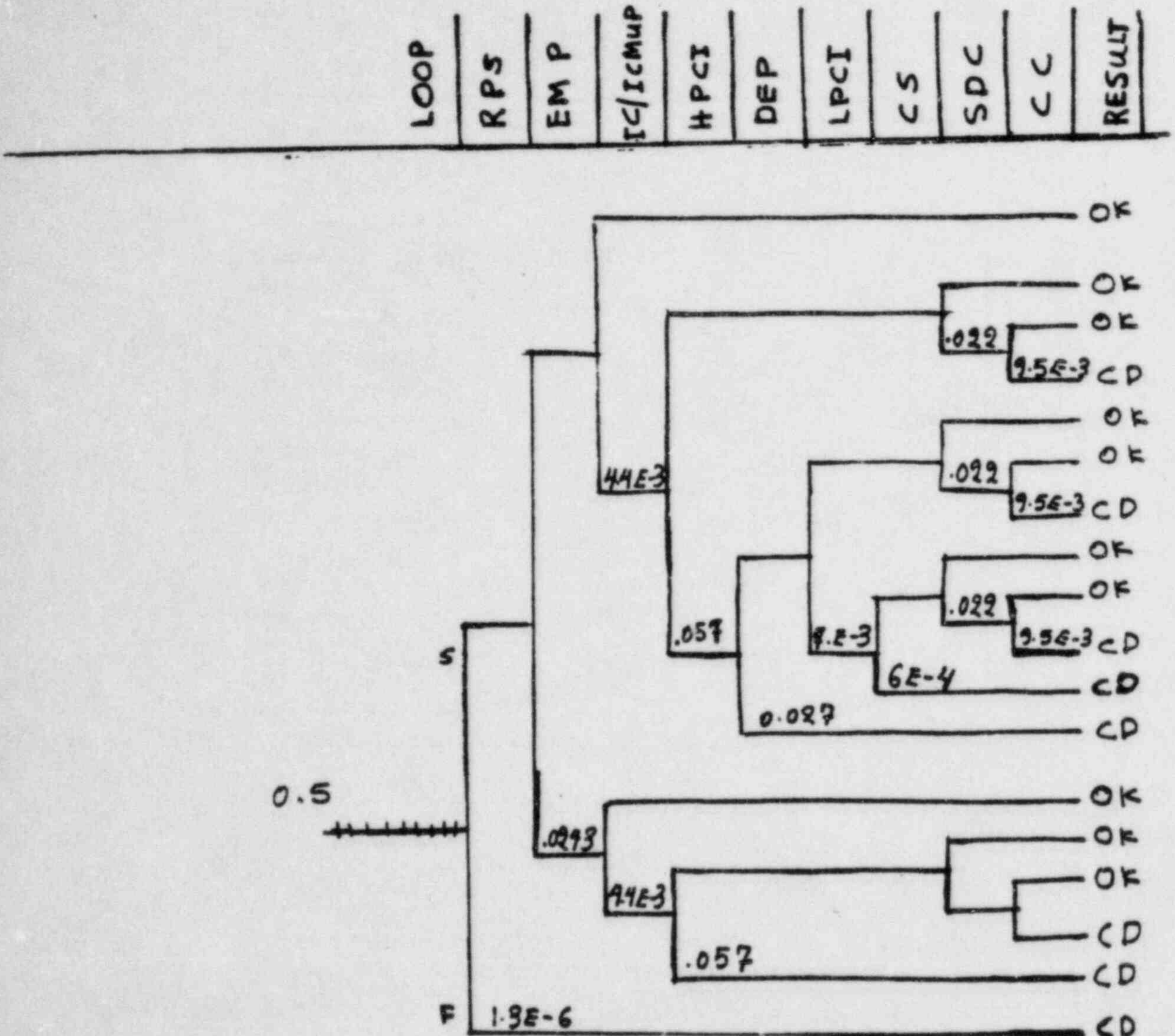
Category C

P = 2.13 E-4

RESULT

OK = NO CORE DAMAGE
CD = CORE DAMAGE
S = SUCCESS
F = Failure

*Factor of 1.0 makes the RCIC/HPCI prob. equal to ASP prob.



(NSIC 63129) - Sequence of Interest for a Scram Caused by Electrical Load Rejection at La Crosse, Applied in Category D

P = 7.58 E-6

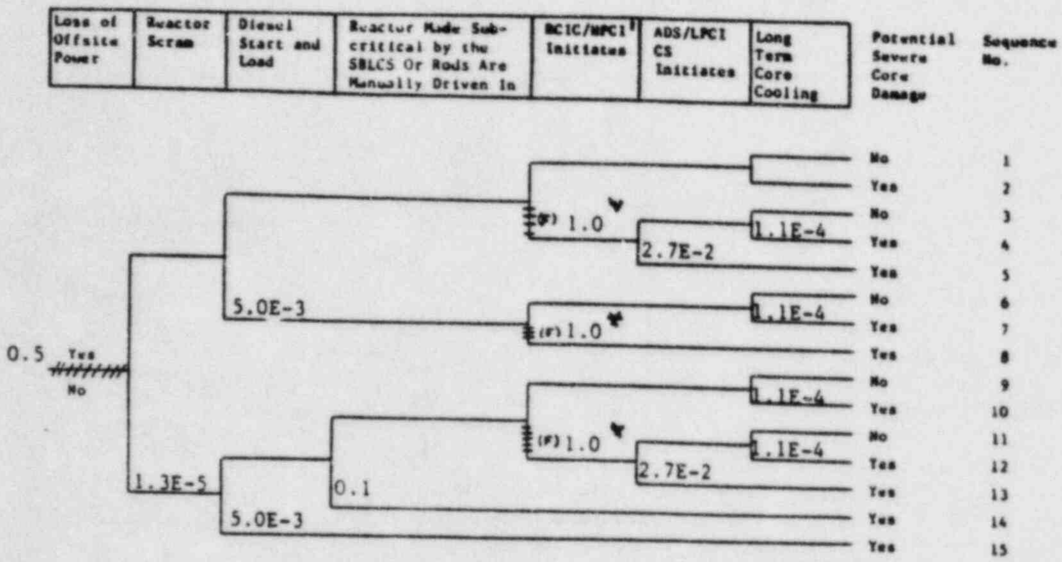
RESULT

OK = NO CORE DAMAGE

CD = CORE DAMAGE

S = Success

F = Failure

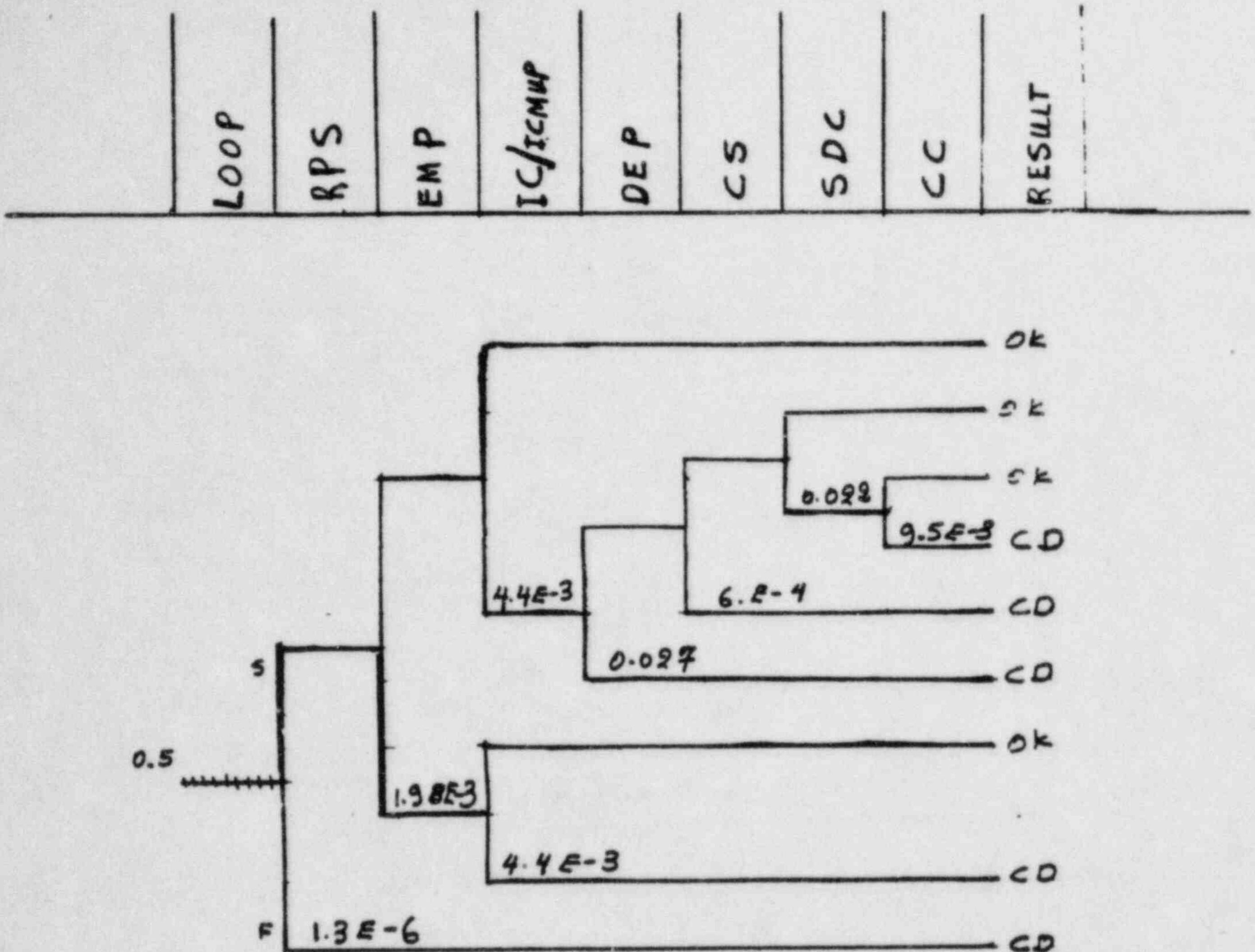


P = 1.8E-2 (SC = 18)

NSIC 63129 – Sequence of Interest for A Scram Caused by Electrical Load Rejection at La Crosse) Applied in Category B

[1]La Crosse utilizes shutdown condenser and condensate pumps instead of RCIC and HPCI.

* Failure applies only to Category B



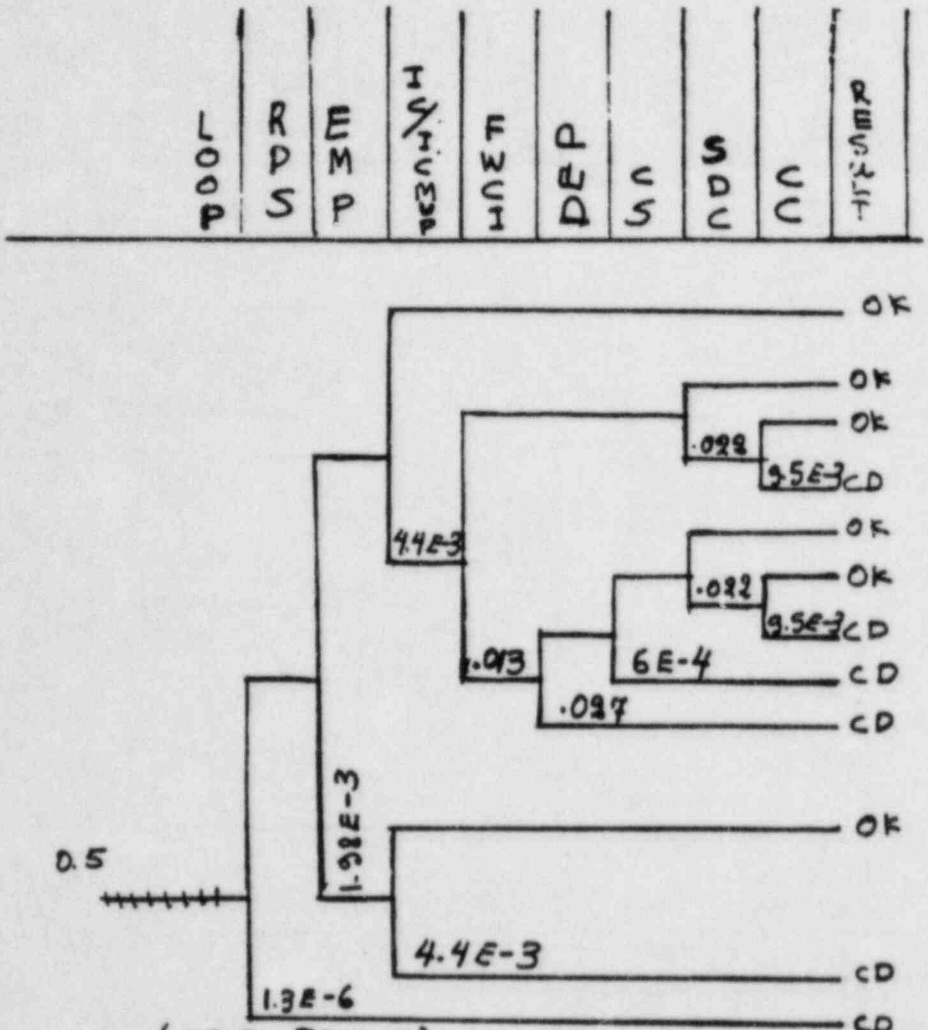
(NSIC 79565)-Sequence of Interest of Loss of Normal Station Power Causes Cooling System Transient at Vermont Y., Applied in Category A1

P= 6.62E-5

RESULT

OK = NO CORE DAMAGE   S = SUCCESS

CD = CORE DAMAGE   F = Failure

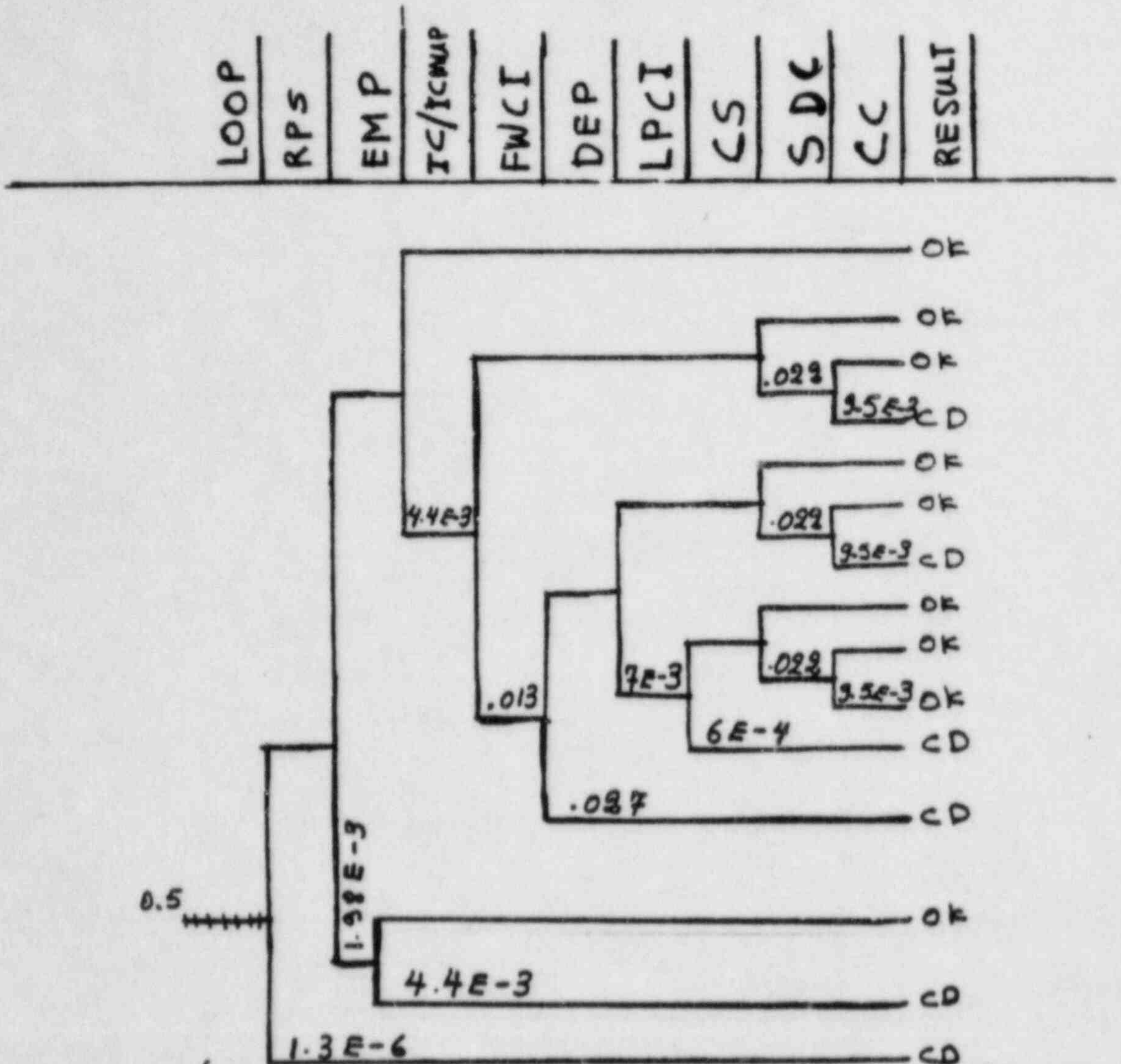


(NSIC 79565) - Sequence of Interest of Loss of Normal Station Power Causes Cooling System Transient at Vermont Y., Applied in Category A2

P = 6.26E-6

RESULT

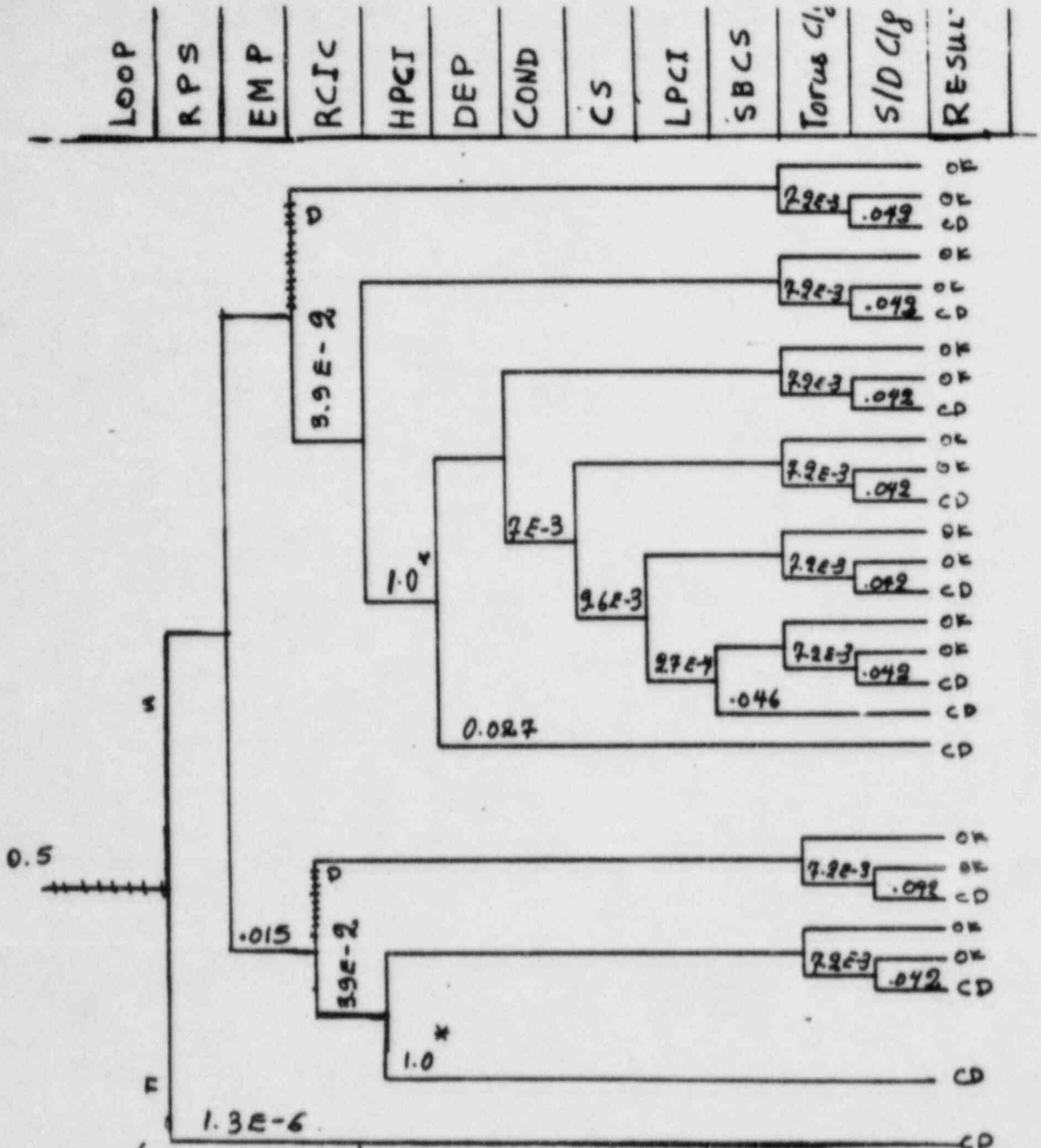
OK = NO CORE DAMAGE
CD = CORE DAMAGE



(NSIC 79565) - Sequence of Interest of Loss of Normal Station Power Causes Cooling System Transient at Vermont Y., Applied in Category A3

P= 6.24E-6

RESULT
OK = NO CORE DAMAGE
CD = CORE DAMAGE
S = Success
F = Failure



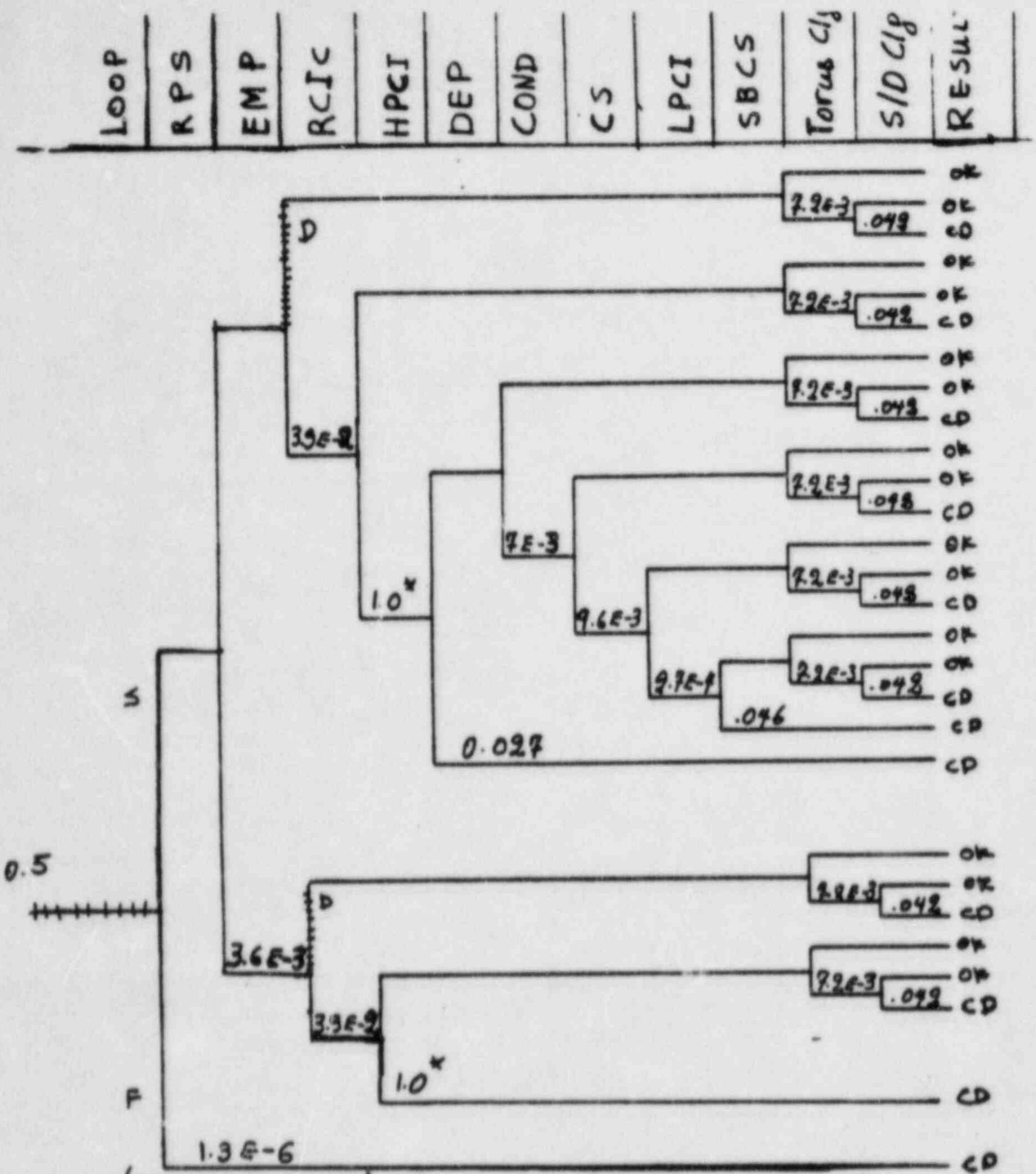
(NSIC 79365) - Sequence of Interest of Loss of Normal Station Power Causes Cooling System Transient in Vermont Y., Applied in Category B

P= 9.8 E-4

RESULT

OK = NO CORE DAMAGE
CD = CORE DAMAGE
S = Success
F = Failure

1. Factor of 1.0 makes the RCIC/HPCI probability equal to ASP probability.



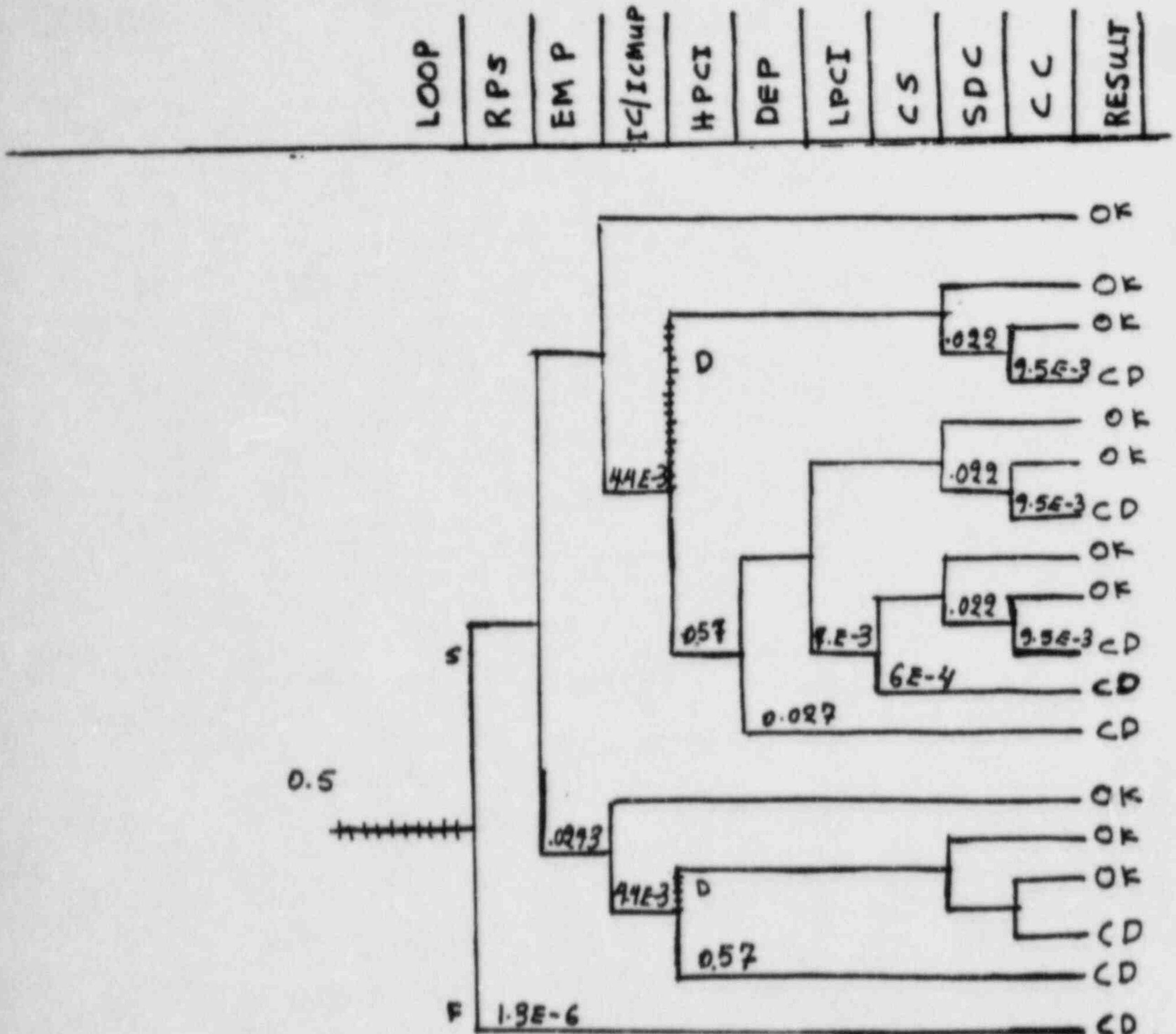
(NSIC 79565) - Sequence of Interest of Loss of Normal Station Power Causes Cooling System Transient at Vermont Y., Applied in Category C

P = 7.55 E-4

RESULT

OK = NO CORE DAMAGE
CD = CORE DAMAGE
S = Success
F = Failure

* Factor of 1.0 makes the RCIC/HPCI prob. equal to ASP prob.



(NSIC 79565) - Sequence of Interest of Loss of Normal Station Power Causes Cooling System Transient at Vermont Y. Applied in

Category D

P= 6.57E-5

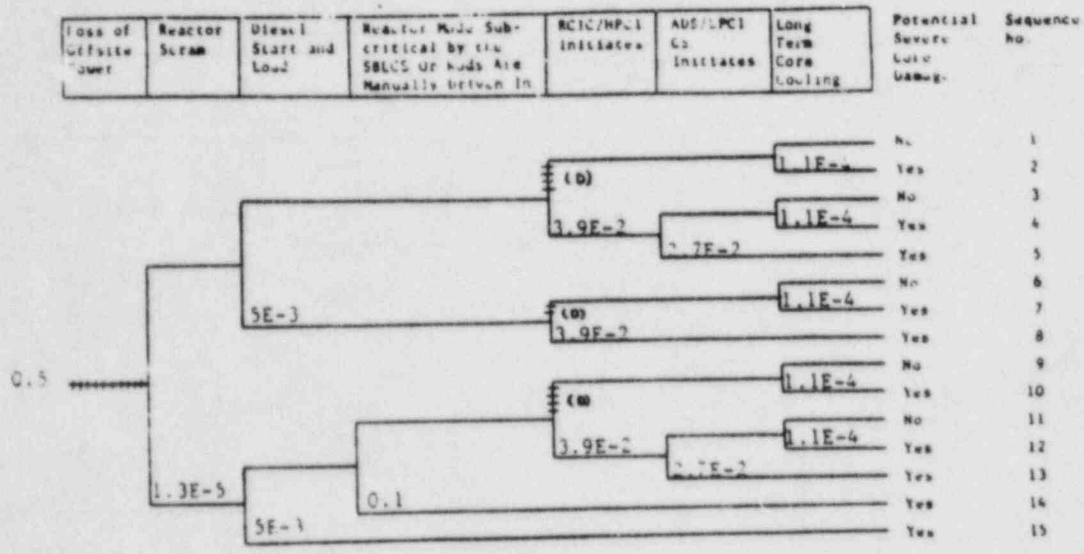
RESULT

OK = NO CORE DAMAGE

CD = CORE DAMAGE

S = Success

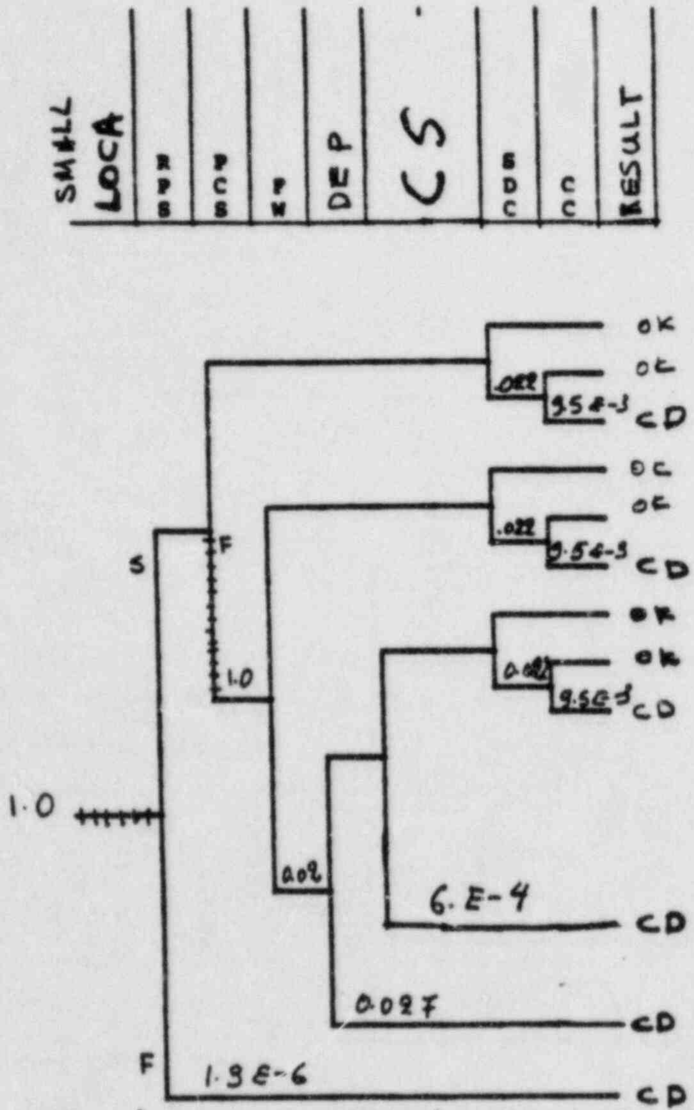
F = Failure



P (LOOP) = 6.8E-4 (SC = 32)

NSIC 79565 - Sequence of Interest of Loss of Normal Station Power Causes Cooling System Transient at Vermont Y.

Applied in Category E



(NSIC 77916) - Sequence of Interest for Several Valve Malfunctions at Oyster Creek, Applied in

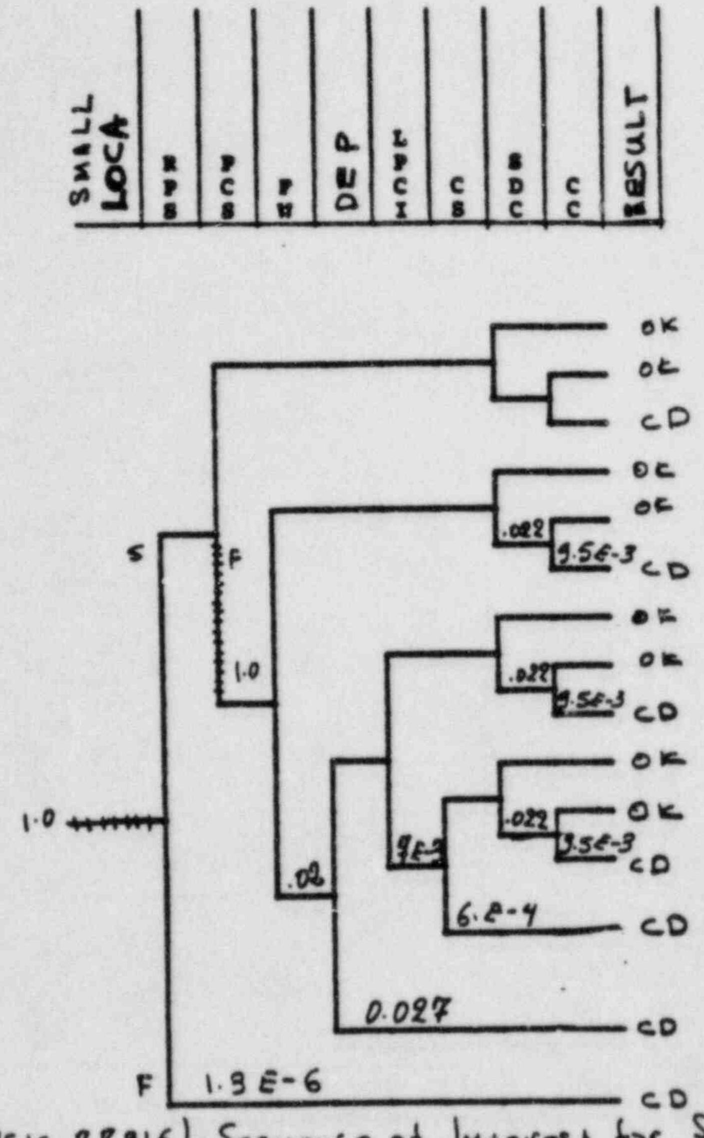
CATEGORIES A1 AND A2

P = 9.76E-4

RESULT

OK = NON CORE DAMAGE S = SUCCESS

CD = CORE DAMAGE F = Failure



(NSIC 77916) - Sequence of Interest for Several Valve Malfunctions at Oyster Creek Applied in

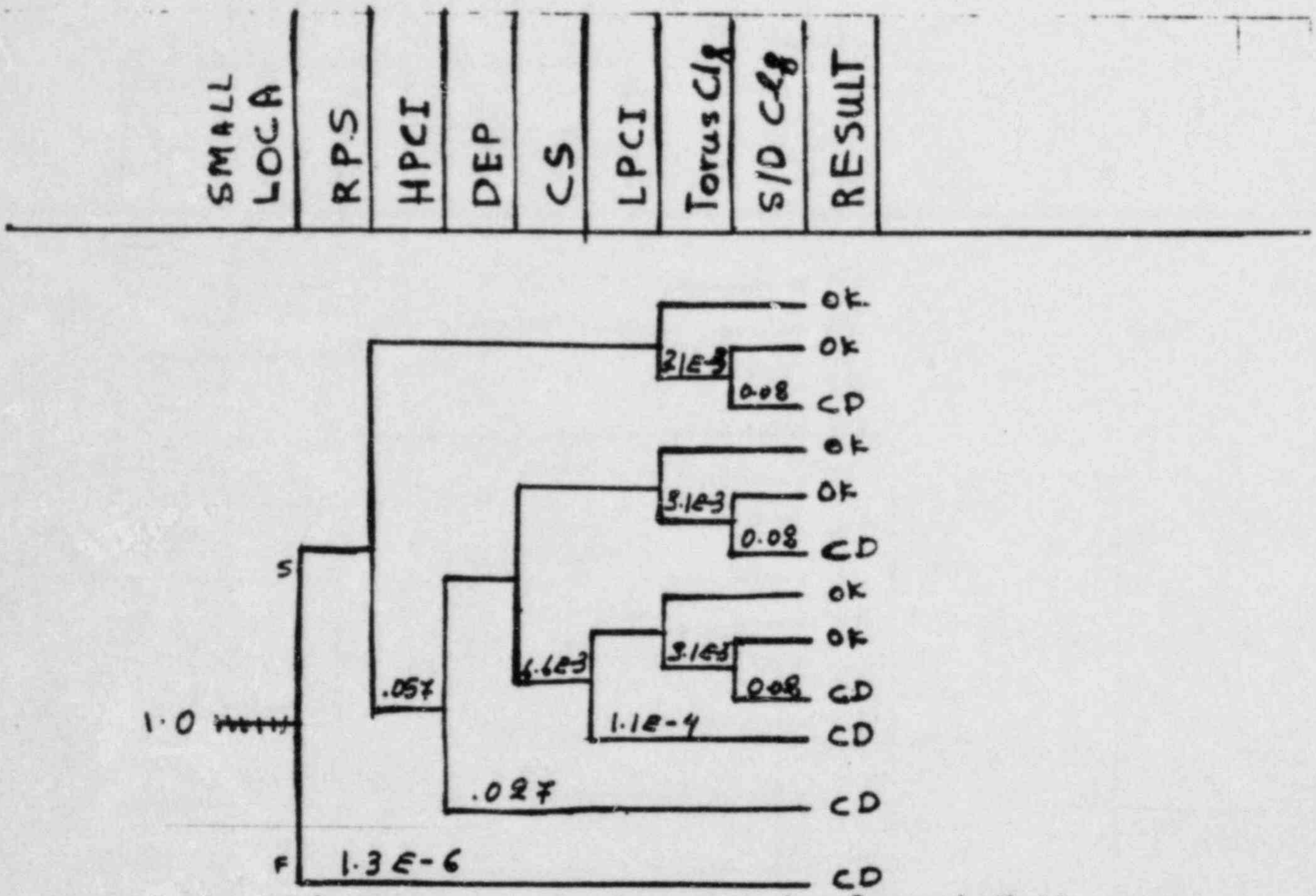
Category A3

P = 9.6E-4

RESULT

OK = NON CORE DAMAGE S = Success

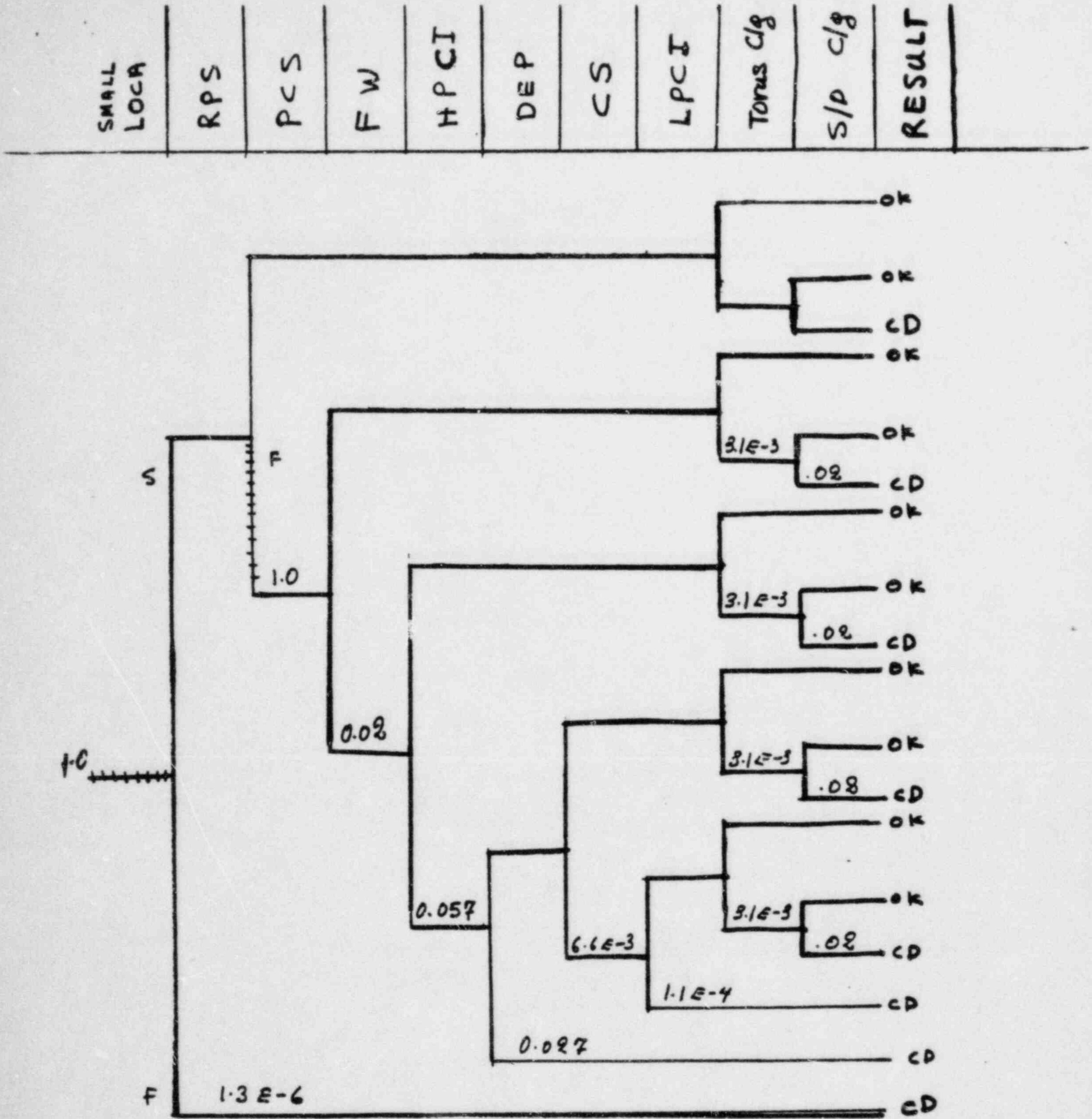
CD = CORE DAMAGE F = Failure



(NSIC 77916) - Sequence of Interest for Several Malfunctions at Oyster Creek, Applied in Category B

P = 1.6 E-3

RESULT
OK = NON CORE DAMAGE S = SUCCESS
CD = CORE DAMAGE F = Failure



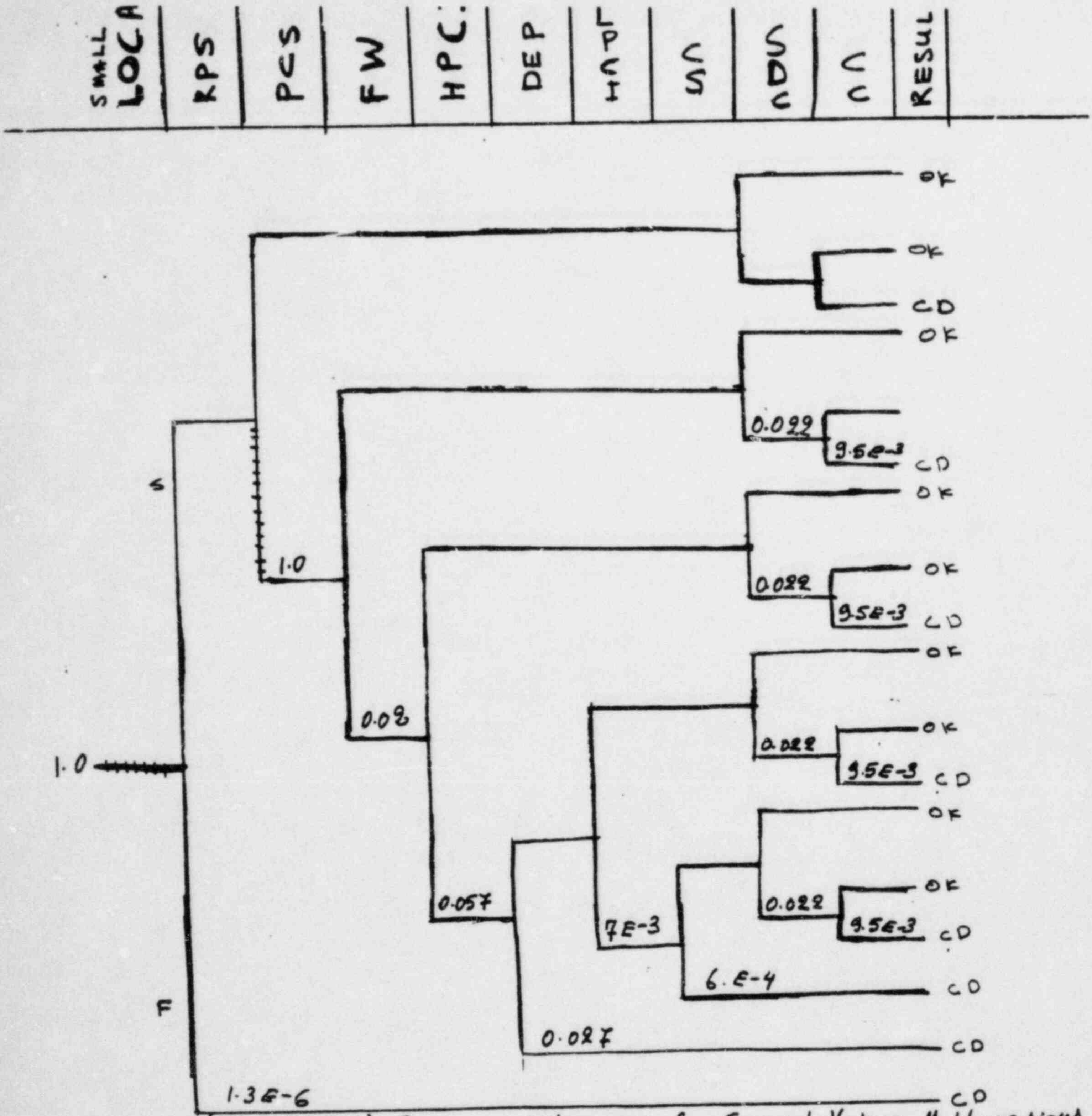
(NSIC 77916) - Sequence of Interest for Several Valves Malfunctions at Oyster Creek, Applied in Category C

P=1.57E-4

RESULT

OK = NON CORE DAMAGE S = Success

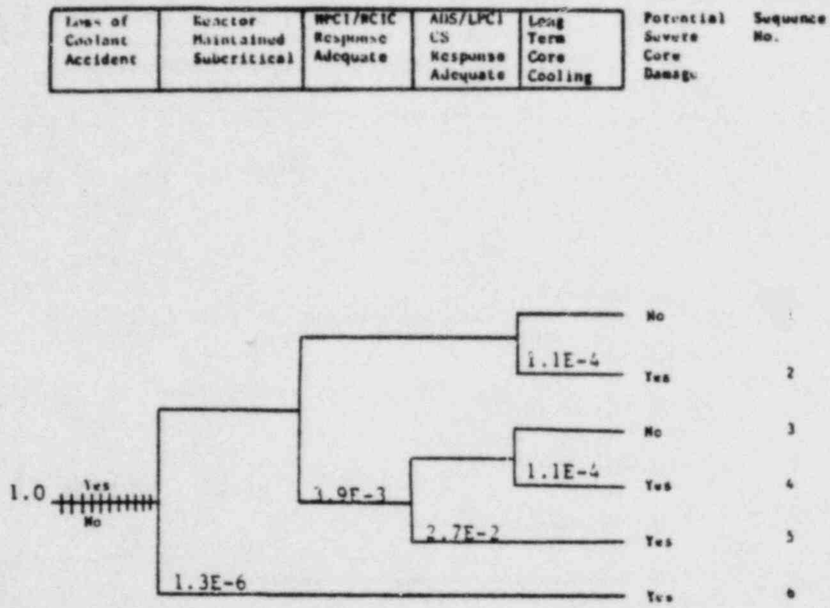
CD = CORE DAMAGE F = Failure



(NSIC 77916) - Sequence of Interest for Several Valves Malfunctions at Oyster Crek Applied in Category D

P= 4.54 E-4

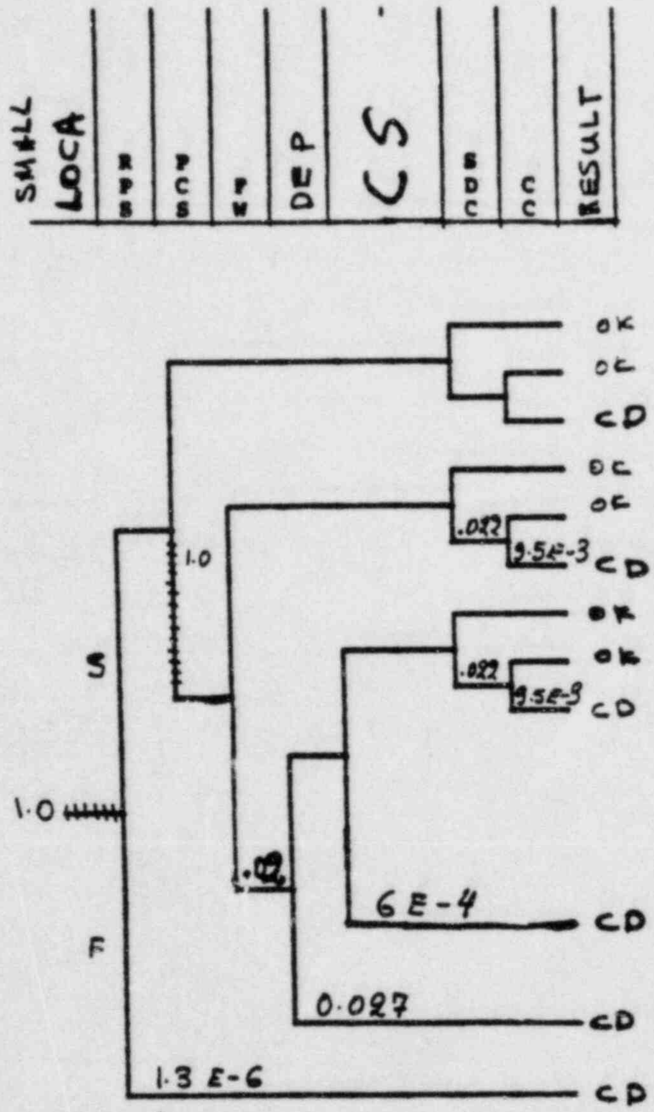
RESULT
OK = NON CORE DAMAGE S = Success
CD = CORE DAMAGE F = Failure



P = 2.1E-4 (SC = 37)

NSIC 77916 - Sequence of Interest for Several Valves Malfunctions at Oyster Creek

Applied in Category E



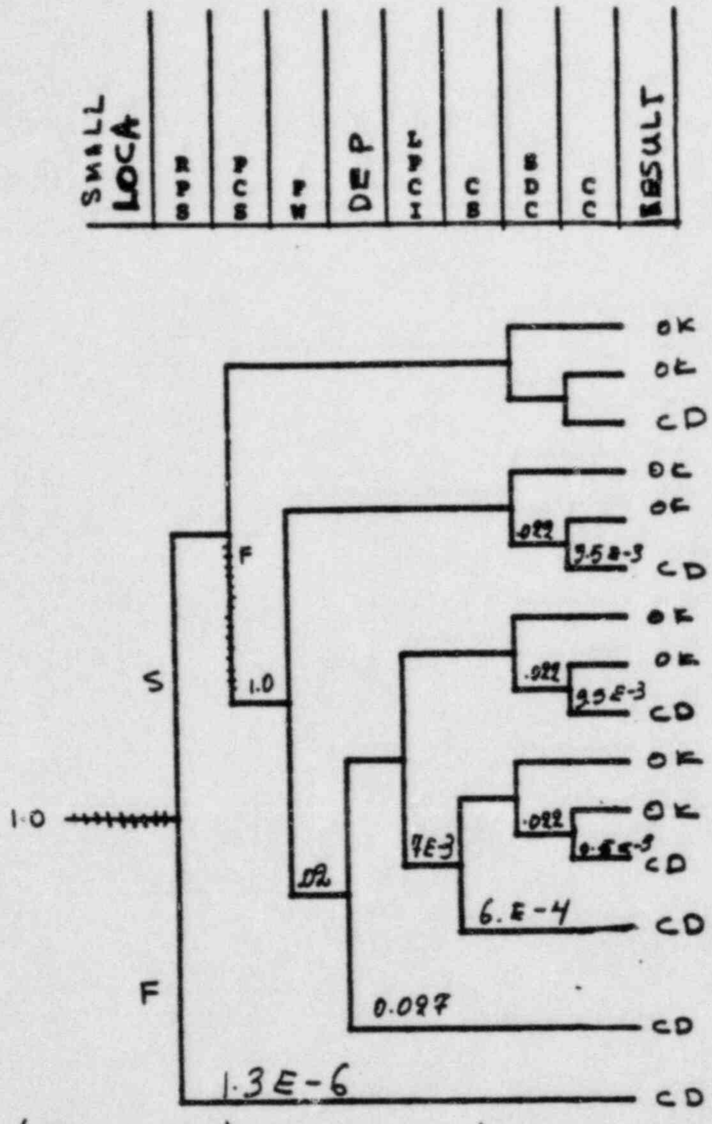
(NSIC 66996) - Sequence of Interest for Pressure Transient and Blowdown at Millstone Point 1, Applied in Categories A1 and A2

P = 9.76 E-4

RESULT

OK = NON CORE DAMAGE S = SUCCESS

CD = CORE DAMAGE F = Failure



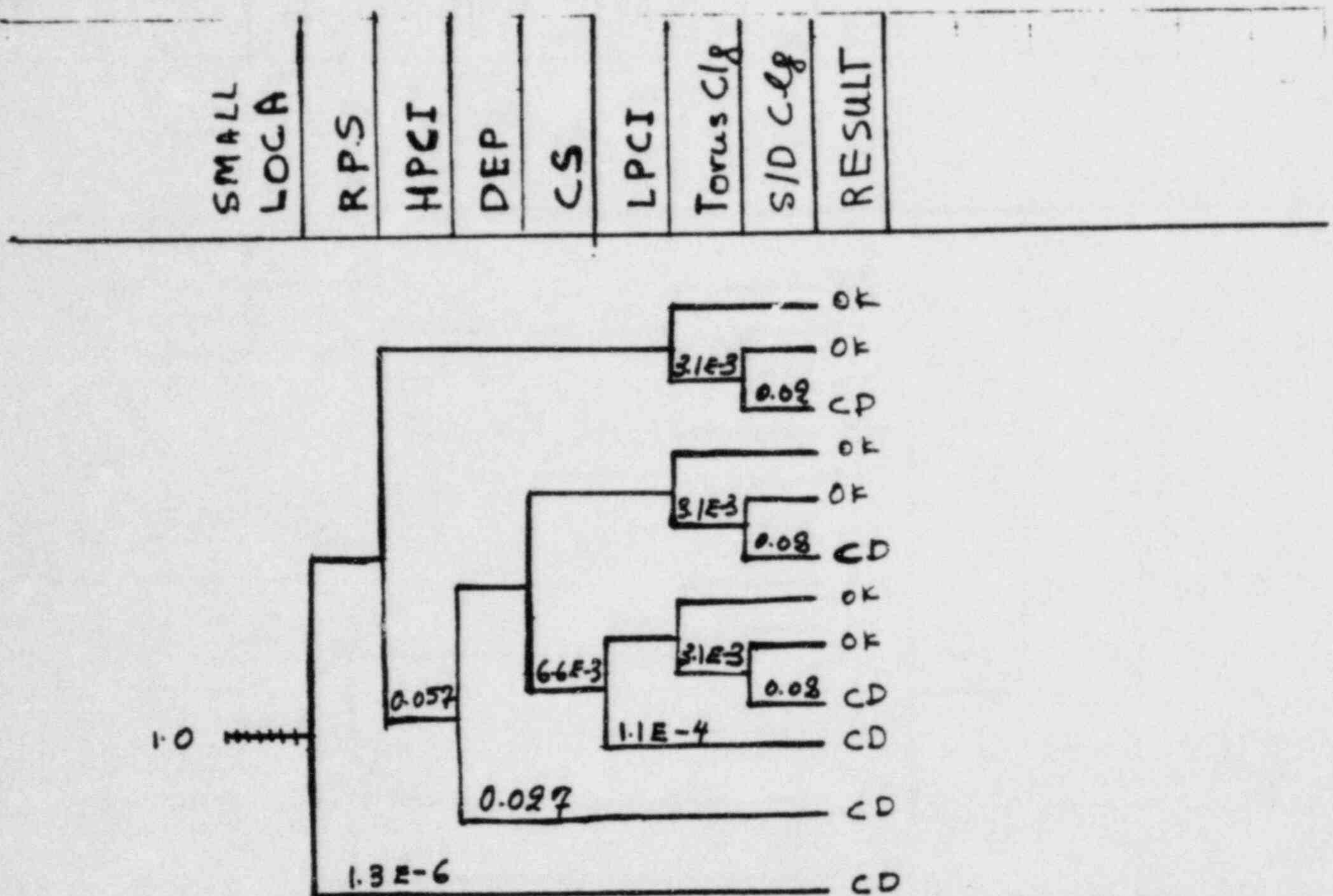
(NSIC 66996) - Sequence of Interest for Pressure Transient and Blowdown at Millstone Point 1, Applied in Category A3

P = 9.6 E-4

RESULT

OK = NON CORE DAMAGE   S = success

CD = CORE DAMAGE   F = Failure

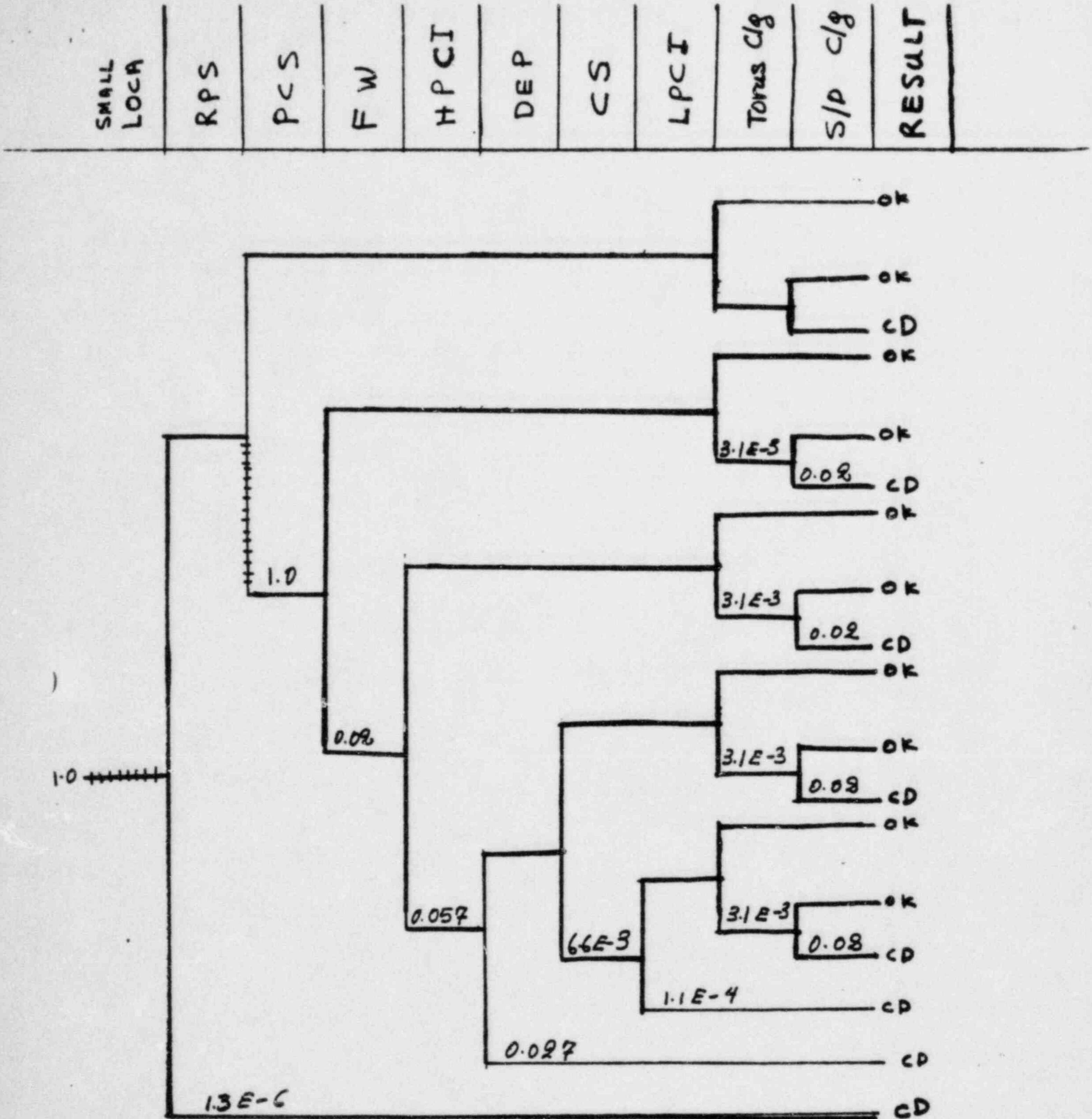


(NSIC 66996)-Sequence of Interest for Pressure Transient and Blowdown at Millstone Point 1, Applied in Category B

P=1.6 E-3

RESULT
OK= NON CORE DAMAGE
CD= CORE DAMAGE

S = success
F = Failure



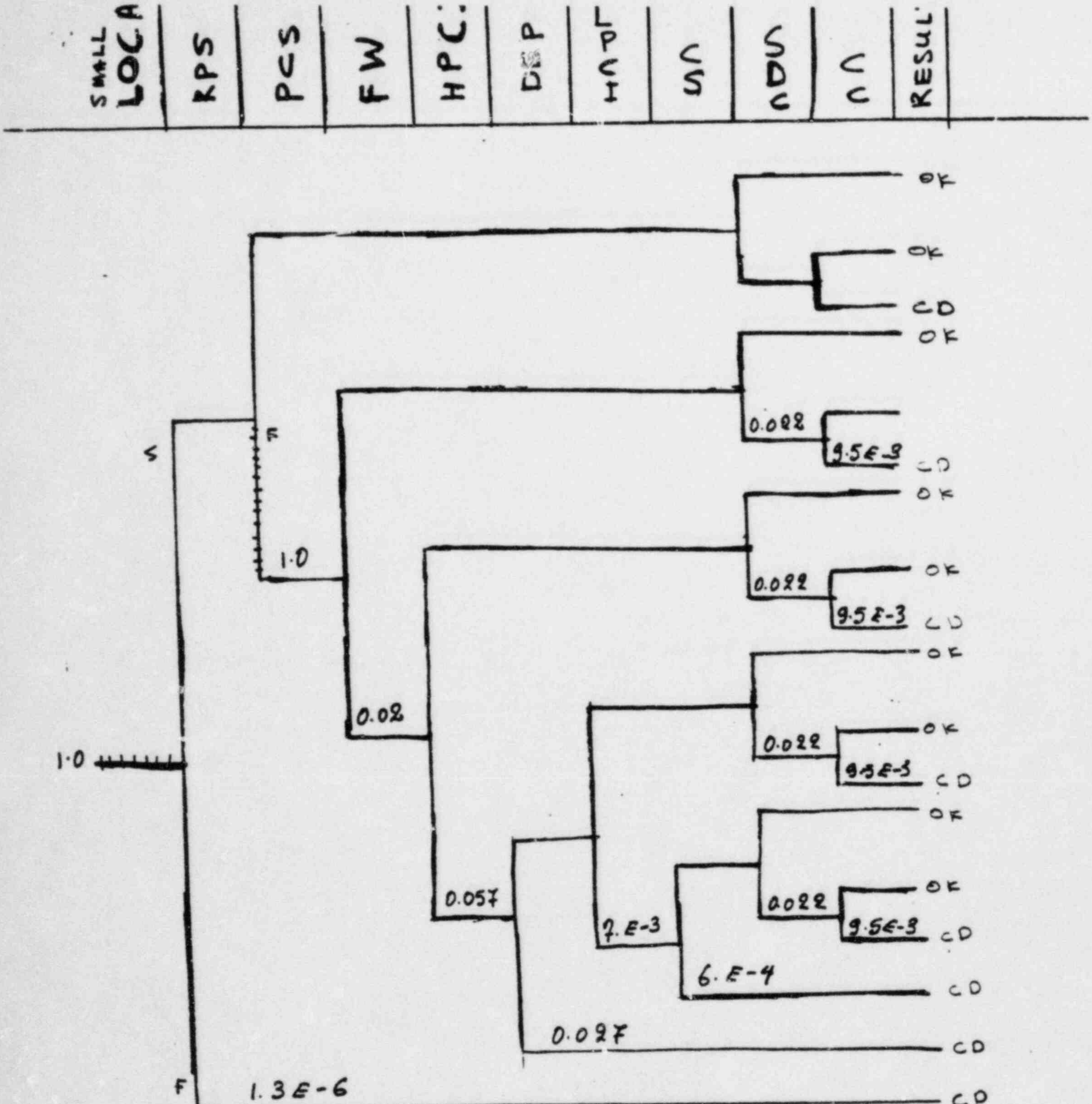
(NSIC 66996) - Sequence of Interest for Pressure Transient and Blowdown at Millstone Point 1, Applied in Category C

$P = 1.57\ E-4$

RESULT

OK = NON CORE DAMAGE S = Success

CD = CORE DAMAGE F = Failure



(NSIC 66996) - Sequence of Interest for Pressure Transient and Blowdown at Millstone Point 1 Applied in

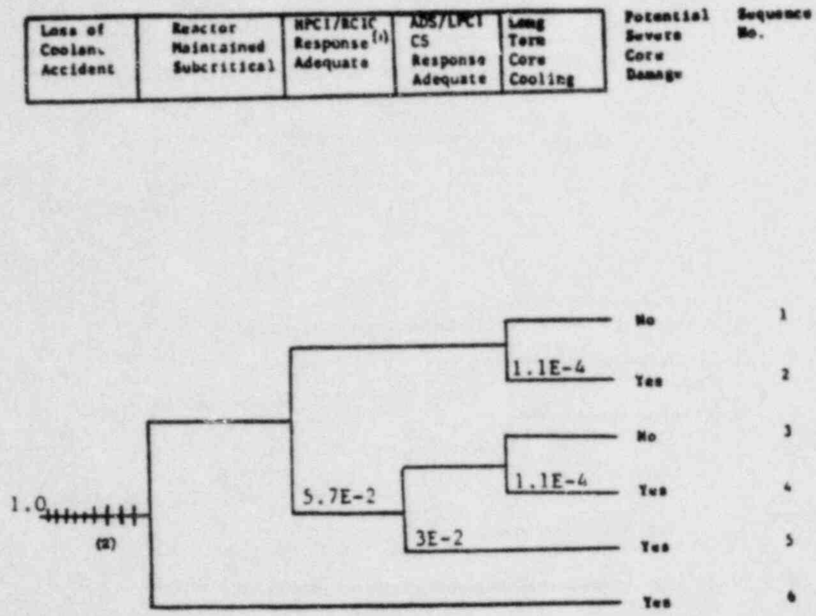
Category D

P= 4.54E-4

RESULT

OK = NON CORE DAMAGE S=success

CD = CORE DAMAGE F=failure

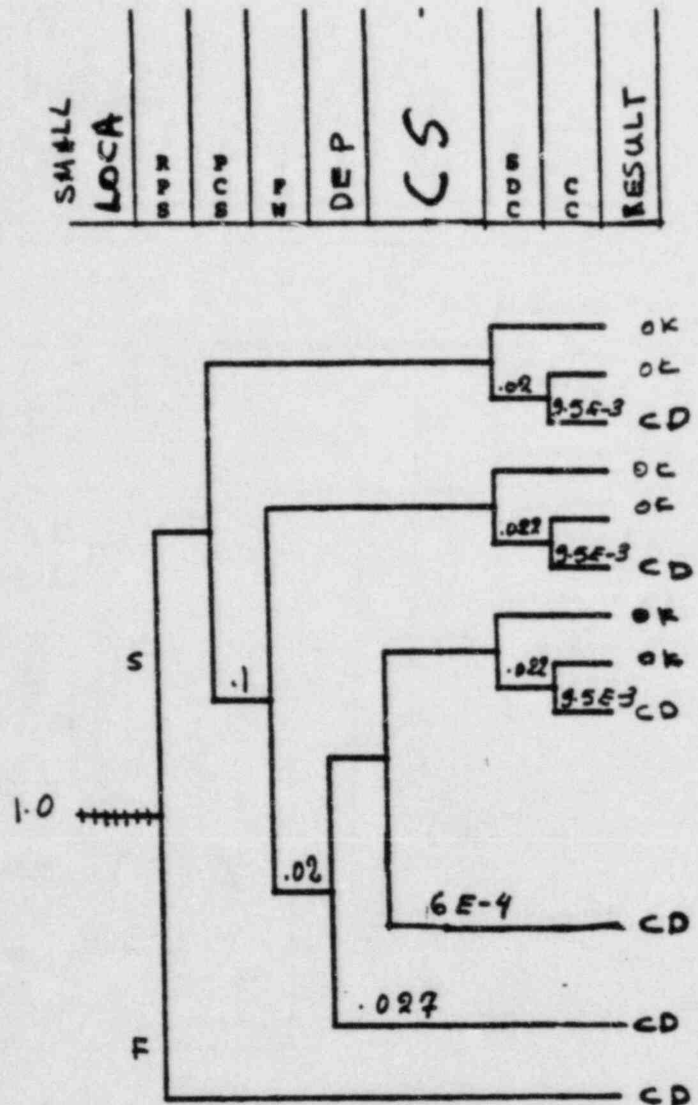


P = 1.8E-3 (SC = 27)

NSIC 66996 – Sequence of Interest for Pressure Transient and Blowdown at Millstone Point 1, Applied in Category E

[1] Millstone Point 1 utilizes IC, and FWCI instead of RCIC and HPCI

[2] Stuck open relief valve.



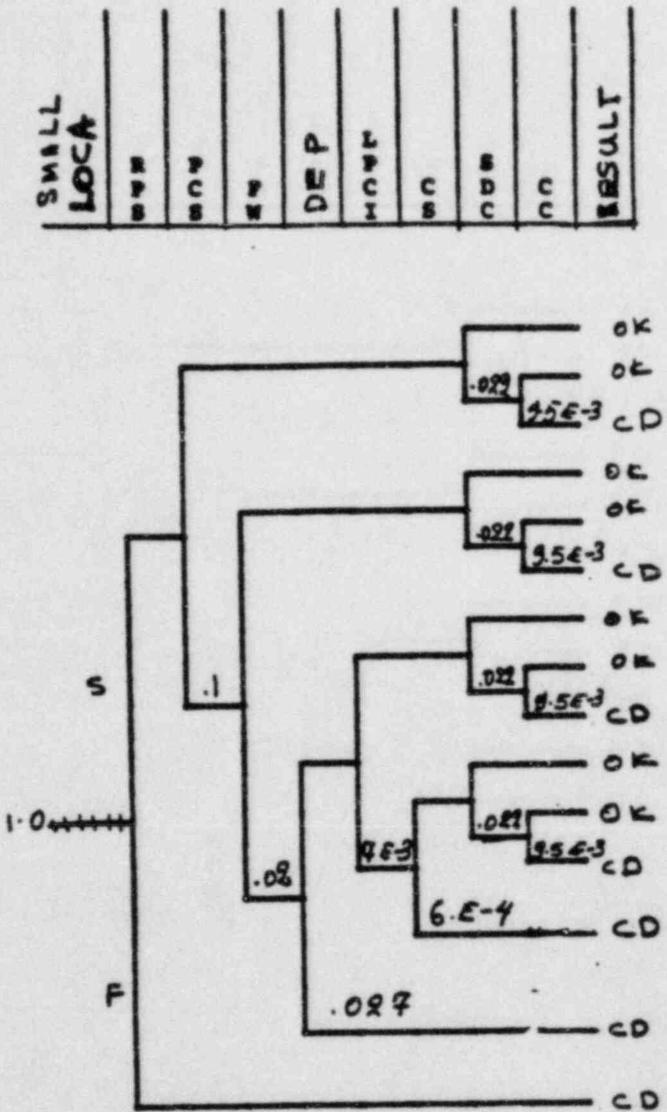
(NSIC 128569)- Sequence of Interest for Safety Relief Valve Fails to reset at Brunswick 2, Applied in Categories A1 and A2

P= 2.87 E-4

RESULT

OK = NON CORE DAMAGE S = Success

CD = CORE DAMAGE F = Failure



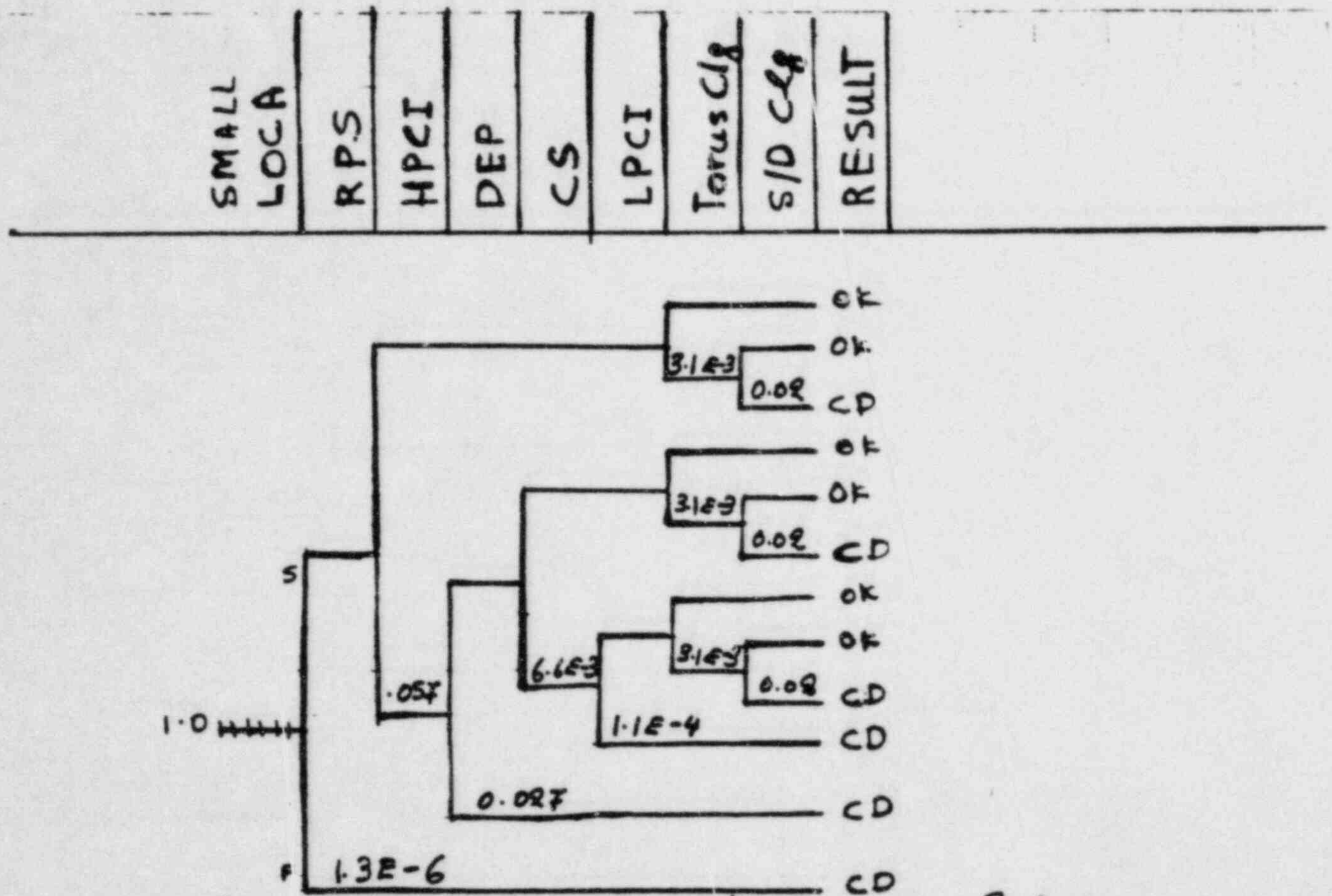
(NSIC 128569) - Sequence of Interest for Safety Relief Valve Fails to Reset at Brunswick 2, Applied in Category A3

P = 1.36 E-5

RESULT

OK = NON CORE DAMAGE S = success

CD = CORE DAMAGE F = Failure



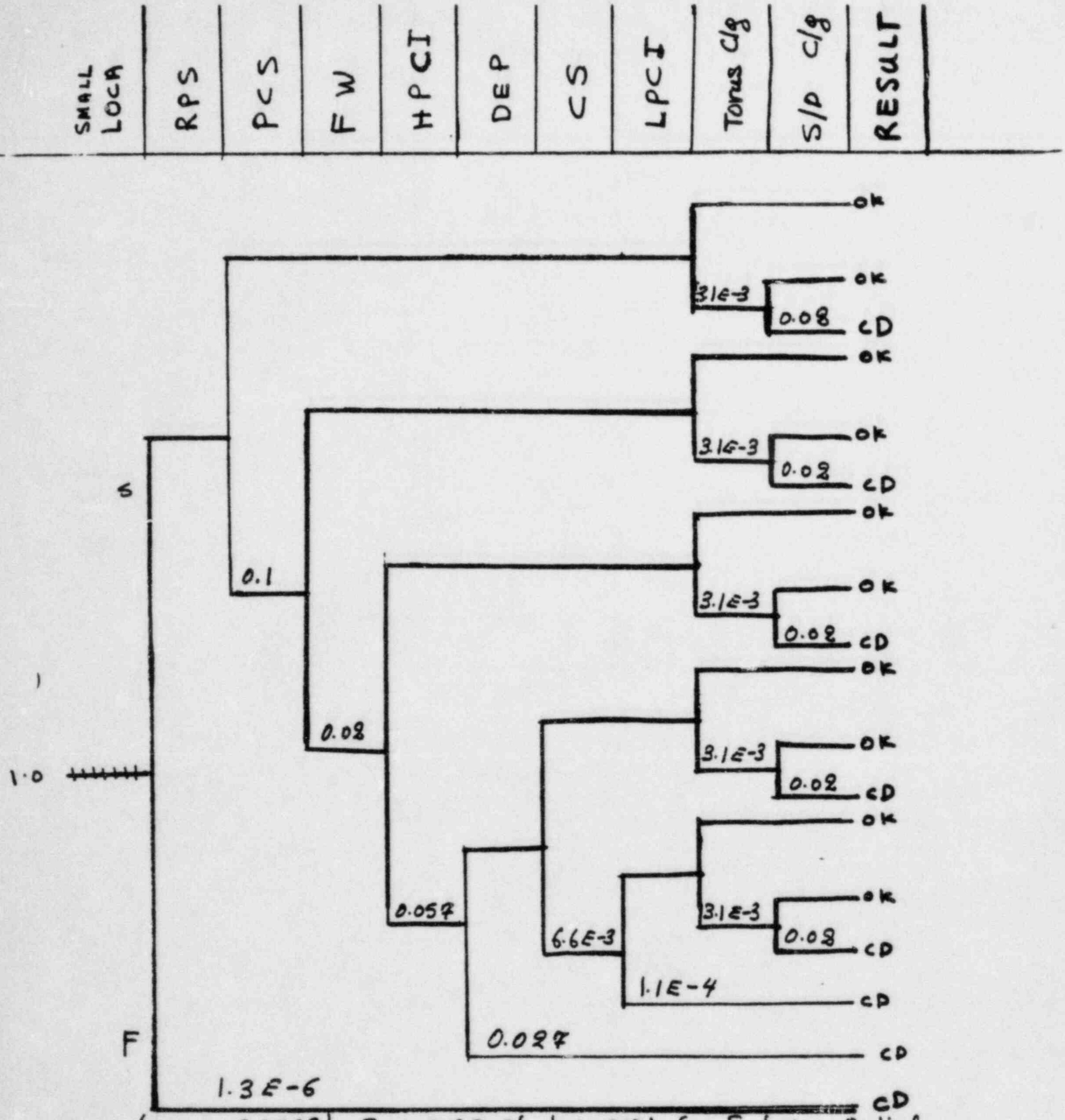
(NSIC 128569) - Sequence of Interest for Safety Relief Valve Fails to Reset at Brunswick 2, Applied in Category B

P = 1.6E-4

RESULT

OK = NON CORE DAMAGE   S = Success

CD = CORE DAMAGE   F = Failure



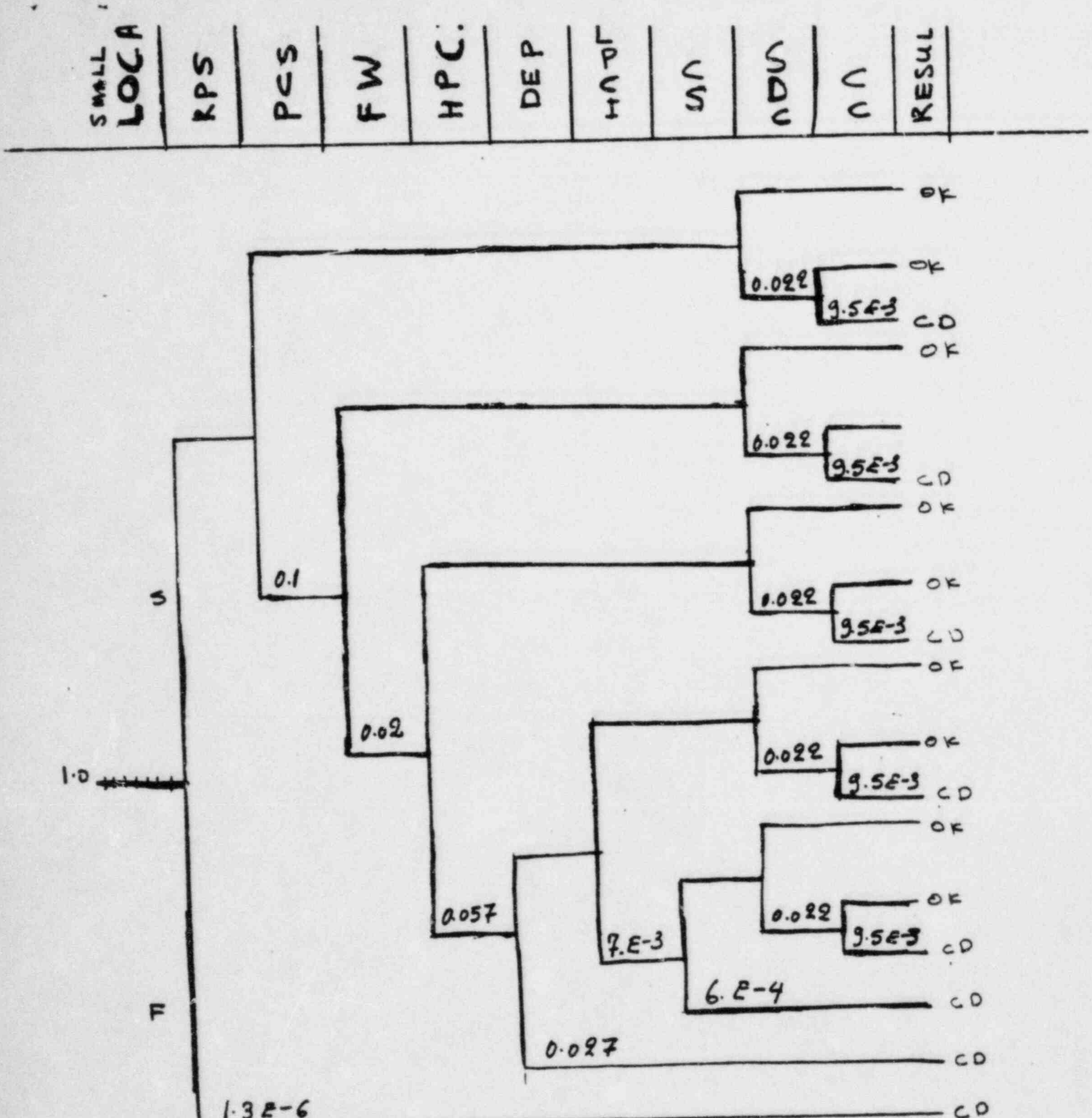
(NSIC 128569) - Sequence of Interest for Safety Relief Valve Fails to Reset at Brunswick 2 Applied in Category C

P = 7.3E-5

RESULT

OK = NON CORE DAMAGE S = SUCCESS

CD = CORE DAMAGE F = Failure



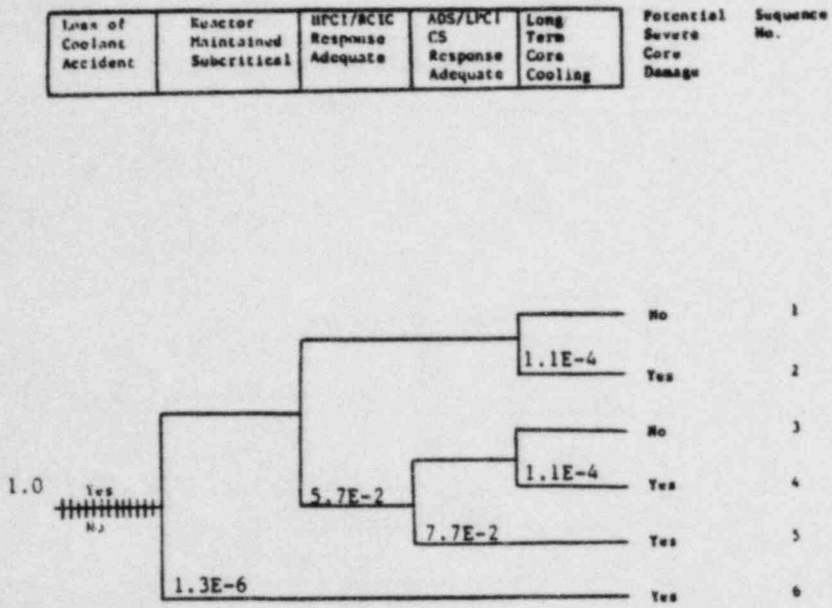
(NSIC 188569) - Sequence of Interest for Safety Relief Valve Fails to Reset at Brunswick 2, Applied in Category D

$P = 2.35E-4$

RESULT

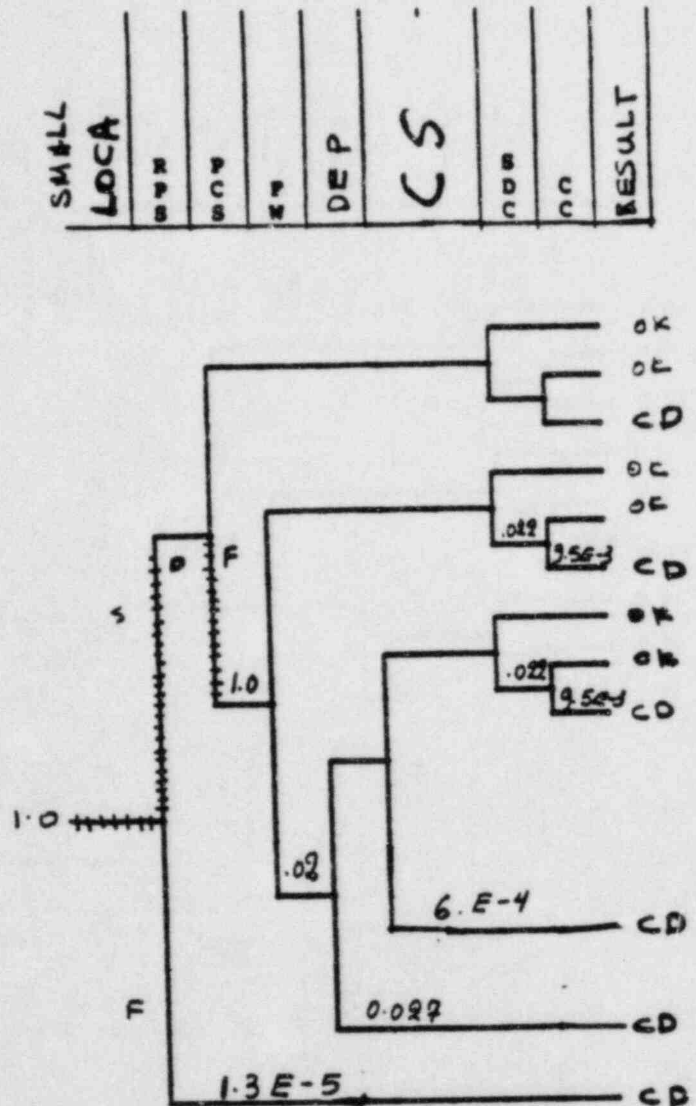
OK = NON CORE DAMAGE S = SUCCESS

CD = CORE DAMAGE F = Failure



P = 1.8E-3 (SC = 27)

NSIC 178569 - Sequence of Interest for Safety Relief Valve Fails to Reset at Brunswick 2, Applied in Category E

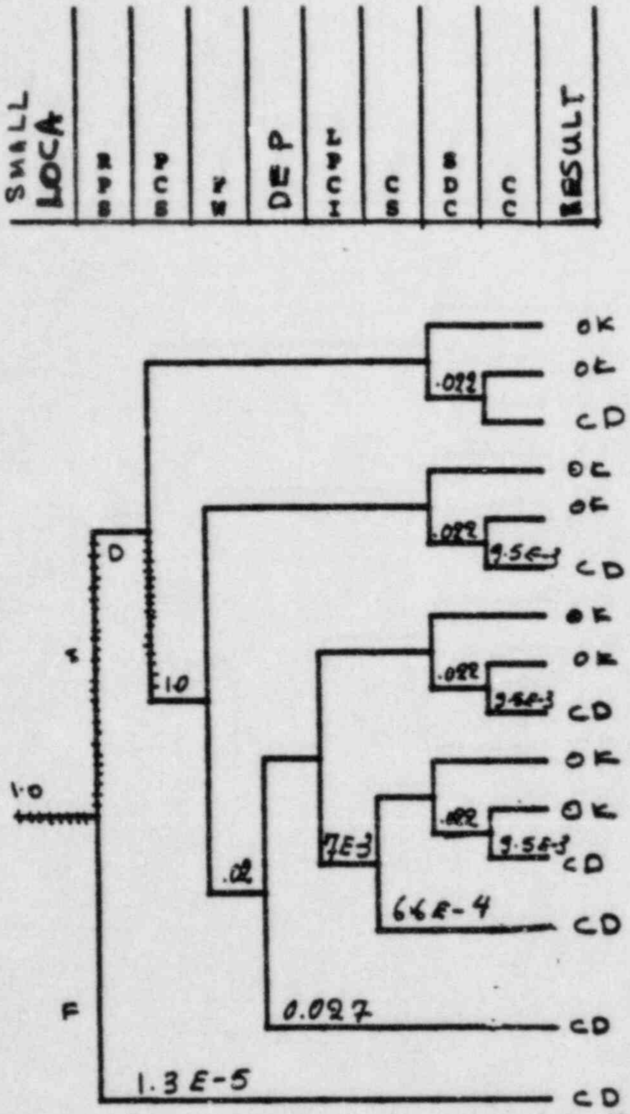


(NSIC 103002) – Sequence of Interest for Multiple Valve Failures and RCIC Inoperable at Brunswick 2 Applied in CATEGORIES A1 AND A2

P = 9.76 E-4

RESULT

OK = NON CORE DAMAGE
CD = CORE DAMAGE
S = Success
F = Failure



(NSIC 103002) - Sequence of Interest for Multiple Valve Failures and RCIC Inoperable at Brunswick 2 Applied

IN CATEGORY A3

P = 9.6 E-4

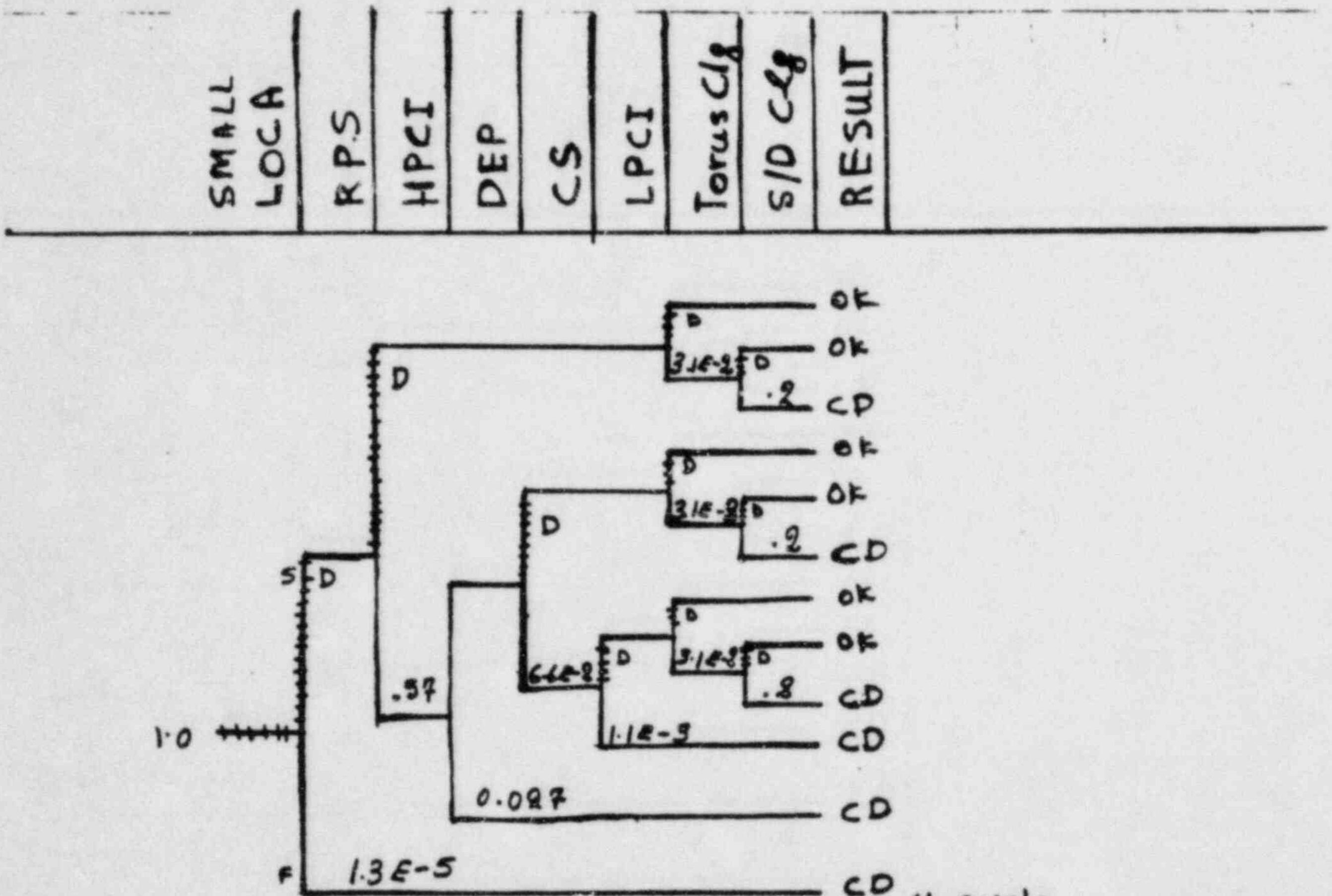
RESULT

OK = NON CORE DAMAGE

CD = CORE DAMAGE

S = Success

F = Failure



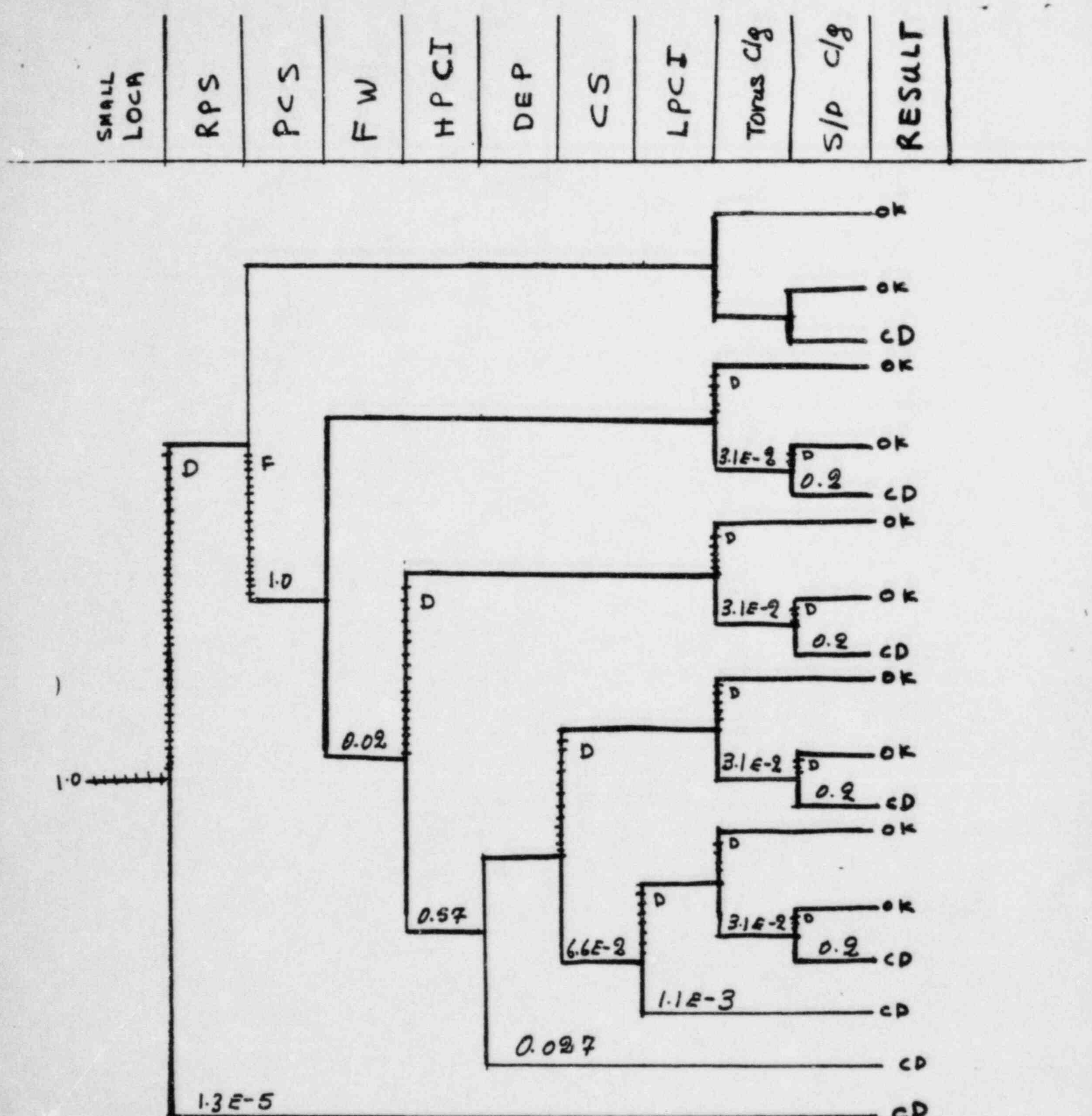
(NSIC 103002) - Sequence of Interest for Multiple Valve Failures and RCIC Inoperable at Brunswick 2 Applied in Category B

$P = 2.53\ E-2$

RESULT

OK = NON CORE DAMAGE S = Success

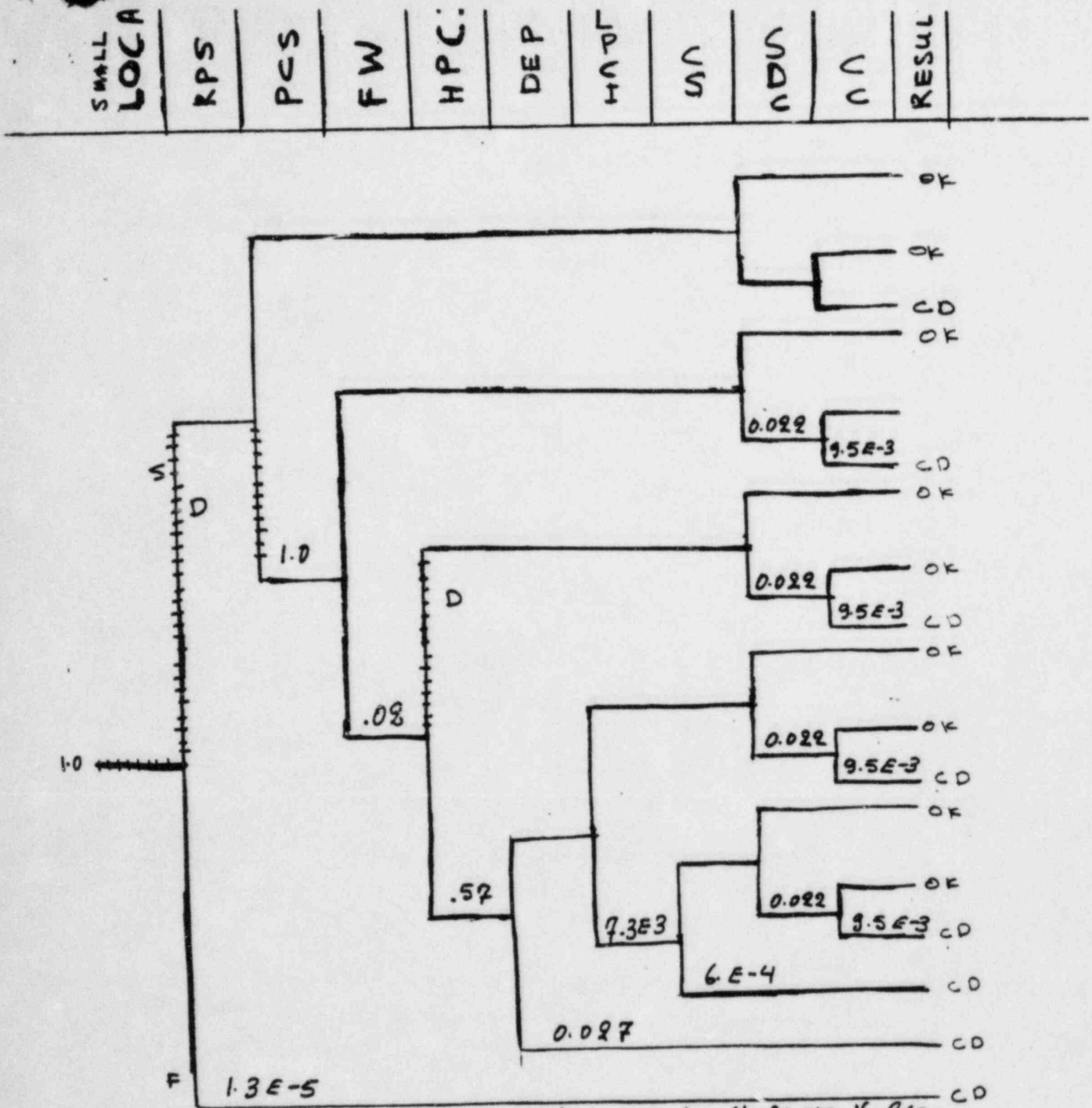
CD = CORE DAMAGE F = Failure



(NSIC 103002) - Sequence of Interest for Multiple Valve Failures and RCC Inoperable at Brunswick 2 Applied in Category C

P= 6.71E-3

RESULT
OK = NON CORE DAMAGE S = success
CD = CORE DAMAGE F = Failure

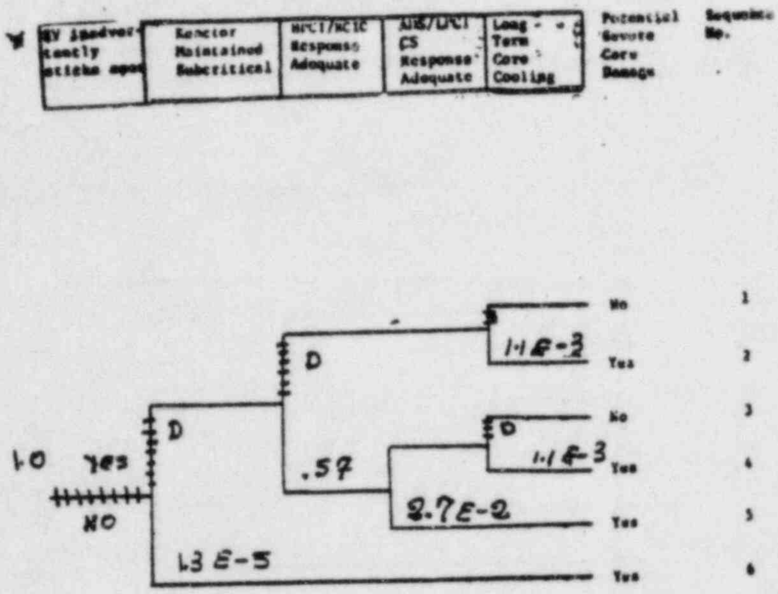


NSIC 103008 - Sequence of Interest for Multiple Valve Failures and RCIC Inoperable at Brunswick 2 Applied in Category D

P= 2.55 E-4

RESULT
OK = NON CORE DAMAGE
CD = CORE DAMAGE

S=Success
F=Failure



P = 1.65E-2

(NSIC 103002)-Sequence of Interest for Multiple Valve Failures and RCIC Inoperable at Brunswick 2 Applied in Category E

* SV indvertently sticks open is a LOCA event. Nevertheless a LOFW tree was used by the ASP study. In doing so, a 3.9E-2 was used for degrated RCIC/HPCI ... compared to .57 that should be used for a LOCA event, resulting a probability estimate one order of magnitude less than the above estimate.

A LOCA event tree was applied in all categories of this analysis.