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July 20, 1994

C. R. Hutchinson
Vice President
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U.S. Nuclear Regulatory Commission
Mail Station P1-37
Washington, D.C. 20555

Attention: Document Control Desk

Subject: Grand Gulf Nuclear Station
Docket No. 50-416
License No. NPF-29
Appendix J Exemption Request
Response to Additional Information Request Dated June 10, 1994

GNRO-94/00099

Gentlemen:

Enclosed are the responses to two staff questions associated with our Appendix J exemption request and transmitted by your letter dated June 10, 1994.

As you know, we have discussed much of the response with the staff during several telephone conferences. However, please note that we are providing additional information by this letter which was not available at the time of our discussions.

It is our understanding that the staff intends to proceed with approval of our proposed Appendix J performance-based testing program for a period of two refueling outages. At that point, it is our intent to adopt the new Appendix J rulemaking which is currently in preparation.

It is also our understanding that during the rulemaking phase the staff will address and resolve the application of performance data and probabilistic safety assessment techniques to determining appropriate local leak rate testing intervals. This issue remains open from the review of the Grand Gulf exemption request.

Since your questions, and our responses, are directly pertinent to this open issue, we request that you continue your review, albeit for purposes of rulemaking. In this context, we also request your response as to the acceptability of the attached information. Should you find our testing interval basis to be incomplete, please also provide timely guidance as to what constitutes an acceptable methodology for determining a local leak rate testing interval.

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Finally, we wish to express our appreciation for the NRC's effort in reviewing this exemption request. The Containment Systems Branch and Research staff have been uniformly professional and constructive. We believe that the results of this effort will significantly contribute to an improved focus on those aspects of nuclear operation which are important to safety while relieving unnecessary regulatory burden.

Yours truly,

CRH/MJM/be

attachment: Response to Additional Information Request Dated June 10, 1994

cc:

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Question:

The response to NRC Question 26, in your May 11, 1994 letter to the NRC stated that

> "The 5 and 10 year intervals were chosen by GGNS based on the past testing history of the components and the risk assessment outlined in the application."

We do not consider this to adequately justify the specific 5 and 10 year intervals. Please provide a detailed analysis, using the data from past testing history, that demonstrates the acceptability of these intervals. State clearly what criteria are used to determine acceptability. Also, identify any data, not specific to Grand Gulf, that were used to justify the 5 and 10 year intervals.

The staff does not consider the results of a probabilistic safety analysis showing that overall risk is not exceeded as adequate justification for these specific testing intervals.

Response:

Introduction

There are several issues raised by this question that should be addressed:

- Can probabilistic safety analysis (PSA) form the basis for a testing interval?
- The staff implies that past performance history alone can be used to justify an interval length. Is this possible?
- What, if any, additional information and analysis is available to support the testing intervals requested by Grand Gulf?

Use of PSA

As discussed in more detail below, the Grand Gulf analyses supporting our exemption request, are a blend of deterministic and probabilistic analyses. PSA is not employed as a sole means of justification, nor do we conclude that the proposed testing intervals are acceptable because "overall risk is not exceeded".

Few regulatory and safety issues are resolved today without at least some basis founded in PSA. The proposed Appendix J rulemaking itself would be considered almost solely based on PSA. Changes to Technical Specification surveillance intervals are routinely based on PSA because PSA is the only technology available that can actually be used to optimize an interval based on competing (i.e., increasing and decreasing) safety effects.

Without reliance on PSA, to at least some degree, the staff's question implies that performance data alone can be used to define a safe testing interval. As discussed in the following section, past performance data cannot be used to define safe intervals. It is necessary to introduce an analytic technique to relate performance and safety.

Necessary Elements of an Interval Analysis

A performance-based approach to defining leak rate testing intervals must, by necessity, combine elements of prior component performance data with deterministic and probabilistic techniques. As noted in the summary of technical findings in draft NUREG-1493, "Performance-based requirements are those whose limits are based upon consideration of operating history and risk insight." In this case, the "limits" are the length of the leak rate testing intervals.

Past good performance can only provide increased confidence in the likelihood of continued good performance in the future. Past good performance alone cannot guarantee future good performance nor can it define an interval which is "safe". But, past performance data can provide a reliable measure of the probability of good performance at varying points in the future or, its inverse, a measure of failure probability.

In order to determine a "safe" interval it is necessary to introduce a measure of safety. In the case of leak rate testing, a key measure of safety is off-site dose consequence (i.e., person-rem).

Finally, it is necessary to develop a relationship between past performance (e.g., number of successive passed tests) and safety (person-rem). Clearly, this cannot be done based upon performance data alone. We need a model which will determine the off-site dose consequences resulting from a range of component failure probabilities. Given that model, we can choose a value of off-site dose consequence which is acceptable and thereby define a testing interval. Of course, such models already exist in plant IPEs. Their primary purpose is to determine the level of adverse consequence for the modeled plant configuration based upon the failure frequencies of the modeled components.

What Performance Data Alone Can Tell Us

Although performance data alone cannot be used to determine interval lengths, it can be used as confirmatory information in support of intervals - i.e., a check on the "reasonability" of the proposed intervals. For instance, using the approach of NUREG-1493 (Figure A-7), we can plot the frequency of relatively gross component leak rates (i.e., > 257 scfh) versus time since maintenance. Using Grand Gulf data which covers nearly a 10 year period (Figure 1) we find that large component leak rates peak approximately one refueling outage following maintenance. Thereafter, components with large leakage rates stay in the 1-2 range up to the second refueling outage following maintenance, and are non-existent after two refueling outages. The performance data support the proposed scheme of not allowing extended test intervals until two successful passed tests are achieved and suggest that a third successful test (to go to a 10 year interval) may not be necessary.

We can also examine component behavior at lower "failure" levels - i.e., failure to meet licensee administrative limits.

- Figures 2 and 3 plot the period of time which elapses prior to a component's first failure for Type B and C components, respectively. In fact, most components have never failed in nearly 10 years of operation (represented by the point labeled "Passed"). Those few components which do fail to meet administrative limits usually do so within the first couple of refueling outages, a similar behavior to the grosser leakage failures presented in Figure 1.

- For components that have experienced a failure we can measure the effectiveness of corrective action by plotting the period of time which has elapsed without another failure occurring, for Type B (Figure 4) and Type C (Figure 5) components. As shown, most components stay "fixed" following a failure for an extended period of time.

And, we can examine the effects of the proposed Type C test intervals on the minimum/maximum pathway leakage for a given containment penetration. Using actual leakage measurements, we calculated the minimum/maximum penetration pathway leakage for three cases using testing information from 1985 to the present. The results are presented in Figure 6.

- Case 1 - Represents the effects of not having a testing or maintenance program (columns B and C of Figure 6). In this case, the worst as-found test leakage in each inboard/outboard penetration is used to calculate min/max pathway leakage. The penetrations with high min/max pathway leakage (designated by "XXXXXX") were mainly due to MSIV and Feedwater components whose leakage exceeded instrumentation capability to measure.

- Case 2 - Represents the effects of applying the proposed Type C performance-based testing program (columns E and F of Figure 6). The leakage values were obtained by using the as-found leakage results at the components' proposed interval due dates or GGNS' last outage (RF06) if the test due date would have been beyond RF06. The leakage values for MSIVs and Feedwater IVs were obtained using RF06 as-left test results.

- Case 3 - Represents the current Appendix J testing program (columns H and I of Figure 6). The leakage values were obtained from RF06 as-left leakage data.

As shown in Figure 6, the change in min/max pathway leakage due to the proposed Type C performance-based testing program compared to the existing program is small. Minimum pathway leakage increases from 5253 sccm to 7200 sccm. Maximum pathway leakage increases from 35,597 sccm to 91,198 sccm. All results are well below L_a (211,600 sccm).

Finally, we can go beyond a simple examination of performance data and apply statistical techniques (other than probabilistic safety assessment) to gain confidence in performance-based programs. For instance, one concern expressed by the NRC in discussing the Grand Gulf exemption has to do with the so-called "bathtub curve". In simple terms, the "bathtub curve" relates to the distribution of component failures over time wherein an initially higher failure rate is followed by a period of low and relatively constant failure rate, and ending with a period of higher failure rate -- in other words, the failure history describes a bathtub shape. While this behavior has been observed in many different applications, what is not clear for Type C components is how long the benign period of low failure rate lasts.

We can get a feel for how long the low failure rate period lasts by calculating the mean time between failure (MTBF) for Type C components using a Weibull distribution. As noted in references 1 and 2, a Weibull distribution is commonly applied to a wide range of failure data and statistical problems to model and assess failure rates and aging predictions, amongst other applications. When applied to first failures of Grand Gulf Type C components between commercial operation and the last refueling outage (RF06) we find that the MTBF is approximately 480 months. This result is well in excess of the proposed 10 year interval for components that have successfully passed three consecutive tests, and suggests that the "bathtub curve", if it exists for Type C components, should have no adverse effect within the time periods covered by the exemption request.

In summary, performance data can be viewed from many different perspectives and can be manipulated to provide insights supportive of a particular application. In the case of the Grand Gulf Appendix J exemption request, the performance data over nearly a 10 year period strongly supports the proposed testing intervals. However, the data itself cannot determine a "safe" interval. To do that we need to expand our discussion to include measures of safety.

<u>Overall Safety Significance of Increased Containment Leakage</u>

Before discussing a more detailed technical basis for our requested Type B and C testing intervals, it is important to lend perspective to the overall safety importance of relatively small variations in containment leakage rates.

As the testing intervals for containment leak rate testing are extended (whether Type A, B or C testing) the rate of containment leakage will likely increase correspondingly. A number of studies have been conducted which conclude that off-site dose consequences of severe accidents are relatively insensitive to even large (several orders of magnitude) increases in containment leakage rate. For instance:

- NUREG/CR-4330 built upon earlier study results and examined the safety impact of modifying containment leak rate testing requirements for several plants, including Grand Gulf. The study concluded, in part, that because off-site consequences are dominated by severe accident scenarios involving the bypass or failure of containment, overall off-site consequences are insensitive to containment leakage.

- NUREG-1150 provided additional, more detailed confirmation of the insensitivity of off-site dose consequences to containment leakage rates. For example, increasing containment leakage rates by two orders of magnitude resulted in population exposure increases on the order of 3%. The study also served to emphasize the lower sensitivity of BWRs compared to PWRs due to the higher likelihood of containment failure during severe accidents for BWRs as well as the beneficial scrubbing effect of the suppression pool.

These type of study results are instructive in understanding the relative importance of varying containment leak rate testing intervals.

Although good valve testing performance is important, these study results also serve to demonstrate that the more important factor in relaxation of Appendix J requirements is the underlying low safety importance of increased containment leakage. In fact, it is precisely this conclusion which prompted identification of Appendix J as a requirement marginal to safety, and which underlies the technical basis for proposed rulemaking.

Therefore, from the broad viewpoint of these studies, we can provide an answer to part of the general question posed by the NRC: Is there a significant difference in safety between 2, 5 and 10 year Type B and C testing intervals? Given responsible administration of a testing and maintenance program, there cannot be any significant safety impact from extending these intervals because at worst the difference in interval can only cause a fractional shift in an already small fraction of severe accident consequence due to containment leakage.

Safety Basis Discussed in Grand Gulf's Exemption Request

The Grand Gulf exemption request went well beyond the general study conclusions discussed above in justifying the low safety impact associated with extended Type B and C testing intervals.

In addition to demonstrating strong component performance histories, our exemption request laid out strict programmatic controls to minimize the potential for unidentified common mode failures, to minimize the potential impact of random component failures and to prohibit the application of extended intervals to a small set of components with relatively poor performance history and relatively higher safety significance.

In this context, we also examined in detail those deterministic and probabilistic analyses which could be adversely affected by increased leakage due to extended testing intervals. In effect, we demonstrated that for those deterministic and probabilistic event scenarios of concern, the Grand Gulf design and performance restricted their frequency to a very low level regardless of the length of the testing interval. We also demonstrated that there were corresponding safety benefits (such as increased shutdown safety effects) which were of the same order of magnitude, effectively resulting in a safety-neutral change.

While we feel the Grand Gulf analysis is compelling and provides an adequate basis for our exemption request, we were not able to extend the analysis to include a direct measure of off-site consequences. Since the time our request was submitted, however, both the NRC and EPRI have analyzed the effect of interval length on off-site consequences. Their work is directly applicable to and supports our exemption request.

Draft NUREG-1493

Draft NUREG-1493 (Revision 2) provides the technical basis for the NRC's proposed performanced-based rulemaking to modify Appendix J. This approach blends deterministic and probabilistic techniques to develop a model which was applied to actual Grand Gulf testing performance data. Specifically, as noted in Appendix A of NUREG-1493:

> "Extensive test result data and component data were collected at the Grand Gulf Nuclear Station... This data collection effort was performed to provide sufficient information for calculating the costs and man-rem exposure associated with local leak-rate testing, and to identify and quantify the effect of component and system parameters on component leak rates and component leak-rate frequencies. This information was also used to develop models for evaluating the impact of alternative local leak-rate testing schemes on the probability and magnitude of containment leak rates."

In the course of their analysis, the NRC examined a range of alternative local leak rate testing intervals. In general, the staff concluded that performance-based alternatives to local leak rate testing requirements are feasible without significant risk impacts.

In particular, the NUREG-1493 analysis examined various testing interval schemes including one quite similar to the Grand Gulf exemption request (test scheme option 3):

- Skip no tests if pass 1 test or failed previous test
- Skip 2 tests if pass 2 tests (approximately every 5 years)
- Skip 5 tests if pass 3 tests (approximately every 10 years)

For the range of alternative schemes analyzed, the NUREG concluded, in part, that:

- Given a component failure, there is a high probability that the component will fail again in the next two operating cycles. If the component does not fail within two operating cycles, further failures appear to be governed by the random failure rate of the component. (It is worthwhile noting that this conclusion also confirms that it is not possible to define the limits of a testing interval based only on past performance data. In other words, past performance cannot predict the timing of future random failures.)

- Of the performance-based testing schemes evaluated, none increase the probability of containment leakage by more than a factor of approximately 3, and none increase the containment leakage contribution to overall plant risk by more than a few percent.

- Any test scheme considered should require a failed component pass at least two consecutive tests before allowing an extended test interval.

Grand Gulf agrees with the methodology applied for this analysis and its conclusions. We believe the results provide strong support that the 5 and 10 year proposed testing intervals are acceptable.

One weakness of NUREG-1493 is that it did not identify all safety improvements resulting from the proposed changes nor compare the improvements to the calculated adverse safety impacts. For instance:

- Decreased Type B and C testing leads to increased availability of safety systems during shutdown conditions. Since shutdown safety, particularly early in an outage, is sensitive to safety system availability, shutdown safety is increased in roughly direct proportion to testing interval length. (See Grand Gulf exemption request.)

- Decreased Type B and C testing leads to decreased on-site worker exposure. In fact, the actual decrease in worker exposure exceeds (by an order of magnitude) the potential off-site dose increases due to the extended intervals. (See Table 10-1 of NUREG-1493). Again, the benefit (decreased worker exposure) is roughly proportional to testing interval length.

When these and other benefits associated with the proposed testing intervals are taken into account, there is clearly a strong basis upon which to approve the exemption as requested.

<u>EPRI Study</u>

The Nuclear Energy Institute (NEI), in conjunction with the NRC, is developing licensee guidance which can be used to implement the proposed Appendix J rulemaking once it is approved. A key element in guidance development is the determination of Type B and C testing interval lengths.

In order to support the testing intervals which will be included in the NEI guidance document, NEI requested the assistance of the Electric Power Research Institute (EPRI) in conducting a study. The following information is extracted from the draft study and is, therefore, preliminary.

There are many points of similarity betwen the NUREG-1493 effort and the EPRI study both in methodlogy and assumption, reflecting close agreement on the elements important to safety for containment leak rate testing. The similarity also extends to the analysis results. The EPRI study confirms the low safety significance associated with Type B and C testing intervals up to 120 months provided that the component in question has successfully passed two consecutive tests.

The EPRI study quantified baseline plant risk for representative plants. Using extensive industry leak rate testing data (including the Grand Gulf data), the study evaluated the change in baseline risk associated with a range of local and integrated leak rate test intervals. To evaluate the effect of extending Type B and C testing intervals, the NEI study was able to go beyond NUREG-1493 by developing a simplified safety model which directly examined IPE containment event tree sequences which were relevant to changes in the status of the containment isolation system. By classifying accident sequences by isolation failure mode and degree of potential penetration leakage, results could be directly correlated with Type B and C test interval extensions.

The EPRI study showed that the combined effects of 10 year intervals for Type A, B and C testing result in a negligible increase in plant risk (less than 1% of total plant risk).

The EPRI results are directly applicable to Grand Gulf and envelope the Grand Gulf exemption request. Although the EPRI analysis considered 10 year Type B and C testing intervals acceptable following two successful passed tests, the Grand Gulf request does not allow a 10 year interval until completion of three successful tests.

<u>The First 10 Year Interval Is Equivalent To A Five Year Interval</u>

The proposed Grand Gulf performance-based program requires that the testing of components on an extended interval be spread approximately evenly across that interval. In other words, for components on ten year intervals (and assuming an 18 month fuel cycle), roughly 1/6 of the ten year components would be tested in each of the six refueling outages during that ten year interval. For components on a five year interval, roughly 1/3 would be tested every refueling outage.

As a result of this testing scheme, most components will be tested well in advance of their allowed interval. In effect, components on a 10 year interval will, on average, only experience a five year interval.

In some sense, the effect of staggered testing is to turn the first ten year period into a conservative pilot project that is equivalent to approval of five year intervals without staggered testing.

Summary

- Past performance data is useful in suggesting good future performance, in determining component failure probabilities, and in qualitatively supporting a given interval. It is not helpful in determining "safe" testing intervals because the performance data itself contains no measure of safety.

- Combined deterministic and probabilistic analyses provide the basis for determining "safe" intervals by demonstrating the effect of varying intervals on safety measures.

- Without exception, all studies reviewed confirmed the insensitivity of offsite dose consequences to containment leakage rates.

- The Grand Gulf exemption proposal is safety neutral when combining the small increase in risk due to increased leakage with the decrease in risk associated with less testing.

- The NUREG-1493 and EPRI analyses confirm that the effects of five and ten year Type B and C testing intervals requested by Grand Gulf are acceptable.

- Due to Grand Gulf's staggered testing approach, approving ten year intervals for components that have passed three consecutive tests, is equivalent to an average five year interval, during the first 10 year period.

References

1. AFWAL-TR-83-2079, "Weibull Analysis Handbook", by Dr. R. B. Abernathy, et al, November 1983, Air Force Systems Command, Wright-Patterson AFB, Ohio.

2. "Handbook of Reliability Engineering and Management", by W. Grant Ireson and Clyde F. Coombs, Jr., McGraw Hill Book Company, 1988.

Component Leak Rate > 257 SCFH vs Time Since Maintenance (RFO1-RFO6)

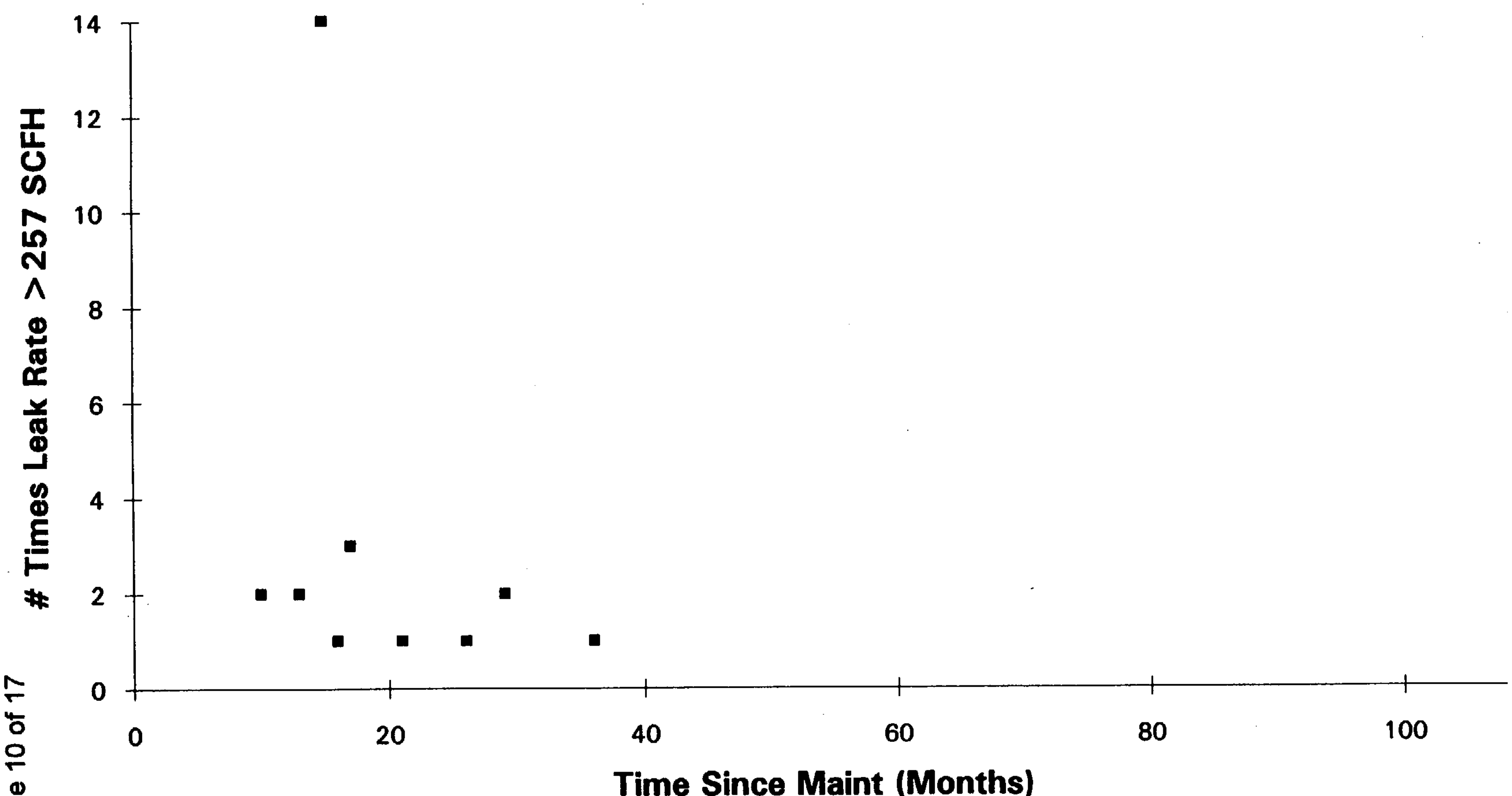


Figure 1

Months Until First Type B Component Failure

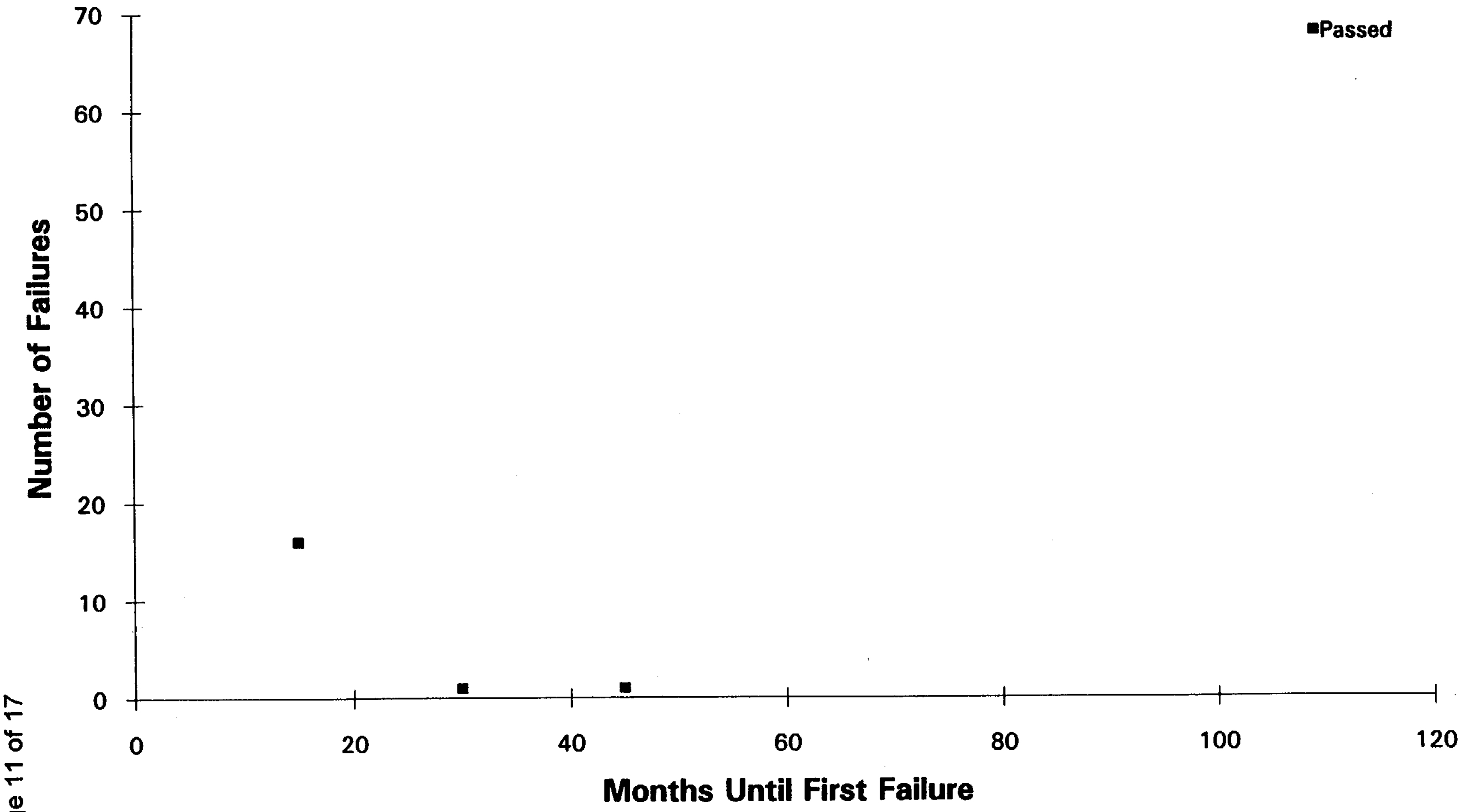
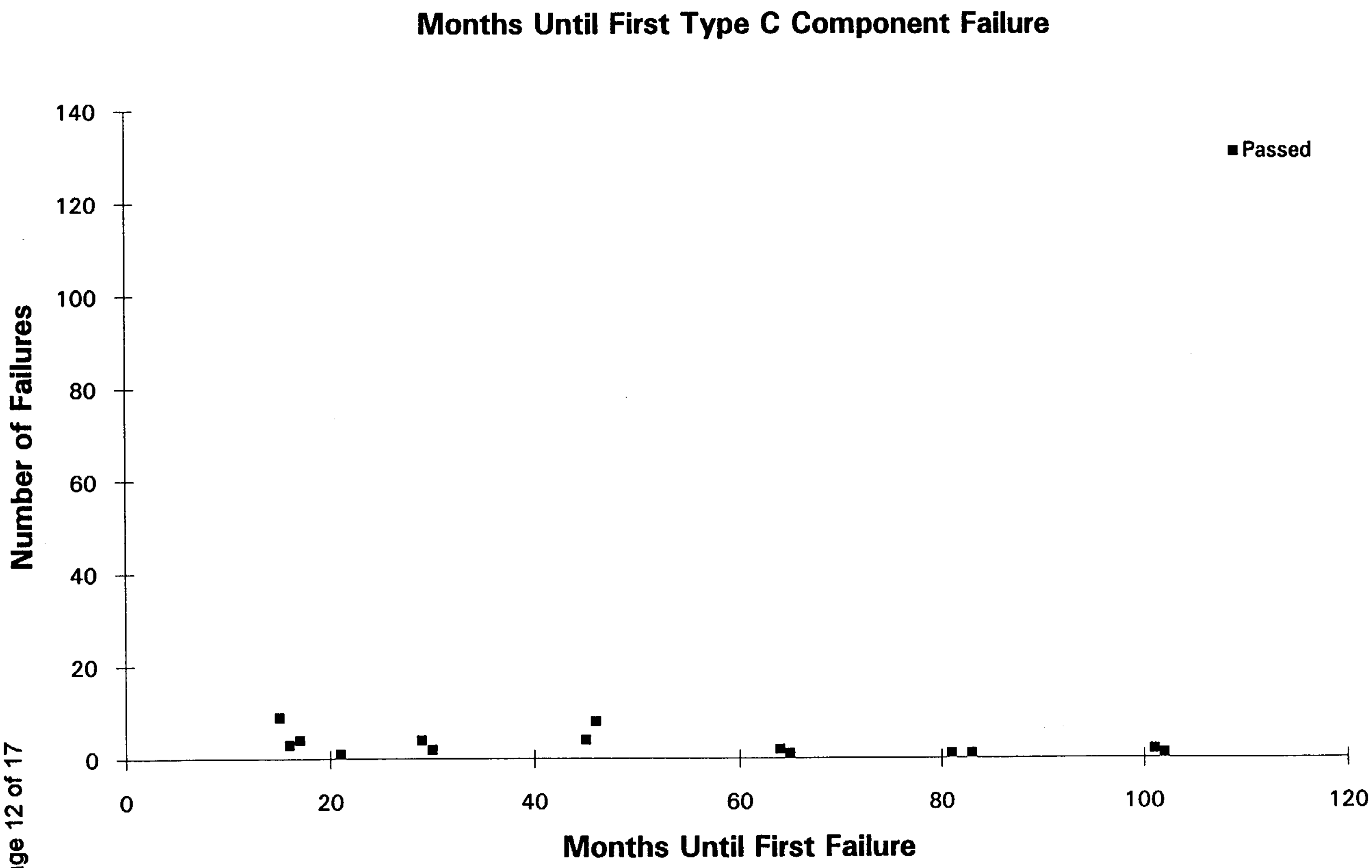


Figure 2



Months Until First Type C Component Failure
Passed
Number of Failures
140
120
100
80
60
40
20
0
0
20
40
60
80
100
120
Months Until First Failure

Figure 3

Months Since Last Type B Component Failure

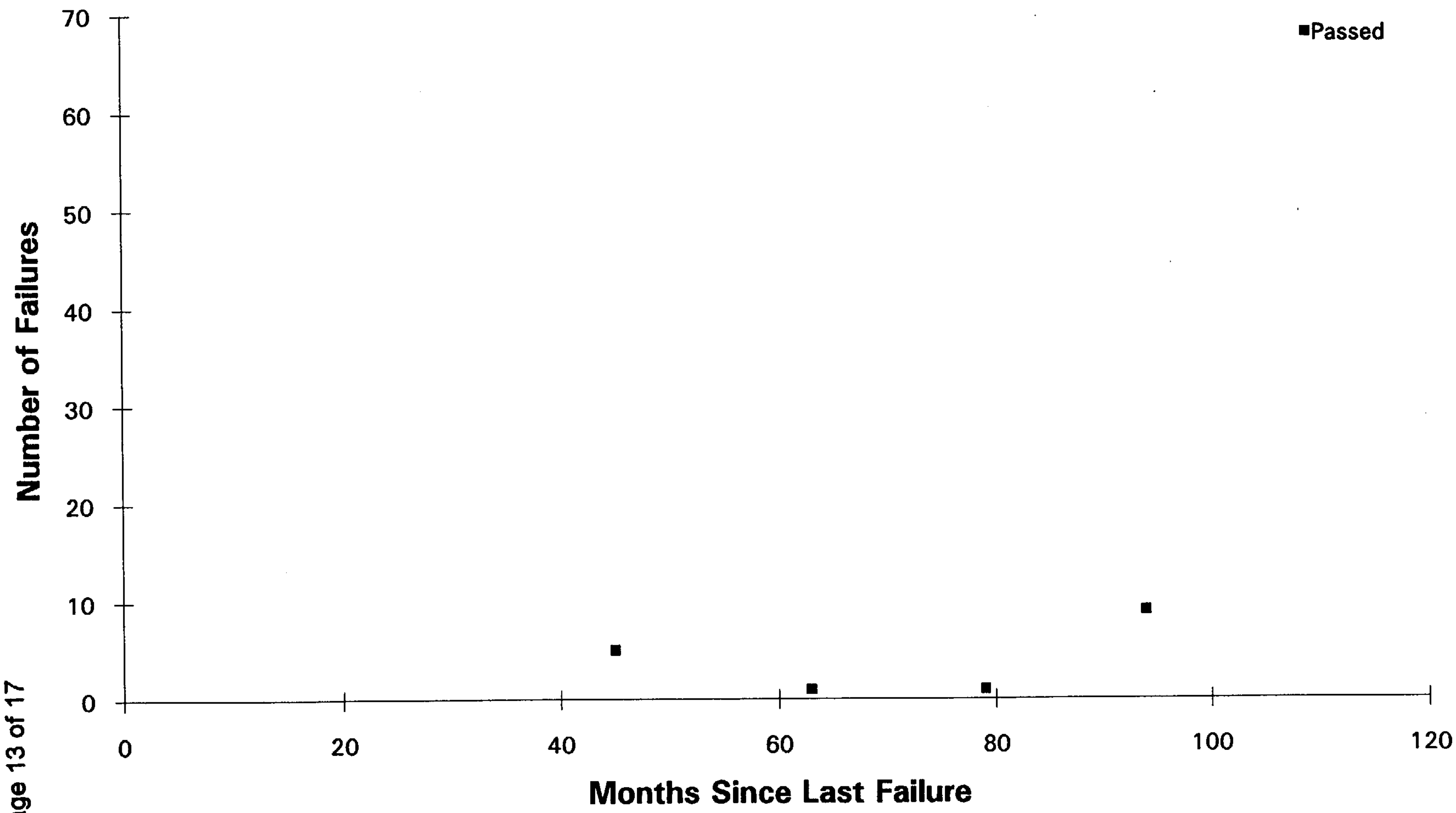


Figure 4

Months Since Last Type C Component Failure

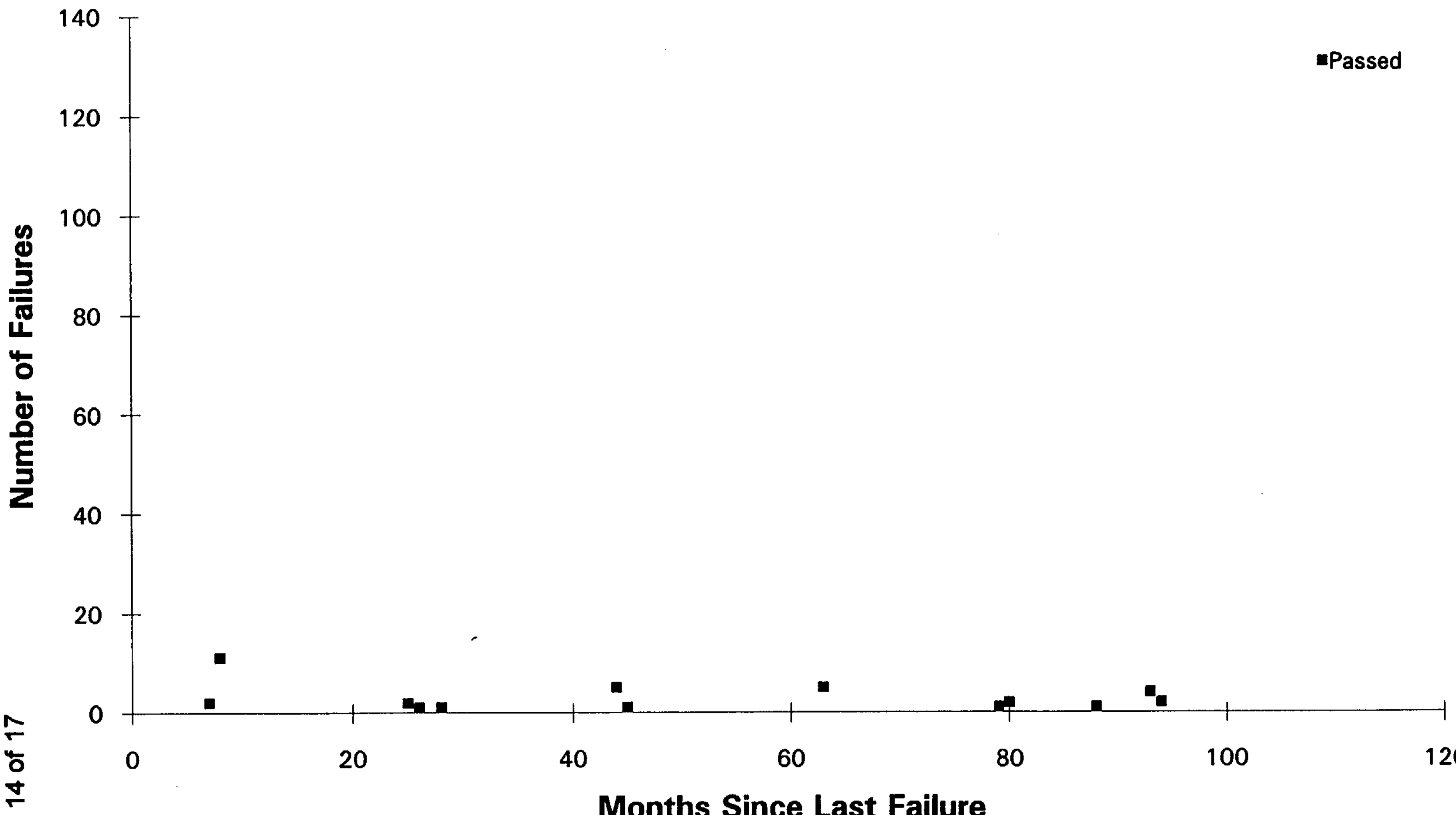


Figure 5

Figure 6

	A	B	C	D	E	F	G	H	I
1	Type C Penetration Min. Max Path Way Leakage Evaluation (All Leakage is in SCCM)								
2									
3		Min. Max. Path Way Leakage			Min. Max. Path Way Leakage			Min. Max. Path Way Leakage	
4		Worst Test Per Penetration			With test program applied			With existing test program applied	
5		From 1985-1994			From 1985-Present			Present	
6									
7	Penetration No.	Min. Path Way	Max. Path Way		Min. Path Way	Max. Path Way		Min. Path Way	Max. Path Way
8	5	44987	XXXXXX		0	4500		0	4500
9	6	14734	25544		138	4442		138	4442
10	7	XXXXXX	XXXXXX		1205	8837		1205	8837
11	8	17720	XXXXXX		101	120		101	120
12	9	XXXXXX	XXXXXX		303	3000		303	3000
13	10	XXXXXX	XXXXXX		200	220		200	220
14	14	200	350		200	350		200	350
15	17	260	1000		70	459		0	30
16	18	40	XXXXXX		0	41		0	0
17	19	20	40		40	80		40	80
18	20	1584	2780		0	1246		0	1246
19	21	874	2840		874	4089		874	1250
20	22	802	XXXXXX		0	1965		0	1965
21	26	13972	XXXXXX		0	13972		0	405
22	29	3221	3221		535	1070		161	161
23	31	402	2914		402	2914		0	2914
24	33	350	6660		0	350		0	0
25	34	0	16		0	0		0	0
26	35	56	56		0	0		0	0
27	36	0	840		0	0		0	0
28	37	248	13000		8	248		0	0
29	38	30	1603		30	1603		0	0
30	39	0	20		0	20		0	0
31	41	1048	XXXXXX		861	1048		322	504
32	42	900	1503		100	101		100	101
33	43	243	350		0	243		0	200
34	44	120	12000		0	120		0	0
35	45	77	405		0	0		0	0
36	47	39	39		0	0		0	0
37	48	336	384		336	384		336	384
38	49	50	15000		0	13325		0	0

Figure 6

	A	B	C	D	E	F	G	H	I
3		Min. Max. Path Way Leakage			Min. Max. Path Way Leakage			Min. Max. Path Way Leakage	
4		Worst Test Per Penetration			With test program applied			With existing test program applied	
5		From 1985-1994			From 1985-Present			Present	
6									
7	Penetration No.	Min. Path Way	Max. Path Way		Min. Path Way	Max. Path Way		Min. Path Way	Max. Path Way
39	50	321	2000		0	100		0	100
40	51	160	200		0	20		0	20
41	54	20	555		0	0		0	0
42	56	0	2879		0	2879		0	1206
43	57	30	XXXXXX		0	0		0	0
44	58	0	1477		0	0		0	0
45	60	271	281		0	20		0	20
46	61	0	100		91	100		91	100
47	65	10	10		0	0		0	0
48	66	40	40		0	0		0	0
49	70	10	2514		0	2541		0	40
50	73	80	80		0	0		0	0
51	75	20	20		20	20		0	0
52	76B	40	40		0	0		0	0
53	77	336	384		336	384		336	384
54	81	0	356		0	0		0	0
55	83	884	1193		606	884		606	884
56	84	0	20		0	0		0	0
57	85	240	17321		240	17321		240	1954
58	86	0	100		0	80		0	80
59	87	504	2002		504	2002		0	0
60	88	199	873		0	100		0	100
61	109A	20	90		0	0		0	0
62	109B	140	150		0	0		0	0
63									
64	Leakage Total	XXXXXX	XXXXXX		7200	91198		5253	35597
65	GGNS La	211600	211600		211600	211600		211600	211600
66	% La used	>100%	>100%		3%	43%		2%	17%

Question:

Figure A-7 on page A-35 of draft NUREG-1493, "Performance-Based Containment Leak Test Program," contains a plot showing the number of times a component with a leak rate of 257 scf/h or more was found versus time since the last maintenance of the component. The plot was generated using data from another power plant. The 257 scf/h corresponds to the highest detectable leak rate for that power plant.

Please provide a plot similar to Figure A-7 using Grand Gulf specific data and the maximum detectable leak rate for Grand Gulf.

The staff intends to use this plot as one indication of the suitability of the 5 and 10 year test intervals proposed by Entergy, Inc., for Grand Gulf.

Response:

The requested figure is included in the response to the previous question as Figure 1.