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Technical Report

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REPORT SUMMARY

As a result of the implementation of 10 CFR 50.65, the Maintenance Rule, EPRI formed the EPRI Maintenance Rule User Group (MRUG) in 2000. This group has evolved into a voice for the nuclear power industry with the U.S. Nuclear Regulatory Commission (NRC) and other organizations. Additionally, this organization has developed documents that address special needs of the organization. These documents have included guidelines, evaluations, and white papers that help the members deal with the subtleties of the Maintenance Rule. This report is a collection of these papers.

Background

Much of the success of the Maintenance Rule has come about as a result of the collaborative effort among the various member utilities, the NRC, and other industry organizations, including EPRI. As issues have arisen, MRUG has created working groups or contracted with consultants to provide documents that provide suggested guidance for the resolution of the issue. The documents that have been generated over the last two years are collected here.

Objectives

- To provide a collection of these documents so that users requiring quick access to the information will not have to search several locations and files to find them

Approach

The documents contained in this volume have been incorporated directly as written so that they may be used independently of the other items in the volume. The authors and associated working groups are included as part of each document to facilitate references.

EPRI Perspective

The fundamental value of forming users groups is the synergy that is formed by the collaborative effort. When issues surface, the group can quickly and effectively form functional working groups that evaluate the issues and pool the collective wisdom to resolve the issues. When this resolution is documented in a written format, the knowledge of the group can be shared with all interested people. This is what has happened and is happening with the MRUG. This group has identified and resolved many issues, and this volume of insights from the group provides a collection of their wisdom.

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Effectiveness assessment

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Pam Kowalewski	(Duke Power), Chair (a)(3) Working Group
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Mark Ferrel	(Wolf Creek), Run-To-Failure Guidance
Paul Southerland	(First Energy), Perry Preventive Maintenance Classification
Dave Worledge	(ARM), Author - Reliability and Risk White Papers

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EPRI WHITE PAPER 96-11-01: MONITORING RELIABILITY FOR THE MAINTENANCE RULE

Authors: J. Gisclon, EPRI, D. Worledge ARM, November, 1996

1.1 Background

Most nuclear plant licensees have chosen to monitor the number of functional failures or maintenance preventable functional failures for systems, structures, or components (SSCs) that require reliability to be monitored under paragraph (a)(2) of 10 CFR 50.65, the Maintenance Rule. In four out of the first five maintenance rule baseline inspections, potential violations of 10 CFR 50.65 have been found that relate to the way reliability is being monitored. Specifically, the inspection findings have indicated that there is not an adequate link between the performance criteria expressed in terms of failures per operating cycle, and individual plant examination or probabilistic safety assessment (IPE/PSA) assumptions and data. Licensees have expressed concern that the solution to this conflict will require them to track the number of demands experienced by each standby SSC with a failure performance criterion, and to monitor the probability of failure-on-demand, rather than simply to monitor the number of failures.

This technical bulletin describes a process, and its technical basis, that would address the U.S. Nuclear Regulatory Commission (NRC) concerns by establishing a quantitative relationship between the performance criteria and PSA data without requiring that demands be tracked, and which would justify the practice of monitoring failures. The process has been described before, in the May 1996 EPRI report TR-106280, *Insights From EPRI Maintenance Rule Projects,* Section 6, “Technical Basis for Performance Criteria.”

1.2 Outline of the Link to PSA

It will be demonstrated below that it is not technically possible to monitor an individual SSCs reliability by monitoring the number of failures and demands that it experiences over a time as short as one operating cycle. (Exceptions include emergency diesel generators, because they are tested monthly, and other SSCs with very frequent test or demand schedules.) The reason is that any estimate of the probability of failure-on-demand from such data will be too uncertain to draw useful conclusions as to whether the probability of failure-on-demand is in reasonable consonance with the value used in the IPE/PSA. Reasonable estimates can be made, but only by increasing the time duration to include a greater number of tests, and/or by including data on the performance of other similar SSCs from other trains, systems, or other units in the same plant (site). Such estimates are very suitable for PSA purposes, but will not serve 10 CFR 50.65 which requires individual SSCs to be monitored over single operating cycles.

The recent response from Mr. Frank J. Miraglia, NRC Acting Director of the Office of Nuclear Reactor Regulation to Mr. Ralph E. Beedle, Senior Vice President and Chief Nuclear Officer of the Nuclear Energy Institute, dated October 22, 1996, contains a number of qualifications that indicate that the required consistency with IPE/PSA assumptions can be achieved by the EPRI-recommended process for establishing performance criteria on reliability, despite the impossibility of directly monitoring the probability of failure-on-demand.

Mr. Miraglia notes that although a clear link to IPE/PSA assumptions is required, this may be achieved by using the results of monitoring to confirm the performance or condition in the IPE/PSA. He also notes that the NRC does not expect highly sophisticated or rigorous analyses to demonstrate this confirmation, but a reasonable and appropriate basis with some consideration of demands for standby systems and service times for normally operating systems.

1.3 Estimating the Probability of Failure-on-Demand

If r failures are experienced in n tests, the best estimate of the probability of failure-on-demand, P, is P=r/n. In a period of two years, an SSC that is tested quarterly would experience only eight test demands. For longer periods between tests, the number of tests is smaller. More tests might be included for operational reasons, for preparing the SSC for testing, or as post-maintenance functional tests. Consequently, the number of legitimate demands for an SSC that is tested quarterly is not likely to exceed about 20 per cycle. Some SSCs covered by 10 CFR 50.65 are tested much less frequently than quarterly so that their estimates of reliability might need to be based on four tests, or even fewer.

Figure1-1 shows results calculated using the binomial distribution for an SSC that experiences up to five failures in 10 tests. Figure 1-2 shows similar results for 20 tests. The binomial distribution is universally acknowledged as the correct model for devices that experience random failures with a constant probability of failure at each demand (for example, tossing a coin), as assumed by many IPE/PSA's. The results for both 10 and 20 test demands (Figures 1-1 and 1-2) include two charts. The first chart shows the ratio of the value *best estimate plus two standard deviations* to the best estimate. The second shows the ratio of the upper 80% and 90% confidence limits to the best estimate. These ratios indicate the degree of precision with which statements can be made about the probability of failure-on-demand.

Although the tables and charts show results for up to five failures, it should be remembered that the expected number of failures for nuclear plant SSCs over a period of a year or two will be close to zero. The expected number of failures is just the IPE value for the probability of failure-on-demand times the number of demands. This number will typically be of order 0.1 (~ 0.01x10) or less. This means that, in agreement with experience, the actual number of failures on a specific SSC over one operating cycle is mostly zero, with occasionally one, or possibly two failures occurring. It is the results for one failure that are the main focus of attention here because two failures will be recommended as being unacceptable and constituting an exceedance of the performance criterion.

Table 1-1
Standard Deviations and Confidence Bounds for 1 to 5 Failures in 10 Test Demands

10	Tests (=n)	r	s	P = r/n	r	(P+s)/P	r	(P+2s)/P
Number of failures = r		1	0.095	0.1	1	1.949	1	2.897
Estimate of prob. of		2	0.126	0.2	2	1.632	2	2.265
Failure on demand =		3	0.145	0.3	3	1.483	3	1.966
P = r/n		4	0.155	0.4	4	1.387	4	1.775
s is the standard deviation in P		5	0.158	0.5	5	1.316	5	1.632

r	L80%	U80%	P=r/n	U80%/P	U80/L80	U90%	P=r/n	U90%/P
1	0.01	0.337	0.1	3.370	33.70	0.394	0.1	3.940
2	0.055	0.45	0.2	2.250	8.18	0.507	0.2	2.535
3	0.116	0.552	0.3	1.840	4.76	0.607	0.3	2.023
4	0.188	0.646	0.4	1.615	3.44	0.697	0.4	1.743
5	0.267	0.733	0.5	1.466	2.75	0.778	0.5	1.556

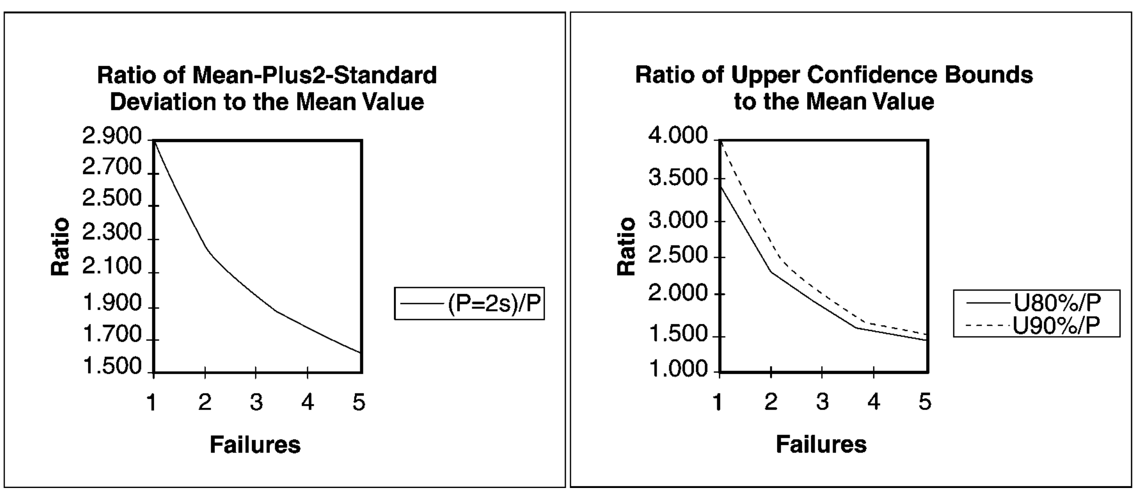
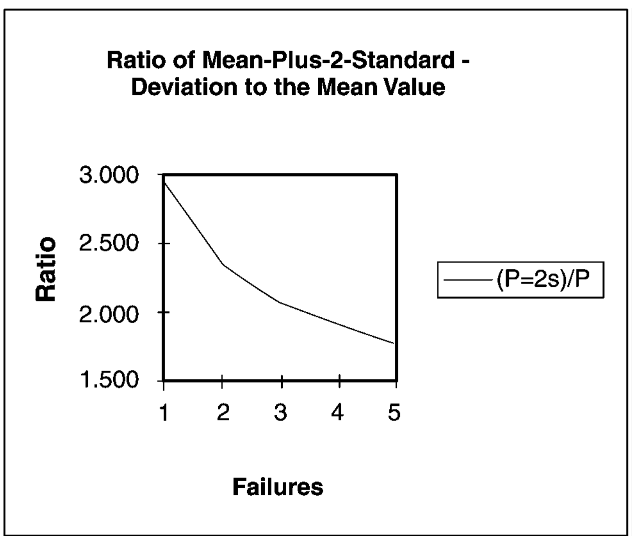


Figure 1-1

Table 1-2
Standard Deviations and Confidence Bounds for 1 to 5 Failures in 20 Test Demands

20	Tests (=n)	r	s	P = r/n	r	(P+s)/P	r	(P+2s)/P
Number of failures = r		1	0.049	0.05	1	1.975	1	2.949
Estimate of prob. of		2	0.067	0.1	2	1.671	2	2.342
Failure on demand =		3	0.080	0.15	3	1.532	3	2.065
P = r/n		4	0.089	0.2	4	1.447	4	1.894
s is the standard deviation in P		5	0.097	0.25	5	1.387	5	1.775

r	L80%	U80%	P=r/n	U80%/P	U80/L80	U90%	P=r/n	U90%/P
1	0.006	0.182	0.1	1.820	30.33	0.215	0.1	2.150
2	0.027	0.245	0.2	1.225	9.07	0.283	0.2	1.415
3	0.056	0.304	0.3	1.013	5.43	0.344	0.3	1.147
4	0.09	0.361	0.4	0.903	4.01	0.401	0.4	1.003
5	0.127	0.415	0.5	0.830	3.27	0.456	0.5	0.912



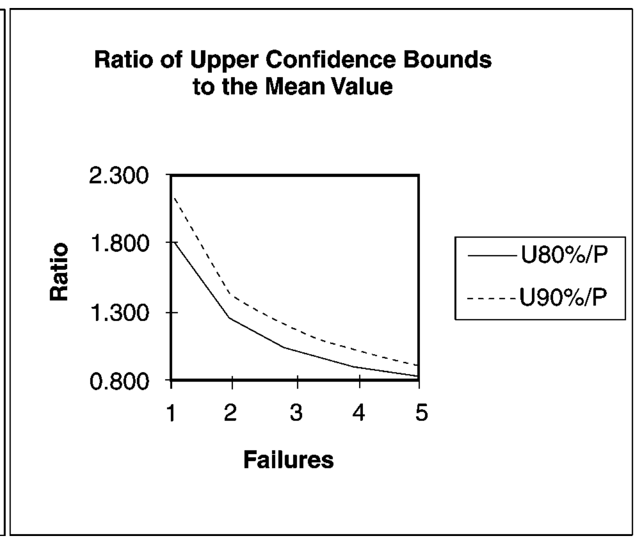


Figure 1-2

If zero, one, or two failures occur, both the mean-plus-two-standard deviations limit, as well as the upper confidence limits, permit estimates of the probability of failure-on-demand that extend a factor of two to four above the best estimate. Even wider constraints apply below the best estimate as can be seen from the ratio of the upper 80% bound to the lower 80% bound, which is greater than 30 if one failure is observed, and is eight or nine if two failures are observed.

These results show that the observance of zero, one, or two failures in 10 or 20 tests provides a poor capability to constrain the value of the probability of failure-on-demand; the discriminating power is so weak that it could not be used sensibly in any monitoring scheme. If more than 20 test demands are accumulated the precision improves, so that at least the occurrence of two failures begins to be a practical predictor of the probability of failure-on-demand.

The conclusion is that even if demands were tracked, they could not be used to provide useful estimates of the probability of failure-on-demand in the monitoring processes of the maintenance rule. Of course, after several operating cycles have passed, the precision for any individual SSC will improve if all the data for the whole period since the start of the rule is pooled together. However, this will only provide an estimate of the average performance over the whole period and still will not indicate the performance over the most recent cycle.

1.4 Expected Number of Failures

The situation is not quite hopeless, however, because a quantitative link with the IPE/PSA value can be obtained by asking what that value implies about the probability of actually observing a specific number of failures, rather than asking the question the other way round, as above. The binomial density function gives a simple way to calculate the probability of zero, one, two, or more failures. For r failures in n demands, this function is (note that P is distinct from $P_n(r)$):

$$P_n(r) = \frac{n!}{r!(n-r)!} \cdot P^r \cdot (1 - P)^{(n-r)} \qquad \textbf{Eq. 1-1}$$

So that:

$$P_n(0) = (1 - P)^n$$

$$P_n(1) = nP(1 - P)^{(n-1)}$$

$$P_n(2) = \frac{n(n-1)}{2} \cdot P^2 \cdot (1 - P)^{(n-2)}$$

where P is the probability of failure-on-demand used in the PSA.

The following table shows the probability of observing zero failures when 10 and 20 tests are performed.

Table 1-3

Number of Tests	Probability of Zero Failures	
	When IPE/PSA Value is P = 0.01	When IPE/PSA Value is P = 0.001
10	90.4%	99.0%
20	81.8%	98.0%

The following table shows the probability of observing a single failure when 10 and 20 tests are performed.

Table 1-4

Number of Tests	Probability of One Failure	
	When IPE/PSA Value is P = 0.01	When IPE/PSA Value is P = 0.001
10	9.1%	1.0%
20	16.5%	2.0%

Although Table 1-3 above shows that zero failures is by far the most likely outcome in each case, it can be seen that there is a 1% to almost 20 % chance of observing one failure.

The chance of observing two failures, however, is much smaller than the chance of observing a single failure. Table1-5 below shows the probability of observing exactly two failures when 10 and 20 tests are performed.

Table 1-5

Number of Tests	Probability of Two Failures	
	When IPE/PSA Value is P = 0.01	When IPE/PSA Value is P = 0.001
10	0.4%	0.0045%
20	1.6%	0.019%

The results show that for most cases of interest, a single failure is many times more likely than two failures.

We have seen that even when the underlying probability of failure-on-demand is in the range 0.01 to 0.001, one failure will be experienced by 1% to 16% of SSCs in one cycle. We have also seen that the best estimates of the probability of failure-on-demand from this experience are in the range 0.05 to 0.1, and reasonable upper bounds are 0.2 to 0.4. This means that a monitoring process that tried to estimate P on the basis of these results can be incorrect by a factor of 20 to 400. This is further evidence that trying to estimate the reliability from the number of failures and demands is an unsuitable way to address maintenance effectiveness.

1.5 Performance Criterion on Failures

From this analysis it can be seen that single failures can easily occur given the likely PSA input values and the large number of SSCs that are being monitored, but that two failures should be quite rare. This conclusion applies for a wide range of values of the number of tests and IPE/PSA values of the probability of failure-on-demand. The conclusion becomes less valid as the probability of failure-on-demand approaches 0.1 (the chance of two failures becomes significant), and as it decreases below 0.001 (the chance of one failure becomes less than 1%). However, the conclusion will remain valid for a large fraction of the SSCs in the maintenance rule.

The conclusion supports performance criteria such as *1 failure can occur, 2 failures are an exceedance*, or *2 failures can occur, 3 failures are an exceedance*. The specifics of such criteria should always be checked against the actual IPE/PSA value and the number of legitimate demands to be expected in one operating cycle. This is the vital link with the IPE/PSA assumption. However, it must be stressed that if the criteria are set according to these requirements, *they will remain appropriate criteria for a wide range of values of the number of demands (for example from 0 to more than 20 demands)*. There will be no added value in closely monitoring the number of demands unless it exceeds a minimum of at least 20. (The minimum number depends on the IPE/PSA value; for P=0.001 the minimum would be many hundreds of demands.) As shown earlier in this paper, for small numbers of demands there is no way to make use of the exact number when only zero, one or two failures are likely to occur.

1.6 Summary

It is not possible to monitor the reliability of most SSCs over a period as short as two years. This is because, even if the exact number of demands were known, a result of zero, one or two failures would not permit meaningful bounds to be placed on the probability of failure-on-demand for the purpose of comparison with the IPE/PSA input value. This conclusion depends mostly on the low values of the number of failures involved, and much less on the number of demands, providing this is below about 20. The conclusion is not sensitive to whether standard deviations or confidence bounds are used. It is not sensitive to the value of confidence assumed (two-sided 80%, and 90% bounds in the calculations above), and thus is not sensitive to whether one-sided or two-sided bounds are used.

Instead, the chance of observing zero, one or two failures can be calculated using the IPE/PSA input value, and the expected number of legitimate demands. A failure criterion should be selected that acknowledges that possibly one, or in some instances two failures might occur, consistent with the IPE/PSA input value, but that the chance of additional failures should be very much less. One failure can occur randomly within an operating cycle even when preventive maintenance is performed effectively, because many factors concerning service conditions and rates of degradation cannot be known with certainty. However, if two failures occur, such performance criteria would indicate that these failures are very unlikely to be random events, and probably represent a trend toward poor performance requiring appropriate cause analysis and corrective action.

In most cases the *estimated* number of demands is quite sufficient for this calculation because the above conclusions will remain true for a wide range of numbers of demands. No added value is provided to the maintenance rule monitoring process by deriving a detailed knowledge of the number of demands.

2
EPRI WHITE PAPER 97-3-01: MONITORING RELIABILITY FOR THE MAINTENANCE RULE

Authors: J. Gisclon, EPRI, D. Worledge ARM, March, 1997

2.1 Background

EPRI Technical Bulletin 96-11-01 was issued in November 1996 to provide guidance on setting maintenance rule performance criteria for failures to start of standby SSCs. It has since become clear that guidance is also needed for Failures-to-Run of continuously operating SSCs, and for the cases where two or more SSCs are regularly alternated so each provides service for a period of time. This Technical Bulletin addresses both of these issues. The objective will once again be to provide a logical but practical link between PSA assumptions and the performance criteria.

2.2 Outline of the Link to PSA

EPRI Technical Bulletin 96-11-01 established that for a wide range of typical cases, it is not possible to make meaningful estimates of the probability of failure-to-start for nuclear power plant standby equipment using data from a small number of test demands on single items of equipment, or even on small numbers of equipments.

The same conclusion is true for estimates of the failure rate in time of continuously running power plant equipment when the data is restricted to a single item of equipment, or small numbers of equipments, over periods as short as two years. Typical failure rates range from 0.01 failures per year to 0.5 failures per year on equipment such as pumps, motors, turbines, check valves, and heat exchangers. To make reasonable estimates of failure rates, the data sample needs to include several failures, normally requiring several mean times between failure. The failure rates quoted above show that this would require from several years to several hundred years of run time. Even when a system train runs continuously, this amount of run time obviously cannot be reached in a two year operating cycle. If two 100% pumps/motors are used alternately (for example, for two weeks at a time) the total run time on each amounts to only one year in a two-year operating cycle.

It is possible to perform an analysis similar to that in EPRI Technical Bulletin 96-11-01 to consider how confidence bounds for estimates of failure rates could be used to compare with PSA values. Such an analysis would assume the failure rate is constant and that the number of failures in a period of time follows a Poisson distribution. In this case a Chi-Squared distribution rather than a binomial distribution is used to estimate the confidence bounds. These are standard assumptions, consistent with PSA practice and reliability theory. However, as in the standby case, the results would show that the bounds are far too wide to be useful. A simple demonstration of this can be obtained by calculating the upper one-sided confidence limit for the failure rate when no failures are observed in a total run time T. This case is meaningful for maintenance rule situations and has an especially simple closed form solution:

Upper confidence limit on failure rate (λ) at a one-sided confidence level of 100(1-α)% is:

$$\lambda_{upper} = -(\log_e \alpha) / T \qquad \textbf{Eq. 2-1}$$

At 80% confidence ($\alpha = 0.2$), $\lambda_{upper} = 1.6 / T$. This means that if T is one year, then at 80% confidence we can only claim that the failure rate is less than 1.6 failures per year when we have observed zero failures in a single year. The result is 2.3 failures per year at 90% confidence. This could be the case for a two-year operating cycle, with each of two pumps running alternately for equal amounts of time. The PSA assumption, based on a much more meaningful data sample, is likely to be in the range 0.01 to 0.5 failures per year as mentioned above. Such a comparison does not throw much light on the level of reliability being monitored and is clearly insufficient for deciding whether maintenance is effective.

This bulletin will therefore not spend more time in demonstrating the impossibility of trending reliability for continuously operating equipment. We will proceed directly to describe the calculation of the probability of experiencing a specific number of failures in one operating cycle so that performance criteria can be set according to the PSA assumptions and a tolerable level of false alarms. The method is analogous to that described for standby equipment in the previous EPRI Technical Bulletin, but uses statistical assumptions appropriate for continuously operating equipment rather than standby equipment.

2.3 The Expected Number of Failures

Continuously operating equipment experiences failures that occur randomly in time but which nevertheless can be assigned an average failure rate, λ, in failures per year. This leads to a simple expression for the expected number of failures (that is, the average number of failures) in T years as λT. For example, if the failure rate is 0.1 failures per year, then 0.3 failures would be expected in 3 years (=0.1 x 3), and two failures would be expected in 20 years.

Despite the fact that λT failures are expected on average in a run time of T years, the actual result could be more or less than this owing to the random nature of the times to failure. The Poisson probability density gives the probability, P(n), of observing n failures in a time T when you expect λT failures on average:

$$P(n) = e^{-\lambda T} \times (\lambda T)^n / n! \quad \textbf{Eq. 2-2}$$

so that

$$P(0) = e^{-\lambda T}$$

$$P(1) = \lambda T e^{-\lambda T}$$

$$P(2) = (\lambda T)^2 e^{-\lambda T} / 2$$

$$P(3) = (\lambda T)^3 e^{-\lambda T} / 6, \quad \text{and so on.}$$

Note that the probability of observing a single failure is λTe-λT, which is well approximated by λT whenever λT ≤ 0.1.

2.4 Performance Criterion on Failures

The Poisson function depends only on n and the product λT, so that a table can display the probability of observing n failures for a range of values of λT. The following table relates the probability of experiencing specific numbers of failures to the product λT:

Table 2-1
The Probability (%) of Observing Different Numbers of Failures

Number of Failures	λT = 0.001	λT = 0.005	λT = 0.01	λT = 0.05	λT = 0.1	λT = 0.5	λT = 1.3
0	99.9	99.5	99.0	95	90	61	27
1	0.10	0.50	0.99	4.8	9.0	30	35
2	5.0 E-7	1.2 E-3	5.0 E-3	0.12	0.45	7.6	23
3	~0	2.1 E-6	1.7 E-5	2.0 E-3	1.5 E-2	1.3	10
≥4	~0	~0	~0	~0	3.8 E-4	0.18	4.3

The table shows that when λT is 0.01 or smaller, the only result that can reasonably be expected is zero failures. For λT = 0.05, there is a ~5 % chance of having one failure. At λT = 0.1, there is a 9% chance of having one failure, and at λT = 0.5, there is a ~9% chance of two or more failures. At λT = 1.3, there is an almost 15% chance of three failures or more. If a reasonably tolerable false alarm rate is in the range 5% to 10%, then a performance criterion on the number of failures could be that even one failure is unacceptable when λT is 0.05 or less, one failure is acceptable but two failures are unacceptable when λT is ~0.1 to 0.5, and three failures are acceptable when λT ~ 1.3.

To decide which value of λT is appropriate for a particular case, the failure rate should correspond to that used in the PSA because the purpose of this exercise is to establish consistency with the PSA assumptions. Generally, the PSA will have included only *in-service failure events* in deriving the value of λ, and this is a suitable basis for application to the maintenance rule. It is necessary to verify that the failure rate does not exclude events caused by personnel errors provided they are related to the performance of *Maintenance* as it is defined in NUMARC 93-01. This definition includes all the supporting activities for maintenance such as the setting and clearing of tags, and the alignment and realignment of equipment. Removal of equipment from service for the performance of preventive maintenance to prevent in-service failures should not be added to, or included in, the estimation of λ, when a reasonable amount of time is available for planning the outage. These are not failures but occurrences that show that maintenance is working effectively. Similarly, failures that occur during post-maintenance testing should not be added or included because the equipment is not yet in service. A difference between maintenance rule practice and the PSA will occur when only maintenance preventable failures are being monitored in the maintenance rule, whereas the PSA will tend to include all types of in-service failures. In the latter case an adjustment must be made to make the failure rate from the PSA correspond to a reduced failure rate in the maintenance rule.

The appropriate value of T is the total run time of the SSC regardless of interruptions caused by switching periodically between alternative trains or components. For example, in the case quoted previously where two 100% trains are rotated in and out of service every two weeks, the total run time for each train is half of the operating cycle. It does not matter if the alternating periods are of short or long duration, or how many there are. If the run time is not spread equally between trains, then it should be apportioned according to the actual total run time on each. The same principle applies regardless of how many trains there are and regardless of whether more than one train is running and/or needed simultaneously. The objective is to set a performance criterion for each train at the train level without the sophistication of rolling them up to the system level where the success criteria for the system would become important.

An exception to this is where the performance of several trains is pooled together to avoid a zero failure performance criterion for single trains. In this case the total number of component run time years, T, over a calendar interval X, is that accumulated by all the trains together. For example, when there are always two pumps out of three running and the third is regularly alternated among the three, the total run time is $T = 2X$ component years. This is because N alternating periods contain 2N pump periods since two pumps are always running; it does not matter how long a period is.

Having decided on the values of λ and T, it should be straightforward to calculate the probability of observing zero, one, two, or three failures, despite the fact that you expect λT failures. Alternatively, Attachment 1 contains a table and charts that connect P(n) and λT for zero, one, and two failures. It will be up to each utility to decide what false alarm level is acceptable. Utilities should be cautious and accept a level no higher than 10% because enough performance criteria exists that a few false exceedances are bound to occur. If you have only 10 SSCs with such criteria, a level of 10% will mean you have one false exceedance on average every operating cycle. In general it will not be possible to detect which ones are chance exceedances, and the corresponding SSCs are likely to end up under paragraph (a)(1) of the rule. This will increase the cost of implementing the rule and will confuse the process of improving maintenance.

2.5 Standby Aspects of Alternating Continuously Operating Trains

In the above examples of multiple trains that are alternated in operation so that some are in standby when others are continuously operating for a period of time, it may happen that the ability to start on demand for the standby train is very important. This could be in order to avoid a transient or power reduction upon failure of the operating train(s), or it could be to permit frequent essential preventive maintenance such as cleaning out heat exchangers on the operating trains.

If it is thought necessary to have performance criteria for the standby features (each utility has to decide this depending on the importance of the functions, the ability to delay the switchover, and the level of redundancy), it should be straightforward to develop them following the procedure in EPRI Technical Bulletin 96-11-01.

However, this carries the implication that a utility will be willing to invest resources in developing and monitoring to two performance criteria, a standby criterion, and a continuous running criterion for each SSC of this type. It would be simpler to combine the values and to use a single criterion. The combination could be effected by adding the individual criteria so that, for example: a Standby Criterion of ≤ 2 failures and a Run Criterion of ≤ 1 failure would become a Failure Criterion of ≤ 3 failures. There would then be no need to identify whether a failure is of one type or the other.

Alternatively, a generally more conservative (that is, tighter) performance criterion could be derived by adding the expected number of failures in one cycle from each contribution (standby and running) and using the result as the value of λT in the above procedure. Although this process mixes the intermediate results and then uses only the rate model to derive the criterion, it is nevertheless likely to give better results than adding the separate criteria because the bounding approximation enters only once at the end.

This process is, in principle, open to the objection that it would be possible to exceed one of the underlying criterion without exceeding the overall criteria, and that this would defeat the purpose of the monitoring, enabling ineffective maintenance to be causing too many failures of one type without timely detection, or without being detected at all, in circumstances where it would otherwise certainly have been detected. If it is true that the standby and run failures are clearly distinguishable and have essentially separate causes, then a combined scheme is unlikely to be acceptable.

This bulletin takes the position that a single combined failure performance criterion is justifiable because the standby and run failures of alternated equipment are simply two manifestations of the same underlying processes. The justification for ignoring the distinction between the two types of failure treatment (that is, a constant probability of failure-on-demand for the standby failures versus a failure rate in time for the run time failures) is based on two facts.

The first fact is that the constant probability of failure-on-demand model for standby failures ignores the most likely time-related causes of standby equipment failure, and overweights the importance of demands in causing failures. This approach became popular during the 1980's when large numbers of PSA studies were being done, and was introduced more for the convenience of analysts than for the validity of its application. A straightforward alternative is to model standby failures as a failure rate process where failures develop over time during standby. However, this ignores the legitimate effects of the number of demands on the number of failures. Many PSAs make extensive use of standby failure rate modeling for some standby components, as well as the probability of failure-on-demand for others, although strong claims are not made in the industry for the appropriateness of these choices. The Institute of Electrical and Electronic Engineers (IEEE) data on reliability often provides both forms of failure data for the same equipment. The industry has not worked to eliminate one or the other approach because, given the same data, they each approximate reality and typically give results that are the same within a factor of about two. Uncertainties of this magnitude are acknowledged in both models.

The second fact is that, if it is acknowledged that much equipment degradation always occurs over time, then for equipment that is alternated for equal periods between standby and running continuously, the time of failure is determined both by time spent running and in standby.

Attachment 2 provides a more detailed examination of failures of standby equipment and justifies the process of combining standby and run time failures for maintenance rule monitoring of alternately operated equipment.

Therefore, for maintenance rule monitoring purposes, the distinction between standby and run time failure types does not possess a sufficiently compelling technical basis to prevent the pooling of the failures into one homogeneous set governed by a single failure criterion. The concern that might be expressed about exceeding one of the underlying *separate* criteria without exceeding the overall criterion is an artifact of the way analysts historically made arbitrary choices between suboptimal failure models.

2.6 Summary

It is not possible to monitor the reliability of individual continuously operated SSCs over a period as short as two years. However, the chance of observing zero, one, two, three etc. failures can be calculated using a Poisson distribution, and can be used to select a performance criterion that gives an acceptably small probability of accidentally exceeding the criterion when the reliability is equal to the PSA value. The formulas, tables, and graphs included in Attachment 1 enable this process to be implemented with a minimum of calculation.

If it is necessary to provide performance criteria to address the standby failures of equipment that is alternately operated and in standby, this can be done using the former EPRI Bulletin 96-11-01, but it results in a separate standby criterion in addition to the run time criterion.

If a utility does not wish to develop and monitor a separate standby criterion as well as a run time criterion, the two criteria can be combined by addition to a single overall criterion wherein no distinction is made between standby and runtime failures. The first step to justify this process refers to the ambiguity over whether failures to start on demand are actually failures that have already occurred in time during the standby period, even though they may be triggered by the stress of a demand, or whether they are actually caused only by wear and damage sustained during demands. The second step observes that whether a failure occurs during standby or while running, the degradation that leads to it takes place during a combination of both standby periods and running periods. The designation of the failure as standby or run time is then more accidental than meaningful.

Attachment 1: The Probability of Observing a Particular Number of Failures

This attachment provides a table and charts of P(n), the probability of observing n failures, when the expected (average) number of failures is λT during a total period of observation of T component years, for a process that has an average rate of occurrence of λ failures per year.

Table 2-2

This Table provides values of P(n) as percentages for n = 0, 1, or 2. The values are plotted on the accompanying charts.

λT	Probability (% for n = 0)	Probability (% for n = 1)	Probability (% for n = 2)
0.0010	99.9000	0.0999	0.0000
0.0015	99.8501	0.1498	0.0001
0.0020	99.8002	0.1996	0.0002
0.0025	99.7503	0.2494	0.0003
0.0030	99.7004	0.2991	0.0004
0.0035	99.6506	0.3488	0.0006
0.0040	99.6008	0.3984	0.0008
0.0045	99.5510	0.4480	0.0010
0.0050	99.5012	0.4975	0.0012
0.0055	99.4515	0.5470	0.0015
0.0060	99.4018	0.5964	0.0018
0.0065	99.3521	0.6458	0.0021
0.0070	99.3024	0.6951	0.0024
0.0080	99.2032	0.7936	0.0032
0.0090	99.1040	0.8919	0.0040
0.0100	99.0050	0.9900	0.0050
0.0125	98.7578	1.2345	0.0077
0.0150	98.5112	1.4777	0.0111
0.0175	98.2652	1.7196	0.0150
0.0200	98.0199	1.9604	0.0196
0.0225	97.7751	2.1999	0.0247
0.0250	97.5310	2.4383	0.0305
0.0300	97.0446	2.9113	0.0437
0.0350	96.5605	3.3796	0.0591
0.0400	96.0789	3.8432	0.0769
0.0450	95.5997	4.3020	0.0968
0.0500	95.1229	4.7561	0.1189
0.0550	94.6485	5.2057	0.1432
0.0600	94.1765	5.6506	0.1695
0.0650	93.7067	6.0909	0.1980
0.0700	93.2394	6.5268	0.2284
0.0800	92.3116	7.3849	0.2954
0.0900	91.3931	8.2254	0.3701
0.1000	90.4837	9.0484	0.4524
0.1250	88.2497	11.0312	0.6895
0.1500	86.0708	12.9106	0.9683
0.1750	83.9457	14.6905	1.2854
0.2000	81.8731	16.3746	1.6375
0.2250	79.8516	17.9666	2.0212
0.2500	77.8801	19.4700	2.4338
0.3000	74.0818	22.2245	3.3337
0.3500	70.4688	24.6641	4.3162
0.4000	67.0320	26.8128	5.3626
0.4500	63.7628	28.6933	6.4560
0.5000	60.6531	30.3265	7.5816

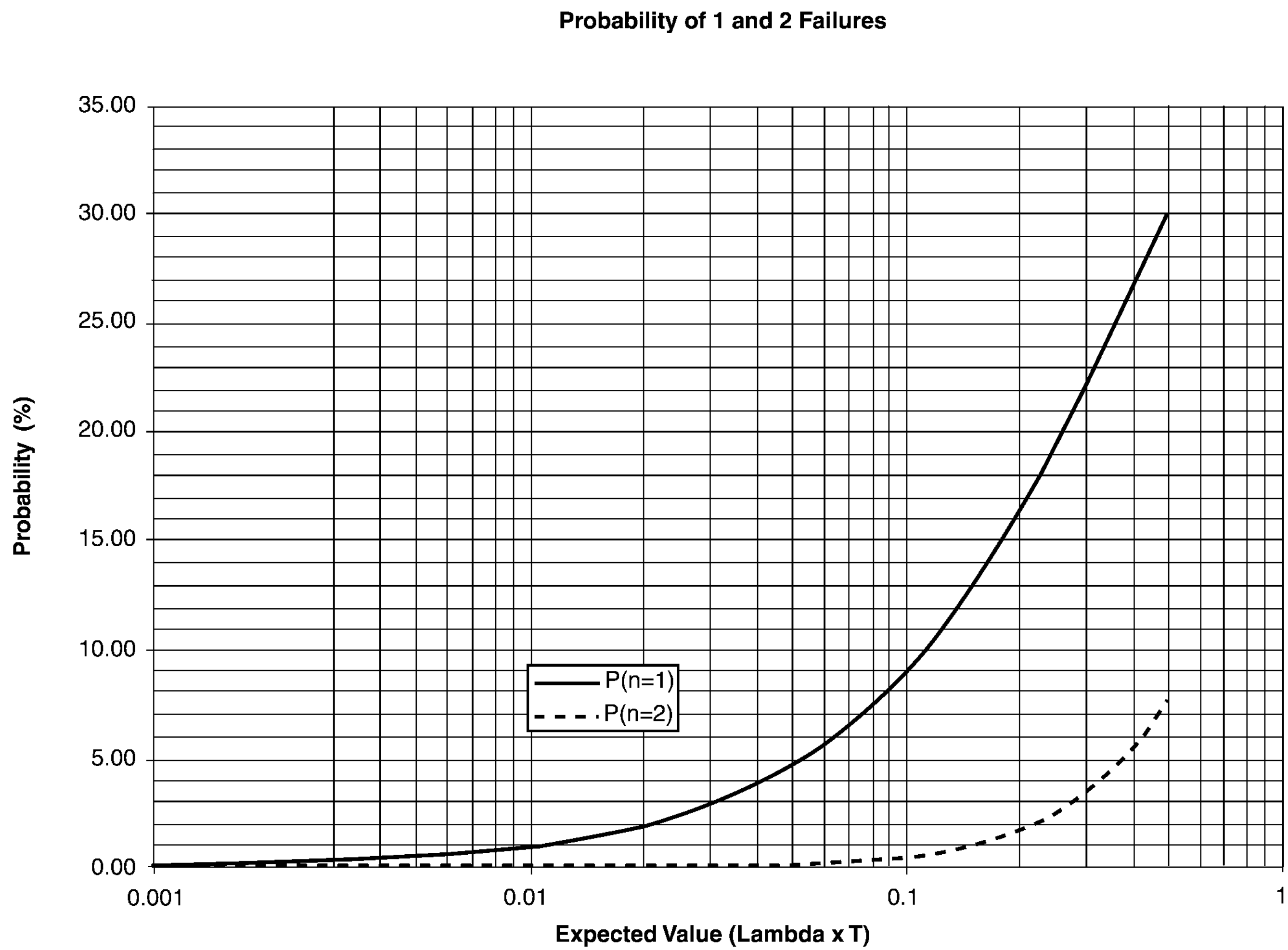

Probability of 1 and 2 Failures
Probability (%)
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
0.001
0.01
0.1
1
Expected Value (Lambda x T)
P(n=1)
P(n=2)

Figure 2-1

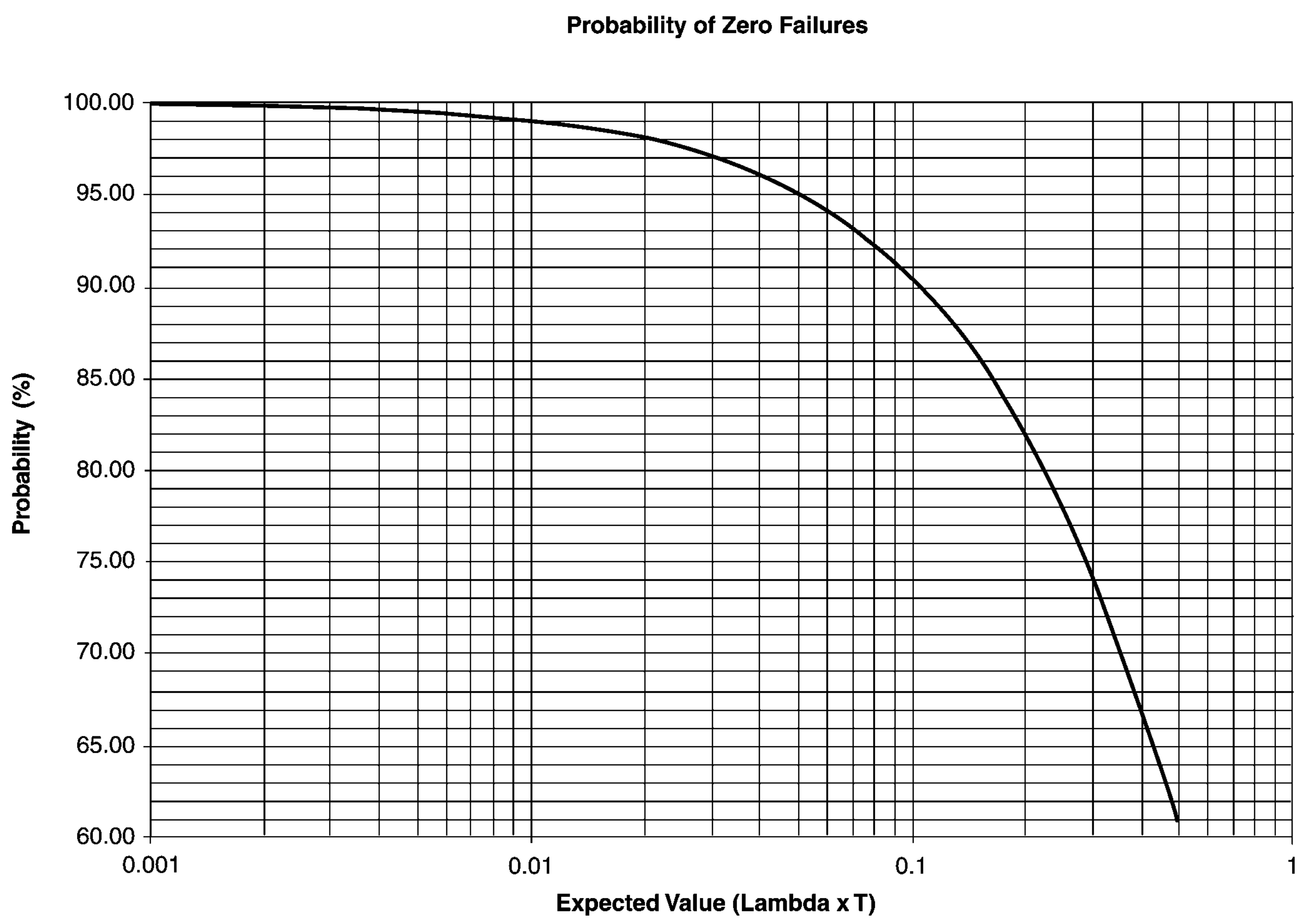

Probability of Zero Failures
Probability (%)
100.00
95.00
90.00
85.00
80.00
75.00
70.00
65.00
60.00
0.001
0.01
0.1
1
Expected Value (Lambda x T)

Figure 2-2

Attachment 2: Justification for Combining Standby and Run-Type Failure Criteria

The idea that two kinds of failure types exist is at the root of the concern that in some circumstances two types of performance criteria might be needed for failures of a single SSC. The use of a failure rate in time to describe failures of continuously operating components is supported by the knowledge that such equipment suffers from accumulating wear, material property degradation both mechanical and electrical, fatigue cracking, corrosion and erosion, diminishing effectiveness of lubricants, the accumulation of contamination, the loosening of fasteners, deformation or settling of frames, mounts and other parts, and the random failure of some electronic items. These degradation pathways are influenced to a great degree by environmental factors such as heat, moisture, and radiation. It is a matter of common experience that the damage accumulates over time until the failure point is approached, whereupon an increase in stress, such as a temperature transient, or a sudden pressure pulse, precipitates a failure. Central to all of these processes is the passage of time. Even when the rates of degradation in time are extremely variable, or when random events cause the failures, a large enough population of components and plant applications gives a more or less consistent average rate of failure occurrence. The time rate model of failure occurrence simply means that the passage of more time indubitably leads to more failures. The passage of less time does not allow as much damage to accumulate and the number of failures is less.

Standby equipment also fails from the same causes as operating equipment, but usually at a lower rate because the amount of wear is less, heat and mechanical stresses are lower, and standby rotating equipment is not pulling in environmental influences such as dust and salt spray to the same extent as when it is operating. Failure rates in time for standby equipment may therefore be lower than for normally operating equipment, although alternated equipment may not experience as much difference. On the other hand, some influences can be more detrimental during standby, such as the relocation of lubricant, or the sagging and bowing of a horizontal shaft. Whether these effects subsequently accelerate wear and other damage in an amount proportional to run time during tests, or by the action of starting or cycling, depends on the equipment. In either case, however, the deleterious effects of a demand are added to those of the time-driven influences. The same is true of random influences such as damage or misalignment by personnel, or miscalibration; their influences add to the others which are always present.

At least a major part of the influences on failures of standby equipment such as pumps, motors, switchgear, check valves, modulating valves, and heat exchangers comes from processes occurring over time. Only in very specific circumstances (for example, pressure relieving valves) are demand-caused failures a sufficiently dominating addition to this picture to unquestionably warrant the adoption of the failure-on-demand treatment at the expense of ignoring the time-driven effects. Most cases are in between.

The extent to which standby equipment should be treated as having a constant probability of failure-on-demand rather than a constant failure rate in time is a matter of which influences are dominant. For standby equipment of a particular type, it is instructive to conduct two separate thought experiments. The first imagines two identical pieces of equipment that are subject to the same total number of demands, but over very different standby time periods. Are approximately the same number of failures experienced on each piece of equipment? If not, which has the most failures? The second experiment imagines the same two equipments, but now one is subjected to many more demands (tests or operational cycles) than the other, but over identical time periods. Are approximately the same number of failures experienced on each piece of equipment? If not, which has the most failures?

For power plant equipment that is alternated between being run and in standby (switchgear, motors, pumps, check valves, modulating valves such as AOVs, and heat exchangers), the answers are likely either to favor the failure rate model (no appreciable change with demands, but an increase in failures with time in standby), or the situations are too uncertain or difficult to decide upon. A quick survey of the degradation mechanisms and influences encountered in a current EPRI project, which is preparing a technical basis for preventive maintenance programs, resulted in roughly three times more degradation influences on electric motors that were associated with time in standby than those associated with the number of demands. This rough survey does not include the relative strength of the influences.

Whether one model or the other was used in the PSA was a matter mostly of convenience. Data and knowledge did not, and do not, exist to mix the models in the right proportions. We are, therefore, obliged to choose between the models to calculate numerical results even though reality is not well served by either model on its own. The result of the analysis in this Technical Bulletin is to cast doubt on the engineering feasibility and the necessity of distinguishing failures that occur during time in standby from those that occur because of the demand, especially for equipment that alternates between operation and standby. The difficulty of distinguishing these failures and the reasons why they are hard to differentiate, certainly justify the position adopted. The model choice made in the PSA should be respected in regard to the numerical result it produces, but it should not obscure the real nature of the underlying causes of failures.

Now that it is clear that standby failures almost always have many characteristics that connect them to processes occurring in time with a failure rate, we can consider the relation between failures that occur during standby and those that occur during run time for equipment that is alternated between standby and running. These failures are also essentially indistinguishable apart from the random event of when the SSC finally becomes so fragile that it fails. This is because the progression of the degradation mechanisms leading to failure is driven by what happens during the time periods spent in standby, as well as by what happens during the alternating time periods when it is running. Consequently, these two determinants of failure times are inextricably interactive. Separating the failures into two groups, run and standby, would therefore be artificial, would lack technical validity, and would probably be misleading.

Attachment 3: Application to Standby Failures of Safety Equipment Modeled by a Standby Failure Rate

The previous EPRI Technical Bulletin 96-11-01 addressed the topic of failure performance criteria for standby equipment modeled using a constant probability of failure-on-demand. The treatment of the preceding sections enables a further clarification to be made in respect to the additional case where standby safety equipment (that is, permanently or predominantly in standby) is modeled in the PSA using a failure rate in time rather than a failure-on-demand probability.

When equipment is presumed to fail over time during standby, the PSA modeling approach uses the standby failure rate to estimate the average unavailability caused by such events, on the basis that a failure since the last successful test will have left the equipment unavailable for an unknown amount of time. The average unavailability produced by this process is $\lambda T/2$. This quantity is added by the PSA to other sources of unavailability of the equipment. Most PSAs include this model for some standby equipment, and some PSAs use this model predominantly. Many PSAs use the probability of failure-on-demand approach for the majority of standby equipment.

In the Maintenance Rule it is not possible for a monitoring scheme to incorporate this unavailability ($\lambda T/2$) because it is not an observable data value; instead it is a calculated constant mean value. Two avenues are open if it is desired to develop failure performance criteria for these cases. The first is to use the failure statistics that are the basis for the value of λ, together with an estimate of the number of demands, to calculate a value for an equivalent probability of failure-on-demand. The procedure would then use the method of Technical Bulletin 96-11-01 to develop performance criteria. However, most of the time the original failure statistics would not be readily available, and the method departs from the modeling approach used in the PSA.

A simpler method is to use the value of the standby failure rate, λ, from the PSA together with the approach described earlier in this Technical Bulletin for continuously operating equipment. *The time T will now be the time spent in standby for the Maintenance Rule monitoring period, usually the duration of the operating cycle*. This has nothing to do with the surveillance test period used in the PSA for the value of T. Having decided the values of λ and T, the formulas, table, and charts in this Technical Bulletin are directly applicable.

Example: The PSA uses a value of $\lambda = 0.08$ failures per year in standby for a motor that has a surveillance test interval of 6 months (= 0.5 years). From this the PSA estimates an average standby unavailability as $\lambda T/2 = 0.08 \times 0.5 \times 0.5 = 2.0\%$. For Maintenance Rule monitoring, assuming the motor is in standby for a 2 year operating cycle, the product λT is $0.08 \times 2 = 0.16$. Therefore we should expect 0.16 failures per cycle. The table and charts of Attachment 1 show that at this expected value there is a ~13% probability of observing one failure and a ~1% probability of observing two failures. Therefore, a practical performance criterion would be ≤ 1 failure per operating period. Zero failures might also be a reasonable choice from the point of view of chance exceedances, but would require some supplemental condition criterion to make it trendable. In many cases increasing the monitoring period to three or four years may be a practical way to avoid a zero failure criterion.

Note that the PSA standby unavailability use of the surveillance test period for T, and its resulting average unavailability, is not relevant to the Maintenance Rule monitoring procedure. Also note that an allowance for the amount of time the plant is actually operating during the cycle is not important because the underlying assumption is that the equipment is degrading all the time. Clearly there is also the implicit assumption that at least two demands (not necessarily test demands) are made on the equipment during the cycle, otherwise two failures could not be discovered. One of these demands could be made after the end of the cycle.

3
MANAGING THE (A)(1) LIST

3.1 Introduction

The Maintenance Rule 10 CFR 50.65 requires nuclear power plants to monitor the performance of SSCs to ensure that they are capable of fulfilling their intended function. The monitoring of SSCs may be performed under the provisions of paragraph (a)(1) or paragraph (a)(2) of the rule, depending on the performance of the SSC. Generally, SSCs are monitored under paragraph (a)(2) of the rule if they meet performance criteria set by the utility. If the SSC fails to meet its expected performance criteria, it is monitored under paragraph (a)(1) of the rule and goal setting is required.

3.2 Purpose/Objective

The MRUG developed this guideline to provide guidance on placing SSCs in (a)(1), managing the SSCs in (a)(1), and returning SSC to (a)(2).

Paragraph (a)(1) of 10 CFR 50.65 states:

> Each holder of an operating license under §§ 50.21(b) or 50.22 shall monitor the performance or condition of structures, systems, or components, against licensee-established goals, in a manner sufficient to provide reasonable assurance that such structures, systems, and components, as defined in paragraph (b), are capable of fulfilling their intended functions. Such goals shall be established commensurate with safety and, where practical, take into account industry-wide operating experience. When the performance or condition of a structure, system, or component does not meet established goals, appropriate corrective action shall be taken.

NUMARC 93-01 discusses the basic steps to take in evaluating SSC performance. The intent of this document is to describe how the NUMARC 93-01 guidance may be implemented within the framework of a plant organization and corrective action program structure. The purpose of this guideline is to expand on the guidance in NUMARC 93-01 and provide information for the practical implementation of NUMARC 93-01. Parts or all of this guideline may be used in developing or revising plant procedures. This guideline may provide a consistent approach to implementation where several units want a standardized approach.

This guideline presumes that SSCs are being monitored under paragraph (a)(2) of the rule, performance criteria are evaluated periodically, plant events are evaluated to determine if a functional failure has occurred, cause evaluations are performed, and corrective actions are taken to address functional failures.

This guideline will discuss when to place an SSC in (a)(1) monitoring, what to include in (a)(1) performance improvement plans (PIP), how to monitor progress toward meeting a goal, and how to disposition an SSC back to (a)(2).

This guideline discusses placing SSCs in (a)(1). A utility may choose to place a system, a part of a system, a function, or a component group in (a)(1). Programs are not placed in (a)(1). The choice of what to designate as (a)(1) is dependent on how the Maintenance Rule program is organized for the site.

An overview of the process is presented in the flowchart in Figure 3-1 at the end of this section.

3.3 Dispositioning to (a)(1)

There are several steps to determining if an SSC requires goal setting under paragraph (a)(1). The utility may decide to place the SSC in (a)(1) categorization once a performance criterion has been exceeded or after it has been determined that goal setting is required. The decision to place an SSC in (a)(1) is made by the appropriate personnel based on plant procedures. Section 3.5.12 of this report discusses review and approval levels.

3.3.1 Initial Input

The initial input to the decision of whether to place an SSC in (a)(1) is the monitoring that is done under paragraph (a)(2) of the rule. If any of the following conditions are identified as part of that monitoring, a determination of whether or not goal setting is necessary should be documented.

- An SSC goal is not met
- An SSC performance criteria is not met
- A functional failure (or MPFF) of an SSC is identified, even if goals and/or performance criteria are being met
- A repetitive MPFF of any in-scope SSC is identified, even if goals and/or performance criteria are being met
- An overall plant performance criteria has been exceeded
- A declining trend in SSC performance is identified

An action item in the plant corrective action program (CAP) should track the disposition of the SSC once one of these conditions has been identified. These conditions are consistent with the guidance provided by NUMARC 93-01 Section 9.3.4 and 9.4.4.

3.4 Is Goal Setting [(a)(1) Classification] Necessary?

An evaluation of whether or not goal setting is required should consider several factors including appropriateness of performance criteria, cause evaluations for individual events, and overall SSC performance.

3.4.1 Appropriateness of Performance Criteria

If the SSC has exceeded its performance criteria, the criteria are evaluated to determine if they are still appropriate for the SSC. Any changes to performance criteria after they have been exceeded should be carefully considered so as not to give the perception of changes just to avoid (a)(1) status. Reasons for changes should be well documented. Several factors should be considered:

- Has there been a design change that has changed the operation of the SSC? A design change could change the risk significance status or relative importance of the SSC.
- How sensitive is the PSA to a change in performance criteria? This may allow a relaxation of performance criteria to concentrate on more important SSCs.
- Has there been a change in the way the SSC is operated? This could either change the function of the SSC or could change the normal maintenance needed for the SSC. If the SSC is operated more frequently, it may require more unavailability time to maintain the proper availability/reliability balance.

3.4.2 Cause Evaluations for Individual Events

Cause evaluations should be performed for any failure or event that caused significant unavailability of a system, or significantly impacted a performance criterion. This cause evaluation may be an extension of an already completed cause determination. The cause evaluations should determine if the events were maintenance related and if performance is now acceptable as inputs for the (a)(1) determination. All of the cause evaluations should consider maintenance activities, cause determinations already performed, corrective actions (or lack thereof) and the effectiveness of such activities in precluding recurrence of the identified event(s). Cause determination methodologies used for the Corrective Action Program should be employed to the maximum extent practical at the appropriate level when evaluating events. The cause evaluations for individual events should also consider the following elements, depending on the type of event.

Reliability Events:

- Determine if the corrective actions have been completed.
- For events where corrective actions are completed, determine if they were, or will be, adequate and effective in preventing recurrence.
- For events where corrective actions have **not** been completed, identify the planned/scheduled date(s) for completion and determine if they will be adequate and effective in preventing recurrence.

- Determine if the events were maintenance preventable. Guidance for this determination is included in NUMARC 93-01.
- For each event, discuss key points that support acceptable/unacceptable performance.

Repetitive MPFF events:

- Identify the corrective actions taken to preclude recurrence of each event.
- Determine if the corrective actions have been completed.
- Discuss why corrective action(s) were ineffective in preventing the repetitive event.

Unavailability events:

- Was the unavailability for each event planned or unplanned?
- Was the unavailability time minimized?
- Could any changes to the maintenance program have precluded the unplanned unavailability time?
- Was the time frame to perform the work appropriate?
- Were problems encountered that extended the unavailability time of the SSC?
- Did scheduling consider the cumulative unavailability time of the SSC when scheduling the work activity?
- Did the established Maintenance Rule performance criteria consider this unavailability time in the development of the performance criteria?
- For each event discuss key points that support acceptable/unacceptable performance.

Plant level performance criteria events or adverse trend systems:

- The significance of the event and its related effect, if any, on safe and reliable plant operations, operations work arounds, maintenance work loads, long-term equipment reliability, design effects and actual contribution or future possibility to affect loss capability/production.
- For each event, discuss key points that support acceptable/unacceptable performance.

3.4.3 Overall SSC Performance Evaluations

This evaluation looks at the overall SSC performance rather than a single event. This evaluation considers the cause evaluations for individual events, common underlying issues, the effectiveness of maintenance and the appropriateness of the established monitoring program and/or criteria to determine if overall SSC performance is acceptable or unacceptable, and if goal setting is necessary.

- Consider whether any common cause(s) exist between all or some of the events or whether events are isolated and not related. If common causes exist, the SSC should be considered for (a)(1) monitoring.

- Consider bigger picture issues when evaluating the aggregate of events or when evaluating repetitive events, such as establishment of an effective preventive maintenance program for the SSC, ineffective planning and/or scheduling of activities, human performance issues, SSC design problems, industry operating experience, appropriateness of performance criteria, or the established monitoring program. If these issues exist, the SSC should be considered for (a)(1) monitoring.
- Consider if the performance issues are maintenance related. Unacceptable performance due (at least in part) to maintenance related issues suggests (a)(1) monitoring is required.
- Consider if the causes have already been determined and corrective actions taken. Determine if the corrective actions were effective. NUMARC 93-01, Section 9.3.4, identifies that if the cause of failure has been identified and the necessary corrections made (for example, replacement, redesign), a goal **may not** be needed unless it is repetitive and maintenance preventable.
- (a)(1) monitoring **should not** be avoided just because corrective actions have already been implemented for an event(s). There must be a high level of confidence that the corrective actions implemented will preclude future events, or it has been demonstrated that the previous actions were effective such that goal monitoring is not appropriate or necessary. Otherwise, the corrective actions should be considered as part of a PIP and goals **should** be established to monitor the effectiveness of those corrective actions. Additionally, safety significance and potential safety impact of subsequent failures should be considered in making this decision.
- Consider if ineffective corrective actions have been demonstrated by the identification of repetitive MPFFs. If an MPFF is repetitive then (a)(1) monitoring is required. This situation would indicate that maintenance is not effective since previous corrective actions did not prevent the repeat failure.
- Monitoring of repetitive MPFFs is intended to identify when previous corrective actions have not been effective. A repetitive MPFF can be further defined to have occurred only after corrective actions for the first failure have been implemented (assuming they are being implemented in a timely manner and/or are being aggressively pursued.)
- Consider if the established performance criteria or goals are appropriate for this SSC. As applicable, review the performance criteria or goal that was exceeded for appropriateness (see Section 3.2.1). If this review identifies the need for adjustment to the assigned criteria or goal, and that actual SSC performance is acceptable, then a (a)(1) monitoring **may not** be required. Additional actions should be identified to update the criteria or goal as appropriate. Performance criteria are modified in accordance with plant procedures.
- Consider if the performance monitoring program established for this SSC is appropriate. In some cases it may be determined that an SSC, event or condition should be excluded from monitoring. These determinations are made in accordance with plant specific interpretations, which may require additional considerations and documentation be included within the evaluation.

The overall performance evaluation must determine if the performance or condition of the SSC is being effectively controlled through the performance of *appropriate maintenance* such that the SSC remains capable of performing its intended function(s). If not, performance is not acceptable and (a)(1) monitoring is **required.** If the performance criteria are appropriate, and the cause of the failures is maintenance preventable or the performance of the SSC indicates a declining trend in performance, then the SSC should be considered for (a)(1) monitoring. If the SSC is placed in (a)(1) monitoring, a Performance Improvement Plan (PIP) shall be written to document the actions that will be taken to return the SSC to (a)(2) status.

Establishing a PIP is a positive action taken to formally recognize the need for improvement in a maintenance related area and to institute a corrective action plan with increased management attention. When in doubt, a PIP and associated goals and goal monitoring should be established instead of attempting to justify why it is not required.

If the effectiveness of previously identified corrective actions cannot be assessed due to not having been implemented yet or due to lack of an acceptable length of time to justify that the corrective action(s) have effectively prevented recurrence, then (a)(1) monitoring and a PIP should most likely be established to ensure pending actions are monitored for effectiveness.

What SSC to put in (a)(1) should be determined by the SSC requiring corrective actions, if the corrective actions are equipment based. If a support system causes a system to exceed its availability performance criteria, the support system should be considered for (a)(1) placement. It may not be necessary to put the supported system in (a)(1). Some judgment may be used in determining which SSC should be placed in (a)(1). If the SSC that exceeded its performance criteria is not the one placed in (a)(1), the reasoning for this should be adequately documented.

The foregoing evaluation may determine that SSC performance is not acceptable due to factors other than maintenance or that performance cannot be addressed by changes in a maintenance related area. Although not required, a PIP **may** be developed to address other performance issues where judged to be appropriate. Additional actions may also be recommended as part of the performance evaluation that are not related to the development of a PIP. Nonmaintenance-related corrective actions would be addressed by the plant corrective action process.

3.4.4 Disposition of SSC to (a)(1)

If goal setting is required, then the SSC shall be reclassified from (a)(2) status to (a)(1) status. The transition to (a)(1) is in accordance with plant procedures. This change of condition should be tracked in the action item of the plant corrective action program that was generated when performance criteria were identified as being exceeded.

This movement of the SSC from (a)(2) status to (a)(1) status, and the development of a PIP with goal setting described below, serve to focus management attention on poor performing SSCs.

3.4.5 Systems Remaining in (a)(2)

If an SSC is not placed under (a)(1) monitoring even though performance criteria have been exceeded, this should be documented with appropriate approvals in accordance with plant procedures. Types of justification could be based upon the following:

- Performance criteria inappropriate
- Performance evaluated against standards, such as PSA, and performance deemed acceptable at the recorded level
- Performance based upon completely isolated and/or unrelated events for which each has documented effective corrective action complete
- Performance issues whose cumulative effects are not adversely affecting the system
- Other means of performance improvement (that is, LER or CR action) will insure appropriate management attention

3.5 (a)(1) Action/Performance Improvement Plans

Once it has been determined that an SSC will be placed in (a)(1), a Performance Improvement Plan (PIP) including goals should be written. The following elements should be documented in the (a)(1) PIP.

- The overall performance evaluation discussed in this report. This section should include references of condition reports and work orders for the events.
- Industry operating experience.
- Balancing of availability and reliability.
- Actions to improve performance.
- Additional actions.
- Goal setting and monitoring.
- Estimated completion of corrective actions and monitoring.

The (a)(1) action plans are reviewed and approved according to plant procedures. See Section 3.5.12 of this report for a discussion of considerations for determining approvals.

3.5.1 The Overall SSC evaluation

Information that may be included in this section is described in Section 3.4.3. The discussion in the PIP should include a description of the event(s), causes and a discussion of repetitive MPFFs. The detail necessary is dependent on why the system exceeded criteria and the depth of evaluation needed to determine corrective actions. It may not be necessary to include all of the elements from Section 3.4.3. The reason for placing the system in (a)(1) and what issues will be addressed by the PIP should be clearly stated.

3.5.2 Industry Operating Experience

Conduct a search for any applicable industry operating experience (IOE) related to the identified event(s). This search should be conducted for each evaluation. One of the two following options should be documented here:

1. Identify and summarize any relevant data found including the source, or

2. Describe the search that was performed and document that no applicable data was found.

The rule requires that "goals be established commensurate with safety and, where practical, take into account industry-wide operating experience." The use of IOE should not be limited to *goal setting* as it can provide valuable input into other areas of the evaluation process.

Consider the following while conducting the performance evaluation and/or in PIP development:

- Does the IOE data identify potential causes for the event(s) that were not previously considered?
- Does the IOE data identify corrective actions utilized by others to resolve the same/similar type(s) of performance issues that may not have been previously considered for SSC improvement?
- Does the IOE data provide other insights for SSC improvement?
- Does the IOE data indicate that performance may be similar to the industry in that currently-established performance criteria or goals may be inappropriate?
- Does the IOE data provide measures for expected levels of performance and/or methods for monitoring?

3.5.3 Balancing of Availability and Reliability

10 CFR 50.65 requires that the utility maintain a balance of availability and reliability. Most utilities take credit for meeting their performance criteria in this evaluation. Therefore, if the performance criteria are not met, the balance of availability and reliability should be reexamined. This evaluation should consider how past performance has impacted the balance and how corrective actions will impact the balance.

The events that require a performance evaluation should be examined to determine how they have impacted the balance. Generally, this has probably been a negative impact.

If the unavailability criteria is exceeded and not the reliability criteria, the evaluation should determine if decreased routine maintenance is warranted. If reliability criteria have been exceeded and not unavailability, increased unavailability time for planned maintenance may be warranted.

The corrective actions should be evaluated for how they will impact the balance. It may be necessary to negatively impact the balance by incurring unavailability time in order to correct conditions that may lead to future unavailability or unreliability. The end result should be an improvement in the balance. This section should include a discussion of how the plan will restore the balance, if necessary.

3.5.4 Actions to Improve Performance

List the corrective action(s) that will be implemented to correct the problem(s) identified through the performance evaluation and to improve SSC performance. Also include any corrective actions that were identified for the individual events **if** they are not yet completed or the effectiveness of their implementation has not yet been demonstrated. They should be part of the PIP to ensure that goals and goal monitoring will be established to monitor the effectiveness of all corrective actions to improve SSC performance.

Since modifications are usually a long-term item, other methods of addressing the problem should be considered. This could be changing a maintenance interval or a maintenance task. The modification may be pursued as part of the plant corrective action system, but not necessarily tied to the (a)(1) PIP.

If interim corrective actions are taken, goals should be put in place to determine the effectiveness of these actions. Examples of interim goals are:

- Monitoring poor packing closely until the new packing design can be approved and plant conditions allow its installation.
- Monitoring equipment performance after one maintenance activity change or modification while waiting for another activity change or modification to be completed.

Corrective actions should include human performance issues if they are the cause of performance criteria being exceeded. If a root cause evaluation (RCE) or other evaluation has been completed for the event, the corrective actions to prevent recurrence from the RCE should be included in the PIP.

Corrective actions that require additional evaluation and possibly the generation of additional corrective actions for inclusion into the PIP should be avoided. Personnel conducting the performance evaluation should perform, or ensure completion of, all necessary evaluation(s) prior to completing and gaining approval of the PIP. If one issue requires additional research or evaluation, it may be necessary to issue an interim PIP to meet the objective of timeliness.

Corrective actions are completed through the normal plant planning process. Nonoutage items should be completed within six months. Outage actions should be completed at the next outage.

The Corrective Action (CA) statement (s) should include:

- A description of the required action (include reference to any IOE data used in development).
- Identification of the department responsible for implementation.
- Identification of the expected completion date.

- Indicate if the action will be tracked by the corrective action program or another tracking method. It is recommended that there be an action item for each required corrective action.

Examples:

CA-1 To eliminate further bearing failures, incorporate new alignment criteria provided by the vendor as identified through industry experience. Incorporate the new criteria during the reassembly of the pump and motor after return from the repair facility.

- Responsibility: Mechanical Maintenance Department.
- Expected Due Date: Scheduled for system workweek of (date).
- No commitment item needed. Work Order (WO #) will track.

CA-2 Change the Preventive Maintenance (PM) program to incorporate steps in the routine PM task for pump inspection to utilize a new style (floating pad) bearing for the inboard pump bearing for all future overhauls. Also include a new alignment criterion that requires the pump to be set .013 mills higher than the motor with a fare coupling face.

- Responsibility: Work Control - PM Coordinator
- Expected Due Date: Prior to (date)
- Corrective action item is needed.

3.5.5 Additional Actions

Additional actions may be considered based on the condition of the system. These would typically be any additional actions or *opportunities for improvement* that could enhance SSC performance as a proactive/preventive measure or that are needed to implement criteria or monitoring program changes. These recommended actions **are not** associated with required *corrective actions* of a PIP and do not require goals and goal monitoring. This section may be useful if the document is to be used as an overall description of system health or a summary of actions pending on the system.

Document any additional action(s) recommended and identify the department responsible for implementation. Indicate if the corrective action program or another tracking method will track the actions.

If no additional actions are recommended, state: NONE.

3.5.6 Goal Setting and Monitoring

The establishment of goals is required to ensure/prove that the corrective actions taken are effective in preventing recurrence of the event or condition. Goals provide a measure to determine when the SSC is demonstrating acceptable performance such that goals and goal monitoring are no longer required. Identify the established goal(s) and define how the goal(s) will be monitored including frequency and responsibility for monitoring.

Goals and goal monitoring shall consider the safety significance of the SSC and the particular performance issue(s) and/or event(s) identified. This would include consideration of the appropriate level at which to assign goals (that is, structure, system, train, or component).

The following should be considered when establishing goals:

- Goals should provide a **quantitative** value against which performance can be measured. Consideration should be given to various goal setting criteria such as existing industry indicators, industry codes and standards, failure rates, duty cycles and other performance related data when determining values. Quantitative values for goals may also be established based on judgment resulting from a review of the basis for risk significance and currently established performance criteria.
- Goals **should be** set at a lower level than overall performance criteria and/or should utilize predictive methodologies, when appropriate, to provide a more focused monitoring program to ensure specific corrective actions(s) are effective and to identify unacceptable performance **prior** to failure.
- The goal may be established at the component level for the component that caused the SSC performance criteria to be exceeded. Component level goals are appropriate for repetitive failures (RMPFFs) of a component.
- Existing performance criteria should be used with care. Will they really measure the effectiveness of the corrective action? It is better to specifically target the corrective action with a goal?
- Use of existing monitoring programs and activities is recommended, for example, ISI, IST, Appendix J, Maintenance Rule monitoring, Vibration/Oil/Thermography programs and techniques, plant process parameters - pressures, temperatures, flows.
  - If the expected failure rate for the failure being addressed is greater than two years, condition monitoring should be considered for goal setting.
  - The frequency of monitoring and/or established limits may be adjusted, if necessary, to allow for early detection and timely correction of negative trends. Additional testing and/or surveillance activities may also be recommended if determined to be appropriate.
- The following goal monitoring periods are recommended. These are consistent with NUMARC 93-01.
  - Acceptable performance has been demonstrated for three monitoring periods where the monitoring periods are equal to or less than six months; or
  - - Acceptable performance has been demonstrated for two monitoring periods where the monitoring periods are greater than six months, but no greater than two fuel cycles; or
  - An approved and documented technical assessment assures the cause is known and corrected and thus monitoring against goals is unnecessary.

  - If the system is a normally operating system, the performance should be monitored for 6 months to ensure the corrective actions were effective.

- In addition to the NUMARC guidance, the probability of the failure recurring should also be considered when deciding how long goals should be monitored. Removing goals and goal monitoring too soon may not accurately provide assurance of satisfactory performance, and/or the effectiveness of corrective actions. It is better to monitor performance against goals for a longer period of time to ensure effective corrective action than to reestablish goals and a new monitoring program at a later date.
- Each defined corrective action should have a goal that will monitor the effectiveness of the action. However, one goal can monitor multiple corrective actions.

The goal statement(s) should include:

- A description of the goal (include reference to any IOE data used in development)
- Identification of the corrective action(s) that the goal is intended to monitor
- Identification of how the goal will be monitored including frequency
- Identification of the department responsible for goal monitoring
- Identification of the expected monitoring period after which the goal would be considered satisfied or met (that is, performance has demonstrated that corrective action was effective)
- Identification if a commitment tracking item is needed to ensure implementation of the monitoring program

Example:

G-1 Pump vibration levels not to exceed 0.125 inches/second vibration velocity with no 1x, 2x, or 3x order peaks above 0.2 inches/second.

- Corrective Actions Monitored: CA-1, CA-2
- Goal Monitoring Program:
- Vibration readings to be taken by Maintenance Department during routine quarterly Tech. Spec. surveillance testing under (list procedure). Maintenance Engineering to review vibration data against the established goal.
- Responsibility: Maintenance Engineering
- Expected Time Frame:
- Monitor against established goal for three (3) quarters following pump rebuild using new alignment criteria. (Dates).
- Corrective action item needed.

3.5.7 Estimated Completion of Corrective Actions and Monitoring

Based on implementation of the defined corrective actions and the subsequent monitoring against the established goal(s), provide an estimate when the performance of the SSC can be reassessed for possible removal from the goal monitoring program and return to (a)(2) status.

NUMARC 93-01 identifies that SSCs should normally remain under their Performance Improvement Plan and have goals monitored until all corrective actions have been completed **and** goals have been monitored for an appropriate time.

Removing goals and goal monitoring too soon may not accurately provide assurance of satisfactory performance, and/or the effectiveness of corrective actions. It is better to monitor performance against goals for a longer period of time to ensure effective correction rather than to re-establish goals and a new monitoring program at a later date.

3.5.8 Timing of Putting an SSC into (a)(1)

The evaluation of whether or not the SSC should be covered by (a)(1) should take place within 60-90 days of the event that required the cause evaluation. The evaluation of what corrective actions are needed to return the SSC to (a)(2) should be completed within the same period of time. The timeframe allowed for the evaluations should be consistent with the corrective action program. From Reg Guide 1.160, "Licensees are to undertake and accomplish activities associated with the maintenance rule in a manner commensurate with the safety significance of the SSC and complexity of the issue being addressed."

3.5.9 Tracking Plans

Corrective actions, monitoring, and trending actions taken to address performance of SSCs in (a)(1) should be documented in the corrective action system. A record in the corrective action program (CAP) should be created for each corrective action item from the PIP. If the action is not addressed in the CAP, it should be tracked by some other method to ensure timely action. If the action is already covered under an existing action item, another action item is not necessary, but the existing item should be referenced in the (a)(1) corrective action (CA) document. Some method of tagging all corrective actions related to (a)(1) PIPs will aid in tracking completion of the plans. Each of the records associated with a corrective action in the PIP should reference the original (a)(1) CA document and be referenced in the original CA document. An action item for completion of the PIP and any monitoring should remain open until the SSC returns to (a)(2) status.

The actions required to return an SSC to (a)(2) should be trended toward completion to ensure progress is made in accordance with the plan. This may be accomplished in the corrective action program by flagging the items and monitoring due dates.

Any modifications or work orders whose completion is required for the action plan should be flagged as such to alert other plant groups to the importance of completing the task on schedule. New revisions to the plans should be made visible and available to the entire organization.

The (a)(1) status of an action item should be part of the plant priority system.

If an SSC experiences another failure while in (a)(1), the issue should be escalated to a higher level in the corrective action program.

3.5.10 (a)(1) Plan Changes

Once an (a)(1) PIP is established and approved, a responsible utility individual should be assigned to monitor implementation of the corrective actions and goals as outlined in the plan. This monitoring process should be established in order to assess the overall effectiveness of the plan and the need for plan revisions. The utility should define a minimum frequency at which the plan monitoring should take place, which may be integrated into the utility's corrective action program internal monitoring processes. Continuous monitoring of the plan's actions and goals will allow the utility to be proactive in adjusting expected completions. The utility should identify the need to change established due dates prior to the planned action becoming overdue.

If at any time the defined corrective actions are **not** completed in accordance with the plan, which **will** cause the goals (including dates) not to be met, then the responsible individual should inform management utilizing an established means, that is, CAP if within established threshold. This condition would typically require a plan revision to establish new due dates and goals for completion.

If **not** completing corrective actions in accordance with the plan, however, **will not** affect the overall goal (including dates), then this notification may not be required. This may be a result of minor date slippage, which would have negligible effect on meeting the established goals. This condition may not require a plan revision.

Additional items to consider during the monitoring process, which may require a plan revision, are:

- New maintenance rule functional failures associated with the functions included within the original plan's scope are experienced.
- Unacceptable unavailability trends for the applicable function.
- Additional performance criteria for the same SSC are not met.
- Additional actions are needed to address the original (a)(1) concerns.
- Some actions are no longer necessary based on the outcome of completed actions or evaluations.

These conditions would normally be monitored as part of the utility's program implementation activities.

Revised plans should be processed through the same routing and approval as the original plan. Minor editorial or non-intent type changes do not necessarily require this review. Also, minor editorial and/or non-intent changes should not require immediate plan revision. These types of changes should be considered for inclusion during the next required revision.

New revisions to the plans should be made visible and available to the entire organization through the same methods used for the original plans. Additionally, old revisions or affected data should be maintained for reference purposes. Long-term record retention should be in accordance with the utility's quality assurance program.

3.5.11 Disposition of an SSC Back to (a)(2)

Based on SSC performance meeting all established goals and corrective actions as required under the goal monitoring program(s), the SSC is a candidate for removal from (a)(1) status. All corrective actions in the PIP must be completed before the SSC is returned to (a)(2). If some of the actions have been determined not to be needed, the plan should be revised and receive appropriate approval before returning the SSC to (a)(1). All of the goals in the PIP shall be met before returning the SSC to (a)(2).

A document shall be generated which will provide the technical justification for disposition of the SSC back to (a)(2) status. Documentation that should be included when dispositioning SSCs to (a)(2) include:

- A summary of the actions from the original action plan and how they were completed
- A list of the goals from the action plan and current status of the SSC relative to the goals or how the goals were met
- Evidence that a positive performance trend is exhibited
- SSC performance criteria and SSC performance relative to the performance criteria

References with more details will also be noted.

If the SSC will not be meeting its original performance criteria when it is returned to (a)(2), this should be noted in the documentation and some method should be in place to clearly state why this is acceptable and what criteria will be used for evaluating the performance criteria in the future. This situation could occur if an SSC is placed in (a)(1) because of high unavailability. The performance criteria may monitor the SSC over a two or three year period. If the corrective actions are taken and the appropriate number of surveillance tests have been passed, the SSC could be returned to (a)(2) even though the original unavailability performance criteria is not met. This situation may be handled by either changing the performance criteria for some period of time after returning the SSC to (a)(2), designating some hours as no longer counting against the performance criteria, or having an expert panel review periodically to ensure that the SSC should still remain (a)(2).

Dispositioning an SSC from (a)(1) to (a)(2) is approved by the appropriate level of management. (See the following section on review and approvals.)

3.5.12 Review and Approvals

There are several ways to address approvals for the various parts of the process. A few of them will be discussed here with some reasons for consideration.

The SSC may be placed in (a)(1) monitoring by the system engineer or person performing the ongoing evaluation of performance. This allows the system to be flagged as (a)(1) as soon as the performance criterion has been exceeded.

The SSC may require expert panel or plant manager approval to be placed in (a)(1). This eliminates the system engineer from putting the SSC into (a)(1) just to address an SSC improvement that they would like.

If a SSC has exceeded its performance criteria but will not be placed in (a)(1) status, this determination needs to be justified and should be approved by the expert panel or appropriate level of management. The level of management should be consistent with who approves returning a system to (a)(2) that has been in (a)(1).

The appropriate people should approve action plans at a level to ensure that the plans get the support needed for completion. Each department that has an action item should agree to the items that are assigned to them, along with the due dates. It may also mean getting approvals through the plant budgeting process to ensure that the budget will support completion of the items. These approvals should be obtained before the final approval of the overall plan by the expert panel or plant management.

Goals in the action plan for returning an SSC to (a)(2) should be approved by the same people who approve performance criteria, since they should be aware of the requirements for goals or performance criteria.

Approvals can be documented on a coversheet or with initials by the appropriate department manager next to their action items within the body of the plan. Two examples are shown in Sections 3.5.14 and 3.5.15 of this report.

Approval of returning the SSC to (a)(2) may be by the expert panel or the plant manager. Since the plant manager has overall responsibility for ensuring that the plant equipment is performing acceptably, it may be appropriate for that level of management to approve the return to (a)(2). The expert panel may be more familiar with the plan and the Maintenance Rule requirements and, therefore, be the ones to approve the disposition. An SSC should not be returned to (a)(2) until all of the actions in the PIP have been completed and the actions have proven to be effective.

Revised plans should be processed through the same routing and approval as the original plan. This routing at a minimum should require re-review by the utility's Maintenance Rule Expert panel and any other committees established to support the CAP, as necessary.

The level for the approval of any of the steps in the process should consider several factors: 1) who has the best information to make the decision, 2) what is the normal plant approval process for similar documents, 3) how well integrated is management into the process, 4) who understands the requirements, 5) who needs to approve resource allocations where necessary, and 6) who needs to know.

3.5.13 Communicating Action Plans

The performance improvement plans should be available to the organization. This may be accomplished through dissemination of posters, site newsletters, plan-of-the day, or web sites, which could include a summary of the plan's corrective actions and goals. This would allow the entire organization to be kept informed of the items requiring support to return a given SSC to acceptable performance.

One way to increase the visibility of the (a)(1) status of a system is to include it in the system health reporting system. If system health reports are used, the color of the system could reflect the status of the action plan. Or the status of the action plan could be incorporated into how the color is determined. For example, if the plan has not yet been written, the system is red (or the worst designation). If the plan is being implemented, the color can be red or yellow depending on other system factors. If the corrective actions are complete, the system may be red, yellow, or white, but not green (or the best designation). Alternatively, one of the line items on the health report could be the (a)(1)/(a)(2) status of the system. The system performance criteria may also be an input into the system health report. This could be based on how close the actual performance is to the performance criteria.

Periodic presentations to plant staff or upper management can be an aid in identifying roadblocks and obtaining support to keep the plans on track. These presentations will usually be brief updates after the initial one describing the issues behind the (a)(1) classification.

System or Issue Team reports may be used to provide a summary of activities to management.

A graph showing the expected completion rate of action items and their actual completion dates may be used to communicate this information to the plant.

A weekly report to station management and (a)(1) action owners that lists (a)(1) actions that are due within the next sixty days, as well as any overdue actions and any actions extended since the previous report, will heighten awareness of the status of items.

3.5.14 Performance Evaluation/PIP Review and Approval

Revision (Original) Dated (mm/dd/yy)

Prior to Expert panel review and approval all departments responsible for additional or corrective actions SHALL have reviewed and provided preliminary approval of any assigned responsibilities for the actions (if applicable).

Prepared By: ___________________________/________
System Engineers / Evaluator Date

Approved By: ___________________________/________
System Engineering Manager Date

Approved By: ___________________________/________
Expert Panel Chairman Date

Plant Manager review and approval is required for initial disposition of SSCs to the (a)(1) category only. If the performance evaluation concludes that the SSC will remain in the (a)(2) category, approval up through the Expert panel is all that is required.

Reviewed By: ___________________________/________
Plant Manager Date

3.5.15 Maintenance Rule (a)(1) System

Action Plan Checklist and Approval

System ____________________

This plan is: (check one) ☐ Initial Plan ☐ Added Plan ☐ Revised/(Replacement) Plan

Ensure the following are included in the Action Plan:

1. Description of why the system is an (a)(1) system ________________
2. Cause for system being (a)(1) ________________
3. Evaluation of the balance between availability and reliability ________________
4. References, including Condition Report documenting (a)(1) status ________________
5. Information from review of industry operating experience (IOE) and IOE references ________________
6. Specific actions to be taken to correct problem/improve performance ________________
7. Goals to measure effectiveness and progress toward redisposition to (a)(2) status ________________

Preparer: ______________________________ Date: ________________

Approvals:

Operations Representative: ____________________ Date: ____________

Maintenance Representative: ____________________ Date: ____________

Site Engineering Representative: ____________________ Date: ____________

Maint. Rule Coordinator (for goals): ____________________ Date: ____________

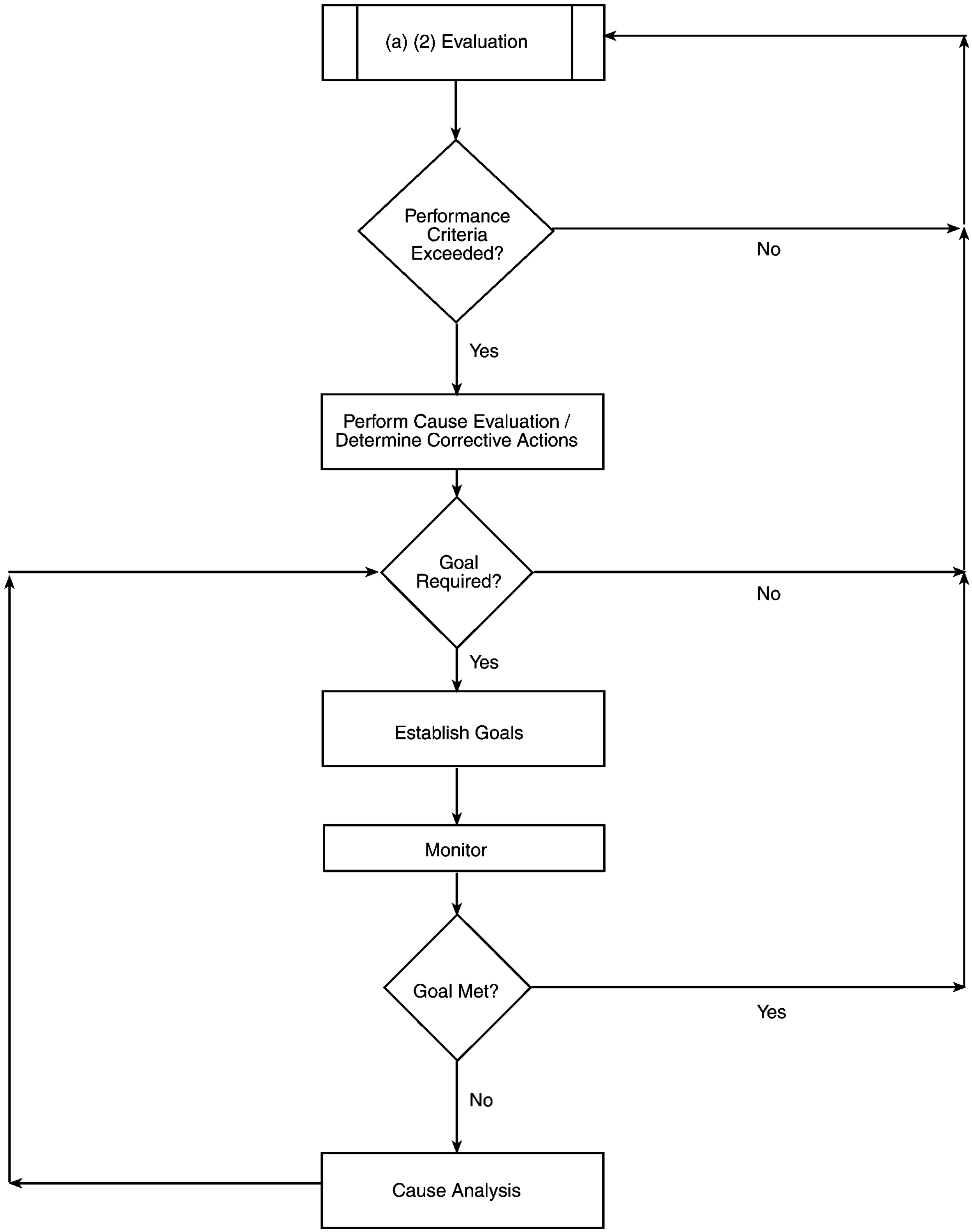

(a) (2) Evaluation
Performance Criteria Exceeded?
No
Yes
Perform Cause Evaluation / Determine Corrective Actions
Goal Required?
No
Yes
Establish Goals
Monitor
Goal Met?
Yes
No
Cause Analysis

Figure 3-1

4
(A)(3) ASSESSMENT GUIDELINE

4.1 Introduction

Each U.S. nuclear plant is required by the Maintenance Rule 10 CFR 50.65 (a)(3) to complete a periodic assessment of maintenance effectiveness, as measured by the Maintenance Rule program, at least once every 24 months. The content and level of effort for the periodic assessment varies considerably among utilities. These differences are believed to be the result of: 1) flexible requirements and guidance for the activity in the industry guideline NUMARC 93-01, and 2) large variation in the approach and purpose of the plant staffs in performing the assessment. In many cases, the periodic assessments are quite labor intensive. Often, the periodic assessments lack good organization. In some cases, the periodic assessments may not meet all of the requirements specified by the NRC and the NUMARC 93-01 Guideline.

4.2 Purpose/Objective

The EPRI Maintenance Rule Users Group (MRUG) desires to develop a guideline and template for performing a periodic assessment that is based on best practices among its members. Development of the guideline and template will be directed and reviewed by an MRUG Working Group.

The *Maintenance Rule Periodic Assessment Guideline and Template* are intended to provide a cost-effective process for performing a high quality Maintenance Rule Periodic Assessment. Existing periodic assessments that were submitted to EPRI by various utilities were reviewed, and best practices were observed in many of the existing periodic assessments. *The Guideline and Template* are intended to provide the following benefits, and are based in part on the best practices observed in the periodic assessments reviewed:

1. Reduce the resource requirements to perform the periodic assessment

2. Standardize the content of the periodic assessment

3. Improve the quality of the periodic assessment

4. Develop more consistent format and content in periodic assessments between utilities

5. Improve maintenance effectiveness

All of these benefits are intended to be achieved by use of the *Guideline and Template*. The *Guideline and Template* as currently written, only to a limited extent provide methods to further improve maintenance effectiveness. This guideline is meant to meet the minimum requirements of NUMARC 93-01; however, utility management may elect to include other objectives. A near-term second initiative by MRUG will be to provide guidance on how maintenance rule performance criteria monitoring results can be utilized to further enhance maintenance effectiveness. This information will be incorporated into a later revision of the *Guideline and Template*. This MRUG document does not include guidance on the assessment of (a)(4), NUMARC 93-01 Section 11.0 “Assessment of Risk Resulting form Performance of Maintenance Activities.” Prior to revision 3 of NUMARC 93-01, this assessment was requirement as a part of (a)(3), NUMARC 93-01 Section 12.0. This is no longer a requirement.

The *Guideline and Template* reference documents such as “Quarterly Reports,” “Maintenance Rule (a)(1) Action Plans,” and “System Health Reports.” It is understood that many of the specifics in the *Guideline and Template* need to be tailored to match the existing Maintenance Rule Programs at each utility. It is understood that “Quarterly Reports” may be monthly, bi-monthly, or quarterly, and that the guidance is still applicable.

The *Guideline and Template* assume the Expert panel reviews and approves (a)(1) action plans. At some plants, another group of senior level personnel performs these functions. In those cases, the *Guideline* should be interpreted such that the senior level personnel should perform the roles of the Expert panel.

The primary way of reducing the resources required to perform the periodic assessment (that is, streamline the periodic assessment) is to rely on ongoing processes and documentation to meet the needs of the periodic assessment. Section 12.2.4 states, “The requirements for performing the periodic assessment can be satisfied through the use of ongoing assessments combined with a higher level summary assessment performed at least once per refueling cycle not to exceed 24 months between evaluation.” The Quarterly Reports (or monthly), (a)(1) actions plans, functional failure evaluations, or Expert panel reviews can be easily tailored to meet most of the requirements of the periodic assessment.

4.3 Maintenance Rule Periodic Assessment Template

A “Template for Maintenance Rule Periodic Assessment” was developed based in part on the best practices observed in existing periodic assessments.

One of the major objectives of the *Guideline and Template* is to reduce the resources required to produce the periodic assessment, without sacrificing any quality. For the periodic assessment to be streamlined, certain items that might ordinarily be addressed only during the periodic assessment must be explicitly addressed and documented in Maintenance Rule Quarterly Reports (or monthly reports), Goal Setting Evaluations, and expert panel meetings. The ongoing activities and documentation necessary to support a streamlined periodic assessment are discussed in this *Guideline*.

It is recognized that many utilities are likely to continue to follow their own format for the periodic assessments. The intent, however, is that at least parts of the *Template* can be used or customized by each utility, regardless of their periodic assessment format. It should be noted that most of the periodic assessment reviewed met all of the NRC and NUMARC requirements.

Thus, the primary benefit of the *Guideline and Template* is to reduce the resources needed to perform a periodic assessment.

The Maintenance Rule Periodic Assessment Template is organized consistent with the guidance of NUMARC 93-01, and is divided into ten sections and an Executive Summary. The sections are:

- Executive Summary
- Introduction
- Review of Goals (a)(1)
- Review of SSC Performance (a)(2), Plant Level Criteria
- Review of SSC Performance (a)(2), SSC Performance Criteria
- Review of SSC Performance (a)(2), Industry Operating Experience
- Review of Effectiveness of (a)(1) Corrective Actions
- Optimizing Availability and Reliability for SSCs
- Documentation of periodic assessment
- Review of structural monitoring program
- Optional Items (Expert panel Effectiveness, Maintenance Rule Knowledge and Training, PSA Update, Living Maintenance Rule Program, Self Assessments)

Each section of the template is organized with three subsections: a verbatim documentation of the NUMARC guidance for the Section, Conclusions, and Discussion/Details. These subsections are defined as follows:

- The verbatim documentation is an exact listing of the NUMARC requirement for the particular section of the report.
- Conclusions documents specific conclusions, findings, or weaknesses identified in the particular section of the periodic assessment report.
- Discussion/Details is a discussion of how the routine actives support the periodic assessment, how the activities are documented, and either reference to the results, or a listing/summary of the results.

4.4 Discussion of Periodic Assessment Guideline

The remainder of the *Guideline* discusses each of the sections in the Periodic Assessment Template. For each section of the *Guideline*, there are two subsections that are described below.

4.4.1 Specific Ongoing Activities and Documentation Required to Support Streamlined Assessment

In this subsection, ongoing activities, responsible individuals, and required documentation to support a streamlined periodic assessment are discussed. Many of the activities are already being performed, so no changes in existing programs may be necessary. However, in some cases, the level of review and documentation may have to be improved.

4.4.2 Discussion of Suggested Content for Periodic Assessment Section

In this subsection, the suggested content for the periodic assessment section is presented.

4.5 Executive Summary Section of Periodic Assessment

4.5.1 Specific Ongoing Activities and Documentation Required to Support Streamlined Assessment

No specific ongoing activities or documentation are required for this section to support a streamlined assessment, since this section is a summary of the periodic assessment, including the overall results, conclusions, and findings.

4.5.2 Discussion of Suggested Content for Periodic Assessment Section

The following items should be discussed in the Executive Summary.

- State the assessment is required per 10 CFR 50.65 (a)(3).
- State the period of the current assessment, and the previous assessments.
- Describe how periodic assessment relies on ongoing activities, and is a summary document.
- Provide a summary of effectiveness of maintenance as measured by plant level criteria, SSC criteria, reliability, and condition trends.
- Discuss whether placement of items into (a)(1) was effective (timely, goals and corrective actions resolved problems.).
- Discuss the format and content of the periodic assessment.
- Summarize major conclusions, results, and findings.

4.6 Introduction Section of Periodic Assessment (NUMARC 93-01 Sections 12.1 and 12.2)

Performance and condition monitoring activities and associated goals and preventive maintenance activities shall be evaluated at least every refueling cycle provided that the interval between evaluations does not exceed 24 months. The evaluation shall take into account, where practical, industry-wide operating experience. Adjustments shall be made where necessary to ensure that the objective of preventing failures of structures, systems, and components through maintenance is appropriately balanced against the objective of minimizing unavailability of structures, systems, and components due to monitoring or preventative maintenance.

Periodic assessments shall be performed to establish the effectiveness of maintenance actions. These assessments shall take into account, where practical, industry-wide operating experience. The assessment consists of several activities to assure an effective maintenance program and to identify necessary adjustments that should be made to the program. The periodic assessments, cause determination, monitoring, and other activities associated with the Maintenance Rule, provide an opportunity to feedback lessons learned into the process.

4.6.1 Specific Documentation Required to Support Streamlined Assessment

No specific ongoing activities or documentation are required for this section to support a streamlined assessment, since this section is an introduction. This section of the NUMARC Guidance is a summary of the other sections in Section 12 of the NUMARC Guidance.

4.6.2 Discussion of Suggested Content for Periodic Assessment Section

- State the requirement from 10 CFR 50.65 (a)(3) to perform the periodic assessment.
- State that the assessment is organized so each section of the periodic assessment corresponds to a portion of Sections 12 or 13 of the NUMARC 93-01 Guideline.
- List the period of the periodic assessment, and list the periods of the previous periodic assessments.
- List any applicable plant procedures that provide guidance for performing the periodic assessment.
- State the periodic assessment follows the guidance of NUMARC 93-01.
- State that in each section, a conclusion relative to the implementation of the guideline is included.
- State that each section includes a description of how the ongoing activities and documentation satisfy the periodic assessment requirements.
- Describe how the periodic assessment is a higher level summary assessment, since the periodic assessment requirements are largely satisfied in the Maintenance Rule Quarterly Reports, the (a)(1) goal setting evaluations, the functional failure evaluations, and the System Health Reports.

- State that in accordance with Section 12.2.4, the requirements for performing the periodic assessment are satisfied through the use of ongoing assessments combined with a higher level summary assessment performed at least every 24 months.
- State how the ongoing Maintenance Rule activities and processes satisfy the majority of the requirements of the periodic assessment.

4.7 NUMARC 93-01 Section 12.2, Guidance

4.7.1 NUMARC 93-01 Section 12.2.1, Review of Goals (a)(1)

On a periodic basis, goals established under (a)(1) of the Maintenance Rule shall be reviewed. The review should include an evaluation of the performance of the applicable SSCs against their respective goals and should also evaluate each goal for its continued applicability.

Specific Ongoing Activities and Documentation Required to Support Streamlined Assessment for Section 12.2.1

Typically, the responsible system engineer should be reviewing the goals established under (a)(1) on an ongoing basis. The system engineers should be responsible for the following ongoing activities to support a streamlined periodic assessment Section 12.2.1.

- Routinely evaluating performance of the applicable SSCs against their goals, and evaluating each goal for its continued applicability
- Where appropriate, proposing changes to the (a)(1) action plans for expert panel review
- Providing input for the Maintenance Rule Quarterly Report and the Maintenance Rule database (if applicable) on the status of goals

The expert panel (or other oversight group) should perform the following activities to support a streamlined periodic assessment. Responsibilities for the expert panel needed to support a streamlined periodic assessment for all of the periodic assessment sections are summarized in Table 4-4.

- Approval of goals for SSCs being placed in (a)(1) status. At some plants, a manager approves the goals, and the expert panel reviews the goals at a later date.
- Review the existing goals established under (a)(1) on at least a quarterly basis, typically by reviewing the Quarterly Reports.
- Ensuring that goals are being appropriately monitored.
- If goals (including schedule) need to be modified, the expert panel should approve the changes in goals.
- SSCs that are ready to be reclassified from (a)(1) to (a)(2) should be reviewed by the expert panel.

- The timeliness of actions associated with (a)(1) SSCs should be reviewed on a quarterly basis by the Maintenance Rule expert panel, as part of their review of the Maintenance Rule Quarterly Report.

The Maintenance Rule (a)(1) action plans should document the corrective actions, and goals, regarding the SSCs. Table 4-1 identifies all of the items that should be in an (a)(1) action plan to support a streamlined assessment. For SSCs, where goals were not met, the Maintenance Rule (a)(1) action plans should describe the revised goals and/or corrective actions.

The Maintenance Rule Quarterly Reports should contain the following information regarding goals to support a streamlined periodic assessment. An expert panel or other oversight group, on at least a quarterly basis, should review each of these items. Table 4-2 lists suggested contents for a Quarterly Report to support a streamlined periodic assessment.

- The status and results of monitoring activities for SSCs under (a)(1), including the results of goals that were met. (In some cases this information is included instead in the (a)(1) SSC health report, since the applicable system engineers is responsible for this monitoring.)
- A summary of SSCs reclassified from (a)(1) to (a)(2), and the basis.
- A summary of SSCs reclassified from (a)(2) to (a)(1) and the basis. (In some cases this information is included instead in the (a)(1) SSC health report, since the applicable system engineers is responsible for this monitoring.)
- A summary of any changes to goals or corrective actions.
- A discussion on timeliness of actions associated with (a)(1) SSCs.

Discussion of Suggested Content for Periodic Assessment Section

The Conclusions Subsection should summarize the overall findings for this section of the report, including any noted weaknesses.

The Discussion/Details Subsection should describe how the activities of the system engineer and the expert panel, as well as the documentation in the Quarterly Report (or Monthly Report or System Health Reports) and the Maintenance Rule (a)(1) action plans fulfill the requirements of this section. Overall results and any significant conclusions or observations should be documented in the periodic assessment.

The details to include in this section [such as the SSCs dispositioned from (a)(1) to (a)(2)] are up to each utility. As a minimum, the appropriate Quarterly Reports and (a)(1) action plans where the details are documented should be referenced. Alternatively, the Quarterly Reports and (a)(1) action plans can be attached to the report. A final option is to extract the appropriate details from the documentation (copy and paste).

4.7.2 NUMARC 93-01 Section 12.2.2, Review of SSC Performance (a)(2), Plant Level Criteria

On a periodic basis, SSC performance related to plant level criteria should be assessed to determine maintenance effectiveness. The assessment should determine if performance is acceptable. If performance is not acceptable, the cause should be determined and corrective action implemented.

Specific Ongoing Activities and Documentation Required to Support Streamlined Assessment

Typically, the Maintenance Rule Coordinator is responsible for monitoring the Plant Level Performance Criteria. The Maintenance Rule Coordinator should be responsible for the following activities to support a streamlined assessment.

- Entering plant level events into the Maintenance Rule database, or other applicable document (at least quarterly).
- Reporting the plant level performance and performance criteria in the Quarterly Report.
- Confirming cause determination activities are initiated following plant level events, including significant unplanned capability or capacity factor losses.
- Confirming appropriate changes in maintenance practice are initiated to prevent recurrence of established causes (possibly by reviewing root cause evaluation, or by checking with appropriate system engineers).
- If Plant Level Performance Criteria are exceeded, the Maintenance Rule Coordinator determines whether a (a)(1) classification is appropriate and presents the recommendation to the expert panel for approval.

The expert panel should review the plant level performance, at least on a quarterly basis. Specifically, the expert panel should be responsible for the following items:

- Reviewing the Maintenance Rule Coordinator recommendations for (a)(1) classification when performance criteria are exceeded
- Reviewing actual plant level performance for the quarter to assess maintenance effectiveness

The Maintenance Rule database (or other applicable document) should contain the status of plant level performance, and contain reference to plant level events.

The Maintenance Rule Quarterly Report should contain the following information to support a streamlined assessment:

- Actual plant level performance relative to the plant level performance criteria
- Discussion of plant level SSCs that have exceeded the performance criteria, and whether the SSCs are being placed in (a)(1)

Discussion of Suggested Content for Periodic Assessment Section

The Conclusions Subsection should summarize the overall findings for this section of the report, including any noted weaknesses.

The Discussion/Details Subsection should describe how the activities of the Maintenance Rule Coordinator and the expert panel, as well as the documentation in the Quarterly Report (or Monthly Report or System Health Reports), the Maintenance Rule database (if applicable), and the Maintenance Rule (a)(1) action plans fulfill the requirements of this section. Overall results and any significant conclusions or observations should be documented in the periodic assessment.

The details to include in this section (such as a summary of plant level performance for the reporting period) are up to each utility. As a minimum, the appropriate Quarterly Reports, Maintenance Rule database (if applicable), and (a)(1) action plans where the details are documented should be referenced. Alternatively, the Quarterly Reports and (a)(1) action plans can be attached to the report. A final option is to extract the appropriate details from the documentation (copy and paste).

4.7.3 NUMARC 93-01 Section 12.2.2, Review of SSC Performance (a)(2), SSC Performance Criteria

For SSCs that are being monitored under (a)(2), the periodic assessment should include a review of the performance against the established criteria.

Specific Ongoing Activities and Documentation Required to Support Streamlined Assessment

Typically, the system engineers routinely monitor the performance of SSCs on a monthly basis, and enter data into the Maintenance Rule database (or another applicable document). The system engineer evaluates equipment problems that are potential functional failures to determine if they are actual functional failures and MPFFs.

The Maintenance Rule Coordinator, or another designated individual should periodically (quarterly) review a sampling of condition reports (or other appropriate source of potential equipment problems) and associated Maintenance Rule documentation to determine if the correct functional failure and MPFF determinations are made. The results of the review are reported to the expert panel. If deficiencies are found, appropriate action is taken.

The expert panel should review a sampling of the SSCs in (a)(2) at least on a quarterly basis, and assure actions are taken when significant adverse trends are observed, or when performance criteria are exceeded. Also, the expert panel should verify that all of the system engineers are continuing to monitor and report the SSCs in (a)(2).

Documentation should be maintained for all potential functional failures. The documentation should provide the basis for the decisions whether an equipment problem is classified as a functional failure and an MPFF. Documentation can be in the Maintenance Rule database, or other locations. A potential functional failure is one where it takes a certain amount of investigation to determine if the equipment problem is a functional failure. If it is obvious that an equipment problem is not a functional failure, then it is not necessary to document it; otherwise the equipment problem should be documented as a *potential functional failure*.

The Maintenance Rule Quarterly Report (or system health reports) should document the SSC performance against the established performance criteria. Any significant trends or SSCs that have exceeded performance criteria should be noted, including the disposition. Any functional failures and MPFFs for the quarter should be highlighted.

Discussion of Suggested Content for Periodic Assessment Section

The Conclusions Subsection should summarize the overall findings for this section of the report, including any noted weaknesses.

The Discussion/Details Subsection should describe how the activities of the system engineers, the Maintenance Rule Coordinator and the expert panel, as well as the documentation in the Quarterly Report (or Monthly Report or System Health Reports), the Maintenance Rule database (if applicable), and the functional failure documentation fulfill the requirements of this section. Overall results and any significant conclusions or observations should be documented in the periodic assessment.

The details to include in this section (such as a showing the actual performance against the performance criteria) are up to each utility. As a minimum, the appropriate Quarterly Reports, Maintenance Rule database (if applicable), and functional failure documentation where the details are documented should be referenced. Alternatively, the Quarterly Reports and a listing of functional failures can be attached to the report. A final option is to extract the appropriate details from the documentation (copy and paste).

4.7.4 NUMARC 93-01 Section 12.2.2, Review of SSC Performance (a)(2), Industry Operating Experience

Where appropriate, industrywide operating experience should be reviewed to identify potential problems that are applicable to the plant. Applicable industry problems should be evaluated and compared with the existing maintenance and monitoring activities. Where appropriate, adjustments should be made to the existing programs.

Specific Ongoing Activities and Documentation Required to Support Streamlined Assessment

The system engineer should be responsible for the following activities related to industry operating experience:

- Reviews IOE in the establishment of goals/corrective actions for SSCs entering (a)(1). Documents the review, including the information sources in the Maintenance Rule (a)(1) action plans.
- Reviews industry-operating experience when evaluating MPFFs or FFs. Reviews the IOE to see if an event could have been prevented. Documents the review in the functional failure documentation.
- The system engineer should evaluate industry problems identified through the IOE Program, and make adjustments to the existing programs when appropriate.

The expert panel should assure the Maintenance Rule (a)(1) action plans have considered IOE as part of their review.

The MPFF reviews should document the review of industry operating experience when determining if MPFFs are repetitive. This needs to be a requirement - the system engineer must review potential MPFFs, using industry-operating experience to determine if the functional failures are repetitive.

The Maintenance Rule (a)(1) action plans should document the review of industry operating experience in the formulation of corrective actions/goals, including the industry sources reviewed.

The Operating Experience Program typically handles the routine incorporation of industry wide operating experience into the maintenance program. Any instances where the Operating Experience Program, as it relates to maintenance practices, is found to be ineffective should be documented in the Maintenance Rule Program. For example, if an MPFF occurred and it was determined that the plant failed to apply a lesson learned from an industry event that should have been handled in the Operating Experience Program this should be documented, discussed in the Quarterly Report, and considered for goal setting.

Discussion of Suggested Content for Periodic Assessment Section

The Conclusions Subsection should summarize the overall findings for this section of the report, including any noted weaknesses.

The Discussion/Details Subsection should describe how IOE is handled in the (a)(1) process, in the MPFF or FF review process, and how the Operating Experience Program interfaces with the Maintenance Rule program. Overall results and any significant conclusions or observations should be documented in the periodic assessment.

The details to include in this section are up to each utility. As a minimum, the (a)(1) action plans and the functional failure evaluation documentation where the details are documented should be referenced. Additionally, the role of the Operating Experience Program should be discussed. Alternatively, the (a)(1) action plans and the functional failure evaluation documentation can be attached to the report. A final option is to extract the appropriate details from the documentation (copy and paste).

4.7.5 NUMARC 93-01 Section 12.2.3, Review of Effectiveness of Corrective Actions

As part of the periodic review, corrective actions taken as a result of ongoing maintenance activities or goal setting should be evaluated to ensure action was initiated when appropriate and the action(s) taken resulted in improved performance of the SSC. Corrective actions that should be reviewed include the following:

- Actions to ensure that SSC performance meets goals established by requirements of (a)(1)
- Actions taken as a result of cause determination as required in Section 9.3.3 or 10.2.2, and
- Status of problem resolution, if any, identified during the previous periodic assessment

Specific Ongoing Activities and Documentation Required to Support Streamlined Assessment

The system engineer should be responsible for the following activities related to corrective actions:

- Identifying corrective actions for SSCs being placed in (a)(1) for review
- Identifying corrective actions for SSCs in (a)(1) that are ineffective, and proposing revised corrective actions
- When (a)(1) corrective actions cannot be completed on schedule, bringing the issue to the attention of the expert panel to change the priority on the corrective action or to revise the schedule for completing the corrective actions.
- Include (a)(1) status update in system specific health report, or Quarterly Report
- Identifying corrective actions for SSCs remaining in (a)(2) status and evaluating the effectiveness of corrective actions taken to ensure continued (a)(2) status

The expert panel should be responsible for the following activities related to corrective actions:

- Reviewing (and in many cases approving) the corrective actions for SSCs being placed in (a)(1), including revised corrective actions for those that have been ineffective.
- Where corrective actions are not being completed on schedule, taking action to assure completion of corrective actions receives the appropriate priority, and where appropriate, approving changes to the schedule for completing corrective actions.

- The timeliness of identifying and completing corrective actions associated with (a)(1) SSCs should be reviewed on a quarterly basis by the expert panel, as part of their review of the Maintenance Rule Quarterly Report (also discussed in Section 12.2.1).
- Reviewing on a quarterly basis the status of problem resolution, if any identified during the previous periodic assessment. Additionally, the status of problem resolution for any other problems identified by self-assessments, NRC inspections, or QA audits should be reviewed quarterly by the expert panel.

The Maintenance Rule (a)(1) action plans should include the following items. Table 4-1 contains a complete list of suggested items to include in the (a)(1) action plans to address all of the periodic assessment requirements.

- List of corrective actions, and schedule for completion of corrective actions
- Documentation of corrective actions that were ineffective
- Documentation of corrective actions that were not completed on schedule, and the basis for revising the schedule

The Maintenance Rule Quarterly Report should document the following items. Table 4-2 contains a complete list of suggested items to include in the (a)(1) action plans to address all of the periodic assessment requirements.

- Summary of SSCs in (a)(1), including the corrective actions
- Corrective actions that have been ineffective
- Corrective actions that have been completed, particularly if all corrective actions for an SSC in (a)(1) have been completed (monitoring phase of goal setting)
- Summarizing the status of problem resolution, if any, identified during the previous periodic assessment. Additionally, the status of problem resolution for any other problems identified by self-assessments, NRC inspections, or QA audits should be summarized
- Corrective actions that are not completed on schedule, and the actions taken

The functional failure documentation (Table 4-3) should discuss or reference actions (corrective) taken as a result of the failure.

Discussion of Suggested Content for Periodic Assessment Section

The Conclusions Subsection should summarize the overall findings for this section of the report, including any noted weaknesses.

The Discussion/Details Subsection should describe how the ongoing activities handle corrective actions, and in particular, (a)(1) corrective actions. Also, the actions taken as a result of the various cause determinations performed during the period should be discussed. It might be concluded that they appear to be effective in that additional goal setting was not required due to an adverse trend or exceedance of a performance criteria. Overall results and any significant conclusions or observations should be documented in the periodic assessment. The overall effectiveness of (a)(1) corrective actions and the status of problem resolution from the previous assessment should be definitely summarized.

The details to include in this section are up to each utility. As a minimum, the (a)(1) action plans, Maintenance Rule Quarterly Report, and the functional failure evaluation documentation where the details are documented should be referenced. Alternatively, the Maintenance Rule Quarterly Reports, (a)(1) action plans and the functional failure evaluation documentation can be attached to the report. A final option is to extract the appropriate details from the documentation (copy and paste).

4.7.6 NUMARC 93-01 Section 12.2.4, Optimizing Availability and Reliability for SSCs

For risk-significant SSCs, adjustments shall be made where necessary to maintenance activities to ensure that the objective of preventing failures is appropriately balanced against the objective of assuring acceptable SSC availability. For operating nonrisk-significant SSCs, it is acceptable to measure SSC performance against overall plant performance criteria and for standby systems to measure performance against specific criteria.

The intent is to optimize availability and reliability of the safety functions by properly managing the occurrence of SSCs being out of service for preventive maintenance activities. This optimization could be achieved by any of the following:

- Ensuring that appropriate preventive maintenance is performed to meet availability objectives as stated in plant risk analysis, FSAR, or other reliability approaches to maintenance
- Allocating preventive maintenance to applicable tasks commensurate with anticipated performance improvement (for example, pump vibration analysis instead of teardown)
- Reviewing to determine that availability of SSCs has been acceptable
- Focusing maintenance resources on preventing those failure modes that affect a safety function, or
- Scheduling, as necessary, the amount, type, or frequency of preventive maintenance to appropriately limit the time out of service

Specific Ongoing Activities and Documentation Required to Support Streamlined Assessment

The system engineer should be responsible for the following actives that address the Optimizing of Reliability and Availability of risk significant SSCs:

- Considering the balancing of reliability and availability when placing an SSC in (a)(1) and documenting the balancing evaluation in the Maintenance Rule (a)(1) action plan
- Considering and documenting the balancing of reliability and availability when a performance criteria is exceeded, and the SSC is not placed in (a)(1).

The expert panel should be responsible for the following activities that address the Optimizing of Reliability and Availability:

- Assuring the balancing of reliability and availability was evaluated for all SSCs being placed in (a)(1)
- Assuring the balancing of reliability and availability was also evaluated for SSCs, which had performance criteria, exceeded, and the SSC was not placed in (a)(1)

No special balancing evaluation is required for SSCs in (a)(2). These SSCs can be considered balanced if the established performance criteria are not exceeded. However, the utility may choose to credit some of the following activities to demonstrate balancing of reliability and availability:

- Credit for a Reliability Centered Maintenance program or a Preventive Maintenance Optimization program
- Use of PSA *Cumulative Risk Curves*, showing the impact of equipment out of service on overall plant risk.
- Discussion of how the (a)(4) work control process achieves the goal of balancing reliability and availability

The Maintenance Rule (a)(1) action plans should include a discussion of the evaluation of the balancing of reliability and availability.

For SSCs that exceed performance criteria, but the SSC is not placed in (a)(1), the FF documentation should include a discussion of the evaluation of the balancing of reliability and availability.

The Maintenance Rule Quarterly Report should list any SSCs where the performance criteria was revised to achieve a better balance between reliability and availability.

Discussion of Suggested Content for Periodic Assessment Section

The Conclusions Subsection should summarize the overall findings for this section of the report, including any noted weaknesses.

The Discussion/Details Subsection should describe how the ongoing activities handle optimizing of reliability and availability. The balancing evaluations performed for SSCs entering (a)(1), or SSCs that exceed performance criteria, should be discussed. There should be a discussion stating that no special balancing evaluation is required for SSCs in (a)(2). These SSCs can be considered balanced if the established performance criteria are not exceeded. However, the utility may choose to credit some other activities to demonstrate balancing of reliability and availability. The utility may choose to describe how the work control program (a)(4) achieves a balance of reliability and availability.

The details to include in this section are up to each utility. As a minimum, the balancing evaluations or (a)(1) items should be discussed. Also, references should be provided listing where the balancing evaluations are documented. Alternatively, the balancing evaluations contained in the (a)(1) action plans and the functional failure evaluation documentation can be attached to the report. A final option is to extract the appropriate details from the documentation (copy and paste).

4.7.7 NUMARC 93-01 Section 13.5, Documentation of Periodic Assessment

The periodic assessment described above should be documented. Appropriate details or summaries of results should be available on the following topics:

- The results of monitoring activities for SSCs considered under (a)(1). The documentation should include the results of goals that were met
- Evaluation of performance criteria or goals that were not met, along with the cause determinations and associated corrective actions taken
- Corrective actions for (a)(1) and (a)(2) that were not effective
- A summary of SSCs redispositioned from (a)(2) to (a)(1), and the basis
- A summary of SSCs redispositioned from (a)(1) to (a)(2), and the basis
- Identify changes to maintenance activities that result in improving the relationship of availability and preventive maintenance

Specific Ongoing Activities and Documentation Required to Support Streamlined Assessment

No specific ongoing activities or documentation are required for this section to support a streamlined assessment. The purpose of including this section is to ensure all of the documentation requirements are addressed in other sections of the report. Each of the documentation requirements is addressed below:

- The results of monitoring activities for SSCs considered under (a)(1). The documentation should include the results of goals that were met. The documentation requirements to address results of monitoring activities under (a)(1) are discussed in the section on Review of Goals above.
- Evaluation of performance criteria or goals that were not met, along with the cause determinations and associated corrective actions taken. The documentation requirements to address performance criteria or goals that were not met, along with the cause determinations and corrective actions taken is discussed in several sections. They are: Review of Goals, SSC Performance Criteria, Plant Level Criteria, and Effectiveness of Corrective Actions.
- Corrective actions for (a)(1) and (a)(2) that were not effective. The documentation addressing corrective actions for (a)(1) and (a)(2) that were not effective are discussed in the Corrective Actions Section.
- A summary of SSCs reclassified from (a)(2) to (a)(1), and the basis. The documentation discussing SSCs reclassified to (a)(1) is in the Review of Goals section above.

- A summary of SSCs reclassified from (a)(1) to (a)(2), and the basis. The documentation discussing SSCs reclassified to (a)(2) is in the Review of Goals section above
- Identify changes to maintenance activities that result in improving the relationship of availability and preventive maintenance. Documentation summarizing changes to maintenance activities that result in improving the relationship of availability and preventive maintenance is in the Optimizing Reliability and Availability section above.

Discussion of Suggested Content for Periodic Assessment Section

Section 13.5 of NUMARC 93-01 specifies numerous items to document in the periodic assessment. The method of complying with the NUMARC requirements is described below. In this section, the method of addressing each documentation requirement should be discussed. The required documentation is as follows:

- The results of monitoring activities for SSCs considered under (a)(1). The documentation should include the results of goals that were met.
- Evaluation of performance criteria or goals that were not met, along with the cause determinations and associated corrective actions taken.
- Corrective actions for (a)(1) and (a)(2) that were not effective.
- A summary of SSCs redispositioned from (a)(2) to (a)(1), and the basis.
- A summary of SSCs redispositioned from (a)(1) to (a)(2), and the basis.
- Identify changes to maintenance activities that result in improving the relationship of availability and preventive maintenance.

4.7.8 *Structural Monitoring Program*

Specific Ongoing Activities and Documentation Required to Support Streamlined Assessment

The structural monitoring program is not called out as a separate periodic assessment item in the NUMARC guidance. Nevertheless, since the structural monitoring program is included as part of the Maintenance Rule, the status of the program should be addressed as part of the periodic assessment. Since the activities associated with the structural monitoring program are typically different than the other Maintenance Rule activities, the structural monitoring program should be addressed as a separate periodic assessment section. Alternatively, a separate periodic assessment could be issued for the structural monitoring program.

No special ongoing activities or documentation regarding structural monitoring should be required to support the periodic assessment:

Discussion of Suggested Content for Periodic Assessment Section

Typically, the structural monitoring program is not addressed in the Maintenance Rule Quarterly Report or other standard Maintenance Rule documentation. Thus, many of the details of the structural monitoring program should be described in the periodic assessment:

- List the procedures or guidelines that govern the structural monitoring program and activities
- Describe the structural monitoring activities or milestones that were accomplished during the period
- Document the results from the structural monitoring program
- Identify any structures in (a)(1), the corrective actions, goals, and schedule for reclassifying to (a)(2)
- Identify any significant problems with structures that did not result in a (a)(1) classification

4.7.9 Optional Subjects for Periodic Assessment

There are many subjects that are not required by the NRC or by the NUMARC Guideline to be included in a periodic assessment, but have been added by several utilities. The following items are optional items to include in the periodic assessment:

- Review of (a)(4) program
- Maintenance Rule knowledge and training
- Expert panel effectiveness
- Incorporation of PSA updates into Maintenance Rule program
- Maintaining a Living Maintenance Rule Program (impact of design changes, procedure changes, PSA changes)

Specific Ongoing Activities and Documentation Required to Support Streamlined Assessment

Since these items are optional, there are no specific recommendations on how ongoing activities should handle these items.

Discussion of Suggested Content for Periodic Assessment Section

Since these items are optional, there are no specific recommendations on how these items should be documented in the periodic assessment.

Table 4-1
Suggested Content in Maintenance Rule (a)(1) Action Plans to Support Streamlined Maintenance Rule Periodic Assessment

- The applicable SSC(s) and SSC function(s).
- The performance criteria exceeded, including the performance criteria and the actual performance.
- The cause for not meeting the performance criteria.
- Description of the analysis performed relative to the balance of availability and reliability (required per NUMARC 12.2.4 for risk-significant SSCs exceeding their availability or reliability PCs, and optional for nonrisk-significant SSCs exceeding their PCs).
- Summary of corrective actions and the specific condition report numbers. Include the schedule for completion of each corrective action.
- Description of the IOE sources considered in developing the recommended corrective actions and goals.
- Optional: For risk-significant functions, description of the effect the actual performance had on the core damage frequency or large early release frequency (quantitative or qualitative assessment).
- Specific quantitative performance monitoring goal(s), including method of monitoring, numeric value(s), frequency and duration of monitoring period.
- Describe when the SSC can return to (a)(2) status.
- Schedule for completion of monitoring.
- Description of changes to corrective actions and monitoring, including schedule or actions.

Table 4-2
Suggested Content in Maintenance Rule Quarterly Report to Support Streamlined Maintenance Rule Periodic Assessment

1. SSCs that have entered (a)(1) and basis
2. SSCs that have moved to (a)(2) and basis
3. SSCs in (a)(1), schedule for return to (a)(2) and basis
4. List of corrective actions that have been ineffective, or needed modification
5. Attach Maintenance Rule (a)(1) Action Plans
6. Summary of performance criteria and actual performance (SSC and plant level)
7. Listing of functional failures, MPFFs, and RMPFFs for quarter
8. Discussion of timeliness (system engineer MPFF evaluations, development of (a)(1) action plans)
9. Status of problem resolution (previous periodic assessment, Maintenance Rule self-assessments, NRC inspections, QA audits)
10. List any examples where performance criteria was revised to achieve a better balance between reliability and availability

Table 4-3
Suggested Documentation for Maintenance Rule Cause Determination (for Evaluation of Functional Failures)

1. Any potential functional failure (FF) must be documented and retrievable.
2. Document basis for determination if condition is not considered an FF. This should be performed for any potential FFs.
3. For FF, discussion if the failure was maintenance preventable (MPFF), that is, the cause of the failure. Document basis for determination if condition is not considered a MPFF.
4. For MPFFs, discussion if failure was repetitive (RPMFF). Include review of plant history and industry operating experience for RMPFF determination. Includes documentation of plant sources and industry sources and conclusion reached.

Table 4-4
Requirements for Expert Panel Review

1. For SSCs considered for (a)(1), assure actions are being taken in a timely manner commensurate with the safety significance of the SSC.

2. For SSCs considered for (a)(1), assure IOE properly evaluated.

3. For risk significant SSCs considered for (a)(1), assure review of balancing was done.

4. For SSCs considered for (a)(1), assure corrective actions and goals are appropriate, including schedule.

5. For SSCs in (a)(1), assure corrective actions being completed on schedule. Corrective actions being delayed should be reviewed and approved by the expert panel.

6. Review (a)(2) SSCs at least quarterly to assure actions are being taken when adverse trends are noted, or if performance criteria are exceeded.

5
RUN-TO-FAILURE GUIDELINE

5.1 Introduction

This report provides a non-binding, generic run to failure guideline to meet the Maintenance Rule requirement described by the NUMARC 93-01 Industry Guideline. Equipment that is determined to provide little or no contribution to system safety function can be allowed to run to failure and perform corrective maintenance rather than preventive maintenance.

Maintenance and reliability professionals should be aware that run to failure described by the NUMARC 93-01 Industry Guideline may be different from the run to failure described in earlier Reliability Centered Maintenance programs or some Preventive Maintenance programs. In the Maintenance Rule program, if an SSC is designated as run to failure, then failure finding and condition monitoring preventive maintenance that has economic value may still be performed.

This guideline provides run to failure determination guidance for equipment that is modeled in the PRA or is not modeled in the PRA. This report uses two criteria to determine if the equipment provides little or no contribution to system safety function: 1) not risk significant, and 2) no more than a little contribution to system safety function. This guideline recommends the methodology for determining the risk significance of equipment in the PRA model be adjusted to use only two risk importance measures, the Risk Achievement Worth and the Fussell-Vesely. The first criterion of not risk-significant shows run to failure is the appropriate preventive maintenance classification in accordance with the Quadrant Chart For Preventive Maintenance Objectives methodology developed in the EPRI report on *Reliability and Risk Significance For Maintenance And Reliability Professionals At Nuclear Power Plants*. The current NUMARC 93-01 Industry Guideline for determining risk significant equipment does **not** specify how to adjust the truncation level in PRA software so that all the risk significant components with a Risk Achievement Worth greater than threshold are identified in the final cut set equation. Therefore, this guideline recommends adding truncation level criteria to assure this methodology is valid with the pending Nuclear Energy Institute (NEI) risk informed guideline. This report uses the specific guidance for determining the values of the importance measure from the pending draft revision of the NEI 00-04, 10 CFR 50.69 SSC Categorization Guideline to assure all the risk significant components are identified on the Quadrant Chart. The second criterion of no more than a little contribution to safety system function meets the NUMARC 93-01 Industry Guideline using plant specific criteria.

This risk informed guideline may conflict with the improved criteria for the identification of run to failure in the INPO AP-913, Equipment Reliability Process Description. The improved criteria in Revision 1 uses the PRA model as only one of the tools to perform this evaluation, and is not integrated with the risk informed process used in the EPRI report on Reliability and Risk Significance or the NEI 00-04, 10 CFR 50.69 SSC Categorization Guideline.

This non-binding, generic guideline describes the necessary elements of run to failure determination for those personnel with the responsibility for the Maintenance Rule and Preventive Maintenance programs, or the nuclear power plant systems and components.

5.2 Background

As of July 10, 1996 with the implementation date of the Maintenance Rule, all structures, systems and components (SSCs) that are within the scope of the Maintenance Rule have been categorized as either (a)(1) or (a)(2) and are required to be part of the preventive maintenance program. Listed below are: the requirement, industry guideline, Nuclear Regulatory Commission (NRC) web page response, and others that apply to the Maintenance Rule program, as well as pending draft revision of the NEI 00-04, 10 CFR 50.69 SSC Categorization Guideline.

5.2.1 10 CFR 50.65 (a)(2) Requirement

This requirement for monitoring the effectiveness of maintenance at nuclear power plants is stated in part 50.65 of the Code of Federal Regulations in paragraph (a)(2) as provided below.

> Monitoring as specified in paragraph (a)(1) of this section is not required where it has been demonstrated that the performance or condition of a structure, system, or component is being effectively controlled through the performance of appropriate preventive maintenance, such that the structure, system, or component remains capable of performing its intended function.

NUMARC 93-01 Industry Guideline for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants

The Nuclear Energy Institute (NEI) has developed and maintained an industry guideline to assist the industry in implementing the Maintenance Rule[1]. Section 10.0 of that guideline provides guidance on SSCs Subject To Effective Preventive Maintenance Programs.

Note this guideline defines the preventive maintenance programs as including both the preventive maintenance and the predictive maintenance programs. This is noted for clarification, because at some nuclear power plants the organizational chart may have two separate programs, predictive maintenance and preventive maintenance.

[1] *Industry Guideline for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants* NUMARC 93-01, Revision 3, July 2000.

Guidance

All SSCs determined to be within the scope of the Maintenance Rule are subject to an effective PM program as indicated by (a)(2) (see Section 10.0). SSCs that are within the scope of (a)(2) could be included in the formal PM program, be inherently reliable (for example, visual inspection during walkdowns to meet licensee requirements that already exist), or be allowed to run to failure (provide little or no contribution to system safety function).

Evaluating SSCs Against Risk Significance and Performance Criteria

SSCs that provide little or no contribution to system safety function could be allowed to run to failure (that is, perform corrective maintenance rather than preventive maintenance) and are addressed by (a)(2).

Maintenance Preventable Functional Failures (MPFFs)

Examples That Are Not MPFFs: Intentionally Run-to-failure

Guidance

The methodology for implementing the Maintenance Rule by demonstrating maintenance program effectiveness or inherent reliability in lieu of SSC goal setting is shown on the Industry Guideline Implementation Logic Diagram (Figure 1). Although goals are set and monitored as part of (a)(1), the preventive maintenance (PM) and performance monitoring activities are part of (a)(2) and apply to all SSCs that are within the scope of the Maintenance Rule. SSCs that are within the scope of (a)(2) could be included in the formal PM program, be inherently reliable (for example, visual inspection during walkdowns to meet licensee requirements that already exist), or be allowed to run to failure (provide little or no contribution to system safety function).

. . .

SSCs that provide little or no contribution to system safety function, therefore could be allowed to run to failure (that is, perform corrective maintenance rather than preventive maintenance) and are addressed by (a)(2).

Regulatory Guide (RG) 1.160 [2] endorses Revision 2 of the industry guideline with provisions and clarifications. Regulatory Guide (RG) 1.182 [3] endorses the updated section 11 in Revision 3 of the industry guideline with provisions and clarifications.

The industry guideline provides methods that are acceptable to the NRC for complying with the requirements of the Maintenance Rule. The Nuclear Regulatory Office of Enforcement has identified that the industry guideline is nonbinding and thus, does not represent requirements. Inspectors generally reference the Regulatory Guide and the industry guideline to understand how licensees typically implement their Maintenance Rule programs and in defining terms as they are commonly used with respect to the implementing guideline. Therefore, this Maintenance Rule Run-to-Failure Guideline continues to define industry guideline terms as they are commonly used.

This Maintenance Rule Run-to-Failure Guideline applies a new methodology summarized by the Quadrant Chart For Preventive Maintenance Objectives that was developed in the EPRI report on Reliability and Risk Significance[4]. The Quadrant Chart For Preventive Maintenance Objectives enables the Maintenance Rule program and preventive maintenance program staff to determine run to failure classification decisions based on the quantitative risk of SSCs modeled in the plant Probabilistic Risk Assessment (PRA). The Quadrant Chart For Preventive Maintenance Objectives summarily defines the PM classification of Critical, Non-Critical and Run-to-Failure in a manner that can be easily implemented by the staff, and succinctly presented to plant management and inspectors.

NRC Maintenance Rule Web Page Response to Frequently Asked Questions

The Maintenance Rule Run-to-Failure Guideline included the NRC Maintenance Rule Web Page response to run-to-failure. The guideline incorporated the general intent of the NRC recommendation that any criteria established for run-to-failure should be based on the key principles for risk-informed decision making. The principles are: 1) current regulations must be met, 2) defense-in-depth must be maintained, 3) safety margins must be maintained, and 4) increases in Core Damage Frequency (CDF) or risk should be small and consistent with the intent of NRC's Safety Goal Policy Statement[5].

Interface With INPO Intolerance for Unanticipated Failure of Important Equipment

The Institute of Nuclear Power Operations (INPO) has issued a standard of excellence for equipment reliability. INPO has issued a letter to achieve the common success factor of an

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[2] U.S. Regulatory Commission. *Monitoring the Effectiveness of Maintenance at Nuclear Power Plants.* Regulatory Guide 1.160, Revision 2, March 1997.

[3] U.S. Regulatory Commission. *Assessing and Managing Risk Before Maintenance Activities at Maintenance at Nuclear Power Plants.* Regulatory Guide 1.182, Revision 0, May 2000.

[4] Reliability and Risk Significance for Maintenance and Reliability Professionals at Nuclear Power Plants, EPRI, Palo Alto, CA: December 2001.

[5] U.S. Regulatory Commission., "Safety Goals for the Operation of Nuclear Power Plants; Policy Statement," *Federal Register*, Volume 51, page 30028 (51 FR 30028), August 4, 1986.

intolerance for unanticipated failures of important (critical) **equipment** at all levels of each plant's organization[6].

This risk informed Maintenance Rule Run-to-Failure Guideline may conflict with the improved criteria for the identification of critical and run to failure in the INPO AP-913, Equipment Reliability Process Description. Revision 1 of INPO AP-913, Equipment Reliability Process Description was issued in November 2001, which is the same month INPO issued the letter on the standard of excellence for equipment reliability. The improved criteria in Revision 1 uses the PRA model as only one of the tools to perform this evaluation, and is not integrated with the risk informed process used in the EPRI report on Reliability and Risk Significance or the NEI 00-04, 10 CFR 50.69 SSC Categorization Guideline.

The potential for conflict in program application was shown in May 2002, during the INPO assistance visit at the First Energy Nuclear Operating Company (FENOC) Perry Nuclear Power Plant. Assistance was provided in the areas of equipment performance and implementation of INPO AP-913, Equipment Reliability Process Description. The action plan included a key improvement opportunity to modify the FENOC definition of critical components to be consistent with AP-913. As a result of the INPO action plan, the planned Perry Preventive Maintenance Classification (in Appendix B) was not implemented until a future revision to INPO AP-913 includes a risk-informed methodology for the definition of critical components.

Pending Risk Informed 10 CFR 50.69 Regulation And South Texas Special Exemption

The pending Nuclear Energy Institute (NEI) 00-04, 10 CFR 50.69 SSC Categorization Guideline[7] provides detailed guidance on categorizing structures, systems and components for licensees that choose to adopt the pending 10 CFR 50.69, Scope of Structures, Systems and Components Governed by Special Treatment Requirements. 10 CFR 50.69 defines two categories of safety significance: high and low. Safety-related SSCs categorized as low safety significant would not be subject to special treatment, would be removed from the licensee's Maintenance Rule program, and would require monitoring to provide reasonable assurance the function is maintained. NEI 00-04 describes the methodology to obtain the Fussell-Vesely and Risk Achievement Worth importance measures and to solve the cutset equation with recommended truncation valves.

This risk informed Safety Significance Categorization option to establish special treatment is similar to the Exception Request that has been granted to the South Texas Project.

When the Maintenance Rule program is revised with 10 CFR 50.69 or with the South Texas Project Exemption Request, the requirement for run-to-failure classification is no longer relevant, since the SSCs that are risk ranked as low-safety significant are removed from the scope of the Maintenance Rule. The safety-related SSCs that are categorized as high-safety significant will remain in scope and are too important to be classified as run-to-failure.

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6 INPO Letter to Executive Points of Contact, November 2, 2000.

7 *10 CFR 50.69 SSC Categorization Guideline*, NEI 00-04 Draft Revision C, June 2002.

The Maintenance Rule Run-to-Failure Guideline has followed the NEI-04 10 CFR 50.69 SSC Categorization Guideline method for determining the safety significance.

The Maintenance Rule Run-to-Failure Guideline has also considered the NEI-04 10 CFR 50.69 SSC Categorization Guideline which follows the risk informed regulation principles of NRC Regulatory Guide 1.174, *An Approach for Using Probabilistic Risk Assessment In Risk-Informed Decisions On Plant Specific Changes to the Licensing Basis.*

The principles that were considered to verify the run-to-failure determination does not require a license amendment are as follows:

- Proposed increases in risk, if any, are small and are consistent with the Commission's safety goal policy statement.
- The process will result in changes that are consistent with defense-in-depth philosophy.

The Maintenance Rule run-to-failure Guideline has included the principle listed on the NRC Web Page that current regulations must be met as follows:

- Current regulations are met

The Maintenance Rule run-to-failure determination methodology includes the Maintenance Rule requirement for establishing specific performance criteria to assure that this requirement is not inadvertently eliminated. Inadvertent elimination could potentially occur with the incorrect justification that since the SSC provides little or no contribution to system safety function, performance monitoring is not required.

Objectives

The objectives of this report on Maintenance Rule run-to-failure guideline are the following:

1. Develop a generic, non-binding guideline for all plants to assure compliance with 50.65
2. Review the Reliability Centered Maintenance that included run to failure classification
3. Develop a methodology to determine the key importance measure values that is in accordance with the specific guidance from the pending NEI 00-04, 10 CFR 50.69 SSC Categorization Guideline
4. Identify the necessary run-to-failure allowance criteria
5. Verify the run-to-failure determination does not effect a change to the plant's operating license
6. Assure appropriate specific performance criteria are established for run to failure equipment
7. Develop the program administration when the run-to-failure specific performance criterion is exceeded that an evaluation is required to determine if any corrective action is warranted and

if the SSC should remain in (a)(2), and note that an apparent cause investigation is not required

8. Provide application examples of evaluating: 1) not risk significant, and 2) no more than a little contribution to safety function

Approach

The guideline commences by showing the process is limited to equipment items in the scope of the Maintenance Rule that have the potential to be classified as run-to-failure in the preventive maintenance program pending Maintenance Rule final approval. This process does not consider if predictive maintenance or preventive maintenance is warranted for economic or other consideration, since this is generally the responsibility of the preventive maintenance program.

- Review the Reliability Centered Maintenance classification of run to failure and clarify that Reliability Centered Maintenance in not necessary for this generic guideline.
- Present the Quadrant Chart For Preventive Maintenance Objectives methodology developed in the EPRI report on *Reliability and Risk Significance for Maintenance and Reliability Professionals at Nuclear Power Plants*. The quadrant that is not risk significant by Risk Achievement Worth or Fussell-Vesely justifies that the run to failure classification is the appropriate preventive maintenance classification. The methodology for determining the values of the PRA importance measures includes specific guidance taken from the pending draft revision of the Nuclear Energy Institute 10 CFR 50.69 SSC Categorization Guideline to sufficiently reduce the truncation values so all risk significant components are identified.
- Provide the option of plant-specific criteria to meet the NUMARC 93-01 Industry Guideline to determine if the item provides no more than a little contribution to safety system function.
- Verify the run-to-failure change does not effect a change to the plant's licensing basis by reviewing principles for risk-informed decision making.
- Establish tolerant performance criteria (if specific performance criteria is required) commensurate with the potential to exceed the risk threshold of the Fussell-Vesely importance.

Results

Most maintenance and reliability professionals will benefit from the results of the simple, confident run to failure determination of the equipment that is not risk significant. This report should be useful to the PRA professionals to become knowledgeable of the Maintenance Rule requirements for determining risk significance and monitoring of equipment classified as run to failure. The report recommends the revision of the PRA methodology that quantifies the final cut set equation for Maintenance Rule and preventive maintenance application to specify adjusting the truncation to ensure the identification of all risk-significant, critical components. This identification of all risk-significant critical components will include the highly reliable components which are identified in the Reliability Centered Maintenance process, but which may have been omitted due to truncation during the PSA quantification process. The PRA updating of failure data for equipment classified as run-to-failure is expected to be included in the standard update process to ensure the assumptions of the Maintenance Rule risk significance determination are met. Also, this report addresses equipment that is not modeled in the PRA.

Abstract

This report provides a generic guideline for the Maintenance Rule program to make the final determination that equipment can be run-to-failure in accordance with the Maintenance Rule guideline that this equipment provide "little or no contribution to system safety function." This report uses two criteria to determine if the equipment should be allowed to run to failure: 1) not risk significant, and 2) no more than a little contribution to safety system function. The criterion of not risk significant shows that the run to failure classification is the appropriate preventive maintenance classification in accordance with the Quadrant Chart For Preventive Maintenance Objectives methodology developed in the EPRI report on *Reliability and Risk Significance For Maintenance And Reliability Professionals At Nuclear Power Plants*. When quantitative risk information is not implicitly or explicitly in a PRA model, this report provides guidelines based on qualitative assumptions made in reliability approaches to maintenance. Examples are provided to demonstrate application.

5.3 Maintenance Rule Run-To-Failure Guideline

5.3.1 Introduction

This report explains how the Maintenance Rule program makes the final approval of run-to-failure Determination and justifies not performing preventive maintenance using risk significant parameters.

Section 5.4 describes the Preventive Maintenance Acceptance of run-to-failure, and presents a summary of the Reliability Centered Maintenance Process and the INPO Equipment Reliability Process with emphasis on run-to-failure.

Section 5.5 describes the Quadrant Chart methodology from the EPRI report on Reliability and Risk Significance For Maintenance Rule Reliability Professionals At Nuclear Power Plants. The Quadrant Charts classified the components as run-to-failure that are in the quadrant which is not risk-significant, and do not require simple preventive maintenance. The current NUMARC 93-01 Industry Guideline for determining risk significant equipment does not specify how to adjust the truncation level in various types of PRA software so that all the risk significant components with a Risk Achievement Worth greater than 2.0 are identified in the final cut set equation. This methodology for determining the values of the PRA importance measures includes specific guidance taken from the pending draft revision of the NEI 00-04, 10 CFR 50.69 SSC Categorization Guideline. This specific guidance may or may not require quantifying the final cutset equation with truncation level set sufficiently low to identify all risk significant components.

Section 5.6 describes the Maintenance Rule Run-to-Failure Determination methodology. Two criteria are used to determine if the equipment provides little or no contribution to system safety function: 1) not risk significant by two risk importance measures: Risk Achievement Worth and

Fussell-Vesely, and 2) no more than a minimal safety impact when evaluated by the Maintenance Rule program using plant specific criteria. Verification is included that the run-to-failure change does not effect a change to the plant licensing basis using three principles: current regulations met, consistent with defense-in-depth philosophy, and proposed increases in risk –if any – are small and consistent with the Commission's safety goal statement. The requirement for establishing tolerant performance criterion where specific performance criterion is required by the Maintenance Rule is included for completeness. Run-to-Failure Determination is generally applied to components, however, this may be extended to other items, such as sub-components or piece parts.

Section 5.7 provides Applications of Run-to-Failure Determinations in the last section to demonstrate each application case to the maintenance and reliability professionals.

5.4 Preventive Maintenance Acceptance of Run-to-Failure

Nuclear power plant preventive maintenance programs and the Maintenance Rule allow equipment to be run to failure, when failure is acceptable. The reliability of equipment in a nuclear power plant which can be run to failure and repaired with corrective maintenance can result in a reliability performance which ranges from very high to acceptably low.

The industry has developed Reliability Centered Maintenance (RCM) with the guidance of several EPRI reportswhich provides a qualitative template for run-to-failure guidance.[8, 9, 10] The RCM process determines functionally critical plant equipment and assigns appropriate preventive maintenance and/or predictive maintenance to prevent failure. The process evaluates the equipment determined to be non-critical from a system functional standpoint, and determines if preventive maintenance and/or predictive maintenance activities are appropriate based on economic or other consideration, or if the equipment should have no proactive maintenance and should be repaired after being run-to-failure. A summary of the Reliability Centered Maintenance Process including the run-to-failure component classification is shown in Figure 5-1, Summary of Reliability Centered Maintenance Process.

The Reliability Centered Maintenance Run-to-Failure guideline was developed before the implementation of the Maintenance Rule in July 1996. This initial process had no criteria to demonstrate implementation of the NUMARC 93-01 industry guideline for "SSCs that provide little or no contribution to system safety function." The RCM programs were initially developed with no requirement to utilize the importance measures results of the PRA models to determine the preventive maintenance classification of system components as Critical, Non-Critical or run-to-failure. Note that RCM program criteria and resulting component classification may vary from plant to plant, since each program development has the option to conservatively tailor the criteria for the classification of components.

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[8] *Guide for Generic Application of Reliability Centered Maintenance (RCM) Recommendations*. EPRI, Palo Alto, CA: February 1991. NP-7134.
[9] *Guide for Monitoring Effectiveness of Utility Reliability Centered Maintenance (RCM) Programs*. EPRI, Palo Alto, CA: February 1991. NP-7133.
[10] *Comprehensive Low-Cost Reliability Centered Maintenance*. EPRI, Palo Alto, CA: September 1995. NP-105365.

Note that run-to-failure described by the NUMARC 93-01 Industry Guideline may be different from the run-to-failure described in earlier Reliability Centered Maintenance or some preventive maintenance programs. In Reliability Centered Maintenance or some preventive maintenance programs if an SSC is designated as run-to-failure, then no preventive maintenance is performed and the SSC is allowed to run-to-failure when corrective maintenance is performed. But in the Maintenance Rule program, if an SSC is designated as run-to-failure, then failure finding and condition monitoring preventive maintenance that has economic value may still be performed.

A summary of the INPO AP-913 Equipment Reliability Process for the Critical, Noncritical and run-to-failure component classification is shown in Figure 5-2. The figure shows the improved Revision 1 criteria for the identification of component classification uses the PRA model as only one of the tools to perform this evaluation. INPO AP-913 is not integrated with the risk informed process used in the EPRI report on Reliability and Risk Significance or the NEI 00-04, 10 CFR 50.69 SSC Categorization Guideline. Notable attributes of Critical in the INPO AP-913 Equipment Reliability Process (shown in Figure 5-2) that conflict with the risk informed process since these may result in conservative Critical classifications are the following:

- Loss of a redundant safety function
- Unplanned entry into a technical specification LCO

The potential for conflict in program application was discovered in May 2002 during the INPO assistance visit at the First Energy Nuclear Operating Company (FENOC) Perry Nuclear Power Plant. Assistance was provided in the areas of equipment performance and implementation of INPO AP-913, Equipment Reliability Process Description. The action plan included a key improvement opportunity to modify the FENOC definition of critical components to be consistent with AP-913. As a result of the INPO action plan, the planned Perry Preventive Maintenance Classification (in Appendix B) was not implemented until a future revision to INPO AP-913 includes a risk-informed methodology for the definition of critical components.

The opportunity exists for the industry to collaborate with INPO to develop a risk informed revision to the INPO AP-913 Equipment Reliability Process Description which provides appropriate engineering principles and expectations that can be consistently understood and applied, and includes the option of justifying exceptions. An example of an exception is a highly reliable component in a risk-significant function which controls reactor water level that can be justified as not critical based on an industry standard engineering methodology or the plant specific PRA assessment, which shows this highly reliable component is not risk-significant.

The EPRI report on Reliability and Risk Significance issued in December 2001 uses the correlations between the Fussell-Vesely and Risk Achievement Worth importance measures to classify a component as Critical, Non-Critical or run-to-failure. Risk-informed information from the EPRI report on Reliability and Risk Significance incorporated in the Maintenance Rule Run-to-Failure Guideline is presented in Section 5.5, Quadrant Chart For Preventive Maintenance Objectives.

Since not all plants have implemented Reliability Centered Maintenance, this Maintenance Rule Run-to-Failure Guideline has developed a generic guideline to demonstrate compliance for the Maintenance Rule program. This Maintenance Rule Run-to-Failure Guideline was developed as a generic guideline to interface with the existing preventive maintenance program which has the purpose of making adjustments, and/or optimizing preventive and predictive maintenance. The Maintenance Rule program is only required to determine that the SSC provides “little or no contribution to system safety function” and is not responsible for making adjustments and/or optimizing preventive maintenance tasks that are the responsibility of the preventive maintenance program. Therefore, the Maintenance Rule Run-to-Failure Determination flow charts in Figure 5-3 and Figure 5-4 commences with the following selection statement:

> Select component (or, subcomponent or piece part) in the scope of the Maintenance Rule that has the potential to be classified as run-to-failure in the preventive maintenance program pending Maintenance Rule program final approval.

This Maintenance Rule Run-to-Failure guideline considers the first principle in determining “little or no contribution to system safety function” is to verify the component (or, subcomponent or piece part) is not risk-significant. This guideline recommends that the Fussell-Vesely and Risk Achievement Worth importance measures determine the component not risk-significant as described in the EPRI report on Reliability and Risk Significance and described in the pending NEI 00-04, 10 CFR 50.69 SSC Categorization Guideline[11]. This guideline does not utilize the Core Damage Frequency Contribution (Top 90% Cut Sets) listed in section 9.3.1 of the NUMARC 93-01 industry guideline, since this is not consistent with the Option 2 Implementation method of determining high safety significance and low safety significance. This guideline recommends the Core Damage Frequency Contribution (Top 90% Cut Sets) importance measure be removed from the Maintenance Rule program as a method to determine risk-significant SSCs. This program change can be implemented in accordance with NUMARC 93-01, which allows optional sensitivity methods to determine risk significance. Section 9.3.1 of the NUMARC 93-01 industry guideline states that utilities may use additional sensitivity methods if they have been performed and are available. If the Fussell-Vesely is utilized with a risk threshold of 0.005 and the Top 90% Cut Sets is removed, then the Maintenance Rule Program could justify the program change based on the NEI 00-04, SSC Categorization Guideline and the EPRI report on Reliability and Risk Significance.

[11] *Option 2 Categorization Guideline*, NEI 00-04 Draft Revision C, June 2002.

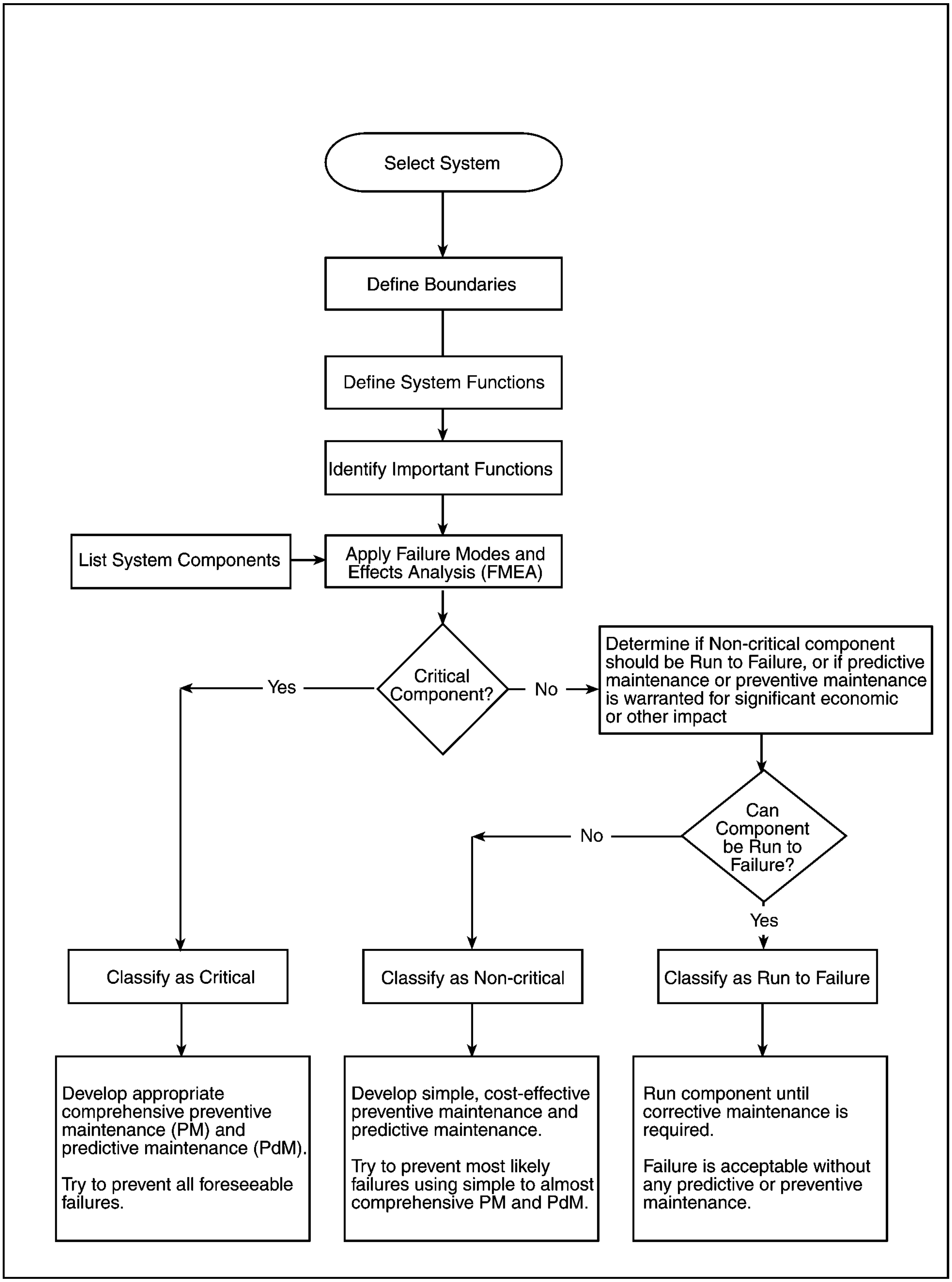

Figure 5-1
Summary of Reliability-Centered Maintenance Process

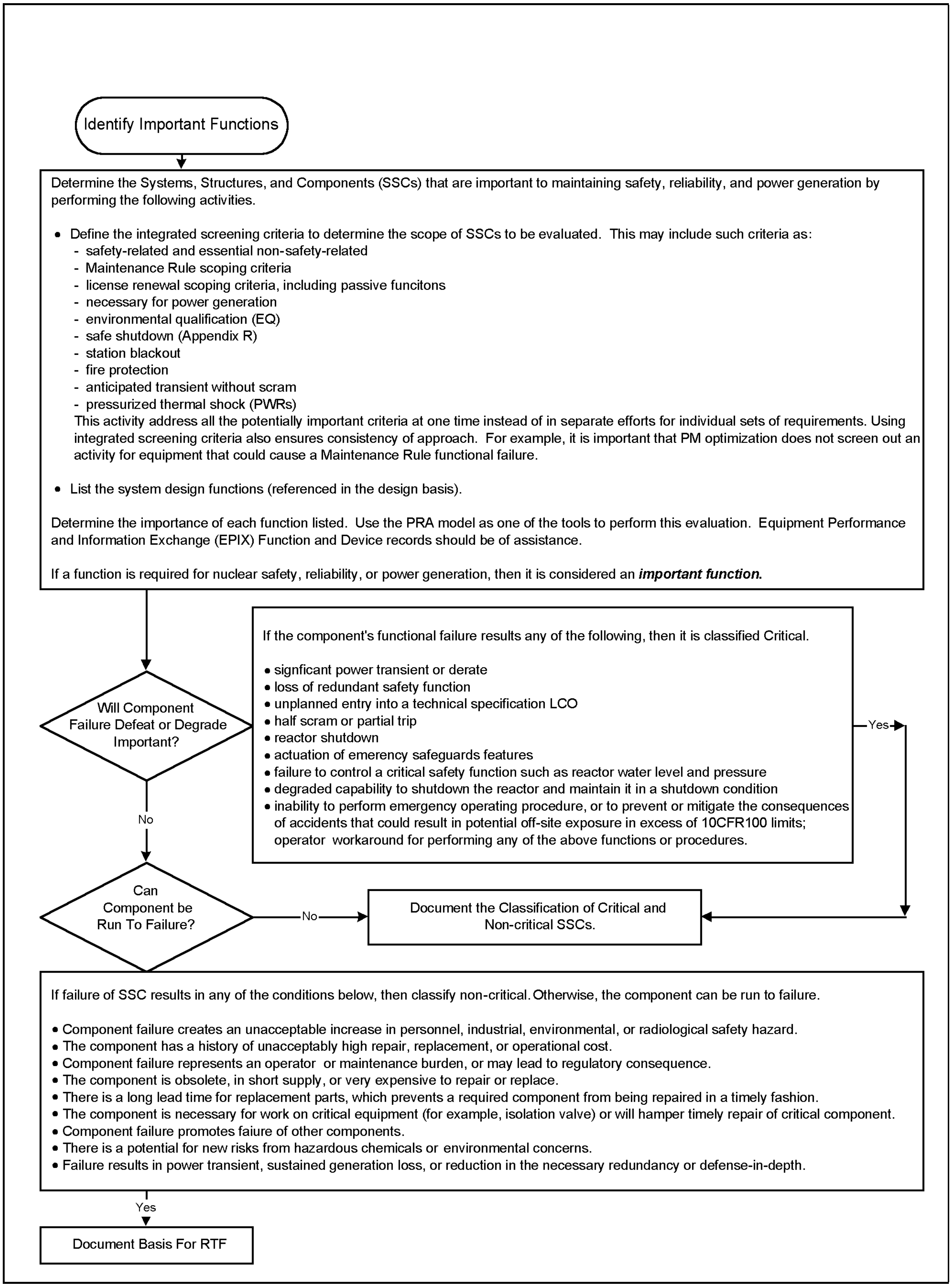

Figure 5-2
Summary of INPO AP-913 Equipment Reliability Process

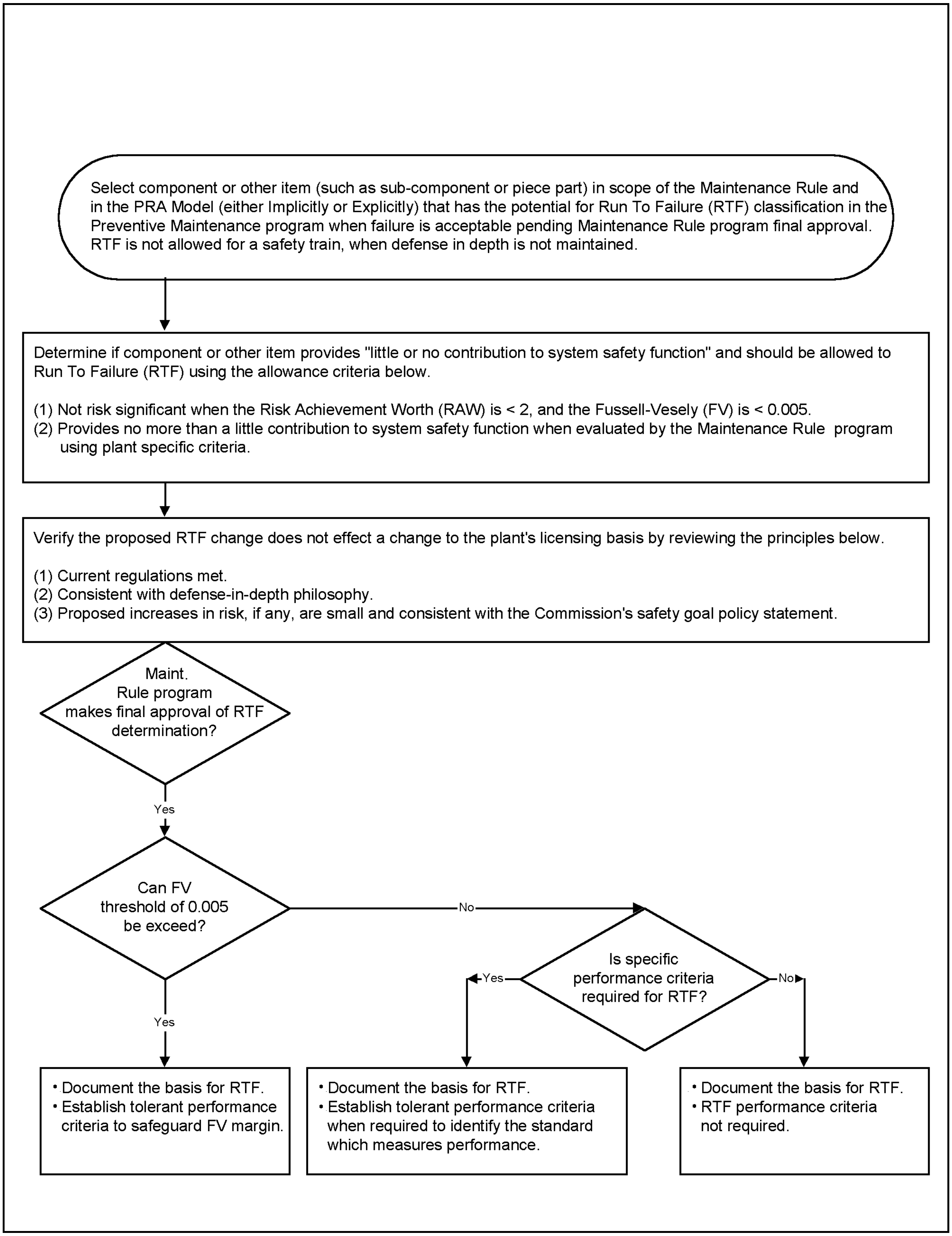

Figure 5-3
Maintenance Rule Run-to-Failure Determination of Component or Item in the PRA Model

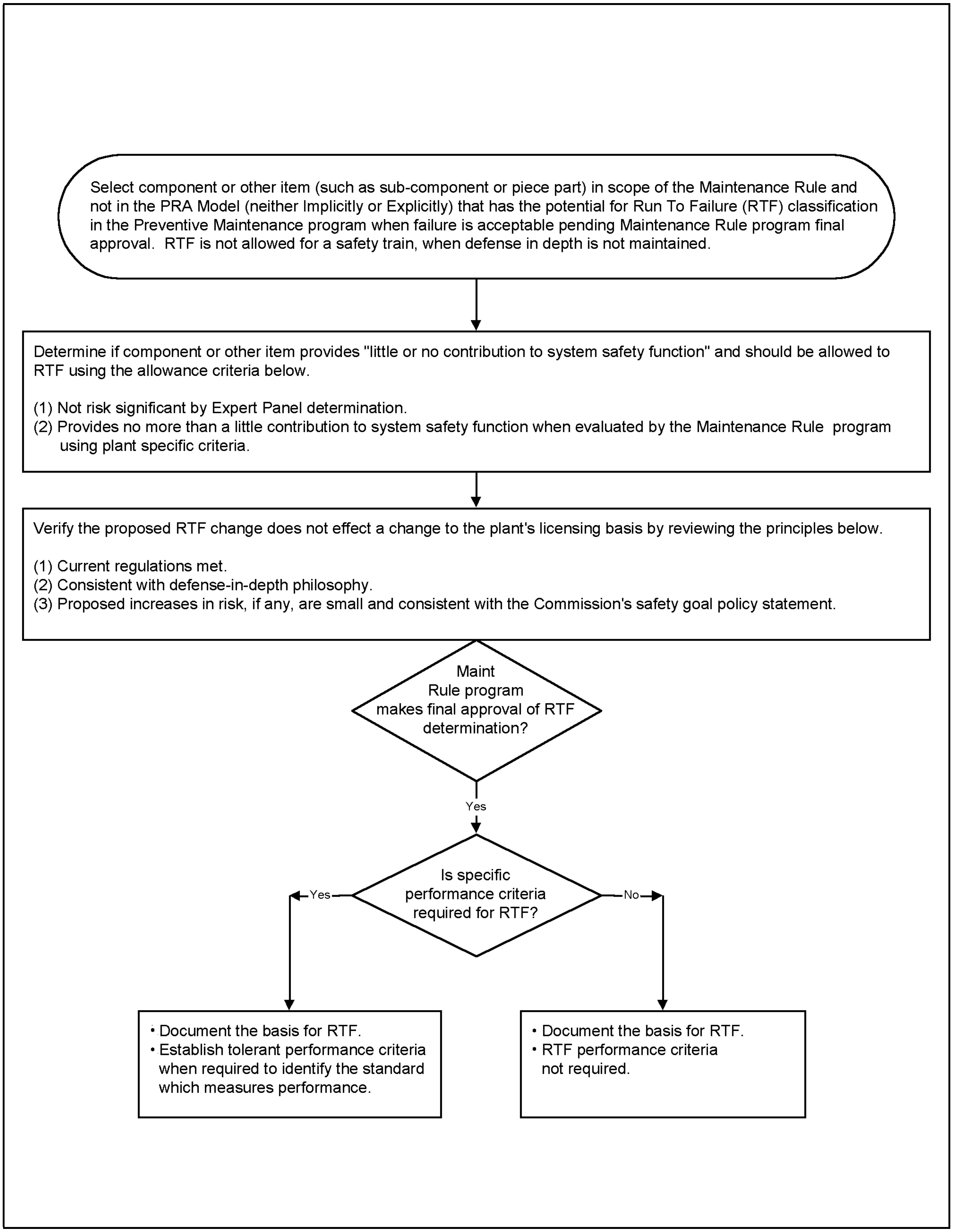

Figure 5-4
Maintenance Rule Run-to-Failure Determination of Component or Item Not in the PRA Model

5.5 EPRI Quadrant Chart For Preventive Maintenance Objectives

The quadrant chart for preventive maintenance objectives was technically developed in the EPRI report, *Reliability and Risk Significance for Maintenance and Reliability Professionals at Nuclear Power Plants*. The quadrant chart summarizing the objectives for preventive maintenance tasks is shown below as Figure 5-5.

This quadrant chart applying the Fussell-Vesely (FV) importance measure on the x-axis and Risk Achievement Worth (RAW) importance measure on the y-axis represents all the System, Structure and Component basic events in the PRA model. This has become known as a quadrant chart because it is customary to insert a line to show the Risk Achievement Worth risk significant threshold value of 2.0, and to insert a line to show the Fussell-Vesely risk significant threshold value of 0.005. These two risk significant lines separate the chart into four quadrants.

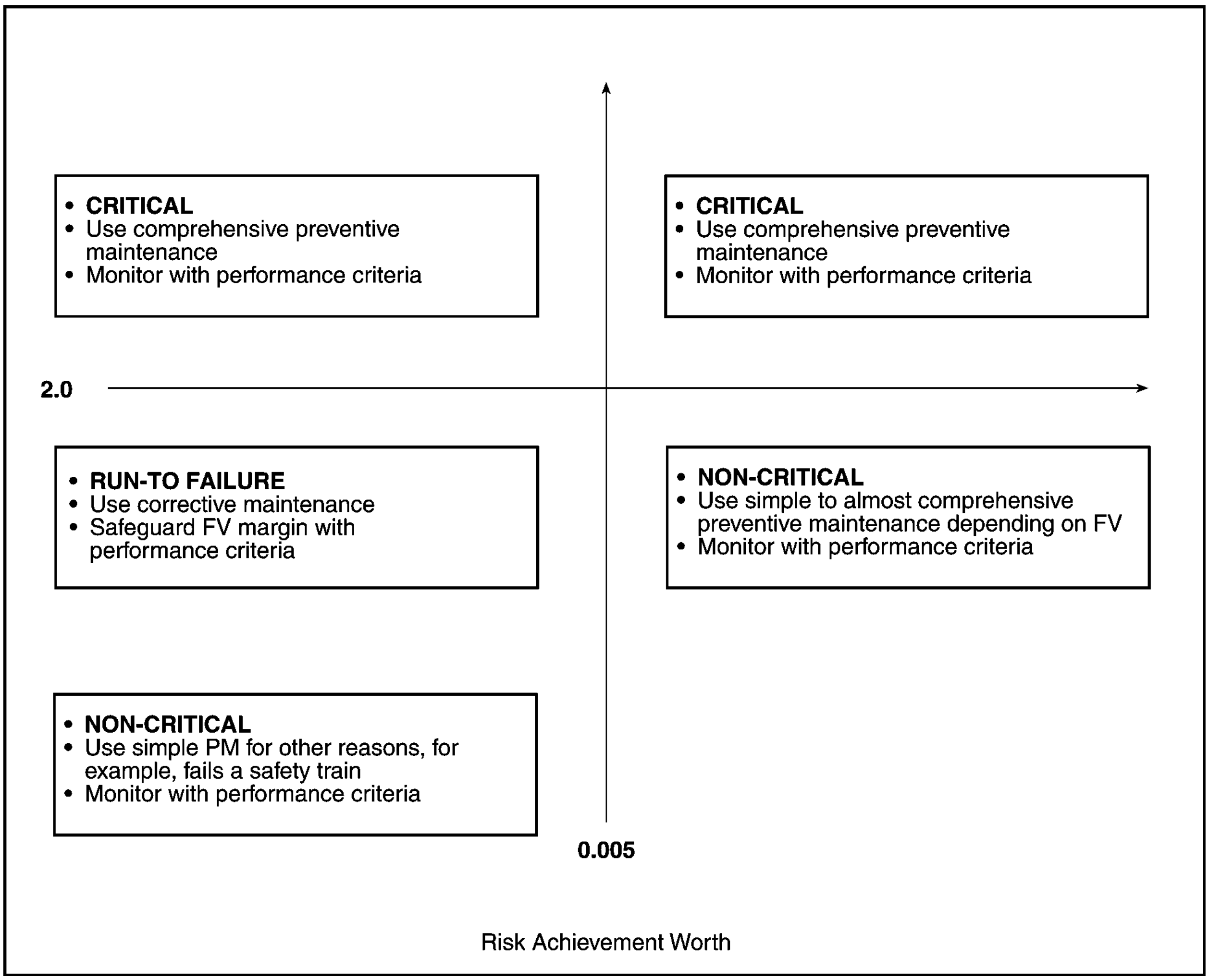

Figure 5-5
Summaries of PM Objectives Depending on FV And RAW Values

The NEI 00-04, 10 CFR 50.69 SSC Categorization Guideline section 5.1 on Internal Event Assessment describes the methodology to obtain the Fussell-Vesely and Risk Achievement Worth importance measures after solving the cutset equation with recommended truncation values. The 10 CFR 50.69 Categorization Guideline Table 5-1, Example Importance Summary shows how to obtain the Component Importance from the summed Fussell-Vesely importance values and the maximum Risk Achievement Worth for the basic events involving the component. The Fussell-Vesely (FV) value for a component is obtained by adding the Fussell-Vesely values for all the reliability basic events of the component (which represent the different failure modes including common cause). The Risk Achievement Worth (RAW) value is selected from the largest RAW among the basic events, except the common cause events. Until this method of determining the RAW value for the component is approved in an issued regulatory guide, it is recommended that the RAW value be selected from the largest RAW among the all the basic events, including the common cause events.

When calculating the Fussell-Vesely values, NEI 00-04 recommends a truncation level of at least five orders of magnitude below the baseline Core Damage Frequency (or Large Early Release Frequency) be used for linked fault trees. In addition, the truncation level should support an overall Core Damage Frequency (or Large Early Release Frequency), which has converged. When the Risk Achievement Worth is calculated by a full re-solution of the plant PRA model, then the truncation level does not significantly affect the Risk Achievement Worth values, and a default truncation of 1E-9/year seems reasonable. However, if a pre-solved set of cutsets is used to calculate Risk Achievement Worths, then the truncation level should be set to a sufficiently low value so that all the reliability basic events with a RAW greater than 2.0 are identified. (For example, set the truncation value to 1E-10/year or lower.) The truncation of the PRA model should be checked to ensure that the Core Damage Frequency and Large Early Release Frequency values have converged and that the importance measures are stabilized.

The EPRI report, *Reliability and Risk Significance for Maintenance and Reliability Professionals at Nuclear Power Plants*, includes section 2.5.1, Effects Of Accident Sequence Truncation On FV And RAW, which provides additional discussion of truncation. Note that the truncation level requirements in NEI 00-04 may be lower than the previous value (which may have ranged from 10^{-8} to 10^{-10}/year) that was used for the initial Maintenance Rule program determination of risk significance. The convergence requirements of NEI 00-04 should result in a convergence error on the order of 1% of the Core Damage Frequency and Large Early Release Frequency.

The NUMARC 93-01 Industry Guideline includes awareness of the limitation of PRA implementation associated with cut set truncation is included in the near the end of Section 9.3.1, Establishing Risk Significant Criteria, as follows:

> The use of an expert panel would compensate for the limitations of PRA implementation approaches resulting from the PRA structure (for example, model assumptions, treatment of support systems, level of definition of cut sets, cut set truncation, shadowing effect of very large (high frequency) cut sets, and inclusion of repair or restoration of failed equipment) and limitations in the meanings of the importance measures.

The NUMARC 93-01 Industry Guideline for determining risk significant equipment does **not** specify how to adjust the truncation level in PRA software so that all the required risk significant components with a Risk Achievement Worth greater than threshold are identified in the final cut set equation. This guideline recommends revising the risk significance determination methodology to include adjusting the truncation level in accordance with the NEI 00-04 guideline to assure the component is a valid candidate for run to failure.

The EPRI report, *Reliability and Risk Significance for Maintenance and Reliability Professionals at Nuclear Power Plants*, section 2.4.5 explains the run-to-failure quadrant, when not risk significant by Fussell-Vesely or by Risk Achievement Worth as follows.

The low RAW value means that the risk increase when the basic event occurs is not large; therefore it is hard to justify any additional program on the basis of a great need to prevent individual failures.

The low FV value means that the component does not contribute significantly to the CDF. This combination of FV and RAW values does not place any bounds on average performance, which may be good or poor. The low value of FV means that there is no safety incentive to improve performance even if it is not good.

Although it will increase the FV value, deterioration in performance will not be a problem providing the existing margin to the FV risk significance threshold is sufficient. Therefore, ensure the FV margin is sufficient. If it is not sufficient, existing programs may need to be strengthened to improve the component's performance, or that of other components.

From the perspective of preventive maintenance, this component could be run-to-failure, unless reducing the existing PM would cause the FV value to exceed the FV threshold. If this is likely, set tolerant performance criteria to monitor the FV margin, and use a non-critical, that is, simple, level of PM. The fact that reliability/availability may be good or poor, should not influence the choice of run-to-failure unless there are also economic reasons for doing PM, for example, secondary damage to other equipment, or the high cost of corrective maintenance.

The Maintenance Rule Run-to-Failure Guideline utilizes the Quadrant Chart For Preventive Maintenance Objectives methodology to select components for run-to-failure classification and the direction to not classify as run-to-failure if there are other reasons for simple preventive maintenance. For example, if failure results in loss of a safety train needed to directly mitigate an accident and defense in depth is not maintained, then the component should not be classified as run to failure.

The Maintenance Rule Run-to-Failure Guideline utilizes the Quadrant Chart For Preventive Maintenance Objectives run-to-failure risk insight to safeguard the Fussell-Vesely margin with tolerant Maintenance Rule performance criteria, when required. This is required if reducing the existing preventive maintenance could cause the Fussell-Vesely value to exceed the Fussell-Vesely risk threshold and could result in the classification of the SSC as risk significant.

The application section provides examples demonstrating how to ensure the FV margin is sufficient.

It is expected the use of the summed Fussell-Vesely value for all the reliability basic events of the component may commence with individual cases or with a program revision to incorporate the Fussell-Vesely as an additional sensitivity method for determining risk significance. During the NRC baseline inspections the determination of risk significant SSCs was expected to include all of the following importance measures listed in section 9.3 of the (NUMARC 93-01) industry guideline: Risk Achievement Worth, Risk Reduction Worth (RRW), and Core Damage Frequency Contribution (Top 90% Cut Sets). The Fussell-Vesely importance measure was not required during initial implementation. RRW measures the same concept as the Fussell-Vesely parameter but expresses it differently. Whenever the FV is < 0.1, which is true for most components, RRW is approximated by 1 + FV, since RRW is equal to 1/(1 – FV).

5.6 Maintenance Rule Run-to-Failure Determination

Section 1.3 of this report describes the risk informed Run-to-Failure Determination methodology. The preventive maintenance program and Maintenance Rule program is typically applied to components. The methodology may be extended to other items, such as subcomponents or piece parts, to provide an efficient comprehensive program, since many issues associated with the Maintenance Rule are on the subcomponent and piece part level. This methodology allows components, subcomponents and piece-parts to be placed in different risk significant categories, for example, the pressure boundary of a valve may be risk-significant, but the active components may be not risk-significant. This non-binding, generic guideline documents that different plant specific run-to-failure applications are excepted and are acceptable.

5.6.1 Maintenance Rule Run-to-Failure Determination Methodology

1. Select a component or other item (such as, a subcomponent or piece part) in the scope of the Maintenance Rule that has the potential to be classified as run-to-failure in the preventive maintenance program pending Maintenance Rule final approval.

   Note that run-to-failure is not allowed for a safety train, when defense in depth is not maintained. For guidance on defense in depth reference Regulatory Guide 1.174 and NEI 00-04, 10 CFR 50.69 SSC Categorization Guideline.

2. Determine if the component or other item is implicitly or explicitly modeled in PRA. If the component or other item is not in the PRA model, then a qualitative evaluation can be used.

3. Determine if the component or other item provides “little or no contribution to system safety function” and should be allowed to run-to-failure using the allowance criteria below.

   If in the PRA Model:

   - Not risk significant when RAW < 2 and FV < 0.005.
   - Provides no more than a little contribution to system safety function when evaluated by the Maintenance Rule program using plant specific criteria.

If not in the PRA Model:

- Not risk significant by expert panel determination.
- Provides no more than a little contribution to system safety function when evaluated by the Maintenance Rule program using plant specific criteria.

  The reason for determining the component or other item is not risk significant is to show run-to-failure is the appropriate preventive maintenance classification in accordance with the EPRI report on *Reliability and Risk Significance for Maintenance and Reliability Professionals at Nuclear Power Plants*.

  The reason for using provides no more than a little contribution to system safety function when evaluated by the Maintenance Rule program is to show run to failure is the appropriate preventive maintenance classification in accordance with the *Industry Guideline for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants*. The use of plant specific criteria allows the definition of bases that are appropriate for each plant.

4. Verify the run-to-failure change does not effect a change on the plant's licensing basis by reviewing the principles below.
   - Current regulations met, including 10 CFR 50.59.
   - Consistent with defense-in-depth philosophy (as described in Regulatory Guide 1.174[11] and the NEI 00-04, 10 CFR 50.69 SSC Categorization Guideline).
   - Proposed increases in risk, if any, are small and consistent with the Commission's safety goal policy statement. (The NRC's Safety Goal Policy Statement set a Core Damage Frequency safety goal of less than 1.0 % E-4 per reactor year for nuclear plants.)

5. Maintenance Rule program makes the final approval of the Run-to-Failure Determination. The final review and approval uses the determination criteria (listed in item 3 above, and verifies the run-to-failure change does not effect a change to the licensing basis by reviewing key principles (listed in item 4).

6. Can the Fussell-Vesely threshold of 0.005 be exceeded? This question is only used if the component or other item is in the PRA model. The PRA assessment may find that the component failure can be fully bounded and not challenge the threshold, or can exceed Fussell-Vesely threshold of 0.005 at some tolerant performance criteria. If the determination is YES, then establish tolerant performance criteria to safeguard the Fussell-Vesely margin. If the determination is NO, then proceed to the next item.

7. Is specific performance criteria required for run-to-failure?

   Note that a portion of Maintenance Rule equipment that can be allowed to run to failure is under the requirement of specific performance criterion which includes the following types of equipment: indications, alarms, snubbers, and relief valves. Additionally another portion

[11] U.S. Nuclear Regulatory Commission. *An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis.* Regulatory Guide 1.174, Revision 0, August 1998.

of Maintenance Rule equipment that can be allowed to run-to-failure is under requirement of plant level performance criteria, and this equipment is excluded from any additional performance monitoring.

- If the determination is YES, then establish tolerant performance criteria to identify a standard that measures performance. Note that when the run-to-failure specific performance criterion is exceeded an evaluation is required to determine if any corrective action is warranted and if the SSC should remain in (a)(2); however, an apparent cause investigation is not required for Maintenance Rule compliance.
- If the determination is NO, then no specific performance criteria is required.

The flow chart describing the Maintenance Rule Run-to-Failure Determination methodology for component or item in the PRA is presented in Figure 5-3, and the methodology for component or item not in the PRA is presented in Figure 5-4.

5.6.2 Plant Specific Maintenance Rule Run-to-Failure Applications

The following plant-specific run-to-failure applications are provided to document different acceptable solutions.

1. The option of using the 50.59 criteria for concluding a change has no more than a “minimal” safety impact is being considered at Perry to provide enhanced administrative control to further ensure the 50.59 regulation is met. Also, note the initial Perry plans to implement an additional preventive maintenance classification and to use condition-monitoring performance criteria for run-to-failure. See Appendix B notes On run-to-failure.

2. South Texas Project has received an exemption request. Therefore, it no longer needs to justify that run-to-failure is acceptable, and is planning to remove the low and non-risk significant SSCs from the scope of the Maintenance Rule.

   South Texas Project has used the following screening guidance to determine which SSCs are run-to-failure candidates, where most or all of the items should be met.

   - The cost and unavailable time of repairing a failed SSC with corrective maintenance may be no more than the cost and unavailable time of maintaining the SSC with planned, preventive maintenance tasks.
   - The assessment of planned preventive maintenance task on a SSC that is not risk significant may find the task results in the unavailability of risk significant SSCs.
   - Benefits in reduced dose, contamination, or cost without impacting safety.
   - SSC should not have a “hidden failure” that would not be recognized until the function was demanded. Alarms or operator rounds (etc.) should readily identify the failure.
   - The inability to determine a mean time between failures or to determine any method to predict failure shows that preventive maintenance is not effective.

- Allow run-to-failure only after considering other ways to address problem. For example, better design, new Preventive Maintenance task, different Preventive Maintenance frequency, condition monitoring, better cause determination, etc.
- Redundancy should not be used as the only justification.

  Note if run-to-failure is allowed, then evaluate compensatory actions to manage the effects of the failure. For example, require the corrective maintenance task to expedite the SSC replacement and minimize the unavailable time.

An example of a run-to-failure evaluation is provided in Appendix C, South Texas Project Evaluation of run-to-failure for components in the radiation monitoring system.

South Texas Project monitors run-to-failure SSCs (usually with Maintenance Rule Functional Failures or Functional Failures) to ensure that a large increase in failures does not occur that could invalidate the original assumptions. Run-to-failures do not need to be counted as repetitive and therefore, do not need to be treated as repetitive maintenance preventable functional failures that require Maintenance Rule (a)(1) evaluation.

3. Wolf Creek plans to include the Run-to-Failure Guidance provided in Appendix D.

5.7 Applications of Maintenance Rule Run-to-Failure Determination

5.7.1 Quantitative Examples Based on Implicit or Explicit PRA Model

Explicit PRA Model Quantitative Examples

An explicitly modeled component or super-component in the PRA model provides qualitative input for calculating the importance measures are not risk significant and the change has no more than a minimal safety impact. Examples of explicit components are pumps and valves. Examples of explicit super-components are diesel generators and diesel fire-pumps.

Can the Fussell-Vesely Threshold of 0.005 Be Exceeded?

A simple sensitivity study can calculate if the Fussell-Vesely threshold of 0.005 can be exceeded by performing a completely bounding run-to-failure study. A completely bounding run-to-failure study sets one of the performance assumptions to the maximum failure value, and then re-quantifies the final cutset solution.

If the sensitivity study shows with completely bounding RTF performance assumptions that the summed component Fussell-Vesely remains below the risk significant threshold of 0.005, then no change would be necessary to establish tolerant performance criteria to safeguard the Fussell-Vesely margin. Application examples are: 1) bounding sensitivity of an explicit component in the cut set equation that remains below the Fussell-Vesely below the risk significant threshold, and 2) bounding sensitivity of an explicit component in the PRA model that remains below the Fussell-Vesely below the risk significant threshold.

If the sensitivity study shows the Fussell-Vesely Threshold of 0.005 can be exceeded, then establish tolerant performance criteria to safeguard the Fussell-Vesely margin. To establish a tolerant performance criteria to safeguard the Fussell-Vesely margin, perform a Fussell-Vesely margin study that shows the summed component Fussell-Vesely remains below the risk significant threshold of 0.005 by some safeguard margin. For example, show the Fussell-Vesely safeguard margin of 0.004 cannot be exceeded. Commence this study by setting the component basic events for unavailability and unreliability to the appropriate values with justification. The unreliability basic event value is calculated by dividing the tolerant Run-to-Failure Performance criteria by the number of estimated demands in the monitoring period. The unavailability basic event value is set equal to the tolerant run-to-failure performance criteria. Then requantify the final cutset solution to show the summed component Fussell-Vesely remains below the risk significant threshold of 0.005 by some safeguard margin. An application example is a redundant support component that supports a train function (such a diesel generator building ventilation subtrain fan that supports a diesel generator).

Implicit PRA Model Quantitative Examples

An implicitly modeled system or component in the PRA model provides limited qualitative input for calculating the importance measures are not risk significant and the change has no more than a minimal safety impact. Implicit PRA Model examples are the following:

- Train or system that is modeled on the summary top level. The PRA model is basic event that represents the estimated failure rate without detailed modeling.
- System that only has part of the system modeled. A BWR example is the Reactor Water Cleanup System that only includes two containment isolation valves. These divisional valves are modeled as support for the Standby Liquid Control System operation, but the rest of the system is modeled.
- Component, train, or system is modeled as part of the system it supports. A BWR example is the Leak Detection System that is modeled with Residual Heat Removal as an isolation event.

Can the Fussell-Vesely Threshold of 0.005 Be Exceeded?

An implicit sensitivity study can calculate if the Fussell-Vesely threshold of 0.005 can be exceeded by performing a completely bounding run-to-failure study as described above, if the implicit basic event has the appropriate justification.

If the implicit sensitivity study shows with completely bounding run-to-failure performance assumptions, the summed component Fussell-Vesely remains below the risk significant threshold of 0.005, then no change would be necessary to establish tolerant performance criteria to safeguard the Fussell-Vesely margin. An application example is a system modeled on the summary top level.

Qualitative Examples

Those systems, trains, and components not implicitly or explicitly modeled in the PRA that can be qualitatively addressed by the expert panel. Application examples are the following:

- Non-safety related control room alarms and indication, when failure is acceptable.
- Non-safety related redundant communication systems and components, other than batteries which may warrant simple preventive maintenance.
- Safety-related system or component whose intended function is to fail into a *safe* state.
- Safety-related redundant component whose failure has no affect on the intended function. For example, a redundant reactivity control system subtrain optical isolator that is not in the PRA model, which supports a redundant reactivity control system train, and the failure is alarmed or identified in a timely manner by inspection or testing.
- Safety-related ASME Class 2 & 3 relief valves installed to provide thermal over-pressure protection when a safety train was taken out of service for maintenance whose failure has no effect on the intended function. Note that these may be classified as inherently reliable.
- Safety related snubbers, when failure is acceptable.

A
NEW REQUIREMENT ALLOWS MINIMAL INCREASE AND ELIMINATES THE ZERO STANDARD

The new 50.59 requirement affirmed a regulatory threshold allowing minimal increase and eliminated the zero standard. The margin of safety was replaced by two new criteria on integrity of fission product barriers, and methods of evaluation.

This requirement for changes, tests, and experiments, and obtaining a license amendment, is stated in part 50.59 of the Code of Federal Regulations in paragraph (c)(2) as provided below.

A licensee shall obtain a license amendment pursuant to § 50.90 prior to implementing a proposed change, test, or experiment if the change, test, or experiment would:

(i) Result in more than a minimal increase in the frequency of occurrence of an accident previously evaluated in the final safety analysis report (as updated);

(ii) Result in more than a minimal increase in the likelihood of occurrence of a malfunction of a structure, system, or component (SSC) important to safety previously evaluated in the final safety analysis report (as updated);

(iii) Result in more than a minimal increase in the consequences of an accident previously evaluated in the final safety analysis report (as updated);

(iv) Result in more than a minimal increase in the consequences of a malfunction of an SSC important to safety previously evaluated in the final safety analysis report (as updated);

(v) Create a possibility for an accident of a different type than any previously evaluated in the final safety analysis report (as updated);

(vi) Create a possibility for a malfunction of an SSC important to safety with a different result than any previously evaluated in the final safety analysis report (as updated);

(vii) Result in a design basis limit for a fission product barrier as described in the FSAR (as updated) being exceeded or altered; or

(viii) Result in a departure from a method of evaluation described in the FSAR (as updated) used in establishing the design bases or in the safety analyses.

The 10 CFR 50.59 final rule was implemented in the first quarter of 2001, 90 days after the Regulatory Guide 1.187 [[12]].

A.1 NEI 96-07, Revision 1, Guidelines for 10 CFR 50.59 Implementation

The Nuclear Energy Institute (NEI) transformed NSAC-125, Guidelines for 10 CFR 50.59 Evaluations into NEI-96-07 to address specific NRC concerns. Revision 1 of this document was developed with the 10 CFR 50.59 Task Force and the Regulatory Process Working Group [[13]]. The foreword provides a summary of the revised regulation and outlines how the changes made are more focused and efficient. The focused, efficient changes made available by this revision are considered appropriately in this Maintenance Rule Run-to-Failure Guideline.

A.1.1 Foreword (First Part From the First Three Paragraphs)

> In 1999, the NRC revised its regulation controlling changes, tests and experiments performed by nuclear plant licensees—the first changes to 10 CFR 50.59 in more than 30 years. The changes were prompted by the need to resolve differences in interpretation of the rule's requirements by the industry and the NRC that came in clear focus in 1996. These differences existed despite general recognition that licensee implementation of 10 CFR 50.59 has been effective in controlling activities affecting plant design and operation. The rule changes had two principal objectives, both aimed at restoring much-needed regulatory stability to this extensively used regulation:
>
> - Establish clear definitions to promote common understanding of the rule's requirements
> - Clarify the criteria for determining when changes, tests and experiments require prior NRC approval
>
> While effective at controlling changes, 10 CFR 50.59 was, at the same time, viewed as overly restrictive of licensee changes and unduly burdensome. License amendment requests were prepared, submitted and reviewed by the NRC for many changes having little or no impact on the plant design or operation. Indeed, some beneficial changes were withdrawn by licensees upon determination that the change would have to go through the burdensome license amendment process.
>
> Moreover, substantial resources were expended each year by licensees to process and submit to NRC lengthy evaluations for numerous insignificant changes. The changes approved by the Commission in 1999 made 10 CFR 50.59 more focused and efficient by:
>
> - Providing greater flexibility to licensees, primarily by allowing changes that have minimal safety impact to be made without prior NRC approval
> - Clarifying the threshold for "screening out" changes that do not require full evaluation under 10 CFR 50.59, primarily by adoption of key definitions.

[12] U.S. Nuclear Reglatory Commission. *Guideline for Implemention of 10 CFR 50.59, Changes, Tests, and Experiments.* Regulatory Guide 1.187, Revision 0, November 2000.

[13] *Guidelines For 10 CFR 50.59 Implementation*. NEI 96-07, Revision 1, November 2000.

> These changes will conserve both licensee and NRC resources while continuing to ensure that significant changes are thoroughly evaluated and approved by the NRC as appropriate.

This Maintenance Rule Run-to-Failure Guideline has taken the revised 50.59 regulation which “allows changes that have minimal safety impact to be made without prior NRC approval” as one criterion that the SSC provides “more than a little contribution to system safety function.

B
PERRY PREVENTIVE MAINTENANCE CLASSIFICATION

B.1 Perry Preventive Maintenance (PM) Classification Depending on FV and RAW Values

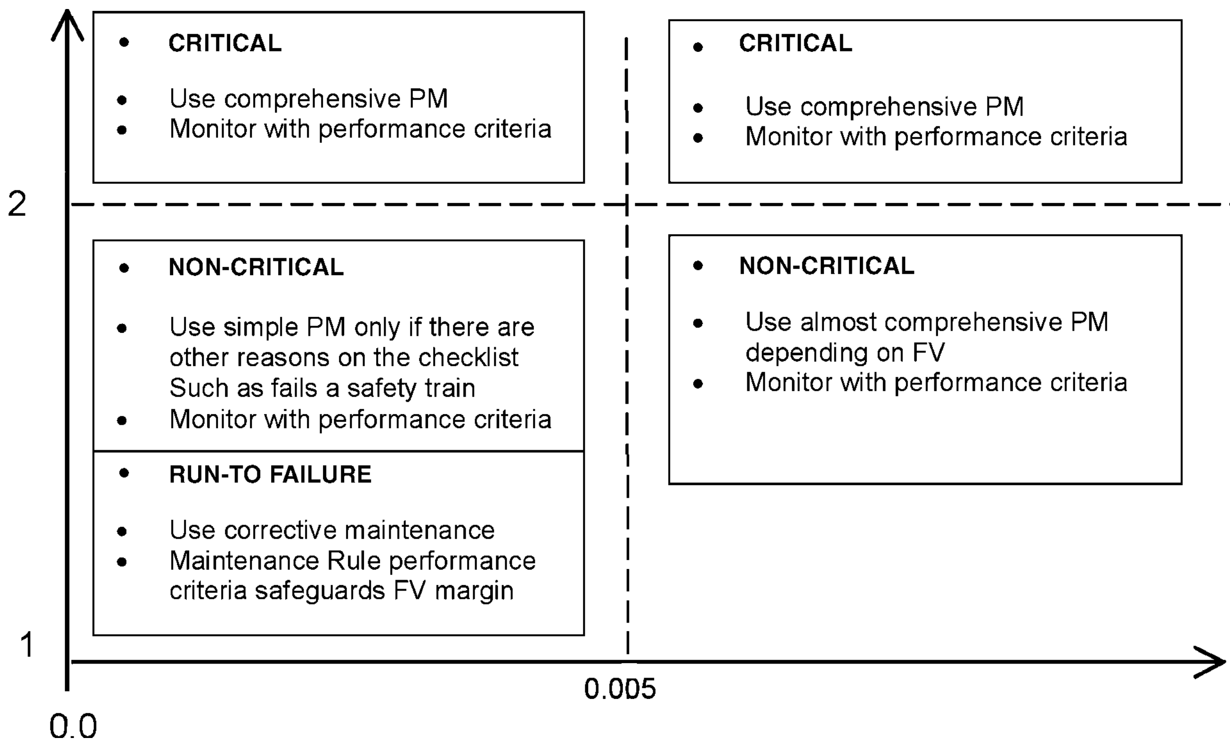

Figure B-1

Perry had planned to use an addition classification of Significant, which is implied in the Non-Critical classification of Figure 5-5, Summary of PM Objectives Depending On FV and RAW. The Significant classification uses an almost comprehensive PM, and the Non-Critical classification uses a simple PM. However, based on an INPO finding during a self assessment of the preventive maintenance program, this plan was not implemented until a revision to the INPO AP-913 Equipment Reliability Process Description includes a risk-informed methodology.

B.1.1 Notes on Maintenance Rule Monitoring of Run-to-Failure

The Maintenance Rule performance criteria to monitor run-to-failure plans to use the monitoring attribute of *condition monitoring failure*.

C
SOUTH TEXAS PROJECT RUN-TO-FAILURE EVALUATION FOR COMPONENTS IN THE RADIATION MONITORING SYSTEM

C.1 Facts

There are a total of 127 radiation monitors located throughout the South Texas Project site. Currently 48 of these radiation monitors are scoped in the Maintenance Rule. These include the Unit Vent, Main Steam Line, Steam Generator Blowdown, Engineered Safety Features (ESF) Noble Gas, Reactor Containment Building Atmosphere, Reactor Containment Building High Range Area, and Nitrogen-16 monitors. Thirty-four of the Maintenance Rule monitors are identified in the Technical Specifications. Six are referenced in the Offsite Dose Calculation Manual (ODCM). A management directive states that N-16 monitor repairs will be assigned the same priority as plant safety-related instrumentation. (CR 97-9528)

C.2 Discussion

Risk significance classification is governed by procedure 0PGP02-ZA-0003, Comprehensive Risk Management. This procedure is approved for use in assessing the risk significance of plant systems, structures, and components (SSCs) and determining the appropriate levels of controls and oversight. This procedure also includes the Graded Quality Assurance (GQA) process by which risk-informed methodologies and deterministic and performance-based information analysis are combined to establish appropriate levels of programmatic controls for systems, structures, and components in order to provide necessary assurance that items will operate safely and activities are accomplished as prescribed.

The Probabilistic Risk Assessment (PRA) program (0PGP04-ZA-0604) models components in the radiation monitoring system for containment isolation purposes only. Loss of this function will have an impact on containment performance, that is, Large, Early Release Frequency (LERF), given a core damage event. The PRA models the two containment penetrations used for radiation monitor RT-8011, with each penetration containing two isolation Motor Operated Valves (MOVs). The radiation monitoring system does not provide a direct role in preventing or mitigating an initiating event or core damage event.

The GQA process has evaluated the risk significance of Radiation Monitors (5A050GARA01). Eighteen Radiation Monitors were evaluated to be low risk significant and the remaining were evaluated as non risk significant. The 18 low risk significant monitors are scoped in the Maintenance Rule and include the Reactor Containment Building Atmosphere, Reactor

Containment Building High Range Area, Fuel Handling Building ESF Noble Gas, and Main Steam Line monitors. Thirty of the monitors evaluated to be non risk significant are also scoped in the Maintenance Rule.

Because the radiation monitoring system has been evaluated to have low or non risk significance by the GQA process, and because the radiation monitoring system does not provide a direct role in preventing or mitigating an initiating event or core damage event, the components can be run-to-failure for the radiation monitoring system.

Run-to-failure is acceptable because:

- A failure of these components will result in an alarm indicating that a failure has occurred.
- Technical specification, management directive, and Offsite Dose Calculation Manual (ODCM) requirements will ensure that components are replaced or corrected in a timely manner.
- There is no economical method that can be used to predict failure.
- Running the components to failure will not result in an unsafe condition.
- Demand Preventative Maintenance instructions are in place (or will be in place) prior to making major components run to failure. This will allow components to be replaced in a timely manner and the monitors returned to service.
- These monitors do not impact systems, structures, or components covered by (a)(3) or (a)(4).
- The radiation monitoring system is not considered a risk significant system in the Maintenance Rule Program.

C.3 Options

There are two options available:

1. Continue to count the failures of components as Maintenance Rule Functional Failures and as Maintenance Rule Repetitive Failures when two components performing the same function fail within 18 months.

2. Continue to count the failures of components as Maintenance Rule Functional Failures but NOT as Repetitive Maintenance Rule Functional Failures when two components performing the same function fail within 18 months.

C.4 Recommendations

Section 9.3.3 of NUMARC 93-01 states that "systems, structures, and components that provide little or no contribution to system safety function could be allowed to run to failure.[3]" NUMAC 93-01 also states, " a decision to replace a failed component that provides little or no contribution to safety function rather than performance of a preventative maintenance activity may reduce exposure, contamination, and cost without impacting safety." A decision to run the radiation monitor components to failure will have no impact on the safety of the plant. A failure of these components will result in an alarm indicating that a failure has occurred.

Based on the criteria that:

- The system, structure, and components are low or non risk significant
- The time to discovery is less than 1 shift
- The demand PM can be completed within 48 hours of discovery, and
- The component's unavailability does not impact a SSC covered by (a)(3)/(a)(4)

then the requirements for the Maintenance Rule are satisfied.

The recommendation of this evaluation is for Option 2. The components of the Radiation Monitors can be run to failure without impacting the safety of the plant. The number of Maintenance Rule Functional Failures will still be evaluated against a set goal for the radiation monitoring system in any given 18 month period.

Note that the original CR 99-9771-1 document was signed by the Preparer (system engineer for radiation monitors); the PRA expert panel member and the MRC (both as reviewers); and the system engineer's Supervisor (as approver).

D
WOLF CREEK RUN-TO-FAILURE GUIDANCE

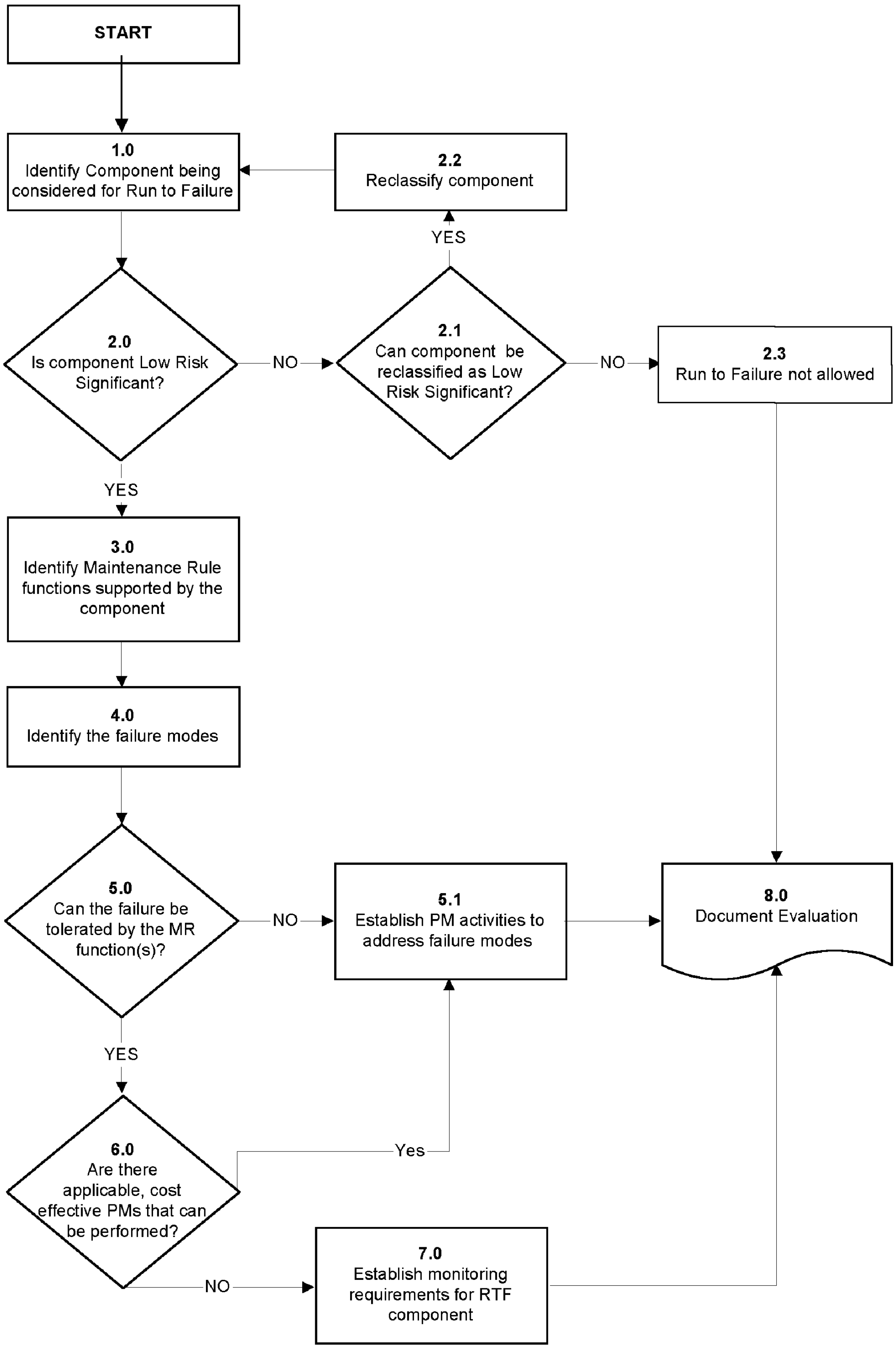
START
1.0
Identify Component being considered for Run to Failure
2.2
Reclassify component
YES
2.0
Is component Low Risk Significant?
NO
2.1
Can component be reclassified as Low Risk Significant?
NO
2.3
Run to Failure not allowed
YES
3.0
Identify Maintenance Rule functions supported by the component
4.0
Identify the failure modes
5.0
Can the failure be tolerated by the MR function(s)?
NO
5.1
Establish PM activities to address failure modes
8.0
Document Evaluation
YES
6.0
Are there applicable, cost effective PMs that can be performed?
Yes
NO
7.0
Establish monitoring requirements for RTF component

Figure D-1

1.0
Identify Component being considered for Run to Failure

Clearly identify the system, train, function, component, or subcomponent that is being evaluated for run-to-failure (RTF). For systems, trains, and functions, specify what portion of the system is included in the evaluation. For components and subcomponents, identify the specific applications that are being evaluated as RTF.

NOTE: Component will be used to represent the system, train, component, or subcomponent that is being evaluated for RTF.

2.0
Is component Low Risk Significant?

Determine if the component is low risk significant. Previous analysis performed during MR scoping or by the Probabilistic Safety Assessment (PSA) group can be used to make this determination. NUMARC 93-01 recommended using an expert panel for risk significance determinations to compensate for limitations of PSA analysis.

Normally the component will have the same safety significance as the Maintenance Rule (MR) function it supports. If the component supports more than one MR function, the component would generally be classified with the function having the highest safety significance.

If the component is high risk significant, go to step 2.1.

If the component (or the portion which is being evaluated) is low risk significant, go to step 3.0.

2.1
Can component be reclassified as Low Risk Significant?

If a run to failure evaluation is still desired, perform an evaluation to determine if the component can be classified as low risk significant.

2.2 Reclassify component

Once the component is classified as low risk significant, go to step 3.0.

2.3 Run to Failure not allowed

If the component is classified as high risk significant, run-to-failure is not allowed per references 2 and 3. Go to step 8.0

3.0 Identify Maintenance Rule functions supported by the component

Identify all the MR functions the component supports or that could be effected by failure of the component. Review MR scoping documentation to identify MR functions.

A containment isolation valve could affect three different MR functions depending on how scoping was performed: 1) it must close to provide containment isolation, 2) it must open to allow safety injection flow, 3) it must be leak tight to provide containment integrity.

4.0 Identify the failure modes

Identify all failure modes that will adversely affect the MR functions identified. Potential sources of information:

- EPRI PM basis document/program
- Reliability centered maintenance evaluation
- Preventive maintenance basis documents
- Site-Specific historical data
- Industry experience (EPIX, NRC/INPO bulletins)
- Vendor information

5.0
Can the failure be tolerated by the MR function(s)?

For each failure mode identified, determine the consequences of the failure on the MR function. This must be done for each MR function identified. It should be assumed that the failure occurs randomly [2]. The evaluation should take into account all modes and plant configurations (such as scheduled system outages) that the function is required.

In order to answer this question yes, it should be demonstrated that the failure of the component can be tolerated and managed. The failure will have little or no adverse impact on the MR function(s) involved [2]. The evaluation should consider redundancy within the function and the availability to use other components to accomplish the same task.

Focus on the functions of the component that support or affect MR functions. If an air-operated valve is only in the scope of the MR because it must close, the maintenance rule RTF evaluation only needs to focus on the close function of the valve.

If a failure can't be tolerated for a MR function, proceed to step 5.1.

If all failure modes can be tolerated, proceed to step 6.0.

5.1
Establish PM activities to address failure modes.

If a failure cannot be tolerated, PM activities should be established for the failure modes identified. Initiate document per site specific process to establish PM activities. Go to step 8.0.

6.0
Are there applicable, cost effective PMs that can be performed?

Are there any reasonable, cost-effective PMs that would prevent or significantly reduce the probability of failure? Use EPRI PM database, plant and industry experience. If an air operated valve only has to close to support an MR function, only PMs that help maintain the close function need to be considered. PMs that help maintain the open function are not a concern, unless they also affect the close function.

If PM activities are available, are the activities to preserve the function because of the risk to the public health and safety, or are the PMs based on reducing the economic impact on the plant? An example would be when the expense of replacing a failed component is much greater than the cost of a PM that extends the service life. While the economic impact is a consideration for run to failure evaluations performed for reliability centered maintenance, economic impact does not need to be part of the evaluation when performing a run to failure evaluation for Maintenance Rule.

Does the use of PM activities balance unavailability and reliability? Is it more efficient to periodically take the component out of service to perform PM activities to reduce failures? Or is it more effective to perform corrective maintenance once the component has failed. If the failure is readily identified and the component can be quickly fixed and returned to service, it may be more efficient to run the component to failure.

7.0
Establish monitoring requirements for RTF component

Although NUMARC 93-01 allows the use of RTF, it does not oleivate the requirement to perform monitoring. In addition, there are assumptions built into each run to failure evaluation. In order to meet the requirements of NUMARC 93-01 and to ensure the RTF assumptions are met, monitoring is required. What is monitored will depend on the details of the RTF evaluation. Even with RTF components a certain level of performance is still expected. Unavailability, reliability and failure rate can be used to monitor the effectiveness of the RTF approach. If criteria is exceeded, it would be treated the same as exceeding any other MR performance criteria.

8.0
Document Evaluation

Document the evaluation, conclusion and performance criteria.

Definitions

Maintenance - The aggregate of those functions required to preserve or restore safety, reliability, and availability of plant structures, systems and components as defined by NUMAR 93-01.

Preventive Maintenance - Predictive, periodic, and planned maintenance actions taken prior to SSC failure to maintain the SSC within design operating conditions by controlling degradation or failure. The purpose of preventive maintenance is: 1) Prevent failure, 2) Detect the onset of failure, and/or 3) Discover hidden failures.

Low Risk Significant - Those SSCs that are small contributors to risk as determined by PRA, IPE, MREP, or other methods.

Failure - The unplanned inability of an SSC to be able to perform its intended function(s).

Functional Failure - A failure that results in loss of a maintenance rule function.

Failure Mode - The particular type or manner of failure. A failure mode describes what can or has happened. Examples: Pump fails to run, a circuit breaker fails to open.

Run-to-Failure - A maintenance strategy that allows selected components to operate until failure occurs. No preventive maintenance is performed to preserve the maintenance rule function(s) the component supports.

Failure Effects - The consequence of the failure on the associated maintenance rule function(s).

References:

1. A. M. Smith. *Reliability Centered Maintenance*. McGraw-Hill, Inc. 1993.

2. U.S. Nuclear Regulatory Commission. *Maintenance Rule Frequently Asked Questions (FAQs)* @ http://www.nrc,gov/NRR/mrule/mrfaq.htm.

Nuclear Guidelines for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants.NUMARC 93-01, Rev. 3, July 2000.

Target:
Nuclear Power

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