Surveillance Strategy for a Four Year Operating Cycle in Commercial Boiling Water Reactors

by

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A SURVEILLANCE STRATEGY FOR A FOUR YEAR OPERATING CYCLE IN COMMERCIAL BOILING WATER REACTORS

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ABSTRACT

The economic performance of U.S. nuclear power plants must be improved if they are to exist and compete in the deregulated electricity market. One measure of economic performance is the plant capacity factor, i.e. the ratio of actual power produced to theoretical power which could have been produced over a given time period. Even for outage durations minimized to the nation's best of about 30 days, extended fuel cycles can result in significant increases in plant capacity factor. Arguments against extended fuel cycles have been the economic optimums of core life and a perceived need to shut down to perform preventive maintenance and testing. But, the latter argument has never been thoroughly investigated. If the testing and maintenance requirements (the surveillance requirements) could be adjusted to allow longer operating cycles, the financial penalties of operating a longer life core could be outweighed by the economic gains associated with the increased plant capacity factor. Three methods of overcoming surveillance requirements exist: one, performing the surveillance on-line, two, extending the surveillance performance interval so that it is consistent with the proposed refueling interval, and three, justifying the elimination of the surveillance.

A methodology to determine resolution options for individual surveillances was generated. A model which would identify the most economic performance modes was proposed. The regulatory mandated surveillances of an operating plant were analyzed to determine resolution options. Of the 66 types of surveillances studied at a commercial BWR, 61 would likely support an extended fuel cycle. A few sample on-line performance justifications and interval extension justifications were generated. The format of these examples is proposed as a general guide to utilities for their use in justifying a surveillance's on-line performance or performance interval extension. Finally, a compilation of subtle, but important fuel cycle extension issues which would require engineering and managerial attention was generated.

Thesis Supervisor: Dr. Neil E. Todreas
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Chapter 1 - Introduction

1.1. Impetus

The economic performance of U.S. nuclear power plants must be improved if they are to exist and compete in the deregulated electricity market.

Currently, conventionally fueled power plants have an economic advantage over nuclear plants. Conventional plants can operate at much lower plant staff levels. They also have lower interest payments since construction costs are much less. The one decided benefit of nuclear plants is the lower fuel costs.

To combat this economic disadvantage, the nuclear industry is focusing its efforts on improving plant performance and simultaneously reducing plant staff levels. While plant staff reduction is needed and will cut costs, achieving a staff level comparable to that of conventional plants is unrealistic due to the inherent complexity and risk potential of nuclear power relative to other electricity options.

The difference in production costs between conventional and nuclear power must therefore be made up by improved nuclear plant economic performance. One element strongly influencing economic performance is the plant capacity factor. Plant capacity factor is defined as the amount of electricity produced over a given time period divided by the amount of electricity which could have been produced if the plant had run at 100% power for the entire period. Capacity factor is therefore directly impacted by the number of off-line days experienced.

Off-line days are the result of either forced or planned outages. Forced outages are usually due to plant system failures or operator errors. Planned outages are used to perform refueling operations, corrective maintenance, preventive maintenance, and/or system testing.

The plant capacity factor can be improved by minimizing planned outages, minimizing forced outages, and increasing the run time between refuelings. This project focuses on the latter strategy by investigating a plan for a 48 month fuel cycle.

While most U.S. nuclear power plants operate on 12 or 18 month fuel cycles, approximately 17% have made or are now making the transition to a 24 month fuel cycle. If the number of outage days remains relatively constant, there are significant lifetime capacity factor gains to be achieved in such an extension. The logical next step is to investigate the economic consequences associated with extending operating cycles even further. In the past, the arguments against an extended fuel cycle have been the economic optimums of core life and a perceived need to shut down to perform preventive maintenance and testing. But, the latter argument has never been thoroughly investigated. If the testing and maintenance requirements (the surveillance requirements) could be adjusted to allow longer operating cycles, the financial penalties of operating a longer life core could be outweighed by the economic gains associated with the increased plant capacity factor.

These capacity factor gains are substantial if forced outages are kept to a minimum. Given a 35 day refueling outage length (the approximate length successful utilities are achieving), the maximum theoretical plant capacity factor (assuming no unplanned outages) would be as shown in Table 1.1 for various cycle lengths.

Cycle Length	Maximum Capacity Factor
12 Months	90.5%
18 Months	93.5%
24 Months	95%
48 Months	97%

Table 1.1 - Capacity Factor Potential Given a 35 Day Refuel Outage

If a value of $0.5 million per effective full power day (EFPD) is assumed, each 1% increase in capacity factor results in an approximate economic benefit of $1.83 million per year. Therefore, an investigation to develop a strategy for adoption of an extended fuel cycle is clearly warranted.

Such a strategy should address the following areas:

- **Core Design Issues.** A fuel core should be designed which is capable of a nominal 48 month lifetime. For practicality, it should be retrofittable into existing nuclear power plants and the fuel burnup should be maintained at or below current licensing limits.[1]

[1] Even if conversion to a 48 month fuel cycle is impractical because of limited time remaining for licensed operation, significant financial benefits can be achieved by adopting a surveillance strategy which would have supported a 48 month fuel cycle.

- **Required Reliability and Availability Performance.** A strategy for attaining the plant levels of reliability and availability needed to make a 48 month operating cycle attractive should be formulated.
- **Surveillance Requirements.** All maintenance and testing activities, called surveillances, which a utility is currently required to perform *off-line* at intervals *less than 48 months* must be made consistent with a 48 month cycle. Resolution can be in one of three forms: the surveillance's performance interval can be extended to at least 48 months, the surveillance's performance mode can be changed from the off-line to the on-line workscope or, in some cases, the surveillance can be eliminated.

This report will focus exclusively on the development of a strategy to establish surveillance requirements which support a 48 month operating cycle in BWR's. A similar study is underway in parallel with this one to establish a surveillance strategy for pressurized water reactors (PWR's). Some of the ideas and methodologies presented in this report were generated as result of joint research conducted with the author of that report, Thomas J. Moore.

1.2. Thesis Objective

Develop a strategy for establishing surveillance requirements consistent with a 48 month fuel cycle in commercial boiling water reactor power plants.

How does a utility approach the significant obstacle of aligning surveillance requirements to be consistent with a 48 month fuel cycle? The answer is by first meticulously exploring the possibilities of performing each individual surveillance on-line. If it is not possible to perform it on-line, then the issue of performance interval extension needs to be investigated. Once all the performance options are identified, the most economic options can be chosen (given no change in the overall safety of the plant).

This report presents a methodology for identifying the surveillance performance options. This Surveillance Resolution Methodology is described in Chapter 2. This is a systematic procedure which can be applied to each surveillance which currently precludes a 48 month cycle. A flowchart operation is used to identify the possibilities for resolution with an extended fuel cycle. The methodology yields a conclusion that the particular surveillance either is a candidate for on-line performance (Category A), a candidate for performance interval extension (Category B), or a potential difficulty which requires further study (Category C).

The remainder of the report demonstrates that the blueprint approach laid out in the Surveillance Resolution Methodology is viable. Chapter 3 answers the question, "What kind of results can a typical BWR expect if an extensive '48 Month Fuel Cycle Surveillance Resolution Study' is carried out?" The technical specification and other regulatory mandated surveillance requirements of an operating BWR were analyzed. Surveillance performance procedures and historical surveillance records were used to identify possible candidates for Categories A, B, and C. Plant personnel were consulted to ensure surveillance classifications were appropriate. Ultimately, expert judgment was relied upon to assign final individual surveillance categorizations. It is important to note that 'investment protection' surveillances were not analyzed as part of this study. These surveillances are those imposed on the utility by the utility for economic reasons. While the regulatory mandated surveillances are much more daunting obstacles to an extended cycle, it is likely that some investment protection surveillances would also preclude fuel cycle extension. These investment protection surveillances will be the topic of further study within the 48 month fuel cycle project.

Chapter 4 tackles the question, "What type of engineering justification is necessary to change a surveillance's performance mode (off-line to on-line) or its performance interval?" A few representative on-line performance justifications and interval extension justifications were generated. The format of these examples is proposed as a general guide to utilities for justifying a surveillance's on-line performance or performance interval extension. By presenting a few examples of appropriate justifications, this chapter illustrates the effort required to complete a 48 month fuel cycle surveillance resolution project. For this report, complete justification of all candidate surveillances was a prohibitively large task. Also, it was assumed that actual surveillance resolutions will vary somewhat from plant to plant. Consequently, complete surveillance justification is left to the individual utility.

Finally, chapter 5 is a compilation of management principles and engineering points of interest related to an extended fuel cycle. It is intended to answer the question, "What are the major management and engineering issues which should be kept in mind when pursuing surveillance requirement resolution?" Topics discussed include on-line surveillance scheduling aids, methods of transition to an extended cycle, mid-cycle maintenance outages, and others.

A significant future work section is included at the end of this report to identify related projects currently underway or not yet begun. One area of study in progress is the development of a quantified methodology for justification of surveillance performance interval extension. In the past, the performance intervals of non-instrumentation related surveillances have been extended primarily on the basis of expert judgment. It is reasonable to assume that expert judgment will not be sufficient in all cases when attempting to extend intervals to 48 months. The quantified methodology is expected to fill that justification void.

Performance interval extensions will also be aided by the adoption of event-based testing. As more knowledge is gathered concerning the root causes of failure mechanisms, a transition to event-based (e.g. every X starts) testing intervals from the current time-based (e.g. every Y months) testing intervals could be justified for some components. This transition, along with the development of the methodology for optimizing time based testing intervals, will facilitate performance interval extension and ultimately, operating cycle extension.

An area of study which has not yet begun concerns the optimization of surveillance categorization. The methodology of chapter two identifies the surveillance performance possibilities. If a utility finds that it could either perform a surveillance on-line or extend the surveillance's performance interval, a decision must be made. A project to develop a model which could weigh the economic benefits of the two options (given no overall change in plant risk) is currently being contemplated.

Chapter 2 - Surveillance Resolution Methodology

2.1. Introduction

The term 'surveillance' is broad in scope. As it is used in this report, it defines a variety of component tests, inspections, overhauls, and preventive maintenance activities. For example, a few of the many surveillances a plant performs are diesel generator operability tests, accumulator integrity inspections, electrical breaker overhauls, and valve internals preventive maintenance activities. A typical nuclear power plant conducts as many as one thousand different surveillances per fuel cycle.

In order to adopt a four year fuel cycle, the performance mode or the performance interval of all the surveillances which a plant currently performs (1) at intervals of less than 48 months and (2) while the reactor is shutdown, must be altered. There are two fundamental ways a surveillance can be conducted to support a 48 month operating cycle. The surveillance can be performed while the plant is at power or the surveillance performance interval can be extended to at least 48 months.

This chapter discusses these two surveillance resolution paths in depth and presents a methodology for determining the resolution options a plant has for its individual surveillances. The methodology is in the form of a flowchart. The output of this flowchart is a determination as to whether the surveillance can be performed on-line, whether the surveillance performance interval can be extended, or whether both options are a possibility. The chapter then proposes an optimization model for surveillances which can be resolved by both options. The output of the model would be the most economic combination of surveillance performance modes and surveillance performance intervals while maintaining original plant safety risk levels.

2.2. Resolution Options

As mentioned above, there are only two fundamental ways a surveillance can support a four year fuel cycle. For the purposes of this report, surveillances which are candidates for these two methods will be termed Category A and Category B surveillances. Category A surveillances are those which could be performed on-line. Category B surveillances are those which could support a performance interval extension to 48 months. If a surveillance can not be readily classified as either Category A or B based on initial engineering assessment, then it is termed Category C. Category C surveillances are those surveillances for which a more detailed engineering solution must be sought in order to support a four year operating cycle.

2.2.1. Category A - On-Line Surveillance Performance

A major U.S. industry thrust to reduce the length of refueling outages began in the 1980's. The impetus was the large savings to be realized by returning the plant to operational status and producing electricity as soon as possible. The first mechanism used to achieve shorter refuel outages was improved outage planning. Outage surveillance agendas were examined to develop a schedule which would improve outage efficiency by maximizing the number of surveillances performed simultaneously, thus reducing the total amount of time the plant was off-line.

Once a satisfactory level of outage efficiency was obtained, plant managers focused their attention on eliminating surveillances in the outage surveillance agenda. As a result, on-line surveillance performance has increased substantially in the industry and has been the theme of many industry-wide publications from major nuclear power organizations, including the Nuclear Regulatory Commission[1] (NRC).

There are many other advantages aside from reduced outage scope which result from performing surveillances on-line. These advantages include the greater attention which can be afforded surveillances performed on-line, the levelized workload over the course of the cycle, and the labor cost reduction from work performed by full-time

[1] "Evaluation of On-Line Maintenance", Temporary Instruction 2515/126, Nuclear Regulatory Commission, 27 October 94.

employees rather than more expensive outside contractors. These and other factors are discussed in depth below.

Certainly one of the primary reasons for moving a surveillance from the off-line to the on-line workscope is the reduction of the refuel outage length which can result. Plants generally estimate each refuel outage day to be worth $500,000 of lost revenue from the lack of electricity production. With this degree of incentive, extensive effort to reduce the outage length by even a few hours is justifiable.

It is important to analyze the on-line performance possibilities of all surveillances, even those which are not part of the outage's critical path. While justifying such a surveillance to the on-line workscope may not result in a direct refuel outage length reduction, it may shorten the outage indirectly since emergent maintenance as a result of surveillance failure often becomes part of the critical path. If a surveillance is justified for performance on-line, then it is possible that any emergent maintenance resulting from surveillance failure could also be accomplished at power.

During refueling outages, the number of tasks performed and the increased staff level generates a degree of fatigue and confusion not experienced during normal plant operation. Senior engineering oversight gets stretched thin when so many people are performing so many different activities at once. In contrast, on-line surveillance performance can be afforded much more oversight and planning. More time can be given to pre-surveillance training and more thought can be given to contingencies which could arise during surveillance performance. Consequently, on-line surveillance performance often results in higher quality maintenance and more precise test execution.

Another human factor advantage associated with performing a surveillance on-line is the increased probability of it being performed by full-time plant employees rather than more expensive outside contractors. The magnitude of the work to be done during a refueling outage and the incentive to minimize the outage length mandates hiring outside contractors to perform a significant portion of the surveillances during an outage. If a surveillance can be performed on-line, the relatively light daily plant workload facilitates surveillance performance by full-time plant personnel. This results in two direct benefits.

The first is the increased attention which is likely since the plant employee has to live with the performance of the component on a daily basis. This is in contrast to the workers employed by contractors who might perform the assigned task, collect their fee, and move on. Such workers are not necessarily long term employees of the contractor and therefore may not have a stake in the contractor receiving repeat business from the plant. While this fact probably does not affect the worker on a conscious level, it may affect the quality of his work on a subconscious level. With the exception of surveillances performed by workers who specialize in the particular task, the full time plant employee's 'ownership' of the component is likely to produce more attention to detail.

The second direct benefit resulting from surveillance performance by plant personnel is the increased component familiarity acquired. Reading the report of a surveillance performed by a contractor can only communicate a certain degree of component status. Having someone on-site everyday who performed the latest diagnostic checks of a component and is intimately aware of the results of those checks is extremely valuable. Such a person will be more cognizant of the likely failure mechanisms suggested by the latest surveillance performed than if he has only read the contractor's comments regarding the work performed during the last outage.

Along with the advantages in human factors from performing a surveillance on-line, some surveillances are simply safer to do while the plant is operating. For example, from a risk standpoint the Residual Heat Removal (RHR) System plays a larger safety role when the plant is being refueled. Therefore, surveillances which require the system to be inoperable are safer to perform on-line. In the case of the RHR, performing the applicable surveillances during the outage could limit the plant's capability to successfully cope with a Loss of Cooling Accident (LOCA).

Another incentive to justifying surveillances to the on-line workscope is the increased frequency with which they can be performed. If a component is suspected of operating below rated performance, as long as the surveillance itself is not in any way destructive, the frequency of surveillance performance can be increased to monitor for degradation. Failure mechanisms can then be diagnosed and corrected before catastrophic component failure occurs. In this way, on-line surveillance performance provides an enhanced component monitoring capability.

This monitoring capability ultimately results in improved equipment performance. If preventive maintenance and diagnostic checks can be performed whenever a problem is suspected rather than at set intervals (dictated by the refueling outages), then problems can be avoided. Fewer breakdowns can result in extended component life. For example, a motor for which the oil can be changed whenever the motor exceeds a certain number of hours running will likely last longer than a motor for which the oil can only be changed every X number of years regardless of the amount of hours it ran during those years.

While there are many advantages to on-line surveillance performance, it is not without its risks. The safety impact of taking systems out of service for surveillance performance must be carefully considered prior to any on-line work. On-line, Probabilistic Risk Assessment based risk monitors can play an important role in the pre-surveillance planning stage. They greatly enhance a surveillance scheduler's ability to identify potentially hazardous system configurations. However, they is no substitute for the thorough preparation and training of the workers who will actually be performing the testing. It is the responsibility of senior management to ensure that everyone involved in on-line surveillance performance understands the possible complications of the proposed work. Surveillance performance can often have a significant effect on other seemingly independent equipment. For example, many instrument calibrations are fairly routine when they are performed during an outage. But, if they are performed on-line, simply valving an instrument in and out of the system can cause potentially dangerous fluctuations in other instruments monitoring vital plant parameters. Workers must thoroughly understand critical system interdependencies such as these when they perform any surveillance during power operations.

2.2.2. Performance Interval Extension

During the early years of the nuclear power industry, plant engineers had very little operating experience upon which they could base component reliability judgments.

Consequently, it was not unusual for a plant to shutdown every few months to test vital systems. While the industry has proceeded beyond this 'test to see if it's broke' mentality, many current surveillance intervals are still indirectly a consequence of that reasoning. Intervals started out short and have only been gradually extended as the plant required it, not necessarily as the component dictated it. In other words, many performance intervals have not been optimized. Instead, they have been determined so that they meet two conditions: one, that they are conservative, and two, that they support the current plant operating cycle length. This second condition is evident in the relatively lenient surveillance performance extension requirements mandated by NRC Generic Letter 91-04 for utilities making a fuel cycle extension from 18 to 24 months. Essentially, only expert opinion stating that a performance interval extension was safe and supported by historical test data was required. This is not to imply that the NRC was inappropriately lenient. The fact is that no methodology for quantifying the optimum surveillance performance interval currently exists. However, such a methodology is being developed as part of this fuel cycle extension project and will be discussed further in chapters 5 and 7.

This methodology will facilitate justifying the extension of surveillances which currently have conservative performance intervals. If a component has been employed for a significant period and has never been found out of specifications, it is reasonable to question the performance interval. Surveillance performance requires time and labor. Resources are poorly allocated if they go toward over-testing a proven component.

Another tool which will aid in interval extension justification is event-based (instead of time-based) testing. This is a subset of performance based testing which is gaining interest within the industry. The theory is that if failure mechanisms are found to be predominantly event-dependent rather than time-dependent, a correlation can be determined between events such as motor start-up or valve cycling and the required surveillance performance. The result would be surveillance testing mandated every X motor start-ups or valve strokes instead of every X months or years.

In some cases it is reasonable to expect that the existing component simply will not support an extended surveillance performance interval. In such a case the only solution may be to upgrade the component to a performance level which could support the necessary interval. The question then arises, "How does a utility know that an upgraded component will support an extended operating cycle before the component is even installed?" One answer is through databases such as the Nuclear Plant Reliability Data System (NPRDS) which is maintained by INPO. It is likely that the proposed upgrade is currently employed by some other plant(s) in the nuclear industry. NPRDS provides reliability data for that component at the other plant(s). From this information, an educated decision on whether the component is likely to support the extended fuel cycle can be made.

2.3. Surveillance Resolution

This section presents a surveillance resolution procedure. This procedure is a systematic method of determining the resolution options for each individual surveillance. Once the various options are identified for each surveillance requirement, the proposed Economic Optimization Model/Engine would determine the most economical combination of performance modes for all the surveillances while maintaining current plant risk levels. The risks involved include those associated with core damage as well as other undesirable economic end-states such as the need for emergency depressurization in a boiling water reactor or feed-and-bleed in a pressurized water reactor. Although both types of risks will be analyzed by the Economic Optimization Model/Engine, plant safety and economic risks will be considered separately.

2.3.1. Category A Resolution Flowchart

The first resolution task is to decide whether on-line surveillance performance is possible. To accomplish this, let us refer to the Category A Resolution Flowchart in Figure 2.2 (a flowchart legend is provided in Figure 2.1). Within this flowchart, the boolean variable 'A' will represent the event that the surveillance can be performed on-line. If A = True, then the surveillance could be performed on-line. If A = False, then the surveillance could not be performed on-line.

Let us discuss the various decisions and processes of the Category A Resolution Flowchart:

◊ Can the surveillance be eliminated?

This is a fundamental issue independent of whether the surveillance falls into Category A or B. If performance of the surveillance has no effect on plant safety or reliability, then the surveillance should be eliminated. Additionally, if surveillance performance has only a small effect on plant safety and could be compensated for by increasing the frequency of selected on-line surveillances, it may be possible to eliminate the surveillance with no net effect on the Core Damage Frequency (CDF). Such a balancing of risk would be accomplished by the proposed Economic Optimization Model which, if the surveillance could be eliminated, is the next step in the flowchart. The Economic Optimization Model will be discussed later in this chapter.

◊ Is the component accessible at power?

If the component is not accessible either directly or remotely, modifications will have to be made or the surveillance will have to be performed while shutdown. Inaccessible equipment would include any component inside the bio-shield or under the reactor but may also include components that are located in high radiation areas.

◊ Can modifications be made to make the component accessible?

If such modifications are not possible, then the surveillance involving the component cannot be performed on-line, A = False, and surveillance resolution analysis should proceed to the Category B Resolution Flowchart which will be discussed later.

Flowchart Legend

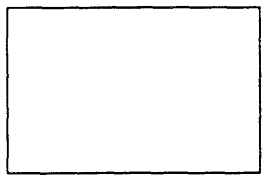
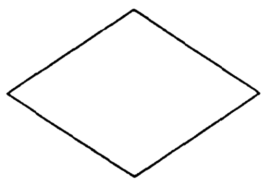
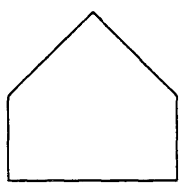
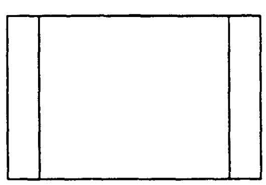
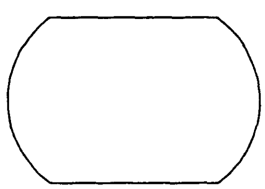
Symbol	Function
	Process
	Decision
	Offpage Connector
	Predetermined Process
	Terminal

Figure 2.1

Category A Resolution Flowchart

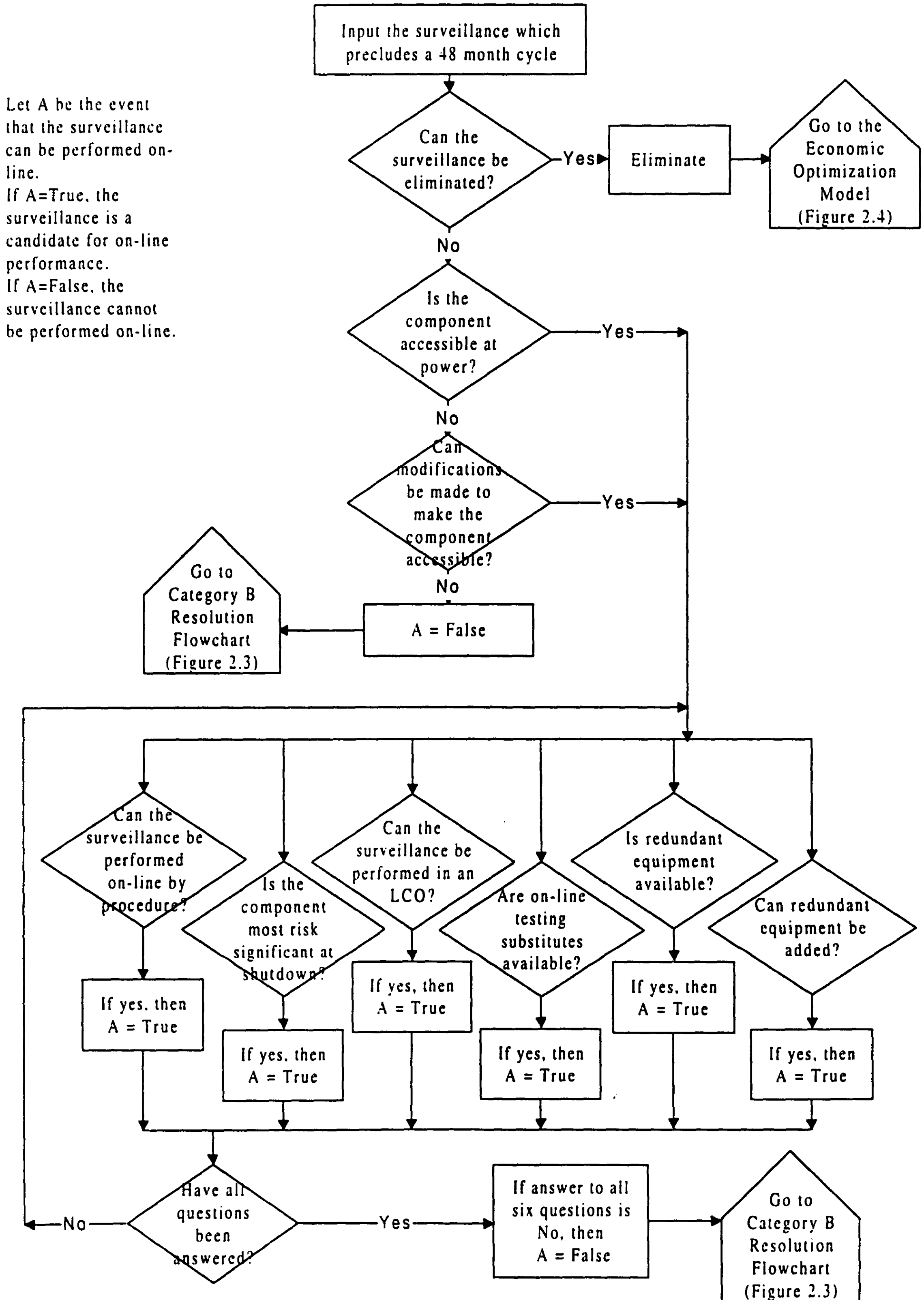


Figure 2.2

◊ Can the surveillance be performed on-line by procedure?

If an on-line performance option already exists in the current surveillance procedure, then a determination must be made as to why the utility currently chooses to perform the surveillance off-line. This could include reasons ranging from economic cost, a perceived risk of operator errors causing unplanned shutdowns, increased man-rem exposure, or no current incentive to perform the surveillance on-line given current plant cycle and refueling lengths. Whatever the reason, action would have to be taken to ensure that on-line surveillance performance does not constitute an unjustified risk. The risk issue will be addressed in the Economic Optimization Model later in this chapter.

◊ Is the component most risk significant at shutdown?

Most components/systems which would fall into this category are shutdown safety systems such as the Residual Heat Removal (RHR) system. In many instances, it would be more desirable to test the system on-line to confirm its operability than to wait for a shutdown condition when its use may be essential.

◊ Can the surveillance be performed in a Limiting Condition of Operation (LCO)?

LCO's are plant configurations involving the unavailability of a particular component or system which are allowed for short periods of time by the plant technical specifications, i.e. its licensing basis. Their purpose is to minimize unnecessary shutdowns in instances where components or systems can be restored to service relatively quickly. In the past , the NRC's position has been that LCO's were only to be used for the performance of corrective maintenance. The NRC is now allowing the use of LCO's to perform surveillances on-line provided the utility can demonstrate an acceptable understanding of the risks associated with on-line performance.

◊ Are on-line testing substitutes available?

On-line testing methods such as radiography or ultrasonic testing may provide an alternative to many of the open and inspect surveillances resulting from the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code Section XI.

◊ Is redundant equipment available?

If redundant equipment is available, the component or system can likely be removed from service in order to perform the surveillance on-line. This is particularly applicable to instrumentation where two or more measurement channels for each parameter are provided. For example, the improved Westinghouse Standard Technical Specifications approved by the NRC specifically allow the removal from service of a redundant channel for a predetermined time interval for maintenance or calibration.

◊ Can redundant equipment be added?

The answer to this question will not only depend on the particular component and its function, but also on the layout and space availability of the plant.

If the answer to <u>any</u> of the six questions above is yes, then A = True and on-line surveillance performance is a possibility. It is not necessarily the best method of surveillance resolution, but it is a possibility.

If the answer to <u>all</u> of the six questions above is no, then A = False and on-line performance is not an option.

Regardless of whether A = True or False, the next step is to determine whether performance interval extension is possible. For this decision, the Category B Resolution Flowchart will be used.

2.3.2. Category B Resolution Flowchart

The next resolution task is to decide whether performance interval extension is an option. To accomplish this, let us refer to the Category B Resolution Flowchart in Figure 2.3. Within this flowchart, the boolean variable 'B' represents the event that the surveillance performance interval can be extended. If B = True, then the surveillance performance interval could be extended. If B = False, then the surveillance performance interval could not be extended. The boolean variable 'C' represents the event that the surveillance performance interval cannot be extended and the surveillance cannot be performed on-line. C = True if A = False and B = False. If C = True, then the surveillance will require further study before it is consistent with a 48 month operating cycle.

Let us discuss the various decisions and processes of the Category B Resolution Flowchart.

◊ Can the interval be extended on the basis of a technical evaluation?

  This will be the primary method for justifying extension of surveillance performance intervals. NRC Generic Letter 91-04 would form the basis of the technical evaluation. The evaluation must consider issues such as surveillance history, corrective maintenance history, preventive maintenance regularly performed on the component/system, time dependent failure modes, and system engineer technical opinion. If the answer to this question is yes, then B = True and resolution analysis should proceed to the Economic Optimization Model.

◊ Can the interval be extended based on a lack of risk significance?

  If extending the performance interval of a particular surveillance has a relatively small impact on the overall Core Damage Frequency (CDF), then its interval can likely be extended. The increase in CDF could be offset by additional on-line testing which would decrease the CDF.

◊ Can the interval be extended by increasing the scope of the surveillance?

If the scope of a surveillance is increased, it may be possible to perform it on a less frequent basis. For example, let us say a particular pump is completely overhauled every 10 years, but an inspection is performed every 24 months while the plant is shutdown. Suppose plant inspection data and industry data show that time dependent failures only occur at frequencies approaching 10 years. If pump components which exhibited the most time dependent failure rate were replaced on a more frequent basis than once every 10 years, the plant may be able to justify extending the inspection interval to coincide with the replacement of these components.

◊ Can the interval be extended by performing on-line monitoring?

On-line monitoring programs are increasing in use and sophistication. Some of the current on-line monitoring programs include techniques such as vibration analysis of pumps and turbines, acoustic flow detection and monitoring to measure valve performance, radiography, and lube oil analysis. The application of these techniques may allow for actual inspection intervals to be extended. This would have the added benefit of reducing the number of times a component must be taken apart for inspection.

◊ Can the interval be extended by upgrading the component?

Many surveillance performance intervals are based on the failure history of particular components. If a superior component or system exists, performance interval extension might be possible by replacing the existing component. Upgrades of components could also entail more elaborate installation and alignment techniques. For example, many pump failures are due to improper or insufficiently precise alignments. An improvement in the alignment of the shaft through the use of a modern alignment technique could result in a surveillance performance interval extension.

Category B Resolution Flowchart

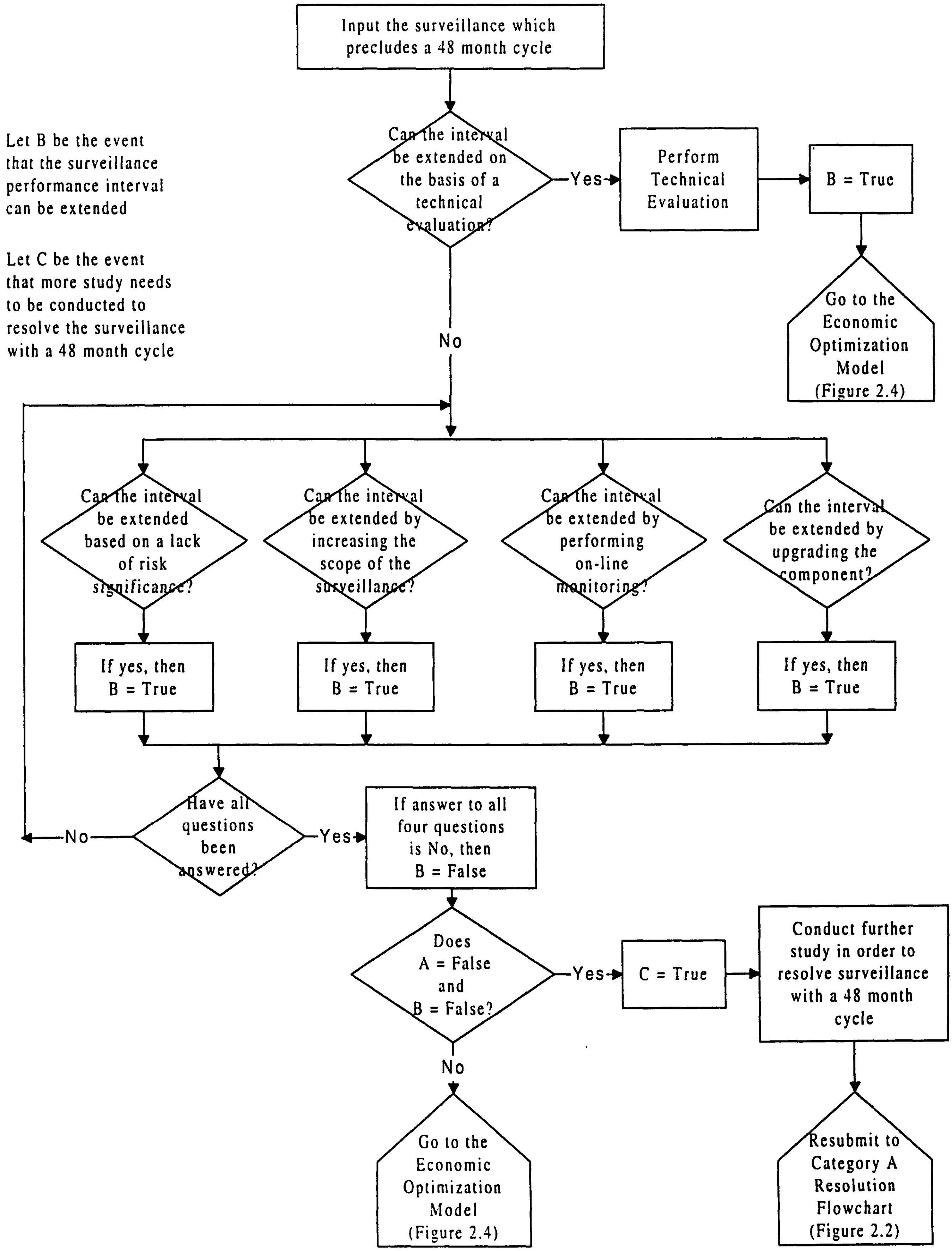


Figure 2.3

If the answer to <u>any</u> of the four questions above is yes, then B = True and the surveillance could be performed at extended intervals.

If the answer to <u>all</u> of the four question above is no, then B = False and the surveillance could not be performed at extended intervals.

If A = False and B = False, then the surveillance is classified as Category C and must be studied further in order to resolve it consistent with an extended operating cycle. All other surveillances are input into the economic optimization model.

2.3.3. Economic Optimization Model

The purpose of the Economic Optimization Model, represented in the flowchart of Figure 2.4, is to identify the various surveillance performance variables needed for the proposed Economic Optimization Engine which will be discussed later in the chapter. These variables are required for the Engine to determine the most economic combination of surveillance performance modes while maintaining current risk levels. Variable determination is accomplished in the process boxes of the Economic Optimization Model. (The specific quantification methods for determination of the variables is left as future work.)

Maintaining current risk levels involves accounting for changes in the probability of core damage as well as other undesirable economic end-states. The two types of risk are dealt with separately in the form of CDF and the probability of Limiting Plant Events (i.e. any event which has a substantial economic impact on the plant), respectively. One stipulation to the output of the Economic Optimization Engine would be that the ultimate integrated CDF over the course of the cycle would be equal to the original value before fuel cycle extension.[1] Another requirement would be that the Engine's recommendations do not contradict the appropriate legal authority, i.e. technical specifications or other legal code. Finally, a limit would be placed on the instantaneous CDF which could be experienced by the plant so that dangerous plant configurations would be avoided.

[1] Note that if a percentage decrease or increase in the integrated CDF was required or desired, the Engine could be easily modified to provide this.

In the descriptions below, variables are classified as either "given" or "input". A "given" variable concerns a surveillance which has only one possible means of resolution with a 48 month operating cycle. An "input" variable concerns a surveillance which has more than one possible means of resolution with a 48 month operating cycle.

Now let us elaborate on what is entailed in each process box: (the numbers in parentheses refer to the numbers next to the process boxes in Figure 2.4)

- (1) Determine the change in CDF from surveillance elimination

  The elimination of a surveillance is likely to (at least) slightly increase the CDF of the plant. This increase might be accounted for by a decrease in the CDF as a result of either a change in the performance mode or a change in the performance interval of some other surveillance. <u>The increase in the CDF as result of surveillance elimination is a "given" variable</u> with regard to the Economic Optimization Engine because no other performance option for the surveillance is considered since surveillance elimination is characterized by such large economic savings. Ultimately, the increase in the CDF must be accounted for in the output of the Economic Optimization Engine.

- (2) Determine the change in CDF from switching to on-line performance

  Switching to on-line surveillance performance may have an impact on the CDF. This impact may be either an increase (as in the case where a plant transient resulting from human error may be more likely) or a decrease (as in the case where the surveillance involves a system or component which is most risk significant during shutdown). <u>The change in the CDF from switching to on-line performance for A = True, B = False surveillances is a "given" variable</u> with

Economic Optimization Model

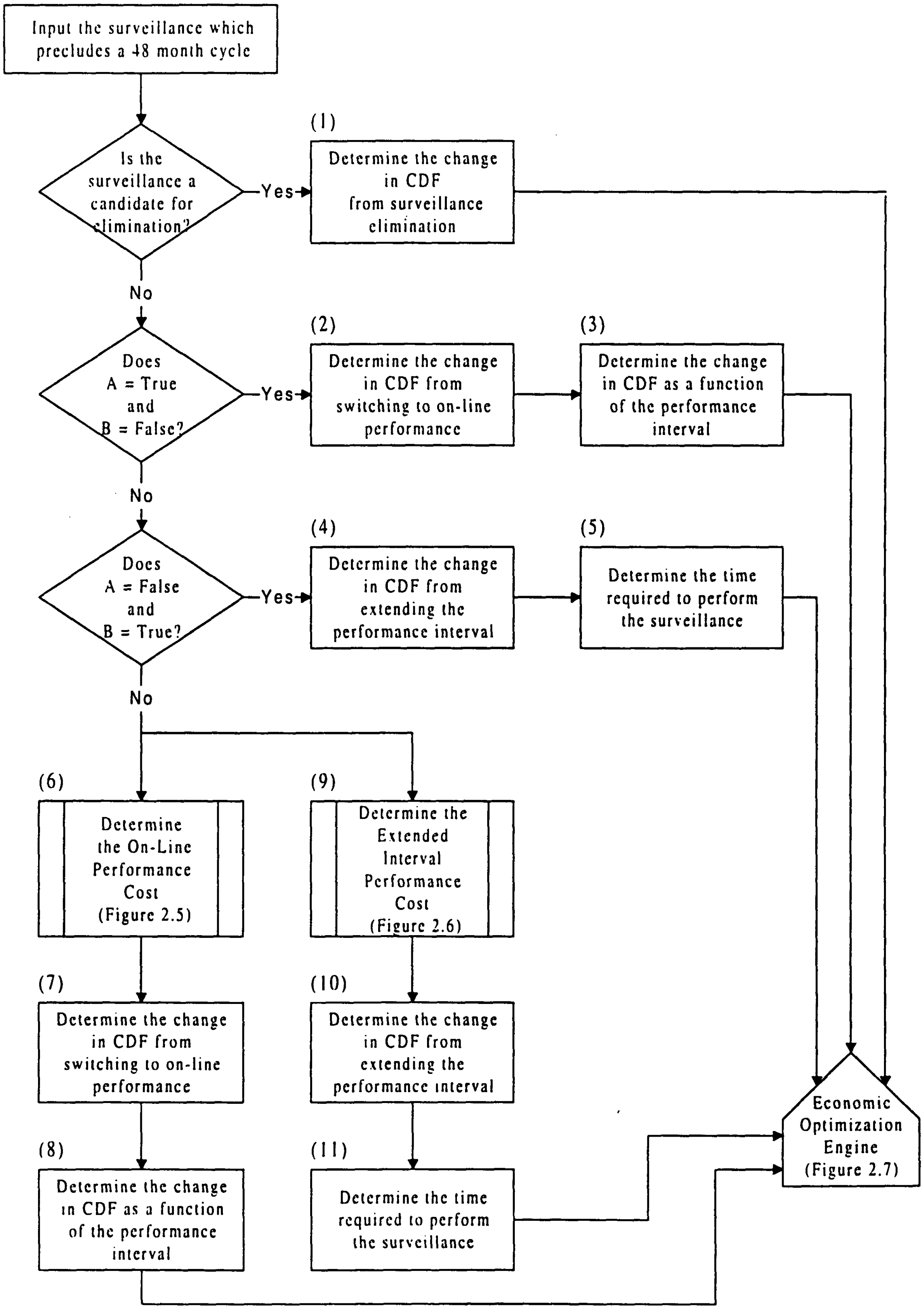


Figure 2.4

On-Line Performance Cost Factors

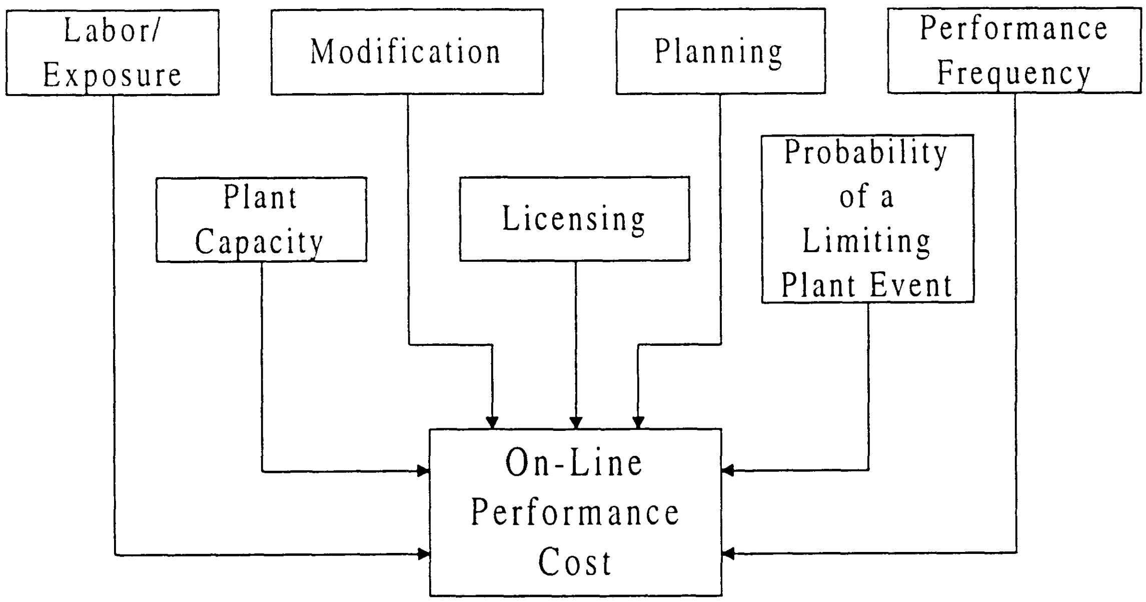


Figure 2.5

Extended Interval Performance Cost Factors

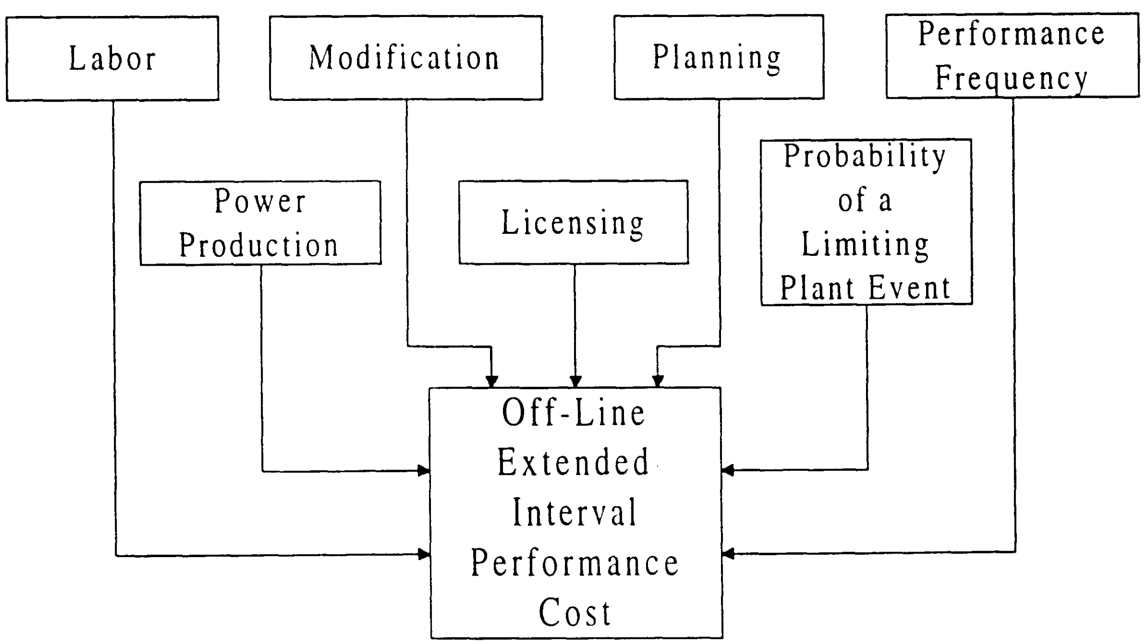


Figure 2.6

regard to the Economic Optimization Engine because off-line performance interval extension is not an option. Ultimately, the change in the CDF must be accounted for in the output of the Economic Optimization Engine.

❒ (3) Determine the change in CDF as a function of the performance interval

When the performance mode of a surveillance is switched from off-line to on-line, increased surveillance performance frequencies become an option. Increasing performance frequencies, as long as the surveillance itself is not a destructive examination of the component, can result in a decrease in the CDF (as in the case where a preventive maintenance activity can be performed more frequently). This decrease in CDF may be needed to offset the increase in CDF which could result from changing the performance mode or performance interval of other surveillances. <u>The change in CDF as a function of the performance interval for A = True, B = False surveillances is a "given" variable</u> with regard to the Economic Optimization Engine because off-line performance interval extension is not an option. Part of the output of the Economic Optimization Engine will be a determination of the performance intervals of all A = True, B = False surveillances so that the net change in the CDF over the course of operating cycle extension will be zero.

❒ (4) Determine the change in CDF from extending the performance interval

Extending the surveillance performance intervals of surveillances performed during the outages may result in an increase in the CDF (as in the case where the operation of an integral safety system will be verified less frequently). <u>The change in CDF from surveillance performance interval extension for A = False, B = True surveillances is a "given" variable</u> with regard to the Economic Optimization Engine because on-line surveillance performance is not an option. Ultimately, the change in the CDF must be accounted for in the output of the Economic Optimization Engine.

❐ (5) Determine the time required to perform the surveillance

During a refueling outage, while the core is being refueled, surveillances can be performed in parallel without any additional loss of electricity production revenue. Once the core is completely refueled, surveillances which still need to be performed may be in the critical path to plant start-up and power production. Consequently, surveillances performed after the refueling of the core is completed can be extremely expensive. Therefore, the time required to perform a surveillance during an outage must be considered by the Economic Optimization Engine in order to determine a combination of surveillance performance modes which will minimize the number of surveillances performed after the core has been refueled. <u>The time required to perform A = False, B = True surveillances is a "given" variable</u> with regard to the Economic Optimization Engine because on-line surveillance performance is not an option.

◫ (6) Determine the On-Line Performance Cost (Refer to Figure 2.5)

If a surveillance can be made compatible with an extended operating cycle by either performing it on-line or extending the performance interval, a resolution decision must be made. A key variable which will play a major role in this decision is the cost of performing the surveillance on-line. Several of the factors which determine the cost of performing a surveillance on-line are discussed below.

❐ Labor/Exposure

A surveillance which is routine when conducted off-line may be extremely complex when performed at power. Extra surveillance preparation time may be required when performing a surveillance on-line because system interdependencies and contingencies must be considered. Actual surveillance performance may have to proceed at a slower than usual pace to ensure no mistakes are made which could cause a plant transient or trip the plant off the line. Another potential drawback of on-line surveillance performance is the increased radiation exposure to plant personnel which may result. (A figure of $10,000 per man-rem is the figure used at the plant where research was conducted.) Increased surveillance performance time and increased radiation exposure result in increased surveillance performance costs.

❒ Modification

In order to perform the surveillance on-line it may be necessary to make modifications to the existing plant configuration or additions to the plant inventory. Changes may have to be made simply to gain access (directly or remotely) to the component or system involved in the surveillance. Redundant equipment may have to be added so that the component or system to be tested can be taken out of service while the plant is at power. On-line testing equipment may have to be added to the plant's inventory. Any changes to the plant configuration or additions to the plant inventory result in extra on-line performance cost.

❒ Planning

The extra training of plant personnel which will likely be required if a surveillance is performed on-line must be developed. Normal testing line-ups may have to be altered if a surveillance performance mode is changed from off-line to on-line. Such changes would require analysis by senior engineers. As the number of senior level personnel required to plan surveillance performance increases, the cost of the surveillance increases.

❒ Performance Frequency

In order to maintain current risk levels when an extended fuel cycle is adopted, it may be necessary to perform on-line surveillances more frequently. If the frequency of surveillance performance increases, the cost associated with that surveillance increases proportionally.

- Plant Capacity

  To perform some surveillances on-line, a reduction in plant power may be required. Reduction of plant power results directly in loss of revenue. However, many of the surveillances which require a reduction in plant power could likely be performed simultaneously, minimizing the loss of electricity production.

- Licensing

  Changing the performance mode of some surveillances will require approval by the appropriate authority. The mode change justification packet will require analysis by support engineering. The time spent producing the analysis will be part of the on-line performance cost.

- Probability of a Limiting Plant Event (LPE)

  An LPE is defined as any event which has a substantial economic impact on the plant. Such an event could be as minor as a plant trip where the plant can be brought back to power quickly, or as major as a reactor depressurization trip with the resulting containment contamination. Performing a surveillance on-line may have an impact on the probability of an LPE. For example the instantaneous trip frequency may increase while the surveillance is being performed because an operator error could result in a plant trip. However, the overall trip frequency may decrease if a component which is in a degraded state is diagnosed and corrected on-line as a result of the surveillance performance. An increase or decrease in the probability of an LPE can be translated into economic cost or savings.

The sum of all seven of the above cost factors will yield the overall on-line surveillance performance cost. <u>This on-line surveillance performance cost for A = True, B = True surveillances is an "input" variable</u> because the alternative, extending the performance interval, is an option and the Economic Optimization Engine will ultimately determine the performance mode.

❐ (7) Determine the change in CDF from switching to on-line performance

If the surveillance is performed on-line the CDF may be impacted. The impact may be in the form of either an increase (as in the case where a plant transient resulting from human error may be more likely) or a decrease (as in the case where the surveillance involves a system or component which is most risk significant during shutdown). The change in the CDF from performing A = True, B = True surveillances on-line is an "input" variable with regard to the Economic Optimization Engine because the alternative, extending the performance interval, is an option and the Economic Optimization Engine will ultimately determine the performance mode. If on-line performance is chosen, the change in CDF must be accounted for.

❐ (8) Determine the change in CDF as a function of the performance interval

If the surveillance is performed on-line, increased surveillance performance frequencies become an option. Increasing performance frequencies, as long as the surveillance itself is not a destructive examination of the component, can result in a decrease in the CDF (as in the case where a preventive maintenance activity can be performed more frequently). This decrease in CDF may be needed to offset the increase in CDF which could result from changing the performance mode or performance interval of other surveillances. The change in CDF as a function of the performance interval for A = True, B = True surveillances is an "input" variable with regard to the Economic Optimization Engine because the alternative, extending the performance interval, is an option and the Economic Optimization Engine will ultimately determine the performance mode as well as the performance frequency (if on-line performance is chosen).

◫ (9) Determine the Extended Interval Performance Cost (Refer to Figure 2.6)

If a surveillance can be made consistent with an extended operating cycle by either performing it on-line or extending the performance interval, a resolution decision must be made. A key variable which will play a major role in this decision is the cost of extending the surveillance interval and performing the surveillance off-line. Several of the factors which determine the cost of extending the surveillance interval and performing the surveillance off-line are discussed below.

❐ Labor

The amount of work which must be conducted during refueling outages usually mandates the hiring of contract workers. Because they are not full-time employees of the plant, these workers constitute an avoidable additional outage cost. If a surveillance must be done during the outage, extra contract workers may have to be hired to perform the work without increasing the length of the outage. This will be a factor in the overall cost of extending the surveillance interval and performing the surveillance off-line.

❐ Modification

Performance interval extension may require upgrading a particular component or system. Designing, buying, and installing the new equipment is an expense which must be included in the overall off-line extended interval performance cost.

❐ Planning

Outage planning is one of the most specialized areas in the nuclear power industry. Outage planners are hard pressed to schedule outages so that the maximum number of surveillances can be performed while the core is refueled. Extending the performance intervals of surveillances keeps them in the outage workscope and therefore contributes to the outage planning burden. The larger the outage surveillance agenda, the larger the outage planning cost.

❐ Performance Frequency

Let us say that a surveillance is currently performed on a 24 month interval during refuel outages. If that performance interval is extended to 48 months, surveillance performance costs will be reduced because the surveillance will be performed half the number of times it would have been performed had the 24 month interval been maintained.

- ❒ Power Production

If, during the refueling outage, a surveillance cannot be performed while the core is being refueled because too many other surveillance activities are already scheduled, then surveillance performance may result in an extension of the refueling outage. The loss of revenue from the lack of electricity production would then be an added cost of off-line extended interval performance. Most plants estimate loss of revenue to be approximately $500,000 for every day that the plant is shutdown.

- ❒ Licensing

Changing the performance interval of some surveillances will likely require approval from the appropriate authority. The interval extension justification packet will require analysis by a support engineer. The time this engineer spends producing the packet will be part of the off-line extended interval performance cost.

- ❒ Probability of a Limiting Plant Event (LPE)

Extending a surveillance performance interval may result in a decrease in the reliability of a component or system. This decrease in reliability could translate into an increase in the plant trip frequency. The resulting increase in the probability of an LPE must be translated into an economic cost and considered part of the off-line extended interval performance cost.

The sum of all seven of the above cost factors will yield the overall off-line extended interval performance cost. <u>This off-line extended interval performance cost for A = True, B = True surveillances is an "input" variable</u> because the alternative, performing the surveillance on-line, is an option and the Economic Optimization Engine will ultimately determine the performance mode.

❐ (10) Determine the change in CDF from extending the performance interval

Extending the performance intervals of surveillances performed during the outages may result in an increase in the CDF (as in the case where the operation of an integral safety system can be verified less frequently). <u>The change in CDF from surveillance performance interval extension for A = True, B = True surveillances is an "input" variable</u> because the alternative, on-line surveillance performance, is an option and the Economic Optimization Engine will ultimately determine the performance. (If performance interval extension is chosen, the change in the CDF must be accounted for.)

❐ (11) Determine the time required to perform the surveillance

During a refueling outage, surveillances can be performed without any additional loss of electricity production revenue as a direct result. Once the core is completely refueled, surveillances which still need to be performed become the critical path towards plant start-up and power production. Consequently, surveillances performed after the refueling of the core is completed are extremely expensive. Therefore, the time required to perform and the interdependencies between surveillances during an outage must be considered by the Economic Optimization Engine in order to determine a combination of surveillance performance modes which will minimize the number of surveillances performed after the core has been refueled during the refuel outage. <u>The time required to perform A = True, B = True surveillances is an "input" variable</u> because the alternative, on-line surveillance performance, is an option and the Economic Optimization Engine will ultimately determine the performance mode.

2.3.4. Economic Optimization Engine

The proposed Economic Optimization Engine would be a computer based tool which considers all of the "given" and "input" variables of every plant surveillance and determines the most economic surveillance performance mode combination which maintains current risk levels. In other words, there would be two requirements on the Engine's surveillance performance mode combination conclusion, one, that the change in the CDF from the plant's original operating cycle would be at least zero, and two, that the combination would result in the greatest economic benefit.

There would be three distinct outputs of the Engine: (as represented in Figure 2.7)

1. The optimal performance mode of all A = True, B = True surveillances

   Since both resolution options are possible, the Engine must determine which option, in combination with all other surveillance performance modes, will be the most economic route to follow.

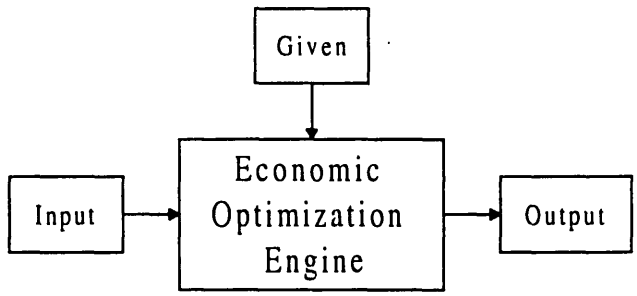
2. The performance frequency of all A = True, B = True surveillances selected for on-line performance

   If on-line surveillance performance is selected for surveillances which also have the option of interval extension, a surveillance performance interval must be chosen. The interval may have to be increased in order to balance the increase in CDF which could result from the change of the performance mode or performance interval of some other surveillance.

3. The performance frequency of all A = True, B = False surveillances

   The surveillance performance interval may have to be increased in order to balance the increase in CDF which could result from the change of the performance mode or performance interval of some other surveillance.

Economic Optimization Engine



GIVEN:
(1) The change in CDF from surveillance elimination
(2) The change in CDF from switching to on-line performance (A = True, B = False)
(3) The change in CDF as a function of the performance interval (A = True, B = False)
(4) The change in CDF from extending the performance interval (A = False, B = True)
(5) The time required to perform the surveillance (A = False, B = True)

INPUT:
All variables refer to surveillances with A = True and B = True
(6) The On-Line Performance Cost
(7) The change in CDF from switching to on-line performance
(8) The change in CDF as a function of the performance interval
(9) The Extended Interval Performance Cost
(10) The change in CDF from extending the performance interval
(11) The time required to perform the surveillance

OUTPUT:
1. The optimal performance mode of all A = True, B = True surveillances
2. The performance frequency of all A = True, B = True surveillances selected for on-line performance
3. The performance frequency of all A = True, B = False surveillances

Figure 2.7

2.4. Summary

Figure 2.8 summarizes the entire surveillance resolution methodology. First, a determination is made as to whether the surveillance can be performed on-line. Next, a determination is made as to whether the performance interval of the surveillance can be extended to support an extended operating cycle. The surveillances which could employ either resolution option are input into the Economic Optimization Engine. (The dotted lines represent the "given" variables role in the Engine.) The Engine determines the most economic performance mode and performance interval for these surveillances. The stipulation on this combination of performance modes and intervals is that the CDF must remain unchanged from its original value prior to operating cycle extension. Any substantial increase in the probability of an LPE would be avoided because it would be translated into a performance mode which is too expensive.

The tools necessary to determine the change in CDF as a result of changes in the performance modes and performance intervals of surveillances already exist in the on-line risk monitors currently being developed throughout the industry. The two major tasks still required to make the Economic Optimization Model/Engine a reality is the development of the specific quantification methods of the cost factors illustrated in Figures 2.5 and 2.6, and the computer-based Engine itself. These are both formidable jobs but ones which, when completed, could play a revolutionary role in reducing the operation and maintenance costs of nuclear plants.

The benefits of the proposed Economic Optimization Model would not necessarily be limited to fuel cycle extension projects. The Model could also be used by plants that wish to reduce operation and maintenance costs without an operating cycle extension. In such a case, a minor modification of the Engine would be required to allow the option of leaving a surveillance's performance mode and interval unchanged. The Engine would recommend one of three options for each surveillance: one, performing the surveillance on-line, two, maintaining the current performance mode and interval, and three, extending the performance interval while still performing the surveillance off-line. Even though the operating cycle would not be extended, this final option would be sought for many surveillances because performing a surveillance less frequently could result in significant savings.

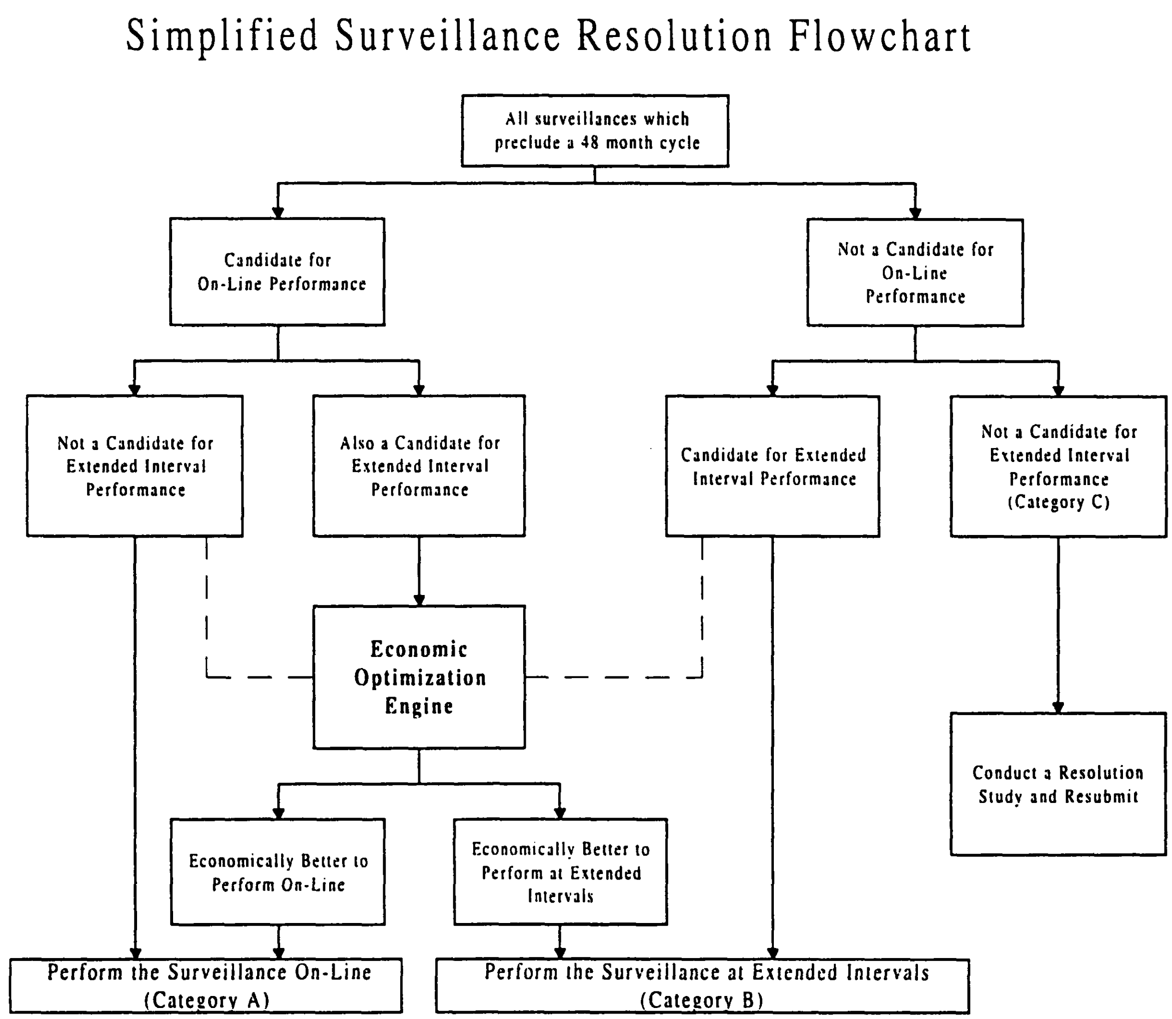


Figure 2.8

Chapter 3 - Plant Surveillance Categorization

3.1. Introduction

In today's electricity market, utilities do not have excess resources which can be allocated to projects which may not produce valuable results. Committing resources to a fuel cycle extension project only to find the desired conclusion unattainable is money wasted. Therefore, research was conducted at a U.S. boiling water reactor power plant (which is currently on a two year operating cycle) to explore four year operating cycle surveillance resolution possibilities.

All surveillances scheduled for performance during planned outages were compiled. Surveillances not performed to satisfy a technical specification or other regulatory requirement were eliminated (i.e. surveillances imposed on the utility by the utility and based primarily on investment protection or other economic considerations were eliminated; they will be analyzed in a future study), as were surveillances with performance intervals of 48 months or more. The result was a list of 610 technical specification or other regulatory mandated surveillances, currently performed off-line, with intervals precluding a 48 month fuel cycle.

The format of the surveillance tracking database at the plant facilitated placing these surveillances into one of seven groups. Placement in the groups is based on the division at the plant which performs the surveillance. The groups and the number of surveillances associated with each are represented in Table 3.1.

Surveillances Requiring Shutdown

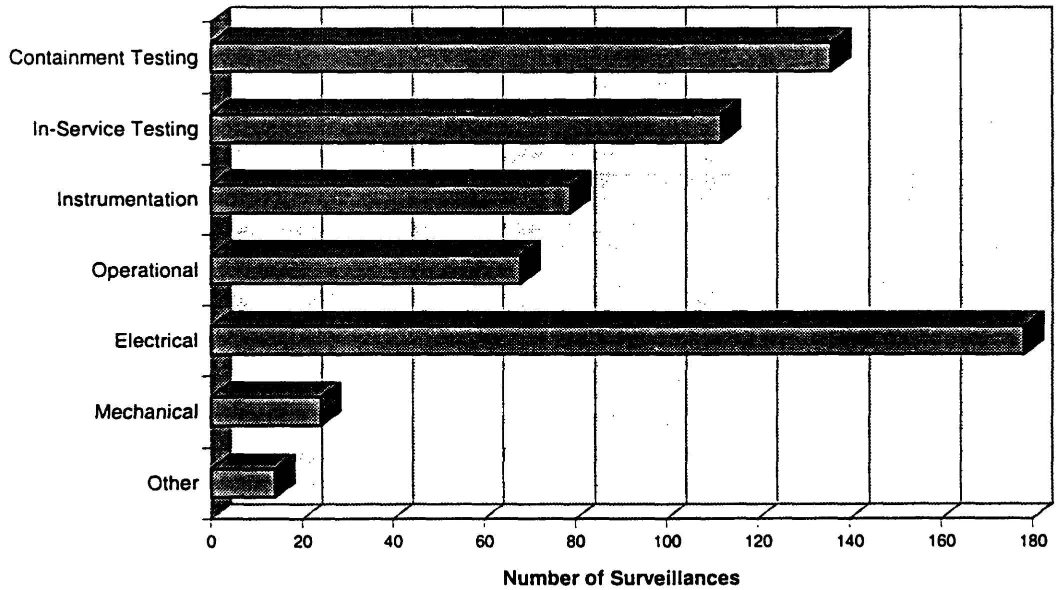


Table 3.1

Each surveillance was analyzed in order to classify it as a candidate for Category A, B, or C (on-line performance, performance interval extension, or requiring more detailed engineering solution). Categorization was conducted as follows:

Plant surveillance procedures were examined to explore the possibility of performing the surveillance on-line. Many procedures did not identify a specific plant mode as a prerequisite for the surveillance and many of them could, in fact, support on-line performance. Other surveillances, although currently performed off-line, had procedures specifically allowing on-line performance.

Plant surveillances records were then analyzed to identify candidates for performance interval extension. It was not unusual to find that a component had never failed its corresponding surveillance test. If a component has never been found out of specifications, it is reasonable to question the surveillance interval.

Finally, plant personnel were consulted to ensure that classifications into Categories A and B were appropriate. These interviews illustrated surveillance idiosyncrasies not apparent in the procedures and historical records. The expert opinions obtained were relied upon to assign final individual surveillance categories. Some surveillances were placed into Category C as a result. However, plant engineers maintained that most components and their associated surveillances would probably support an extended fuel cycle.

The remainder of this chapter presents the types of surveillances which were placed into the various categories, A, B, and C, based on surveillance analysis and expert opinion. A thorough line by line categorization of each individual surveillance is provided in the appendices.

It is important to note that surveillances were analyzed with a focus on the physical limitations of the system rather than the legal limitations. If a surveillance's historical record suggested that an extended performance interval could be justified, then it was classified as Category B even though there may be some legal limitations currently preventing a 48 month interval. This methodology was adopted in light of the fact that legal obstacles can be overcome as a result of a technical justification showing that the physical characteristics of the system support the change.

One of the most important results of this study is not necessarily the identification of the surveillances which can be classified as Category A or B. Knowing which surveillances are Category C, i.e. which surveillances will pose a problem to a 48 month cycle, is as valuable because work must now be concentrated on these areas in order to find innovative surveillance resolution options.

It should be reiterated here that, in general, the surveillance categorizations were not based on rigorous on-line performance and performance interval extension justifications. Rather, they are the result of a preliminary surveillance resolution analysis and rely heavily on expert opinion. Also, since neither the effects of this categorization on the core damage frequency nor the trip rate of the plant have been analyzed, this categorization is not necessarily what a plant should do to achieve a 48 month fuel cycle, but rather what it could do. Finally, though thorough cycle extension studies at any given plant will likely produce unique results, the findings presented in this chapter are considered a reasonable, generally applicable set of the results a complete project would yield. The categorization that follows is intended as a guide to show utilities the types of options which should be pursued.

3.2. Containment Testing

With a few exceptions, the surveillances which will transition most readily to an extended fuel cycle are containment leak rate tests. The purpose of containment leakage testing is to verify the overall integrity of the reactor containment as well as to ensure that:

> "1) leakage through the primary reactor containment, including systems and components penetrating primary containment, shall not exceed allowable leakage rate values as specified in Technical Specifications or associated bases and 2) periodic surveillance of reactor containment penetrations and isolation valves is performed so that proper maintenance and repairs are made during the service life of containment including systems and components penetrating primary containment."[1]

Containment leak rate tests are divided into three types by the governing code, Chapter 10, Part 50, Appendix J of the Code of Federal Regulations (10 CFR 50 Appendix J). The three types of tests are designated Types A, B, and C (not to be confused with this report's Categories A, B, and C of surveillance resolutions).

Type A tests are "intended to measure the primary reactor containment overall integrated leakage rate (1) after the containment has been completed and is ready for operation, and (2) at periodic intervals thereafter."

Type B tests are "intended to detect local leaks and to measure leakage across each pressure-containing or leakage-limiting boundary for the following primary reactor containment penetrations:

---

[1] Plant procedure 8.7.1.5

1. Containment penetrations whose design incorporates resilient seals, gaskets, or sealant componds, piping penetrations fitted with expansion bellows, and electrical penetrations fitted with flexible metal seal assemblies.

2. Air lock door seals, including door operating mechanism penetrations which are part of the containment pressure boundary.

3. Doors with resilient seals or gaskets except for seal-welded doors."

Type C tests are "intended to measure containment isolation valve leakage rates. The containment isolation valves included are those that:

1. Provide a direct connection between the inside and outside atmospheres of the primary reactor containment under normal operation, such as purge and ventilation, vacuum relief, and instrument valves.

2. Are required to close automatically upon receipt of a containment isolation signal in response to controls intended to effect containment isolation.

3. Are required to operate intermittently under post-accident conditions.

4. Are in main steam and feedwater piping and other systems which penetrate containment of direct-cycle boiling water power reactors."[1]

A recent, major regulation development makes resolution of containment testing much easier. Option B to Appendix J published on September 26, 1995 allows containment testing intervals to become plant-specific performance based. Upon two successive satisfactory tests, the maximum intervals for type A, B, and C tests will be 10 years, 10 years, and 5 years, respectively. The exceptions to these intervals are tests on the main steam and feedwater isolation valves.

With interval extension a real and attainable option, the containment leak tests were then analyzed to investigate the possibility of performance on-line. A significant number of tests were found to have no physical limitations preventing performance during power operations. To clarify the resolution possibilities, let us discuss each type of test individually.

[1] 10 CFR 50 Appendix J.

3.2.1. Type A Integrated Leak Rate Tests

Technically there are two type A surveillances conducted but one is simply a preparation procedure for the actual type A Integrated Leak Rate Test (ILRT). During the test, all plant systems are aligned to their normal positions following a design basis accident and closure of all containment isolation valves (CIV) is accomplished by normal operation. The containment is then pressurized to 45 psig and the integrated leak rate is measured.

With the modification to 10 CFR 50 Appendix J, the maximum allowable interval, upon successive satisfactory test performances, will be 10 years. This will be sufficient to resolve the test to a four year fuel cycle. The two type A leak rate tests are classified as Category B surveillances.

3.2.2. Type B Containment Leak Rate Tests

At the plant where the research was conducted, a total of 47 type B containment leak rate tests are performed. Upon a series of satisfactory test performances, all of these are eligible for the surveillance performance interval extension to 10 years, the interval allowed by Option B to 10 CFR 50 Appendix J.

In addition to being eligible for the Option B extension, 35 of the tests were found to be possibilities for on-line performance. The majority of these 35 involve testing of neutron monitoring, control rod drive, or electrical containment penetrations. Since there are no physical limitations preventing on-line performance, these 35 tests are classified as both Category A and B surveillances.

The remaining 12 type B surveillances involve access hatches or human walkway penetrations with physical characteristics preventing on-line performance. These tests are classified as Category B surveillances.

3.2.3. Type C Containment Leak Rate Tests

A total of 87 type C containment leak rate tests are performed at the plant. Upon two successive satisfactory test performances, except for tests on the main steam and feedwater isolation valves (12 total tests), all are eligible for the surveillance performance interval extension to 5 years allowed by Option B to 10 CFR 50 Appendix J.

In addition to being eligible for the Option B extension, 24 tests were found to be possibilities for on-line performance. These 24 type C containment leak rate tests are classified as both Category A and B surveillances. The tests involve H_2/O_2 analyzer line valves, gas sample return line valves, and traversing in-core probe (TIP) isolation valves. The on-line performance of the TIP valves is made possible by the manual isolation valve scheme proposed in section 4.4.

The remaining 63 type C tests involve valves which are inaccessible while the plant is on-line. Some of the valve types which are included in this group are high pressure core injection isolation valves, reactor core isolation cooling valves, drywell test connection valves, and drywell drain valves. Except for the main steam isolation valves and the main feedwater valves, all are eligible for performance interval extension according to Option B of 10 CFR 50 Appendix J. A total of 51 surveillances are classified as Category B.

Because of their exclusion from the Option B modification and the integral role they play in power production, the 8 main steam isolation valve leak rate tests and the 4 main feedwater isolation valve leak rate tests are classified as Category C surveillances. They are discussed further in section 3.9.5.

Containment Testing	
Category	Number of Surveillances
A & B	59
B	65
C	12

Table 3.2

Containment Testing surveillance categorizations are summarized in Table 3.2. For a complete listing of the categorization of all containment testing surveillances see Appendix A.

3.3. In-Service Testing

3.3.1. Category A Surveillances

3.3.1.1. Hydrodynamic Valve Leak Testing

There are 34 hydrodynamic valve leak test candidates for on-line performance which are conducted as a part of the in-service testing program. Twenty-two of the 34 tests are actually subject to the same 10 CFR 50 Appendix J which was referenced in the containment testing section above. However, these tests vary from those above in that they verify leak tight integrity for water rather than gas seal systems. The water seal system at issue here is part of the torus. All 22 are water seal leak tests subject to Appendix J performed on the torus water inventory primary containment isolation valves. Since the configuration of these valves makes on-line performance an option and they are subject to Option B of Appendix J, these 22 surveillances are classified as both Category A and B surveillances.

The other 12 hydrodynamic leak tests which are candidates for on-line performance involve various systems. These systems include the residual heat removal system, the high pressure core injection system, the reactor core isolation cooling system, and the core spray system. In all cases, the valves are accessible and therefore testable when the plant is in an LCO during power operations. These twelve are classified as Category A surveillances.

3.3.1.2. Position Indication Verification Testing

There are 22 Post Accident Sampling System (PASS) and H_2/O_2 Analyzer Valve Position Indication Verification surveillances and 4 Residual Heat Removal System Sample Valve Position Indication Verification surveillances. These surveillances test the valves to prove operability in accordance with ASME Boiler and Pressure Vessel Code, Section XI, Rules for In-Service Inspection of Nuclear Power Plant Components. There is no plant mode specified as a prerequisite for surveillance performance in the governing procedure. Since expert opinion is that on-line performance is an option and the governing procedure does not require that the plant be shutdown for surveillance performance, it is concluded that on-line performance is a viable option for all 26 surveillances. All 26 surveillances are classified as Category A.

3.3.1.3. Flow Testing

Five flow exercise surveillances have been designated as candidates for on-line performance. Flow exercises test for operability by verifying that the check valve will open and close upon changing flow direction. Three of the tests are actually designated as cold shutdown tests. However, they involve directional flow exercises for valves in the high pressure core injection system and the reactor core isolation cooling system. Since these systems are stand-by safety systems, each valve in question is accessible and testable during respective LCO operations. The other two surveillances are not designated cold shutdown surveillances and involve valves which are also accessible during on-line LCO operations. All five surveillances are classified as Category A.

3.3.2. Category B Surveillances

3.3.2.1. Hydrodynamic Valve Leak Testing

Thirteen of the total 26 hydrodynamic valve leak test surveillances involve primary containment isolation valves. These valves isolate the reactor from various systems such as the residual heat removal system, the core spray system, the high pressure core injection system, and the reactor core isolation cooling system. The valves protect against an inter-system loss of cooling accident (LOCA). Expert opinion is that historical surveillance results indicate that they are candidates for performance interval extension. They should be pursued as Category B surveillance possibilities.

The Scram Discharge Vent and Drain Valves are also inaccessible at power because closing them for a leak rate test would likely cause a scram discharge instrument volume level trip. Yet they have a reliable performance history and interval extension is likely an attainable goal. They account for eight of the 26 surveillances.

Three of the surveillances involve leak tests of the check valves in the Control Rod Drive system. The tests verify that there is no potential path for primary coolant to leak outside both the primary containment and the secondary containment after a design basis accident if the Control Rod Drive Water Pumps are not operating. Although the check valves are inaccessible at power, expert opinion concludes that past surveillance results support an interval extension.

The final two leak tests involve a Stand-by Liquid Control check valve leakage test and a Reactor Vessel Pressurization and Temperature Control System leakage test. These two tests are usually performed in conjunction. They involve the reactor coolant pressure boundary and are generally only performed when the reactor head is removed. Since the reactor head will only be removed once every four years in the proposed cycle, these surveillances are prime candidates for performance interval extension.

3.3.2.2. Safety/Relief Valve Testing

The nine safety/relief valve surveillances are designed to meet the testing requirements and administrative guidelines associated with ANSI/ASME OM-1-1987. Testing of the valves during power operation could cause reactor depressurization. However, testing requirements demand that all valves are tested only every ten years with a certain percentage being tested every refueling outage. A modification would have to be made to redefine the length of time between refuel outages, but ultimately these surveillances would support a 48 month operating cycle. Therefore, these inspections are classified as Category B surveillances.

3.3.2.3. Valve Disassembly Inspections

This category of In-Service Testing consists of four surveillances which make up the Check Valve Sample Disassembly and Inspection Program. The program involves grouping similar valves and testing one valve in each category during every refueling outage. Proper testing requires manual forward flow exercising, closure verification, as well as disassembly. Such testing of the valves in the program is not possible during power operations due to plant configuration. However, given excellent historical component performance and the sampling based nature of the program, expert opinion concludes that relief from the governing ASME, Section XI code requirements could be successfully pursued. These inspections are classified as Category B surveillances.

3.3.2.4. Position Indication Verification Testing

Three surveillances are position indication tests which, due to power operation requirements are not performable on-line. Two are part of the residual heat removal system and the third is part of the control rod drive system. Position indication surveillance intervals are relatively easy to justify extending because the tests essentially verify the wiring of the system. If a system has not been tampered with over the course of a cycle, it is extremely unlikely to register a position indication surveillance failure. These three surveillances are therefore classified as Category B surveillances.

3.3.2.5. Valve Operability Testing

The In-Service Testing program requires forward flow exercising and alternate (closed) position verification of various critical check valves. The two check valve surveillances in this category are part of the HPCI and RCIC systems, respectively. The design of both systems prevents testing during power operations. Although they are part of stand-by safety systems, these valves are not accessible during an LCO. However, no significant problems are apparent in the history of these two check valves. Interval extension is an option supported by surveillance records. These two surveillances are classified as Category B surveillances.

3.3.2.6. Accumulator Testing

One of the two surveillances of this type involves the Automatic Depressurization System (ADS) Accumulator. This accumulator provides a backup supply of air to allow cycling of the ADS relief valves upon loss of instrument air. During a seismic event, the Instrument Air Supply is assumed to fail with a small leak. This surveillance verifies that each ADS accumulator shall function as required even with loss of instrument air and a small line break. The accumulator system is reliable and few significant surveillance problems have been observed. The surveillance is classified as a Category B surveillance.

The other surveillance involving accumulators is an integrity test of the Main Steam Isolation Valve accumulator system. These integrity tests are essentially performed only because the opportunity presents itself when the plant is shut down. There is no significant integrity problem which has been observed at the plant. Therefore, the surveillance is a candidate for Category B.

In-Service Testing	
Category	Number of Surveillances
A	43
A & B	22
B	46
C	0

Table 3.3

In-Service Testing surveillance categorizations are summarized in Table 3.3. For a complete listing of the categorization of all In-Service Testing surveillances see Appendix B.

3.4. Instrumentation Surveillances

3.4.1. Category A Surveillances

3.4.1.1. Instrument Calibrations

Of the 44 instrumentation calibrations designated as candidates for on-line performance, the governing procedures specifically allow performance during power operations in 26 cases. The remaining 18 surveillances make no mention of plant mode prerequisites.

Although allowed by procedure, there would definitely be an increased plant trip risk if some of these calibrations were performed on-line. For example, if a control rod drive flow instrumentation calibration were performed on-line, great care would have to be taken to "operate valves slowly to prevent spurious trips caused by instruments connected to common headers on instrument racks."[1] Such a risk has to be weighed against a possible decrease in reliability which could result from extending the calibration interval to four years. Depending on the system, such a decrease in reliability could also translate to an increase in plant trip frequency.

However, the trip risk associated with a particular calibration is not solely a function of the surveillance being performed. In many cases, the surveillances are designated 'high risk' because it is easy for the worker to make a mistake which would result in a plant trip during the course of surveillance performance. Consequently, meticulous preparation and training can significantly reduce the chances of plant trip as a result of operator error.

Ultimately, the potential cost associated with an especially high risk on-line calibration could dictate that performance interval extension be pursued instead of performing the calibration on-line. Nonetheless, inclusion in the off-line workscope without complete analysis of the trip frequency risk should be avoided.

While some of the governing procedures make no mention of the required plant configuration, some do mandate that the system in question be out of service while the calibration is performed. In the past, this often meant that the plant had to be shutdown. But now with the useful tool of surveillance performance during an LCO, many calibrations can be performed with the plant at full power. For example, calibration of the instruments which monitor the reactor core injection cooling (RCIC) pump can be accomplished during a RCIC system LCO.

[1] Plant procedure 8.E.3.1

Instrumentation calibration is a complicated area with regard to surveillance resolution to a 48 month cycle. Given that a calibration can be performed on-line, the difficult decision as to whether it should be performed on-line will benefit greatly from the Economic Optimization Model discussed in detail in Chapter 2 and designated as future work in Chapter 7.

3.4.1.2. Squib Testing

Squib charges are explosive charges which propel a shear valve isolating the traversing in-core probe system in an accident situation. The four tests categorized here account for testing of the four traversing in-core probe assemblies. The surveillances consist of sample testing of the explosive charges and preventive maintenance on the ball valves which provide system isolation in the normal operating mode and preventive maintenance of the shear valves which provide isolation in an abnormal operating mode. The factor currently preventing on-line performance in this case is the inability to isolate the containment while maintenance on the ball valve is conducted. To solve this problem, installation of a simple manual isolation valve is proposed. This minor plant modification would facilitate on-line surveillance performance and increase overall system flexibility. For an extensive justification of on-line performance for the four squib tests, see section 4.4.

3.4.1.3. Instrument Valve Testing

The four surveillances in this category test instrumentation which controls valve operation. The first is a valve interlock test within the residual heat removal system. The governing procedure for this test does not specify a plant mode as a prerequisite. It does, however, warn that great care should be taken to follow instructions lest reactor scram occur. Obviously the procedure was written with on-line performance in mind.

Two of the surveillances are valve control functional tests, again within the residual heat removal system. For these surveillances, the procedures would have to be rewritten so that the instrumentation could be tested on-line while the valves themselves would not be required to cycle. Assuming that all time dependent valve stroking failures are manageable, this is a reasonable solution.

The final surveillance in this category is a turbine stop valve closure inspection. No plant mode is specified for performance of this surveillance. The procedure does state that performance of the inspection will not cause a significant reduction in power. This implies that the surveillance can be performed on-line, although it would result in significant dose for workers.

3.4.2. Category B Surveillances

3.4.2.1. Instrument Calibrations

Plant instrumentation is one of the areas where modern technology has had a dramatic impact. Many transmitters manufactured within the last decade are so precise that the general consensus within the industry is that if one of these instruments is found out of its ‘no adjust’ band, it is most likely due to some form of human error in its original calibration. Studies to support fuel cycle extension to 24 months have concluded that, in general, the drift rates of these transmitters are not time dependent. Rather, the minute inaccuracies sometimes found are likely due to environmental fluctuations over the course of the cycle.

Systems where these extremely accurate transmitters are employed include the post-accident monitoring system, the off-gas effluent monitoring system, the instrumentation used to monitor jet pump flow, and the instrumentation used to monitor scram discharge instrument volume level. The transmitters’ “dead-on” performance history makes the 20 surveillances in this category prime candidates for calibration interval extension.

3.4.2.2. Logic Testing

Chronic problems with regularly scheduled logic tests do not generally occur. Logic circuits are not subject to the same time dependent failure mechanisms which plague many mechanical components. The four surveillances categorized here are no exception to this rule.

Two of the four surveillances are logic tests of automatic valve actuation circuits. Both involve the primary containment isolation valves and surveillance records reveal that neither have demonstrated consistent problems.

Another surveillance performs a logic system functional test of the automatic depressurization system auto-initiation trip system. This test must be performed when the reactor is in a shutdown, depressurized condition. Its recorded history illustrates no major obstacle to performance interval extension.

The last logic test verifies isolation of the mechanical vacuum pump upon a signal of high radioactivity in the main steam lines. The isolation configuration of the pump prevents on-line performance but a technical evaluation would likely support interval extension.

3.4.2.3. Limit Switch Testing

Each main steam isolation valve (MSIV) has two reactor protection system (RPS) limit switches, one inboard and outboard of containment. These limit switches provide input to the RPS when MSIV position is less than or equal to 90% open. Inspecting and functionally testing these limit switches is impossible during power operations because the isolation valves are normally fully open. However, no significant problems have plagued limit switch performance and inspection intervals are candidates for extension to 48 months.

3.4.2.4 Valve Testing

The one surveillance categorized here is a reactor instrument flow check valve test. The check valves are tested for seat leakage to minimize reactor coolant pressure boundary leakage in case of an instrument line failure. The location of the valves in the reactor instrument flow line prevents closure and testing of the valves at power. But the valves in question have an excellent leakage surveillance record which demonstrates no time dependent failure mechanisms. Expert opinion is that they can likely support performance interval extension to 48 months.

Instrumentation Surveillances	
Category	Number of Surveillances
A	52
B	27
C	0

Table 3.4

Instrumentation surveillance categorization is summarized in Table 3.4. For a complete list of the categorization of all instrumentation surveillances, see Appendix C.

3.5. Operational Surveillances

3.5.1. Category A Surveillances

3.5.1.1. Valve Operability Testing

The first of the three surveillances categorized here involves normally locked valves in the process flow path of safety related systems. The object is to simply ensure that the valves have not seized. No mention of a prerequisite plant mode is made in the governing procedure. During appropriate LCO's, the surveillance could be very quickly and easily performed at power.

The remaining two surveillances, involving the standby gas treatment system and the residual heat removal system, are both performable on-line as long as specific reactor pressure conditions are met. The two tests are designed to verify valve operability from various control locations.

3.5.1.2. Leak Testing

The first of the two surveillances categorized here is the secondary containment leak rate test. This test is specifically allowed to be performed on-line in its governing procedure. The one stipulation is that it may have to be performed in parts because the test requires that the reactor building be isolated. Therefore, performance of the various portions of this test must be staggered, but they can be performed on-line.

The second test is the drywell to suppression chamber vacuum breaker leakage rate test. The test is normally performed as the plant is coming up to power. Therefore, the ultimate performance interval may rely somewhat on the forced outage rate. However, the system engineer in this case believes there is a good chance of re-engineering performance of this test so that it could be conducted at full power without a problem.

3.5.1.3. Containment Atmospheric Dilution Testing

This is a functional test of the containment atmospheric dilution (CAD) system. The test requires that the drywell pressure be decreased. Since the pressure in the drywell must be decreased to perform the drywell to suppression chamber vacuum breaker leakage rate test discussed above, the CAD testing could be performed immediately after the leakage rate test and could be done on-line.

3.5.1.4. Reactor Core Isolation Cooling System Turbine Testing

This surveillance involves an overspeed trip test of the RCIC turbine. The governing procedure specifically allows the testing to be performed during an LCO for the RCIC system.

3.5.1.5. Stand-By Liquid Control System Testing

This surveillance consists of manual initiation testing of one of the stand-by liquid control systems. The test could be performed on-line as long as the procedure was rewritten so that it stopped short of actually injecting boron into the core. The injection testing interval would have to be extended to 48 months but the remainder of the test could be done on-line.

3.5.2. Category B Surveillances

3.5.2.1. Fire Protection Testing

Fifteen of the twenty-one surveillances in this category involve the inspection of fire barriers. The purpose of these barriers is to minimize the ultimate plant consequences of an uncontrollable fire. ALARA issues prevent verification of the integrity of barriers located in inaccessible areas. However, the barriers have shown few signs of degradation and justification of extended inspection intervals would not be difficult.

The remaining six surveillances consist of functional testing and inspection of firefighting equipment including sprinklers, fire extinguishers, and fire hoses. Similar to the fire barriers, the equipment locations prevent on-line testing. However, these firefighting systems have proven reliable in the nuclear as well as other industries. Time dependent failures are not common and inspection interval extension could be justified.

3.5.2.2. Valve Operability Testing

Two of the three surveillances categorized here can be administratively extended to a 48 month performance interval. They involve operability tests of the reactor cavity sparger check valves. The test is only performed during the reactor cavity fill operation in a refuel outage because the valves are needed when the reactor cavity head is removed and water is injected through the spargers for purposes of cooling the fuel in the reactor vessel.

The third surveillance consists of the core spray system check valves operability test. It involves a full flow injection to the reactor vessel to prove a satisfactory forward flow to the core spray injection check valves. The performance interval could be extended on the basis of surveillance performance records. However, if a failure of the surveillance were to occur the performance frequency may have to be increased. Consequently, extensive preventive maintenance should be performed during planned outages.

3.5.2.3. Diesel Generator Testing

These two diesel generator surveillances verify that the generators can be operated from two alternate control panels. These panels are maintained in case the primary diesel control location becomes inaccessible in an accident situation. Justifying these tests out to a 48 month performance interval on the basis of past records would not be difficult.

3.5.2.4. Reactor Core Isolation Cooling System Testing

This RCIC functional test demonstrates the operability and verifies flow rate at approximately 150 psig steam pressure. Although on-line performance may be possible, the performance interval could be easily extended because the operating cycle length is the main factor in establishing this test interval, e.g. the equipment itself does not mandate frequent testing, rather the equipment is tested whenever testing is possible. Therefore, if the operating cycle was extended, this surveillance's performance interval would follow suit.

3.5.2.5. Fuel Handling Inspection

This surveillance is extended without impediment because obviously no handling of the fuel is performed unless the core is in the process of being refueled.

3.5.2.6. Reactor Mode Switch Testing

This surveillance verifies that when the reactor mode switch is placed in the 'shutdown' position a full reactor scram would occur. It is only performed when the plant is already in the shutdown state. Surveillance performance history suggests that the performance interval could be extended administratively.

3.5.2.7. Vacuum Breaker Testing

This surveillance performs functional testing of the drywell to pressure suppression chamber vacuum breakers. Surveillance performance requires entry into the drywell so performance interval extension is the only option for surveillance resolution. However, the tests have been successful and expert opinion is that the equipment would support an extension although some standards, including ASME Section XI, would have to be modified.

3.5.3. Category C Surveillances

3.5.3.1. Cold Shutdown Operability Tests

The 28 surveillances categorized here pose a potential problem to a 48 month operating cycle. They are discussed further in section 3.9.1.

3.5.3.2. Automatic Depressurization System Operability Tests

The two surveillances categorized here pose a potential problem to a 48 month operating cycle. They are discussed further in section 3.9.2.

Operational Surveillances	
Category	Number of Surveillances
A	8
B	30
C	30

Table 3.5

Operational surveillance categorizations have been summarized in Table 3.5. For a complete listing of the categorization of all of the operational surveillances, see Appendix D.

3.6. Electrical Testing

3.6.1. Category A Surveillances

3.6.1.1. Transformer/Relay Testing

A large effort would be required to transition testing of important transformers and vital bus relays to the on-line workscope. Modifications to procedures as well as to hardware would probably be necessary. Nonetheless, expert opinion maintains that this testing would ultimately not stand in the way of an extended fuel cycle.

In some cases it may be possible to divide a surveillance and perform 95% of it on-line. The remaining 5% would have to be extended to four year intervals. A risk argument could be made that this was acceptable on the basis that the 5% of the surveillance which is extended had a low failure rate. In extreme cases extra on-line diagnostic equipment may be required to monitor the 5% but generally the extension could be justified as the equipment exists today. Another plant modification which may be required to perform these surveillances on-line is the addition of electrical cut-off switches. These switches would enable isolation of a particular relay or transformer for on-line testing.

In conclusion, although this area of testing would likely entail significant effort to resolve to an extended fuel cycle, it is considered achievable by those most experienced with the equipment.

3.6.1.2. Battery Charger Testing

The plant maintains two 125-volt battery chargers, one backup 125-volt charger, one primary 250-volt charger, and one backup 250-volt charger. Maintenance and testing of these five chargers makes up the five surveillances in this category. The governing procedure allows surveillance performance while the reactor is on-line as long as the charger in question is out of service. Taking a charger out of service would require an LCO. All of the battery charger surveillances could be performed in the allowed outage time.

3.6.1.3. Motor Brush Inspections

The four surveillances categorized here all involve motors which are a part of either the high pressure core injection system or the reactor core isolation cooling system. Surveillance performance can be accomplished satisfactorily in the appropriate HPCI or RCIC LCO on-line.

3.6.1.4. Breaker Interlock Testing

Currently, the maximum interval on this type of electrical equipment is three years as defined by the electrical standards. Therefore, on-line performance is the easier route for resolution of these two surveillances to a four year operating cycle. In order to perform them on-line cut-out switches would have to be added to the lockout relays. The surveillances take only ten minutes to perform and consequently, could then be easily performed during an LCO.

3.6.1.5. Automatic Load Sequencing Testing

This test is a verification of the diesel generator's ability to accept the loads forced upon it in an accident situation. Complicated valve and circuit line-ups prevent performance of this test on-line as the procedure is currently written. However, the expert opinion on this surveillance is that it could be performed on-line in a diesel generator LCO if artificial resistive loads were supplied on portable trailers. As long as the loads were sequenced properly, the artificial test would adequately test the ability of the diesel generator to function in the accident scenario. Therefore, this test is classified as Category A.

3.6.2. Category B Surveillances

3.6.2.1. Breaker Inspections

All 48 surveillances in this category involve the overhaul or maintenance of 4 kilo-volt breakers or 480-volt load center breakers. For all 48, the plant is already in the process of achieving a 48 month surveillance performance interval. The standard procedure was to alternate conducting overhauls and maintenance activities during the outages every 24 months. The new plan will be to perform the overhauls every 48 months and replace the maintenance activity with an on-line performance verification. In addition to this surveillance scheduling plan, if a problem were to arise with one of the breakers during the course of the cycle, replacement breakers are maintained on-site and could be easily installed during an LCO.

3.6.2.2. Insulation Testing

The insulation testing in question here is performed on components including the startup transformer, the shutdown transformer, load centers, vital buses, and the emergency diesel generators. All expert opinions obtained at the plant termed performance interval extension of this testing to be "no problem." This consensual attitude stems from the fact that no major problems have ever been found by the tests. The transition of this testing to conform with a 48 month fuel cycle would be mostly an administrative exercise.

3.6.2.3. Diesel Generator Initiation Testing

These two surveillances are performed to verify that both diesel generators will start after having received an emergency start signal from the undervoltage logic circuitry. On the basis of excellent past performance in all tests conducted, these surveillances are considered extendable by the engineers responsible for the operability of the diesel generators.

3.6.2.4. Load Shed Relay Testing

The purpose of these two surveillances is to demonstrate the operability of the load shedding logic circuits without actually starting the diesel generators. The surveillances are resolved by a combination of both interval extension and performance on-line. First, one would have to justify that the 4 kilo-volt breaker contacts are verified when the breakers are overhauled once every four years (this would probably not be difficult). The remaining portion of the surveillances tests undervoltage relays and slave relays. If isolated individually, the verification of these relays could be performed on-line.

3.6.2.5. Recirculation Motor Generator Testing

Performance interval extension of these two surveillances is contingent on the performance interval extension of the surveillance governing the drive motor breaker. This breaker is included the breaker inspection category above. Although at the plant studied this particular breaker's poor design has been a thorn in the past, in general, a well-designed reliable breaker would facilitate interval extension for the testing of the reactor recirculation system motor generator set.

3.6.2.6. Shutdown Transformer Testing

This surveillance is performed in order to verify the ability of the 24 kilo-volt grid to provide sufficient power to the plant emergency supply buses on demand. At the plant where this study was conducted, in order to achieve a 48 month test interval, older equipment would have to be changed out with more modern components currently available. Expert opinion maintains that with the newer equipment interval extension will be administratively achieved.

3.6.3. Category C Surveillances

3.6.3.1. Motor Operated Valve Testing

The 83 surveillances categorized here pose a potential barrier to a 48 month operating cycle. They are discussed further in section 3.9.3.

3.6.3.2. Battery Service Discharge Testing

The 3 surveillances categorized here pose a potential barrier to a 48 month operating cycle. They are discussed further in section 3.9.4.

Electrical Testing	
Category	Number of Surveillances
A	22
B	69
C	87

Table 3.6

Electrical testing categorizations have been summarized in Table 3.6. For a complete listing of the categorization of all the electrical surveillances, see Appendix E.

3.7. Mechanical Surveillances

3.7.1. Category A Surveillances

None of the mechanical surveillances were designated as candidates for performance on-line.

3.7.2. Category B Surveillances

3.7.2.1. Accumulator Inspections

The 16 surveillances in this category consist of the accumulator inspections of the main steam isolation valve, relief valve, and torus vacuum breaker accumulators. The requirements necessitating these inspections are insurance based. All engineers consulted about these inspections considered them a waste of time at the current two year performance interval. There have never been any problems discovered. Administratively justifying performance interval extension would not be difficult.

3.7.2.2. Safety/Relief Valve Inspections

The mechanical testing of the safety/relief valves is in the process of getting either eliminated from the surveillance performance list or integrated into the in-service testing performed on the valves. The plant recently discovered that it was not required to perform the disassemble and inspect surveillance. The valve inspections which make up the other two surveillances in this category will become part of the in-service testing which can be justified to 48 month performance intervals.

3.7.2.3. Mechanical Inspections

The suppression chamber interior surface inspection and the drywell interior surface inspection are essentially performed because it is possible to perform them when the plant is refueling. The engineer in charge of mechanical maintenance asserted that these are not inspections which would force a plant to shutdown. No discrepancies have been discovered in past tests and the performance interval could change as a function of the refueling interval.

3.7.2.4. Snubber Inspections

Snubbers are stabilizers designed to protect plant equipment in a seismic event. The plant where research was conducted for this project has had considerable problems with snubbers failing inspections due to environmental degradation. Most failures observed were of the seals of the hydraulic snubbers. This failure tendency is not an issue at most other plants because they employ only mechanical snubbers. Indeed, after consulting other plants it was concluded that snubber failure is not a generic failure problem within the industry. While the plant studied would have to replace many of its snubbers (one option is a passive restraint system recently approved by the NRC which requires no testing and little maintenance), most plants could administratively extend snubber inspection intervals.

Mechanical Surveillances	
Category	Number of Surveillances
A	0
B	24
C	0

Table 3.7

Mechanical surveillances categorizations are summarized in Table 3.7. For a complete listing of the categorization of all the mechanical surveillances, see Appendix F.

3.8. Other Surveillances

3.8.1. Category A Surveillances

3.8.1.1. Radiation/Gas Monitor Testing

These five surveillances entail calibration of radiation and gas monitors. The first is a source calibration of the containment high radiation monitoring system. Analysis of the governing procedure revealed that it would be possible, though difficult, to perform this surveillance on-line because the detector is in a difficult to reach location.

The other radiation monitor surveillance involves calibration of the main steam line process radiation monitors. The objective of these monitors is to watch for the gross release of fission products from the fuel. The main steam lines are not used for a control function when the plant is operating. Therefore, the calibration could be performed on-line.

The remaining three surveillances are all source calibration of high range gas monitors. The three locations of the monitors are the reactor building vent, the main steam vent, and the turbine building vent. All three calibrations could be performed on-line although the turbine vent calibration would be the most difficult because of ALARA issues.

3.8.1.2. Enrichment Sample Collection

This surveillance determines the concentration of sodium pentaborate in the stand-by liquid control tank. The surveillance is regularly performed while the plant is at power. However, the plant's technical specifications also require that a sample be taken while the plant is shutdown. The standard technical specifications available throughout the industry do not require the sample to be taken during the outage. Ultimately, this surveillance will not pose an obstacle to an extended fuel cycle.

3.8.2. Category B Surveillances

3.8.2.1. Piping Inspections

The four piping inspection surveillances categorized here cannot be performed on-line because of environmental conditions at the piping locations. The two salt service water piping inspections are sample based tests where every pipe must be examined at least once every ten years. If a four year operating cycle were adopted, 50% of the pipes would have to be inspected every refueling outage.

The piping erosion/corrosion monitoring program selects various areas to be inspected for possible erosion and corrosion. Although there are limits on the time allowed between inspections, there is no concrete interval which would preclude an extended operating cycle.

The last piping surveillance is the annulus drain inspection. The surveillance has never revealed any failures or signs of impending failures. According to the system engineer, a performance interval extension justification could be easily produced.

3.8.2.2. Radiation Monitor Testing

The objectives of the steam jet air ejector off-gas radiation monitoring system is to "indicate when limits for the release of radioactive material to the environs are approached and to effect appropriate control of the off-gas so that the limits are not exceeded during planned operation." These objectives make calibration during power operation impossible. However, the expert opinion on the system is that calibration intervals could be administratively extended based on past performance history.

All of the Category A and Category B radiation and gas monitoring surveillances require a vendor to come to the plant with a radiological source. The vendor is usually employed for a few days by the plant at a cost of approximately $5,000 to $6,000. If a 48 month fuel cycle were adopted, the cost of this service would remain constant because the plant would still require the service at the same two year interval. The vendor would simply alternate doing calibrations on-line and then off-line every two years.

3.8.2.3. Core Spray Sparger Inspection

This surveillance is a mechanical inspection of the integrity of the sparger. Degradation over the years has not been significant and performance interval extension would be allowable.

3.8.2.4. Shutdown Margin Check

The purpose of this surveillance is "to demonstrate that the reactor will be subcritical throughout the fuel cycle with any single control rod fully withdrawn and all other operable rods inserted."[1] The surveillance is performed whenever the core is refueled. Consequently, if a four year fuel cycle were adopted, this surveillance would be performed at four year intervals.

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[1] Plant procedure 9.16.1

Other Surveillances	
Category	Number of Surveillances
A	6
B	8
C	0

Table 3.8

The remaining surveillance categorizations are summarized in Table 3.8. For a complete listing of the categorization of all remaining surveillances, see Appendix G.

3.9. Category C Surveillances

3.9.1. Cold Shutdown Operability Tests

The ASME Boiler and Pressure Vessel Code, Section XI, "Rules for In-Service Inspection of Nuclear Power Plant Components" requires that all safety related pumps and valves be tested for operability on a quarterly basis. In some cases, as in the 28 surveillances categorized here, it is hazardous or simply impossible to perform the tests while the plant is at power. In general, surveillances which are hazardous to perform on-line involve stand-by systems such as the Residual Heat Removal System. Surveillances which cannot be performed on-line involve active systems such as the Salt Service Water System and the Reactor Recirculation System. Rather than shut down every three months to perform the operability tests, utilities petition the NRC to designate such troublesome tests as Cold Shutdown Tests.

Once a surveillance is designated a Cold Shutdown Test, it does not have to be performed every three months if the plant is running continuously over that period of time. The specific requirements of Cold Shutdown Testing are outlined in the following plant procedure excerpt.

- Testing is to commence as soon as practical when the Cold Shutdown condition is achieved, but no later than 48 hours after shutdown, and continue until complete or the plant is ready to return to power.
- Completion of all testing is not a prerequisite to return to power. Any testing not completed during one cold shutdown should be performed during any subsequent cold shutdown starting with those tests not previously completed.
- Testing need not be performed more often than once every 3 months.
- In the case of extended cold shutdown, the testing need not be started within the 48-hour limitation. However, in extended cold shutdowns, all Cold Shutdown Testing must be completed prior to returning to power.[1]

Theoretically, if a plant ran uninterrupted for the entire cycle, the test would only be performed during the two refueling outages. Since the longest operating cycle in the United States is currently 24 months, the maximum allowable interval on a Cold Shutdown Test would be 24 months. The logical question is then, "If a plant was on a 48 month cycle and ran uninterrupted, would it be allowed to run the entire four years without performing the Cold Shutdown Test?" The consensus answer to this question at the plant where research for this study was conducted is "No." System engineers believe that since occasional surveillance failures have occurred and the components are highly risk significant, the surveillance performance intervals could not be extended to 48 months.

The tests, however, are generally very quick and easy to perform, and the Cold Shutdown Tests are excellent candidates for a surveillance performance hotlist. This hotlist would track those surveillances which should be performed immediately whenever the plant comes down for any reason.

Even with this prime eligibility for a surveillance performance hotlist, new technologies should be investigated to search for a means of justifying surveillance performance intervals out to 48 months. Application of innovative monitoring

[1] Plant procedure 8.1.11.12

technologies could provide enough on-line diagnostic information on the various pumps and valves to ensure operability upon demand. This would ultimately remedy the burden of maintaining some or all of the Cold Shutdown Operability Tests on the surveillance performance hotlist.

A listing of the specific pumps and valves is provided in Appendix D.

3.9.2. Automatic Depressurization System Operability Testing

The first of the two surveillances in this category is a test of the manual operability of the reactor vessel relief valves. The surveillance involves valve full-stroke exercising, position indication verification, and fail-safe testing. It is a relatively quick and easy test involving four valves. The risk significance of the relief valves prevents performance interval extension. As the surveillance procedure is written, it could be performed on-line as long as only one relief valve was tested at a time. However, performing the test on-line could result in potentially dangerous plant transients as the containment is subject to depressurization. A more conservative resolution strategy would be to place this surveillance on the same performance hotlist suggested for the Cold Shutdown Operability Tests of section 3.9.1.

The second surveillance in this category tests the operability of the Automatic Depressurization System solenoid valves from an alternate control panel. This surveillance can only be performed when the plant is in the cold shutdown condition. Its risk significance currently prevents performance interval extension. The relatively quick test involves simply cycling the four solenoid valves from the alternate control position. The speed with which it can be performed also makes it a candidate for the surveillance performance hotlist.

Although both tests are prime candidates for the surveillance hotlist, the possibility of developing an on-line monitoring technique which could justify performance interval extension should not be discounted.

3.9.3. Motor Operated Valve Testing

When a motor operated valve functions properly an electric motor drives a worm. A spring pack opposes worm motion along the worm's shaft. A drive sleeve is rotated by the worm gear. This drive sleeve encompasses the valve operating stem. The valve stem is forced in or out by rotation of the drive sleeve. As the valve stem meets resistance, torque is translated to the worm gear, compressing the spring pack. The motor gear train actuates position limiting switches. The worm actuates torque limiting switches. Together, the limit switches control the valve.

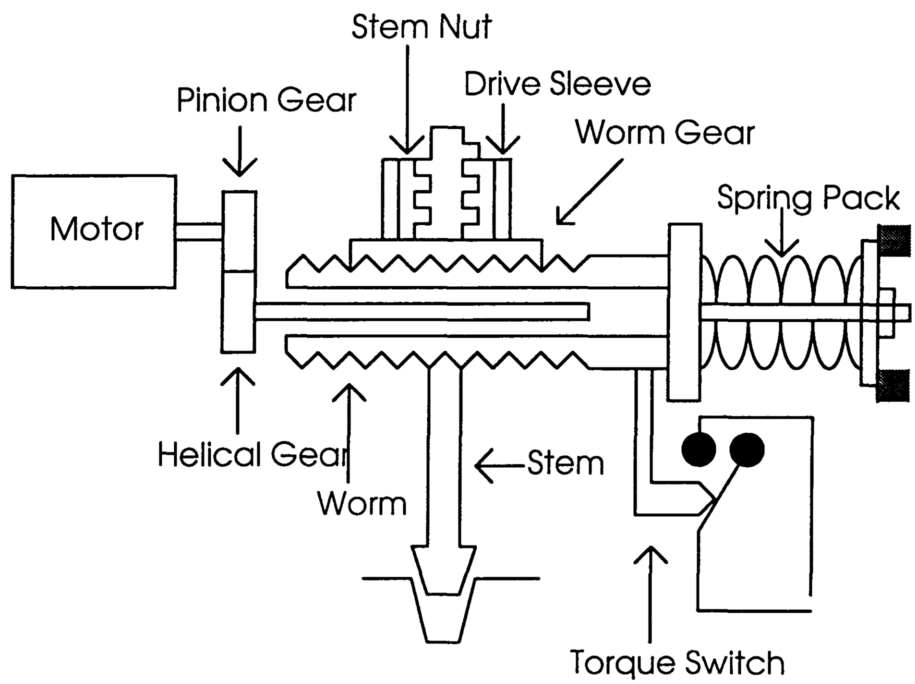

Figure 3.1 - Schematic Diagram of a Motor Operated Valve

Preventive maintenance on these parts and testing of critical parameters is required for 83 MOV's in the plant researched for this study. The critical parameters include stem thrust, actuator torque, motor current, and control switch operation. The test ultimately provides two assurances: that the motor will provide enough force (thrust and torque) to operate the valve and that the necessary safety interlocks operate properly.

The NRC's Generic Letter 89-10 requires utilities to conduct a risk ranking study of all MOV's employed in their respective plants. The results of these studies should provide the information necessary to place MOV surveillances into one of three categories. One, valves for which performance interval extension to 48 months is an option because of the lack of risk significance of the valve even if it should fail during the cycle (for example, if the MOV is part of the service water system, it is normally open and it would not be required to change position in the event of an accident). Two, valves for which on-line performance is an option because cycling the valve would not result in a plant transient. And three, valves which, because of their risk significance and integral role in power production, pose substantial obstacles to an extended operating cycle.

An MOV performance monitoring system project was begun but never finished by a research group at MIT. The findings of this group and the directions of study it proposed will be analyzed for applicability to this extended fuel cycle project.

3.9.4. Battery Service Discharge Testing

The three surveillances categorized here involve discharge testing designed to verify that the station battery has maintained its rated output capacity. The governing industry standard is ANSI/IEEE Std 450-1987, "IEEE Recommended Practice for Maintenance, Testing, and Replacement of Large Lead Storage Batteries for Generating Stations and Substations." While this standard does not prescribe a specific testing interval for the battery service discharge test, performance interval extension is currently not an option because the batteries are too risk significant to allow them to sit dormant for four uninterrupted years. Further, the discharge test cannot be performed during power operations because it renders the batteries inoperable until they can be fully recharged.

One possible resolution option is to build a redundancy into the system so that one set of batteries could be taken off the line to be tested while the other is available in the stand-by mode. However, this would be an expensive modification to the current plant configuration.

Another, more attractive resolution option is possible as a result of an innovative technology being developed by the Electric Power Research Institute (EPRI). The purpose of the EPRI project "is to establish and refine the degree of correlation between battery impedance/conductance and battery capacity."[1] Since battery impedance and conductance can measured without taking the battery out of service, this correlation will provide an on-line diagnostic vehicle to monitor the capacity of the battery without conducting a debilitating discharge test. While the EPRI project is currently focused on small batteries which provide emergency lighting, the ultimate goal is generate a correlation which will apply to station batteries like the kind that pose the current obstacle to the 48 month operating cycle.

This EPRI project is scheduled to develop its final conclusions at the end of 1996. The status of the project will be monitored by the Extended Fuel Cycle Group until then.

3.9.5. Main Steam Isolation Valve and Feedwater Valve Testing

The NRC originally planned to include these valves in Option B to 10 CFR 50 Appendix J. They were excluded in response to public comments prior to Option B publication. Primary arguments were that operating experience and safety significance did not support maximum performance interval extension to 5 years like other Type C leak rate tests.

The integral role these valves play in power production currently precludes on-line test performance. Innovative on-line monitoring technologies should be sought which could facilitate the inclusion of these valves in the modification to the code in Option B to 10 CFR 50 Appendix J.

3.10. Summary

The final tabulation of the categorizations of each individual surveillance discussed in this chapter is illustrated in Figure 3.2. However, Figure 3.3 is a more informative graph because it represents the categorizations of the various <u>types</u> of

[1] EPRI project conducted by Edan Engineering Corporation

surveillances. For example, the same surveillance is conducted on 83 different MOV's. Consequently, Figure 3.1 can be misleading since it is based on the total number of surveillances and does not convey the fact that one application of an innovative technology could resolve all 83 surveillances.

To fully comprehend the difference between Figures 3.2 and 3.3, consider that Figure 3.2 illustrates that there are 128 Category C surveillances relative to the total 610 (21%). Figure 3.3 shows that there are 5 types of Category C surveillances relative to the total 66 (8%).

Although the categorization of surveillances at every plant will likely vary somewhat, these figures are considered generally applicable to BWR's. They are very promising in their illustration of the practicability of surveillance resolution to an extended operating cycle.

Categorization of Surveillances

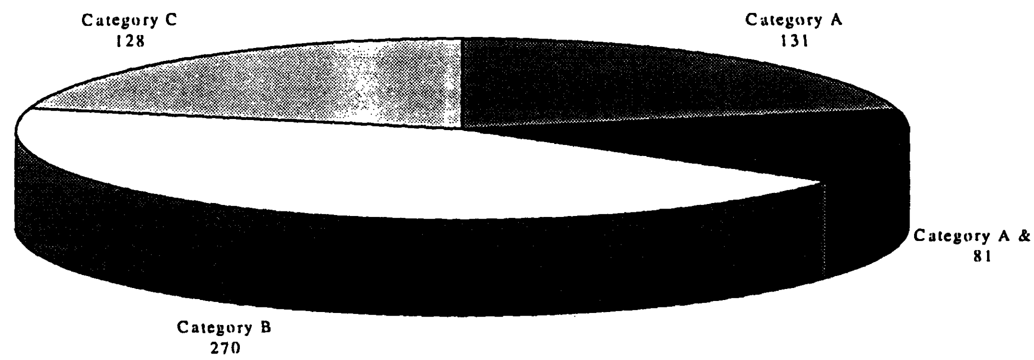

Figure 3.2

Categorization of Types of Surveillances

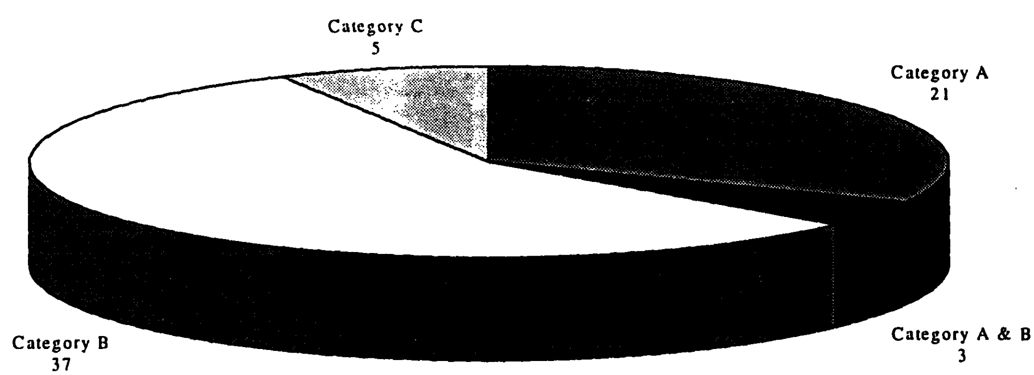

Figure 3.3

Chapter 4 - Example Surveillance Justifications

4.1. Introduction

This chapter presents two on-line performance justifications and one performance interval extension justification. The format of these examples is proposed as a general guide to utilities for their use in justifying a surveillance's on-line performance or performance interval extension. By presenting a few examples of appropriate justifications, this chapter illustrates the type of effort required to effect a complete 48 month fuel cycle surveillance resolution project. For this report, complete justification of all candidate surveillances was a prohibitively large task. Also, it was assumed that actual surveillance resolutions will vary somewhat from plant to plant. Consequently, complete surveillance justification is left to the individual utility.

4.2. Performance Interval Extension Justification:

Setpoint Calculation to Allow Calibration Interval Extension to Four Years

4.2.1. Background

The design of boiling water reactors necessitates control rod insertion from the bottom up. Therefore, gravity is not the driving force for insertion, as in a pressurized water reactor. Instead, the driving force of the control rods is water pressure. In order for the rods to insert uniformly upon receipt of a scram signal, there must be an adequate volume available for collection of the water used to drive the control rods. Otherwise, back pressure could build, all rods may not fully insert, and a dangerous transient could result.

The discharge volume consists of a Discharge Header (DH) which dumps to two Scram Discharge Instrument Volumes (SDIV's), designated East and West. A scram signal is transmitted when the water level in either SDIV reaches a point above which there would not be sufficient volume for a proper scram. The water level in the SDIV's is monitored by two redundant and diverse systems.

1. Direct Water Level Monitoring System (DWLMS)

A one-inch standpipe is attached to the SDIV (see Figure 4.1). A transmitter actively monitors the level of the tank by gauging the pressure differential at the base of the standpipe. When the pressure reaches a predetermined setpoint, a scram is initiated by instrument switches. These instrument switches, calibrated on-line every three months, are not affected by the fuel cycle extension. However, the transmitters are calibrated off-line at refueling intervals. They must be analyzed for drift effects as a result of a 48 month fuel cycle.

2. Temperature Element Monitoring System (TEMS)

A temperature element is installed at a <u>fixed</u> position inside the tank. When the water level in the tank reaches the level of the temperature element, the element is cooled. When the element is cooled, a scram is initiated by instrument switches.

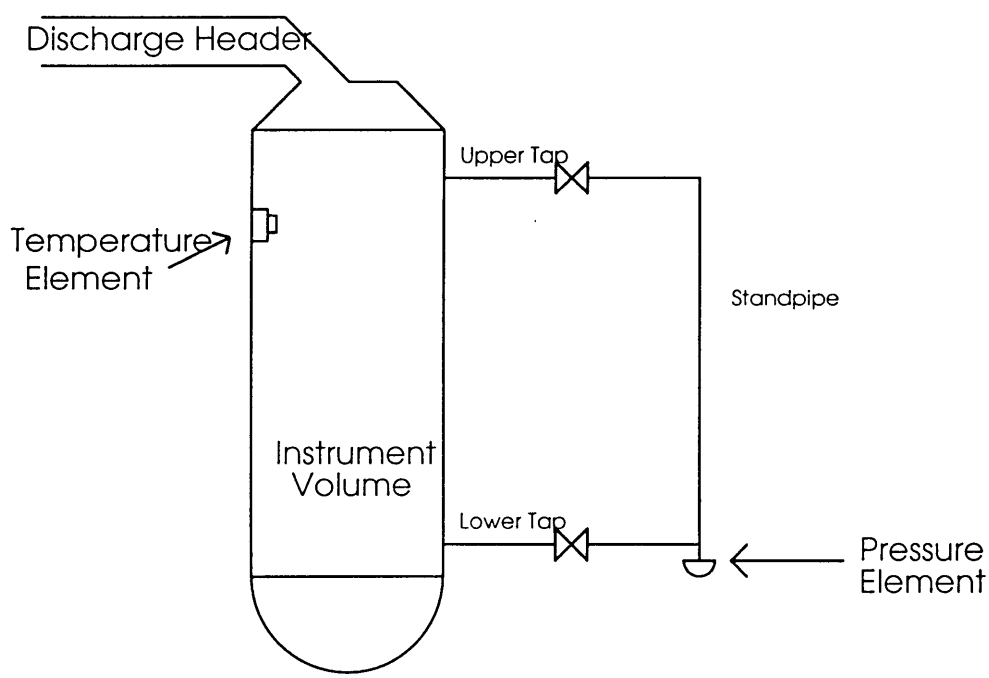

Figure 4.1 - Simplified SDIV System Diagram

4.2.2. Methodology[1]

If a four year calibration interval is adopted, a new trip setpoint must be calculated for the DWLMS. This new setpoint must then be compared to the fixed setpoint of the TEMS to determine if the TEMS would still perform a safety function. For example, if the setpoint calculated for the DWLMS for a 48 month fuel cycle is 45 gallons, and the fixed setpoint of the TEMS is 50 gallons, the TEMS now performs no real safety function since the two systems are not effectively redundant. In order for it to perform a safety function, the fixed temperature element would have to be moved. This would likely be an expensive evolution requiring significant plant downtime.

The NRC Generic Safety Evaluation Report, BWR Scram Discharge System, requires that an in-leakage to the SDIV of 5 gpm per Control Rod Drive (CRD) be assumed for all setpoint calculations. Furthermore, although the SDIV's are nominally vented and drained, the NRC requires that a discharge rate of 0 gpm be assumed once a scram signal is transmitted. Therefore, the time between transmitting the scram signal and actual scram initiation must be considered when determining the scram setpoint because water is constantly leaking in. Another factor to be considered is the volume of water already present in the Discharge Header (DH) but not in the SDIV when the scram signal is transmitted. This volume, called intransit leakage, is present in the Combined Volume (CV) of the DH and the SDIV but is not yet represented in the SDIV water level.

Consider the following simple calculation:

Task: Determine the appropriate scram setpoint (in gallons)

Given:

Combined volume of DH and SDIV =	100 gal.
Volume required for proper scram =	50 gal.
Intransit Leakage =	10 gal.
Number of control rod drives =	5

[1] Time independent data and the general methodology of the calculation were taken from the plant calculation performed to support fuel cycle extension from 18 to 24 months. (Doc. # 25-226-C015)

Rate of in-leakage = 5 gpm/CRD

Time between transmitting scram signal and scram initiation = 1 min.

Rate of SDIV discharge = 0 gpm

Answer:

(100 gal.) - (50 gal.) - (10 gal.) - [(5 CRD) × (5gpm/CRD) × (1 min.)]

+ [(0gpm) × (1 min.)] = **15 gal.**

4.2.2.1. DWLMS Setpoint Calculation

The West and East SDIV's have 72 and 73 CRD's routed to them, respectively. The West CV is 9.52 gallons smaller than the East CV and is therefore, even with one less CRD routed to it, the more restrictive case. The setpoint calculation will be conducted for the West SDIV.

Basic SDIV Data	
Volume of the Discharge Header (DH)	235 gal.
Scram Discharge Instrument Volume (SDIV)	46.84 gal.
Combined Volume (CV)	281.84 gal.
Intransit Leakage (IL)	57 gal.
Maximum Pressure Allowed in SDIV after Scram	65 psig
Initial Volume Required in SDIV	2.18 gal./CRD
Number of CRD's	72

Table 4.1

The system's analytical limit is the volume of water which can be present in the SDIV when scram initiation takes place.

<u>Calculation of Analytical Limit</u>

AL = Combined Volume - Volume Required for Scram - Intransit Leakage

= (281.84 gal.) - (2.18 gal./CRD × 72 CRD] - [57 gal.]

= 281.84 - 156.96 - 57 = 67.88 gal.

= 67 gal. (truncated for conservatism)

Next, the volume of water which leaks into the SDIV after scram signal transmission but before actual scram initiation must be calculated. This volume is dependent upon equipment inaccuracies. It is in this part of the calculation where the added error of going to a four year calibration interval must be accounted for.

Table 4.2 shows the basic inaccuracies associated with various factors. These inaccuracies are time independent and are easily calculated from vendor specifications. Factors with relatively more complex inaccuracy calculations follow.

	[redacted]	
Calibrated Range of the SDIV (Range)	2.34 - 43.84 gal.	41.5 gal.
Range of Power Supply (P-Range)	23.5 - 28 Volts	4.5 Volts
Sensor Calibration Accuracy (Sca)	(.25%) × Range	± 0.104 gal.
Rack Temperature Effects (Rte)	(.20%)×(40F/100F) × Range	± 0.033 gal.
Sensor Basic Accuracy (Sa)	(.25%)×Range	± 0.104 gal.
Sensor Power Supply Effects (Spse)	(.005%)×(P-Range)×(Range)	± 0.0093 gal.
Rack Equipment Drift (Red)	(.23%)×Range	± 0.096 gal.
Sensor Tolerance (St)	(.25%)×Range	± 0.104 gal.
Rack Equipment Tolerance (Ret)	(.13%)×Range	± 0.055 gal.
Remote Diaphragm Seal Temperature Effect (Rde)		± 0.917 gal.[1]

Table 4.2

4.2.2.1.1. Seismic Effect (Se)

According to the vendor manual, the seismic error associated with the transmitter is ± 0.5% of its upper limit capability. This upper limit capability, in gallons, is 81.9.

[1] This calculation was relatively more complex. The details are included in plant Doc. # 25-226-C015, note 6

Since a seismic event affects the whole plant, the consequence on the master trip unit must also be considered. The seismic error associated with the master trip unit is ± 0.13% of the transmitter range. This range i.e. the calibrated range of the SDIV, from Table 4.2, is 41.5 gallons.

For this system, there are no voltage fluctuations expected during a seismic effect.

The transmitter and master trip unit errors are combined by the root sum of the squares method. The combined seismic effect is:

$$Se = \pm\sqrt{(\pm 0.005 \times 81.90)^2 + (\pm 0.0013 \times 41.5)^2}$$

$$= \pm 0.415 \text{ gal}$$

4.2.2.1.2. Sensor Temperature Effect (Ste)

According to the vendor manual, the total sensor temperature error associated with the transmitter is the sum of ± 0.75% of its upper limit capability (81.9 gal.) and ± 0.5% of the actual transmitter range (41.5 gal.) multiplied by the thermal range in the SDIV environment per one hundred degrees. The thermal range is expected to be from 60° F to 105° F.

$$\begin{aligned} Ste &= \pm \left[(.0075)\times(81.9 \text{ gal.}) + (.005)\times(41.5 \text{ gal.})\right]\times\left(\frac{105° \text{F} - 60° \text{F}}{100° \text{F}}\right) \\ &= \pm (0.614 + 0.208)\times 0.45 \\ &= \pm 0.370 \text{ gal.} \end{aligned}$$

4.2.2.1.3. Sensor Drift Effect (Sd)

The magnitude of this error is dependent upon the frequency of transmitter calibrations. Consequently, extending the fuel cycle length causes this error to increase. The drift rate for the transmitters at the current maximum calibration interval, 30 months, is ± 0.2% times the transmitter's upper limit capability (81.9 gal.). Assuming a linear drift rate (a liberal assumption with a very precise Rosemount Transmitter) and a 48 month calibration interval, the sensor drift effect is:

$$Sd = (\pm 0.002) \times (48/30) \times (81.9 \text{ gal.})$$

$$= \pm 0.262 \text{ gal.}$$

4.2.2.1.4. Process Measurement Accuracy (Pma)

Pma takes into account the three mechanisms which introduce delays between the actual water level and the level which is sensed by the transmitter. They are:

- the hydraulic delay introduced by having the sensor monitor the level in a standpipe attached to the SDIV (rather than the SDIV itself)
- the hydraulic delay associated with a capillary remote seal device between the standpipe and the transmitter
- the time response of the transmitter based on its lowest expected operating temperature

Determination of Pma is the most involved error calculation. For clarity and since the procedure is more important than the actual numbers, only the methodology of the calculation is included here.[1]

First, hydraulic loss coefficients, which are a function of the specific geometry of the tank must be determined. These coefficients determine the velocity of flow into the standpipe from the SDIV upper and lower taps (ν_{UT} and ν_{LT}) given a constant instrument volume in-leakage of 5 gpm per CRD. Standpipe water level (Z_{spipe}) is determined from rate of flow.

$$Z_{spipe}^{n+1} = Z_{spipe}^{n} + (\nu_{UT}^{n} + \nu_{LT}^{n}) \times \Delta t^{n+1}$$

Standpipe water level determines the pressure differential (DP_{Spipe}) at the base of the standpipe where the transmitter is located.

$$DP_{Spipe} = Z_{spipe} \times \rho_{SDIV}$$

---

[1] The calculation for the system is available in plant document 25-226-C015, Note 4.

where ρ_{SDIV} is the density of the water inside the tank. The differential pressure sensed by the transmitter (DP_{Xtr}) is a response to the pressure differential at the base of the standpipe. Vendor specifications determine the transmitter time constant (τ) as a function of the remote seal capillary length so that:

$$DP_{Xtr}^{n+1} = DP_{Xtr}^{n} + (\Delta t/\tau) \times (DP_{Spipe}^{n} - DP_{Xtr}^{n})$$

Then, the output of the transmitter (Xtr_O) in gallons is a function of the transmitter's internal time constant (τ_{int}) which is a function of the temperature of the environment. Vendor specifications provide internal time constants for varying temperatures. Selection of the internal time constant corresponding to the coldest temperature the transmitter is expected to function in is the conservative choice.

$$Xtr_O^{n+1} = [Xtr_O^{n} + (\Delta t/\tau_{int}) \times (DP_{Xtr}^{n} \times C_1 - Xtr_O^{n})] \times C_2$$

where C_1 is a conversion factor to inches and C_2 is a conversion factor to gallons.

The result is that the transmitter output lags the actual water level by 3.9 seconds. Therefore, Pma is calculated as follows:

$$Pma = 3.9 \text{ sec.} \times (1 \text{ min./60 sec.}) \times (5\text{gpm/CRD}) \times 72 \text{ CRD}$$

$$= - 23.5 \text{ gal.}$$

Pma is a system bias and is negative because it refers to in-leakage prior to actual reactor scram.

4.2.2.1.5. Setpoint Calculation

The system allowable setpoint can now be calculated. The various system uncertainties can be grouped into seven major categories as shown in Table 4.3. Using the root sum of the squares method, each major group has an uncertainty associated with it, as shown in Table 4.4.

SDIV System Uncertainty Factors

ENVIRONMENTAL ALLOWANCE (EA)	Seismic Effect	Se = +/-	0.415	gal.
PROCESS ALLOWANCE (PA)	Process Measurement Accuracy	Pma = -	23.46	gal.
CALIBRATION ALLOWANCE (CA)	Sensor Calibration Accuracy	Sca = +/-	0.104	gal.
RACK EQUIPMENT ALLOWANCE (RA)	Rack Temperature Effect	Rte = +/-	0.033	gal.
SENSOR ALLOWANCE (SA)	Sensor Basic Accuracy	Sa = +/-	0.104	gal.
	Sensor Temperature Effect	Ste = +/-	0.370	gal.
	Sensor Power Supply Effect	Spse = +/-	0.011	gal.
	Remote Diaphragm Seal Temperature Effect	Rde = +/-	0.917	gal.
DRIFT ALLOWANCE (DA)	Sensor Drift	Sd = +/-	0.262	gal.
	Rack Equipment Drift	Red = +/-	0.096	gal.
TOLERANCE ALLOWANCE (TA)	Sensor Tolerance	St = +/-	0.104	gal.
	Rack Equipment Tolerance	Ret = +/-	0.055	gal.

Table 4.3

SDIV System Uncertainties

PROCESS ALLOWANCE

PA = - 23.46 gal.

CALIBRATION ALLOWANCE

CA = +/- 0.104 gal.

RACK EQUIPMENT ALLOWANCE

RA = +/- 0.033 gal.

SENSOR ALLOWANCE

$$SA = \sqrt{(Sa)^2 + (Ste)^2 + (Spse)^2 + (Rde)^2}$$

$$SA = \sqrt{(0.104)^2 + (0.370)^2 + (0.011)^2 + (0.917)^2}$$

SA = +/- 0.995 gal.

DRIFT ALLOWANCE

$$DA = \sqrt{(Sd)^2 + (Red)^2}$$

$$DA = \sqrt{(0.262)^2 + (0.096)^2}$$

DA = +/- 0.279 gal.

TOLERANCE ALLOWANCE

$$TA = \sqrt{(St)^2 + (Ret)^2}$$

$$TA = \sqrt{(0.104)^2 + (0.055)^2}$$

TA = +/- 0.118 gal.

Table 4.4

From these values the Total Loop Uncertainty (TLU), Total Loop Bias (TLB), and Maximum Loop Error (MLE) can be calculated.

Total Loop Uncertainty (TLU)

$$TLU = \sqrt{(EA)^2 + (CA)^2 + (RA)^2 + (SA)^2 + (DA)^2 + (TA)^2}$$

$$TLU = \sqrt{(0.415)^2 + (0.104)^2 + (0.033)^2 + (0.995)^2 + (0.279)^2 + (0.118)^2}$$

TLU = +/- 1.125 gal.

Total Loop Bias (TLB)

TLB = Pma = -23.46 gal.

Maximum Loop Error (MLE)

MLE = TLB + TLU

MLE = -23.46 - 1.125

MLE = -24.59 gal.

The Maximum Allowable Setpoint (MAS) for the transmitter is then:

MAS = (Analytical Limit) + (Maximum Loop Error)

= 67 gal. - 24.59 gal.

= 42.41 gal.

The MAS is not necessarily the value which should be applied to the actual setpoint. Although conservatism is inserted at every point in the calculation, lowering the setpoint even further is the norm. At operating plants the technical specification allowable value is below this MAS, and then the actual setpoint is even lower.

4.2.2.2. Verification of Relevance of TEMS Setpoint

Since the setpoint of the TEMS system cannot be easily changed, the object at this point is to (1) verify that the existing TEMS setpoint is below the maximum allowable setpoint calculated for the DWLMS above, and (2) calculate the new maximum allowable setpoint for the TEMS and verify that it is greater than the existing setpoint. Number one is easy to verify. The number of gallons present at the TEMS setpoint is 37.84 gallons, 4.57 gallons less than the DWLMS maximum allowable setpoint. For number two, the first step is to calculate the new maximum allowable setpoint for the TEMS.

There is only one sensor inaccuracy factor and one sensor bias factor associated with the TEMS, Sensor Basic Accuracy (Sa) and Process Measurement Accuracy (Pma), respectively.

4.2.2.2.1. Sensor Basic Accuracy (Sa)

Vendor specifications do not specify a drift error, and there are not enough data points to calculate a statistically significant drift error from plant experience. However, the vendor does provide a time independent sensor accuracy of 1/16 inches. This translates to:

$$Sa = 0.034 \text{ gal.}$$

Since this is the only uncertainty factor. The total loop uncertainty is:

$$TLU^{TEMS} = Sa = 0.034 \text{ gal.}$$

4.2.2.2.2. Process Measurement Accuracy (Pma)

The temperature element switches are set for a one second time delay. Since there is no time response drift rate specified by the vendor, a review of the limited plant records was performed. It revealed that:

- drift data sets varied in both the positive and negative direction
- the 30 month maximum drift was 1% of the time delay
- recalibrations have never been required or performed

For conservatism, let us assume that for a 48 month cycle the maximum drift of the time response would increase from 1% to 3%. For the various relays associated with transmitting the reactor trip signal, vendor specifications give a 0.058 second time delay. Therefore, the total time delay (TTD) for the TEMS is:

$$TTD = 1 \text{ sec.} + [(1 \text{ sec.})\times(.03)] + 0.058 \text{ sec.} = 1.088 \text{ sec.}$$

The TEMS Pma and the TEMS total loop bias is then

$$Pma^{TEMS} = 1.088 \text{ sec.} \times (1 \text{ min./60 sec.}) \times (5\text{gpm/CRD}) \times 72 \text{ CRD}$$

$$Pma^{TEMS} = TLB^{TEMS} = -\ 6.53 \text{ gal. (negative because it refers to in-leakage)}$$

and the maximum loop error is:

$$MLE^{TEMS} = -\ 6.53 - .034 = -\ 6.56 \text{ gal.}$$

Then, the maximum allowable setpoint for the TEMS is:

$$MAS^{TEMS} = (\text{Analytical Limit}) + (\text{Maximum Loop Error})$$

$$= 67 \text{ gal.} - 6.56 \text{ gal.} = 60.44 \text{ gal.}$$

Since this value is well above the existing TEMS setpoint of 37.84 gal., the system still performs a safety function.

4.2.3. Conclusion

For the following reasons, the current trip setpoints do not have to be altered if the plant switches to a four year operating cycle (see Figure 4.2).

- The four year calibration interval Maximum Allowable Setpoint for the DWLMS system is higher than the current technical specification value and the current setpoint.
- The four year calibration interval Maximum Allowable Setpoint for the TEMS system is higher than the current technical specification value and the current setpoint.

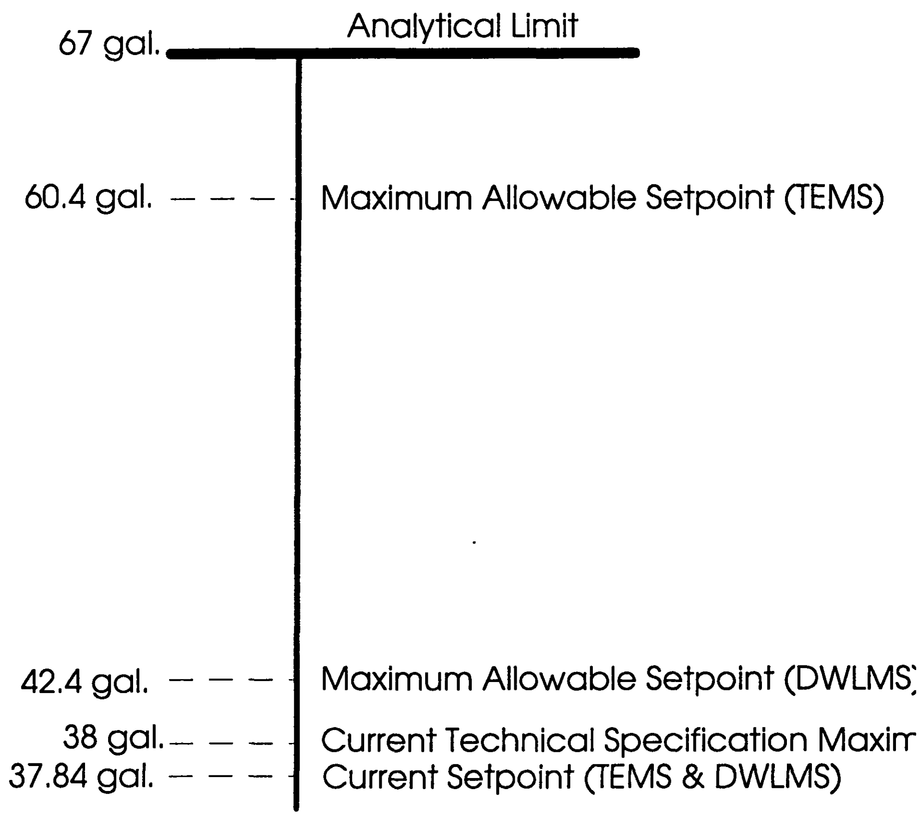

Figure 4.2 - SDIV Setpoint Calculation Summary

4.3. On-Line Surveillance Performance Justification:

Torus Water Inventory Primary Containment Isolation Valve Leak Rate Test

4.3.1. Introduction

Valve 1301-59 is a check valve located between the Reactor Core Isolation Cooling (RCIC) System Vacuum Pump and the Torus within the RCIC System (see Figure 4.3). Testing of the valve is performed by the In-Service Testing division. It is an example of a valve for which a leak rate test can be easily performed during a Limiting Condition of Operation (LCO) at full power.

4.3.2. Background

The RCIC system provides makeup water to the reactor vessel following reactor vessel isolation in order to mitigate the effects of a Loss of Cooling Accident (LOCA). The system includes a steam driven turbine that powers a pump which delivers the water to the reactor.[1]

A cooling water header taps off the discharge header of the RCIC pump. This cooling water header provides a heat sink to the RCIC turbine lube oil cooler. Cooling water from the lube oil cooler enters a barometric condenser and is then strained into a vacuum tank. A vacuum pump discharges any non-condensibles in the vacuum tank through two check valves to the torus. Valve 1301-59 is the second of these two check valves.

The test performed on this valve is mandated by the requirements of 10 CFR 50 Appendix J. The valve is hydrostatically leak tested to a pressure not less than 1.10 Pa. The test verifies the leak tight integrity of the containment isolation valve for the water seal system.

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[1] Plant System Reference Text

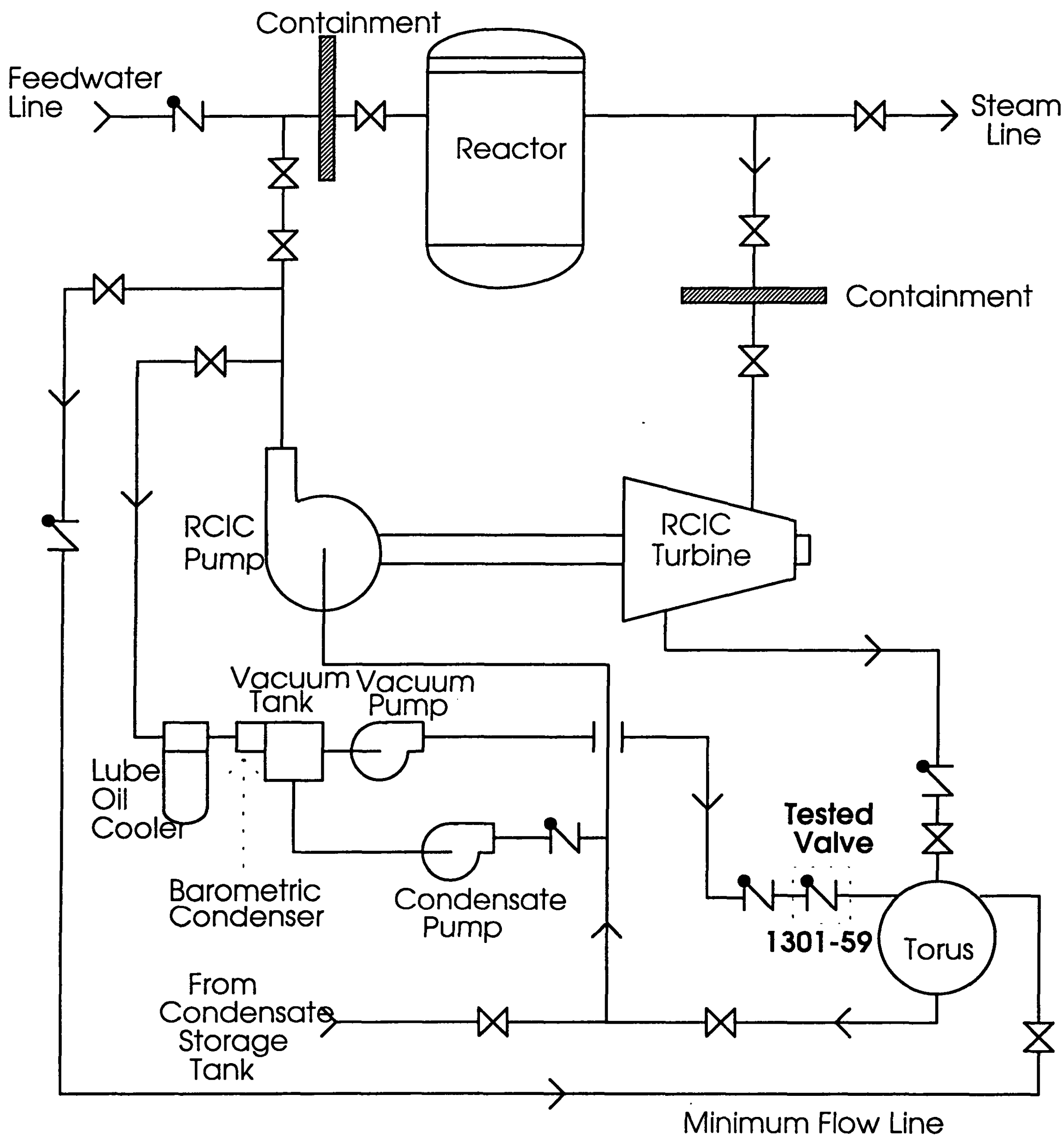

Figure 4.3 - Simplified RCIC Diagram

4.3.3. Current Test Performance

This local leak rate test is presently performed during planned outages because LCO's are not currently entered into solely for the purpose of surveillance performance. If this practice is changed, the leak rate test of valve 1301-59 can be performed at full power.

4.3.4. Proposed Test Performance

The RCIC system is a stand-by safety system. The Allowed Outage Time (AOT) for the RCIC System is defined by plant Technical Specification Section 3.5.D.2 which reads:

> "From and after the date that the RCIC System is made or found to be inoperable for any reason, continued reactor power operation is permissible only during the succeeding fourteen days provided that during such fourteen days the High Pressure Core Injection (HPCI) System is operable."

The leak rate test for valve 1301-59 takes approximately 24 hours.

As shown in Figure 4.4, valves 1301-109 and 1301-40[1] effectively isolate the test path. **Therefore, the test lineup shown does not affect full power operation of the plant and the test can be performed on-line.**

[1] Note that 1301-40 could also be tested on-line since its normal test connection is valve 1301-58B and the vent path is through the vacuum pump into the vacuum tank. Valves 1301-109, 1301-59, and 1301-55 would serve as lines of defense.

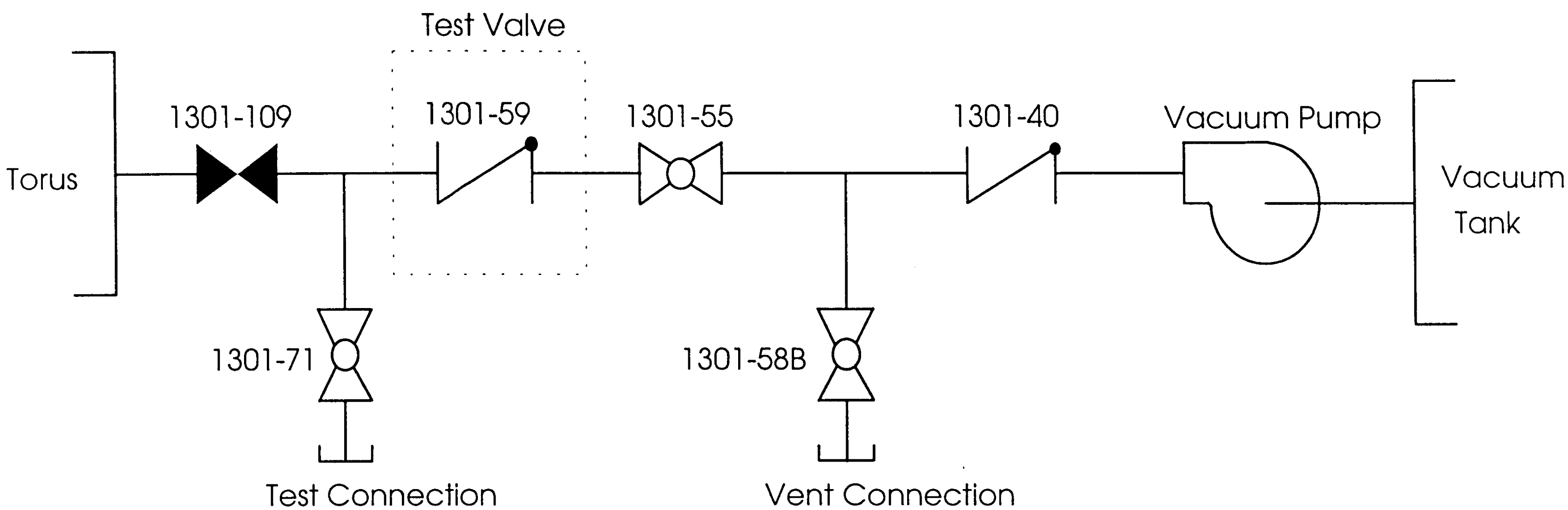

Figure 4.4 - 1301-59 Leak Rate Test Lineup

4.4. On-Line Performance Justification with Plant Modification: Checkout of Traversing In-Core Probe (TIP) Ball and Shear Valve Assembly

4.4.1. Background

The traversing in-core probe system (TIP) provides the capability to plot the neutron flux versus axial position in the core at the 30 radial local power range monitor (LPRM) assemblies. The system also provides a neutron flux signal used for LPRM calibration and process computer input for thermal power calculations. The TIP system consists of four traversing-in-core probe assemblies.

The basic components of one of the TIP assemblies are shown in Figure 4.1. During normal operation, the TIP probe is driven into the core at mandated, regular intervals to verify the correct operation of or to calibrate the LPRM's. As shown in Figure 4.5, in order to get from its housing in the shield chamber to a particular LPRM assembly in the core, the probe must pass through an explosive shear valve, a ball valve, a common shield wall surrounding the reactor, and an indexing mechanism which routes the probe to one of the guide tubes leading to the various LPRM's.

The ball valve is the means of providing containment integrity when the probe is in its normal position, housed in its shield chamber. When the probe is to be deployed, the ball valve is opened and the probe is provided access to the reactor core.

The shear valve provides primary containment isolation during abnormal operation. For example, if the TIP probe is deployed in the reactor and an accident requiring containment isolation occurs, the probe must be retrieved immediately so that the ball valve can be closed to maintain containment integrity. Should the probe get stuck

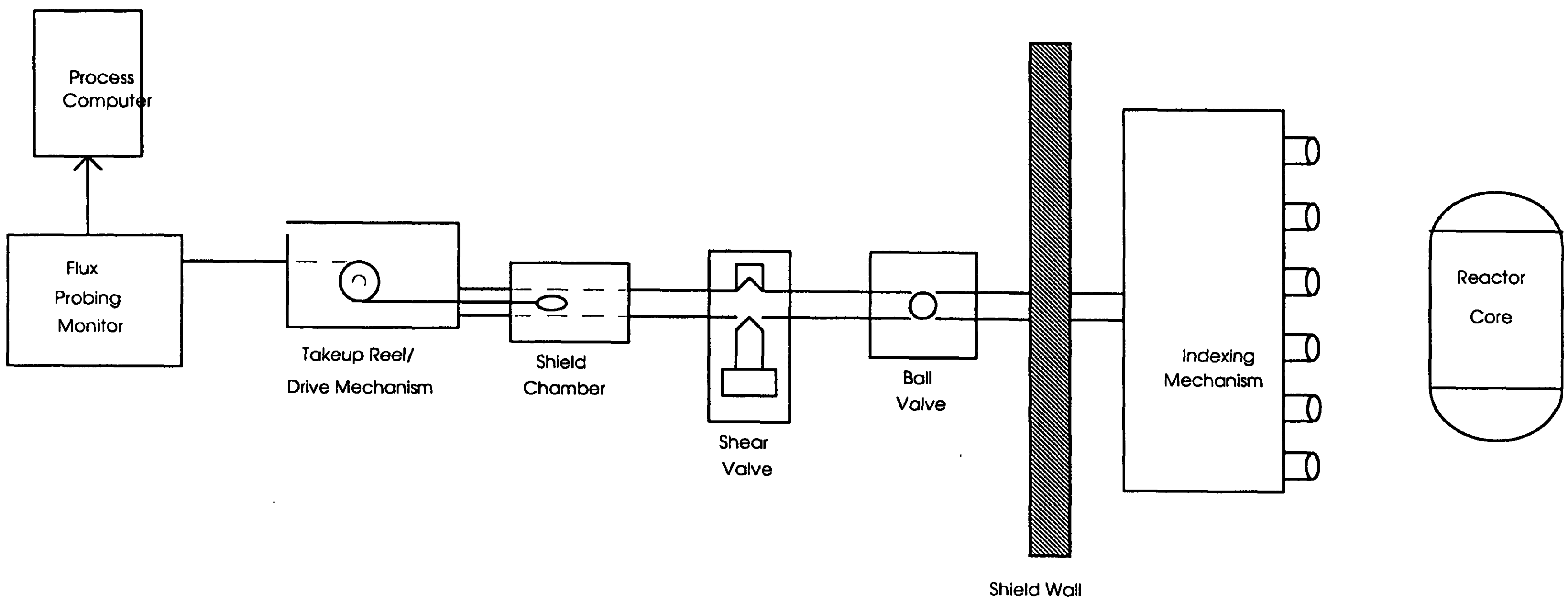

Figure 4.5 Traversing In-Core Probe Assembly Diagram

in the core, an explosive charge above the shear valve would fire and the shear valve would close, severing the probe's tether but providing vital containment isolation.[1]

4.4.2. Surveillance Description

The surveillance in question, "Checkout of Traversing In-core Probe (TIP) Ball and Shear Valve Assembly," is made up of three distinct activities. They are:

- verification of explosive shear valve charge operation (A sampling of the explosive charges, called squib charges, which facilitate shear valve closure must be replaced and tested every two years)
- preventive maintenance on the TIP ball valve
- preventive maintenance on the TIP shear valve

4.4.3. On-Line Performance Justification

From Figure 4.1 it is relatively easy to discern that with the ball valve in the closed position, preventive maintenance of the shear valve as well as testing of the squib charges could be performed on-line. However, it is not possible to perform the required preventive maintenance on the ball valve because there would be no barrier between the workspace and the core.

A tantalizing potential solution to the problem is to perform the shear valve preventive maintenance and the squib charge test on-line (as described above) and attempt to justify extension of the performance interval of the ball valve preventive maintenance to 48 months. But such interval extension attempts are thwarted by the fact that the ball valve is an important component relative to the availability of the plant as a whole. The plant needs each of the four probe assemblies to verify proper calibration of the LPRM's on a regular basis (once every 1000 operating hours). If the ball valve were to malfunction and get stuck in the closed position, the probe would not be able to access

[1] Plant System Reference Text

the core. The plant would have to shut down so that the ball valve could be disassembled and fixed. Therefore, postponing the preventive maintenance on the ball valve is too risky from an economic standpoint.

A better resolution of this surveillance requirement is to install a manual isolation valve between the ball valve and the shield wall. This would allow on-line performance of all three activities making up the surveillance. It would also facilitate on-line performance of the leak rate testing of the ball valves. Since the valves would not be large, the total hardware cost for all four assemblies would be approximately $1,000. The design and labor expense would make up most of the cost, but since it is a relatively simple modification, they can be estimated at about $15,000 to $20,000. **Ultimately, this would be an extremely inexpensive modification which would provide on-line surveillance performance capability as well as greater system flexibility with the resulting ability to isolate.**

The new system diagram is shown in Figure 4.6.

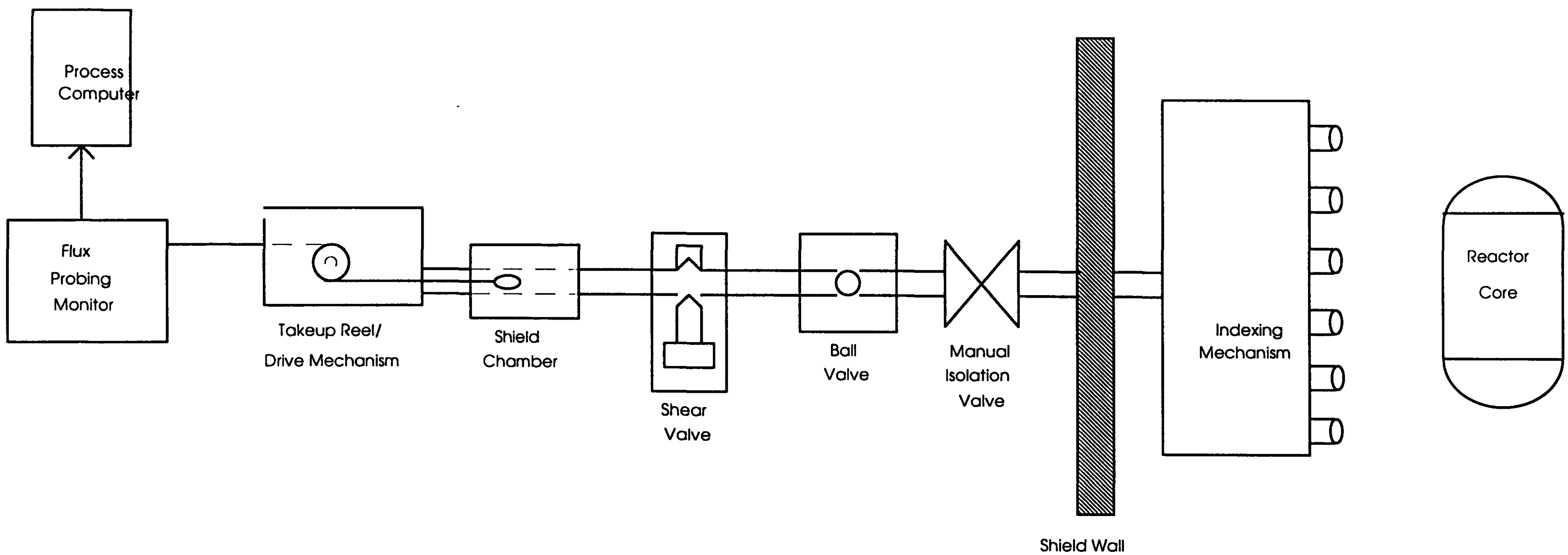

Figure 4.6 - Modified Traversing In-Core Probe Assembly Diagram

Chapter 5 - Fuel Cycle Extension Considerations

5.1. Introduction

This chapter presents a number of mostly managerial issues which are important aspects of achieving a four year fuel cycle. It is divided into three parts, general issues, on-line surveillance performance issues, and surveillance interval extension issues.

5.2. General Issues

5.2.1. Management

The top two priorities of plant management are safe and economic - in that order - operation. However, with deregulation on the horizon, economic operation has gone from a distant to a much closer second. Management must now wrestle with making plants cost competitive or face possible extinction. The urgency of the situation calls for innovative ideas for improving plant economic performance. Fuel cycle extension is such an idea, but it is not an appropriate strategy for the poorest performing plants. For such plants, the benefits of extended fuel cycles can probably not be attained without extensive changes in basic management practices.

Interestingly, the people in the industry most optimistic about extending fuel cycles are those who are currently working at the top performing plants. These people believe that, in general, current plant hardware will support fuel cycle extension. And since these people are running plants at the highest levels of productivity in the industry, it is safe to say that they are sufficiently in tune with their systems.

Though they are not doing it with fuel cycle extension specifically in mind, many of the best plants are already pursuing the type of surveillance performance relief necessary to adopt an extended fuel cycle. They are actively looking for surveillances which can be performed on-line and surveillances whose historical records support performance interval extension. As a result, they are regularly petitioning the NRC for line item technical specification changes. These plants recognize that such pursuits ultimately cut costs regardless of cycle length. All plants should pursue such a large scale, forward looking surveillance relief project. But in fact, a plant manager at one of the best BWR's in the country said that if more plants were pursuing the extent of line item technical specification changes which his plant is, the NRC would be so overwhelmed that none would get considered in a timely manner.

It is apparent that there is a distinct management style difference between the plants at the top and bottom of the performance spectrum. Management is generally proactive at the best plants and reactive at the poorer performing plants. The upper tier plants are better prepared for contingencies which can occur during both outages and on-line operations. They have *regularly updated, living* surveillance performance hotlists and the contingency personnel plans to support them. The best plants are also usually much more committed to data gathering and performance indicator trending. This trending leads to the identification of potential trouble spots before failures occur. At the poorer performing plants, trending is more likely a response to a failure in order to determine why something broke.

This type of proactive, 'solve the potential problem before it becomes an existing problem' management style is vital to achieving a 48 month fuel cycle. It is unlikely that a poor performing plant which is constantly trying to catch up to the hardware problems that regularly surface could resurrect its economic life by converting to a longer fuel cycle without changing some of its fundamental operating practices. In fact, it is more reasonable to expect such a plant's performance to degrade upon fuel cycle extension since failures due to poorly maintained hardware will likely be exacerbated because of the increased intervals between scheduled maintenance.

5.2.2. Modes of Transition

This project analyzes the strategy needed to adopt a 48 month fuel cycle. This interval was chosen because it is perceived to be within practical core load limits and yet is significantly longer than any cycle currently employed or currently contemplated at commercial reactors. One of this project's primary objectives is to combat the mindset that extended fuel cycles are unobtainable by showing that a 48 month cycle is achievable. However, it needs to be stated that the best method of achieving a 48 month cycle is probably not in one abrupt fuel cycle extension, but rather in a few incremental ones.

From an engineering standpoint it is more prudent to adopt a 48 month operating cycle incrementally since some hardware is undoubtedly more apt to make the transition successfully if its preventive maintenance intervals are gradually rather than abruptly extended. Also, unforeseen time dependent failures are more prone to cause problems if the transition is abrupt since such failures are less likely to be diagnosed and corrected than if the transition were gradual.

Ultimately, while an abrupt transition may be required and is justified under pressing utility circumstances, the transition mode more likely to be successful is a gradual one with incremental fuel cycle extensions.

5.2.3. Mid-Cycle Maintenance Outages & Surveillance Performance Hotlists

It is reasonable to expect that the age and physical condition of some systems at some plants will create obstacles to a 48 month operating cycle. If it is an important system in terms of safety or plant economic performance and is not accessible at power, the plant may need to shut down to perform a surveillance consisting of some kind of inspection or preventive maintenance activity. Such a surveillance would be a candidate for performance during a mid-cycle maintenance outage.

Although it may be necessary, a planned mid-cycle maintenance outage erodes the capacity factor gains which are the impetus to the entire extended fuel cycle project. As long as the troublesome system's surveillance does not require the reactor head to be removed (since it would only be removed during refueling operations), a well managed and maintained forced outage surveillance performance hotlist should circumvent the need for an actual mid-cycle maintenance outage.

Let us assume that the plant availability and reliability study being accomplished concurrently within this project results in forced outages occurring once per 18 months (an optimistic improvement). This is still six months less than the 24 month surveillance intervals readily attainable in accordance with the NRC Generic Letter 91-04, "Changes in Technical Specification Surveillance Intervals to Accommodate a 24-Month Fuel Cycle." Consequently, a forced outage of some kind can currently be expected before the 24 month point. With proper management and extensive preparation, this forced outage could be used to perform the few surveillances which a plant is not able to resolve to a 48 month fuel cycle. An actual mid-cycle maintenance outage would only be needed if the plant had a successful run of long duration.

As a concluding thought, it should be noted that it is probable that almost all plants capable of a 24 month or longer continuous run are also capable of resolving all of their surveillances to a 48 month cycle.

5.2.4. New Technology

There is significant room for improvement in the area of component performance monitoring in the nuclear power industry. Newly developed technologies have historically made large impacts on the predictive maintenance capabilities of nuclear plants. However, utilities do not appear to be adequately monitoring the development of technologies which have the potential to change the performance modes of surveillances to less expensive alternatives. More resources need to be allocated toward the goal of incorporating new technologies into existing plant surveillance procedures.

One of the predictive maintenance technologies which the industry has been relatively slow to incorporate is non-intrusive flow monitoring. Portable (as well as mounted) flowmeters can efficiently monitor pump and heat exchanger performance. Periodic pump head-flow curves can be compared to reference flow curves provided by the vendor to monitor the condition and performance of the pump. Heat exchangers are monitored by recording primary and secondary water flowrates and both inlet and outlet temperatures. Variations from the norm warn of possible deviations from design conditions developing within exchanger internals.

The improved flowmeters available for pumps and heat exchangers are effective and relatively inexpensive. Accuracy is normally in the range of 1% to 3% of flow. Portable, non-intrusive flowmeters are extremely cost efficient because they can be used on many systems throughout the plant. The flowmeter is one example of a predictive maintenance technology with a savings potential which the nuclear industry has barely tapped.

5.2.5. Odd Length Surveillance Intervals Greater Than Target Cycle Length

A relatively minor issue but one that can easily be overlooked is that of odd length surveillance intervals, i.e. a surveillance greater than, but not a multiple of, four years. The most difficult task with regard to surveillance requirements when extending a fuel cycle to 48 months is resolving those surveillances with intervals less than four years to the cycle goal. However, surveillances with performance intervals of, let us say six years, also require engineering attention because arbitrarily decreasing the interval to four years may not be the best option.

Such a surveillance needs to be performed on-line or its interval must be changed to either four or eight years. Eight years would obviously be the goal so that the surveillance would not have to be performed every refueling outage. Another reason to aim for the eight year performance interval is that some surveillances (such as operability tests of safety system motors) ultimately decrease component life expectancy because of the added wear resulting from surveillance performance. Consequently, somewhere in the fuel cycle transition process engineering attention needs to be given to surveillances with odd length performance intervals.

5.2.6. Radiation Exposure

Adoption of a four year operating cycle will have a significant effect on the modes of radiation exposure of plant personnel. The yearly collective dose received from refuel operations will tend to decrease since the interval between refuelings will be extended. However, increasing the amount of surveillances performed on-line will tend to increase the collective dose.

At the plant where this study was researched, during the last refuel outage, the task of refueling the core accounted for 69 man rem. With a 24 month fuel cycle, this is approximately 35 man-rem per year. If a 48 month cycle were adopted, this would be reduced to about 17.5 man-rem per year. Total dosage for the most recent refueling was approximately 400 man-rem with a total yearly dose of almost 500 man-rem. With the decreased frequency of refuel outages and the increased performance of on-line surveillance performance (in that it decreases the outage scope), the averaged yearly dose from refuel outages as a whole should also decrease.

Working against this improvement is the increased exposure from on-line surveillance performance. Average on-line daily dose collection currently varies from about 200-300 millirem. A significant daily dose increase is a likely result of performing more surveillances on-line.

How radiation exposure will change as a function of operating cycle extension and how this dose will compare to the Institute of Nuclear Power Operations' goals for BWR collective dose (250 man rem for the year 2000) will be the topic of further study within this project.

5.3. On-Line Performance Issues

5.3.1. Risk Monitors

On-line risk monitoring software such as Sentinel and Equipment Out of Service (EOOS) is being incorporated throughout the nuclear industry. These monitors are Probabilistic Risk Assessment (PRA) based risk gauges which quantify the increased risk involved with taking systems and combinations of systems out of service while the plant is operating. Although not all U.S. plants currently have well developed risk monitors, thorough risk monitors will be necessary for the safe performance of the extensive on-line testing and maintenance activities associated with a four year operating cycle.

Plant risk monitors are developed and maintained by PRA engineers. They are designed for use by both surveillance schedulers and plant operators. The monitors enable surveillance schedulers to quantify the risk involved with performing one or more maintenance or testing activities. The schedulers can then optimize work schedules by managing the risk associated with the different activities. For the operator, the risk monitors identify which systems are most important to maintain operable given that another system is inoperable. For example, if the reactor core isolation cooling system is taken off-line, a risk monitor would tell the operator what the overall increased risk is in terms of the Core Damage Frequency and would identify the high pressure core injection system as the most valuable safety system which should be maintained at all costs.

With the greater number of surveillances performed on-line associated with a four year operating cycle, maintenance scheduling will become increasingly complex. A well-developed risk monitor will be valuable to the safe operation of the plant.

5.3.2. Surveillance Performance During Limiting Conditions of Operation (LCO's)

The existing operating procedures of most plants allow for surveillance performance during LCO's as long as certain fundamental principles are adhered to. These procedures generally include principles similar to those quoted below.[1]

1. The maintenance should result in an enhancement to the system or component or represent a net safety benefit and be warranted by operational necessity.
2. An LCO preventive maintenance action on-line is acceptable if it is expected that the reliability of the equipment will improve such that the overall risk to the safe operation of the plant decreases.

[1] Plant procedure 1.2.2

3. Scheduled repeated entry and exit from the LCO for the purpose of resetting the clock for allowable out-of-service time will not be allowed.

4. Other maintenance or testing that increases the likelihood of a plant transient should be avoided. Confidence in the operability of the independent equipment that is redundant (or diverse) to the affected equipment should be high.

5. LCO's for corrective or preventive maintenance will not be scheduled just prior to a refuel outage with the sole intent of reducing outage scope.

6. The planned work should not exceed 50% of the allowable LCO time (this is from inoperable status to operable status).

7. The maintenance activity shall be worked around the clock for equipment with a seven day or less LCO, unless personnel or parts restraints preclude this, such that the out-of-service time is minimized. Around the clock coverage should be considered for all other LCO maintenance.

Such principles pose no insurmountable obstacles to the amount of on-line surveillances which can be performed during LCO's. However, excessive conservatism on the part of the utilities has resulted in this valuable tool being ineffectually utilized. This attitude must change if an extended fuel cycle is to be successful.

Although the above principles support surveillance performance during LCO's, item number 6 could benefit from further thought. Applying this 50% number to all surveillances performed during LCO's is a simplistic answer to a complex problem. Surveillances and their associated governing LCO's should be analyzed on a case by case basis to determine the percentage of time which can be allotted to actual surveillance performance. The percentage determination should be based on factors such as extent of corrective maintenance necessary upon surveillance failure, amount of time necessary to restore the system to operational status following surveillance completion, number of personnel assigned to the job, and trending of past surveillance results.

Finally, it is significant to point out that the excessively conservative attitude toward surveillance performance during LCO's is not held throughout the industry. In fact, there is a movement beginning to do away with LCO's altogether and rely on risk-based technical specifications. In such a scheme, plants would be allowed to perform work on any number of systems for as long as minimum risk level criteria are met. As attractive as such a system might be, it will probably not take form in the near future because the system data necessary to support such risk-based technical specifications has not been adequately compiled over the years.

5.3.3. Performance Indicators

Currently, one of the ways U.S. plants are ranked among their peers is by INPO performance indicators. The weight these indicators hold is significant. Plants which fall at the bottom of the INPO rankings open themselves to much closer scrutiny by the watchdogs of the nuclear industry. Ultimately, financial penalties can result. One of these indicators is the availability of safety systems which are common to all the plants.

Although the total unavailability of these safety systems is an important statistic, it tends to indirectly punish those plants that have an extensive on-line surveillance performance agenda which results in taking safety systems out of service to perform maintenance while the plant is at power. A plant which has put a great deal of effort into performing safe, cost effective on-line maintenance can unjustly be labeled as a plant with problems maintaining valuable safety systems operable. To solve this, further clarification of the INPO Performance Indicators is called for as on-line maintenance becomes more and more of a predominant issue within the industry. For example, if a plant is appraised to have a 2% unavailability of a particular system, the portion of that 2% due to system failure and that due to voluntary system unavailability to perform surveillances should be specified. Although the system is technically unavailable for the entire 2%, the portion due to surveillance performance is necessarily under very controlled conditions. On-line surveillance performance is not conducted unless some kind of contingency plan exists to restore equipment to service should a redundant or backup system become unavailable. Therefore, the system can be brought back to service relatively quickly. This is not the case when the system is unavailable due to failure and is completely inoperable.

Ultimately the growth of on-line surveillance performance within the industry calls for the INPO performance indicators to be identified by two categories: unavailability due to system failure and unavailability due to surveillance performance.

5.3.4. NRC Perspective

Contrary to some lingering opinions in the industry, the NRC supports on-line surveillance performance. The NRC recognizes that it can be a cost effective way to meet surveillance requirements and more importantly, that it can be a safer way of meeting them. In contrast to an outage, during power operations more attention can be focused on the safe performance of surveillances because there are not as many activities competing for the time of plant personnel. In addition to the extra oversight and attention to detail which can be given to surveillances on-line, it is inherently safer to perform surveillances on some systems on-line. One example is the residual heat removal system. During refueling operations, this is a crucial safety system to have in standby should a transient occur. It is a system whose safety function is more valuable when the plant is shutdown than when the plant is operating. Therefore, surveillances performed on it should be conducted at power.

A major NRC concern with regard to on-line surveillance performance is that plant personnel have a firm understanding of the consequences and possible contingencies of taking systems out of service. The resolution of this substantiated concern lies in the hands of management who must ensure that all workers are thoroughly prepared prior to on-line surveillance performance.

5.3.5. Operations Obstacles to On-Line Surveillance Performance

The people responsible for the day to day operation of the plant, the operators, are at times the most formidable obstacles to on-line surveillance performance. The possibility of a plant trip on "their watch" often stands in the way of the signature necessary to perform the surveillance. Knowledgeable operators are fully aware of the increased plant trip potential while the surveillance is being performed. They are not always aware or fully convinced that performing the surveillance on-line will likely decrease the plant trip frequency over the life of the cycle because component failure mechanisms will be diagnosed sooner. Such a doubting attitude is especially common at plants where there is little interaction between operators and support engineers. Efforts must be made to get operators to support on-line surveillance performance. One step taken at many plants is incorporating the operators into the on-line surveillance performance justification process. With ownership of the process often comes approval of its results.

Another, although less frequent obstacle to on-line surveillance performance is the operators' fear that if the system fails the surveillance, the plant may be forced to shutdown. This a non-conservative attitude. It should be the priority of everyone at the plant to learn of any possible situation which could pose a safety problem. If a system is operating in a deteriorated state which could jeopardize the plant, the operators should want to know about it and be willing to shutdown to fix it.

5.3.6. Degradation from Over-Testing

For a surveillance which can be moved to the on-line workscope, the possibility of overtesting the system exists. Maintenance personnel consulted for this project expressed the concern that management would increase the frequency of testing simply because they could if some surveillances were now performed on-line without entering into an LCO. They communicated that the potential negative consequences *as a result* of performing excessive surveillances were not satisfactorily understood by upper management. For example, human errors during surveillance performance can cause a system which was performing well to experience problems upon being brought back to operational status. Consequently, a thorough justification should be made if a surveillance frequency increase is sought. Otherwise, unjustified frequency increases could ultimately result in availability problems.

5.4. Performance Interval Extension Issues

5.4.1. Quantification of Extension Justifications and Data Availability

The NRC's Generic Letter 91-04 specifically identifies the documentation required to extend technical specification surveillance intervals to 24 months. In order to extend the calibration interval on instrumentation, a utility must present a detailed, quantified justification "in order to confirm that drift will not result in instrument errors that exceed the assumptions of the safety analysis." However, with regard to other non-instrumentation surveillances, the requirements for interval extension justification are not as stringent and can be based heavily on expert judgment. In addition to ensuring that the increased interval does not invalidate any assumption in the plant licensing basis, the NRC requires only that historical maintenance and surveillance data be checked to be sure that such records do not contradict the expert opinion. In fact, Generic Letter 91-04 states that utilities "need not quantify the effect of the change in surveillance intervals on the availability of individual systems or components." This relatively lenient requirement is a consequence of a deficiency in data availability and trending in the industry and the lack of an identified methodology which quantifies a non-instrumentation performance interval extension justification.

The data deficiency is endemic in many sectors of the nuclear utility industry. At many plants the data has been gathered but has never been compiled into an accessible format. Consequently, the time required to compile the data makes its use impractical. The newer plants seem to have better data availability primarily because data gathering procedures were designed with the computer age in mind. At older plants, conversion of data files to an easy to use, digital format has been a slow process. Ultimately, the lack of data availability and trending is a problem which can be solved if given a high enough priority by management. Since it is reasonable to assume that expert judgment will not be sufficient to justify every non-instrumentation surveillance out to 48 months, this is a problem which must be solved if a four year cycle is to be reality.

The lack of a methodology for quantifying optimum surveillance performance intervals will be rectified among other means by research now being performed in conjunction with the 48 month fuel cycle project. Many factors will be considered to determine optimum surveillance intervals. These factors include component function, component failure modes, component failure rates, consequence of component failure, overall risk significance, and overall economic importance. Ultimately, this methodology will be a means for justifying surveillances to a 48 month performance interval where expert judgment is deemed insufficient.

5.4.2. Calibration Interval Extensions

The rigorous instrumentation calibration interval extension methodology set forth by Generic Letter 91-04 is likely adequate to justify extension to 48 months as well as to the intended 24. The rigorous nature mandates that great care be taken when calibrating instrumentation and when gathering, compiling, and trending instrumentation data.

Some plants have found that work crews occasionally do not take care to record precise as-found readings when performing surveillances if the reading is perceived to be within the no-adjust band. This ill-advised attitude which can result from repetitiously testing extremely accurate and precise equipment must be avoided. Exact as-found readings are an integral part of performance interval extension justifications. Without them, extension may not be justifiable.

Lack of diligence has also led to human errors resulting in instrumentation being out of calibration or incorrectly perceived to be out of calibration. Modern instrumentation is extremely precise. The opinion of many experts is that any problem with components such as Honeywell or Rosemount transmitters is much more likely due to human error in installation or calibration rather than any problem with the component itself.

The economic benefits associated with fuel cycle extension and surveillance interval extension are not achievable unless plant personnel make the effort necessary to maintain and test equipment at the highest levels of proficiency.

Chapter 6 - Conclusions

Chapter 2 presents a systematic procedure which plants should use when attempting to resolve surveillance requirements consistent with a 48 month fuel cycle. It is a thorough methodology for identifying which surveillances are candidates for on-line performance and/or performance interval extension. Once the available options are identified, the resulting economic implications and effect on plant safety would be weighed by the proposed Economic Optimization Engine. The Engine would identify the most economic combination of surveillance performance modes and performance intervals which would maintain original plant risk levels.

Chapter 3 illustrates the surveillance performance options a typical BWR could likely implement in order to make the transition to an extended fuel cycle. Of the types of regulatory surveillances currently preventing a four year operating cycle, approximately 32% could be moved to the on-line workscope, the performance interval could be extended to 48 months for about 55%, both resolution options are possible for approximately 5%, and about 8% require further study. While each plant's surveillance strategy will differ according to its particular design and licensing basis, the findings of Chapter 3 identify the majority of common surveillance resolution options relevant to boiling water reactors.

Chapter 4 consists of three representative performance change justifications. The format and method of the justifications presented is appropriate for the majority of changes which would be required for a fuel cycle extension. By presenting three of the hundreds of surveillance change justifications which would be required, this chapter conveys an idea of the magnitude of the complete 48 month fuel cycle surveillance resolution project which a plant would be required to produce.

Finally, Chapter 5 presents a qualitative compilation of subtle yet important issues which must be addressed to extend a plant's operating cycle. Most of the subjects discussed are managerial issues concerned with overcoming surveillance requirement obstacles.

Chapter 7 - Future Work

7.1. Introduction

The Extended Fuel Cycle Project, of which this BWR surveillance study is just one part, is funded through January 1998. This report is one of the leading papers of the project. Significant time remains to follow up questions arising from this study. This chapter discusses the major areas where further work should be focused.

7.2. Economic Optimization Engine

Two major areas of work remain in the evolution of the Economic Optimization Engine. The first is the development of specific quantification methods for each of the various on-line performance and extended interval performance cost factors. The second is the development of a computer program which would function as the actual Engine. These are both formidable jobs but ones which, when completed, could play a revolutionary role in reducing the operation and maintenance costs of nuclear plants. The two areas are discussed in detail in sections 2.3.3. and 2.3.4., respectively.

7.3. Investment Protection Surveillances

Although the surveillance resolution methodology presented in Chapter 2 can be applied to any surveillance, the preliminary categorization study of Chapter 3 only analyzed those surveillances required by plant technical specifications or by some other regulatory source. It excluded investment protection surveillances, i.e. those imposed on the utility by the utility for economic reasons.

There are probably only a few investment protection surveillances important enough that a plant would shut down solely to perform them. The economic benefits of staying at power would outweigh performance of all but a few surveillances which verify the condition of vital equipment. An example of such equipment is the turbine-generator which is the most valuable, non-safety related component in the plant since, without the turbine-generator power cannot be produced. Several engineers said that if there was one area of concern within the turbine-generator, it would be the turbine valves. These valves should be thoroughly investigated.

With the exception of surveillances related to the turbine-generator, the decision to shut the plant down to perform a particular investment protection surveillance would likely stem from historical plant trouble spots. The suspicion of debilitating past problems resurfacing could lead to a lack of faith in the particular component's ability to perform for four uninterrupted years. Because historical trouble spots tend to vary from plant to plant, the investment protection surveillances which would mandate a shutdown will likely also vary from plant to plant. Since the investment protection surveillances are not generic issues, they were not considered in this study.

Nonetheless, this hypothesis should be verified. A compilation of historical plant trouble areas should be generated to determine which investment protection surveillances would mandate plant shutdown. The surveillances which monitor the condition of the turbine-generator and its associated equipment should also be compiled. Engineering resolutions should be sought for all investment protection surveillances which preclude a 48 month operating cycle.

7.4. Odd Length Surveillance Intervals Greater Than Target Cycle Length

The issue of surveillances that are performed off-line and have performance intervals greater than, but not multiples of, four years was raised in section 5.2.5. The most economic resolution method for many of these surveillances is probably on-line performance. Assuming this is not an option, the next best resolution option is to justify surveillance performance extension to the next multiple of four. For example, an attempt should be made to extend the performance interval of a surveillance currently performed every six years to every eight years. If an eight year interval is not appropriate, then the obvious fall back solution is a four year interval.

A list of the regulatory mandated surveillances with performance intervals greater than, but not multiples of, four years is included in Appendix H. A categorization study like the one presented in Chapter 3 should be conducted on these surveillances.

7.5. Radiation Exposure

Work is required on the issue of collective radiation exposure as a result of fuel cycle extension. As discussed in section 5.2.6., the relative modes of radiation exposure will likely change as a result of cycle extension. What is not easily predictable is the total yearly dose which can be expected for a BWR on a four year cycle.

Chapter 3 categorizes approximately 34% of the regulatory mandated surveillances as possible to be performed on-line. The amount of increased exposure which would result from such a performance mode transition should be determined. The effects of less frequent refueling operations and the overall change in the outage scope should also be considered.

The INPO goals for collective radiation exposure for the year 2000 are already set at 250 man rem. A study to establish an estimate for the total dose expected for a four year cycle and how this estimate compares to the INPO goal is required.

7.6. Category C Surveillances

Five types of surveillances appear to be potential obstacles to a four year operating cycle. They are cold shutdown operability tests, automatic depressurization system operability testing, motor operated valve testing, battery service discharge testing, and leak rate testing of main steam isolation valves and main feedwater valves. These five types of surveillances are discussed in detail in Section 3.9. Innovative technologies and monitoring schemes should be investigated in an effort to make these surveillances consistent with a 48 month operating cycle.

7.7. Methodology for Quantification of Interval Extension Justifications

Many of the engineers consulted during the course of this study stated that there are a significant number of surveillances with performance intervals which are grossly conservative. When asked why efforts have not been made to extend these intervals, answers usually implied that others things simply took a higher priority on a daily basis. Also, interval extension is complicated by the fact that no rigorous methodology currently exists for determining optimal surveillance performance intervals.

The production of such a methodology is currently in the beginning stages as part of the overall Extended Fuel Cycle Project. The end result of the study will be a valuable and long overdue tool in the nuclear industry.

Appendix A

Containment Testing

Category A & B Surveillances:

Type B Tests:

Penet #223 2301-74 INB Flange Type B[1]
Penet #223 2301-74 OTB Flange Type B
Penet #225 1301-64 INB Flange Type B
Penet #225 1301-64 OTB Flange Type B
Penet #102A Electrical Type B
Penet #103A Electrical Type B
Penet #104G CRD Position (Elec) Type B
Penet #104H CRD Position (Elec) Type B
Penet #104J CRD Position (Elec) Type B
Penet #105B Electrical Type B
Penet #202A Electrical Type B
Penet #100A Neutron Monitoring (Elec) Type B
Penet #100B Neutron Monitoring (Elec) Type B
Penet #100C Neutron Monitoring (Elec) Type B
Penet #100D Neutron Monitoring (Elec) Type B
Penet #100E Neutron Monitoring (Elec) Type B
Penet #101A Electrical Type B
Penet #101B Electrical Type B
Penet #102B Electrical Type B
Penet #103B Electrical Type B
Penet #104A CRD Position (Elec) Type B
Penet #104B CRD Position (Elec) Type B
Penet #104C CRD Position (Elec) Type B
Penet #104D CRD Position (Elec) Type B
Penet #104E CRD Position (Elec) Type B
Penet #104F CRD Position (Elec) Type B
Penet #105A Electrical Type B
Penet #106B D/W Humidity & Temp. (Elec) Type B
Penet #223 HPCI Steam to Torus Type B Flanges INB
Penet #223 HPCI Steam to Torus Type B Flanges OTB
Penet #225 RCIC Steam to Torus Type B Flanges IN
Penet #225 RCIC Steam to Torus Type B Flanges OUT
Penet #101C Electrical Type B
Penet #230 Torus Test Conn Flange Type B
Penet #202B Electrical Type B

[1] Penet #223 identifies the particular penetration into the containment. 2301-74 is the component number.

Type C Tests:

Penet #46F H202 Return to DW Type C SV-5065-24A
Penet #46F H202 Return to DW Type C SV-5065-26A
Penet #106AB H202 Analyzer A Type C SV-5065-14A
Penet #106AB H202 Analyzer A Type C SV-5065-21A
Penet #228K H202 Analyzer Type C SV-5065-25B
Penet #228K H202 Analyzer Type C SV-5065-27B
Penet #228G Gas Sample Return Type C SV-5065-77
Penet #228G Gas Sample Return Type C SV-5065-78
Penet #228H Gas Sample Return Type C SV-5065-71
Penet #228H Gas Sample Return Type C SV-5065-72
Penet #29E H2O2 Analyzer A Type C SV-5065-33A
Penet #29E H2O2 Analyzer A Type C SV-5065-37A
Penet #228J H2O2 Analyzer Type C SV-5065-11A
Penet #228J H2O2 Analyzer Type C SV-5065-18A
Penet #15E H2O2 Analyzer B Type C SV-5065-35B
Penet #15E H2O2 Analyzer B Type C SV-5065-31B
Penet #50AD H2O2 Analyzer B Type C SV-5065-13B
Penet #50AD H2O2 Analyzer B Type C SV-5065-20B
Penet #228C H2O2 Analyzer Type C SV-5065-15B
Penet #228C H2O2 Analyzer Type C SV-5065-22B
Penet #35C TIP Ball Vlv 1 Type C 45-300A
Penet #35D TIP Ball Vlv 2 Type C 45-300B
Penet #35B TIP Ball Vlv 3 Type C 45-300C
Penet #35A TIP Ball Vlv 4 Type C 45-300D

Category B Surveillances:

Type A Tests:

Primary Containment Integrated LK Rate TST Prerequisite
Primary Containment Integrated Leak Rate Test

Type B Tests:

Penet #1 D/W Equip Hatch Type B
Drywell Head Type B Test
Penet #47 ILRT Supplemental Flange Type B
GIBS Manway @ 0 Type B Test
GIBS Manway @ 45 Type B
GIBS Manway @ 90 Type B

GIBS Manway @ 135 Type B
GIBS Manway @ 180 Type B
GIBS Manway @ 225 Type B
GIBS Manway @ 270 Type B
GIBS Manway @ 315 Type B
Penet #4 D/W Head Access Hatch Type B

Type C Tests:

Penet #16A A CS Insject Vlv Type C MO-1400-24A
Penet #16A A CS Insject Vlv Type C MO-1400-25A
Penet #223 HPCI Exhaust Type C 2301-74
Penet #223 HPCI Exhaust Type C 2301-218
Penet #223 HPCI Exhaust Type C 2301-45
Penet #223 HPCI Exhaust Type C CV-9068A
Penet #223 HPCI Exhaust Type C CV-9068B
Penet #14 RWCU Supply INB Vlv Type C MO-1201-2
Penet #14 RWCU Supply OTB Vlv Type C MO-1201-5
Penet #9A RCIC Discharge Vlv Type C MO-1301-49
Penet #9B HPCI Discharge Vlv Type C MO-2301-8
Penet #35E TIP N2 Supply CK Vlv Type C
Penet #41A Recirc Pump B Sample Type C AO-220-44
Penet #47 D/W Test Conn Vlv Type C Vlv 102
Penet #47 D/W Test Conn Vlv Type C Vlv 103
Penet #47 D/W Test Conn Vlv Type C Vlv 104
Penet #47 D/W Test Conn Vlv Type C Vlv 105
Penet #41A Recirc Pump B Sample Type C AO-220-45
Penet #46A A Recirc Seal CK Vlv Type C FO-13A
Penet #46A A Recirc Seal CK Vlv Type C FO-17A
Penet #46B B Recirc Seal CK Vlv Type C FO-13B
Penet #46B B Recirc Seal CK Vlv Type C FO-17B
Penet #211A RHR to Torus Type C MO-1001-34A
Penet #211A RHR to Torus Type C MO-1001-37A
Penet #51A A RHR Inject Vlv Type C MO-1001-28A
Penet #32A C-19 Return to DW Type C CV-5065-91
Penet #32A C-19 Return to DW Type C CV-5065-92
Penet #53 RCIC Steam to Turb Type C MO-1301-16
Penet #53 RCIC Steam to Turb Type C MO-1301-17
Penet #51B B RHR Inject Vlv Type C MO-1001-28B
Penet #211B RHR To Torus Type C MO-1001-34B
Penet #211B RHR To Torus Type C MO-1001-37B
Penet #22 Instr Air to D/W Type C 31-CK-167
Penet #51B B RHR Inject Vlv Type C MO-1001-29B
Penet #228E Air Torus Vac Brk Type C 31-CK-434
Penet #228E Air to Torus Vac Brk Type C CV-5046

Penet #16B B CS Inject Vlv Type C MO-1400-24B
Perform Local Leak Rate Test (Tpe C) on Core Spray Valve MO-1400-25B, and Penetration X-16B Per PNPS 8.7.1.5
Penet #12 RHR/Recirc INB Type C MO-1001-50
Penet #12 RHR/Recirc OTB Type C MO-1001-47
Penet #23 RBCCW To D/W Type C 30-CK-432
Penet #18 D/W Floor Drain Vlv Type C AO-7017A
Penet #18 D/W Floor Drain Vlv Type C AO-7017B
Penet #19 D/W Equip Drain Vlv Type C AO-7011-A
Penet #19 D/W Equip Drain Vlv Type C AO-7011-B
Penet #8 MSL Drain INB Vlv Type C MO-220-1
Penet #8 MSL Drain OTB Vlv Type C MO-220-2
Penet #24 RBCCW from DW Type C MO-4002
Penet #52 HPCI Steam to Turb Type C MO-2301-4
Penet #52 HPCI Steam to Turb Type C MO-2301-5
Penet #42 SBLC Check Vlv Type C 1101-16

Category C Surveillances:

Type C Tests:

Penet #7B B INB MSIV Type C AO-203-1B
Penet #7B B OTB MSIV Type C AO-203-2B
Penet #7D D OTB MSIV Type C AO-203-2D
Penet #7C C INB MSIV Type C AO-203-1C
Penet #7D C INB MSIV Type C AO-203-1D
Penet #7A A INB MSIV Type C AO-203-1A
Penet #7A A OTB MSIV Type C AO-203-2A
Penet #7C C OTB MSIV Type C AO-203-2C
Penet #9A A Feed INB CK Vlv Type C 6-58A
Penet #9B B Feed INB CK Vlv Type C 6-58B
Penet #9A A Feed OTB CK Vlv Type C 6-62A
Penet #9B B Feedline OTB CK Vlv Type C 6-62B

Appendix B

In-Service Testing

<u>Category A Surveillances:</u>

<u>Hydrodynamic Valve Leak Testing:</u>

Torus Water Inventory Primary Containment Isolation Valves Leak Rate Test 1001-2B & 1001-2D
Torus Water Inventory Primary Containment Isolation Valves Leak Rate Test CK-1301-41
Torus Water Inventory Primary Containment Isolation Valves Leak Rate Test 1301-64
Torus Water Inventory Primary Containment Isolation Valves Leak Rate Test 1001-2A & 2C
Torus Water Inventory Primary Containment Isolation Valves Leak Rate Test MO-1001-7A
Torus Water Inventory Primary Containment Isolation Valves Leak Rate Test MO-1001-7C
Torus Water Inventory Primary Containment Isolation Valves Leak Rate Test CK-2301-217
Torus Water Inventory Primary Containment Isolation Valves Leak Rate Test CK-2301-34
Torus Water Inventory Primary Containment Isolation Valves Leak Rate Test CK-2301-40
Torus Water Inventory Primary Containment Isolation Valves Leak Rate Test CH-1301-59 (see Chapter 4 for on-line performance justification)
Perform "Torus H2O Inventory Primary Containment Iso Valve L.R.T." on MO-1400-3A
Torus Water Inventory Primary Containment Isolation Valves Leak Rate Test MO-1001-7B
Torus Water Inventory Primary Containment Isolation Valves Leak Rate Test MO-1001-7D
Torus Water Inventory Primary Containment Isolation Valves Leak Rate Test 10-CK-515
Perform "Torus H2O Inventory Primary Containment ISO Valve L.R.T." on MO-1400-3B
Torus Water Inventory Primary Containment Isolation Valves Leak Rate Test Ck-2301-36
Torus Water Inventory Primary Containment Isolation Valves Leak Rate Test (Total Leak Trkg)
Torus Water Inventory Primary Containment Isolation Valves Leak Rate Test MO-1301-25
Perform Water Inventory Primary Containment Isolation Valve Leak Rate Test on 14-CK-35
Perform Water Inventory Primary Containment Isolation Valve Leak Rate Test on 14-CK-214

Torus Water Inventory Primary Containment Isolation valves Leak Rate Test CK-1301-47
Torus Water Inventory Primary Containment Isolation Valves Leak Rate Test CK-1301-40

Perform Core Spray Keepfill Supply Check Valve Seat Leak Test on 14-CK-1400-212A
Hydrodynamic Meas Leak Thru RHR Sys to Radwaste
Hydrodynamic Meas Leak Thru RHR Sys to Radwaste
Perform Cre Spray CST Suction Valve Leak Test on 14-HO-1400-2A
RHR Keep Fill Valve Leak Test
RCIC CST Suction Check Valve Leak Test CK-1301-23
HPCI CST Suction Check Valve Leak Test
RHR Keepfill Valve Leak Test
Perform Core Spray Keepfill Supply Check Valve Seat Leak Test Perform IAW 8.5.1.7
Perform Core Spray CST Suction Valve Leak Test on 14-HO-1400-2B IAW 8.5.1.8
Hydrodynamic Test Leak Thru HPCI SYS 2301-8
Hydrodynamic Leak Test of SBLC Inj Water Check Vlvs

<u>Position Indication Verification Testing:</u>

PASS[1] and H2/O2 Analyzer Valve Position Indication Verification (SV-5065-122A)
PASS and H2/O2 Analyzer Valve Position Indication Verification (SV-5065-67)
PASS and H2/O2 Analyzer Valve Position Indication Verification (SV-5065-68)
PASS and H2/O2 Analyzer Valve Position Indication Verification (SV-5065-69)
PASS and H2/O2 Analyzer Valve Position Indication Verification (SV-5065-70)
PASS and H2/O2 Analyzer Valve Position Indication Verification (SV-5065-73)
PASS and H2/O2 Analyzer Valve Position Indication Verification (SV-5065-74)
PASS and H2/O2 Analyzer Valve Position Indication Verification (SV-5065-75)
PASS and H2/O2 Analyzer Valve Position Indication Verification (SV-5065-76)
PASS and H2/O2 Analyzer Valve Position Indication Verification (SV-5065-79)
PASS and H2/O2 Analyzer Valve Position Indication Verification (SV-5065-80)
PASS and H2/O2 Analyzer Valve Position Indication Verification (SV-5065-81)
PASS and H2/O2 Analyzer Valve Position Indication Verification (SV-5065-82)
PASS and H2/O2 Analyzer Valve Position Indication Verification (SV-5065-87)
PASS and H2/O2 Analyzer Valve Position Indication Verification (SV-5065-88)
PASS and H2/O2 Analyzer Valve Position Indication Verification (SV-5065-89)
PASS and H2/O2 Analyzer Valve Position Indication Verification (SV-5065-90)
PASS and H2/O2 Analyzer Valve Position Indication Verification (SV-5065-122B)
PASS and H2/O2 Analyzer Valve Position Indication Verification (SV-5065-123A)
PASS and H2/O2 Analyzer Valve Position Indication Verification (SV-5065-123B)
PASS and H2/O2 Analyzer Valve Position Indication Verification (SV-5065-124A)
PASS and H2/O2 Analyzer Valve Position Indication Verification (SV-5065-124B)
RHR Sample Valve Position Indication Verification (SV-5065-83)

[1] PASS - Post Accident Sampling System

RHR Sample Valve Position Indication Verification (SV-5065-84)
RHR Sample Vlave Position Indication Verification (SV-5065-65)
RHR Sample Valve Position Indication Verification (SV-5065-66)

Flow Testing:

Perform HPCI/RCIC Vacuum Breaker Line Check Cold Shutdown Operability Test
HPCI/RCIC Vacuum Breaker Line Check Cold Shutdown Operability
Perform Exhaust Drain Pot Check Valve Cold Shutdown Operability Test
RWCU Return CHK (1201-81) Vlv Reverse Flow Exercise
TIP N2 Check CIV Forward Flow Exercise

Category B Surveillances:

Hydrodynamic Valve Leak Testing:

Hydrodynamic Test Leak Thru RHR Sys 1001-MO-29B
Hydrodynamic Test Leak Thru Core Spray Sys 1400-9B Vlv
Hydrodynamic Test Leak Thru Core Spray Sys 1400-MO-25B Vlv
Hydrodynamic Test Leak Thru HPCI Sys 2301-7
Hydrodynamic Test Leak Thru RCIC Sys 1301-50
Hydrodynamic Test Leak Thru Core Spray Sys 1400-9A Vlv
Hydrodynamic Test Leak Thru Core Spray Sys 1400-MO-25A
Hydrodynamic Test Leak Thru RHR Sys 1001-MO-29A
Hydrodynamic Test Leak Thru RCIC Sys 1301-49
Hydrodynamic Test Leak Thru RHR Sys 1001-68B Vlv
Hydrodynamic Leak Test Thru RHR Shutdown Cooling-SYS 1001-MO-47
Hydrodynamic Leak Test Thru RHR Shutdown Cooling-SYS 1001-MO-50
Hydrodynamic Test Leak Thru RHR Sys 1001-68A Vlv

SDV Vent and Drain Valve Leak Test CV302-21A
SDV Vent and Drain Valve Leak Test CV302-23A
SDV Vent and Drain Valve Leak Test CV302-22A
SDV Vent and Drain Valve Leak Test CV302-24A
SDV Vent and Drain Valve Leak Test CV302-21B
SDV Vent and Drain Valve Leak Test CV302-23B
SDV Vent and Drain Valve Leak Test CV302-22B
SDV Vent and Drain Valve Leak Test CV302-24B

CRD System Leakage 301-2A
CRD System Leakage 301-2B
CRD System Leakage 3-CK-151

Reactor Vessel Pressurization and Temperature Control for Class I System Leakage Test
SLC Inboard Injection Check Valve (1101-15) Leak Test

Safety/Relief Valve Testing:

Administrative Control of Safety Relief Valve Testing for Pilot Valve S/N 1208
Administrative Control of Safety Relief Valve Testing for Pilot Valve S/N 1048
Administrative Control of Safety Relief Valve Testing for Pilot Valve S/N 1046
Administrative Control of Safety Relief Valve Testing for Pilot Valve S/N 1040
IST Relief Valve Testing PSV-1105A
IST Relief Valve Testing PSV-1105B
IST Relief Valve Testing ASME IWV-3500 Tracking
IST Relief Valve Testing for CLI Safety Relief Valves
IST Relief Valve Testing for CLI Safety Valves

Valve Disassembly Inspections:

IST Check Valve 2301-39 Disassembly and Exercise
IST Check Valve 1301-27 Disassembly and Exercise
IST Check Valve 1301-24 Disassembly and Exercise CRD System Leakage 3-CK-151
In Service Check Valve Sample Disassembly Program - Tracking

Position Indication Verification Testing:

Perform PIT for 1001-MO-29B
Perform PIT for 1001-MO-29A
CRD Hydraulic CHG WTR CHK Vlv

Valve Operability Testing:

Perform HPCI Check Valve Cold Shutdown Operability Test IAW 8.I.11.7 Ex
RCIC Check Cold Shutdown Operability

Accumulator Testing:

ADS Accumulator SYS
MSIV Accumulator Integrity Test

Appendix C

Instrumentation Surveillances

Category A Surveillances:

Instrument Calibrations:

Post Accident Sampling Sys Inst Cal
RX Press VSL Instrument Cal
Recirculation System Instrumentation Calibration
Containment Press Mntrng Sys Inst Cal
Cal of ATS Trip Transmitters Rack C2251&2252
Cal of ATS Trip Transmitters Rack C2205
Cal of ATS Trip Transmitters Rack C219A&A298
CAL of ATS Trip Transmitters Rack C2256A&C2256B
ATWS Trip System "A" Transmitter Cal
ATWS Trip System "B" Transmitter Cal
TX Press Readout
RX Lvl Readout
RX Lvl Readout
Reactor Level Readout
RCIC Sys Instrument Cal
RCIC Sys Instrument Cal
RCIC Sys Instrument Cal
RCIC Sys Instrument Cal
HPCI Sys Instrument Cal
HPCI Sys Instrument Cal
HPCI Sys Instrument Cal
HPCI Sys Instrument Cal
HPCI Sys Instrument Cal
Torus Wrt Lvl Mntrng Sys Cal
Cntrl Rod Accumulator's Opablty
Cntrl Rod Accumulator's Opablty
Cntrl Drive Flow Instrument Cal
Nitrogen Supply Sys Inst
STBY LQD Cntrl Sys Instrument Cal
RX WTR Cleanup Sys Instrument Cal
RBCCW Sys Instrument Cal
RBCCW Instrument Calibration & Functional Test
FP Sys Instrument Cal
Diesel Fuel Oil Calibration and Alarm Check (Diesel A)
Diesel Fuel Oil Calibration and Alarm Check (Diesel B)
Stby Gas Treatment Sys Instr. Calc
Turb Vib Alarm & Trip Cal

High Range Effluent Monitor Calibration
APRM Calibration Instructions
APRM Calibration Instructions
APRM Calibration Instructions
APRM Calibration Instructions
APRM Calibration Instructions
APRM Calibration Instructions

Squib Testing:

TIP Channel 1 Squib Charge
TIP Channel 2 Squib Charge
Tip Channel 3 Squib Charge
Tip Channel 4 Squib Charge

Instrument Valve Testing:

RHR Shutdown Cooling Valve Interlock Test
RHR ISO Vlv Cntrl TST A - INBRD
RHR ISO Vlv Cntrl TST A - OUTBRD
Turbine Stop Vlv Closure Inspection

Category B Surveillances:

Instrument Calibrations:

Drywell Temperature Elements Calibration
High Water Level Scram Discharge Tank Instrumentation Calibration/Test
SDIV High Water Level Bypass Functional Test
Fuel Pool and Skimmer Surge Tank Instruments
Acoustic Mntrg (S&R Vlvs)
Containment High Rad Mntrs
Jet Pump Instrument Calibration
Jet Pump Instrument Calibration
Jet Pump Instrument Calibration
Jet Pump Instrument Calibration
Off-Gas Instr Cal
RX FW Instrument Cal CHK
RX FW Instrument Cal
Current/Flow Comparator Cal
PAM Short-Term Wtr Lvl Sys
Recirc Sys Instrument Cal
Recirculation System Instrumentation Calibration
Recirculation System Instrumentation Calibration
SSW Instrument Cal & Fntl Test

SDV Vent & Drain Timing

Logic Testing:

Primary Containment Isolation Valve Testing
Grp 1 Prmry Cntmnt ISO Vlv Tstg
ADS LGC RX IS SD
Mech Vac PMP ISO LGC Fntl TST

Limit Switch Testing:

Inboard MSIV Limit Switches Inspection
Outboard MSIV Limit Switch Inspection

Valve Testing:

Instrument Line Flow CHK Vlv TST

Appendix D

Operational Surveillances

<u>Category A Surveillances:</u>

<u>Valve Operability Testing:</u>

Manual Valve Operability
Standby Gas Treatment System Valve Quarterly Operability
RHR MTR Op Vlv Operability FR Alternate SD Panels

<u>Leak Testing:</u>

Secondary Cntmnt Leak Rate Tst
Drywell to Torus Vac Break Leak Rate Test

<u>Containment Atmospheric Dilution Testing:</u>

CAD Fntl Tst

<u>Reactor Core Isolation Cooling System Turbine Testing:</u>

RCIC Overspeed Test

<u>Stand-by Liquid Control System Testing:</u>

MNL Initiation Tst of SBLC Sys

<u>Category B Surveillances:</u>

<u>Fire Protection Testing:</u>

Fire Barrier Seals-Condenser Bay 194.502A
Fire Barrier Seals-Condenser Bay 194.503A
Fire Barrier Seals-Condenser Bay 194.503B
Fire Barrier Seals-Condenser Bay 194.503C
Fire Barrier Seals-Condenser Bay 194.503D
Fire Barrier Seals-Condenser Bay 194.503E
Fire Barrier Seals-Condenser Bay 201.514
Fire Barrier Seals-RB South 63.502A
Fire Barrier Seals-H2 Recombiner 188.501B
Fire Barrier Seals-Steam Tunnel 63.504A
Fire Barrier Seals-Steam Tunnel 63.504B
Fire Barrier Seals-Steam Tunnel 63.504C

Fire Barrier Seals-Steam Tunnel 63.510
Fire Barrier Seals-Steam Tunnel 63.602
Fire Barrier Seals-Torus 201.508
Hydro Seal Sply Oil Unit Area Preactn Sprinkler
Fire Extgsh Quick Checks & Maint. Inspec
Int Fire Hose Sta Vlv Oper funct Test
Turbine Generator Pre-Action System
Hydrostatic Testing of A Fire Hose (High Rad Area)
Wet & Dry Pipe Sprinkler Sys Inspector Test

Valve Operability Testing:

RX Cavity Sparger Check Valve Operability 19-CK-235 & 19-CK-245
RX Cavity Sparger Check Valve Closure Verification 19-CK-235 & 19-CK-245
Perform Core Spray Sys Chk Vlv 14-CK-9A B Operability Test

Diesel Generator Testing:

Diesel Generator Alternate Shutdown Panel Test A Only
Diesel Generator Alternate Shutdown Panel Test B Only

Reactor Core Isolation Cooling System Testing:

RCIC Operability Demonstration and Flow Rate Test at 150#

Fuel Handling Inspection:

Fuel Handling

Reactor Mode Switch Testing:

RX Mode Switch in SD

Vacuum Breaker Testing:

Tsts of Drywell to Press Suprsn Chmbr Brkrs

Category C Surveillances:

Cold Shutdown Operability Tests:

Torus Vac. Brker Accumulator Check Valve Closure Verification 31-CK-15A & 15B
RHR B Loop LPCI In jection CK Valve Cold Shutdown Operability
RHR A Loop LPCI In jection CK Valve Cold Shutdown Operability
Salt Service Water Sys Cold Shutdown Operability Test of Pump A (P-208A)

Salt Service Water Sys Cold Shutdown Operability Test of Pump A (P-208B)
Perform Salt Service Water Cold Shutdown Operability Test of (P-208C)
Perform Salt Service Water System Cold Shutdown Oprability Test on Pump D (P-208D)
Perform Salt Service Water System Cold Shutdown Oprability Test on Pump E (P-208E)
Cold Shutdown Operability Test of RX Bldg Closed Cooling Water Sstem Pump A (P-202A)
RX Bldg Closed Cooling Water Sys Cold Shutdown Operability Test of Pump B (P-202B)
RX Bldg Closed Cooling Water Sys Cold Shutdown Operability Test of Pump C (P-202C)
RX Bldg Closed Cooling Water Sys Cold Shutdown Operability Test of Pump D (P-202D)
RX Bldg Closed Cooling Water Sys Cold Shutdown Operability Test of Pump E (P-202E)
RX Bldg Closed Cooling Water Sys Cold Shutdown Operability Test of Pump F (P-202F)

Reactor Recirculation A Loop Valve Cold Shutdwon Operability
Reactor Recirculation B Loop Valve Cold Shutdwon Operability
ADS Accumulator Checks - Cold Shutdown
RHR A Loop Valve Cold Shutdown Operability
RHR B Loop Valve Cold Shutdown Operability
RHR Miscellaneous Valve Cold shutdown Operability
SRV Disc Line Vacuum Relief Cold Shutdown Operability
RBCCW Valve Cold Shutdown Operability
React Coolant Press Boundary Isol Vlv Cold SD Operability
Salt Service Water Valve Cold Shutdown Operability
Reactor Recirc A Loop Valve Cold Shutdown Operability
Reactor Recirc B Loop Valve Cold Shutdown Operability
React Coolant Press Boundary Isol Vlv cold SD Operability
Perform HPCI GSC Hotwell Discharge Check Valve Operability Test on 23-CK-2301-76

<u>Automatic Depressurization System Operability Tests:</u>

ADS Subsys MNL Opng of Relief Vlvs (Alt Method)
ADS Operability from ASP (Alternate Shutdown Panel)

Appendix E

Electrical Surveillances

Category A Surveillances:

Transformer/Relay Testing:

Shutdown XFMR To Bus A5
Bus B6 Auto Trans Test, UV & Time Relay Cal
NGV-13 Under Volt (480V Bus 2)
Start-Up XFMR To A5 Bus Relays 152-504
Diesel Gen A to Bus A5 Relays 152-509
Bus A5 Relays
Shutdown XFMR To A5/A6 Tie Relays 152-600
Shutdown XFMR to Bus A6 Relays 152-601
Startup XFRRo A6 Bus Relays 152-604
DSL GNTR B To Bus A6 Relays 152-609
Bus A6 Relays

Battery Charger Testing:

Battery Charger Maintenance and Calibration D11
Battery Charger Maintenance and Calibration D12
Battery Charger Maintenance and Calibration D13
Battery Charger Maintenance and Calibration D14
Battery Charger Maintenance and Calibration D15

Motor Brush Inspections:

Replace Motor Brushes - P220
Replace Motor Brushes - P221
Replace Motor Brushes - P222
Replace Motor Brushes - P223

Breaker Interlock Testing:

4160V Bus A5 Feeder BKRS Interlock Testing
4160V Bus A6 Feeder BKRS Interlock Testing

Automatic Load Sequencing Testing:
Auto ECCS LD SEQ DSL & XFMR W/SIM Loss OFSIT PWR

Category B Surveillances:

Breaker Inspections:

480V Load Center Breaker Preventive Maintenance (BKR 52-101)
480V Load Center Breaker Overhaul (BKR 52-102)
480V Load Center Breaker Preventive Maintenance (BKR 52-103)
480V Load Center Breaker Preventive Maintenance (BKR 52-104)
480V Load Center Breaker Preventive Maintenance (BKR 52-105)
480V Load Center Breaker Preventive Maintenance (BKR 52-106)
480V Load Center Breaker Preventive Maintenance (BKR 52-201)
480V Load Center Breaker Overhaul (BKR 52-202)
480V Load Center Breaker Preventive Maintenance (BKR 52-203)
480V Load Center Breaker Preventive Maintenance (BKR 52-204)
480V Load Center Breaker Preventive Maintenance (BKR 52-205)
480V Load Center Breaker Preventive Maintenance (BKR 52-206)
480V Load Center Breaker Overhaul (BKR 52-601)
480V Load Center Breaker Overhaul (BKR 52-602)
480V Load Center Preventive Maintenance (BKR 52-603)
480V Load Center Breaker Preventive Maintenance (BKR 52-604)
480V Load Center Breaker Preventive Maintenance (BKR 52-605)
480V Load Center Breaker Preventive Maintenance (BKR 52-606)
4KV Breaker Mechanical Inspection For Breaker 152-501
4KV Breaker Mechanical Inspection For Breaker 152-502
4KV Breaker Mechanical Inspection For Breaker 152-503
4KV Breaker Mechanical Inspection For Breaker 152-504
4KV Breaker Mechanical Inspection For Breaker 152-505
4KV Breaker Mechanical Inspection For Breaker 152-506
4KV Breaker Mechanical Inspection For Breaker 152-507
4KV Breaker Mechanical Inspection For Breaker 152-508
4KV Breaker Mechanical Inspection For Breaker 152-509
4KV Breaker Mechanical Inspection For Breaker 152-600
4KV Breaker Mechanical Inspection For Breaker 152-601
4KV Breaker Mechanical Inspection For Breaker 152-602
4KV Breaker Mechanical Inspection For Breaker 152-603
4KV Breaker Mechanical Inspection For Breaker 152-604
4KV Breaker Mechanical Inspection For Breaker 152-605
4KV Breaker Mechanical Inspection For Breaker 152-606
4KV Breaker Mechanical Inspection For Breaker 152-607
4KV Breaker Mechanical Inspection For Breaker 152-608
4KV Breaker Mechanical Inspection For Breaker 152-609
4KV Bus A5 Preventive Maintenance
4KV Bus A6 Preventive Maintenance
4KV Bus for Breaker Cubicle and PT Fuse Drawer Maintenance for Breaker 152-600
4KV Bus Startup Transformer PT Fuse Drawer Maintenance For Cubicals A5-5
480V Load Center Preventive Maintenance (Load Center B6)
480V Load Center Preventive Maintenance (Load Center B2)

480V Load Center Preventive Maintenance (Load Center B1)
Breaker Overhaul - Gen Exciter Field 41E
Breaker Overhaul - Gen Field 41M
Breaker Overhaul (MG Set A) 204A-41A
AKF-25 BKR. Overhaul (Recirc B Field)

Insulation Testing:

Insulation Test (Transformer X22 and 5KV Cables)
Insulation Test (Transformer X22 and 5KV Cables) hard to trend
Insulation Test (B1 Load Center)
Insulation Test (B2 Load Center)
Insulation Tests (B6 Load Center)
Insulation Test (Shutdown Transformer and 5KV Cable)
Insulation Test (Unit Aux. Transformer and 5KV Cables)
Insulation Test (Startup Transformer and 5KV Cable)
Insulation Test (Bus A5)
Insulation Test (Bus A6)
Inspect, Clean, Instrument Test and Insulation Test X21
Inspect, Clean, Instrument Test and Insulation Test X22
Emergency Diesel Generator ("A") Insulation Test
Emergency Diesel Generator ("B") Insulation Test

Diesel Generator Initiation Testing:

DSLGNRTR A Init By Loss of Offsite PWR LGC
DSLGNRTR B Init By Loss of Offsite PWR LGC

Load Shed Relay Testing:

Load Shed Relay Functional Test
Load Shed Relay Functional Test

Recirculation Motor Generator Testing:

Recirc MG Set A Lockout Relay & 4160V Drive Motor Breaker Trip
Recirc MG Set B Lockout Relay & 4160V Drive Motor Breaker Trip

Shutdown Transformer Testing:

Shutdown Transformer Load Test

Category C Surveillances:

MOV Testing:

Motor Operator Valve Maint & Inspection (MO-1301-48)
Motor Operator Valve Maint & Inspection (MO-1301-60)
Motor Operator Valve Maint & Inspection (MO-1301-61)
Motor Operator Valve Maint & Inspection (MO-1301-62)
Motor Operator Valve Maint & Inspection (MO-1301-22)
Motor Operator Valve Maint & Inspection (MO-1301-53)
Motor Operator Valve Maint & Inspection (MO-1301-26)
Motor Operator Valve Maint & Inspection (MO-2301-6)
Motor Operator Valve Maint & Inspection (MO-2301-3)
Motor Operator Valve Maint & Inspection (MO-2301-9)
Motor Operator Valve Maint & Inspection (MO-2301-14)
Motor Operator Valve Maint & Inspection (MO-3800)
Motor Operator Valve Maint & Inspection (MO-3801)
Motor Operator Valve Maint & Inspection (MO-3805)
Motor Operator Valve Maint & Inspection (MO-3806)
Motor Operator Valve Maint & Inspection (MO-3808)
Motor Operator Valve Maint & Inspection (MO-3813)
Motor Operator Valve Maint & Inspection (MO-4083)
Motor Operator Valve Maint & Inspection (MO-4084)
Motor Operator Valve Maint & Inspection (MO-4085A)
Motor Operator Valve Maint & Inspection (MO-220-1)
Motor Operator Valve Maint & Inspection (MO-220-2)
Motor Operator Valve Maint & Inspection (MO-202-5A)
Motor Operator Valve Maint & Inspection (MO-202-5B)
Motor Operator Valve Maint & Inspection (MO-1001-7A)
Motor Operator Valve Maint & Inspection (MO-1001-7B)
Motor Operator Valve Maint & Inspection (MO-1001-7C)
Motor Operator Valve Maint & Inspection (MO-1001-7D)
Motor Operator Valve Maint & Inspection (MO-1001-16A)
Motor Operator Valve Maint & Inspection (MO-1001-16B)
Motor Operator Valve Maint & Inspection (MO-1001-18A)
Motor Operator Valve Maint & Inspection (MO-1001-18B)
Motor Operator Valve Maint & Inspection (MO-1001-19)
Motor Operator Valve Maint & Inspection (MO-1001-21)
Motor Operator Valve Maint & Inspection (MO-1001-23A)
Motor Operator Valve Maint & Inspection (MO-1001-23B)
Motor Operator Valve Maint & Inspection (MO-1001-26A)
Motor Operator Valve Maint & Inspection (MO-1001-26B)
Motor Operator Valve Maint & Inspection (MO-1001-28A)
Motor Operator Valve Maint & Inspection (MO-1001-28B)
Motor Operator Valve Maint & Inspection (MO-1001-29A)
Motor Operator Valve Maint & Inspection (MO-1001-29B)
Motor Operator Valve Maint & Inspection (MO-1001-32)
Motor Operator Valve Maint & Inspection (MO-1001-34A)

Motor Operator Valve Maint & Inspection (MO-1001-34B)
Motor Operator Valve Maint & Inspection (MO-1001-36A)
Motor Operator Valve Maint & Inspection (MO-1001-36B)
Motor Operator Valve Maint & Inspection (MO-1001-37A)
Motor Operator Valve Maint & Inspection (MO-1001-37B)
Motor Operator Valve Maint & Inspection (MO-1001-43A)
Motor Operator Valve Maint & Inspection (MO-1001-43B)
Motor Operator Valve Maint & Inspection (MO-1001-43C)
Motor Operator Valve Maint & Inspection (MO-1001-43D)
Motor Operator Valve Maint & Inspection (MO-1001-47)
Motor Operator Valve Maint & Inspection (MO-1001-50)
Motor Operator Valve Maint & Inspection (MO-1201-2)
Motor Operator Valve Maint & Inspection (MO-1201-5)
Motor Operator Valve Maint & Inspection (MO-1201-80)
Motor Operator Valve Maint & Inspection (MO-1301-16)
Motor Operator Valve Maint & Inspection (MO-1301-17)
Motor Operator Valve Maint & Inspection (MO-1301-25)
Motor Operator Valve Maint & Inspection (MO-1301-49)
Motor Operator Valve Maint & Inspection (MO-1400-3A)
Motor Operator Valve Maint & Inspection (MO-1400-3B)
Motor Operator Valve Maint & Inspection (MO-1400-4A)
Motor Operator Valve Maint & Inspection (MO-1400-4B)
Motor Operator Valve Maint & Inspection (MO-1400-24A)
Motor Operator Valve Maint & Inspection (MO-1400-24B)
Motor Operator Valve Maint & Inspection (MO-1400-25A)
Motor Operator Valve Maint & Inspection (MO-1400-25B)
Motor Operator Valve Maint & Inspection (MO-2301-4)
Motor Operator Valve Maint & Inspection (MO-2301-5)
Motor Operator Valve Maint & Inspection (MO-2301-8)
Motor Operator Valve Maint & Inspection (MO-2301-33)
Motor Operator Valve Maint & Inspection (MO-2301-34)
Motor Operator Valve Maint & Inspection (MO-2301-35)
Motor Operator Valve Maint & Inspection (MO-2301-36)
Motor Operator Valve Maint & Inspection (MO-4002)
Motor Operator Valve Maint & Inspection (MO-4010A)
Motor Operator Valve Maint & Inspection (MO-4010B)
Motor Operator Valve Maint & Inspection (MO-4060A)
Motor Operator Valve Maint & Inspection (MO-4060B)
Motor Operator Valve Maint & Inspection (MO-4065)

Battery Service Discharge Testing:

A 125V D.C. D1 Battery Service Discharge Test
B 125V D2 Battery Service Discharge Test
250V DC D3 Battery Service Discharge Test

Appendix F

Mechanical Surveillances

Category A Surveillances:

none

Category B Surveillances:

Accumulator Inspections:

MSIV Accumulator Inspection
MSIV Accumulator Inspection
MSIV Accumulator Inspection
MSIV Accumulator Inspection
MSIV Accumulators
MSIV Accumulators
MSIV Accumulators
MSIV Accumulators
Relief Valve Accumulators
Relief Valve Accumulators
Relief Valve Accumulators
Relief Valve Accumulators
Torus Vac. Bkr Air Accumulator Inspection
Aux. Torus Vac. Bkr Air Accumulator Inspection
Torus Vac. Bkr Air Accumulator Inspection
Aux. Torus Vac. Bkr Air Accumulator Inspection

Safety/Relief Valve Inspections

Safety/Relief Valves - Test
Safety/Relief Valve - Disassemble & Inspect
Main Steam Safety Vlv

BWR Internals Inspections:

Suppression Chamber Interior Surface Inspection
Drywell Interior Surface Inspection

Snubber Inspections:

Perform Visual Inspection of Safety Related Snubbers (Inaccessible)
Perform Functional Testing of Mechanical Snubbers IAW 3.M.4-63
Perform Hydraulic Snubber Functional Test IAW 3.M.4-37

Appendix G

Categorization of Other Surveillances

Category A Surveillances:

Radiation/Gas Monitor Testing:

Source Cal Of Cntnmt Hi Rad Mntrg Sys (CHRMS)
Source Cal-MS Lines Process Rad Mntr
Source Cal-HI RNG NBL MNTR (RBV)
Source Cal-HI RNG GAS MNTR (MSV)
Source Cal-HI RNG GAS MNTR (TBV)

Enrichment Sample Collection:

Sodium Pentaborate Enrichent Sample Collection

Category B Surveillances:

Piping Inspections:

UT Exam of exposed SSW Piping - B Loop
UT Exam of Exposed SSW Piping A Loop
Piping Erosion/Corrosion Monitoring
4" Annulus Drain Line Inspection

Radiation Monitor Testing:

SJAE Rad Monitor (RM-1705-3A) Calibration
SJAE Rad Monitor (RM-1705-3B) Calibration

Core Spray Sparger Inspection:

Core Spray Sparger Inspection

Shutdown Margin Check:

SD (Shutdown) Margin Check

Appendix H

Surveillances with Odd Length Intervals Greater than Target Cycle Length

Containment Testing:

Currently, there are none, but Option B to 10 CFR 50 Appendix J will result in Type A tests having intervals of 10 years, Type B tests having intervals of 10 years, and Type C tests having intervals of 5 years.

In-Service Testing:	Interval
IST Relief Valve Testing PSV-1001-8008	10Y
IST Relief Valve Testing PSV-1001-8009	10Y
IST Relief Valve Testing PSV-9-4345	10Y
IST Relief Valve Testing PSV-1001-44	10Y
IST Relief Valve Testing PSV-31-9085B	10Y
IST Relief Valve Testing PSV-31-9085C	10Y
IST Relief Valve Testing PSV-31-9085D	10Y
IST Relief Valve Testing PSV-31-9085E	10Y
IST Relief Valve Testing PSV-31-9085F	10Y
IST Relief Valve Testing PSV-31-9085G	10Y
IST Relief Valve Testing PSV-31-9085H	10Y
IST Relief Valve Testing PSV-47-4565B	10Y
IST Relief Valve Testing PSV-47-4563C	10Y
IST Relief Valve Testing PSV-47-4563B	10Y
IST Relief Valve Testing PSV-47-4563D	10Y
IST Relief Valve Testing PSV-47-4563A	10Y
IST Relief Valve Testing PSV-47-4565A	10Y
IST Relief Valve Testing PSV-47-4582A	10Y
IST Relief Valve Testing PSV-47-4582B	10Y
IST Relief Valve Testing PSV-47-4582C	10Y
IST Relief Valve Testing PSV-47-4582D	10Y
IST Relief Valve Testing PSV-30-4036	10Y
IST Relief Valve Testing PSV-31-5003A	10Y
IST Relief Valve Testing PSV-30-4032	10Y
IST Relief Valve Testing PSV-31-5003B	10Y
IST Relief Valve Testing PSV-4020	10Y
IST Relief Valve Testing PSV-4031	10Y
IST Relief Valve Testing PSV-2301-23	10Y
IST Relief Valve Testing PSV-1301-70	10Y
IST Relief Valve Testing PSV-1301-42	10Y
IST Relief Valve Testing PSV-2301-53	10Y
IST Relief Valve Testing PSV-9-4334	10Y
IST Relief Valve Testing PSV-9-5010	10Y

IST Relief Valve Testing PSV-262-F015B	10Y
IST Relief Valve Testing PSV-262-F015A	10Y
IST Relief Valve Testing PSV-1001-8004	10Y
IST Relief Valve Testing PSV-1001-8005	10Y
IST Relief Valve Testing PSV-1401-28A	10Y
IST Relief Valve Testing PSV-1001-22A	10Y
IST Relief Valve Testing PSV-1001-8007	10Y
IST Relief Valve Testing PSV-1401-28B	10Y
IST Relief Valve Testing PSV-1001-22B	10Y
IST Relief Valve Testing PSV-1001-8006	10Y
IST Relief Valve Testing PSV-1001-34B	10Y

Instrumentation Surveillances:

Steam Leak Detection System Instruments Functional and Calibration	5Y
Condensate System Instrument Calibration (RFO Only)	5Y
Condensate System Instrument Calibration	5Y
Drywell Equipment and Floor Sump Level Switch Calibration	5Y

Operational Surveillances:

Drywell Header Inspection & Drywell/Torus Headers & Nozzles Air Test	5Y

Electrical Testing:

Breaker Testing (52-1013)	3RO[1]
Breaker Testing (52-1015)	3RO
Perform Breaker Preventive Maintenance on Breaker 52M-1016	3RO
Breaker Testing (52-1023B)	3RO
Breaker Testing (52-1025)	3RO
Breaker Testing (52-1026)	3RO
Breaker Testing (52-1041)	3RO
Breaker Testing (52-1051)	3RO
Breaker Testing (52-1056)	3RO
Breaker Testing (52-1446)	3RO
Breaker Testing (52-1461)	3RO
Breaker Testing (52-1464)	3RO
Breaker Testing (52-1466)	3RO
Perform Breaker Preventive Maintenance on Breaker 52M-1514	3RO
Breaker Testing (52-1546)	3RO
Breaker Testing (52-1561)	3RO
Breaker Testing (52-1562)	3RO
Breaker Testing (52-1564)	3RO

[1] 3RO is 3 refuel outages. With a current 24 month fuel cycle, this equals 6 years.

Breaker Testing (52-1566)	3RO
Breaker Testing (52-17A13A)	3RO
Breaker Testing (52-17A16)	3RO
Breaker Testing (52-17A31)	3RO
Breaker Testing (52-18A13A)	3RO
Breaker Testing (52-18A16)	3RO
Insulation Testing of Load B15 and its Associated Cables	3RO
Insulation Test (Bus B14 & 600V Cables)	3RO
Insulation Testing of Load B10 and its Associated Cables	3RO
Perform Breaker Preventive Maintenance 72-1021	6Y
Perform Breaker Preventive Maintenance 72-1022	6Y
Perform Breaker Preventive Maintenance 72-1023	6Y
Perform Breaker Preventive Maintenance 72-1031	6Y
Breaker Testing & Maint. 72-164	6Y
Breaker Testing & Maint. 72-165	6Y
Breaker Testing & Maint. 72-174	6Y
Breaker Testing & Maint. 72-175	6Y
125/250 Motor Control Center Breaker Testing	6Y
Breaker Testing & Maint. (D4 BKR 1)	6Y
Breaker Testing & Maint. (D4 BKR 3)	6Y
Breaker Testing & Maint. (D4 BKR 5)	6Y
Breaker Testing & Maint. (D4 BKR 7)	6Y
Breaker Testing & Maint. (D4 BKR 9)	6Y
Breaker Testing & Maint. (D4 BKR 10)	6Y
Breaker Testing & Maint. (D4 BKR 11)	6Y
Breaker Testing & Maint. (D4 BKR 12)	6Y
Breaker Testing & Maint. (D4 BKR 13)	6Y
Breaker Testing & Maint. (D4 BKR 14)	6Y
Breaker Testing & Maint. (D4 BKR 15)	6Y
Breaker Testing & Maint. (D4 BKR 16)	6Y
Breaker Testing & Maint. (D5 BKR 1)	6Y
Breaker Testing & Maint. (D5 BKR 2)	6Y
Breaker Testing & Maint. (D5 BKR 3)	6Y
Breaker Testing & Maint. (D5 BKR 5)	6Y
Breaker Testing & Maint. (D5 BKR 6)	6Y
Breaker Testing & Maint. (D5 BKR 7)	6Y
Breaker Testing & Maint. (D5 BKR 8)	6Y
Breaker Testing & Maint. (D5 BKR 9)	6Y
Breaker Testing & Maint. (D5 BKR 10)	6Y
Breaker Testing & Maint. (D5 BKR 12)	6Y
Breaker Testing & Maint. (D5 BKR 14)	6Y
Breaker Testing & Maint. (D5 BKR 15)	6Y
Breaker Testing & Maint. (D5 BKR 16)	6Y
Breaker Testing & Maint. (D6 BKR 1)	6Y
Breaker Testing & Maint. (D6 BKR 2)	6Y

Breaker Testing & Maint. (D6 BKR 3)	6Y
Breaker Testing & Maint. (D6 BKR 4)	6Y
Breaker Testing & Maint. (D6 BKR 5)	6Y
Breaker Testing & Maint. (D6 BKR 6)	6Y
Breaker Testing & Maint. (D6 BKR 7)	6Y
Breaker Testing & Maint. (D6 BKR 8)	6Y
Breaker Testing & Maint. 72-D6-9	6Y
Breaker Testing & Maint. (D6 BKR 10)	6Y
Breaker Testing & Maint. (D6 BKR 11)	3RO
Breaker Testing & Maint. (D6 BKR 12)	6Y
Breaker Testing & Maint. (D6 BKR 14)	6Y
Breaker Testing & Maint. (D6 BKR 15)	6Y
Breaker Testing & Maint. (D6 BKR 16)	6Y
Breaker Testing & Maint. (D6 BKR 17)	6Y
Breaker Testing & Maint. (D6 BKR 18)	6Y
Breaker Testing & Maint. (D6 BKR 19)	6Y
Breaker Testing & Maint. (D6 BKR 21)	6Y
Breaker Testing & Maint. (D6 BKR 22)	6Y
Breaker Testing & Maint. (D6 BKR 24)	6Y
Breaker Testing & Maint. (D6 BKR 25)	6Y
Breaker Testing & Maint. (D6 BKR 26)	6Y
Breaker Testing & Maint. (D19 BKR 1)	6Y
Breaker Testing & Maint. (D19 BKR 2)	6Y
Breaker Testing & Maint. (D19 BKR 4)	6Y
Breaker Testing & Maint. (D36 BKR 2)	6Y
Breaker Testing & Maint. (D36 BKR 4)	6Y
Breaker Testing & Maint. (D36 BKR 6)	6Y
Breaker Testing & Maint. (D36 BKR 8)	6Y
Breaker Testing & Maint. (D36 BKR 10)	6Y
Breaker Testing & Maint. (D37 BKR 1)	6Y
Breaker Testing & Maint. (D37 BKR 2)	6Y
Breaker Testing & Maint. (D37 BKR 4)	6Y
Breaker Testing & Maint. (D37 BKR 6)	6Y
Breaker Testing & Maint. (D37 BKR 8)	6Y
Insulation Test (Bus B18A)	3RO
Breaker Testing & Maint. (D4 BKR 6)	6Y
Breaker Testing (52M-1023A)	3RO
4KV Breaker Overhaul Completed for Breaker 152-501	3RO
4KV Breaker Overhaul Completed for Breaker 152-502	3RO
4KV Breaker Overhaul Completed for Breaker 152-503	3RO
4KV Breaker Overhaul Completed for Breaker 152-504	3RO
4KV Breaker Overhaul Completed for Breaker 152-505	3RO
4KV Breaker Overhaul Completed for Breaker 152-506	3RO
4KV Breaker Overhaul Completed for Breaker 152-507	3RO
4KV Breaker Overhaul Completed for Breaker 152-508	3RO

4KV Breaker Overhaul Completed for Breaker 152-509	3RO
4KV Breaker Overhaul Completed for Breaker 152-600	3RO
4KV Breaker Overhaul Completed for Breaker 152-601	3RO
4KV Breaker Overhaul Completed for Breaker 152-602	3RO
4KV Breaker Overhaul Completed for Breaker 152-603	3RO
4KV Breaker Overhaul Completed for Breaker 152-604	3RO
4KV Breaker Overhaul Completed for Breaker 152-605	3RO
4KV Breaker Overhaul Completed for Breaker 152-606	3RO
4KV Breaker Overhaul Completed for Breaker 152-607	3RO
4KV Breaker Overhaul Completed for Breaker 152-608	3RO
4KV Breaker Overhaul Completed for Breaker 152-609	3RO
Breaker Testing (52-17A13B)	3RO
B 125V D2 Batter Acceptance or Performance Test	5Y
A 125V DC D1 Battery Acceptance or Performance Test	5Y
250V DC D3 Battery Acceptance or Performance Test	5Y

Mechanical Surveillances:

Replace Rupture Disks PSD 2301-68	5Y
Replacement of Rupture Disks 2301-69	5Y
Replacement of Rupture Disks 1301-9	5Y
Replacement of Rupture Disks 1301-10	5Y
Replacement of Rupture Disks 48-8180	5Y
Replacement of Rupture Disks - West Bank CRD HCU's	5Y
Replacement of Rupture Disks - East Bank CRD HCU's	5Y

Other Surveillances:

In-Service Inspection Program, 10 Year Evaluation	10Y

5284-60