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Cliff:

Attached is some guidance on RAI B.2.22-5 issue. Salem and particularly Beaver Valley SER can be used as guidance, they have a similar issue. I'll send Beaver Valley and Salem's SERs too.

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Age-Related Degradation Inspection Method and Demonstration: In Behalf of Calvert Cliffs Nuclear Power Plant License Renewal Application

In Behalf of Calvert Cliffs Nuclear Power Plant License Renewal Application

Technical Report

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Age-Related Degradation Inspection Method and Demonstration

In Behalf of Calvert Cliffs Nuclear Power Plant License Renewal Application

TR-107514

Final Report, April 1998

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REPORT SUMMARY

Baltimore Gas & Electric (BG&E) recently became the first U.S. utility to submit an application for license renewal to the NRC. As a result of this application, BG&E conducted a plant aging management review, which produced, in part, a list of age-related degradation mechanisms (ARDMs) for five piping systems. Because these ARDMs are neither currently managed by an existing program nor easily dismissed as implausible, BG&E determined that an age-related degradation inspection (ARDI) program is required for each ARDM. This report documents the ARDI method and demonstration at Calvert Cliffs Nuclear Power Plant in behalf of its license renewal application.

Background

Since the mid-1980s, EPRI and BG&E have collaborated on life cycle management and license renewal for the Calvert Cliffs Nuclear Power Plant (CCNPP). Central to the CCNPP license renewal application is the integrated plant assessment (IPA), performed previously and described in EPRI report TR-106843. The IPA is a comprehensive, systematic evaluation of the effectiveness of age-related degradation management for the plant's important systems, structures, and components. This report documents CCNPP's method for performing ARDIs.

Objective

To make available to other utilities methods developed for identifying ARDMs and performing ARDIs in connection with CCNPP's license renewal application.

Approach

Based on system data, a review of degradation mechanism literature, and applied statistical processes, the project team developed a procedure for performing the ARDIs. This procedure involved determining the type and number of piping components requiring inspection as a result of the previous IPA that identified damage mechanisms.

Results

This report describes the process used to develop ARDI requirements and its application to five piping systems at CCNPP—the main feedwater, safety injection, service water, component cooling, and containment spray. Corrosion mechanisms of interest for the five piping systems are included along with a description of the sampling method. Finally, the report provides system-specific data and inspection requirements for each of the five piping systems. Key steps in the ARDI process follow:

- Investigators evaluated each degradation mechanism of interest and wrote a summary describing both general and specific issues for the five piping systems.
- They next evaluated probable mechanism/component pairs to determine exact locations where the degradation is expected to occur and to quantify the amount of degradation expected. These locations were further divided into "more likely to occur" and "less likely to occur" groupings. Established sample sizes for the "more likely" grouping provided a 90% confidence that 90% of the population did not have the degradation mechanism present.
- For each sample size determined, they established inspection locations, procedures, and documentation requirements.

EPRI Perspective

In order to operate a nuclear power plant beyond its initial license term of 40 years, a utility must demonstrate compliance with the License Renewal Rule, 10CFR54. EPRI is working with a number of utilities to establish a viable and predictable process for license renewal. This report focuses primarily on developing a procedure for locating and inspecting for possible age-related degradation in order to qualify components for operation beyond 40 years. While many of the details of the ARDI process are specific to CCNPP, other utilities can use the results to guide their ARDIs or to gain insights into the results expected. In related work, EPRI documented CCNPP's license renewal thermal fatigue effects evaluation (EPRI report TR-107515).

TR-107514

Interest Categories

Piping, reactor vessel and internals
Licensing and safety assessment
Plant life cycle management

Keywords

Calvert Cliffs Nuclear Power Plant
License renewal
Age-related degradation mechanisms
Piping systems
Inspection
PWR

ABSTRACT

Central to the License Renewal Application for the Calvert Cliffs Nuclear Power Plant is the Integrated Plant Assessment (IPA). The IPA is a comprehensive, systematic evaluation of the effectiveness of age-related degradation management for the plant's important systems, structures, and components. Items of systems identified as within the scope of license renewal in the screening step are evaluated to determine if they are subject to aging management review. For those that are, further evaluations of aging issues are performed. At Calvert Cliffs, a detailed method and procedures for conducting component evaluations have been developed and thoroughly tested. The development and application of these procedures have resolved problems that other utilities can avoid by adapting these methods to their own plants.

The first set of steps in the IPA process, called screening, identifies systems, structures, and components that are within the scope of license renewal. The second set of steps in the assessment process, component evaluation, assesses aging management for passive long lived components of important systems.

The end result of an aging management review of a piping system is a list of age-related degradation mechanisms for components in the piping system which are neither currently managed by an existing program nor easily dismissed as not plausible. BGE has determined that an age-related degradation inspection program is required for each of these ARDMs. This report presents the results of such an evaluation for five piping systems: Main Feedwater, Safety Injection, Service Water, Component Cooling and Containment Spray.

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INTRODUCTION

1.1 Background

Central to the License Renewal Application for the Calvert Cliffs Nuclear Power Plant is the Integrated Plant Assessment (IPA). The IPA is a comprehensive, systematic evaluation of the effectiveness of age-related degradation management for the plant's important systems, structures, and components. Items of systems identified as within the scope of license renewal in the screening step are evaluated to determine if they are subject to aging management review. For those that are, further evaluations of aging issues are performed. At Calvert Cliffs, a detailed method and procedures for conducting component evaluations have been developed and thoroughly tested. The development and application of these procedures have resolved problems that other utilities can avoid by adapting these methods to their own plants.

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The technical basis for the Calvert Cliffs Nuclear Power Plant License Renewal Application is provided in EPRI TR-106843 [44].

1.2 Overview of Report

This report describes the process used to develop age-related degradation inspection requirements and applies this process to five piping systems at CCNPP. A substantial portion of the system specific application of the process is unique to CCNPP. However, seeing how the process is utilized and what results from its application should be useful to other plants considering a similar program. The process is described in the body of the report. A summary of the corrosion/aging mechanisms of interest for the five piping systems is provided in Chapter 3. A description of the sampling methodology used is described in Chapter 4. System specific data and inspection requirements for the five piping systems can be found in Chapters 5 to 9.

2

AGE-RELATED DEGRADATION INSPECTION PROGRAM

2.1 Program Need Description

As part of the BGE license renewal effort, each passive long lived system, structure or component within the scope of License Renewal has to be evaluated to identify all possible age related degradation mechanisms (ARDM's). Elimination of postulated mechanisms is performed based on two criteria. First, the mechanism is conclusively shown to not be possible given the system, environment, and materials. Or, the effects of the mechanism, if left unmanaged, could not impact the license renewal function of the item. The result of this elimination process is a conservative listing of all "plausible" ARDM's. That is, an ARDM is considered to be plausible for a specific item if, when allowed to continue without prevention or mitigation measures or enhanced monitoring techniques, it could not be shown that the item would maintain its capability to perform its intended passive function throughout the period of extended operation. The evaluation of the function of each system, structure and component, and the determination of "plausibility" of each ARDM are contained in the Aging Management Review reports (AMRR) which have been compiled based on a system or commodity grouping [12,39,41,42,43].

Once all plausible ARDM's are known, a disposition of the management of the ARDM during the renewal period is required. Because the list of plausible ARDM's includes all mechanisms which could not be absolutely shown to not exist, a portion of the ARDM's have questionable credibility. In many cases, however, the ARDM is extremely credible. Furthermore, the majority of the ARDM's are managed or can be managed through existing programs and practices such as the ISI program. Based on this, the plausible ARDM's can be grouped into three categories:

- Known or highly probable which are managed by existing plant programs.
- Known or highly probable low grade ARDMs which are managed by existing programs, but there is no existing conclusive evidence of the effectiveness of the program, (e.g. general corrosion in the service water system).
- Highly unlikely which may require confirmation determination only,(e.g. crevice corrosion in the feedwater system).

The first item requires no further action since the aging mechanism is already being adequately managed. The second item requires an inspection to demonstrate the effectiveness of an existing aging management program (e.g. water chemistry), or to show that the mechanism is not occurring to a significant degree. The third item requires an inspection to demonstrate that a degradation mechanism is not occurring or that , if it is occurring, does not effect the intended passive function of the item for the license renewal period.

As part of the AMRR, a strategy to manage each plausible mechanism has been proposed. In cases where there is little documented evidence with regard to the effectiveness of a program relative to the period of extended operation which is being proposed to manage an ARDM it is necessary to establish the credibility or confidence level for the effectiveness of the program. One way that this can be done is by direct inspection to determine the condition of the item relative to the anticipated condition. These inspections are called ARDIs (Age Related Degradation Inspections).

A second reason to perform an ARDI would be to address those mechanisms in the third ARDM category listed above. If the ARDM is very unlikely to occur or unlikely to occur at a rate which represents a challenge to the safety function of an item, and an inspection or series of inspections could be performed to demonstrate the ARDM does not exist or exists in a minimal way such that it does not represent a credible challenge to the passive intended function of the item, it could be concluded that further management is not necessary. Conversely, if the ARDM is found to exist in a manner which may compromise the items intended function now or during the period of extended operation, the ARDI would have to be expanded to manage the ARDM. Once the ARDI sample is done, the issue either is documented closed for License Renewal or goes into corrective action.

The purpose of this report is to document a method or process which can be used to define in what manner the ARDI should be completed for the five piping systems. This task will not perform the actual inspections. However, it will establish the purpose, scope, bases, method, location, and periodicity (if more than one time) for each inspection. Also, this ARDI will recommend acceptance criteria or action values with appropriate corrective actions to ensure that relevant conditions that are discovered are managed in an appropriate manner.

2.2 Program Methodology Description

The Aging Management Review Report (AMRR) for the various systems was carefully reviewed and summarized relative to Age Related Degradation Inspection (ARDI) requirements.

Each degradation mechanism of interest was evaluated and a summary written describing general as well as specific issues. Next, the component particulars were summarized including geometry, materials and operating parameters.

The above data was used to determine if the mechanism being considered for a particular system was either probable (expected to occur), possible (not expected to occur) or impossible (cannot occur). These results were compared to the AMRR conclusions and any discrepancies resolved.

Probable mechanism / component pairs were evaluated to determine exact locations where the degradation is expected to occur and to quantify the amount of degradation expected. If the expected location and quantity of degradation is found to be significant, an Issue Report [33] will be prepared immediately. Issue Reports are a tool used at CCNPP to document and track identified issues which require a formal response resolution. If it is found to not be significant, then a sample plan will be developed. This sample plan is discussed later.

Possible mechanism / component pairs will be evaluated to determine potential locations where the degradation is expected to occur, if at all. It is possible that there may be more than one mechanism/component pair per component. These locations were further divided into "more likely" and "less likely" groupings. The "more likely" locations were used to determine a population size. From this population size, a sample size was determined to give a 90% confidence that 90% of the population does not have the degradation mechanism present [38]. For each sample size determined, inspection locations, procedures and documentation requirements was developed. When the inspections are performed in the field, the inspector will find either no evidence of the degradation mechanism or he will find some evidence of its existence. If nothing is found, the process is complete and the mechanism is demonstrated to not be a factor for license renewal. If some evidence of the degradation mechanism is found, an operability check will be required for the short term. Next, a program will be developed to control the long term (license renewal period) effect. Additionally, if any other adverse condition is discovered during an inspection it shall be documented and its impact evaluated.

Impossible mechanism / component pairs will be documented as such and the AMRR will be revised.

A flow chart showing this process can be seen in Figure 2-1.

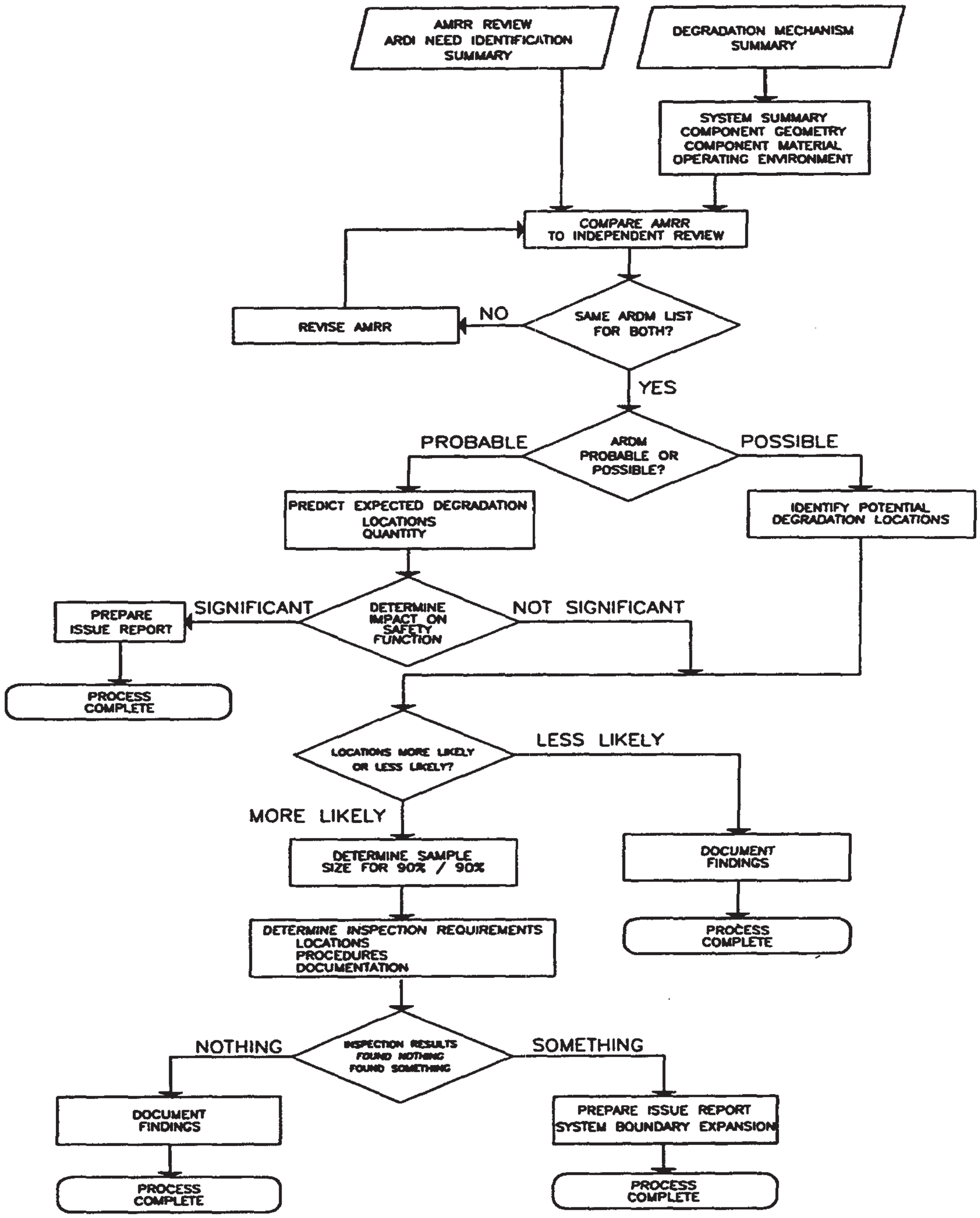


Figure 2-1 ARDI Process Flow Diagram

3

GENERAL AGING MECHANISM DESCRIPTIONS FOR PIPING SYSTEMS

3.1 Crevice Corrosion

Intensive localized corrosion frequently occurs within crevices and other shielded areas on metal surfaces exposed to corrosives. This type of attack is usually associated with small volumes of stagnant solution caused by holes, gasket surfaces, lap joints, surface deposits, and crevices under bolt and rivet heads.

Examples of deposits that may produce crevice corrosion (or deposit attack) are sand, dirt, corrosion products, and other solids. The deposit acts as a shield and creates a stagnant condition thereunder. The deposit could also be a permeable corrosion product. Contact between metal and nonmetallic surfaces can cause crevice corrosion as in the case of a gasket. Wood, plastics, rubber, glass, concrete, asbestos, wax, and fabrics are examples of materials that can cause this type of corrosion. Stainless steels are particularly susceptible to crevice attack.

Although branch lines such as instrument lines also provide stagnant flow regions, the temperature in these lines should be much less than main flow lines, which minimizes this corrosion mechanism.

To function as a corrosion site, a crevice must be wide enough to permit liquid entry but sufficiently narrow to maintain a stagnant zone. For this reason, crevice corrosion usually occurs at openings a few thousandths of an inch or less in width (see Figure 3-1). It rarely occurs within wide (e.g., 1/8 inch) grooves or slots. Fibrous gaskets, which have a wick action, form a completely stagnant solution in contact with the flange face; this condition forms an almost ideal crevice corrosion site.

To illustrate the basic mechanism of crevice corrosion, consider a riveted plate section of metal M (e.g., iron or steel) immersed in chloride-containing water as shown in Figure 3-2. The overall reaction involves the dissolution of metal M and the reduction of oxygen to hydroxide ions.

$$\text{Oxidation } M \rightarrow M^{+} + e$$

$$\text{Reduction } O_2 + 2H_2O + 4e \rightarrow 4OH^{-}$$

Initially, these reactions occur uniformly over the entire surface, including the interior of the crevice. Charge conservation is maintained in both the metal and solution. Every electron produced during the formation of a metal ion is immediately consumed by the oxygen reduction reaction. Also, one hydroxyl ion is produced for every metal ion in the solution. After a short interval, the oxygen within the crevice is depleted because of the restricted convection, so oxygen reduction ceases in this area. This, by

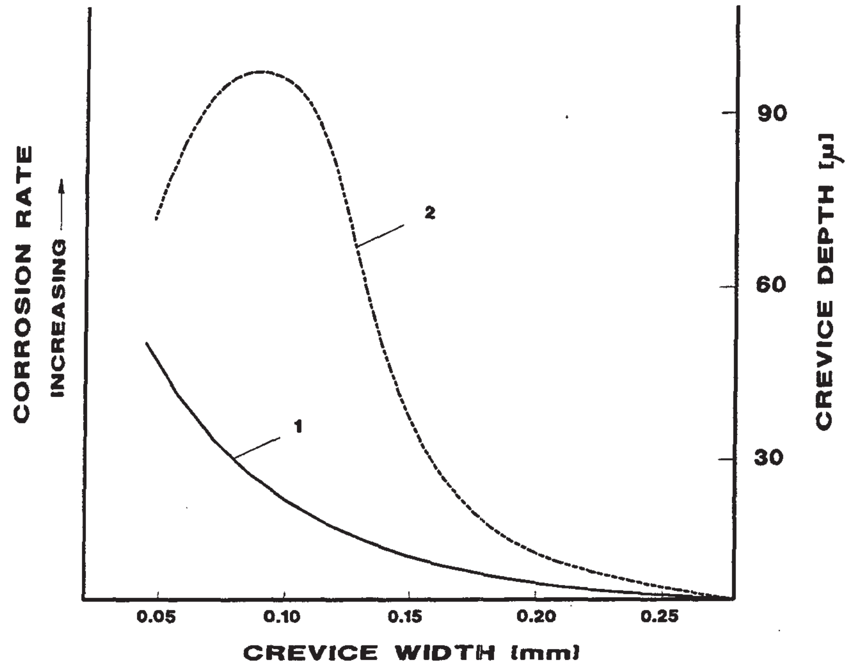


Figure 3-1 Crevice Width Effect on Crevice Depth (1) and Corrosion Rate (2) [18]

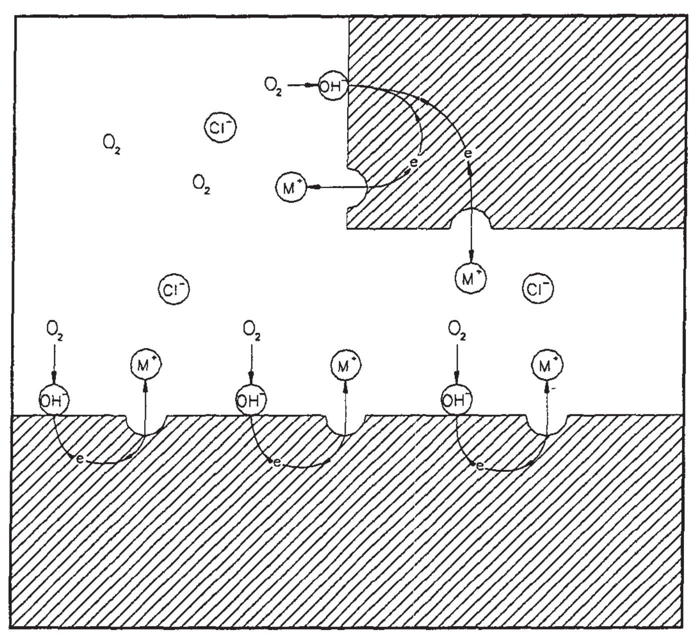


Figure 3-2 Initial Stage of Crevice Corrosion

itself, does not cause any change in corrosion behavior. Since the area within a crevice is usually very small compared with the external area, the overall rate of oxygen reduction remains almost unchanged. Therefore, the rate of corrosion within and without the crevice remains equal.

Oxygen depletion has an important indirect influence, which becomes more pronounced with increasing exposure. After oxygen is depleted, no further oxygen reduction occurs, although the dissolution of metal M continues as shown in Figure 3-3. This tends to produce an excess of positive charge in the solution (M+), which is necessarily balanced by the migration of chloride ions into the crevice. This results in an increased concentration of metal chloride within the crevice.

As the corrosion within the crevice increases, the rate of oxygen reduction on adjacent surfaces also increases, as shown in Figure 3-3. This cathodically protects the external surfaces. Thus during crevice corrosion the attack is localized within shielded areas, while the remaining surface suffers little or no damage.

The above mechanism is consistent with the observed characteristics of crevice corrosion. This type of attack occurs in many mediums, although it is usually most intense in ones containing chloride. There is often a long incubation period associated with crevice attack. Six months to a year or more is sometimes required before attack commences. However, once started, it proceeds at an ever-increasing rate.

Metals or alloys that depend on oxide films or passive layers for corrosion resistance, such as stainless steels, are particularly susceptible to crevice corrosion. These films are destroyed by high concentrations of chloride or hydrogen ions, and dissolution rate markedly increases. The concentration of aggressive ions required to initiate crevice corrosion varies depending on operating conditions, materials, and other variables. Corrosion testing under various conditions have measured chloride concentrations at which crevice corrosion begins. For crevice corrosion to occur in stainless steel materials, the minimum required concentration of chloride (or other corrosive ions) is estimated to be 10 to 100 parts per million [16, 18]. Plain carbon steels are less susceptible to crevice corrosion than stainless steels.

Crevice corrosion can be reduced or prevented by the following:

- Reduce the acidity and the concentration of aggressive ions, such as chloride, in the bulk fluid.
- Reduce oxidizing agents in the bulk fluid.
- Reduce temperature of the bulk fluid.
- Add corrosion inhibitors such as hydroxide to the bulk fluid.
- Use pitting-resistant materials, such as high molybdenum stainless steels, overalloyed welds, and high alloy linings.
- Design components to avoid crevices when possible. For example: use butt welded joints with good quality welds instead of socket welds or bolted joints; weld instead of rolling tubes in tube sheets.
- Design fluid-filled systems to allow complete drainage and to avoid stagnant areas.
- Use filtration and frequent cleaning to prevent deposit build-up.
- Use solid, non-absorbent gaskets, such as Teflon, whenever possible.
- Use cathodic protection in crevice areas.

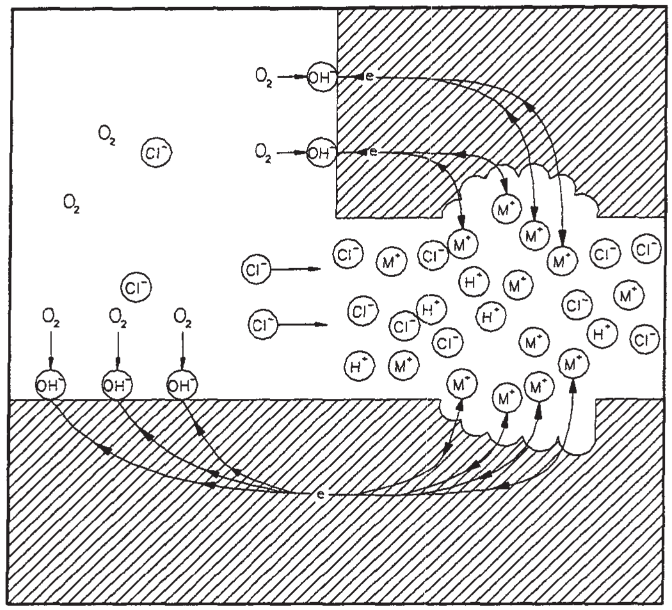


Figure 3-3 Later Stage of Crevice Corrosion

Generally, visual inspection is used to detect the existence and extent of crevice corrosion damage. An inspection procedure is provided by ASTM G 46 [25] which describes various inspection methods, including visual inspection, along with guidelines on how to quantify the extent of damage. The ASTM G 46 procedure is specifically written for evaluation of pitting corrosion, but it is applicable to crevice corrosion.

3.2 Pitting

Pitting is a form of localized corrosion that results in formation of holes in metal, often leading to rapid penetration of the wall thickness. It may initiate on an open, freely exposed surface, or at random imperfections in an otherwise protective surface film or coating. Pitting is one of the most destructive and insidious forms of corrosion because of its unpredictability and the extreme suddenness of resulting holes. Pits can be difficult to detect because of their small size and because the pits are often covered with corrosion products.

During pitting, a microgalvanic couple is set up between the interior of the pit and the external unattached surface. The interior contains acidic, hydrolyzed salts which are quite corrosive in comparison to the bulk solution. An anode is established within the pit, with the surrounding surfaces acting as cathodes. This is particularly the case for alloys which rely on a resistant, passive film for protection, such as stainless steels, titanium, and aluminum. The pitting process is autocatalytic, meaning that the corrosion processes within the pit produce conditions that are both stimulating and necessary for the continuing activity of the pit. This process is illustrated in Figure 3-4. In this example, a metal M is being pitted by an aerated chloride solution. Rapid dissolution of the metal occurs in the pit, producing an excess of positive charge in this area, attracting more chloride ions to the pit to maintain electroneutrality. Therefore there is a high concentration of chloride ions and, due to hydrolysis, hydrogen ions in the pit, both of which stimulate metal dissolution and accelerate the process. No oxygen reduction occurs in the pit because of the low solubility of oxygen in the concentrated solution. The cathodic oxygen reduction on the surfaces adjacent to pits tend to suppress corrosion, protecting these areas.

The high specific gravity of the corrosion products within the pit cause leakage out of the pit in the direction of gravity. Wherever these products come in contact with the passive metal surface, additional dissolution occurs. This is the reason for the elongation of pits in the direction of gravity that is often observed in practice. A pit stops growing only if the surface within the pit is passivated, or in other words, the electrochemical potential of the pit and adjacent material are equalized. Dissolved oxygen or passivator ions, such as NO_3^-, can return pits to a passive state if adequate stirring of the bulk fluid occurs. Pit geometry must also allow the passivating compounds to enter the pit.

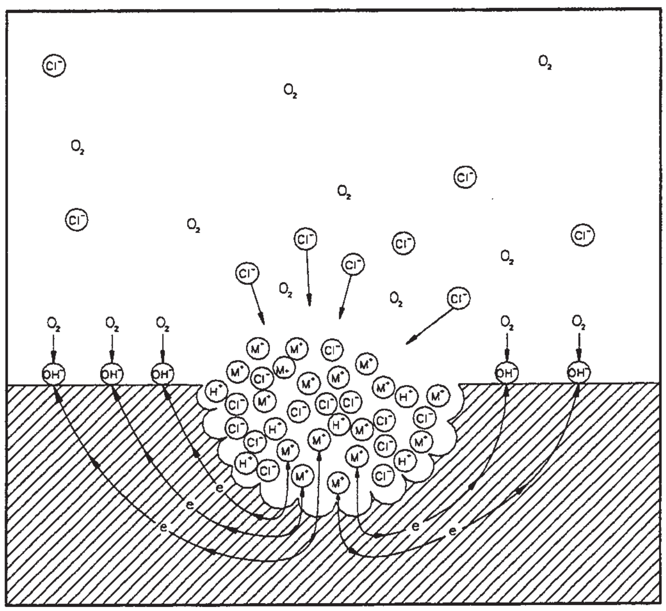


Figure 3-4 Autocatalytic Process in a Corrosion Pit

Pitting corrosion occurs in most commonly used metals and alloys. Stainless steel alloys are more susceptible to damage by pitting corrosion than any other group of metals. Within this group, 316 stainless steel is more resistant to pitting than 304 stainless. Ordinary steel is more resistant to pitting corrosion than stainless steel. General corrosion of steel is more severe than for stainless steel, but pitting damage is less likely. Some other materials that are subject to pitting include: aluminum, magnesium, tin, zinc, and chromium-nickel alloys. Titanium is highly resistant to pitting on boldly exposed surfaces.

Due to the poor pitting resistance of stainless steels, efforts have been made to improve resistance with alloy additives. The addition of chromium, nickel, molybdenum, or nitrogen alloying elements increase the pitting resistance of stainless steel. Of these additives, molybdenum is especially effective. For example, the addition of 2% Mo to type 304 stainless steel, producing type 316, results in a very large increase in resistance to pitting. Some additives are known to decrease the pitting resistance of stainless steel; these include silicon, sulfur, selenium, and carbon. With respect to processing, holding stainless steels in the sensitizing temperature range (950° F to 1450° F) decreases pitting resistance, while austenitic stainless steels are most resistant to pitting when solution-quenched above 1800° F. Surface finish can have a significant effect on pitting resistance. Pitting is less likely to occur on polished surfaces than on etched or ground surfaces.

Most pitting failures are caused by chloride and chlorine containing ions. Pitting often occurs in systems that handle sea water or bleaches. Bromides and other halide ions will cause pitting, and well as sulfate, nitrate, and acetate solutions. The most aggressive pitting occurs in cupric, ferric, and mercuric halides, which will damage the most corrosion-resistant alloys. These halides do not require the presence of oxygen to promote attack because their cations can be cathodically reduced. At temperatures above 212° F, pitting can occur without aggressive anions, if oxygen levels are high. Pitting can be inhibited by hydroxide, chromate, or silicate salts in solution, but if the corrosive attack is not stopped completely, the pitting intensity may be increased. In general, pitting activity increases as the fluid temperature increases. Pitting is also more likely in stagnant areas, such as a low portion of an inactive pipe system. Less pitting occurs in areas of flow movement, and with greater velocity, pitting is further reduced.

Pitting and crevice corrosion are closely related. Pitting may be a special case of crevice corrosion where the crevice is provided by micropores on a metal surface. Another theory states that crevice corrosion occurs when pitting is initiated inside of a crevice. Crevice corrosion initiates earlier, proceeds faster, and can occur in less aggressive environments than pitting (see Figure 3-5). On a component that contains suitable crevices, crevice corrosion will occur before pitting.

Pitting corrosion can be reduced or prevented by the following:

- Reduce the acidity and the concentration of aggressive ions, such as chloride, in the bulk fluid.
- Reduce oxidizing agents in the bulk fluid.
- Reduce temperature of the bulk fluid.
- Add corrosion inhibitors such as hydroxide to the bulk fluid.
- Use pitting-resistant materials, such as high molybdenum stainless steels, overalloyed welds, and high alloy linings.
- In some specific applications, barrier coatings can prevent corrosion, such as coatings on threaded fasteners. However, on exposed surfaces, attack may be concentrated at imperfections in the coating.
- Use cathodic protection on exposed surfaces.
- Design the system to avoid crevices, eliminate stagnation, and ensure proper drainage.

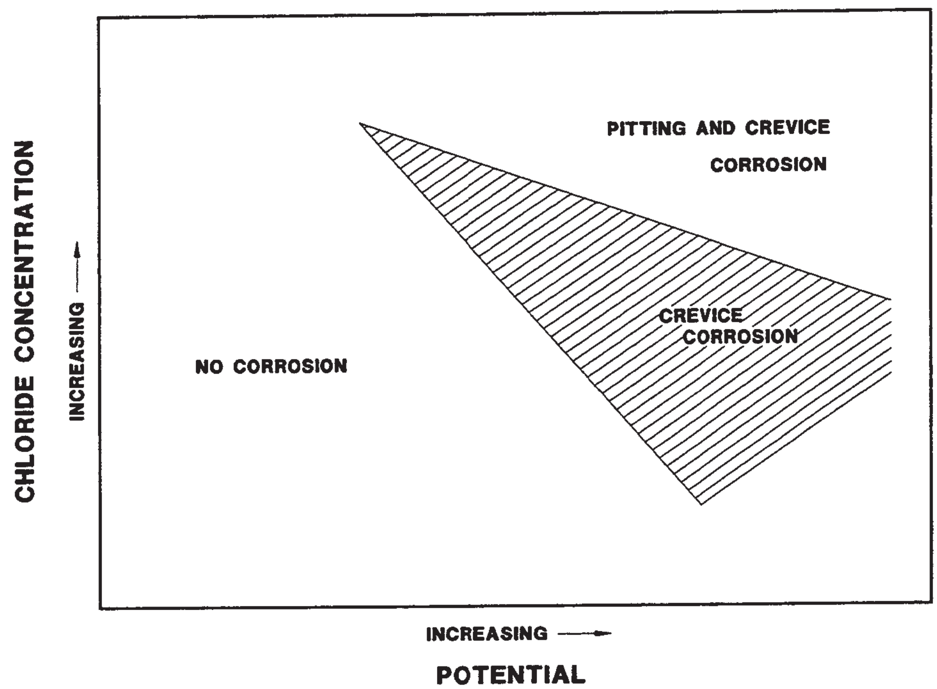


Figure 3-5 Pitting and Crevice Corrosion Behavior of 304 Stainless Steel [18]

Generally, visual inspection is used to detect the existence and extent of pitting damage. An inspection procedure is provided by ASTM G 46 which describes various inspection methods, including visual inspection, along with guidelines on how to quantify the extent of pitting damage.

3.3 General Corrosion

General corrosion, or uniform corrosion, is the thinning or wastage of a metal, more or less uniformly, by chemical attack (dissolution) at the surface by an aggressive environment. Typical examples include rust on iron or steel or the dissolution of zinc immersed in dilute sulfuric acid.

General corrosion is the most common form of corrosion and leads to the greatest destruction of metal on a tonnage basis. The consequence of general corrosion is wall thinning, which can lead to pipe leakage or rupture. However, general corrosion is less of a concern than localized corrosion from a failure prediction standpoint, because life can be predicted based on fairly simple tests. The proposed material is immersed in a simulated operating environment and the corrosion rate measured.

Carbon steels are particularly susceptible to uniform attack in a borated water environment, while austenitic stainless steel alloys are not at risk for this type of corrosion. In environments with low concentrations of corrosive ions, such as systems with controlled water chemistry, only minimal corrosion will occur. A protective layer of corrosion product (magnetite) is formed which prevents further attack. Additional damage can occur if the protective layer is removed by erosion.

General corrosion can be reduced or prevented by the following:

- Use corrosion resistant materials and/or coatings.
- Add inhibitors to the environment.
- Use cathodic protection.

Visual inspection can be used to detect severe general corrosion by checking for material loss and corrosion products, but other non-destructive techniques are necessary to measure the extent of damage. For example, wall thinning of pipes can be measured using ultrasonic testing.

3.4 Erosion Corrosion

Erosion corrosion is an accelerated attack on a metal due to relative movement between a corrosive fluid and the metal surface. The mechanism occurs under high-velocity conditions, turbulence, and impingement. Mechanical wear effects or abrasion are involved, causing metal to be removed from the surface as dissolved ions or to form corrosion products that are stripped away from the metal surface. Failures due to erosion corrosion can occur fairly rapidly and unexpectedly because corrosion testing is often performed under static conditions that do not take erosion effects into account.

Most metals and alloys are susceptible to erosion-corrosion damage. Metals that are normally resistant to corrosion because they are protected by an oxide surface film can be damaged by erosion corrosion after fast-flowing fluid wears away the protective film. These metals include aluminum, lead, and stainless steel. Increasing the alloy content of carbon steel significantly improves the resistance to erosion corrosion. Field experience indicates that 2 1/4 Cr - 1 Mo steel has four times the erosion corrosion resistance of carbon steel with 0.02% chromium content. Austenitic stainless steels are highly resistant to erosion corrosion attack. The characteristics of the protective surface film have a significant effect on the resistance to erosion corrosion. Surface films that are hard, adherent, and that quickly regenerate will provide a high degree of protection. Soft metals are more susceptible to erosion corrosion because they are more subject to mechanical wear. However, hardening of metals by heat treatment generally reduces corrosion resistance, thereby reducing resistance to erosion corrosion.

Erosion corrosion can occur in a variety of corrosive mediums, including gases, aqueous solutions, organic systems, and liquid metals. In water systems, the most important chemical parameters are oxygen concentration and pH. High rates of erosion corrosion occur with pH levels between 7 and 9 or below 6. High levels of dissolved oxygen in water reduce the rate of erosion corrosion by keeping the steel surface passive. For example, in condensate-feedwater systems in boiling-water reactors, where the recommended dissolved oxygen level is around 30 ppb, operating experience indicates that little erosion corrosion occurs. For single-phase carbon steels, erosion corrosion piping degradation has been reported within the temperature range of 80 to 230°C, and for two-phase steels, from 140 to 260°C. Maximum damage occurs in the range from 130 to 150°C for single phase steels.

Erosion corrosion attack generally increases with increasing fluid velocity and flow rate. Usually there is a critical velocity above which the attack increases at a rapid rate. Higher flow rates increase the rate of attack because oxide dissolution products are carried away faster. Some metals and alloys that are resistant to corrosion in a particular environment at low velocities can be damaged at high velocities. For example, chromium stainless valve seats and plugs are adequate for most steam applications, but grooving or "wire drawing" occurs in high velocity throttling valves. In some cases, increased velocity can reduce erosion corrosion, such as when corrosion inhibitors are used and increased velocity delivers the inhibitors to the metal surface at a faster rate. Material loss rates can be estimated based on extensive test data. For example, Figure 3-6 shows erosion corrosion material loss rates as a function of temperature and flow rate.

Areas of flow impingement or turbulent flow are more likely to experience erosion corrosion. Some examples include: the turbulent region at the inlet ends of tubing in shell-and-tube heat exchangers, where liquid flows from the larger exchanger head into the smaller tubes; also pump impellers and steam turbine blades. Within piping, impingement occurs at locations where the flow changes direction, such as elbows and tees, so these areas are more susceptible to erosion corrosion. Local geometrical discontinuities, such as backing rings for welding, can create turbulence that leads to attack.

The methods to prevent or minimize erosion corrosion damage are as follows:

- Use corrosion resistant materials or protective coatings.
- Design systems to reduce flow velocity, turbulence, and impingement effects. For example, use larger pipe diameters and streamline bend areas.
- Add extra thickness at vulnerable locations or install replaceable impingement plates or baffles.
- Add inhibitors to the fluid environment and filter out solid impurities.
- Reduce operating temperature as much as possible.
- Use cathodic protection.

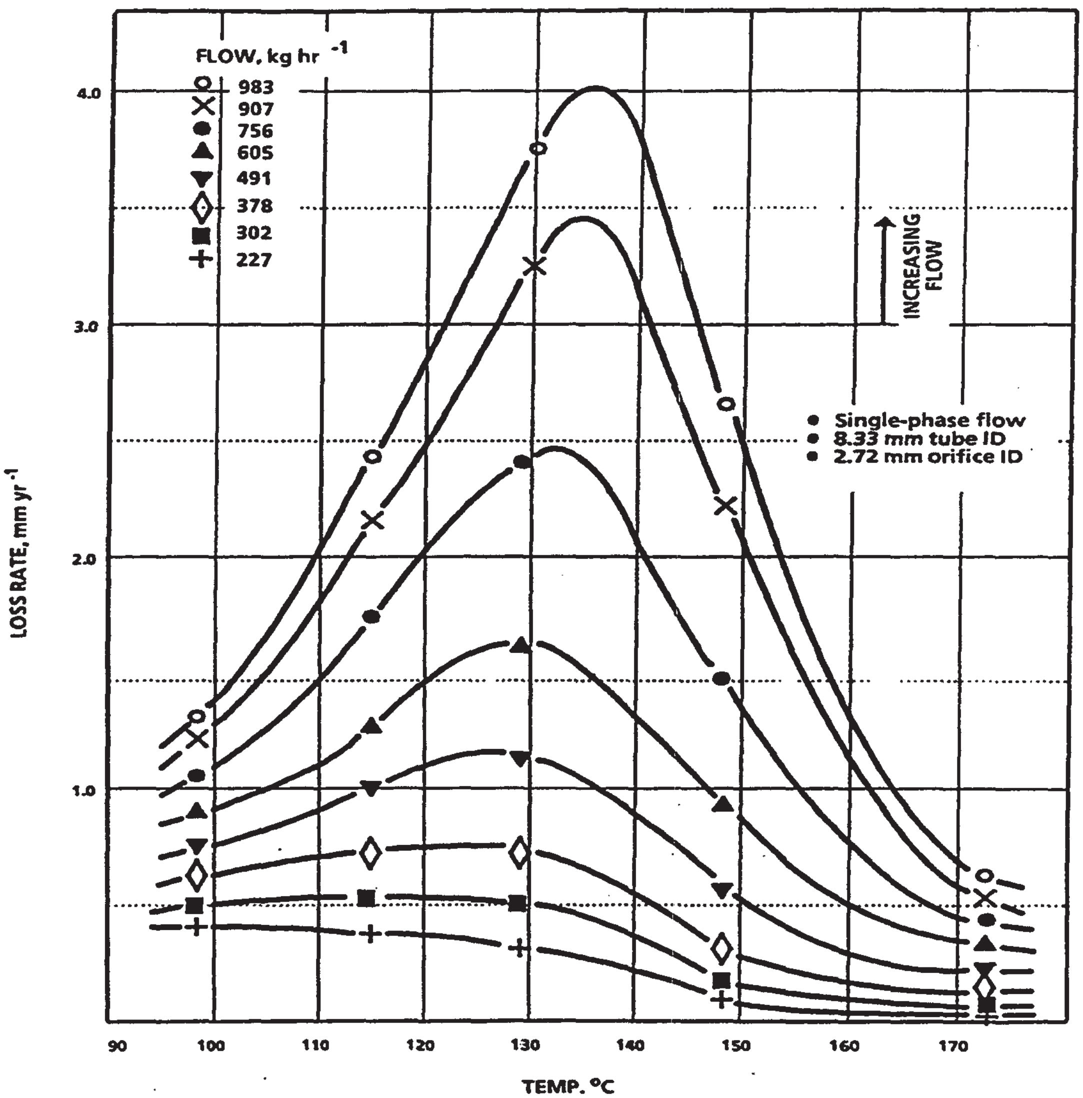
Visual inspection can be used to determine if erosion corrosion damage has occurred. Erosion corrosion appears as grooves, gullies, waves, rounded holes, or valleys, and usually exhibits a directional pattern. The extent of pipe wall thinning due to erosion corrosion is usually measured with ultrasonic testing, occasionally supplemented with radiography.

3.5 Selective Leaching

Selective leaching is the removal of one element from a solid alloy by corrosion processes. The most common example is the selective removal of zinc in brass alloys (dezincification). Similar processes occur in alloys where aluminum, iron, cobalt, chromium, and other elements are removed. Overall dimensions do not change significantly when leaching occurs, and sudden failure can result due to the poor strength of the dealloyed material.

There are two general types of dezincification: uniform (layer type) and localized (plug type). Both types are easily recognizable and can be seen with the naked eye as a red or copper coloring in contrast to the original yellow color of the brass. The layer type of dezincification is more likely in brasses with higher zinc content and acid environments. Plug type dezincification occurs more often in lower zinc brasses and neutral, alkaline, or slightly acidic conditions. Dezincification is more likely in stagnant areas because of scale formation or depositing on the metal surface. The higher the zinc content of the brass, the more extensive the dezincification. For example, Muntz metal (40% zinc) and red brass (15% zinc) were exposed to a chloride solution for several months. The loss of tensile strength of the Muntz metal was 100%, while the red brass loss lost only 5% of its tensile strength.

The commonly accepted theoretical mechanism for dezincification consists of three steps: 1) the brass dissolves, 2) zinc ions stay in solution, and 3) the copper plates back on. This model is based on the fact



Flow/Temperature Dependence of Post-Orifice Erosion/Corrosion Rates

Figure 3-6 Representative Erosion Corrosion Material Loss Rates [19]

that zinc is much more reactive than copper. Oxygen increases the rate of attack when present, but the process can occur in water without the presence of dissolved oxygen.

Dezincification can be prevented by the following:

- Reduce the aggressiveness of the environment.
- Use cathodic protection.
- Use a less susceptible alloy, such as: brasses with lower zinc, such as red brass; alloys with tin (Admiralty Metal) or other inhibitors (arsenic, antimony, phosphorus).

Selective leaching of gray cast iron can occur when iron or steel is removed, leaving the graphite network (graphitization). The surface layer takes on the appearance of graphite and becomes soft. The mechanism occurs because graphite is cathodic to iron, creating a galvanic cell that dissolves the iron, leaving a porous mass behind. The cast iron loses its strength, even thought the attack can appear superficial. Graphitization proceeds slowly, with the extent of strength loss dependent on the depth of attack. Nodular or malleable cast irons and white cast iron are not susceptible to graphitization.

Visual inspection can be used to detect selective leaching by checking for material loss and the characteristic appearance of leaching on surfaces such as brass. Other non-destructive techniques can be used to measure the extent of damage, such as the measurement of wall thinning with ultrasonic testing.

3.6 Wear

Wear is defined as the loss of material from a surface by transfer to another surface or the creation of wear debris. Wear is probably the most important factor in deterioration of machinery with moving parts, leading to reduced performance and shortened operating life. A number of methods of classifying wear have been proposed. Modern research has established four primary wear mechanisms: adhesive wear, abrasive wear, surface fatigue wear (spalling or pitting), and corrosive wear.

Adhesive wear is the most common and predictable type of wear and therefore rarely results in sudden failures. Adhesive wear occurs due to the welding together and subsequent shearing of asperites on metal surfaces that are sliding past each other. Wear studies have shown that the amount of adhesive wear is proportional to normal load and sliding distance. Hard materials are usually more resistant to wear due to reduced plastic deformation and low coefficient of adhesion. Lubrication reduces the coefficient of friction and the amount of material removal because the lubricant helps to prevent adhesive bonding between the surfaces. To minimize adhesive wear, the following factors should be considered:

- Use of appropriate lubrication.
- Use of as hard a material as possible.
- Use of materials that have low interaction, i.e., low adhesion to each other, such as a metal and a non-metal.

Abrasive wear occurs when two surfaces are in sliding contact and one of the surfaces is harder and rougher than the other. Damage also can occur when one of the surfaces contains abrasive imbedded particles. The resulting effect is a plowing action; the harder asperites or particles create grooves or furrows in the softer material. Abrasive wear is more dangerous than adhesive wear due to high wear rates that may result in sudden, catastrophic failure. For example, the introduction of a contaminant into a system can result in rapid, unexpected abrasive damage. There are three main types of abrasive wear:

gouging - massive physical deformation caused by a large diameter abrasive driven along the surface under heavy loading; grinding - material removal by small abrasive grains located between two surfaces in sliding contact; and erosion - wear of a surface due to impingement of abrasive grains suspended in a fluid. The primary method of reducing abrasive wear is to use a material that has a surface hardness greater than that of the abrasive. This can be accomplished through the use of harder alloys, heat treatments, or surface hardness treatments, such as nitriding. If possible, the system should be kept free of abrasive contaminants.

Surface fatigue wear occurs due to repeated application of relatively low stresses. For example, continuous rolling contact in bearings can result in pitting of the surface. Surface fatigue is similar to fatigue of bulk specimens. However, surface fatigue life test data shows greater fluctuation than bulk fatigue life data, and a fatigue limit stress, below which damage does not occur, does not exist for surface fatigue wear. Percussive mechanical wear occurring on mutually-impacting surfaces is referred to as impact wear. Metals with high toughness are most resistant to impact wear. Toughness is the ability to absorb energy by plastic deformation before failing. Because materials with high toughness may be too soft, the materials are surface-hardened or plated to provide hardness at the contact region. Alternatively, a soft coating can be applied to provide reduction and damping of contact forces. Plain carbon steels and alloy steels are suitable for impact wear applications because of the variability of properties that can be obtained by proper heat treatment and alloying.

Corrosive wear occurs when the environment surrounding a sliding surface interacts chemically with it. The first step in corrosive wear is the initial corrosive attack of an exposed surface, which forms a protective film of reaction products. This film is subsequently worn away as a result of the sliding action.

Wear can be detected visually by looking for pitting, galling, or other gross surface damage. In some cases the damaged surface will appear smooth or even polished. The amount of material loss can be quantified by weighing, mechanical gauging, or other more sophisticated techniques.

3.7 Microbiologically Influenced Corrosion

Microbiologically Influenced Corrosion (MIC) is the deterioration of a metal by corrosion processes that occur directly or indirectly as a result of the activity of living organisms. These organisms include micro forms such as bacteria and macro types such as algae and barnacles. Biological activity can lead to corrosive damage in a variety of environments including soil, natural water, seawater, and natural petroleum products. Many documented cases of MIC have been recorded in the chemical-processing, nuclear power, oil field, and underground pipeline industries. This section will focus on MIC in nuclear power plants.

MIC is a widespread problem in the nuclear power industry. It can occur in steel and nearly all alloys except titanium and in all plant systems. Many different organisms are involved in MIC, but evidence indicates that the following are of principal importance: deposit forming iron and manganese bacteria, slime-forming Pseudomonas type of bacteria, the deposit forming and iron reducing Bacillus type organisms, and the sulfate reducing bacteria. MIC damage occurs because organisms on the metal surface can affect the anodic and cathodic reactions, alter protective surface films, create corrosive conditions such as acidic by-products, or produce deposits that can lead to crevice corrosion. MIC generally takes the form of discrete deposits on the metal surface, with pits forming underneath the deposits. In stainless steels, MIC attack usually occurs at or adjacent to welds. Usually the pits have small entrance holes with larger subsurface cavities underneath. In some cases, tubercules (build-up of microbes, corrosion products, and debris) can form on metal surfaces, causing pitting underneath or severe impediment of flow.

The primary environmental factors affecting the presence of organisms associated with MIC are temperature, pressure, pH, water content, salinity, redox potential, and quantities of nutrients available. Microbes are most often found in the temperature range of 32° F to 180° F, but they can also grow in temperatures as low as 0°F or as high as 400° F. Most organisms can tolerate pressures up to 4500 psi, and in some cases up to 15,000 psi. Organisms can grow in environments having a pH of 1 through 11, with particular organisms preferring more or less acidic conditions. All living organisms require liquid water for survival; however, microbes can live through dry periods, so intermittent drying of equipment may not prevent MIC. Many organisms require some degree of salt content in the environment, but the concentration level can be very low; some microbes can grow very well in deionized or demineralized water. Microbes can require the presence of oxygen (aerobic type), the absence of oxygen (anaerobic type), or can grow under either condition (facultatively anaerobic). Organisms from each of these groups are involved in MIC. Organisms require organic and/or inorganic (ammonia, nitrate, methane, etc.) molecules for energy and growth. However, removing nutrient molecules from bulk water (e.g., demineralization) may not prevent MIC because nutrient molecules can accumulate at pipe and tank surfaces, allowing bacteria to grow at these locations.

The primary method of preventing MIC in nuclear plants is through water treatment. These treatments consist of biocides (chlorine, bromine, etc.), which kill the organisms; chemical cleaning agents, which clean metal surfaces of microbes, scale, and corrosion products; and corrosion inhibitors, which help to reduce both MIC and non-MIC corrosion. Additional factors which can reduce or prevent MIC include:

- Maintain high flow velocity to prevent attachment of organisms to surfaces.
- Use mechanical cleaning of surfaces to remove deposits.
- Keep systems clean continuously from fabrication through start-up, operation, and outages, and avoid standing water during outages.
- Operate above 180° F when possible.

MIC can often be identified visually by evidence of deposits and discoloration. However, to determine the specific organism and mechanism involved, laboratory testing is required.

3.8 Stress Corrosion Cracking

Stress Corrosion Cracking (SCC) is cracking caused by the simultaneous presence of tensile stress and a corrosive medium. During SCC, the metal is virtually unattached over most of its surface, while fine cracks progress through it. The cracks create the impression of brittleness in the material because little or no macroscopic plastic deformation occurs. A metal that suffers from SCC appears normal except for the cracked region, and maintains typical mechanical strength properties. The three necessary conditions for SCC are:

1) Susceptible material
2) Tensile stress (can be applied, residual, or both)
3) Corrosive environment

The cracks normally proceed perpendicularly to the tensile stress, and are very narrow in shape. SCC is a progressive failure similar to fatigue. The cracks grow gradually until a critical size is obtained, sometimes resulting in sudden brittle fracture of the remaining material. In other cases, the cracks grow away from high stress areas and stop when no longer stressed in tension. SCC occurs along grain boundaries (intergranular) or across grains (transgranular). Both types can occur in the same alloy. The mechanism of SCC is not fully understood and involves complex interactions of metal, interface, and environment properties.

The major factors affecting SCC are temperature, solution composition, metal composition and structure, and stress. SCC is accelerated by increasing temperature. Most alloys susceptible to SCC will begin to crack above 212° F. Different materials require different solution compositions for SCC to occur. Oxidizers such as dissolved oxygen and chlorides can lead to cracking of 304 stainless steel. Alternate wetting and drying can cause concentration of corrosives such as chloride, resulting in rapid and severe SCC damage. Pure metals are usually more resistant to cracking. SCC susceptibility is a function of alloy composition; for example, SCC resistance of stainless steels increases as the ferrite percentage is increased. Inconel, with a higher nickel content, is more resistant than 304 stainless steel. Carbon steels are more resistant to SCC than stainless steels. Alloys that have been sensitized during fabrication, such as during welding, are more susceptible to SCC. Increased stress decreases the time for cracking to initiate. The minimum stress required for SCC depends on the environment and material. In pure water conditions, the threshold stress is believed to be greater than the at-temperature yield stress. However, under some conditions, SCC can occur at 10% of yield.

Numerous cases of SCC failures in nuclear power plants have been documented. These failures include cracking of A-286 reactor coolant pump bolting, SCC of Alloy 600 steam generator tubing, and intergranular SCC of stainless steel piping.

Methods of reducing or preventing SCC are as follows:

- Lower the tensile stress below the threshold, if known.
- Eliminate corrosives in the environment.
- Change the material to a more resistant alloy.
- Use cathodic protection.
- Add corrosion inhibitors or protective coatings.
- Employ shot-peening to produce compressive residual stress in the material.
- Use improved welding procedures to reduce sensitization and eliminate tensile residual stresses in the heat-affected zone.

Cracks resulting from SCC can be detected visually or with magnetic particle or die penetrant testing. Component history, crack characteristics, and microstructural features are used to identify SCC. Identification of SCC can be difficult and is often confused with other types of fracture.

4

SAMPLING PROGRAM DESCRIPTION

It is desired to provide a 90% confidence level that 90% of a given population is not experiencing degradation (corrosion, wear, etc.). The following analysis determines the required sample size to obtain the desired confidence level as a function of population size. From [4], sampling from a finite population, we start with:

$$\frac{X - np}{\sqrt{np(1-p)}\sqrt{\frac{N-n}{N-1}}} = \pm z_\alpha$$

where,

X = Number of items in the sample with degradation (assume X = 0)

n = Sample size

p = Fraction of population size with degradation (use 10%)

N = Population size

z_α = Confidence parameter

Setting X=0 and squaring both sides, we get

$$\left(\frac{-np}{\sqrt{np(1-p)}\sqrt{\frac{N-n}{N-1}}}\right)^2 = (\pm z_\alpha)^2$$

$$\frac{(np)^2}{np(1-p)\left(\frac{N-n}{N-1}\right)} = z_\alpha^{\ 2}$$

Rearrange terms to solve for n,

$$(np)^2 = z_\alpha^{\ 2} np(1-p)\left(\frac{N-n}{N-1}\right)$$

$$np^2 = z_\alpha^{\ 2}(p-p^2)\left(\frac{N-n}{N-1}\right)$$

$$np^2 - \frac{z_\alpha^{\ 2}N(p-p^2)}{N-1} + \frac{nz_\alpha^{\ 2}(p-p^2)}{N-1} = 0$$

$$n\left[p^2 + \frac{z_\alpha^{\ 2}(p-p^2)}{N-1}\right] = \frac{z_\alpha^{\ 2}N(p-p^2)}{N-1}$$

$$n = \frac{z_\alpha^{\ 2}N}{\frac{p(N-1)}{(1-p)} + z_\alpha^{\ 2}}$$

For 90% confidence, $z_\alpha = 1.645$ and for $p = 0.10$ (10% of population size has degradation). Substituting these values we find a relationship between population size, N, and the required sample size, n, for a 90% confidence level that 90% of the population does not contain the attribute.

$$n = \frac{(1.645)^2 N}{\frac{(.10)(N-1)}{(1-.10)} + (1.645)^2}$$

$$n = \frac{(24.35)N}{N + (23.35)}$$

As $N \rightarrow \infty$, $n \rightarrow 24.35$, which we round up to 25 samples. This is the maximum number of samples required for any given population size. Plotting required sample size, n, as a function of population size, N, we get the curve shown in Figure 4-1.

This sampling program differs from those used for manufacturing processes (e.g. MIL-STD-105 or EPRI NP-7218) in that our sample population is finite and discrete. Sampling plans used for manufacturing processes assume that continuous lots of an item are being fabricated and concern themselves with the risks of accepting a "bad" lot or rejecting a "good" lot. Our interest is to provide a certain confidence level that a large percentage of the finite population does not contain an attribute of interest. The 90/90 level chosen for this report was based upon a CCNPP internal memorandum on the topic [45,46]. It would certainly be possible to select more or less restrictive criteria. As an example, a 95/95 limits selection would require a maximum of 75 samples for a very large population size. We believe that the 90/90 approach is the best choice initially. As results are obtained from field inspections, then adjustments should be considered (either up or down) on a mechanism, component, or system basis.

One key feature of this approach is the assumption that none of the inspected items will contain significant levels of a degradation mechanism (X=0). If it is found during inspections that even a single item in the sample population has a degradation mechanism of interest, then the sample size computed in this report is not the correct one to use. The correct sample size could be computed by setting X equal to the value found in the previous equations and completing additional inspections. However, the underlying assumption used throughout this report is that the degradation mechanism in question does not exist for the system/component being investigated and the inspection program's intent is to provide reasonable assurance that this is so. If significant degradation is found, then a new strategy should be developed to manage the discovered degradation mechanism. This can be seen graphically in Figure 2-1.

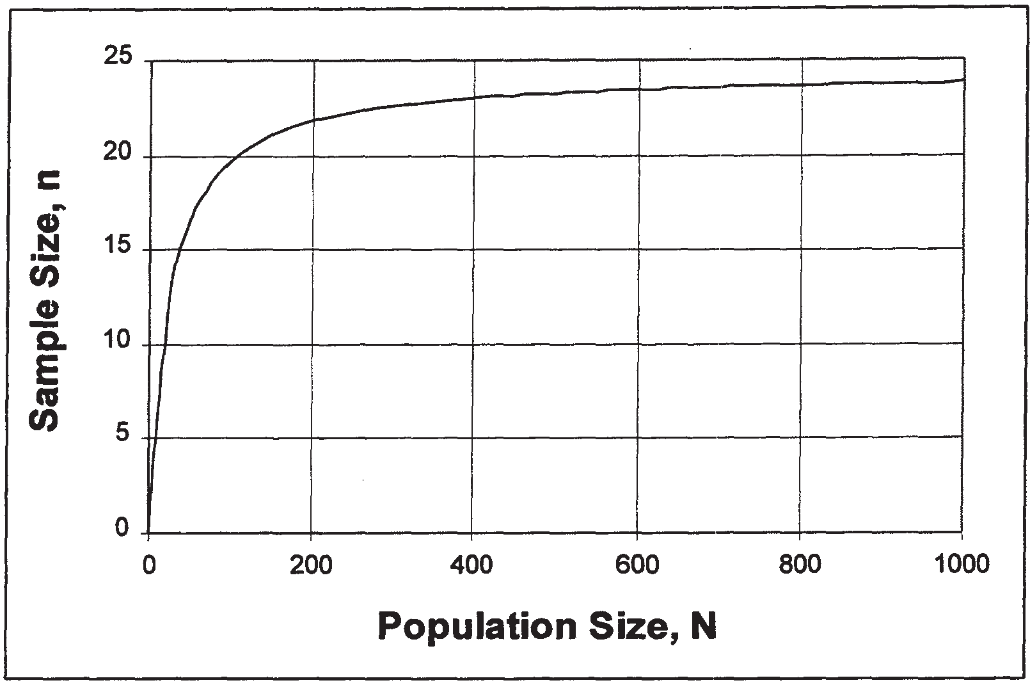


Figure 4-1 Required Sample Size Versus Population Size for 90% Confidence that 90% of the Population Does Not Contain an Attribute

5

MAIN FEEDWATER SYSTEM ARDI PROGRAM

5.1 SYSTEM DESCRIPTION

5.1.1 Operating Environment

The internal environment for the Main Feedwater System components during power generation is chemically treated, demineralized, high pressure water that increases in temperature with plant power level from 100° F to approximately 435° F at full power. The system is subject to thermal transient conditions due to plant start-up/shut-down and operational transients. The external environment is climate controlled atmospheric air. The operating pressure is 1300 PSIG. System flow rates and fluid velocities are high at full power conditions. During all normal modes of plant operation, the system bulk fluid is subcooled water. During plant shutdown conditions, the system may be drained or maintained completely filled with water.

The CCNPP Chemistry Program monitors and controls fluid chemistry in order to minimize the concentration of corrosive impurities (chlorides, sulfates, oxygen) and optimizes fluid pH. Control of fluid chemistry minimizes the corrosive environment for Main Feedwater System components, and limits the rate and effects of corrosion. The Secondary Chemistry program CP-217 for the Steam Generators [14] controls Feedwater chemistry, and has the following corrosive impurity targets:

Power Operation:	pH	≥ 8.7
	Chloride	≤ 1.4 parts per billion
	Sulfate	≤ 1.4 parts per billion
	Oxygen	≤ 1.0 parts per billion
Hot Standby:	pH	≥ 8.7
	Chloride	≤ 50 parts per billion
	Sulfate	≤ 50 parts per billion
	Oxygen	not specified

Wet Layup	pH	≥ 9.8
	Chloride	≤ 100 parts per billion
	Sulfate	≤ 100 parts per billion
	Oxygen	≤ 100 parts per billion

These are extraordinary measures to optimize corrosion resistance [37]. However, in areas which are not exposed to the main flowstream, local fluid chemistry conditions may deviate from bulk fluid system chemistry. These areas include crevices and branch lines with little or no flow through them. Furthermore, the water chemistry may be outside of the target range during plant outages.

5.1.2 Piping

The piping within the system scope runs from the feedwater isolation MOV outside of containment to the steam generator nozzle. The piping is Class II, design code B31.1-1967, or Class II, design code B31.7-1969. The feedwater piping is 16" schedule 80 seamless A-106 Gr. C carbon steel with A-234 cast steel fittings. Some segments have been replaced with chromium-molybdenum (Cr-Mo) low alloy steel piping and fittings. Large bore piping joints are butt-welded. Small bore piping for the drain and instrument lines to the isolation valves are also included and assumed to be carbon steel material.

5.1.3 Temperature Element

The element material is ASTM A182 Gr. F22 (2 1/4 Cr - 1 Mo low alloy steel). There are two temperature elements (both in Unit 1), located outside of containment on the Main Feedwater piping downstream of the isolation MOV. As stated in the Feedwater AMRR [12], only the thermowell (not the thermocouple) is considered critical for passive safety function capability.

5.1.4 Check Valve

The Feedwater check valves are manufactured by Rockwell-Edward. The check valves are located on the Main Feedwater piping inside containment, and their purpose is to prevent reverse flow from the Steam Generators. There are two check valves in each unit, for a total of four check valves. The valve body is ASTM A216 Grade WCB or WCC cast steel. The pressure seal cover is ASTM A216 Grade WCB or ASME SA-105 forged steel or ASME SA-182 Grade F11 Class 2 or 3 steel. The disk base is forged ASTM A182 Grade F11 or F11HT alloy steel. The gasket material is AISI 1015 steel or flexible graphite. There is a corrosion resistant inlay at the pressure seal gasket. As stated in the Feedwater AMRR [39], only the check valve body, pressure seal cover, and drain assembly are considered critical for passive safety function capability. Only the Unit 2 check valves have a drain assembly.

5.1.5 Hand Valve

The hand valves are divided into two main groups: Group 045-HV-01, located on the Steam Generator instrumentation lines, and Group 045-HV-02, located on the drain lines off of the Main Feedwater piping. There are forty-eight 045-HV-01 valves in each unit, for a total of ninety-six valves, and there are two 045-HV-02 valves in each unit, for a total of four valves.

The 045-HV-01 valves are 3/4" globe valves constructed of cast or forged carbon steel with 13 Cr trim. The connections to the pipe are threaded. The maximum operating temperature for the 045-HV-01 valves is 550° F (higher than the 435° F maximum operating temperature of the other components considered in this ARDI). The normal operating position is open. As stated in [39], only the valve body and bonnet are considered critical for passive safety function capability.

The 045-HV-02 valves are 1" gate valves constructed of forged or cast carbon steel. The connections to the pipe are threaded. The maximum operating temperature is 435° F. The normal operating position is closed. As stated in [39], only the valve body and bonnet are considered critical for passive safety function capability.

5.1.6 Motor Operated Valve

The valve is a 16" gate valve, manufactured by Velan. There are two MOVs in each unit, for a total of four MOVs in the Main Feedwater scope of license renewal. The MOVs are located on the Main Feedwater piping outside of containment. The valve body is ASTM A105 Gr. 11 carbon steel and the bonnet is ASTM A350 Gr. LF1 carbon steel. The wedge is ASTM A350 Gr. LF2 carbon steel, and the stem is ASTM A276 stainless steel. The seat ring is ASTM A105 Gr. 11 carbon steel. Wear surfaces on the wedge, body, bonnet, and seat ring are hard faced with stellite No. 5 or 6. The normal operating position for the MOVs is open, and the maximum operating temperature is 435° F. As stated in [39], only the body, bonnet, wedge, and seat are considered critical for passive safety function capability.

5.2 POSSIBLE LOCATION IDENTIFICATION

AMRR Overview

The Main Feedwater System components and degradation mechanisms that require an ARDI evaluation are summarized in the table below [39]:

GROUP IDENTIFICATION NUMBER	AGE RELATED DEGRADATION MECHANISM			
	CREVICE CORROSION	EROSION CORROSION	GENERAL CORROSION	PITTING
045-DB-01	X		X	X
045-DB-02	X		X	X
045-CKV-01	X		X	X
045-HV-01	X		X	X
045-HV-02	X		X	X
045-MOV-01	X	X	X	X
045-TE-01	X	X	X	X

The Main Feedwater ARDMs can be categorized as either:

1) Probable (expected to occur) and not adequately managed by existing programs or

2) Possible (not expected to occur) which may require confirmation determination or

3) Impossible (cannot occur).

All ARDMs are in Category 2 because, given the system, environment, and materials, the degradation mechanism can occur. However, they are not expected to be present. These ARDMs require only confirmation that the ARDM is not occurring.

As stated in Section 3.2, crevice corrosion will generally occur before pitting corrosion if suitable crevices are present. Therefore, if the inspection for crevice corrosion finds no evidence of this degradation mechanism, pitting corrosion can also be eliminated from consideration. An inspection program will be developed only for crevice corrosion. If evidence of the mechanism is found, the need for additional pitting inspection will be reevaluated.

5.3 SELECTION OF HIGH AND LOW RISK LOCATIONS

In the table below, ARDM locations are ranked for each mechanism according to risk of occurrence as either "more likely" or "less likely". Sample locations from the "more likely" category will be inspected. If no evidence of degradation is found in this group, it will be concluded that no degradation exists in the "less likely" group. Sample sizes will be selected based on the total number of locations in the "more likely" group. Careful consideration will be given to the population size of "more likely" locations relative to a population size of the combination of "less likely" and "more likely" locations. The intent of this discrimination is to provide a biased sample which should produce results exceeding the 90%/90% statistical target. The intent is not to reduce the sample size of required inspection locations. This approach also assumes that all of the "more likely" locations selected have an equal probability of occurrence and that any of the "more likely" locations has a greater probability of occurrence than any of the "less likely" locations.

5.3.1 Crevice Corrosion

COMPONENT	LOCATION	RISK	BASIS
Piping	Butt weld	Less likely	Exposed to Feedwater flowstream so stagnant conditions are rare; system chemistry program limits amount of corrosive impurities. Part of ISI program.
	Backing ring	Less likely	Exposed to Feedwater flowstream so stagnant conditions are rare; system chemistry program limits amount of corrosive impurities; backing ring usage is not standard practice so probably not present in Feedwater system. Part of ISI program.
	Socket joint	Less likely	Crevice dimensions less critical than other nearby components.
	Surface deposit	Less likely	Feedwater system is filtered and maintained relatively free of impurities so depositing is unlikely.
TE	Gap between thermowell and pipe wall	Less likely	System chemistry program limits the amount of corrosive impurities; gap probably too large for crevice corrosion to occur.
Check valve	Body / pressure seal cover interface	More likely	Gasketed joint is a common location for crevice corrosion.
	Body drain assembly	More likely	Threaded or socket area between body, nipple and cap provides crevice; also stagnant conditions likely at this location.

	Surface deposit	Less likely	Feedwater system is filtered and maintained relatively free of impurities so depositing is unlikely.
Hand valve	Body / bonnet interface	More likely	Gasketed or threaded joints are common locations for crevice corrosion.
	Seat ring / body interface	More likely	Two part construction creates narrow crevice.
	Pipe thread/ body interface	More likely	Threaded joint is ideal crevice corrosion site.
	Stem / bonnet interface	More likely	Packing area is ideal stagnant crevice corrosion site.
	Surface deposit	Less likely	Feedwater system is filtered and maintained relatively free of impurities so depositing is unlikely.
MOV	Body / bonnet interface	More likely	Gasketed or threaded joints are common locations for crevice corrosion.
	Stem / bonnet interface	More likely	Packing area is ideal stagnant crevice corrosion site.
	Seat ring / body interface	More likely	Two part construction creates narrow crevice.
	Surface deposit	Less likely	Feedwater system is filtered and maintained relatively free of impurities so depositing is unlikely.

5.3.2 Pitting

COMPONENT	LOCATION	RISK	BASIS
Piping	Inner surface	Less likely	Exposed to Feedwater flowstream so stagnant conditions are rare; system chemistry program limits amount of corrosive impurities.
TE	Outer surface	Less likely	Exposed to Feedwater flowstream so stagnant conditions are rare; system chemistry program limits amount of corrosive impurities.
Check valve	Exposed inner surfaces (steel)	Less likely	Generally high flow rate through check valve; steel less susceptible to pitting.

	Replacement pressure seal cover (SS)	More likely	Stainless steel more susceptible to pitting.
	Drain pipe	More likely	Stagnant conditions are likely in this area.
Hand valve	Exposed inner surfaces	More likely	Stagnant conditions are likely in the upper chambers or throughout valve if closed; higher operating temperature in some cases.
MOV	Exposed inner surfaces	More likely	Stagnant conditions are likely in the upper chamber above the wedge.

5.3.3 General Corrosion

COMPONENT	LOCATION	RISK	BASIS
Piping	Inner surface	Less likely	Existing erosion corrosion program monitors thinning [28, 36].
TE	Outer surface	Less likely	Low alloy steel more resistant to general corrosion.
Check valve	Exposed inner surfaces (steel)	Less likely	Existing reptask monitors thinning [29, 30, 31, 32, 36].
	Replacement pressure seal cover (SS)	Less likely	Stainless steel less susceptible to general corrosion.
	Drain assembly	More likely	Stagnant conditions are likely in this area. Probably not part of erosion corrosion program.
Hand valve	Exposed inner surfaces	More likely	Stagnant conditions are likely. Higher operating temperature in some cases. Not part of erosion corrosion program.
MOV	Bonnet inner surfaces	More likely	Stagnant conditions are likely in the upper chamber above the wedge. Not part of erosion corrosion program.

5.3.4 Erosion Corrosion

COMPONENT	LOCATION	RISK	BASIS
TE	Outer surface	Less likely	Low alloy steel material is more resistant to erosion corrosion than carbon steel.
MOV	Exposed inner surfaces	More likely	Carbon steel material is susceptible to erosion corrosion.

5.4 INSPECTION

5.4.1 Crevice Corrosion

Sample Size

The total number of "more likely" locations for the occurrence of crevice corrosion is tabulated below:

Component	Location	Locations per component	Total number of locations
Check valve	Body / pressure seal cover interface	1	4
	Body drain pipe threads or socket	1	4
Hand valve	Body / bonnet interface	1	100
	Seat ring / body interface	1 or 2	104
	Pipe thread / body interface	2	200
	Plug or wedge / stem interface	1	100
	Stem / bonnet interface	1	100

MOV	Body / bonnet interface	1	4
	Stem / bonnet interface	1	4
	Seat ring / body interface	2	8
	Wedge / stem interface	1	4
TOTAL			632

Therefore the lot size to be sampled consists of 632 surface pairs. If a sample size of 25 is selected, and no evidence of crevice corrosion is found, there will be 90% confidence that 90% of the surface pairs do not have crevice corrosion [4, 20, 21, 22].

Locations

To obtain the sample size of at least 25, the following inspections will be performed:

Two check valves -- one in Unit 1, one in Unit 2

2 Body / pressure seal cover interface

1 Body drain pipe threads or sockets (Unit 2 only)

Two hand valves -- 1 Globe, 1 gate (selection criteria below)

2 Body / bonnet interface

3 Seat ring / body interface

4 Pipe thread / body interface

2 Stem / bonnet interface

2 Plug or wedge / stem interface

Two MOVs -- one in Unit 1, one in Unit 2

2 Body / bonnet interface

2 Stem / bonnet interface

4 Seat ring / body interface

2 Wedge / stem interface

TOTAL: 26 surface pairs

This sample size of 26 is greater than the minimum required sample size of 25.

Selection guidelines

The valves to be inspected will be selected based on the following criteria:

Inspect check valves with:

- Longest time in service
- Pressure seal cover replaced with stainless steel
- Ease of access

Inspect hand valves with:

- Longest time in service
- Highest operating temperature
- Most stagnant or lowest flow conditions
- Gasket at body / bonnet interface (instead of screwed and seal welded joint)
- Ease of access

Inspect MOVs with:

- Longest time in service
- Ease of access

The above criteria are provided to aid the selection process. Final sample selection decisions are to be made by an appropriate system engineer who has thorough knowledge of the Main Feedwater system.

Procedure

Visual inspection will be used to determine if crevice corrosion is occurring at a particular location. The inspection procedure will be as specified in Calvert Cliffs Administrative Procedure MN-3-101 for Nondestructive Evaluation [23] and Administrative Procedure MN-3-105 for Qualification of Nondestructive Personnel and Procedures [24]. In addition, the procedure will follow visual inspection guidelines provided by ASTM G 46, Standard Guide for Examination and Evaluation Of Pitting Corrosion [25]. Guidelines from ASTM G 46 include the following:

- Document any corrosion products found.
- Clean surface to remove corrosion products and fully expose crevices.
- Examine with naked eye followed by low power magnification.
- Depth of pits can be measured with micrometer or depth gage or with destructive methods such as sectioning.

Requirements

The visual inspection for crevice corrosion will meet inspection personnel requirements as specified by MN-3-101. Inspection documentation will meet requirements as specified by Calvert Cliffs Administrative Procedure MN-3-303, Nondestructive Examination Report Tracking [26]. No signs of crevice corrosion are expected to be discovered during the inspections. However, if evidence of corrosion is found, recommended inspection documentation items include:

- Identification of corrosion products.
- Metallurgical and surface treatments of the component and final surface finish during test.
- Environmental conditions and exposure duration.
- Appearance of corroded surface before and after cleaning.
- Component descriptions, numbers, and manufacturer.
- Characterization of pits:

    Pit size

    Pit shape

    Number of pits

Pit depth (average and maximum)

Pit locations

Acceptance Criteria

The acceptance criteria for the inspection will be: any measurable evidence of crevice corrosion is unacceptable. Measurable evidence of crevice corrosion is defined as a pit of at least 30 mil depth with visible corrosion products in or around the pit.

If evidence of crevice corrosion is found, an Issue Report will be generated per QL-2-100 [33]. Inspection requirements for pitting will be reconsidered (see Section 6.2 below) and the system boundary will need to be re-evaluated to include other potentially impacted items such as the instrument lines and other sections of the Main Feedwater System.

If no measurable evidence of crevice corrosion is found, then no further inspections are required.

5.4.2 Pitting

Crevice corrosion initiates earlier, proceeds faster, and can occur in less aggressive environments than pitting (see Figure 3-5). On a component that contains suitable crevices, crevice corrosion will occur before pitting. All of the "more likely" locations for pitting corrosion are located in the check valves, hand valves, and MOVs, all of which contain suitable crevices for crevice corrosion. Therefore, pitting is less likely in these valves than crevice corrosion. As stated above, if no crevice corrosion is found during the inspection described in Section 5.4.1, there is 90% confidence that 90% of locations are free of crevice corrosion. If pitting is less likely than crevice corrosion, then at least the same level of confidence will exist for the occurrence of pitting as for crevice corrosion. Consequently, a separate inspection plan for pitting will not be required.

5.4.3 General Corrosion

Sample Size

The total number of "more likely" locations for the occurrence of general corrosion is tabulated below:

Component	Location	Locations per component	Total number of locations
Check valve	Drain assembly	2	4
Hand valve	Exposed inner surfaces	1	100
MOV	Bonnet inner surfaces	1	4
TOTAL			108

Therefore the lot size to be sampled consists of 108 surfaces. If a sample size of 20 is selected, and no evidence of general corrosion is found, there will be 90% confidence that 90% of the surfaces do not have general corrosion [4, 20, 21, 22].

<u>Locations</u>

To obtain the sample size of at least 20, the following inspections will be performed:

One check valve - one in Unit 2

1 Body drain pipe

1 Body drain cap

Two MOVs - one in Unit 1, one in Unit 2

2 Bonnets

Sixteen Hand valves - seven Globe and one gate in Unit 1, seven globe and one gate in Unit 2.

<u>16 Hand valve piping (just upstream of valve)</u>

TOTAL: 20 Wall thicknesses

<u>Selection Guidelines</u>

The valves to be inspected will be selected based on the following criteria:

Inspect same check valve as selected for the crevice corrosion inspection

Inspect same MOVs as selected for the crevice corrosion inspection

Inspect same two hand valves selected for crevice corrosion inspection and fourteen additional hand valves with:

- Longest time in service
- Highest operating temperature
- Most stagnant or lowest flow conditions
- Ease of access

The above criteria are provided to aid the selection process. Final sample selection decisions are to be made by an appropriate system engineer who has thorough knowledge of the Main Feedwater system.

Procedure

Ultrasonic testing will be used to inspect for general corrosion. The inspection procedure will be as specified in Calvert Cliffs Administrative Procedure MN-3-101 for Nondestructive Evaluation and Administrative Procedure MN-3-105 for Qualification of Nondestructive Personnel and Procedures. Two measurements will be required at separate times to calculate a corrosion rate. Corrosion rate will be determined following the procedures outlined in MN-3-202.

Requirements

Ultrasonic inspection for general corrosion will meet inspection personnel requirements as specified by MN-3-101. Inspection documentation will meet requirements as specified by Calvert Cliffs Administrative Procedure MN-3-303, Nondestructive Examination Report Tracking [26].

Acceptance Criteria

The acceptance criteria for the inspections will be if evidence of general corrosion is found, minimum wall thicknesses will be predicted at the end of the license renewal period and evaluated for acceptability. If significant corrosion is found during the first inspection, then an Issue Report will be generated per QL-2-100 [33]. If no general corrosion is detected, then no further inspections are required.

5.4.4 Erosion Corrosion

Sample Size

The total number of "more likely" locations for the occurrence of erosion corrosion is:

Component	Location	Locations per component	Total number of locations
MOV	Exposed inner surfaces	1	4
TOTAL			4

Therefore the lot size to be sampled consists of 4 units. A sample size of two will be used because of the extensive methods in use to control erosion corrosion in the piping and the check valve [28, 29, 30, 31, 32, 36].

Locations

To obtain the sample size of two, the following inspections will be performed:

Two MOVs -- one in Unit 1, one in Unit 2

2 Exposed inner surface

TOTAL: 2 surfaces

The critical locations to check for erosion corrosion within the MOVs are the exposed carbon steel surfaces that experience the highest flow rates through the valve. For example, inspect the lower portion of the body adjacent to the inflow and outflow openings.

Selection Guidelines

The valves to be inspected will be selected based on the following criteria:

Inspect same MOVs as selected for the crevice corrosion inspection

The above criteria are provided to aid the selection process. Final sample selection decisions are to be made by an appropriate system engineer who has thorough knowledge of the Main Feedwater system.

Procedure

Visual inspection will be used to determine if erosion corrosion is occurring at a particular location. The inspection procedure will be as specified in Calvert Cliffs Administrative Procedure MN-3-101 for Nondestructive Evaluation [23] and Administrative Procedure MN-3-105 for Qualification of Nondestructive Personnel and Procedures [24].

Requirements

The visual inspection for erosion corrosion will meet inspection personnel requirements as specified by MN-3-101. Inspection documentation will meet requirements as specified by Calvert Cliffs Administrative Procedure MN-3-303, Nondestructive Examination Report Tracking [26].

Acceptance Criteria

If significant evidence of erosion corrosion is found, then an Issue Report will be generated per QL-2-100 [33].

If no evidence of erosion corrosion is found, then no further inspections are required.

6

SAFETY INJECTION SYSTEM ARDI PROGRAM

6.1 SYSTEM DESCRIPTION

6.1.1 Operating Environment

The purpose of the Safety Injection System (SIS) is to inject borated water into the Reactor Coolant System to provide cooling following a loss of coolant accident and to provide reactor cooling under other normal and transient operating conditions. The system also transfers refueling water from the refueling water tank to the refueling pool and returns it to the tank after refueling. The internal environment is borated water, with various operating temperatures and pressures for individual components. The external environment is climate controlled atmospheric air.

The CCNPP Chemistry Program monitors and controls fluid chemistry in order to minimize the concentration of corrosive impurities. Control of fluid chemistry minimizes the corrosive environment for Safety Injection System components, and limits the rate and effects of corrosion. Technical Procedure CP-204, Specifications and Surveillance: Primary Systems [14] controls the Safety Injection Tank Chemistry, and has the following impurity targets:

Chloride	<20 parts per billion
Fluoride	<20 parts per billion
Sulfate	<20 parts per billion

In areas which are not exposed to the main flow stream, local fluid chemistry conditions may deviate from bulk fluid system chemistry. These areas include crevices and branch lines with little or no flow through them. Furthermore, the water chemistry may be outside of the target range during plant outages.

6.1.2 Piping

The piping within the scope of the Safety Injection System ARDI program consists of four piping classes: CC, DC, GC and HC. Piping in each class are divided into subgroups; the subgroups are described below:

CC-01

2-1/2" and larger SIS piping upstream of second isolation valve from RC loop (CC13) and redundant HP SIS piping (CC6).

Normal operating conditions: CC6 - 120° F, 2235 psig

CC13 - 294° F, 2235 psig

Material: ASTM A376 Type 316 stainless steel

Schedule: 120, 140, 160

Class: I, II or MC (current)

Design code: B31.7-1969 (Class II original design)

Joints: Butt-welded

CC-02

Under 2-1/2" SIS piping upstream of second isolation valve from RC loop (CC13) and redundant HP SIS piping (CC6).

Normal operating conditions: CC6 - 120° F, 2235 psig

CC13 - 294° F, 2235 psig

Material: ASTM A376 or A312 Type 316 stainless steel

Schedule: 160

Class: I, II or MC (current)

Design code: B31.7-1969 (Class II original design)

Joints: Socket-welded

CC-04

2-1/2" and larger SIS piping from second valve to RC loop (CC4) and shutdown cooling through isolation valves (CC14).

Normal operating conditions: CC4 - 550° F, 2235 psig

CC14 - 604° F, 2235 psig

Material: ASTM A376 Type 316 stainless steel

Schedule: 120, 140

Class: I or MC (current)

Design code: B31.7-1969 Class I

Joints: Butt-welded

CC-07 Under 2-1/2" SIS piping from second valve to RC loop.

Normal operating conditions: CC4 - 550° F, 2235 psig

Material: ASTM A376 or A312 Type 316 stainless steel

Schedule: 80S

Class: I

Design code: B31.7-1969 Class I

Joints: Socket-welded

DC-01 2-1/2" and larger HP SI to primary loop (DC1) and SI recirculation to refueling water tank (DC2).

Normal operating conditions: DC1, 2 - 300° F, 1250 psig

Material: ASTM A376 Type 304 stainless steel

Schedule: 80S

Class: II

Design code: B31.7-1969 Class II

Joints: Butt-welded

DC-02 Under 2-1/2" HP SI to primary loop (DC1) and SI recirculation to refueling water tank (DC2).

Normal operating conditions: DC1, 2 - 300° F, 1250 psig

Material: ASTM A376 Type 304 stainless steel

Schedule: 80S

Class: II

Design code: B31.7-1969 Class II

Joints: Socket-welded

GC-01 — 2-1/2" and larger LP SI pump discharge system to RC loop upstream of flow control system (GC1), HP SI pump suction from shutdown HX discharge (GC3), RC to LP SI pumps suction (GC5), and SI tank to check valve on tank outlet (GC9).

Normal operating conditions: GC1 - 300° F, 150 psig

GC3 - 130° F, 150 psig

GC5 - 300° F, 300 psig

GC9 - 120° F, 200 psig

Material: ASTM A376 or A312 Type 304 stainless steel

Schedule: 0.250", 40S

Class: II, III, or Non-class

Design code: B31.7-1969 Class II

Joints: Butt-welded

GC-04 — Under 2-1/2" nitrogen to SI tanks piping (GC4), RC to LPSI pumps suction (GC5), and SI and containment spray pumps recirculation to refueling water tank (GC7).

Normal operating conditions: GC4 - 150° F, 250 psig

GC5 - 300° F, 300 psig

GC7 - 100° F, 180 psig

Material: ASTM A376 or A312 Type 304 stainless steel

Schedule: 40S

Class: II, III, MC, or Non-class

Design code: B31.7-1969 Class II

Joints: Socket-welded

HC-01 — 2-1/2" and larger EECS pumps suction piping from containment sump and RWT to isolation MOVs (HC3), spent fuel cooling (HC4), and refueling water tank misc. piping (HC23).

Normal operating conditions: HC3 - 100° F, 40 psig

HC4 - 125° F, 103 psig

HC23 - 105° F, 90 psig

Material: ASTM A376, A358 CL1, or A312 Type 304 stainless steel

Schedule: 0.250", 10S

Class: II, MC, or Non-class

Design code: B31.7-1969 Class II or III

Joints: Butt-welded

HC-04 Under 2-1/2" EECS pumps suction piping from containment sump and RWT to isolation MOVs (HC3).

Normal operating conditions: HC3 - 100° F, 40 psig

Material: ASTM A376 or A312 Type 304 stainless steel

Schedule: 40S

Class: II or MC

Design code: B31.7-1969 Class II

Joints: Socket-welded

HC-07 Containment sump drains (HC3).

Normal operating conditions: HC3 - 100° F, 40 psig

Material: ASTM A358 CL1 or A312 Type 304 stainless steel

Schedule: 10S or 0.250"

Class: II or MC

Design code: B31.7-1969 Class II

Joints: Butt-welded

Joints are welded except at flanged equipment connections; joints are butt-welded on 2-1/2" and larger piping and socket-welded on 2" and smaller piping. Gaskets are flexitallic type. Small bore branch piping for drain and instrument lines to the isolation valves are also included and assumed to be stainless steel.

6.1.3 Check Valves

The check valves included in the SIS ARDI are divided into four groups:

052-CKV-01 Swing check valve and piston check valve

Material: (Body/bonnet) A182 F316 forged stainless steel

(Studs) A193 Gr B7 Cr-Mo alloy steel

(Nuts) A194 Gr 2H carbon steel

Location: Various SIS locations

Quantity: 25 in each unit

Included in ARDI: Body, bonnet, studs and nuts

052-CKV-03 Swing check valve

Material: (Body/bonnet) A182 F316 forged stainless steel

(Studs) A193 Gr B7 Cr-Mo alloy steel

(Nuts) A194 Gr 2H carbon steel

(Disc/seat/other internals) Stainless steel

Location: SI header check valve

Quantity: 4 in each unit

Included in ARDI: Body, bonnet, studs, nuts and internals (disc, seat, swing mechanism)

052-CKV-04 Swing check valve

Material: (Body/bonnet) SA351 CF8M / SA240 Gr. 316 stainless steel

(Studs) A193 Gr B7 Cr-Mo alloy steel

(Nuts) A194 Gr 2H carbon steel

(Disc/seat/other internals) Stainless steel / Stellite

Location: SIT outlet check valve

Quantity: 4 in each unit

Included in ARDI: Body, bonnet, studs, and nuts

052-CKV-05 Swing type

Material: (Body/bonnet) A182 F316 forged stainless steel

(Studs) A193 Gr B7 Cr-Mo alloy steel

(Nuts) A194 Gr 2H carbon steel

Location: Loop inlet check valve

Quantity: 4 in each unit

Included in ARDI: Body, bonnet, studs, and nuts

6.1.4 Control Valves

The control valves included in the SIS ARDI are divided into three groups:

052-CV-01 Plug valve

Material: (Body/bonnet) A351 Gr. CF8M stainless steel

(Stem) ASTM A479 Type 316 stainless steel

(Studs) A193 Gr B7 Cr-Mo alloy steel

(Nuts) A194 Gr 2H carbon steel

Location: LP SI Flow control

Quantity: 1 in each unit

Included in ARDI: Body, bonnet, stem, studs and nuts

052-CV-02 Plug valve

Material: (Body/bonnet) A351 Gr. CF8M / A182 Gr. F316 stainless steel

(Stem) 316 stainless steel

(Studs) A193 Gr B7 Cr-Mo alloy steel

(Nuts) A194 Gr 2H carbon steel

Location: SI tank fill and leakoff to RCDT CVs

Quantity: 5 in each unit

Included in ARDI: Body, bonnet, stem, studs and nuts

052-CV-06 Plug valve

Material: (Body/bonnet) A351 Gr. CF8M / A182 Gr. F316 stainless steel

(Stem) 17-4PH H-1100 stainless steel

(Studs) A193 Gr B7 Cr-Mo alloy steel

(Nuts) A194 Gr 2H carbon steel

Location: SI tank CKV LKG control valve

Quantity: 4 in each unit

Included in ARDI: Body, bonnet, stem, studs and nuts

6.1.5 Hand Valves

The hand valves included in the SIS ARDI are divided into five groups:

052-HV-01 Butterfly valve

Material: (Body/bonnet) A516 Gr. 55 carbon steel

(Stem) A276 Type 316 stainless steel

Location: 11 RWT to SFP CLG

Quantity: 1

Included in ARDI: Body, bonnet and stem

Normal valve position: Not known

052-HV-02 Globe or gate valve

Material: (Body/bonnet) A351 CF8M cast or A182 F316 forged stainless steel

(Stem) Type 316 or 630 stainless steel

(Studs) A193 Gr B7 Cr-Mo alloy steel

(Nuts) A194 Gr 2H carbon steel

Location: Throughout SIS and 21 RWT to SFP CLG

Quantity: 97 in each unit, one in SFP system

Included in ARDI: Body, bonnet, stem, studs and nuts

Normal valve position: Open

<u>052-HV-03</u> Globe or gate valve

Material: (Body/bonnet) A351 CF8M cast or A182 F316 forged stainless steel

(Stem) Type 316 or 630 stainless steel

(Studs) A193 Gr B7 Cr-Mo alloy steel

(Nuts) A194 Gr 2H carbon steel

(Disc/seat) Type 316 or 630 stainless steel

Location: Throughout SIS and U1/U2 S/D CLG supp. vent

Quantity: 115 in Unit 1, 111 in Unit 2, 2 in SFP system

Included in ARDI: Body, bonnet, stem, studs, nuts, disc and seat

Normal valve position: Closed

<u>052-HV-09</u> Globe or gate valve

Material: (Body/bonnet) A351 CF8M cast or A182 F316 forged stainless steel

(Stem) 316 or 630 stainless steel

(Studs) A193 Gr B7 Cr-Mo alloy steel

(Nuts) A194 Gr 2H carbon steel

Location: PT Root, SI Tank CKV leakage isolation

Quantity: 8 in each unit

Included in ARDI: Body, bonnet, stem, studs and nuts

Normal valve position: Open

052-HV-10 Globe or gate valve

Material: (Body/bonnet) A351 CF8M cast or A182 F316 forged stainless steel

(Stem) Type 316 or 630 stainless steel

(Studs) A193 Gr B7 Cr-Mo alloy steel

(Nuts) A194 Gr 2H carbon steel

(Disc/seat) Type 316 or 630 stainless steel

Location: SDC return

Quantity: 3 in each unit

Included in ARDI: Body, bonnet, stem, studs, nuts, disc and seat

Normal valve position: Closed

6.1.6 Relief Valves

The relief valves included in the SIS ARDI are divided into four groups:

052-RV-01 Nozzle type relief valve - Nitrogen service

Material: (Body/bonnet) A351 Gr. CF8M cast stainless steel

(Adjusting bolt) Type 316 stainless steel

(Nozzle) A351 Gr. CF8M cast stainless steel

(Studs) A193 Gr B7 Cr-Mo alloy steel

(Nuts) A194 Gr 2H carbon steel

(Disc holder/insert) A479 Type 316 stainless steel

(Spring/washer) Inconel X750/Type 316 stainless steel

(Spindle) Type 316 stainless steel

Location: SI Tank relief valves

Quantity: 4 in each unit

Included in ARDI: Nozzle, disc holder and insert (only components subject to plausible ARDMs)

052-RV-02 Nozzle type relief valve:

Material: (Base/cylinder) A479 Type 316/A182 Gr. F316 or A351 Gr. CF8M stainless steel

(Adjusting bolt) A479 Type 316 stainless steel

(Disc) Inconel 706 or Stellite 6B

(Spindle) A479 Type 316 stainless steel

(Spring/washer) A313/A479 Type 316 stainless steel

Location: Various SIS locations

Quantity: 6 in Unit 1, 5 in Unit 2

Included in ARDI: Base, cylinder, adjusting bolt, disc, spindle, spring and washer

052-RV-03 Nozzle type relief valve

Material: (Body/bonnet) A351 Gr. CF8M cast stainless steel

(Spindle point/adj. bolt) A479 Type 316 stainless Steel

(Nozzle/disc) A479 Type 316 or A182 F316 stainless steel

(Studs) A193 Gr B7 Cr-Mo alloy steel

(Nuts) A194 Gr 2H carbon steel

(Spring/washer) A313 Type 316/A479 Type 316 stainless steel

Location: SI leakoff and SDC return header RVs

Quantity: 2 in each unit

Included in ARDI: Body, bonnet, spindle point, adjusting bolt, nozzle, disc, studs, nuts, spring, and washer

052-RV-04 Nozzle type relief valve

Material: (Base/cylinder) A479 Type 316/A351 Gr. CF8M stainless steel

(Adjusting bolt) A479 Type 316 stainless steel

(Disc) Stellite 6B

(Spindle) A479 Type 316 stainless steel

(Spring/washer) A313/A479 Type 316 stainless steel

Location: SDC return header RVs

Quantity: 1 in each unit

Included in ARDI: Base, cylinder, adjusting bolt, disc, spindle, spring and washer

6.1.7 Motor Operated Valves

The MOVs included in the SIS ARDI are divided into three groups:

052-MOV-01 Bolted bonnet gate MOV

Material: (Body/bonnet) A182 F316 forged stainless steel

(Stem) 17-4PH, A564 TP 630 or A276 Type 316 stainless steel

(Studs) A193 Gr B7 Cr-Mo alloy steel

(Nuts) A194 Gr 2H carbon steel

Location: Various SIS locations

Quantity: 12 in each unit

Included in ARDI: Body, bonnet, stem, studs and nuts

052-MOV-02 Bolted bonnet gate MOV

Material: (Body/bonnet) A182 F316 forged stainless steel

(Stem) A276 Type 316 stainless steel

(Studs) A193 Gr B7 Cr-Mo alloy steel

(Nuts) A194 Gr 2H carbon steel

Location: SI Tank outlet and SDC return isolation

Quantity: 5 in each unit

Included in ARDI: Body, bonnet, stem, studs and nuts

052-MOV-03 Globe type MOV

Material: (Body/bonnet) A182 F316 forged stainless steel

(Stem) 17-4PH Type 630 or A461 stainless steel

(Studs) A193 Gr B7 Cr-Mo alloy steel

(Nuts) A194 Gr 2H carbon steel

(Disc/seat) Stainless steel/stellite

Location: HP, LP and Aux SI Loop isolation

Quantity: 12 in each unit

Included in ARDI: Body, bonnet, stem, disc, seat, studs and nuts

6.1.8 Flow Elements and Flow Orifices

The SIS flow element is manufactured by Fischer & Porter. The element consists of measurement hardware and an orifice plate inserted at a flange joint in the SIS piping. Only the orifice plate is critical for passive intended function capability. The orifice plate material is 316 stainless steel. There are eleven flow elements in each unit.

There are three types of flow orifices considered in the SIS ARDI. All three types have an orifice body composed of stainless steel. There are a total of seven flow orifices in each unit.

6.1.9 Heat Exchangers

The heat exchangers included in the SIS ARDI consist of three groups:

052-HX-02 HPSI Pump seal water cooler, borated water and Component Cooling water service

Borg Warner models SS7434/SS7423

Material: (Tubing) 304/316 stainless steel

(Case/cover) Cast iron

(Socket weld connection) 316 stainless steel

(Studs) A193 Gr B7 Cr-Mo alloy steel

(Nuts) A194 Gr 2H carbon steel

(Flex connector) Brass

Quantity: 3 in each unit

Included in ARDI: Tubing, case, cover, socket joint, studs, nuts, and flex connector

052-HX-03 LPSI Pump seal water cooler, borated water and Component Cooling water service Borg Warner model NX7050FW

Material: (Tubing) 304/316 stainless steel

(Case/cover) Cast iron

(Socket weld connection) 304/316 stainless steel

(Bolts) A193 Gr B7 Cr-Mo alloy steel

(Nuts) A194 Gr 2H carbon steel

(Flex connector) Brass

Quantity: 2 in each unit

Included in ARDI: Tubing, case, cover, socket joint, studs, nuts, and flex connector

052-HX-04 SI Refueling Water Tank heat exchanger, shell and tube type, borated water and non-treated water service

Shell side - 75 psi, 250° F (untreated water)

Tube side - 100 psi, 250° F (SIS water)

Atlas type AEM

Material: (Shell) A53B Carbon steel

(Fittings) A181-1 forged carbon steel

(Tubes/bonnets/covers/SS welds) 304 stainless steel

(Studs) A193 Gr B7 Cr-Mo alloy steel

(Nuts) A194 Gr 2H carbon steel

(Supports) A36 Carbon steel

Quantity: 1 in each unit

Included in ARDI: Fittings, bonnets, covers, tubes, SS welds, studs, nuts, and supports

6.1.10 Level Transmitters

The LT is manufactured by Rosemount, model number 1154DP4RG. The LT components are composed primarily of stainless steel; the flange bolting material is A540 plated alloy steel. There are two LTs, both located in Unit 2 at the containment sumps.

6.1.11 Pumps

The pumps included in the SIS ARDI consist of three types:

052-PUMP-01 HP SI Pump, seven stage horizontal centrifugal type, borated water service Bingham-Williamette model 3X4X9A MSD

Material: (Casing) A351 Gr. CF8 cast stainless steel

(Case studs) A193 Gr B7 Cr-Mo alloy steel

(Case nuts) A194 Gr 2H carbon steel

(Shaft) AISI 416 stainless steel

(Mechanical seal) A182 Type 304/316 stainless steel

(Seal wear surfaces) Tungsten carbide

Quantity: 3 in each unit

Included in ARDI: Casing, nuts, studs, shaft, mechanical seal

052-PUMP-02 LP SI Pump, single stage horizontal centrifugal type, borated water service Ingersoll-Rand model 8X21AL

Material: (Casing) A351 Gr. CF8 cast stainless steel

(Studs) A193 Gr B7 Cr-Mo alloy steel

(Nuts) A194 Gr 2H carbon steel

(Shaft) A276 Type 316 stainless steel

(Mechanical seal) 316 stainless steel

(Seal wear surfaces) Tungsten carbide

Quantity: 2 in each unit

Included in ARDI: Casing, nuts, studs, shaft, mechanical seal

052-PUMP-03 SI Refueling Water Tank Recirculation Pump, centrifugal type, borated water service Goulds model 3196ST

Material: (Casing) Type 316 stainless steel

(Studs) Type 304 stainless steel

(Nuts) Type 304 stainless steel

(Shaft) Type 316 stainless steel

(Adapter ring) Ductile iron

Quantity: 1 in each unit

Included in ARDI: Casing, nuts, studs, and shaft

6.1.12 Temperature Elements and Indicators

The temperature element is manufactured by Rosemount. The TE consists of a temperature instrument enclosed in a Type 316 stainless steel thermowell that is inserted in the SIS piping. The thermowell is screwed into the piping well and welded. Only the thermowell is included in this ARDI. There are four temperature elements in each unit.

The temperature indicator is manufactured by Weston. The TI consists of a temperature instrument enclosed in a Type 316 stainless steel thermowell that is inserted in and welded to the SIS piping. Only the thermowell is included in this ARDI. There are three temperature indicators in each unit.

6.1.13 Tanks

There are two types of tanks included in the SIS ARDI: 052-TK-01 - Safety Injection Refueling Water Tank, and 052-TK-02 - Safety Injection Tank.

The SI Refueling Water Tank is manufactured by Pittsburgh-Des Moines Steel Company. The shell, penetrations, and manhole are Type 304 stainless steel, and the welds are stainless steel weld material. The bolts are A193 Gr. B7 alloy steel and the nuts are A194 Gr. 2H carbon steel. The perimeter seal is fibrated cold plastic coal tar pitch flashing. There is one RWT in each unit.

The SI Tank is manufactured by Air Preheater. The tank is oriented vertically and is approximately 427 inches tall, 109-3/4 inches in diameter, and has a wall thickness of 0.875 inches. The shell and skirt plate are carbon steel; the shell has stainless steel cladding. The manway, studs, nuts, inlet, and overflow are Type 304 stainless steel. The welds are stainless steel weld material. Design pressure and temperature are 250 psig and 200°F. There are four SI tanks in each unit.

6.2 POSSIBLE LOCATION IDENTIFICATION

AMRR Overview

The Safety Injection System components and degradation mechanisms that require an ARDI evaluation are summarized in the table below [43]:

	AGE RELATED DEGRADATION MECHANISM					
GROUP IDENTIFICATION NUMBER	CREVICE CORROSION	GENERAL CORROSION	PITTING	MIC	SCC	WEAR
052-#CC-01	X		X			
052-#CC-02	X		X			
052-#CC-04	X		X			
052-#CC-07	X		X			
052-#DC-01	X		X			
052-#DC-02	X		X			
052-#GC-01	X		X			
052-#GC-04	X		X			
052-#HC-01	X		X			
052-#HC-04	X		X			

052-#HC-07	X		X	X		
052-CKV-01	X		X			
052-CKV-03	X		X			X
052-CKV-04	X		X			
052-CKV-05	X		X			
052-CV-01	X		X			
052-CV-02	X		X			
052-CV-06	X		X			
052-FE-01	X		X			
052-FO-01	X		X			
052-FO-02	X		X			
052-FO-03	X		X			
052-HV-01	X	X	X			
052-HV-02	X		X			
052-HV-03	X		X			
052-HV-09	X		X			
052-HV-10	X		X			
052-HX-02	X	X	X			
052-HX-03	X	X	X			
052-HX-04	X		X			
052-LT-02	X		X			
052-MOV-01	X		X			
052-MOV-02	X					
052-MOV-03	X		X			
052-PUMP-01	X	X	X			
052-PUMP-02	X	X	X			

052-PUMP-03	X		X			
052-RV-01						X
052-RV-02	X		X			X
052-RV-03	X		X			X
052-RV-04	X		X			X
052-TE-01	X		X			
052-TI-01	X		X			
052-TK-01	X		X		X	
052-TK-02	X		X			

The Safety Injection System ARDMs can be categorized as either:

1) Probable (expected to occur) and not adequately managed by existing programs or

2) Possible (not expected to occur) which may require confirmation determination or

3) Impossible (cannot occur).

All ARDMs are in Category 2 because, given the system, environment, and materials, the degradation mechanism can occur. These ARDMs require only confirmation that the ARDM is not occurring.

As stated in Section 3.2, crevice corrosion will generally occur before pitting corrosion if suitable crevices are present. Therefore, if the inspection for crevice corrosion finds no evidence of this degradation mechanism, pitting corrosion can also be eliminated from consideration. An inspection program will be developed only for crevice corrosion. If evidence of the mechanism is found, the need for additional pitting inspection will be reevaluated.

6.3 SELECTION OF HIGH AND LOW RISK LOCATIONS

In the tables below, ARDM locations are ranked for each mechanism according to risk of occurrence as either "more likely" or "less likely". Sample locations from the "more likely" category will be inspected. If no evidence of degradation is found in this group, it will be concluded that no degradation exists in the "less likely" group. Sample sizes will be selected based on the total number of locations in the "more likely" group. Careful consideration will be given to the population size of "more likely" locations relative to a population size of the combination of "less likely" and "more likely" locations. The intent of this discrimination is to provide a biased sample which should produce results exceeding the 90%/90% statistical target. The intent is not to reduce the sample size of required inspection locations. This approach also assumes that all of the "more likely" locations selected have an equal probability of occurrence and that any of the "more likely" locations has a greater probability of occurrence than any of the "less likely" locations.

6.3.1 Crevice Corrosion

COMPONENT	LOCATION	RISK	BASIS
Piping	Butt weld	Less likely	Good weld quality expected.
	Socket weld	Less likely	Crevice dimensions less critical than other nearby components.
	Backing ring	Less likely	Backing ring usage is not standard practice so probably not present in SI system.
	Surface deposit	Less likely	SI system is filtered and maintained relatively free of impurities so depositing is unlikely.
Check valve	Body / pressure seal cover interface	More likely	Gasketed joint is a common location for crevice corrosion.
	Seat / body interface	More likely	Two part construction creates narrow crevice.
	Disc swing or piston mechanism	More likely	Suitable crevices likely in this area.
	Socket welds (valve sizes 2" or under)	More likely	Suitable crevice likely at socket joint.
	Under nuts / stud & nut threads	More likely	Bolting is a common location for crevice corrosion; only slight leakage of borated water is necessary to cause corrosion of bolting.
	Surface deposit	Less likely	SI system is filtered and maintained relatively free of impurities so depositing is unlikely.
Control valve	Body / bonnet interface	More likely	Gasketed joint is a common location for crevice corrosion.
	Around cage gasket	More	Gasketed joint is a common location

		likely	for crevice corrosion.
	On stem in packing area	More likely	Narrow gap exists between shaft and packing.
	Socket welds (valve sizes 2" or under)	More likely	Suitable crevice likely at socket joint.
	Under nuts / stud & nut threads	More likely	Bolting is a common location for crevice corrosion; only slight leakage of borated water is necessary to cause corrosion of bolting.
	Surface deposit	Less likely	SI system is filtered and maintained relatively free of impurities so depositing is unlikely.
Hand valve (Globe or Gate type)	Body / bonnet interface	More likely	Gasketed or threaded joints are common locations for crevice corrosion.
	Seat ring / body interface	More likely	Two part construction creates narrow crevice.
	Socket welds (valve sizes 2" or under)	More likely	Suitable crevice likely at socket joint.
	Stem / bonnet interface	More likely	Packing area is potential stagnant crevice corrosion site.
	Under nuts / stud & nut threads	More likely	Bolting is a common location for crevice corrosion; only slight leakage of borated water is necessary to cause corrosion of bolting.
	Surface deposit	Less likely	SI system is filtered and maintained relatively free of impurities so depositing is unlikely.
Hand valve (Butterfly type)	Between shaft and bushings	More likely	Stagnant area; common crevice corrosion location.
	Shaft / vane interface	More likely	Two part construction creates narrow crevice.
	On shaft in packing area	More likely	Narrow gap exists between shaft and packing.
	Under nuts / stud & nut threads	More likely	Bolting is a common location for crevice corrosion; only slight leakage of borated water is necessary to

			cause corrosion of bolting.
	Surface deposit	Less likely	SI system is filtered and maintained relatively free of impurities so depositing is unlikely.
Relief valve (052-RV-02 and 052-RV-04)	Base / cylinder interface (threads and gasket)	More likely	Threads and gasketed joints are common crevice corrosion locations.
	Spindle ball bearing	Less likely	Gaps probably too large.
	Between washers and spindle / spring	More likely	Two part construction creates narrow crevice.
	Threads between adj. bolt / cylinder	More likely	Threads are common locations for crevice corrosion.
	Socket welds (valve sizes 2" or under)	More likely	Suitable crevice likely at socket joint.
	Surface deposit	Less likely	SI system is filtered and maintained relatively free of impurities so depositing is unlikely.
Additional locations for 052-RV-03	Threads between body and nozzle	More likely	Threads are common locations for crevice corrosion.
	Between bonnet gasket and bonnet and/or guide	More likely	Gasketed joints are common crevice corrosion locations.
	Between guide gasket and body and/or guide	More likely	Gasketed joints are common crevice corrosion locations.
	Under nuts / stud & nut threads	More likely	Bolting is a common location for crevice corrosion; only slight leakage of borated water is necessary to cause corrosion of bolting.
MOV	Body / bonnet interface	More likely	Gasketed or threaded joints are common locations for crevice corrosion.
	Stem in packing area	More likely	Packing area is a potential stagnant crevice corrosion site.
	Seat ring / body interface	More likely	Two part construction creates narrow crevice.

	Wedge / stem interface	More likely	Two part construction creates narrow crevice.
	Under nuts / stud & nut threads	More likely	Bolting is a common location for crevice corrosion; only slight leakage of borated water is necessary to cause corrosion of bolting.
	Surface deposit	Less likely	SI system is filtered and maintained relatively free of impurities so depositing is unlikely.
FE	Around flange gasket	More likely	Gasketed joints are common crevice corrosion locations.
FO	Around flange gasket	More likely	Gasketed joints are common crevice corrosion locations.
HX	Under nuts / stud & nut threads	More likely	Bolting is a common location for crevice corrosion; only slight leakage of borated water is necessary to cause corrosion of bolting.
	Socket welds	More likely	Suitable crevice likely at socket joint.
	Between tubes and tubesheets	More likely	Crevice corrosion of heat exchangers commonly occurs at this location.
	Around cover flange gaskets	More likely	Gasketed joints are common crevice corrosion locations.
	Surface deposit	Less likely	SI system is filtered and maintained relatively free of impurities so depositing is unlikely.
LT	Under nuts / stud & nut threads	Less likely	Low temperature conditions so corrosion less likely.
	Process flange gasket	Less likely	Low temperature conditions so corrosion less likely.
	Fittings	Less likely	Low temperature conditions so corrosion less likely.
Pumps	Around casing gasket	More likely	Gasketed joints are common crevice corrosion locations.
	Wear ring / casing interface	More likely	Two part construction creates narrow crevice.
	Between the gasket and bearing housing	More likely	Two part construction creates narrow crevice.
	Under nuts / stud & nut threads	More likely	Bolting is a common location for crevice corrosion; only slight leakage of borated water is necessary to

			cause corrosion of bolting.
	Surface deposit	Less likely	SI system is filtered and maintained relatively free of impurities so depositing is unlikely.
TE	Threads between thermowell and pipe wall	More likely	Threads are common locations for crevice corrosion.
TI	Gap between thermowell and piping wall	Less likely	Gap probably too large for crevice corrosion.
Tanks	Gasketed flange joints	More likely	Gasketed joints are common locations for crevice corrosion.
	Weld flaws	Less likely	Weld flaws not expected.
	Penetrations	More likely	Geometry creates tight crevice.
	Under nuts / stud & nut threads	More likely	Bolting is a common location for crevice corrosion; only slight leakage of borated water is necessary to cause corrosion of bolting.
	Inner shell surface deposit	Less likely	SI system is filtered and maintained relatively free of impurities so depositing is unlikely.

6.3.2 Pitting

COMPONENT	LOCATION	RISK	BASIS
Piping	Exposed inner surface	More likely	Stainless steel material is susceptible to pitting.
Check valve	Stainless steel internal surfaces	More likely	Stainless steel material is susceptible to pitting.
Control valve	Stainless steel internal surfaces	More likely	Stainless steel material is susceptible to pitting.
Hand valve	Stainless steel internal surfaces	More likely	Stainless steel material is susceptible to pitting.
Relief valves	Stainless steel internal surfaces	More likely	Stainless steel material is susceptible to pitting.

MOV	Stainless steel internal surfaces	More likely	Stainless steel material is susceptible to pitting.
FE	Exposed surfaces	More likely	Stainless steel material is susceptible to pitting.
FO	Exposed surfaces	More likely	Stainless steel material is susceptible to pitting.
HX	Stainless steel components	More likely	Stainless steel material is susceptible to pitting.
LT	Stainless steel surfaces	Less likely	Low temperature conditions so corrosion less likely.
Pumps	Stainless steel components	More likely	Stainless steel material is susceptible to pitting.
TE	Exposed surfaces	More likely	Stainless steel material is susceptible to pitting.
TI	Exposed surfaces	More likely	Stainless steel material is susceptible to pitting.
Tanks	Inner surface of tank (especially near waterline)	More likely	Stainless steel material is susceptible to pitting; stagnant conditions in tank.

6.3.3 General Corrosion

COMPONENT	LOCATION	RISK	BASIS
Hand valve	Carbon steel or iron surfaces	More likely	Materials susceptible to general corrosion.
HX	Carbon steel or iron surfaces	More likely	Stainless steel material less susceptible to general corrosion.
Pumps	Tungsten carbide wear rings	More likely	Material susceptible to general corrosion.

6.3.4 Microbiologically Induced Corrosion of Piping

Only one possible location exists for MIC: the inner surface of the Group 052-HC-07 piping, with highest susceptibility at or near the welds. Therefore selection of more and less likely locations is not necessary.

6.3.5 Stress Corrosion Cracking of Tanks

Only two possible locations exist for SCC: the SI Refueling Water Tank penetrations and welds. Therefore selection of more and less likely locations is not necessary.

6.3.6 Wear

COMPONENT	LOCATION	RISK	BASIS
Check valve	Hanger Pin	More likely	Relative motion cycling as valve disc moves.
	Bushings	More likely	Relative motion cycling as valve disc moves.
Relief valve	Nozzle ring	More likely	Experiences impact cycle when valve closes.
	Disc or disc insert	More likely	Experiences impact cycle when valve closes.
	Spindle ball bearing	More likely	Experiences impact cycle when valve closes.

6.4 INSPECTION

6.4.1 Crevice Corrosion

Sample Size

The total number of "more likely" locations for the occurrence of crevice corrosion is tabulated below:

COMPONENT	LOCATION	LOCATIONS PER COMPONENT	TOTAL NUMBER OF LOCATIONS
Check valve	Body / pressure seal cover interface	1	74
	Seat / body interface	1	74
	Disc swing or piston mechanism	1	74
	Socket welds (valve sizes 2" or under)	2	Not known
	Under nuts / stud & nut threads	4 minimum	296 minimum
Control valve	Body / bonnet interface	1	20
	Around cage gasket	1	20
	On stem in packing area	1	20
	Socket welds (valve sizes 2" or under)	2	Not known
	Under nuts / stud & nut threads	4	80
Hand valve (Globe or Gate type)	Body / bonnet interface	1	442
	Seat ring / body interface	1 (assumed)	442
	Socket welds (valve sizes 2" or under)	2	Not known
	Stem / bonnet interface	1	442

	Under nuts / stud & nut threads	4	1768
Hand valve (Butterfly type)	Between shaft and bushings	2	2
	Shaft / vane interface	2	2
	On shaft in packing area	1	1
	Under nuts / stud & nut threads	2	2
Relief valve (052-RV-02 and 052-RV-04)	Base / cylinder interface (threads and gasket)	1	13
	Between washers and spindle / spring	2	26
	Threads between adj. bolt / cylinder	1	13
	Socket welds (valve sizes 2" or under)	2	Not known
Additional locations for 052-RV-03	Threads between body and nozzle	1	4
	Between bonnet gasket and bonnet and/or guide	1	4
	Between guide gasket and body and/or guide	1	4
	Under nuts / stud & nut threads	4	16
MOV	Body / bonnet interface	1	58
	Stem in packing area	1	58
	Seat ring / body	2	116

	interface		
	Wedge / stem interface	1	58
	Under nuts / stud & nut threads	12 minimum unless bonnetless	696 approx.
FE	Around flange gasket	1	22
FO	Around flange gasket	1	14
HX	Under nuts / stud & nut threads	Multiple locations	Multiple locations
	Socket welds	2	20
	Between tubes and tubesheets	74	148
	Around cover flange gaskets	2	24
Pumps	Around casing gasket	1	12
	Wear ring / casing interface	1	12
	Between the gasket and bearing housing	1	12
	Under nuts / stud & nut threads	Not known	Not known
TE	Threads between thermowell and pipe wall	1	8
Tanks	Gasketed flange joints	2 minimum	20 minimum
	Penetrations	Not known	Not known
	Under nuts / stud & nut threads	Not known	Not known
TOTAL			Over 5100

The lot size to be sampled is over 5100 known surface pairs. Therefore, if a sample size of 25 is inspected and no evidence of crevice corrosion is found, there will be 90% confidence that 90% of the surface pairs are not experiencing crevice corrosion [4, 20, 21, 22].

Locations

To obtain the sample size of at least 25, the following inspections will be performed:

One check valve

1 Body / pressure seal cover interface

1 Seat / body interface

1 Disc swing mechanism

4 Stud / nut

One control valve

1 Body / bonnet interface

1 cage gasket area

1 Stem in packing area

4 Stud / nut

One hand valve (Globe or gate type)

1 Body / bonnet interface

1 Seat ring / body interface

1 Stem / bonnet interface

4 Stud / nut

2 Socket welds

One relief valve

1 Base / cylinder interface

2 Washer / spindle / spring interfaces

1 Threads between adj. bolt and cylinder

2 socket welds

One SI Refueling Water Tank Heat Exchanger or Pump Seal Cooler

4 Tube / tubesheet interfaces

2 Cover gaskets

2 Stud / nut

One pump

1 Casing gasket area

1 Wear ring / casing interface

1 Gasket / bearing housing interface

2 Stud / nut

One tank

1 flange

2 Stud /nut

TOTAL: 45 surface pairs

This sample size of 45 is greater than the minimum required sample size of 25.

Selection guidelines

The components to be inspected will be selected based on the following criteria:

Inspect check valves with:

- Longest time in service
- Ease of access

Inspect control valves with:

- Longest time in service
- Ease of access

Inspect hand valves with:

- Socket welds
- Longest time in service
- Highest operating temperature
- Most stagnant or lowest flow conditions
- Gasket at body / bonnet interface (instead of screwed and seal welded joint)
- Ease of access

Inspect relief valves with:

- Borated water service (not nitrogen)
- Socket welds
- Longest time in service
- Highest operating temperature
- Ease of access

Inspect heat exchangers with:

- Longest time in service
- Ease of access

Inspect pumps with:

- Longest time in service
- Most often in idle condition
- Ease of access

Inspect tank with:

- Longest time in service
- Ease of access

The above criteria are provided to aid the selection process. Final sample selection decisions are to be made by an appropriate system engineer who has thorough knowledge of the SIS system.

Procedure

Visual inspection will be used to determine if crevice corrosion is occurring at a particular location. The inspection procedure will be as specified in Calvert Cliffs Administrative Procedure MN-3-101 for Nondestructive Evaluation [23] and Administrative Procedure MN-3-105 for Qualification of Nondestructive Personnel and Procedures [24]. In addition, the procedure will follow visual inspection guidelines provided by ASTM G 46, Standard Guide for Examination and Evaluation Of Pitting Corrosion [25]. Guidelines from ASTM G 46 include the following:

- Document any corrosion products found.
- Clean surface to remove corrosion products and fully expose pits.
- Examine with naked eye followed by low power magnification.
- Depth of pits can be measured with micrometer or depth gage or with destructive methods such as sectioning.

Requirements

The visual inspection for crevice corrosion will meet inspection personnel requirements as specified by MN-3-101. Inspection documentation will meet requirements as specified by Calvert Cliffs Administrative Procedure MN-3-303, Nondestructive Examination Report Tracking [26]. No signs of crevice corrosion are expected to be discovered during the inspections. However, if evidence of corrosion is found, recommended inspection documentation items include:

- Identification of corrosion products.
- Metallurgical and surface treatments of the component and final surface finish during test.
- Environmental conditions and exposure duration.
- Appearance of corroded surface before and after cleaning.
- Component descriptions, numbers, and manufacturer.
- Characterization of pits:

Pit size

Pit shape

Number of pits

Pit depth (average and maximum)

Pit locations

Acceptance Criteria

The acceptance criteria for the inspection will be: any measurable evidence of crevice corrosion is unacceptable. Measurable evidence of crevice corrosion is defined as a pit of at least 30 mil depth with visible corrosion products in or around the pit.

If evidence of crevice corrosion is found, an Issue Report will be generated per QL-2-100 [33]. Inspection requirements for pitting will be reconsidered (see Section 6.2 below) and the system boundary will need to be re-evaluated to include other potentially impacted items such as the instrument lines and other sections of the SI system.

If no measurable evidence of crevice corrosion is found, then no further inspections are required.

6.4.2 Pitting

Crevice corrosion initiates earlier, proceeds faster, and can occur in less aggressive environments (see Figure 3-5) than pitting. On a component that contains suitable crevices, crevice corrosion will occur before pitting. All of the "more likely" locations for pitting corrosion are located in the valves, elements, and head tanks, all of which are likely to contain suitable crevices for crevice corrosion. Therefore, pitting is less likely in these components than crevice corrosion. As stated above, if no crevice corrosion is found during the inspection described in Section 6.4.1, there is 90% confidence that 90% of locations are free of crevice corrosion. If pitting is less likely than crevice corrosion, then at least the same level of confidence will exist for the occurrence of pitting as for crevice corrosion. Consequently, a separate inspection plan for pitting will not be required.

6.4.3 General Corrosion

Sample Size

The total number of "more likely" locations for the occurrence of general corrosion is tabulated below:

Component	Location	Locations per component	Total number of locations
Hand valve	Carbon steel or iron surfaces	1	1
HX	Carbon steel or iron surfaces	1	12
Pump	Tungsten carbide wear rings	1	12
TOTAL			25

The lot size to be sampled consists of 25 surfaces. Therefore, if a sample size of 13 is inspected and no evidence of general corrosion is found, there will be 90% confidence that 90% of the surfaces are not experiencing general corrosion [4, 20, 21, 22].

Locations

To obtain the sample size of 13, inspect the following:

Six heat exchangers

6 carbon steel cases / shells

Seven pumps

7 wear rings

Total: 13 inspection locations

Selection Guidelines

Inspect components with the longest time in service and the greatest accessibility. Final sample selection decision are to be made by an appropriate System Engineer who has thorough knowledge of the Safety Injection System.

Procedure

Ultrasonic testing and/or visual inspection will be used to inspect for general corrosion. The inspection procedure will be as specified in Calvert Cliffs Administrative Procedure MN-3-101 for Nondestructive Evaluation and Administrative Procedure MN-3-105 for Qualification of Nondestructive

Personnel and Procedures. For ultrasonic testing, two measurements will be required at separate times to calculate a corrosion rate. Corrosion rate will be determined following the procedures outlined in MN-3-202.

Requirements

Ultrasonic inspection and visual inspection for general corrosion will meet inspection personnel requirements as specified by MN-3-101. Inspection documentation will meet requirements as specified by Calvert Cliffs Administrative Procedure MN-3-303, Nondestructive Examination Report Tracking.

Acceptance Criteria

The acceptance criteria for the ultrasonic inspections will be if evidence of general corrosion is found, minimum wall thicknesses will be predicted at the end of the license renewal period and evaluated for acceptability. The acceptance criteria for visual inspections will be if evidence of general corrosion is found, will the amount of material loss affect the component function. If significant corrosion is found during the first inspection, then an Issue Report will be generated per QL-2-100. If no general corrosion is detected, then no further inspections are required.

6.4.4 Microbiologically Induced Corrosion

Sample Size

The critical location for MIC is at the sump drain system piping welds. There are assumed to be less than 200 piping joint welds in this section of piping. Therefore the maximum estimated lot size to be sampled is 200 welds. If a sample size of 22 is inspected and no evidence of MIC is found, there will be 90% confidence that 90% of the welds are not experiencing MIC [4, 20, 21, 22].

Locations

Inspect 22 pipe joint welds on the sump drain system piping. Inspect portions of this piping that are the most stagnant.

Procedure

Visual inspection will be used to determine if MIC is occurring at a particular location. The inspection procedure will be as specified in Calvert Cliffs Administrative Procedure MN-3-101 for Nondestructive Evaluation [23] and Administrative Procedure MN-3-105 for Qualification of Nondestructive Personnel and Procedures [24]. In addition, the procedure will follow visual inspection guidelines provided by ASTM G 46, Standard Guide for Examination and Evaluation Of Pitting Corrosion [25]. Guidelines from ASTM G 46 include the following:

- Document any corrosion products found.
- Clean surface to remove corrosion products and fully expose pits.
- Examine with naked eye followed by low power magnification.
- Depth of pits can be measured with micrometer or depth gage or with destructive methods such as sectioning.

<u>Requirements</u>

The visual inspection for MIC will meet inspection personnel requirements as specified by MN-3-101. Inspection documentation will meet requirements as specified by Calvert Cliffs Administrative Procedure MN-3-303, Nondestructive Examination Report Tracking [26]. No signs of MIC are expected to be discovered during the inspections. However, if evidence of corrosion is found, recommended inspection documentation items include:

- Identification of corrosion products.
- Metallurgical and surface treatments of the component and final surface finish during test.
- Environmental conditions and exposure duration.
- Appearance of corroded surface before and after cleaning.
- Component descriptions, numbers, and manufacturer.
- Characterization of pits:

    Pit size

    Pit shape

    Number of pits

    Pit depth (average and maximum)

    Pit locations

Acceptance Criteria

The acceptance criteria for the inspection will be: any measurable evidence of MIC is unacceptable. Measurable evidence of MIC is defined as a pit of at least 30 mil depth and/or typical signs of MIC, such as discoloring or tubercule formation. If evidence of MIC is found, an Issue Report will be generated per QL-2-100 [33]. If no measurable evidence of MIC is found, then no further inspections are required.

6.4.5 Stress Corrosion Cracking

Sample Size

Sampling as utilized for other ARDIs is not applicable here. SCC of the RWT is known to occur [34].

Locations

One hundred percent of all penetrations and welds are to be inspected.

Procedure

Dye penetrant testing shall be performed to determine if SCC is occurring at a particular location. The inspection procedure will be as specified in Calvert Cliffs Administrative Procedure MN-3-101 for Nondestructive Evaluation [23] and Administrative Procedure MN-3-105 for Qualification of Nondestructive Personnel and Procedures.

Requirements

The dye penetrant inspection for SCC will meet inspection personnel requirements as specified by MN-3-101. Inspection documentation will meet requirements as specified by Calvert Cliffs Administrative Procedure MN-3-303, Nondestructive Examination Report Tracking [26]. All locations where SCC is identified shall be documented.

Acceptance Criteria

Since SCC has occurred on the tank before, some SCC is expected to be found. All SCC locations identified shall be repaired by suitable means.

6.4.6 Wear

Sample Size

The total number of "more likely" locations for the occurrence of wear is:

Component	Location	Locations per component	Total number of locations
Check valve	Hanger pin	1	8
	Set of bushings	1	8
Relief valve	Nozzle ring	1	25
	Disc or disc insert	1	25
	Spindle ball bearing	1	25
TOTAL			91

The lot size to be sampled consists of 91 locations. Therefore, if a sample size of 20 is inspected and no evidence of wear is found, there will be 90% confidence that 90% of the locations are not experiencing wear [4, 20, 21, 22].

Locations

To obtain the sample size of 20, inspect the following:

One check valve (Group 052-CKV-03)

1 hanger pin

1 set of bushings

Six relief valves

6 nozzle rings

6 discs / disc inserts

6 spindle ball bearings

Total: 20 locations

Selection Guidelines

Inspect the same check valve that is inspected for crevice corrosion. Inspect relief valves with:

- Operating conditions that cause the highest number of open / close cycles
- Longest time in service
- Ease of access

Final sample selection decisions are to be made by an appropriate System Engineer who has thorough knowledge of the Safety Injection System.

Procedure

Visual inspection will be used to determine if wear is occurring at a particular location. Components will be measured to determine if critical dimensions are out of tolerance. Leakage in relief valves is a sign of component wear. The inspection procedure will be as specified in Calvert Cliffs Administrative Procedure MN-3-101 for Nondestructive Evaluation [23] and Administrative Procedure MN-3-105 for Qualification of Nondestructive Personnel and Procedures [24].

Requirements

The visual inspection for wear will meet inspection personnel requirements as specified by MN-3-101. Inspection documentation will meet requirements as specified by Calvert Cliffs Administrative Procedure MN-3-303, Nondestructive Examination Report Tracking [26].

Acceptance Criteria

If significant evidence of wear is found, an Issue Report will be generated per QL-2-100 [33].

If no evidence of wear is found, then no further inspections are required.

7

SERVICE WATER SYSTEM ARDI PROGRAM

7.1 SYSTEM DESCRIPTION

7.1.1 Operating Environment

The Service Water (SRW) system is an enclosed system that supplies cooling water to various components in the auxiliary building, the containment building, and the turbine building. The water is demineralized with a corrosion inhibitor added. The normal operating conditions for the majority of the system are: water temperature 130° F, pressure 102 psig. The maximum operating conditions are 175° F and 110 psig. Temperatures and pressures of individual components that differ from the above conditions are specified below in the component descriptions. The external environment is climate controlled atmospheric air. Flow rates can range from fairly high in operating sections of the system to stagnant conditions in idled sections.

The CCNPP Chemistry Program (CP-206 is specific to the SRW system) monitors and controls fluid chemistry in order to minimize the concentration of corrosive impurities (chlorides, oxygen) and optimizes fluid pH. Control of fluid chemistry minimizes the corrosive environment for SRW components, and limits the rate and effects of corrosion. Technical Procedure CP-206, Specifications and Surveillance: Component Cooling/Service Water System [2] controls SRW chemistry, and has the following impurity targets:

pH (@ 25°)	9.0 to 9.8
Chloride	≤ 25 parts per billion
Dissolved oxygen	≤ 5 parts per billion
Suspended solids	≤ 1000 parts per billion

In areas which are not exposed to the main flowstream, local fluid chemistry conditions may deviate from bulk fluid system chemistry. These areas include crevices and branch lines with little or no flow through them. Furthermore, the water chemistry may be outside of the target range during plant outages.

7.1.2 Piping

The Service Water piping carries water from heat exchangers cooled by the Saltwater System to components in the auxiliary building, containment building, and turbine building. The piping consists of the following types:

HB-1 Demineralized water supply piping

Normal operating conditions: 70° F, 130 psig

Maximum operating conditions: 100° F, 170 psig

Material: ASTM A106 Gr B carbon steel

Class: III

Design code: B31.1-1967

HB-18 Service water penetration piping

Normal operating conditions: 130° F, 102 psig

Maximum operating conditions: same

Material: ASTM A106 Gr B carbon steel

Class: III / MC (current)

Design code: B31.7-1969 (Class II original design)

HB-22 Service water piping (non-penetration)

Normal operating conditions: 130° F, 102 psig

Maximum operating conditions: 175° F, 110 psig

Material: ASTM A106 Gr B carbon steel

Class: III / Non-class

Design code: B31.7-1969 (Class II original design)

Joints are welded except at flanged equipment connections; joints are butt-welded on 2-1/2" and larger piping and socket-welded on 2" and smaller piping. Flanges are 150 lb ANSI standard forged carbon steel; connections are slip-on or weld neck for 12" or larger piping, weld neck for 2-1/2" to 10" piping, and socket welded on 2" and under piping. Gaskets are flexitallic, style CG, type 304 SS asbestos filler or rubber-vegetable fiber. Small bore branch piping for drain and instrument lines to the isolation valves are also included and assumed to be carbon steel.

Also included in the piping are two flow orifices (group ID 011-FO-01), one in each unit. They are constructed of stainless steel.

7.1.3 Elements

There are three types of elements included in the SRW AMRR: flow elements (011-FE-01), radiation elements (011-RE-01), and temperature elements (011-TE-01). The parts of the elements that are exposed to the SRW flowstream are composed of stainless steel. There are six flow elements in Unit 1 and seven in Unit 2. There is one radiation element in each unit. There are seven temperature elements in Unit 1 and eight in Unit 2.

7.1.4 Indicators

There are two types of temperature indicators in the SRW AMRR, both manufactured by Weston. One type, 011-TI-01, is composed of carbon steel. The other type, 011-TI-02, is composed of stainless steel. Both types consist of a temperature instrument enclosed in a thermowell that is inserted in the SRW piping. Only the thermowell is included in this ARDI. The 011-TI-01 group consists of nine indicators in Unit 1 and five indicators in Unit 2. The 011-TI-02 group consists of four indicators, all in Unit 2.

7.1.5 Pumps

The pumps in Group 011-PUMP-02 are the radiation element pumps. The pumps are centrifugal type, manufactured by Westinghouse. The pump casing, impeller, and shaft are cast iron (some pumps may have bronze impellers and shafts). The pump seal is iron. There is one pump in each unit, one for each radiation element.

7.1.6 Check Valves

The check valves included in the SRW AMRR are divided into three groups:

011-CKV-01	Duo-Chek double plate check valve
	Material: Carbon steel
	Location: Not known
	Quantity: 3 in each unit
	Included in ARDI: Body only

011-CKV-02	Duo-Chek or bolted bonnet swing check valve
	Material: Carbon steel
	Location: Upstream of Containment Air Coolers and upstream of flow into Turbine Bldg.
	Quantity: 7 in each unit
	Included in ARDI: Body and disc only
011-CKV-03	Bolted bonnet swing check valve
	Material: Carbon steel
	Location: Not known
	Quantity: 1 in Unit 1, 2 in Unit 2
	Included in ARDI: Body only

7.1.7 Control Valves

The control valves included in the SRW AMRR are divided into four groups:

011-CV-01	4", 8", and 10" - 150 lb butterfly valve
	Material: (Body) A-216 Gr. WCB or equiv. cast carbon steel
	(Shaft) Stainless steel
	Location: Throughout SRW system
	Quantity: 20 in Unit 1, 21 in Unit 2
	Included in ARDI: Body and shaft only
	Normal valve position: Open except 1CV1588, 2CV1587, and 2CV1588
011-CV-02	Butterfly valve
	Material: (Body) Cast iron
	(Disc) Stainless steel
	(Shaft) Stainless steel

(Liner) Buna-N w/steel insert

Location: Upstream of flow into Turbine Bldg.

Quantity: 2 in Unit 1, 2 in Unit 2

Included in ARDI: Body, disc, shaft, liner

Normal valve position:

011-CV-03 Plug valve

Material: (Body) Carbon steel

(Stem) Stainless steel or stellited carbon steel

Location: Upstream of SRW Head Tanks

Quantity: 2 in Unit 1, 2 in Unit 2

Included in ARDI: Body and stem only

Normal valve position: Open

The fourth group, 011-CV-04, are air-actuated control valve operators, manufactured by Bettis Actuator. They are not exposed to the SRW flowstream; the internal environment is normally clean dry air. The operator components that are critical for passive safety function capability, along with their materials of construction, are:

Cylinder, center bar, end cap, adjusting screw - Carbon steel

Piston and body - Cast iron

Piston, rod, end screw cap seals - Buna-N

Center bar seal - Copper

There are 4 operators in each unit.

7.1.8 Hand Valves

The hand valves included in the SRW AMRR are divided into eight groups:

011-HV-01 Gate or globe valve

Material: (Body/bonnet) Carbon steel

(Stem) Stainless steel

(Disc) Stellited carbon steel, stellite, or stainless steel

Location: Throughout SRW system

Quantity: 61 in Unit 1, 85 in Unit 2

Included in ARDI: Body, bonnet, stem, and disc

Normal valve position: Closed

<u>011-HV-02</u> Gate or globe valve

Material: (Body/bonnet) Carbon steel

(Stem) Stainless steel

(Disc) Carbon steel

Location: At Service Water Head Tank and other locations

Quantity: 4 in Unit 1, 6 in Unit 2

Included in ARDI: Body, bonnet, stem, and disc

Normal valve position: Closed

<u>011-HV-03</u> Gate or globe valve

Material: (Body/bonnet) Carbon steel

(Stem) Stainless steel

Location: Throughout SRW system

Quantity: 97 in Unit 1, 79 in Unit 2

Included in ARDI: Body, bonnet, and stem

Normal valve position: Open

<u>011-HV-04</u> Butterfly valve

Material: (Body/bonnet) Cast iron

(Stem) Stainless steel

(Disc) Cast iron or Ni-Resist

(Liner/seat) Bonded rubber

Location: Throughout SRW system

Quantity: 55 in Unit 1, 51 in Unit 2

Included in ARDI: Body, bonnet, stem, disc, liner, and seat

Normal valve position: Open or closed depending on system operating status

011-HV-05 Butterfly valve

Material: (Body/bonnet) Cast iron

(Stem) Stainless steel

Location: Throughout SRW system

Quantity: 8 in Unit 1, 16 in Unit 2

Included in ARDI: Body, bonnet, and stem

Normal valve position: Open

011-HV-06 Automatic vent type, manufactured by Hoffmann, Model no. 78

Material: (Base) Cast brass

(Shell) Cast brass

(Float/pin) Stainless steel

Location: Throughout SRW system

Quantity: 28 in Unit 1, 14 in Unit 2

Included in ARDI: Base, shell, float, and pin

Normal valve position:

011-HV-07 Type: Not known

Material: (Body assembly) Brass

(Stem) Stainless steel

Location: Not known

Quantity: 1 in Unit 1, 2 in Unit 2

Included in ARDI: Body assembly and stem

Normal valve position: Open

011-HV-08 Type: Not known

Material: (Body assembly) Brass

(Stem/disc assembly) Stainless steel

Location: Not known

Quantity: 1 in Unit 1, 2 in Unit 2

Included in ARDI: Body assembly, stem, and disc assembly

Normal valve position: Closed

7.1.9 Accumulators

The Service Water Head Tank is approximately 144 inches tall and 72 inches in diameter, with a wall thickness of 5/16". The tank was manufactured by Buffalo Tank. The shell and head material is A-455 Gr. A high strength carbon-manganese steel and the joints are butt welded. The flanges are A-181 Gr. I or II or A-105 carbon steel and the gaskets are Raybestos Manhattan #625 or Neoprene. There are two head tanks in each unit.

7.2 POSSIBLE LOCATION IDENTIFICATION

AMRR Overview

The Service Water System components and degradation mechanisms that require an ARDI evaluation are summarized in the table below [12]:

GROUP IDENTIFICATION NUMBER	AGE RELATED DEGRADATION MECHANISM				
	CREVICE CORROSION	EROSION CORROSION	GENERAL CORROSION	PITTING	SELECTIVE LEACHING
011-HB-01	X	X	X	X	
011-CKV-01	X		X	X	
011-CKV-02	X		X	X	
011-CKV-03	X		X	X	
011-CV-01	X		X	X	
011-CV-02	X		X	X	X
011-CV-03	X		X	X	
011-CV-04			X		
011-FE-01	X			X	
011-FO-01	X			X	
011-HV-01	X		X	X	
011-HV-02	X		X	X	
011-HV-03	X		X	X	
011-HV-04	X		X	X	X
011-HV-05	X		X	X	X
011-HV-06	X			X	X
011-HV-07	X			X	X
011-HV-08	X			X	X
011-PUMP-02	X		X	X	X
011-RE-01	X			X	
011-TE-01	X			X	
011-TI-01	X		X	X	
011-TI-02	X			X	
011-TK-01	X		X	X	

The Service Water ARDMs can be categorized as either:

1) Probable (expected to occur) and not adequately managed by existing programs or

2) Possible (not expected to occur) which may require confirmation determination or

3) Impossible (cannot occur).

All ARDMs are in Category 2 because, given the system, environment, and materials, the degradation mechanism can occur. These ARDMs require only confirmation that the ARDM is not occurring.

As stated in Section 3.2 above, crevice corrosion will generally occur before pitting corrosion if suitable crevices are present. Therefore, if the inspection for crevice corrosion finds no evidence of this degradation mechanism, pitting corrosion can also be eliminated from consideration. An inspection program will be developed only for crevice corrosion. If evidence of the mechanism is found, the need for additional pitting inspection will be reevaluated.

7.3 SELECTION OF HIGH AND LOW RISK LOCATIONS

In the table below, ARDM locations are ranked for each mechanism according to risk of occurrence as either "more likely" or "less likely". Sample locations from the "more likely" category will be inspected. If no evidence of degradation is found in this group, it will be concluded that no degradation exists in the "less likely" group. Sample sizes will be selected based on the total number of locations in the "more likely" group. Careful consideration will be given to the population size of "more likely" locations relative to a population size of the combination of "less likely" and "more likely" locations. The intent of this discrimination is to provide a biased sample which should produce results exceeding the 90%/90% statistical target. The intent is not to reduce the sample size of required inspection locations. This approach also assumes that all of the "more likely" locations selected have an equal probability of occurrence and that any of the "more likely" locations has a greater probability of occurrence than any of the "less likely" locations.

7.3.1 Crevice Corrosion

COMPONENT	LOCATION	RISK	BASIS
Piping	Butt weld	Less likely	System chemistry program limits amount of corrosive impurities; good weld quality expected.
	Socket weld	Less likely	Crevice dimensions less critical than other nearby components.
	Backing ring	Less likely	System chemistry program limits amount of corrosive impurities; backing ring usage is not standard practice so probably not present in Service Water system.

	Flow orifice flange	More likely	Gasketed flange is common location for crevice corrosion.
	Surface deposit	Less likely	Service Water system is filtered and maintained relatively free of impurities so depositing is unlikely.
TE	Threads between thermowell and pipe wall	More likely	Threaded areas are common crevice corrosion location.
FE (Annubar type)	Threads between weld coupling and probe	More likely	Threaded areas are common crevice corrosion location.
(Orifice type)	Flange	More likely	Gasketed flange is common location for crevice corrosion.
RE	Flange	More likely	Gasketed flanges are common locations for crevice corrosion.
	Detector tube / tank interface	Less likely	Construction probably doesn't create tight crevice.
Indicator	Between thermowell and pipe wall	Less likely	System chemistry program limits amount of corrosive impurities; gap probably too large for crevice corrosion to occur.
Pump	Around casing gasket	More likely	Gasketed joint is a common location for crevice corrosion.
	Impeller / shaft interface	More likely	Two part construction creates narrow crevice.
	Seal / casing interface	More likely	Two part construction creates narrow crevice.
	Surface deposit	Less likely	Service Water system is filtered and maintained relatively free of impurities so depositing is unlikely.
Check valve	Body / pressure seal cover interface	More likely	Gasketed joint is a common location for crevice corrosion.
	Body drain plug assembly	More likely	Threaded area between plug and drain provides ideal crevice; also stagnant conditions likely at this location.
	Seat / body interface	More likely	Two part construction creates narrow crevice.
	Disc swing mechanism	More likely	Suitable crevices likely in this area.
	Surface deposit	Less likely	Service Water system is filtered and maintained relatively free of impurities so

			depositing is unlikely.
Control valve	Between shaft and bushings	More likely	Stagnant area; common crevice corrosion location.
	Shaft / disc interface	More likely	Two part construction creates narrow crevice.
	Liner / shaft interface	More likely	Two part construction creates narrow crevice; corrosion more likely with one side non-metallic.
	Surface deposit	Less likely	Service Water system is filtered and maintained relatively free of impurities so depositing is unlikely.
Hand valve (Globe or Gate type)	Body / bonnet interface	More likely	Gasketed or threaded joints are common locations for crevice corrosion.
	Seat ring / body interface	More likely	Two part construction creates narrow crevice.
	Pipe thread / body interface	More likely	Threaded socket weld joint is ideal crevice corrosion site.
	Stem / bonnet interface	More likely	Packing area is ideal stagnant crevice corrosion site.
	Surface deposit	Less likely	SRW system is filtered and maintained relatively free of impurities so depositing is unlikely.
Hand valve (Butterfly type)	Between shaft and bushings	More likely	Stagnant area; common crevice corrosion location.
	Shaft / vane interface	More likely	Two part construction creates narrow crevice.
	On shaft in packing area	More likely	Narrow gap exists between shaft and packing.
	Surface deposit	Less likely	SRW system is filtered and maintained relatively free of impurities so depositing is unlikely.
Hand valve (Automatic vent type)	Between float pin and shell	More likely	Two part construction creates narrow crevice; stagnant conditions likely.
	Top O-Ring / shell interface	More likely	O-Ring joints are common locations for crevice corrosion.
	Float pin assembly	More likely	Hole / shaft assembly creates potential crevice.
	Bottom O-Ring / base / shell	More likely	O-Ring joints are common locations for crevice corrosion.

	interface		
	Pipe thread/ body interface	More likely	Threaded socket weld joint is ideal crevice corrosion site.
Accumulator	Gasketed flange joints	More likely	Gasketed joints are common locations for crevice corrosion.
	Weld flaws	Less likely	Weld flaws not expected.
	Inner shell surface flaws	Less likely	Surface flaws not expected.
	Inner shell surface deposit	Less likely	Service Water system is filtered and maintained relatively free of impurities so depositing is unlikely.

7.3.2 Pitting

COMPONENT	LOCATION	RISK	BASIS
Piping	Exposed inner surface (carbon steel piping)	Less likely	System chemistry program limits amount of corrosive impurities; carbon steel less susceptible.
	Stainless steel flow orifices	Less likely	System chemistry program limits amount of corrosive impurities; stainless steel more susceptible to pitting but flow rate should be sufficient to prevent attack.
TE	Exposed surfaces	Less likely	System chemistry program limits the amount of corrosive impurities; stainless steel more susceptible to pitting but flow rate should be sufficient to prevent attack unless located in known stagnant area.
FE	Exposed surfaces	Less likely	System chemistry program limits the amount of corrosive impurities; stainless steel more susceptible to pitting but flow rate should be sufficient to prevent attack unless located in known stagnant area.
RE	Exposed surfaces	Less likely	System chemistry program limits the amount of corrosive impurities; stainless steel more susceptible to pitting but flow rate should be sufficient to prevent attack unless located in known stagnant area.
Indicator	Exposed surfaces	Less likely	System chemistry program limits the amount of corrosive impurities; stainless steel indicators are more susceptible to

			pitting but flow rate should be sufficient to prevent attack unless located in known stagnant area.
Pump	Exposed surfaces	Less likely	Materials (cast iron / bronze) less susceptible to pitting.
Check valve	Valve internal surfaces	Less likely	Steel material is less susceptible to pitting.
Control valve	Stainless steel internals on normally closed valves	More likely	Closed valve causes stagnant conditions; stainless steel more susceptible to pitting.
	Lined or non-stainless steel surfaces; open valves	Less likely	Non-stagnant conditions; materials resistant to pitting.
Hand valve	Stainless steel internals on normally closed valves	More likely	Closed valve causes stagnant conditions; stainless steel more susceptible to pitting.
	Non-stainless steel surfaces; open valves	Less likely	Non-stagnant conditions; materials resistant to pitting.
Accumulator	Inner surface of tank (especially near waterline)	More likely	Stagnant conditions in tank.

7.3.3 General Corrosion

COMPONENT	LOCATION	RISK	BASIS
Piping	Exposed inner surface (carbon steel piping)	More likely	Carbon steel susceptible to general corrosion.
	Stainless steel flow orifices	Less likely	Stainless steel less susceptible to general corrosion.
Indicator	Exposed surfaces	Less likely	System chemistry program limits the amount of corrosive impurities; carbon steel indicators are more susceptible to general corrosion but significant material loss not expected.
Pump	Exposed surfaces	More likely	Cast iron susceptible to general corrosion.

Check valve	Steel valve internal surfaces	More likely	Carbon steel susceptible to general corrosion.
Control valve	Lined or stainless steel internals	Less likely	Stainless steel and liner less susceptible to general corrosion.
	Carbon steel or iron surfaces	More likely	Materials susceptible to general corrosion.
Hand valve	Carbon steel or iron surfaces	More likely	Materials susceptible to general corrosion.
	Stainless steel surfaces	Less likely	Materials resistant to general corrosion.
Accumulator	Inner surface of tank (especially near waterline)	More likely	Stagnant conditions in tank; carbon steel material susceptible to general corrosion.

7.3.4 Erosion Corrosion

COMPONENT	LOCATION	RISK	BASIS
Piping	Inner surface of piping near elbows, tees, etc.	More likely	Carbon steel susceptible to erosion corrosion; these areas are exposed to impingement and turbulence.
	Straight runs and stainless steel flow orifices	Less likely	Stainless steel less susceptible to general corrosion; these areas experience steady flow.

7.3.5 Selective Leaching

COMPONENT	LOCATION	RISK	BASIS
Pump	Cast iron internals	Less likely	Cast iron less susceptible to leaching.
Control valve	011-CV-02 cast iron valve body	Less likely	Cast iron less susceptible to leaching.
Hand valve	Cast iron internals	Less likely	Cast iron less susceptible to leaching.

	Brass internals	More likely	Brass more susceptible to leaching.

7.4 INSPECTION

7.4.1 Crevice Corrosion

Sample Size

The total number of "more likely" locations for the occurrence of crevice corrosion is tabulated below:

Component	Location	Locations per component	Total number of locations
Pump	Around casing gasket	1	2
	Impeller/shaft interface	1	2
	Seal/casing interface	1	2
Piping	Flow orifice flange	2	4
Check valve	Body / pressure seal cover interface	1	23
	Seat / body interface	1	23
	Disc swing mechanism	1	23
Control valve	Between shaft and bushings	2	98
	Shaft / disc interface	1	49
	Liner / shaft interface	2	98
Hand valve (Globe or gate)	Body / bonnet interface	1	338
	Seat ring / body interface	1 (assumed)	338
	Pipe thread / body interface	2	676

	Plug or wedge / stem interface	1	338
	Stem / bonnet interface	1	338
Hand valve (Butterfly)	Between shaft and bushings	2	260
	Shaft / vane interface	1	130
	On shaft in packing area	1	130
Hand valve (AVV)	Between float pin and shell	1	42
	Top O-Ring / shell interface	1	42
	Float pin assembly	1	42
	Bottom O-Ring / base / shell interface	1	42
	Pipe thread/ body interface	1	42
RE	Flange	2	4
Accumulator	Flanges	2	8
TOTAL			Over 3000

The lot size to be sampled is over 3000 surface pairs. Therefore, if a sample size of 25 is inspected and no evidence of crevice corrosion is found, there will be 90% confidence that 90% of the surface pairs are not experiencing crevice corrosion [4, 20, 21, 22].

Locations

To obtain the sample size of at least 25, the following inspections will be performed:

Two flow orifice flange faces

One check valve
    1 Body / pressure seal cover interface

1 Seat / body interface

1 Disc swing mechanism

One control valve

2 Shaft / bushing interface

1 Shaft / vane interface

2 Liner / shaft interface

One hand valve -- 1 Globe or gate (selection criteria below)

1 Body / bonnet interface

1 Seat ring / body interface

2 Pipe thread / body interface

1 Stem / bonnet interface

1 Plug or wedge / stem interface

One butterfly type hand valve

2 Shaft / bushing interface

1 Shaft / vane interface

1 Shaft in packing area

One AVV type hand valve

1 Float pin / shell interface

1 Top O-Ring / shell interface

1 Float pin assembly

1 Bottom O-Ring / base / shell interface

1 Pipe thread / body interface

One SRW head tank

1 flange

TOTAL: 26 surface pairs

This sample size of 26 is greater than the minimum required sample size of 25.

Selection guidelines

The components to be inspected will be selected based on the following criteria:

Inspect socket welds at locations in the SRW piping that are normally idled and filled with stagnant water.

Inspect check valves with:

- Longest time in service
- Ease of access

Inspect control valves with:

- Stainless steel components
- Longest time in service
- Ease of access

Inspect hand valves with:

- Longest time in service
- Highest operating temperature
- Most stagnant or lowest flow conditions
- Gasket at body / bonnet interface (instead of screwed and seal welded joint)
- Ease of access

Inspect head tank flange with:

- Longest time in service
- Ease of access

The above criteria are provided to aid the selection process. Final sample selection decisions are to be made by an appropriate system engineer who has thorough knowledge of the SRW system.

Procedure

Visual inspection will be used to determine if crevice corrosion is occurring at a particular location. The inspection procedure will be as specified in Calvert Cliffs Administrative Procedure MN-3-101 for Nondestructive Evaluation [23] and Administrative Procedure MN-3-105 for Qualification of Nondestructive Personnel and Procedures [24]. In addition, the procedure will follow visual inspection guidelines provided by ASTM G 46, Standard Guide for Examination and Evaluation Of Pitting Corrosion [25]. Guidelines from ASTM G 46 include the following:

- Document any corrosion products found.
- Clean surface to remove corrosion products and fully expose pits.
- Examine with naked eye followed by low power magnification.
- Depth of pits can be measured with micrometer or depth gage or with destructive methods such as sectioning.

Requirements

The visual inspection for crevice corrosion will meet inspection personnel requirements as specified by MN-3-101. Inspection documentation will meet requirements as specified by Calvert Cliffs Administrative Procedure MN-3-303, Nondestructive Examination Report Tracking [26]. No signs of crevice corrosion are expected to be discovered during the inspections. However, if evidence of corrosion is found, recommended inspection documentation items include:

- Identification of corrosion products.
- Metallurgical and surface treatments of the component and final surface finish during test.
- Environmental conditions and exposure duration.
- Appearance of corroded surface before and after cleaning.
- Component descriptions, numbers, and manufacturer.
- Characterization of pits:

Pit size

Pit shape

Number of pits

Pit depth (average and maximum)

Pit locations

Acceptance Criteria

The acceptance criteria for the inspection will be: any measurable evidence of crevice corrosion is unacceptable. Measurable evidence of crevice corrosion is defined as a pit of at least 30 mil depth with visible corrosion products in or around the pit.

If evidence of crevice corrosion is found, an Issue Report will be generated per QL-2-100 [33]. Inspection requirements for pitting will be reconsidered and the system boundary will need to be re-evaluated to include other potentially impacted items such as the instrument lines and other sections of the SRW system.

If no measurable evidence of crevice corrosion is found, then no further inspections are required.

7.4.2 Pitting

Crevice corrosion initiates earlier, proceeds faster, and can occur in less aggressive environments (see Figure 3-5) than pitting. On a component that contains suitable crevices, crevice corrosion will occur before pitting. All of the "more likely" locations for pitting corrosion are located in the check valves, hand valves, and head tanks, all of which contain suitable crevices for crevice corrosion. Therefore, pitting is less likely in these components than crevice corrosion. As stated above, if no crevice corrosion is found during the inspection described in Section 7.4.1, there is 90% confidence that 90% of locations are free of crevice corrosion. If pitting is less likely than crevice corrosion, then at least the same level of confidence will exist for the occurrence of pitting as for crevice corrosion. Consequently, a separate inspection plan for pitting will not be required.

7.4.3 General Corrosion

Sample Size

The total number of "more likely" locations for the occurrence of general corrosion is tabulated below:

Component	Location	Locations per component	Total number of locations
Piping	Exposed inner surface	1	1
Pump	Exposed inner surfaces	1	2
Check valve	Exposed inner surfaces (steel)	1	23
Control valve (not including 011-CV-04)	Exposed inner surfaces (non SS)	1	23
Hand valve	Exposed inner surfaces (non SS)	1	500 approx.
Tank	Inner surface	1	4
TOTAL			Over 600

The lot size to be sampled consists of over 600 surfaces. Therefore, if a sample size of 25 is inspected and no evidence of general corrosion is found, there will be 90% confidence that 90% of the surfaces are not experiencing general corrosion [4, 20, 21, 22]. General corrosion of the control valve operators (Group 011-CV-04) is considered separately because the operators are exposed to a different environment (plant instrument air). There are a total of eight operators in the SRW system scope. General corrosion is unlikely because the plant air is normally dry. Therefore, only one operator will be inspected for general corrosion.

Locations

To obtain the sample size of 25, the following inspection will be performed:

One pipe location

1 foot length all around circumference (per MN-3-202)

One check valve

1 valve body

One control valve

1 valve body

Twenty-one hand valves

21 valve piping (just upstream of valve)

One tank

1 shell

Total: 25 wall thickness measurements

Control Valve Operators: Inspect operator cylinder wall thickness.

Selection Guidelines

Components must have non-stainless steel internals. Inspect components with the longest time in service and the greatest accessibility. Final sample selection decisions are to be made by an appropriate System Engineer who has thorough knowledge of the Service Water System.

Procedure

Ultrasonic testing will be used to inspect for general corrosion. The inspection procedure will be as specified in Calvert Cliffs Administrative Procedure MN-3-101 for Nondestructive Evaluation and Administrative Procedure MN-3-105 for Qualification of Nondestructive Personnel and Procedures. Two measurements will be required at separate times to calculate a corrosion rate. Corrosion rate will be determined following the procedures outlined in MN-3-202.

Requirements

Ultrasonic inspection for general corrosion will meet inspection personnel requirements as specified by MN-3-101. Inspection documentation will meet requirements as specified by Calvert Cliffs Administrative Procedure MN-3-303, Nondestructive Examination Report Tracking.

Acceptance Criteria

The acceptance criteria for the inspections will be if evidence of general corrosion is found, minimum wall thicknesses will be predicted at the end of the license renewal period and evaluated for acceptability. If significant corrosion is found during the first inspection, then an Issue Report will be generated per QL-2-100. If no general corrosion is detected, then no further inspections are required.

7.4.4 Erosion Corrosion

Sample Size

The total number of "more likely" locations for the occurrence of erosion corrosion is:

Component	Location	Locations per component	Total number of locations
Piping	Inner surface at tees, elbows, etc.	Multiple locations	Multiple locations
TOTAL			Over 500

The SRW piping system is likely to contain a large number of tees, elbows, and locations of turbulent flow downstream of valves and other components [37]. Therefore, the lot size is estimated to be over 500, which requires a sample size of 25. If a sample size of 25 is inspected and no evidence of erosion corrosion is found, there will be 90% confidence that 90% of the surfaces are not experiencing erosion corrosion [4, 20, 21, 22].

Locations

To obtain the sample size of 25, inspect the following:

Twenty-five piping locations

7 elbows

8 tees

10 locations downstream of valves

TOTAL: 25 surfaces

Selection Guidelines

Selection criteria for piping erosion corrosion inspections should follow guidelines for erosion corrosion monitoring of other piping systems, such as in MN-3-202, Erosion Corrosion Monitoring of Secondary Piping [28]. A large section of Service Water piping is to be removed and replaced during an upcoming outage [36]. Some erosion corrosion piping inspection should be performed on the removed sections of piping (visual) and some should be performed on piping remaining in service (UT).

The above criteria are provided to aid the selection process. Final sample selection decisions are to be made by an appropriate system engineer who has thorough knowledge of the SRW system, in conjunction with the Erosion / Corrosion Engineer [28].

Procedure

Visual inspection and a series of two ultrasonic wall thickness measurements will be used to determine if erosion corrosion is occurring at a particular location. The inspection procedure will be as specified in Calvert Cliffs Administrative Procedure MN-3-101 for Nondestructive Evaluation [23] and Administrative Procedure MN-3-105 for Qualification of Nondestructive Personnel and Procedures [24].

Requirements

The visual and ultrasonic inspection for erosion corrosion will meet inspection personnel requirements as specified by MN-3-101. Inspection documentation will meet requirements as specified by Calvert Cliffs Administrative Procedure MN-3-303, Nondestructive Examination Report Tracking [26].

Acceptance Criteria

If significant evidence of erosion corrosion is found, an Issue Report will be generated per QL-2-100 [33].

If no evidence of erosion corrosion is found, then no further inspections are required.

7.4.5 Selective Leaching

Sample Size

The total number of "more likely" locations for the occurrence of selective leaching is:

Component	Location	Locations per component	Total number of locations
Hand valve	Brass body, base, or shell	1	48
TOTAL			48

The lot size to be sampled consists of 48 surfaces. Therefore, if a sample size of 17 is inspected and no evidence of selective leaching is found, there will be 90% confidence that 90% of the surfaces are not experiencing selective leaching [4, 20, 21, 22]. However, additional samples will be added to the inspection to provide a sample size of 25. The additional samples will be cast iron control valves and hand valves to ensure that selective leaching is not occurring on either brass or cast iron.

Locations

To obtain the sample size of 25, inspect the following:

Seventeen hand valves

17 brass internal surfaces

Seven hand valves

7 cast iron internal surfaces

One control valve

1 cast iron internal surface

TOTAL: 25 surfaces

Selection Guidelines

Inspect components with the longest time in service and the greatest accessibility. Final sample selection decisions are to be made by an appropriate System Engineer who has thorough knowledge of the Service Water System.

Procedure

Visual inspection will be used to determine if selective leaching is occurring at a particular location. For example, selective leaching of brass appears as a red or copper coloring in contrast to the original yellow color of the brass. The inspection procedure will be as specified in Calvert Cliffs Administrative Procedure MN-3-101 for Nondestructive Evaluation [23] and Administrative Procedure MN-3-105 for Qualification of Nondestructive Personnel and Procedures [24].

Requirements

The visual inspection for selective leaching will meet inspection personnel requirements as specified by MN-3-101. Inspection documentation will meet requirements as specified by Calvert Cliffs Administrative Procedure MN-3-303, Nondestructive Examination Report Tracking [26].

Acceptance Criteria

If significant evidence of selective leaching is found, an Issue Report will be generated per QL-2-100 [33].

If no evidence of selective leaching is found, then no further inspections are required.

8

COMPONENT COOLING WATER SYSTEM ARDI PROGRAM

8.1 SYSTEM DESCRIPTION

8.1.1 Operating Environment

The purpose of the Component Cooling Water (CCW) System is to remove heat from various power plant auxiliary systems. The Saltwater System provides the cooling medium for the CCW heat exchangers. The CCW System for each unit consists of three motor-driven CCW circulating pumps, two CCW heat exchangers, a head tank, a chemical additive tank, and associated valves, piping, instrumentation, and controls. The cooling water is demineralized with a corrosion inhibitor added. Maximum design temperature for the system is 180° F and maximum design pressure is 150 psig. Regions of low or stagnant coolant flow may exist within the system. The external environment is climate controlled atmospheric air.

The CCNPP Chemistry Program (CP-206 is specific to the Component Cooling System) monitors and controls fluid chemistry in order to minimize the concentration of corrosive impurities (chlorides, oxygen) and optimizes fluid pH. Control of fluid chemistry minimizes the corrosive environment for CCW System components, and limits the rate and effects of corrosion. Technical Procedure CP-206, Specifications and Surveillance: Component Cooling/Service Water System [2] controls CCW System chemistry, and has the following impurity targets:

pH (@ 25°)	9.0 to 9.8
Chloride	≤ 25 parts per billion
Dissolved oxygen	≤ 5 parts per billion
Suspended solids	≤ 1000 parts per billion

In areas which are not exposed to the main flowstream, local fluid chemistry conditions may deviate from bulk fluid system chemistry. These areas include crevices and branch lines with little or no flow through them. Furthermore, the water chemistry may be outside of the target range during plant outages.

8.1.2 Piping

The Component Cooling Water piping carries water from heat exchangers cooled by the Saltwater System to various auxiliary plant components. The piping consists of the following types:

HB-3 Component Cooling Water penetration piping

Normal operating conditions: 167° F, 65 psig

Maximum operating conditions: 167° F, 150 psig

Material: ASTM A106 Gr B carbon steel

Class: III / MC (current)

Design code: B31.7-1969 (Class II original design)

HB-23 Component Cooling Water piping (non-penetration)

Normal operating conditions: 167° F, 65 psig

Maximum operating conditions: 167° F, 100 psig

Material: ASTM A106 Gr B carbon steel

Class: III or Non-Class

Design code: B31.1-1967

Joints are welded except at flanged equipment connections; joints are butt-welded on 2-1/2" and larger piping and socket-welded on 2" and smaller piping. Flanges are 150 lb ANSI standard forged carbon steel; connections are slip-on or weld neck for 12" or larger piping, weld neck for 2-1/2" to 10" piping, and socket welded on 2" and under piping. Gaskets are flexitallic, style CG, type 304 SS asbestos filler or rubber-vegetable fiber. Small bore branch piping for drain and instrument lines to the isolation valves are also included and assumed to be carbon steel.

8.1.3 Automatic Vent Valves

. Characteristics of this component are summarized below:

Description: Automatic vent type, manufactured by Hoffmann, Model no. 78

Material: (Base) Cast brass

(Shell) Cast brass

(Float/pin) Stainless steel

Location: Throughout CCW system

Quantity: Not known

Included in ARDI: Base, shell, float, and pin

Normal valve position: Varies

8.1.4 Check Valves

The check valves included in the CCW System ARDI are divided into two groups:

015-CKV-01 Duo-Chek check valve

Material: (Body) Carbon steel

Location: At CCW pump discharge and other locations

Quantity: 5 in each unit

Included in ARDI: Body only

015-CKV-02 Duo-Chek check valve

Material: (Body) Carbon steel

(Disc) Carbon steel

Location: Not known

Quantity: 3 in Unit 1, 1 in Unit 2

Included in ARDI: Body and disc only

8.1.5 Control Valves

The control valves included in the CCW System ARDI are divided into five groups:

015-CV-01 Butterfly valve

Material: (Body) ASTM A126 Gr. CLB Cast iron

(Shaft) ASTM A564 Gr. 630 Stainless steel

Location: At CCW and shutdown heat exchangers

Quantity: 7 in each unit

Included in ARDI: Body and shaft only

015-CV-02 Butterfly valve

Material: (Body) Carbon steel

(Disc) Aluminum bronze or stainless steel

(Shaft) Type 17-4PH Stainless steel

(Liner) Butyl

Location: Containment isolation

Quantity: 2 in each unit

Included in ARDI: Body, disc, shaft and liner

015-CV-03 Butterfly valve

Material: (Body) Carbon steel

Location: Not known

Quantity: 1 in each unit

Included in ARDI: Body only

015-CV-04 Type not known

Material: (Body) Stainless steel

(Disc) Stellited carbon steel or stainless steel

(Stem) Stellited carbon steel or stainless steel

Location: Not known

Quantity: 2

Included in ARDI: Body, disc, and stem

015-CV-05 Butterfly valve

Material: (Body) ASTM A126 Gr. CLB Cast iron

(Shaft) ASTM A564 Gr. 630 Stainless steel

(Vane) A351 Type 316 Stainless steel

(Liner) Buna-N with steel insert

Location: Downstream of CCW heat exchangers

Quantity: 1 in each unit

Included in ARDI: Body, shaft, vane and liner

8.1.6 Hand Valves

The hand valves included in the CCW System ARDI are divided into seven groups:

015-HV-01 2" or smaller gate or globe valve

Material: (Body/bonnet) Carbon steel

(Stem) Stainless steel

(Disc) Stellited carbon steel, stellite, or stainless steel

Location: Throughout CCW system

Quantity: 92 in Unit 1, 93 in Unit 2

Included in ARDI: Body, bonnet, stem, and disc

Normal valve position: Closed

015-HV-02 2" or smaller gate valve

Material: (Body/bonnet) Carbon steel

(Stem) Stainless steel

(Disc) Carbon steel

Location: Not known

Quantity: 4 in each unit
Included in ARDI: Body, bonnet, stem, and disc

Normal valve position: Closed

015-HV-03 Gate or globe valve

Material: (Body/bonnet) Carbon steel

(Stem) Stainless steel

Location: Throughout CCW system

Quantity: 143 in Unit 1, 100 in Unit 2

Included in ARDI: Body, bonnet and stem

Normal valve position: Open

015-HV-04 Butterfly valve

Material: (Body/bonnet) Cast iron

(Stem) Stainless steel

(Disc) Cast iron or NI Resist

(Seat) Bonded rubber

Location: Not known

Quantity: 3 in Unit 1, 1 in Unit 2

Included in ARDI: Body, bonnet, stem, disc and seat

Normal valve position: Closed

015-HV-05 Butterfly valve

Material: (Body/bonnet) Cast iron

(Stem) Stainless steel

Location: Throughout CCW system

Quantity: 32 in Unit 1, 29 in Unit 2

Included in ARDI: Body, bonnet, and stem

Normal valve position: Open

015-HV-06 Globe valve

Material: (Body/yoke) Stainless steel

(Stem) Stainless steel

(Disc) Stainless steel or stellite

Location: Throughout CCW system

Quantity: 8 in Unit 1, 6 in Unit 2

Included in ARDI: Body, yoke, stem, and disc

Normal valve position: Closed

015-HV-07 Butterfly valve

Material: (Body/bonnet) Carbon steel

(Stem) Stainless steel

Location: Not known

Quantity: 1 in each unit

Included in ARDI: Body, bonnet, and stem

Normal valve position: Open

8.1.7 Radiation Elements

There is one radiation element in each unit. The detector sampling tank is joined with blind flange connections to the CCW piping. The radiation detector tube is located inside the sample tank. The components exposed to the flowstream are stainless steel.

8.1.8 Solenoid Valves

Characteristics of this component are summarized below:

Description: 2 Way diaphragm operated, pilot controlled solenoid valve, manufacturer: Automatic Switch

Material: (Body) Brass

Location: Upstream of the Waste Gas System aftercoolers

Quantity: 2

Included in ARDI: Body only

Normal valve position: Closed

8.1.9 Temperature Indicators

There are two types of temperature indicators in the CCW System ARDI, type TE and type TI. The TEs are manufactured by Rosemount, model 189-19-3, and the TIs are manufactured by Weston, model 4504. Both types consist of a temperature instrument enclosed in a carbon steel thermowell that is inserted in the CCW System piping. The thermowell is screwed into the piping well and welded. Only the thermowell is included in this ARDI. There are seven indicators in each unit.

8.1.10 Temperature Indicating Controllers

The TIC consists of a temperature instrument enclosed in a stainless steel thermowell that is inserted in the CCW System piping. The thermowell is screwed into the piping well and welded. Only the thermowell is included in this ARDI. There are two temperature indicating controllers in each unit, located at the CCW heat exchangers.

8.1.11 Tanks

The Component Cooling Water Head Tank is oriented horizontally, and is 180" long and 66" in diameter, with a wall thickness of 5/16". The tank was manufactured by Buffalo Tank. The shell and head material is A-455 Gr. A high strength carbon-manganese steel and the joints are butt welded. The flanges are A-181 Gr. I or II carbon steel and the gaskets are Raybestos Manhattan #630 or equivalent. There is one CCW head tank in each unit.

8.2 POSSIBLE LOCATION IDENTIFICATION

AMRR Overview

The Component Cooling Water System components and degradation mechanisms that require an ARDI evaluation are summarized in the table below [42]:

	AGE RELATED DEGRADATION MECHANISM					
GROUP IDENTIFICATION NUMBER	CREVICE CORROSION	EROSION CORROSION	GENERAL CORROSION	PITTING	SELECTIVE LEACHING	WEAR
015-HB-01	X	X	X	X		
015-AVV-01	X			X	X	
015-CKV-01	X		X	X		
015-CKV-02	X		X	X		X
015-CV-01	X		X	X	X	
015-CV-02	X		X	X	X	
015-CV-03	X		X	X		
015-CV-04	X			X		
015-CV-05	X		X	X	X	
015-HV-01	X		X	X		
015-HV-02	X		X	X		
015-HV-03	X		X	X		
015-HV-04	X		X	X	X	
015-HV-05	X		X	X	X	
015-HV-06	X			X		
015-HV-07	X		X	X		
015-RE-01	X			X		
015-SV-01	X			X	X	
015-TI-01	X		X	X		
015-TIC-01	X			X		

015-TK-01	X		X	X		

The Component Cooling Water ARDMs can be categorized as either:

1) Probable (expected to occur) and not adequately managed by existing programs or

2) Possible (not expected to occur) which may require confirmation determination or

3) Impossible (cannot occur).

All ARDMs are in Category 2 because, given the system, environment, and materials, the degradation mechanism can occur. These ARDMs require only confirmation that the ARDM is not occurring.

As stated in Section 3.2, crevice corrosion will generally occur before pitting corrosion if suitable crevices are present. Therefore, if the inspection for crevice corrosion finds no evidence of this degradation mechanism, pitting corrosion can also be eliminated from consideration. An inspection program will be developed only for crevice corrosion. If evidence of the mechanism is found, the need for additional pitting inspection will be reevaluated.

8.3 SELECTION OF HIGH AND LOW RISK LOCATIONS

In the table below, ARDM locations are ranked for each mechanism according to risk of occurrence as either "more likely" or "less likely". Sample locations from the "more likely" category will be inspected. If no evidence of degradation is found in this group, it will be concluded that no degradation exists in the "less likely" group. Sample sizes will be selected based on the total number of locations in the "more likely" group. Careful consideration will be given to the population size of "more likely" locations relative to a population size of the combination of "less likely" and "more likely" locations. The intent of this discrimination is to provide a biased sample which should produce results exceeding the 90%/90% statistical target. The intent is not to reduce the sample size of required inspection locations. This approach also assumes that all of the "more likely" locations selected have an equal probability of occurrence and that any of the "more likely" locations has a greater probability of occurrence than any of the "less likely" locations.

8.3.1 Crevice Corrosion

COMPONENT	LOCATION	RISK	BASIS
Piping	Butt weld	Less likely	System chemistry program limits amount of corrosive impurities; good weld quality expected.

	Socket weld	Less likely	Crevice dimensions less critical than other nearby components.
	Backing ring	Less likely	System chemistry program limits amount of corrosive impurities; backing ring usage is not standard practice so probably not present in CCW system.
	Surface deposit	Less likely	CCW system is filtered and maintained relatively free of impurities so depositing is unlikely.
AVV	Between float pin and shell	More likely	Two part construction creates narrow crevice; stagnant conditions likely.
	Top O-Ring / shell interface	More likely	O-Ring joints are common locations for crevice corrosion.
	Float pin assembly	More likely	Hole / shaft assembly creates potential crevice.
	Bottom O-Ring / base / shell interface	More likely	O-Ring joints are common locations for crevice corrosion.
	Pipe thread/ body interface	More likely	Threaded socket weld joint is ideal crevice corrosion site.
Check valve	Between pin and body	More likely	Hole / shaft assembly creates potential crevice.
	Spring mechanism	More likely	Suitable crevices likely in this area.
	Between pin and lug bearings	More likely	Hole / shaft assembly creates potential crevice.
	Surface deposit	Less likely	CCW system is filtered and maintained relatively free of impurities so depositing is unlikely.
Control valve	Between shaft and bushings	More likely	Stagnant area; common crevice corrosion location.
	Shaft / vane interface	More likely	Two part construction creates narrow crevice.
	Liner / shaft interface	More likely	Two part construction creates narrow crevice; corrosion more likely with one side non-metallic.
	On shaft in packing area	More likely	Narrow gap exists between shaft and packing.
	Surface deposit	Less likely	CCW system is filtered and maintained relatively free of impurities so depositing is unlikely.

Hand valve (Globe or Gate type)	Body / bonnet interface	More likely	Gasketed or threaded joints are common locations for crevice corrosion.
	Seat ring / body interface	More likely	Two part construction creates narrow crevice.
	Pipe thread / body interface	More likely	Threaded socket weld joint is likely crevice corrosion site.
	Stem / bonnet interface	More likely	Packing area is potential stagnant crevice corrosion site.
	Surface deposit	Less likely	CCW system is filtered and maintained relatively free of impurities so depositing is unlikely.
Hand valve (Butterfly type)	Between shaft and bushings	More likely	Stagnant area; common crevice corrosion location.
	Shaft / vane interface	More likely	Two part construction creates narrow crevice.
	On shaft in packing area	More likely	Narrow gap exists between shaft and packing.
	Surface deposit	Less likely	CCW system is filtered and maintained relatively free of impurities so depositing is unlikely.
RE	Flange	More likely	Gasketed flanges are common locations for crevice corrosion.
	Detector tube / tank interface	Less likely	Construction probably doesn't create tight crevice.
Solenoid valve	Body / bonnet interface	More likely	Gasketed or threaded joints are common locations for crevice corrosion.
	Diaphragm / body interface	More likely	Two part construction creates narrow crevice.
	Socket weld at piping joint	More likely	Socket weld joint creates tight crevice.
	Surface deposit	Less likely	CCW system is filtered and maintained relatively free of impurities so depositing is unlikely.
TI	Gap between thermowell and pipe wall	Less likely	System chemistry program limits the amount of corrosive impurities; gap probably too large for crevice corrosion to occur.
TIC	Gap between thermowell and pipe wall	Less likely	System chemistry program limits the amount of corrosive impurities; gap probably too large for crevice corrosion to occur.

Tanks	Gasketed flange joints	More likely	Gasketed joints are common locations for crevice corrosion.
	Weld flaws	Less likely	Weld flaws not expected.
	Inner shell surface flaws	Less likely	Surface flaws not expected.
	Inner shell surface deposit	Less likely	CCW system is filtered and maintained relatively free of impurities so depositing is unlikely.

8.3.2 Pitting

COMPONENT	LOCATION	RISK	BASIS
Piping	Exposed inner surface	Less likely	System chemistry program limits amount of corrosive impurities; carbon steel less susceptible.
AVV	Stainless steel components	More likely	Stainless steel more susceptible to pitting.
	Non stainless steel components	Less likely	Materials less susceptible to pitting.
Check valve	Valve internal surfaces	Less likely	Steel material is less susceptible to pitting.
Control valve	Stainless steel internals on normally closed valves	More likely	Closed valve causes stagnant conditions; stainless steel more susceptible to pitting.
	Lined or non-stainless steel surfaces; open valves	Less likely	Non-stagnant conditions; materials resistant to pitting.
Hand valve	Stainless steel internals on normally closed valves	More likely	Closed valve causes stagnant conditions; stainless steel more susceptible to pitting.
	Non-stainless steel surfaces; open valves	Less likely	Non-stagnant conditions; materials resistant to pitting.
RE	Exposed inner surface	More likely	Stainless steel material susceptible to pitting.

Solenoid valve	Exposed inner surface (brass)	Less likely	Corrosive attack considered under selective leaching.
TI	Exposed surfaces	Less likely	Carbon steel material less susceptible to pitting.
TIC	Exposed surfaces	More likely	Stainless steel material more susceptible to pitting.
Accumulator	Inner surface of tank (especially near waterline)	More likely	Stagnant conditions in tank.

8.3.3 General Corrosion

COMPONENT	LOCATION	RISK	BASIS
Piping	Exposed inner surface	More likely	Carbon steel susceptible to general corrosion.
AVV	Stainless steel components	Less likely	Stainless steel less susceptible to general corrosion.
	Non stainless steel components	More likely	Materials more susceptible to general corrosion.
Check valve	Valve internal surfaces	More likely	Steel material is more susceptible to general corrosion.
Control valve	Lined or stainless steel internals	Less likely	Stainless steel and liner less susceptible to general corrosion.
	Carbon steel or iron surfaces	More likely	Materials susceptible to general corrosion.
Hand valve	Carbon steel or iron surfaces	More likely	Materials susceptible to general corrosion.
	Stainless steel surfaces	Less likely	Materials resistant to general corrosion.
RE	Exposed inner surface	Less likely	Stainless steel material less susceptible to general corrosion.
Solenoid valve	Exposed inner surface (brass)	Less likely	Material less susceptible to general corrosion.

TI	Exposed surfaces	More likely	Carbon steel material more susceptible to general corrosion.
TIC	Exposed surfaces	Less likely	Stainless steel material less susceptible to general corrosion.
Accumulator	Inner surface of tank (especially near waterline)	More likely	Stagnant conditions in tank; carbon steel material susceptible to general corrosion.

8.3.4 Erosion Corrosion

COMPONENT	LOCATION	RISK	BASIS
Piping	Inner surface of piping near elbows, tees, etc.	More likely	Carbon steel susceptible to erosion corrosion; these areas are exposed to impingement and turbulence.
	Straight runs	Less likely	These areas experience steady flow.

8.3.5 Selective Leaching

COMPONENT	LOCATION	RISK	BASIS
AVV	Cast iron internals	Less likely	Cast iron less susceptible to leaching.
	Brass internals	More likely	Brass more susceptible to leaching.
Control valve	Cast iron valve body / alum. bronze disc	Less likely	Materials less susceptible to leaching.
Hand valve	Cast iron internals	Less likely	Cast iron less susceptible to leaching.
Solenoid valve	Inner surface of body	More likely	Brass more susceptible to leaching.

8.3.6 Wear

Only one possible location exists for wear: the disc pin and bearings on the 015-CKV-02 group of check valves. Therefore selection of more and less likely locations is not necessary.

8.4 INSPECTION

8.4.1 Crevice Corrosion

Sample Size

The total number of "more likely" locations for the occurrence of crevice corrosion is tabulated below:

Component	Location	Locations per component	Total number of locations
Piping	Socket weld	Multiple locations	Multiple locations
AVV	Between float pin and shell	1	80 approx.
	Top O-Ring / shell interface	1	80
	Float pin assembly	1	80
	Bottom O-Ring / base / shell interface	1	80
	Pipe thread/ body interface	1	80
Check valve	Between pin and body	2	28
	Spring mechanism	1	14
	Between pin and lug bearings	2	28
Control valve	Between shaft and bushings	2	48
	Shaft / vane interface	1	24
	Liner / shaft	2	48

	interface		
	On shaft in packing area	1	24
Hand valve (Globe or gate)	Body / bonnet interface	1	450
	Seat ring / body interface	1 (assumed)	450
	Pipe thread / body interface	2	900
	Plug or wedge / stem interface	1	450
	Stem / bonnet interface	1	450
Hand valve (Butterfly)	Between shaft and bushings	2	134
	Shaft / vane interface	1	67
	On shaft in packing area	1	67
RE	Flange	2	4
Solenoid valve	Body / bonnet interface	1	2
	Diaphragm / body interface	1	2
	Socket weld at piping joint	2	4
Tank	Flanges	2	4
TOTAL			Over 3500

The lot size to be sampled is over 3500 surface pairs. Therefore, if a sample size of 25 is inspected and no evidence of crevice corrosion is found, there will be 90% confidence that 90% of the surface pairs are not experiencing crevice corrosion [4, 20, 21, 22].

Locations

To obtain the sample size of at least 25, the following inspections will be performed:

One automatic vent valve

1 Float pin / shell interface

1 Top O-Ring / shell interface

1 Float pin assembly

1 Bottom O-Ring / base / shell interface

1 Pipe thread / body interface

One check valve

2 Pin / body interface

1 Spring mechanism

2 Pin / lug bearing area

One control valve

2 Shaft / bushing interface

1 Shaft / vane interface

2 Liner / shaft interface

1 Shaft in packing area

Two hand valves -- 1 Globe, 1 gate

2 Body / bonnet interface

3 Seat ring / body interface

4 Pipe thread / body interface

2 Stem / bonnet interface

2 Plug or wedge / stem interface

One butterfly type hand valve

2 Shaft / bushing interface

1 Shaft / vane interface

1 Shaft in packing area

One CCW head tank

1 flange

TOTAL: 34 surface pairs

This sample size of 34 is greater than the minimum required sample size of 25.

Selection guidelines

The components to be inspected will be selected based on the following criteria:

Inspect socket welds at locations in the CCW piping that are normally idled and filled with stagnant water.

Inspect automatic vent valves with:

- Longest time in service
- Ease of access

Inspect check valves with:

- Inspect same check valve (from Group 015-CKV-02) that is inspected for wear - see Section 8.4.6 below.
- Longest time in service
- Ease of access

Inspect control valves with:

- Stainless steel components
- Longest time in service
- Ease of access

Inspect hand valves with:

- Longest time in service
- Highest operating temperature
- Most stagnant or lowest flow conditions
- Gasket at body / bonnet interface (instead of screwed and seal welded joint)
- Ease of access

Inspect head tank flange with:

- Longest time in service
- Ease of access

The above criteria are provided to aid the selection process. Final sample selection decisions are to be made by an appropriate system engineer who has thorough knowledge of the CCW system.

Procedure

Visual inspection will be used to determine if crevice corrosion is occurring at a particular location. The inspection procedure will be as specified in Calvert Cliffs Administrative Procedure MN-3-101 for Nondestructive Evaluation [23] and Administrative Procedure MN-3-105 for Qualification of Nondestructive Personnel and Procedures [24]. In addition, the procedure will follow visual inspection guidelines provided by ASTM G 46, Standard Guide for Examination and Evaluation Of Pitting Corrosion [25]. Guidelines from ASTM G 46 include the following:

- Document any corrosion products found.
- Clean surface to remove corrosion products and fully expose pits.
- Examine with naked eye followed by low power magnification.
- Depth of pits can be measured with micrometer or depth gage or with destructive methods such as sectioning.

Requirements

The visual inspection for crevice corrosion will meet inspection personnel requirements as specified by MN-3-101. Inspection documentation will meet requirements as specified by Calvert Cliffs Administrative Procedure MN-3-303, Nondestructive Examination Report Tracking [26]. No signs of crevice corrosion are expected to be discovered during the inspections. However, if evidence of corrosion is found, recommended inspection documentation items include:

- Identification of corrosion products.
- Metallurgical and surface treatments of the component and final surface finish during test.
- Environmental conditions and exposure duration.
- Appearance of corroded surface before and after cleaning.
- Component descriptions, numbers, and manufacturer.
- Characterization of pits:

    Pit size

    Pit shape

    Number of pits

    Pit depth (average and maximum)

    Pit locations

Acceptance Criteria

The acceptance criteria for the inspection will be: any measurable evidence of crevice corrosion is unacceptable. Measurable evidence of crevice corrosion is defined as a pit of at least 30 mil depth with visible corrosion products in or around the pit.

If evidence of crevice corrosion is found, an Issue Report will be generated per QL-2-100 [33]. Inspection requirements for pitting will be reconsidered and the system boundary will need to be re-evaluated to include other potentially impacted items such as the instrument lines and other sections of the CCW system.

If no measurable evidence of crevice corrosion is found, then no further inspections are required.

8.4.2 Pitting

Crevice corrosion initiates earlier, proceeds faster, and can occur in less aggressive environments (see Figure 3-5) than pitting. On a component that contains suitable crevices, crevice corrosion will occur before pitting. All of the "more likely" locations for pitting corrosion are located in the valves, elements, and head tanks, all of which are likely to contain suitable crevices for crevice corrosion. Therefore, pitting is less likely in these components than crevice corrosion. As stated above, if no crevice corrosion is found during the inspection described in Section 8.4.1, there is 90% confidence that 90% of locations are free of crevice corrosion. If pitting is less likely than crevice corrosion, then at least the same level of confidence will exist for the occurrence of pitting as for crevice corrosion. Consequently, a separate inspection plan for pitting will not be required.

8.4.3 General Corrosion

Sample Size

The total number of "more likely" locations for the occurrence of general corrosion is tabulated below:

Component	Location	Locations per component	Total number of locations
Piping	Exposed inner surface	1	1
AVV	Non stainless steel surfaces	1	80 approx.
Check valve	Exposed inner surfaces (steel)	1	14
Control valve	Exposed inner surfaces (non SS)	1	22
Hand valve	Exposed inner surfaces (non SS)	1	500 approx.
TI	Exposed surfaces	1	14
Tank	Inner surface	1	2
TOTAL			Over 600

The lot size to be sampled consists of over 600 surfaces. Therefore, if a sample size of 25 is inspected and no evidence of general corrosion is found, there will be 90% confidence that 90% of the surfaces are not experiencing general corrosion [4, 20, 21, 22].

Locations

To obtain the sample size of 25, the following inspections will be performed:

One pipe location

1 foot length all around circumference (per MN-3-202)

Eleven automatic vent valves (AVVs)

11 shells

Eleven hand valves

11 valve piping (just upstream of valve)

Two tanks

2 shells

Total 25 wall thickness measurements

Selection Guidelines

Inspect components with the longest time in service and the greatest accessibility. Final sample selection decisions are to be made by an appropriate System Engineer who has thorough knowledge of the CCW System.

Procedure

Ultrasonic testing will be used to inspect for general corrosion. The inspection procedure will be as specified in Calvert Cliffs Administrative Procedure MN-3-101 for Nondestructive Evaluation and Administrative Procedure MN-3-105 for Qualification of Nondestructive Personnel and Procedures. Two measurements will be required at separate times to calculate a corrosion rate. Corrosion rate will be determined following the procedures outlined in MN-3-202.

Requirements

Ultrasonic inspection for general corrosion will meet inspection personnel requirements as specified by MN-3-101. Inspection documentation will meet requirements as specified by Calvert Cliffs Administrative Procedure MN-3-303, Nondestructive Examination Report Tracking.

Acceptance Criteria

The acceptance criteria for the inspections will be if evidence of general corrosion is found, minimum wall thicknesses will be predicted at the end of the license renewal period and evaluated for acceptability. If significant corrosion is found during the first inspection, then an Issue Report will be generated per QL-2-100. If no general corrosion is detected, then no further inspections are required.

8.4.4 Erosion Corrosion

Sample Size

The total number of "more likely" locations for the occurrence of erosion corrosion is:

Component	Location	Locations per component	Total number of locations
Piping	Inner surface at tees, elbows, etc.	Multiple locations	Multiple locations
TOTAL			Over 500

The CCW piping system is likely to contain a large number of tees, elbows, and locations of turbulent flow downstream of valves and other components. Therefore, the lot size is estimated to be over 500, which requires a sample size of 25. If a sample size of 25 is inspected and no evidence of erosion corrosion is found, there will be 90% confidence that 90% of the surfaces are not experiencing erosion corrosion [4, 20, 21, 22].

Locations

To obtain the sample size of 25, inspect the following:

25 piping locations

10 elbows

10 tees

5 locations downstream of valves

TOTAL: 25 surfaces

Selection Guidelines

Selection criteria for piping erosion corrosion inspections should follow guidelines for erosion corrosion monitoring of other piping systems, such as in MN-3-202, Erosion Corrosion Monitoring of Secondary Piping [28].

The above criteria are provided to aid the selection process. Final sample selection decisions are to be made by an appropriate system engineer who has thorough knowledge of the CCW system, in conjunction with the Erosion / Corrosion Engineer

Procedure

Visual inspection and/or a series of two ultrasonic wall thickness measurements will be used to determine if erosion corrosion is occurring at a particular location. The inspection procedure will be as specified in Calvert Cliffs Administrative Procedure MN-3-101 for Nondestructive Evaluation [23] and Administrative Procedure MN-3-105 for Qualification of Nondestructive Personnel and Procedures [24].

Requirements

The visual and ultrasonic inspection for erosion corrosion will meet inspection personnel requirements as specified by MN-3-101. Inspection documentation will meet requirements as specified by Calvert Cliffs Administrative Procedure MN-3-303, Nondestructive Examination Report Tracking [26].

Acceptance Criteria

If significant evidence of erosion corrosion is found, an Issue Report will be generated per QL-2-100 [33].

If no evidence of erosion corrosion is found, then no further inspections are required.

8.4.5 Selective Leaching

Sample Size

The total number of "more likely" locations for the occurrence of selective leaching is:

Component	Location	Locations per component	Total number of locations
AW	Inner surface of base	1	80 approx.

	and shell		
Solenoid valve	Inner surface of body	1	2
TOTAL			82

Based on the estimate of a total of 80 AVVs, the lot size is 82. Therefore, if a sample size of 19 is inspected and no evidence of selective leaching is found, there will be 90% confidence that 90% of the surfaces are not experiencing selective leaching [4, 20, 21, 22]. However, additional samples will be added to the inspection to provide a sample size of 25. The additional samples will be cast iron control valves and hand valves to ensure that selective leaching is not occurring on either brass or cast iron.

Locations

To obtain the sample size of 25, inspect the following:

Nineteen AVVs

19 internal surfaces

Two control valves (with cast iron internals)

2 internal surfaces

Four hand valves (with cast iron internals)

4 internal surfaces

Total: 25 surfaces

Selection Guidelines

Inspect components with the longest time in service and the greatest accessibility. Final sample selection decisions are to be made by an appropriate System Engineer who has thorough knowledge of the CCW System.

Procedure

Visual inspection will be used to determine if selective leaching is occurring at a particular location. For example, selective leaching of brass appears as a red or copper coloring in contrast to the original yellow color of the brass. The inspection procedure will be as specified in Calvert Cliffs Administrative Procedure MN-3-101 for Nondestructive Evaluation [23] and Administrative

Procedure MN-3-105 for Qualification of Nondestructive Personnel and Procedures [24].

Requirements

The visual inspection for selective leaching will meet inspection personnel requirements as specified by MN-3-101. Inspection documentation will meet requirements as specified by Calvert Cliffs Administrative Procedure MN-3-303, Nondestructive Examination Report Tracking [26].

Acceptance Criteria

If significant evidence of selective leaching is found, an Issue Report will be generated per QL-2-100 [33].

If no evidence of selective leaching is found, then no further inspections are required.

8.4.6 Wear

Sample Size

The total number of "more likely" locations for the occurrence of wear is:

Component	Location	Locations per component	Total number of locations
Check valve (015-CKV-02)	Disc pin and bearings	1	4
TOTAL			4

The lot size of 4 is too small to determine a statistically based sample size. One check valve will be inspected for wear. This sample is considered adequate because of the minimal loading of the check valve pin and bearings, which makes significant wear unlikely.

Locations

The check valve to be inspected for wear will be the same check valve (Group 015-CKV-02) that is inspected for crevice corrosion. The disc pin and bearing assembly will be disassembled and inspected for wear.

Procedure

Visual inspection will be used to determine if wear is occurring at a particular location. Significant play in the disk mechanism is indicative of wear and should be noted if found. The inspection procedure will be as specified in Calvert Cliffs Administrative Procedure MN-3-101 for Nondestructive Evaluation [23] and Administrative Procedure MN-3-105 for Qualification of Nondestructive Personnel and Procedures [24].

Requirements

The visual inspection for wear will meet inspection personnel requirements as specified by MN-3-101. Inspection documentation will meet requirements as specified by Calvert Cliffs Administrative Procedure MN-3-303, Nondestructive Examination Report Tracking [26].

Acceptance Criteria

If significant evidence of wear is found, an Issue Report will be generated per QL-2-100 [33].

If no evidence of wear is found, then no further inspections are required.

9

CONTAINMENT SPRAY SYSTEM ARDI PROGRAM

9.1 SYSTEM DESCRIPTION

9.1.1 Operating Environment

The main purpose of the Containment Spray System (CSS) is to limit containment temperature and pressure after a loss of coolant accident by spraying cold borated water from the Refueling Water Tank (RWT) into the containment atmosphere. The borated water is recirculated and cooled by the shutdown cooling heat exchangers. During normal plant operation, the CSS is maintained in a standby mode. The maximum operating conditions are 200 psig and 300° F on the suction side of the system and 500 psig and 350° F on the discharge side. The internal environment is borated water and the external environment is climate controlled atmospheric air.

The CCNPP Chemistry Program monitors and controls fluid chemistry in order to minimize the concentration of corrosive impurities. Control of fluid chemistry minimizes the corrosive environment for CSS components, and limits the rate and effects of corrosion. Technical procedure CP-204, Specifications and Surveillance: Primary Systems [14] controls the refueling water tank chemistry, and has the following impurity targets:

Chloride	<20 parts per billion
Fluoride	<20 parts per billion
Sulfate	<20 parts per billion
pH at 25C	4.3 - 10.2

In areas which are not exposed to the main flow stream, local fluid chemistry conditions may deviate from bulk fluid system chemistry. These areas include crevices and branch lines with little or no flow through them. Furthermore, the water chemistry may be outside of the target range during plant outages.

9.1.2 Piping

The piping within the scope of the Containment Spray System ARDI program consists of two piping classes: GC and HC. The piping in each class is described below:

GC-01 CSS Piping

Normal operating conditions: GC1 - 300° F, 150 psig

GC2 - 300° F, 150 psig

GC3 - 130° F, 150 psig

GC7 - 100° F, 180 psig

Material: ASTM A358 Cl. 1 or A312 Type 304 stainless steel

Schedule: 0.250", 40S

Class: II

Design code: B31.7-1969 Class II

HC-01 CSS Piping

Normal operating conditions: HC4 - 125° F, 103 psig

HC33 - 120° F, 160 psig

HC38 - 120° F

Material: ASTM A358 Cl. 1 or A312 Type 304 stainless steel

Schedule: 10S

Class: II, III, MC, or Non-class

Design code: B31.7-1969 Class II or III

Joints are welded except at flanged equipment connections; joints are butt-welded on 2-1/2" and larger piping and socket-welded on 2" and smaller piping. Gaskets are flexitallic type. Small bore branch piping for drain and instrument lines to the isolation valves are also included and assumed to be stainless steel.

9.1.3 Check Valves

The check valves included in the CSS ARDI are divided into three groups:

061-CKV-01 Swing check valve

Material: (Body/cover) A182 F316 forged stainless steel

(Studs) A193 Gr B7 Cr-Mo alloy steel

(Nuts) A194 Gr 2H carbon steel

Location: CSS Pump discharge check valves

Quantity: 2 in each unit

Included in ARDI: Body, cover, studs and nuts

061-CKV-02 Swing check valve

Material: (Body/cover) A182 F316 forged stainless steel

(Studs) A193 Gr B7 Cr-Mo alloy steel

(Nuts) A194 Gr 2H carbon steel

(Disc/seat/other internals) Stainless steel/stellite

Location: CSS header and containment check valves

Quantity: 4 in each unit

Included in ARDI: Body, bonnet, studs, nuts and internals (disc, seat, swing mechanism)

061-CKV-03 Piston check valve

Material: (Body/cover) A182 F316 forged stainless steel

(Studs) A193 Gr B7 Cr-Mo alloy steel

(Nuts) A194 Gr 2H carbon steel

Location: CSS Pump mini flow return check valve

Quantity: 2 in each unit

Included in ARDI: Body, cover, studs, and nuts

9.1.4 Control Valves

The control valves included in the CSS ARDI are divided into three groups:

061-CV-01 Plug valve

Material: (Body/bonnet) A182 F316 stainless steel

(Stem) Type 316 stainless steel

(Studs) A193 Gr B7 Cr-Mo alloy steel

(Nuts) A194 Gr 2H carbon steel

Location: CSS Header isolation control valve

Quantity: 2 in each unit

Included in ARDI: Body, bonnet, stem, studs and nuts

061-CV-02 Plug valve

Material: (Body/bonnet) A182 F316 stainless steel

(Stem) Type 316 stainless steel

(Studs) A193 Gr B7 Cr-Mo alloy steel

(Nuts) A194 Gr 2H carbon steel

Location: CSS Header filter isolation control valve

Quantity: 2 in each unit

Included in ARDI: Body, bonnet, stem, studs and nuts

061-CV-03 Plug valve

Material: (Body/bonnet) Type 316 stainless steel

(Stem) Type 316 stainless steel

(Studs) A193 Gr B7 Cr-Mo alloy steel

(Nuts) A194 Gr 2H carbon steel

Location: SDC Temp/flow control valves

Quantity: 1 in each unit

Included in ARDI: Body, bonnet, stem, studs and nuts

9.1.5 Hand Valves

The hand valves included in the CSS ARDI are divided into three groups:

061-HV-01 2" and smaller gate or globe valve

Material: (Body/bonnet) A182/A479 F316 forged stainless steel

(Stem) A564 T630 H1100 stainless steel

(Studs) Stainless steel

(Nuts) Steel

Location: CSS Instrument root valves

Quantity: 10 in Unit 1, 8 in Unit 2

Included in ARDI: Body, bonnet, stem, studs, and nuts

Normal valve position: Open

061-HV-02 2" and smaller gate or globe valve

Material: (Body/bonnet) A182 F316 or 304 or A351 CF8, CF3M or CF8M cast or forged stainless steel

(Stem) Stainless steel

(Studs) Alloy steel

(Nuts) Carbon steel

(Disc and seat) Stainless steel

Location: Throughout CSS

Quantity: 45 in Unit 1, 43 in Unit 2

Included in ARDI: Body, bonnet, stem, studs, nuts and disc/seat

Normal valve position: Closed

061-HV-04 2-1/2" and larger gate valve

Material: (Body/bonnet) A182 F316 or 304 or A351 CF8, CF3M or CF8M cast or forged stainless steel

(Stem) Stainless steel

(Studs) Alloy steel

(Nuts) Carbon steel

(Disc and seat) Stainless steel

Location: Throughout CSS

Quantity: 21 in Unit 1, 22 in Unit 2

Included in ARDI: Body, bonnet, stem, studs, nuts and disc/seat

Normal valve position: Closed

9.1.6 Relief Valves

The relief valves included in the CSS ARDI are described below:

061-RV-01 Nozzle type relief valve

Material: (Base) A479 Type 316 stainless steel

(Cylinder) A351 Gr. CF8M stainless steel
(Adjusting bolt) A479 Type 316 stainless steel

(Disc) Inconel 706

(Spindle) A479 Type 316 stainless steel

(Spring/washer) A313/A479 Type 316 stainless steel

Location: SDC recirculation to HPSI pumps

Quantity: 2 in each unit

Included in ARDI: Base, cylinder, adjusting bolt, disc, spindle, spring and washer.

9.1.7 Motor Operated Valves

The MOVs included in the CSS ARDI are described below:

061-MOV-01 Bolted bonnet gate MOV

Material: (Body/bonnet) A182 F316 forged stainless steel

(Stem) A276 Type 316 stainless steel

(Studs) A193 Gr B7 Cr-Mo alloy steel

(Nuts) A194 Gr 2H carbon steel

Location: SDC recirculation tp HPSI pumps

Quantity: 2 in each unit

Included in ARDI: Body, bonnet, stem, studs and nuts

9.1.8 Flow Elements and Flow Orifices

The CSS flow element is manufactured by Fischer & Porter. The element consists of measurement hardware and an orifice plate inserted at a flange joint in the CSS piping. Only the orifice plate is critical for passive intended function capability. The orifice plate material is 316 stainless steel. There are two flow elements in each unit.

There are two types of flow orifices considered in the CSS ARDI. Both types have an orifice plate composed of Type 304 or 316 stainless steel. There are two flow orifices in Unit 1 and four flow orifices in Unit 2.

9.1.9 Temperature Elements and Indicators

The temperature element is manufactured by Rosemount. The TE consists of a temperature instrument enclosed in a Type 316 stainless steel thermowell that is inserted in the CSS piping. The thermowell is screwed into the piping well and welded. Only the thermowell is included in this ARDI. There are two temperature elements in each unit.

The temperature indicator is manufactured by Decker & Weston Instrument. The TI consists of a temperature instrument enclosed in a Type 316 stainless steel (ASTM A182) thermowell that is inserted in and welded to the CSS piping. Only the thermowell is included in this ARDI. There are two temperature indicators in each unit.

9.1.10 Heat Exchangers

The heat exchangers included in the CSS ARDI are described below:

061-HX-01 Shutdown Cooling heat exchanger, U-Tube type, borated water and Component Cooling water service Engineers & Fabricators model CEV

Material: (Tubing) Stainless steel

(Shell assembly) A515 Gr. 70, A182 Gr. 70, A106 Gr. B and A105 Gr. II carbon steel

(Channel assembly/tubesheet) Stainless steel

(Studs) A193 Gr B7 Cr-Mo alloy steel

(Nuts) A194 Gr 2H carbon steel

(Supports) Carbon steel

Quantity: 2 in each unit

Included in ARDI: Tubing, shell assembly, channel assembly, tubesheet, studs, nuts and supports.

9.1.11 Pumps

The pumps included in the CSS ARDI are described below:

061-PUMP-01 CS Pump, single stage horizontal centrifugal type, borated water service Byron-Jackson model SMJ

Material: (Case/cover) A296 Gr. CA-15 stainless steel

(Studs) A193 Gr B7 Cr-Mo alloy steel

(Nuts) A194 Gr 2H carbon steel

(Shaft) A276 410 stainless steel

(Mechanical seal) Carbon steel / stainless steel / stellite

Quantity: 2 in each unit

Included in ARDI: Casing, cover, nuts, studs, shaft, mechanical seal

9.2 POSSIBLE LOCATION IDENTIFICATION

AMRR Overview

The Containment Spray System components and degradation mechanisms that require an ARDI evaluation are summarized in the table below [41]:

GROUP IDENTIFICATION NUMBER	AGE RELATED DEGRADATION MECHANISM		
	CREVICE CORROSION	GENERAL CORROSION	PITTING
061-CKV-01	X		X
061-CKV-02	X		X
061-CKV-03	X		X
061-CV-01	X		X
061-CV-02	X		X
061-CV-03	X		X
061-FE-01	X		X
061-FO-01	X		X
061-FO-02	X		X
061-GC-01	X		X
061-HC-01	X		X
061-HV-01	X		X
061-HV-02	X		X
061-HV-04	X		X
061-HX-01	X	X	X
061-MOV-01	X		X
061-PUMP-01	X	X	X
061-RV-01	X		X
061-TE-01	X		X
061-TI-01	X		X

The Containment Spray System ARDMs can be categorized as either:

1) Probable (expected to occur) and not adequately managed by existing programs or

2) Possible (not expected to occur) which may require confirmation determination or

3) Impossible (cannot occur).

All ARDMs are in Category 2 because, given the system, environment, and materials, the degradation mechanism can occur. These ARDMs require only confirmation that the ARDM is not occurring.

As stated in Section 3.2, crevice corrosion will generally occur before pitting corrosion if suitable crevices are present. Therefore, if the inspection for crevice corrosion finds no evidence of this degradation mechanism, pitting corrosion can also be eliminated from consideration. An inspection program will be developed only for crevice corrosion. If evidence of the mechanism is found, the need for additional pitting inspection will be reevaluated.

9.3 SELECTION OF HIGH AND LOW RISK LOCATIONS

In the tables below, ARDM locations are ranked for each mechanism according to risk of occurrence as either "more likely" or "less likely". Sample locations from the "more likely" category will be inspected. If no evidence of degradation is found in this group, it will be concluded that no degradation exists in the "less likely" group. Sample sizes will be selected based on the total number of locations in the "more likely" group. Careful consideration will be given to the population size of "more likely" locations relative to a population size of the combination of "less likely" and "more likely" locations. The intent of this discrimination is to provide a biased sample which should produce results exceeding the 90%/90% statistical target. The intent is not to reduce the sample size of required inspection locations. This approach also assumes that all of the "more likely" locations selected have an equal probability of occurrence and that any of the "more likely" locations has a greater probability of occurrence than any of the "less likely" locations.

9.3.1 Crevice Corrosion

COMPONENT	LOCATION	RISK	BASIS
Piping	Butt weld	Less likely	Good weld quality expected.
	Socket weld	Less likely	Crevice dimensions less critical than other nearby components.
	Backing ring	Less likely	Backing ring usage is not standard practice so probably not present in

			CS system.
	Surface deposit	Less likely	CS system is filtered and maintained relatively free of impurities so depositing is unlikely.
Check valve	Body / pressure seal cover interface	More likely	Gasketed joint is a common location for crevice corrosion.
	Seat / body interface	More likely	Two part construction creates narrow crevice.
	Disc swing or piston mechanism	More likely	Suitable crevices likely in this area.
	Socket welds (valve sizes 2" or under)	More likely	Suitable crevice likely at socket joint.
	Under nuts / stud & nut threads	More likely	Bolting is a common location for crevice corrosion; only slight leakage of borated water is necessary to cause corrosion of bolting.
	Surface deposit	Less likely	CS system is filtered and maintained relatively free of impurities so depositing is unlikely.
Control valve	Body / bonnet interface	More likely	Gasketed joint is a common location for crevice corrosion.
	On stem in packing area	More likely	Narrow gap exists between shaft and packing.
	Socket welds (valve sizes 2" or under)	More likely	Suitable crevice likely at socket joint.
	Under nuts / stud & nut threads	More likely	Bolting is a common location for crevice corrosion; only slight leakage of borated water is necessary to cause corrosion of bolting.
	Surface deposit	Less likely	CS system is filtered and maintained relatively free of impurities so depositing is unlikely.
Hand valve	Body / bonnet interface	More likely	Gasketed or threaded joints are common locations for crevice corrosion.

	Seat ring / body interface	More likely	Two part construction creates narrow crevice.
	Socket welds (valve sizes 2" or under)	More likely	Suitable crevice likely at socket joint.
	Stem / bonnet interface	More likely	Packing area is potential stagnant crevice corrosion site.
	Under nuts / stud & nut threads	More likely	Bolting is a common location for crevice corrosion; only slight leakage of borated water is necessary to cause corrosion of bolting.
	Wedge / stem interface	More likely	Two part construction creates narrow crevice.
	Surface deposit	Less likely	CS system is filtered and maintained relatively free of impurities so depositing is unlikely.
Relief valve	Base / cylinder interface (threads and gasket)	More likely	Threads and gasketed joints are common crevice corrosion locations.
	Spindle ball bearing	Less likely	Gaps probably too large.
	Between washers and spindle / spring	More likely	Two part construction creates narrow crevice.
	Threads between adj. bolt / cylinder	More likely	Threads are common locations for crevice corrosion.
	Socket welds	More likely	Suitable crevice likely at socket joint.
	Surface deposit	Less likely	CS system is filtered and maintained relatively free of impurities so depositing is unlikely.
MOV	Body / bonnet interface	More likely	Gasketed or threaded joints are common locations for crevice corrosion.
	Stem in packing area	More likely	Packing area is a potential stagnant crevice corrosion site.
	Seat ring / body interface	More likely	Two part construction creates narrow crevice.

	Wedge / stem interface	More likely	Two part construction creates narrow crevice.
	Under nuts / stud & nut threads	More likely	Bolting is a common location for crevice corrosion; only slight leakage of borated water is necessary to cause corrosion of bolting.
	Surface deposit	Less likely	CS system is filtered and maintained relatively free of impurities so depositing is unlikely.
FE	Around flange gasket	More likely	Gasketed joints are common crevice corrosion locations.
FO	Around flange gasket	More likely	Gasketed joints are common crevice corrosion locations.
TE	Threads between thermowell and pipe wall	More likely	Threads are common locations for crevice corrosion.
TI	Gap between thermowell and piping wall	Less likely	Gap probably too large for crevice corrosion.
HX	Between tubes and tubesheets	More likely	Crevice corrosion of heat exchangers commonly occurs at this location.
	Around channel cover flange gasket	More likely	Gasketed joints are common crevice corrosion locations.
	Around shell / tubesheet flange gasket	More likely	Gasketed joints are common crevice corrosion locations.
	Under nuts / stud & nut threads	More likely	Bolting is a common location for crevice corrosion; only slight leakage of borated water is necessary to cause corrosion of bolting.
	Surface deposit	Less likely	CS system is filtered and maintained relatively free of impurities so depositing is unlikely.
Pumps	Around case to cover gasket	More likely	Gasketed joints are common crevice corrosion locations.
	Wear ring / casing interface	More likely	Two part construction creates narrow crevice.
	Seal / cover interface	More likely	Two part construction creates narrow crevice.

	Under nuts / stud & nut threads	More likely	Bolting is a common location for crevice corrosion; only slight leakage of borated water is necessary to cause corrosion of bolting.
	Surface deposit	Less likely	CS system is filtered and maintained relatively free of impurities so depositing is unlikely.

9.3.2 Pitting

COMPONENT	LOCATION	RISK	BASIS
Piping	Exposed inner surface	More likely	Stainless steel material is susceptible to pitting.
Check valve	Stainless steel internal surfaces	More likely	Stainless steel material is susceptible to pitting.
Control valve	Stainless steel internal surfaces	More likely	Stainless steel material is susceptible to pitting.
Hand valve	Stainless steel internal surfaces	More likely	Stainless steel material is susceptible to pitting.
Relief valve	Stainless steel internal surfaces	More likely	Stainless steel material is susceptible to pitting.
MOV	Stainless steel internal surfaces	More likely	Stainless steel material is susceptible to pitting.
FE	Exposed surfaces	More likely	Stainless steel material is susceptible to pitting.
FO	Exposed surfaces	More likely	Stainless steel material is susceptible to pitting.
TE	Exposed surfaces	More likely	Stainless steel material is susceptible to pitting.
TI	Exposed surfaces	More likely	Stainless steel material is susceptible to pitting.
HX	Stainless steel components	More likely	Stainless steel material is susceptible to pitting.
Pumps	Stainless steel components	More likely	Stainless steel material is susceptible to pitting.

9.3.3 General Corrosion

COMPONENT	LOCATION	RISK	BASIS
HX	Carbon steel shell	More likely	Material susceptible to general corrosion.
Pumps	Carbon steel seal components	More likely	Material susceptible to general corrosion.

9.4 INSPECTION

9.4.1 Crevice Corrosion

Sample Size

The total number of "more likely" locations for the occurrence of crevice corrosion is tabulated below:

COMPONENT	LOCATION	LOCATIONS PER COMPONENT	TOTAL NUMBER OF LOCATIONS
Check valve	Body / pressure seal cover interface	1	16
	Seat / body interface	1	16
	Disc swing or piston mechanism	1	16
	Socket welds (valve sizes 2" or under)	2	Not known
	Under nuts / stud & nut threads	4 - 8	112
Control valve	Body / bonnet interface	1	10
	On stem in packing	1	10

	area		
	Socket welds (valve sizes 2" or under)	2	Not known
	Under nuts / stud & nut threads	4	40
Hand valve	Body / bonnet interface	1	149
	Seat ring / body interface	1 (assumed)	149
	Socket welds (valve sizes 2" or under)	2	212
	Stem / bonnet interface	1	149
	Under nuts / stud & nut threads	4	596
	Wedge / stem interface	1	149
Relief valve	Base / cylinder interface (threads and gasket)	1	4
	Between washers and spindle / spring	2	8
	Threads between adj. bolt / cylinder	1	4
	Socket welds	2	8
MOV	Body / bonnet interface	1	4
	Stem in packing area	1	4
	Seat ring / body interface	2	8

	Wedge / stem interface	1	4
	Under nuts / stud & nut threads	8	32
FE	Around flange gasket	1	4
FO	Around flange gasket	1	6
TE	Threads between thermowell and pipe wall	1	4
HX	Between tubes and tubesheets	859	3436
	Around channel cover flange gasket	1	4
	Around shell / tubesheet flange gasket	1	4
	Under nuts / stud & nut threads	Multiple locations	Multiple locations
Pumps	Around case to cover gasket	1	4
	Wear ring / casing interface	1	4
	Seal / cover interface	1	4
	Under nuts / stud & nut threads	Not known	Not known
TOTAL			Over 5100

The lot size to be sampled is over 5100 known surface pairs. Therefore, if a sample size of 25 is inspected and no evidence of crevice corrosion is found, there will be 90% confidence that 90% of the surface pairs are not experiencing crevice corrosion [4, 20, 21, 22].

Locations

To obtain the sample size of at least 25, the following inspections will be performed:

One check valve (swing type)

1 Body / pressure seal cover interface

1 Seat / body interface

1 Disc swing mechanism

8 Stud / nut

One control valve

1 Body / bonnet interface

1 Stem in packing area

4 Stud / nut

One hand valve (2" or smaller globe or gate type)

1 Body / bonnet interface

1 Seat ring / body interface

2 Socket welds

1 Stem / bonnet interface

4 Stud / nut

One flow element or orifice

1 Flange gasket

One Shutdown Cooling heat exchanger

4 Tube / tubesheet interfaces

1 Channel cover flange gasket area

1 Shell / tubesheet flange gasket area

2 Stud / nut

One Containment Spray pump

1 Case to cover gasket area

1 Wear ring / casing interface

1 Seal / cover interface

2 Stud / nut

TOTAL: 40 surface pairs

This sample size of 40 is greater than the minimum required sample size of 25.

Selection guidelines

The components to be inspected will be selected based on the following criteria:

Inspect socket welds at locations in the CSS piping that are normally idled and filled with stagnant water.

Inspect check valves with:

- Swing type configuration
- Longest time in service
- Ease of access

Inspect control valves with:

- Longest time in service
- Ease of access

Inspect hand valves with:

- Socket welds (2" or smaller)
- Longest time in service
- Highest operating temperature
- Most stagnant or lowest flow conditions
- Gasket at body / bonnet interface (instead of screwed and seal welded joint)
- Ease of access

Inspect flow orifice/element with:

- Longest time in service
- Ease of access

Inspect heat exchangers with:

- Longest time in service
- Ease of access

Inspect pumps with:

- Longest time in service
- Most often in idle condition
- Ease of access

The above criteria are provided to aid the selection process. Final sample selection decisions are to be made by an appropriate system engineer who has thorough knowledge of the CS system.

Procedure

Visual inspection will be used to determine if crevice corrosion is occurring at a particular location. The inspection procedure will be as specified in Calvert Cliffs Administrative Procedure MN-3-101 for Nondestructive Evaluation [23] and Administrative Procedure MN-3-105 for Qualification of Nondestructive Personnel and Procedures [24]. In addition, the procedure will follow visual inspection guidelines provided by ASTM G 46, Standard Guide for Examination and Evaluation Of Pitting Corrosion [25]. Guidelines from ASTM G 46 include the following:

- Document any corrosion products found.
- Clean surface to remove corrosion products and fully expose pits.
- Examine with naked eye followed by low power magnification.
- Depth of pits can be measured with micrometer or depth gage or with destructive methods such as sectioning.

Requirements

The visual inspection for crevice corrosion will meet inspection personnel requirements as specified by MN-3-101. Inspection documentation will meet requirements as specified by Calvert Cliffs Administrative Procedure MN-3-303, Nondestructive Examination Report Tracking [26]. No signs of crevice corrosion are expected to be discovered during the inspections. However, if evidence of corrosion is found, recommended inspection documentation items include:

- Identification of corrosion products.
- Metallurgical and surface treatments of the component and final surface finish during test.
- Environmental conditions and exposure duration.
- Appearance of corroded surface before and after cleaning.
- Component descriptions, numbers, and manufacturer.
- Characterization of pits:

    Pit size

    Pit shape

    Number of pits

    Pit depth (average and maximum)

    Pit locations

Acceptance Criteria

The acceptance criteria for the inspection will be: any measurable evidence of crevice corrosion is unacceptable. Measurable evidence of crevice corrosion is defined as a pit of at least 30 mil depth with visible corrosion products in or around the pit.

If evidence of crevice corrosion is found, an Issue Report will be generated per QL-2-100 [33]. Inspection requirements for pitting will be reconsidered (see Section 6.2 below) and the system boundary will need to be re-evaluated to include other potentially impacted items such as the instrument lines and other sections of the CS system.

If no measurable evidence of crevice corrosion is found, then no further inspections are required.

9.4.2 Pitting

Crevice corrosion initiates earlier, proceeds faster, and can occur in less aggressive environments (see Figure 3-5) than pitting. On a component that contains suitable crevices, crevice corrosion will occur before pitting. All of the "more likely" locations for pitting corrosion are located in the valves, elements, and head tanks, all of which are likely to contain suitable crevices for crevice corrosion. Therefore, pitting is less likely in these components than crevice corrosion. As stated above, if no crevice corrosion is found during the inspection described in Section 9.4.1, there is 90% confidence that 90% of locations are free of crevice corrosion. If pitting is less likely than crevice corrosion, then at least the same level of confidence will exist for the occurrence of pitting as for crevice corrosion. Consequently, a separate inspection plan for pitting will not be required.

9.4.3 General Corrosion

Sample Size

The total number of "more likely" locations for the occurrence of general corrosion is tabulated below:

Component	Location	Locations per component	Total number of locations
HX	Carbon steel shell	1	4
Pump	Carbon steel seal components	1	4
TOTAL			8

The lot size to be sampled consists of 8 surfaces. The lot size of 8 is too small to determine a statistically based sample size. Therefore all eight locations will be inspected.

Locations

Inspect all four heat exchanger shells and all four pump seals for general corrosion.

Procedure

Ultrasonic testing and/or visual inspection will be used to inspect for general corrosion. The inspection procedure will be as specified in Calvert Cliffs Administrative Procedure MN-3-101 for Nondestructive Evaluation and

Administrative Procedure MN-3-105 for Qualification of Nondestructive Personnel and Procedures. For ultrasonic testing, two measurements will be required at separate times to calculate a corrosion rate. Corrosion rate will be determined following the procedures outlined in MN-3-202.

Requirements

Ultrasonic inspection and visual inspection for general corrosion will meet inspection personnel requirements as specified by MN-3-101. Inspection documentation will meet requirements as specified by Calvert Cliffs Administrative Procedure MN-3-303, Nondestructive Examination Report Tracking.

Acceptance Criteria

The acceptance criteria for the ultrasonic inspections will be if evidence of general corrosion is found, minimum wall thicknesses will be predicted at the end of the license renewal period and evaluated for acceptability. The acceptance criteria for visual inspections will be if evidence of general corrosion is found, will the amount of material loss affect the component function (e.g., will seal begin to leak). If significant corrosion is found during the first inspection, then an Issue Report will be generated per QL-2-100. If no general corrosion is detected, then no further inspections are required.

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SUMMARY AND CONCLUSIONS

Five piping systems at CCNPP were evaluated for possible ARDMs. It was determined, for each piping system, in which piping components ARDMs could occur. Possible ARDM locations within the susceptible components were identified. ARDMs were categorized into one of three categories:

1) Probable (expected to occur) and not adequately managed by existing programs, or

2) Possible (not expected to occur) which may require confirmation determination, or

3) Impossible (cannot occur).

All ARDMs discussed in this report were in Category 2 because , given the system, environment, and materials, the degradation mechanism can occur. However, they are not expected to be present. These ARDMs require only confirmation that the ARDM is not occurring.

The possible locations were then ranked for each mechanism according to risk as either more likely or less likely. Sample sizes for inspection were selected based on the total number of locations in the more likely group. A required number of inspections necessary to give 90% confidence that 90% of the components do not have degradation present was then determined.

Selection guidelines, procedures, requirements, and acceptance criteria were developed for each ARDM possible at CCNPP. Many of the inspection and documentation procedures selected were those already in use, and unique to CCNPP. These selection guidelines, procedures, requirements, and acceptance criteria can be modified to be of use at other power plants.

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