BYRON 2

CONFIRMATION OF DESIGN ADEQUACY

FOR JET IMPINGEMENT EFFECTS

JULY 1986

EXECUTIVE SUMMARY

The potential effects of High Energy Line Breaks (HELB's) have been reviewed for Byron 2 with the same level of detail as was done for Byron 1. This report has been prepared as an overview and summary to document the completion of the review and to point out the significant differences between the Unit 1 and 2 analyses. Potential interactions between the various effects of HELB's, such as pressurization, flooding, and pipe whip, have been considered with jet impingement effects. However, only the jet impingement effects are covered in this report.

There are no significant differences between the equipment required for safe shutdown for Byron Unit 2 and Unit 1. However, because of the reduction in the number of breaks and some differences in location of breaks and equipment or routing of cables or piping, there may be differences in the components which could be affected by a break. The majority of these differences are jet effects which were evaluated only on Unit 1 because the break was eliminated on Unit 2. These jet effects are not specifically identified in this report because of the large number of differences. The few instances of a unique jet effect on Unit 2 equipment which did not occur on Unit 1 are covered in the report.

The Byron 2 design includes an inherent protection against the effects of jet impingement. However, a detailed review of the design is required. The procedure used to perform this review included a review of the potential effects of individual jets as well as the resultant effect of the jet on components used to safely shutdown the plant. Break locations were defined using the current methodology. Safe Shutdown components were identified and locations were compared with break locations.

The determination of potential damage was made by comparing the component locations and the break locations and defining the potential interactions. These were examined in detail as described in the text of the report.

For the potential jet impingement damage, the effect on safe shutdown was examined and, if problems existed, more detailed calculations of the jet influence and loading were completed.

The evaluations summarized here are documented fully in calculations and reports which are referenced in the report. These documents directly correspond to calculations and reports which were completed for Byron Unit 1.

Differences between equipment location and cable and pipe routings for the two units are relatively minor. In the auxiliary bulding, a design change made after submittal of the Byron 1 report added temperature sensors to prevent environmental qualification problems. The additional equipment was evaluated for jet impingement at the time of the redesign and is discussed in this report. Also, breaks in the AS and SD systems caused impingement effects for Byron Unit 2 which are different from those identified for Byron Unit 1. In Containment, a pressurizer pressure sensor was affected on Byron Unit 2 but not on Unit 1. Evaluations showed that these differences will not result in safe shutdown concerns.

As a result of this evaluation it has been demonstrated that Byron Unit 2 can be safely shutdown after a HELB considering the combined effects of jet impingement and other effects of the break and a limiting single failure. Because of the reduction in break postulation requirements, the number of potential jet effects on components has been significantly reduced. The common design basis utilized for Byron Units 1 and 2 has resulted in relatively few differences between the HELB effects on the units.

BYRON 2

Confirmation of Design Adequacy

For Jet Impingement Effects

1.0 INTRODUCTION

The design of the Byron station includes extensive separation of redundant mechanical and electrical systems to insure that plant safety will not be compromised by damage resulting from design basis events including High Energy Line Breaks (HELB's), Moderate Energy Line Breaks (MELB's), external flooding, fire, tornadoes, and turbine missiles. This confirmatory report specifically addresses the subject of potential jet impingement effects which could result from high energy line breaks. However, the approach used to incorporate separation, redundancy and diversity into the design of the safety systems provides a high degree of protection against postulated events which could damage safe shutdown equipment.

This report describes the approach taken in the design process and major design features which were incorporated as a result. A review of potential jet effects on safe shutdown components has been completed to confirm that the design approach was, indeed, effective in protecting the plant from potential jet impingement effects.

This study addresses specifically Byron Unit 2. The Byron Unit 1 Confirmatory Report submitted to the NRC in August 1984 is generally applicable to Byron Unit 2 as well as Braidwood Units 1 & 2. This document does not unnecessarily repeat the generic information provided in the Byron 1 report. Instead, sufficient background has been included to make clear the steps taken and the evaluations completed for Byron 2, the differences between the procedures used and the results of the Confirmatory Studies for the two Byron Units are reported in detail.

2.0 DEFINITIONS

Diversity - A plant feature whereby an independent, non-identical system or component is available in the event of a failure of a system or component.

Emergency Core Cooling System (ECCS) - Those systems which function, in the event of a LOCA, to prevent core damage. This includes the Safety Injection System and portions of the Chemical and Volume Control System and the Residual Heat Removal System.

Hazard Zone - A defined bounded area of the plant to be used to investigate the potential extent of damage and system failure following an event which has a physical effect which may be spatially limited (e.g., fire, HELB, missile generation). The initiating event may or may not be limited to one zone depending upon the nature of the event and the nature of the zone boundaries.

High Energy Line - A pipe line which operates during normal plant operations at temperatures in excess of 200°F and/or pressures in excess of 275 psia. Lines which operate at high energy conditions less than 2% of the system operating time are not considered high energy (Standard Review Plan Section 3.6.2).

High Energy Line Break (HELB) - A location within a piping system where, per the guidelines of Standard Review Plan (SRP) Section 3.6.2, a break is to be postulated.

HELB Zone - A hazard zone which contains a postulated HELB.

Loss of Coolant Accident (LOCA) - A HELB in the piping which forms the boundary of the reactor coolant system. For the purpose of this study large LOCA's are defined as those with a break area of greater than $1.0 ft^2$ and small LOCA's are those with a break area less than $1.0 ft^2$.

Redundancy - A plant design feature whereby an independent, functionally identical system or component is available in the event of a failure of a system or component.

Safe Shutdown - A plant condition such that:

1) The reactor can be maintained subcritical,
2) Decay heat can be removed.
3) Offsite release in excess of allowable limits is prevented.

Safe Shutdown Component - Any item of structure, equipment, cable, or piping required to maintain integrity or functionality to achieve safe shutdown following at least one postulated event scenario within the plant design basis.

Safe Shutdown Equipment - Mechanical and electrical equipment (e.g., pumps, valves, switches, instruments) required to function to achieve safe shutdown following at least one postulated event scenario within the plant design basis.

Safety Evaluation Report (SER) - The Byron Safety Evaluation Report (NUREG-0876) including Supplements 1, 2, and 3.

Separation - Physical isolation by distance or barrier of a safe shutdown system or component from a redundant component or hazards such as high energy lines.

Single Failure - Arbitrary failure of a single component to perform its safety function following a postulated initiating event (See Section 4.3)

Standard Review Plan (SRP) - NUREG-75/087. The 1981 revision of the SRP (NUREG-0800) is utilized where it provides clarification of the intent of NUREG-75/087.

3.0 BYRON DESIGN APPROACH

The Byron design includes many features which eliminate or mitigate damaging effects of postulated High Energy Line Breaks (HELB's). This is a result of a design approach which addressed the requirements of General Design Criteria (GDC) 4 of 10CFR50. This design approach followed the guidelines of Branch Technical Position APCSB 3-1 and Section 3.6.1 of the Standard Review Plan (SRP) (Reference 1). These guidelines state that plant designs should protect essential systems and components from the effects of high energy line failure. The preferred methods of protection are separation of the essential systems from high energy line breaks by an adequate distance or by structures. In the event these methods cannot be used, redundant design features which are protected should be provided. If these methods are not used restraints or barriers should be provided.

The safe shutdown systems and components in the Byron design have been separated from high energy lines and also separated from redundant systems to the extent practicable. As a result, relatively few protective restraints and barriers have been required.

4.0 CONFIRMATORY STUDY

In 1984 the Byron 1 Jet Impingement Confirmatory Study was completed to resolve questions raised by the NRC Integrated Design Inspection Team. This study extends the Byron 1 work to Byron 2. Although the design of the two units is almost identical, portions of the Confirmatory Study utilized "As-Built" information which can be unique to one unit. Also, certain changes in NRC requirements in the area of break definition resulted in a change of scope of the study.

This section furnishes an overview of the approach taken in the Byron 2 Jet Impingement evaluation and describes in detail the differences with the Byron 1 effort. Section 5 summarizes the results and provide an assessment of the differences between the two units.

4.1 SCOPE

This Confirmatory Study considers potential jets from postulated high energy line breaks (HELB's) in the Byron 2 Containment and in the Auxiliary Building. HELB's are assumed to occur in piping following the guidelines in SRP Section 3.6.2 with the following two exceptions:

1) Breaks are not postulated in the large piping in the main coolant loops of the Reactor Coolant Loops. These breaks were eliminated for the evaluation of dynamic effects because of the results of studies employing the "Leak Before Break" concept. Use of this approach was approved for use on Byron by the NRC in Reference 5.

2) Arbitrary Intermediate Breaks at low stress level locations, as provided for in the SRP Section 3.6.2, are not postulated. This modification to the SRP approach was approved by the NRC in Reference 6.

The scope of the jet impingement evaluation on Byron 2 was reduced considerably by these changes. Approximately 544 breaks were evaluated in the Byron 1 study. After elimination of the Primary Loop breaks and the Arbitrary Intermediate Breaks, 322 HELB's remained to be evaluated on Byron 2.

Components which might be used to safely shutdown the plant following a postulated HELB (as described above) are included as potential jet targets.

Safe Shutdown Success Criteria

In accordance with the requirements of GDC 4 to protect against the dynamic effects of line break, this study will show that the HELB's in question can be mitigated and the unit brought to a safe shutdown condition. The criteria for achieving safe shutdown are as follows:

1. Reactivity is controlled such that the reactor is subcritical.

2. Mechanisms are provided to remove decay heat.

3. Offsite releases of radioactivity are restricted to the limits of 10CFR100.

Safe Shutdown

Safe shutdown following a LOCA is defined as attaining cold leg recirculation using only qualified (Safety Related) equipment and instrumentation, and maintaining offsite releases within the regulatory limits. Limiting offsite radioactive releases within the regulatory limits is accomplished by maintaining at least one barrier between the radioactivity and the environment (i.e., reactor coolant pressure boundary or reactor containment).

For non-LOCA breaks, safe shutdown is defined as hot standby (T_{avg} greater than or equal to 350 degrees F, zero percent rated thermal power and k_{eff} of less than 0.99). The reactor coolant pressure boundary must be maintained intact using only qualified (Safety Related) equipment.

Cold Shutdown

Byron's licensing basis is hot shutdown, therefore, it is not necessary to demonstrate capability to reach cold shutdown conditions (reactor coolant temperature less than or equal to 200°F, 0% rated thermal power, and k_{eff} of less than or equal to 0.99) using only safety related equipment. However, the existence of a method for reaching cold shutdown without repair or replacement of equipment has been reviewed and is described in this study. Non-safety related equipment may be used to attain cold shutdown.

4.2.3 Reactivity Control

Sufficient negative reactivity can be provided for hot shutdown by rod insertion with or without a single active failure of a worst case stuck control rod. The Byron Refueling Water Storage Tank (RWST) has sufficient boron concentration to assure that reactivity can be controlled in a cold shutdown condition without use of the boric acid transfer system except in a case which combines an unfavorable core history with a single active failure of a stuck control rod. The additional boration can be achieved through operation of boric acid transfer pumps 0AB03P and 2AB03P to utilize the boric acid tank 2AB03T as a source of boration.

4.2.4 Decay Heat Removal

Decay heat can be removed from the reactor in several ways. The primary mode of heat removal is through the steam generators. The Reactor Coolant (RC) system is designed to transfer heat to the steam generators by natural circulation (if forced flow using RC pumps is not available) in all events except large break LOCA's. Following a large break LOCA event, the core is cooled by the Emergency Core Cooling System (ECCS). No active components inside containment are required to function to remove heat when using either steam generator cooldown or ECCS. Instrumentation inside containment is used to monitor the conditions and system functions, but all pumps and valves (other than check valves) which must function for heat removal are located in the Auxiliary Building or Main Steam Tunnel.

Normal cooldown with the primary system in the natural circulation mode removes heat by supplying cool auxiliary feedwater from the condensate storage tank or the essential service water system to the steam generators and employs the steam generator power operated relief valves to reject heat to the atmosphere. One operable steam generator is adequate to remove decay heat (Reference 8).

The ECCS function is to provide cooling water to the core after a LOCA. The sources of water are the accumulator tanks in containment, and the Refueling

Water Storage Tank (RWST) which is located external to the Auxiliary Building, and the containment recirculation sump which collects leakage from the break.

To bring the plant to a cold shutdown condition, the RHR system is normally used. After a non-LOCA HELB, the RHR system will take suction from the Loop 1 or 3 hot leg, cool the fluid in the RHR heat exchangers (transferring heat to the component cooling system) and reinject the fluid into the reactor coolant system cold legs. Following a LOCA, the RWST is used as a suction source followed by the use of the recirculation sump. The only active mechanical components inside containment used for cold shutdown decay heat removal are the RHR hot leg suction valves. These valves are used only in non-LOCA events.

Other options exist for removal of decay heat. Cool down to cold shutdown conditions can be accomplished by increasing the feedwater level in the steam generators with cooler water. This method eliminates the need for any active equipment inside containment to remove decay heat. This method, although available after a HELB, was not found to be required by the postulated events in the scope of this study.

It is also possible to reach cold shutdown conditions by adding cool water to the reactor vessel via the charging system and removing heat via the letdown system, the excess letdown system, or, if these paths are unavailable, the power-operated pressurizer relief valves. This cool down method (primary system feed and bleed) is included in the Byron Emergency Operating Procedures but is not necessary for any event within the scope of this study.

4.2.5 Offsite Release

To prevent offsite radioactive release, a barrier must be maintained between radioactive material such as reactor coolant and the atmosphere. For non-LOCA HELB's the reactor coolant system boundary forms this barrier. No additional barriers are required. After a LOCA, the containment integrity must be preserved. Systems which penetrate the containment must be isolated if they are open to both the primary system (or the containment atmosphere) and the atmosphere outside containment. The Containment Spray System is used to remove radionuclides from the containment atmosphere after a LOCA and to control the sump pH. The Containment Spray, as well as the Reactor Containment Fan Coolers and passive heat sinks, removes heat from the containment atmosphere to maintain containment integrity.

4.3 Single Failure Criteria

The Standard Review Plan (Reference 1) is explicit in its definition of the Single Failure Criteria for high and moderate energy line break. Section 3.6.1 refers in several places to the assumption of a "Single active component failure". This clearly refers to failure of a component which must perform an active (as opposed to passive) function to support operation of a safe shutdown system. Active components are those which must mechanically move or electrically change state to perform the required function. Examples of active components would be pumps which must run or valves which must open or close. Examples of passive components are pipes, valves which are not required to function, cables, breakers, and switches which do not change electrical state or mechanical position.

The definition of single failure in 10CFR50 Appendix A is slightly different from that in Reference 1. A footnote to the Appendix A definition indicates that passive failures of electrical equipment should be assumed and that the requirements for single passive failures of fluid systems are under review. Section 3.6.2 of Reference 1 clarifies the fluid systems single failure requirements. Under loss of offsite power conditions the uncertainty about consideration of passive electrical failures is of no significance because a single active mechanical failure (diesel generator failure) causes loss of one electrical division and bounds all potential active and passive electrical failures.

Events which do not result in loss of offsite power are less well defined with respect to single failures. Loss of an entire electrical division would require a passive failure when offsite power is not lost. Although it is believed that the intent of the SRP is to consider failure of a single active component, for the purpose of this confirmatory study, loss of an electrical division as a single failure has been considered.

4.4 Confirmation Procedure

The procedure used to confirm safe shutdown capability varies depending upon the nature of the component and the area of the plant under investigation. Some components, by their nature, may be assessed independently of other components. However, the operation of redundant system components must be evaluated in relation to other systems function in the event of component failure. These potential interactions have been considered as required. This procedure assures that a review of potential jet effects on safe shutdown components is performed.

The factors considered in the evaluation can be demonstrated by a brief listing of the major steps in the process:

1. Electrical and Mechanical equipment, and power and control cables in a defined HELB zone are assumed to be unavailable due to the specific break in the area. A matrix of damage vs. break is maintained.

2. Instruments, instrument lines, and instrument cables are located with respect to breaks and potential damage for individual breaks is determined.

3. Safe shutdown piping and supports in proximity to HELB's is evaluated for possible loading and for verification that Westinghouse System Standard Criteria (Reference 4) is not violated and that redundant safe shutdown piping is available.

4. Structural components subject to jet loading (as well as pressurization) are determined and checked for adequacy. Components such as block walls which may fail are evaluated for effects on other safe shutdown components such as those listed above.

5. For each defined break, all potential failures determined in this procedure are considered simultaneously along with the limiting Single Failure. Safe shutdown capability is then evaluated.

6. In the event safe shutdown capability cannot be shown, a more detailed review of the geometric relationship of the components and the breaks is performed to show safe shutdown capability.

If this procedure was unsuccessful a design change may have been required to meet the design basis.

4.5 Safe Shutdown Components

Components required to withstand or be protected from the effect of jet impingement have been determined by identifying equipment potentially used to reach safe shutdown, as defined in Section 4.2. It should be noted that, because of the redundancy and diversity of the Byron safety systems design, no single component or system is required for safe shutdown unless failures occur in one or more independent systems. As a result, a unique safe shutdown component list can be established for each postulated combination of initiating event and single failure. To facilitate this confirmatory study, a single list has been established which encompasses the events. If necessary, the list can be modified and edited for specific events to establish safe shutdown capability.

4.5.1 Identification of Safe Shutdown Systems

Safe shutdown systems can be categorized in several ways. A group of fluid safety systems assure the capability to remove decay heat. These systems are:

Chemical and Volume Control	(CV)
Safety Injection	(SI)
Residual Heat Removal	(RH)
Auxiliary Feedwater	(AF)

These systems are supported by two fluid support systems:

Essential Service Water	(SX)
Component Cooling	(CC)

To remove heat from the core in non-LOCA events, the Main Steam (MS) and Reactor Coolant (RC, RY) systems must retain the integrity of pressure boundaries and power operated relief valve operability to the extent that decay heat is removed.

For certain severe HELB events, portions of the Reactor Protection System must be operable to initiate mitigation.

Electrical and HVAC support systems are required to assure operability of fluid systems. The Containment Spray (CS) and HVAC systems may be required to control environmental conditions.

The systems listed here have been designed to assure that safe shutdown can be achieved following initiating events which may disable certain portions of safe shutdown systems because of the physical location or system configuration.

4.6 High Energy Lines

High Energy Lines are defined in Section 3.6.2 of the SRP (Reference 1) as those lines which, in normal plant operations, operate at conditions above 200°F and/or 275 psia for more than 2% of the system operating time. The Byron design purposely limited the number of HELB's in the Auxiliary Building to reduce the hazards associated with these lines. Startup feedwater pumps were installed to assure that Auxiliary Feedwater lines are not required during normal plant operations. Tunnels were designed to contain Main Steam, Feedwater, and Auxiliary Steam lines and to isolate them from safety related equipment.

As a result, in the Byron design, only 6 systems contain piping which qualified as high energy. These systems are:

- Reactor Coolant (RC, RY, SI Accumulators)
- Feedwater (FW)
- Main Steam (MS)
- Chemical and Volume Control (CV)
- Auxiliary Steam (AS)
- Steam Generator Blowdown (SD)

These 6 systems are designed to minimize the number of areas where safe shutdown systems and equipment could be affected by the results of a high energy line break. This is accomplished by utilizing physical separation (distance and barriers) to isolate safe shutdown systems from high energy lines, and by protective features such as pipe whip restraints and jet impingement shields to restrict or eliminate effects of high energy line breaks.

Only the last 3 of these system (CV, AS, SD) are located in the Auxiliary Building and the AS and SD routing in safety related areas is very limited.

4.7 High Energy Line Breaks

In the early phase of design, breaks were postulated in high energy systems following Reg. Guide 1.46. This resulted in breaks postulated at locations judged to potentially threaten safe shutdown components. For this confirmatory study, breaks have been postulated in accordance with the guidelines of Section 3.6.2 of the SRP (Reference 1) with the exceptions noted in Section 4.1 of this study.

4.7.1 Jet Impingement Load Definition

The potential loads and region of influence of high energy line break jet impingement can be defined using the information available in ANS 58.2 (Reference 2), and NUREG-CR/2913 (Reference 3). Jets can be classified as either subcooled, non-flashing liquid jets, or two-phase and steam jets.

ANS 58.2 is used to predict liquid jet loads. These jets are predicted from the charging portion of the CV system and the SI system accumulator piping. The CV system lines are pump discharge lines which are limited in discharge flow by the pump runout and the piping configuration. Calculations (Reference 14) demonstrated that the loads from breaks in these lines are relatively low (less than 500 lbf total). The SI accumulator line breaks could potentially result in higher loads because they are fed from a pressure vessel. However, these are located inside Containment such that they do not pose a safe shutdown hazard.

NUREG-CR/2913 provides a simplified method for determining loads due to two phase and steam jets. The range of conditions applicable to Byron is covered. Two general conclusions can be reached from the report:

1) Loads decrease rapidly as the break to target distance increases with the jet pressure becoming insignificant at some distance

between 5 and 10 pipe break diameters from the break.

2) Loads are lower than predicted by previously used methodologies at distances greater than 1 to 3 pipe break diameters (depending on break conditions).

References 2 and 3 were used to confirm that the Byron design approach has resulted in acceptable protection against the effects of high energy line breaks. When the design was reviewed it was found in many cases that the required components would not be affected by postulated jets. In these cases, a further review of the separation of redundant components was not performed since adequacy was already demonstrated. Separation of components provides additional protection against HELB and other hazards.

5.0 Results of Confirmatory Study

The differences between the evaluation results previously reported for Byron 1 in the 1984 confirmatory report and the corresponding results for Byron 2 are summarized in this section. This is done in a manner which parallels the Byron 1 work. The components in the plant were divided into categories of related components. These categories are equipment and cables, instrument lines and cables, piping and supports, and structure. Each group was reviewed to determine the extent to which the components were vulnerable to jet impingement and the potential interactions between breaks and components were identified. Then the individual breaks were reviewed to evaluate the total effect of each break on the types of components and, in turn, on the capability of the plant safety systems.

This was an efficient approach to the confirmatory effort because most equipment is not affected by HELB effects. The original layout of the plant separates physically most safe shutdown components from the HELB locations. To fully determine the effects of a break on safe shutdown, it is necessary to consider the sum effects on the types of equipment and the resultant effects on the function of safety systems. With the individual components already reviewed for all HELB effects, the results are easily found for the breaks. The process was considerably smaller in scope for Byron 2 because a number of breaks were elimiated as a result of the Arbitrary Intermediate Break and Leak Before Break programs.

Section 5.1 describes the effects of the postulated HELB's in the Auxiliary Building and Section 5.2 describes the effects of the postulated HELB's in the Containment. Appendices were included with the Byron 1 report. These were extensive calculations or summaries of calculations which contained the review of each safe shutdown component. These calculations (References 9, 10, 11, 12, 13 and 15) have also been completed for Byron 2 but are not included with this report. Results of the calculations form the basis of this section. The description of the differences between the Units includes a summary of those instances in which a component was affected by a break in Unit 2 but not in Unit 1, but not the converse. This is due to the large number of Unit 1 interactions which were eliminated because of the reduced number of breaks.

5.1 Auxiliary Building High Energy Line Breaks

Relatively few areas in the Auxiliary Building are potentially exposed to HELB's and jet impingement. The main steam, feedwater and portions of the auxiliary steam and steam generator blowdown systems are located in piping tunnels which contain no safe shutdown components.

In the Auxiliary Building, high energy portions of the Auxiliary Steam, Steam Generator Blowdown, and Chemical and Volume Control Systems are located in 19 HELB Zones. This section will summarize the effects of HELB's in the Auxiliary Building.

5.1.1 Auxiliary Steam Line Breaks

The auxiliary steam (AS) system provides low pressure (50 psig) steam for various plant process uses. The AS system is not a safe shutdown system. It is located in areas near the turbine building and in the radwaste areas. To allow routing of some large diameter AS system piping through the auxiliary building without creating a HELB hazard, a pipe tunnel is used. Since the AS system is common between Byron Units 1 and 2, the evaluation in the Byron Unit 1 confirmatory study is applicable to Byron Unit 2.

5.1.1.1 Additional Byron 2 Analysis

A design modification has been installed which interlocks temperature switches located near postulated break locations in auxiliary steam lines in the auxiliary building with the steam supply valves to limit the environmental temperature and provide automatic AS isolation.

The following safe shutdown equipment and components were identified as differences between postulated jet impingement damages for Byron Unit 2 when compared to Byron Unit 1.

- o Power Cables to steam generator power operated relief valves 2MS018B and 2MS018C
- o Power cables to AS system temperature switches
- o Pipelines 2CC32A2 and 2CC34AB3/4
- o Power cable to motor control center (MCC) 2AP42E

Safe Shutdown Evaluation

Cables which serve steam generator power operated relief valves 2MS018B and 2MS018C are identified as potential targets for Byron Unit 2. Due to assymmetry in the Byron Auxiliary building the Byron Unit 1 cables were not affected by jet impingement from AS system breaks. If two steam generator power operated relief valves are rendered inoperable because of cable damage and a single failure renders a third power operated relief valve inoperable, a single functional power operated relief valve on an unfaulted steam generator would remain operable. This would satisfy the safe shutdown requirements since only one steam generator is required to operate during safe shutdown operations. In addition, the steam generator power operated relief valves can be operated manually via hand pumps per the response to FSAR question 10.58 thereby allowing heat removal by the steam generators.

The control logic circuitry for the AS isolation valves is designed to fail safe if the signal from the temperature switches is interrupted. Therefore, if the switches or cables are rendered inoperable, safe shutdown is not adversely affected. Redundant isolation valves are also included in the design to accommodate single failures.

Component Cooling System piping 2CC32A2 and 2CC34AB3/4 supply cooling water to the boric acid system vent condenser which is not required for safe shutdown. In addition, damage to the CC lines will not degrade the performance of the component cooling system.

The loss of power to MCC 2AP42E will affect the operation of boric acid transfer pump 2AB03P. This is the only safe shutdown equipment supported by MCC 2AP42E. The pump is only required after a LOCA, therefore, it is not required after auxiliary steam line breaks. The RWST has sufficent boron concentration to assure that reactivity can be controlled in a cold shutdown condition without use of the boric acid transfer system.

5.1.2 Steam Generator Blowdown System Breaks

The steam generator blowdown (SD) system consists of lines from each steam generator which are routed from the Containment through the main steam tunnel and from the Auxiliary Building to the blowdown condenser. The SD system is not required for safe shutdown.

A postulated HELB in the SD system may affect safe shutdown capability if the steam source (Steam Generator Blowdown) is not isolated to prevent exposure of safe shutdown equipment in the Auxiliary Building to temperatures in excess of their qualification.

5.1.2.1 Additional Byron 2 Analysis

A design modification has been installed with interlock temperature switches which are located near postulated breaks on SD lines routed in the auxiliary building with a series arrangement for SD automatic isolation.

The safe shutdown equipment located in this zone are the temperature switches which are used for SD system break isolation. These switches and their associated cables have been located such that they are not affected by jet impingement. There is no safe shutdown piping in this zone. However, safe shutdown cables 2MS460 and 2MS469 were identified as potential jet impingement targets for Byron Unit 2.

Safe Shutdown Evaluation

Cables 2MS640 and 2MS649 serve steam generator power operated relief valves 2MS018A and 2MS018D. Due to assymmetry in the Byron Auxiliary building, the Byron Unit 1 cables were not affected by jet impingement from SD system breaks. If two steam generator power operated relief valves are rendered inoperable because of cable damage and a single failure renders a third power operated relief valve inoperable, a single functional Power operated relief valve on an unfaulted steam generator would remain operable. This would satisfy the safe shutdown requirements since only one steam generator is required to operate during safe shutdown operations. In addition, the steam generator power operated relief valves can be operated manually via hand pumps per the response to FSAR questing 10.58 thereby allowing heat removal by the steam generators.

5.1.3 Chemical and Volume Control System Breaks

The chemical and volume control (CV) system is a large and complex system with many functions. However, only a limited portion of the system is considered high energy and only a limited portion of the system is required to safely shutdown the plant.

The high energy portions of the CV system are from the charging pump discharge nozzle to the reactor coolant system and to the RC pump seals and the letdown flow path.

Fifty two HELB's were evaluated for the CV system for Byron Unit 1. However, due to the elimination of Arbitrary Intermediate Breaks thirty three HELB's are evaluated for Byron Unit 2. In addition, since the postulated jet impingement damages due to CV system breaks are caused primarily by terminal end breaks, equipment and components damaged for Byron Units 1 and 2 are the same. Therefore, the results of this analysis are bounded by the results of the Byron Unit 1 Confirmatory study.

5.2 Containment Building High Energy Line Breaks

In the Containment, HELB's are postulated in the Reactor Coolant System (RC, RY), the Chemical and Volume Control System (CV), the Main Steam System (MS), the Feedwater System (FW), the Steam Generator Blowdown System (SD) and the high pressure portion of the SI (Accumulator) System. Breaks in these systems will be categorized according to the effects of the initiating failure and the functions required to mitigate the break and safely shut down the plant. Breaks which cause a LOCA are classified as Reactor Coolant breaks regardless of the specific system identification of the failed piping.

5.2.1 Safe Shutdown Systems

Systems used for shutdown following a HELB inside Containment may be required for all, part, or none of the postulated events. The need for some of the systems is based on availability of other systems. Some of the more important safe shutdown systems can be shown to be unaffected by any postulated HELB's inside containment as a result of the design of the systems. In this section, uses and design features of safe shutdown systems are summarized. Those systems or system functions which are shown to be available after all HELB's will not then be repetitiously discussed for each type of break.

5.2.1.1 Main Steam (MS) System

Following a HELB, the MS System is used in conjunction with the AF System to remove decay heat. The steam generator power operated relief valves and/or safety valves are used to release steam to the atmosphere. The valves are located in the valve rooms of the Main Steam Tunnel. Equipment, instruments, and cables required for the MS system function are not located inside the containment. The MS system will be available for the applicable break cases examined in Section 5.2.2.

5.2.1.2 Feedwater (FW) System

The FW System has no active components inside containment. The only required function of the FW System following a HELB in-containment is to provide a secondary steam system pressure boundary. The FW System will fulfill its safety function for the applicable break cases examined in Section 5.2.2.

5.2.1.3 Essential Service Water (SX) System

The SX System has only one safety function which includes components inside the containment. This is the cooling water supply to the Reactor Containment

Fan Coolers (RCFC's). There are no active components inside Containment. The SX System will fulfull its safety function for the applicable break cases examined in Section 5.2.2.

5.2.1.4 Containment Spray (CS) System

The CS System is used following a LOCA. The CS System will remove heat from the Containment atmosphere and control the concentration of radiation in the Containment atmosphere both by washing the atmosphere and by controlling the containment sump pH. There are no active components inside containment. The CS system will accomplish its safety function for the applicable break cases examined in Section 5.2.2.

5.2.1.5 Residual Heat Removal (RH) System

The RH System functions in two distinct modes following a HELB Inside Containment. Following a LOCA, the RH pumps serve as low head ECCS pumps, initially taking suction from the Refueling Water Storage Tank (RWST) and subsequently from the Containment Sump (recirculation mode). Following a LOCA, RH System equipment, instrumentation, and cables inside containment are not required for safe shutdown. The RH System will fulfill its safety function for the applicable break cases examined in Section 5.2.2.

The RH System is not required to operate to achieve hot shutdown following a non-LOCA HELB event. However, following the non-LOCA HELB, the RH system may be utilized to achieve cold shutdown. In addition, the RHR loop suction valves and associated cables located inside Containment are used for cold shutdown after these events.

5.2.1.6 Reactor Coolant (RC/RY) System

The RC System is considered to include the primary system portion of the RY System and portions of other systems which are connected to the primary coolant system. The RC system can perform its safety functions of heat removal and prevention of radioactive releases since it has no active components which are required to operate during safe shutdown. For the applicable break cases in Section 5.2.2, the potential effects on integrity of the RC System have been reviewed and resolved.

5.2.1.7 Safety Injection (SI) System

The SI System includes injection paths to supply water to the RC System from the centrifugal charging pumps, safety injection pumps, and residual heat removal pumps. The SI System is used following LOCA's. The SI system will fulfill its safety function for the applicable break cases examined in Section 5.2.2.

5.2.1.8 Chemical and volume Control (CV) System

The CV System inside Containment consists of the normal charging, seal injection and letdown paths. Jet impingement effects on the CV System are addressed for the applicable break cases examined in Section 5.2.2.

5.2.1.9 Component Cooling (CC) System

The CC System has only one function inside Containment which may be required for safe shutdown. This is supply of cooling water to the Reactor Coolant Pumps (RCP's) thermal barriers. If seal injection (CV System) flow is interrupted in a non-LOCA event, the CC flow to the thermal barrier insures seal integrity and prevents leakage of primary coolant. Jet impingement effects on the CC system are addressed in the applicable non-LOCA break cases examined in Section 5.2.2.

5.2.1.10 ESF/Reactor Trip

Following a HELB, automatic reactor trip and safety system initiation will occur as required based on signals from qualified instrumentation. After the automatic functions are initiated, manual actions are taken by the plant operators based on qualified instrument readings and the Byron Emergency Operating Procedures. Each type of accident will cause a unique response of the reactor and steam supply system, and therefore requires a different set of functional instruments for automatic actions and monitored output for manual actions. For the breaks postulated in containment, ESF/Reactor Trip instrumentation will be available as required. This is summarized for the applicable breaks in Section 5.2.2.

5.2.1.11 Containment Isolation

Fluid Systems which penetrate Containment but do not have a safety function following a LOCA are automatically isolated following the break if high Containment pressure or radiation signals are generated. Containment isolation will be achieved following postulated LOCA's.

5.2.1.12 Off Gas (OG) System

The OG System is designed to maintain the free hydrogen concentration in the containment atmosphere below the flammability limit of 4.0 volume percent following a LOCA. The OG System is not adversely affected by postulated jet impingement affects.

5.2.1.13 HVAC Inside Containment

The HVAC System inside Containment consists of the Reactor Containment Fan Coolers (RCFC's). The RCFC's are supplied with cooling water by the Essential Service Water (SX) and Chilled Water (WO) Systems. Only the SX is required after a HELB. The Containment Spray system provides a backup means of heat removal from the Containment. The availability of SX water has been addressed in Section 5.2.1.3.

5.2.1.14 Auxiliary Feedwater (AF) System

The Auxiliary Feedwater System is used to supply water to the steam generators to remove decay heat either to maintain the reactor in a hot standby condition or to proceed toward cold shutdown. The AF System contains no active components inside containment.

5.2.2 Summary of Jet Impingement Effects

In this section, the postulated HELB's inside Containment are classified according to the break effects and the systems and components required for subsequent safe shutdown. For each type of break the systems required and the potential effects of jet impingement are reviewed. Single failure is considered and the resulting safe shutdown capability is reviewed to assure that jet impingement from HELB's inside Containment does not adversely affect safe shutdown.

5.2.2.1 Types of HELB's Inside Containment

The postulated HELB's inside containment have been classified into LOCA and non-LOCA events. LOCA's have been divided into three types: Large Liquid LOCA's, Small Liquid LOCA's, and Steam Space (Pressurizer) LOCA's. The non-LOCA HELB's have been divided into six types: Main Feedwater, Main Steam, Bypass Feedwater, Charging, Steam Generator Blowdown, and Safety Injection (Accumulator).

5.2.2.2 LOCA

LOCA's are those HELB events which result in a loss of primary coolant to the Containment. LOCA's which occur in liquid lines may result in a two phase blowdown while those occuring in steam lines result in steam release. LOCA's may or may not be isolable depending upon break location.

5.2.2.2.1 Large Liquid LOCA's

Large liquid LOCA's are defined as those breaks with an area of greater than 1.0 ft^2. These breaks occur in the pressurizer surge line only. All breaks in the main loop of the Reactor Coolant system have been deleted based on the Leak-Before-Break concept. Likewise, the number of breaks occuring in the pressurizer surge line have been reduced to two terminal end breaks due to the elimination of Arbitrary Intermediate Break's (AIB's). As a result, damage due to jet impingement for Byron Unit 2 are enveloped by those for Byron Unit 1.

5.2.2.2.1.1 Safe Shutdown Requirements

To bring the plant to a safe shutdown condition following a large liquid LOCA, the reactor must be tripped and necessary plant parameters monitored. Containment isolation as required to prevent offsite release must be accomplished. Heat must be removed from the containment atmosphere and decay heat must be removed from the reactor vessel. To assure that the event stays within the analyzed designed basis, break propagation must be controlled as described in Westinghouse Design Criteria SS 1.19 (Reference 4).

Pressurizer pressure and containment pressure signals will trip the reactor and initiate containment isolation and Emergency Core Cooling (ECCS). In addition, the wide range Reactor Coolant System (RCS) pressure, the Containment pressure, the Main Steam pressure, the Refueling Water Storage Tank (RWST) level, and Containment Radiation level are used to monitor the plant conditions.

Following this event, the CS system is used to cool the containment and clean the Containment atmosphere. The RCFC's are also used to cool the Containment. The OG system (Hydrogen Recombiners) may be used during the long term containment atmosphere cleanup.

Initial and long term decay heat removal is provided by the ECCS System operating initially in an injection mode (RWST), and ultimately in a recirculation mode (containment sump). For this event, the SI accumulators are required (three injecting and one spilling through break) to reflood the core as well as one of the following three systems or combinations of systems to replace core coolant boil-off:

a. one train of the residual heat removal system, or

b. one train of the high head safety injection system in conjunction with the use of one residual heat removal pump and one residual heat exchanger (of the same train as the high head safety injection system) to provide suction from the sump, or

c. one train of the charging/safety injection system in conjunction with the use of one residual heat removal pump and one residual heat exchanger (of the same train as the charging/safety injection system) to provide suction from the sump.

5.2.2.2.2 <u>Small Liquid LOCA's</u>

Small liquid LOCA's are those with a break area of less than $1.0ft^2$. These breaks are similar in effects to the large breaks except the rate of break flow, RC system depressurization, and Containment pressurization are all slower. The wide range of break sizes add to the total list of equipment and components which may be used because of the variety of options available to achieve safe shutdown. These breaks are located in the lines connected to the reactor coolant loops. Most are located in short sections of piping between the loop and an isolation valve. The RC loop bypass piping and the RTD manifold piping is located between the hot and cold legs of the loop which restricts the breaks to an area near the faulted loop. The small liquid LOCA break outside the secondary shield is in the letdown line. The effects of this break are minimized due to the flow restricting orifices in the line.

Breaks postulated to cause small liquid LOCA's are reduced by over forty percent for Byron Unit 2 when compared to Byron Unit 1 due to the elimination of Arbitrary Intermediate Breaks. This reduction in postulated break locations resulted in less safe shutdown piping, equipment and components being affected by jet impingement for Byron Unit 2 when compared to Byron Unit 1. In addition, the safe shutdown targets identified and evaluated for Byron Unit 2 were also evaluated for Byron Unit 1. Therefore, as determined for Byron Unit 1 the safe shutdown requirements for a small liquid LOCA will not be violated.

5.2.2.2.2.1 Safe Shutdown Requirements

To bring the plant to safe shutdown condition following a small liquid LOCA, the reactor must be tripped and necessary plant parameters monitored. Containment isolation must be accomplished as required to prevent offsite releases. Heat must be removed from the containment atmosphere and decay heat must be removed from the reactor vessel. To limit the severity of the event, break propagation must be restricted.

Instrumentation required for ESF initiation and for monitoring after the event are listed in Reference 7. Pressurizer pressure and containment pressure signals will trip the reactor and initiate containment isolation and emergency core cooling (ECCS). In addition, the wide range RCS pressure, Containment pressure, main steam pressure, RWST level, pressurizer level, narrow range steam generator level, core exit temperature, and containment radiation level are used to monitor the plant conditions.

Following this postulated event, the CS system may be used to cool the Containment and clean the containment atmosphere. The RCFC's are also used to cool the

Containment. The OG (Hydrogen Recombiners) system may be used during a long term containment atmosphere cleanup.

Initial and long term decay heat removal is provided by the ECCS system operating initially in an injection mode (RWST) and ultimately in a recirculation mode (containment sump). For most of these postulated events, the secondary system (steam generators) will remove decay heat also. For these events, the required flow to the reactor vessel is dependent upon break size. For the smallest breaks, the centrifugal charging pumps operating in the safety injection mode can maintain the RC system inventory. For larger breaks, the accumulators (three injecting and one spilling through the faulted line) may be required. Therefore, availability of the accumulators and one train of charging/safety injection, high head safety injection, and residual heat removal was evaluated.

5.2.2.2.3 Steam Space LOCA's

These LOCA's are postulated to occur when a pipe attached to the upper portion of the pressurizer is ruptured. This type of break can occur in the pressurizer spray line, the pressurizer Power Operated Relief Valve (PORV) lines, and the pressurizer safety valve lines. The mass flow rate is less from these breaks than an equivalent liquid break because of the reduced density of the steam. The targets affected due to steam space LOCA's for Byron Unit 2 are the same as those affected for Byron Unit 1. This is because there are no breaks deleted by the Arbitrary Intermediate Break or Leak Before Break criteria which caused steam space LOCA's. Therefore, as proven in the Byron Unit 1 Confirmatory Report safe shutdown capability will not be adversely affected by jet impingement since all the required safe shutdown systems will remain operable subsequent to the HELB.

5.2.2.2.3.1 Safe Shutdown Requirements

To bring the plant to a safe shutdown condition following a steam space LOCA, the reactor must be tripped and necessary plant parameters monitored. Containment isolation as required to prevent off-site release must be accomplished. Heat must be removed from the containment atmosphere and decay heat must be removed from the reactor vessel. As discussed in Westinghouse Design Criteria SS1.19, these breaks are allowed to cause additional primary system steam space breaks but should not cause a liquid LOCA or secondary system breaks.

Instrumentation required for ESF initiation and for monitoring after the event are listed in Reference 7. Pressurizer pressure and containment pressure signals will trip the reactor and initiate containment isolation and emergency core cooling (ECCS). In addition, the wide range RCS pressure, the containment pressure, the main steam pressure, the RWST level, the narrow range steam generator level, the core exit temperature, and containment radiation are used to monitor the plant conditions.

Following this event, the CS system is used to cool the Containment and clean the Containment atmosphere. The RCFC's are also used to cool the Containment. The OG system (Hydrogen Recombiners) may be used during long term containment atmosphere cleanup.

Initial and long term decay heat removal is provided by the ECCS operating initially in an injection mode (RWST) and ultimately in a recirculation mode (Containment sump). Also, the secondary system (steam generators) is available to remove decay heat. As was noted for the small liquid breaks, the SI components used are, to some extent, dependent on the break size and the rate and extent of primary system depressurization. The accumulators and one of the pumps (Charging, Safety Injection or RHR) are adequate to maintain RCS Inventory. The SI system, as noted in Section 5.2.1, is designed such that required equipment or instrumentation is not located inside Containment.

5.2.2.3 Non-LOCA HELB's

HELB's which do not result in a loss of primary coolant occur in the secondary coolant system (Main Steam, Feedwater, Steam Generator Blowdown) and the systems which serve the primary system (charging, Safety Injection). For these events, decay heat is removed via the Auxiliary Feedwater and Main Steam Systems (see Section 5.2.1.1 and 5.2.1.2). Because the primary coolant boundary is intact, the containment isolation function is not required.

5.2.2.3.1 Main Feedwater Line Break

The Main Feedwater lines are four 16-inch lines which supply the four steam generators. Based on the deletion of Arbitrary Intermediate Breaks only two breaks remain per loop. These are located at steam generator nozzles and at containment penetrations. The postulated breaks will cause a reduction in water level and pressure in one steam generator, and subsequently an increase in containment pressure. Due to the reduction in postulated break locations very few safe shutdown targets are impinged by HELB jets and those which are determined to incur impingement were also identified by the Byron Unit 1 Confirmatory study. Therefore, as determined for Byron Unit 1 the safe shutdown requirements for Byron Unit 2 following a Main Feedwater line break will not be violated.

5.2.2.3.1.1 Safe Shutdown Requirements

To reach a safe shutdown condition following the event, the reactor must be tripped and plant conditions monitored. Heat must be removed from the Containment atmosphere and decay heat must be removed from the reactor coolant system. The break must be confined to the secondary system and not cause a release of primary coolant.

Instrumentation required for ESF initiation and for monitoring after the event are listed in Reference 7. Main steam pressure and narrow range steam generator level provide the signals which trip the reactor and initiate ESF functions. Although the containment is isolated on high containment pressure, this is not necessary following a non-LOCA event. Containment pressure is used to monitor the plant conditions, as well as wide range RCS pressure, pressurizer level, and core exit temperature. Containment radiation is monitored to verify the HELB is not a LOCA.

The RCFC's remove containment atmosphere heat. The Containment Spray System, although it is available for heat removal, is not required following a main feedwater line break. One functional Auxiliary Feedwater train and one functional steam generator remove decay heat to maintain the reactor at hot standby conditions.

5.2.2.3.2 Main Steam Break

The four Main Steam lines transport steam from each steam generator to the various system components located in the turbine building. The number of postulated breaks occuring in the main steam lines for the Byron Unit 1 analysis were twenty, however, based on the deletion of Arbitrary Intermediate Breaks only 8 terminal end breaks (two per loop) remained and were analysed for Byron Unit 2. These break locations are postulated to occur at the steam generator nozzles and at containment penetrations. The jet impingement analyses for these breaks determined that no safe shutdown equipment and components required subsequent to a Main Steam Line Break will be damaged by the remaining breaks. Therefore the safe shutdown requirements as discussed below will not be violated and safe shutdown can be achieved.

5.2.2.3.2.1 Safe Shutdown Requirements

To reach a safe shutdown condition following this event, the reactor must be tripped and plant conditions must be monitored. Heat must be removed from the containment atmosphere and decay heat must be removed from the reactor coolant system. The break must be confined to the secondary system and not cause a release of primary coolant.

Instrumentation required for ESF initiation and for monitoring after the event are listed in Reference 7. Main steam and pressurizer pressure reductions and containment pressure increase will cause reactor trip. The containment will also be isolated but this is not necessary following this non-LOCA event. Additional parameters which are monitored are wide range RCS pressure, pressurizer level, narrow range steam generator level, core exit temperature, and containment radiation.

The RCFC's remove containment atmosphere heat. The Containment Spray System, although it is available for heat removal, is not required following a main steam break.

One functional Auxiliary Feedwater system train and one functional steam generator removes decay heat after a Main Steam line break. The charging and safety injection systems, which can be used to maintain RC system volume and boration level during shutdown, contain only piping components inside containment.

The other systems used for safe shutdown are not located in the containment.

5.2.2.3.3 Bypass Feedwater Line Break

Postulated breaks in these lines are reduced to only two per loop which are located at steam generator nozzles and at containment penetrations. These breaks are in 6-inch lines and would initially release two phase fluid, but, as the steam generator level drops this would change to steam. Therefore, the jet impingement zone of influence would be limited to 10 pipe diameters. Due to the reduction in postulated breaks and the limited jet impingement zone of influence no safe shutdown equipment and components which are required subsequent to a bypass feedwater line break will be damaged. Therefore, as determined for Byron Unit 1 the safe shutdown requirements will not be violated.

5.2.2.3.3.1 Safe Shutdown Requirements

To reach a safe shutdown condition following this event, the reactor must be tripped and plant conditions must be monitored. Heat must be removed from the containment atmosphere and decay heat must be removed from the reactor coolant system. The break must be confined to the secondary system and not cause a release of primary coolant.

Instrumentation required for ESF initiation and for monitoring after the event are listed in Reference 7. Containment pressure, main steam pressure, and the narrow range RCS temperature RTD's will provide input to trip the reactor. The Containment pressure, Main Steam pressure, wide range RCS pressure, Pressurizer level, narrow range Steam Generator level, Core Exit temperature, and Containment radiation will be used to monitor the plant condition.

The RCFC's remove containment atmosphere heat. The Containment Spray System, although it is available for heat removal, is not required following a feedwater bypass line break.

One functional Auxiliary Feedwater system train and one functional steam generator will remove decay heat after a feedwater bypass line break.

The charging and safety injection systems, which can be used to maintain RC system volume and boration during shutdown, contain only piping components inside containment.

The other systems used for safe shutdown are not located in the containment.

5.2.2.3.4 Charging Line Break

Charging line breaks are postulated on the normal charging and seal injection lines upsteam of the isolation valves at the RC system and RC pump connections. Other postulated Chemical and Volume Control (CV) System piping breaks will result in a loss of reactor coolant and were addressed in Section 5.2.2.2.2. (Small Liquid LOCA's). Based on the deletion of AIB's, Non-LOCA CV system breaks inside containment were reduced to 33 breaks from a total of 53 for Byron Unit 1. Due to this reduction in postulated break locations fewer safe shutdown equipment and components are identified as being impinged for Byron Unit 2 when compared to Byron Unit 1. In addition, the safe shutdown equipment identified for Byron Unit 2 were also analyzed for the Byron Unit 1 Confirmatory report. However, pressurizer pressure transmitter 2PT-456 may be affected by jet impingement from a charging line break for Byron Unit 2. This transmitter is not required following this type of break. Therefore, the safe shutdown requirements as presented below can be achieved subsequent to a CV system break.

5.2.2.3.4.1 Safe Shutdown Requirements

Following a charging line break, the reactor will not be automatically tripped because no ESF signal will be generated. To bring the plant to a safe shutdown condition normal plant procedures can be used. Charging is still available because two of three paths (Normal, Charging/SI, Seal Injection) will remain functional.

The RCFC's remove containment atmosphere heat. The normal feedwater system or one auxiliary feedwater train in conjunction with at least one functional steam generator remove decay heat. If the break is in the seal injection system, component cooling supply to the RC Pump thermal barriers must be provided to prevent seal damage.

Instrumentation to be available for monitoring after the break are listed in Reference 7. The containment pressure, main steam pressure, and containment radiation instrumentation are outside of the containment. Equipment, cables, and/or sensing lines for the wide range RCS pressure, pressurizer level, narrow range steam generator level, and core exit temperature are located inside containment.

5.2.2.3.5 Steam Generator Blowdown (SD) Line Break

Steam Generator Blowdown line breaks are 1 1/2 inch or 2 inch breaks in the liquid Steam Generator boundary. There were eight breaks per loop previously identified and considered for the Byron Unit 1 analyses. However, these have been reduced to four terminal end breaks per loop which are located at the steam generator nozzles and at containment penetrations. Based on their locations these breaks will not cause the impingement of safe shutdown equipment which are required to function subsequent to SD system breaks. Therefore, the safe shutdown requirements subsequent to SD system breaks will not be violated.

5.2.2.3.5.1 Safe Shutdown Requirements

Following a SD line break, the reactor will be tripped on low level in the affected Steam Generator. A normal shutdown procedure is then used because of the small size of this break.

The Main Steam pressure instrumentation is located outside the Containment. Equipment, cables, and/or sensing lines for the wide range RCS pressure, Pressurizer level, narrow range Steam Generator level, and Core Exit temperature are located inside the Containment.

The RCFC's remove Containment atmosphere heat. One Auxiliary Feedwater Train in conjunction with one functional Steam Generator will remove decay heat.

5.2.2.3.6 Safety Injection Line Break

Safety Injection line breaks are postulated to occur in the portion of piping normally pressurized by the accumulators. The pipes contain ambient temperature liquid at 700 psi. A postulated HELB occuring in SI piping does not cause reactor trip or affect equipment which are required following Safety Injection line breaks. A total 64 breaks were analyzed for Byron Unit 1, however, due to the elimination of Arbitrary Intermediate Breaks only 16 breaks remained and were evaluated for Byron Unit 2. This resulted in very little safe shutdown equipment being impacted and of those which are affected none are required to operate subsequent to a safety injection line break. Therefore, the safe shutdown requirements subsequent to a safety injection line break will not be violated.

5.2.2.3.6.1 Safe Shutdown Requirements

Following a SI line break, the reactor will not be automatically tripped because no ESF signal will result. To bring the plant to a safe shutdown condition, normal plant procedures can be used.

The RCFC's will remove the normal containment heat load. The normal feedwater system or one Auxiliary feedwater train in conjunction with one functional steam generator will remove decay heat.

The main steam pressure instrumentation is located outside containment. Equipment, cables, and/or sensing lines for the wide range RCS pressure, pressurizer level, narrow range steam generator level, and core exit temperature are located inside containment.

6.0 Conclusion

A detailed evaluation of potential jet impingement effects utilizing the current requirements for break postulation and the location and design of Unit 2 safe shutdown components and structures has demonstrated the adequacy of the Byron 2 design. Postulated jet impingement effects will not result in an inability to safely shutdown the plant.

7.0 REFERENCES

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