ARKANSAS POWER & LIGHT COMPANY
POST OFFICE BOX 551 LITTLE ROCK, ARKANSAS 72203 (501) 371-4000

August 5, 1983

2CANØ883Ø7

Director of Nuclear Reactor Regulation
ATTN: Mr. Robert A. Clark, Chief
Operating Reactors Branch #3
Division of Licensing
U. S. Nuclear Regulatory Commission
Washington, DC 20555

SUBJECT: Arkansas Nuclear One - Unit 2
Docket No. 50-368
License No. NPF-6
PPS Information Submittal

Gentlemen:

Our letter dated January 24, 1983, (2CANØ18313) outlined a seven item program for a long term and integrated evaluation of the Plant Protection System (PPS) and Engineered Safety Features Actuation System (ESFAS).

We have completed our review of the functional requirements of the ESFAS and have evaluated the consequences of spurious actuations of combinations of ESFAS. We have also completed a review of the extent to which current analyses described in the FSAR bound potential transients resulting from these postulated spurious actuations.

We have concluded that based on calculations and the information included in the FSAR/Reload Safety Analyses reports the consequences of spurious actuations of ESFAS combinations would be no more severe than scenarios previously analyzed.

The results of these studies are presented in Attachment 1. We believe that our review was comprehensive and commensurate with the importance of this program to safety. The immediate consequences of a spurious actuation of the Safety Injection System (SIS) and the Recirculation System are within previously analyzed events. However, as described in our letters dated December 28, 1982, (2CAN128219) and January 5, 1983, (2CANØ183Ø4), simultaneous actuation of these two systems starts the High Pressure Safety

A001
1/1

Injection (HPSI) pumps and closes the mini-recirculation valves from the HPSI pumps to the Refueling Water Tank (RWT). Should spurious actuation occur at operating pressure, continuous operation of the HPSI pumps would cause pump damage. In order to prevent possible damage an electrical modification was made which eliminated the automatic closure of the mini-recirculation valves upon Recirculation System actuation as described in our letter dated January 5, 1983 (2CAN018304).

In order to improve and enhance the safety of plant operations, it is our intent to restore automatic closure of the mini-recirculation valves upon Recirculation System actuation and install permanent recirculation capability around the HPSI pumps.

Very truly yours,

John R. Marshall

John R. Marshall
Manager, Licensing

JRM:JTE:ac

ATTACHMENT 1

ANALYSIS OF SPURIOUS ACTUATION OF ENGINEERED SAFETY FEATURE SYSTEMS

Table of Contents

ANALYSIS OF SPURIOUS ACTUATION OF
ENGINEERED SAFETY FEATURES SYSTEMS

Background

On December 17, 1982, an inadvertent actuation of the Engineered Safety Features Actuation System (ESFAS) occurred at San Onofre Unit 3 (SONGS-3), resulting in the initiation of all ESFAS signals with the exception of emergency feedwater (EFW). Because of the plant condition at the time of the event (Mode 5), no adverse consequences resulted. However, it was recognized that should a similar event occur with the plant at some other normal operating modes, simultaneous SIAS and RAS signals could lead to damage of both high pressure safety injection pumps without prompt operator action. This issue was partially resolved for Arkansas Nuclear One - Unit 2 (ANO-2) with the design change to remove RAS from the safety injection pump miniflow isolation valves. The NRC expressed concern to Arkansas Power and Light (AP&L) about: 1) the possibility of equipment damage that might occur as a result of other combinations of spurious ESFAS signals over the range of plant operating modes, and 2) how these events relate to those presented in the updated ANO-2 FSAR. This enclosure addresses these concerns.

Introduction

In conjunction with the comprehensive design review of the plant protection system (PPS), a separate study was initiated to evaluate mechanical system responses to multiple spurious actuation signals. The system review conducted did not consider the impact of the spurious engineered safety feature (ESF) signals concurrent with a design bases event. The safety system design basis is for single failures. The PPS design review did not identify that any combination of spurious ESF signals could result from a single failure. It is considered outside the present design basis for ANO-2 to analyze spurious signals generated as a result of multiple, diverse failures in conjunction with design basis events (DBEs). Consequently, this study considered multiple ESFAS actuations from normal operating modes.

The study has been divided into two sections. Section 1 reviews the functional requirements of the engineered safety features actuation system. Part 2 reviews the extent to which the current FSAR analyses bound the potential plant transients resulting from spurious actuation of various combinations of ESFAS signals. Sections 1 and 2 also cover equipment failures resulting from combinations of spurious signals which could be detrimental to mitigating an event or could result in a complete loss of safety function.

1.0 REVIEW OF ESFAS FUNCTIONAL REQUIREMENTS

The Plant Protective System (PPS) is comprised of two parts: the Reactor Protective System (RPS) and the Engineered Safety Features Actuation System (ESFAS). The RPS generates reactor trips and the ESFAS generates signals that actuate the Engineered Safety Features (ESFs). This study is concerned with erroneous ESFAS actuation.

The ESF contains the following seven systems:

1. Containment Isolation System (CIS)
2. Containment Spray System (CSS)
3. Containment Cooling System (CCS)
4. Safety Injection System (SIS)
5. Recirculation System (RS)
6. Main Steam Isolation (MSI)
7. Emergency Feedwater (EFW)

The following actuation signals, when appropriate conditions exist, are generated by the ESFAS:

A. Containment Isolation Actuation Signals (CIAS)
B. Containment Spray Actuation Signal (CSAS)
C. Containment Cooling Actuation Signal (CCAS)
D. Safety Injection Actuation Signal (SIAS)
E. Recirculation Actuation Signal (RAS)
F. Main Steam Isolation Signal (MSIS)
G. Emergency Feedwater Actuation Signal (EFAS)

A discussion of each signal and its appropriate actions is provided to demonstrate the various effects on the NSSS.

CIAS

The CIAS provides assurance that, if required, the containment building fluid systems will be completely isolated and any released radioactivity from a postulated accident is confined. Piping systems affected by this signal include component cooling water. Other valve actions are listed in Table 1-1. The major impact is the loss of cooling water to the reactor coolant pump (RCP) seals and motors. If component cooling water is not restored, tripping of the RCPs by the operator will be required. Thus, CIAS can lead to a decreased reactor coolant flow event.

CSAS

The function of the containment sprays is to provide a means of rapidly reducing containment pressure and temperature following a main steam line break (MSLB) inside containment, or a loss of coolant accident (LOCA). (NOTE: For discussion purposes, include the case of a main feedline break inside containment.)

Although the actuation of the CSS could alter the containment environment, it would not directly affect either the heat removal characteristics of the NSSS or its inventory.

CCAS

Containment cooling has a function similar to the containment spray: maintain containment pressure below design following a MSLB inside containment or LOCA. The unplanned starting of this system will not affect the performance of the NSSS.

MSIS

To prevent blowdown of the steam generators during a steam line break (SLB), MSIS closes both main steam isolation valves, four main feedwater isolation valves (two per train), stops both main feedwater pumps, all four condensate pumps and both heater drain pumps. The additional equipment actions resulting from this signal is a decreasing heat removal event for the RCS, the consequences of which will be discussed later in section 2.1.2.

SIAS

The primary purpose of this system is to inject borated water into the reactor coolant system (RCS) and thereby cool, maintain inventory, and add negative reactivity to the core. SIAS starts both low and high pressure safety injection (LPSI and HPSI) pumps. Additionally, there is a passive injection system (requiring no operator action) via the safety injection tanks. SIAS will also start all charging pumps. These assist the HPSIs and LPSIs in both maintaining RCS inventory and shutdown margin. Relevant actions resulting from an SIAS are listed in Table 1-3. Inadvertent SIAS is not only a cooldown (increased heat removal) event but also an increasing RCS inventory event, the consequences of which will be considered in sections 2.1.1 and 2.1.3. SIAS also results in a load shedding sequence which results in removal of the secondary plant from service. This results in a decreased heat removal event in Modes 1, 2, 3, and 4. Such an event, including the increased heat removal consequences identified above, would be less severe than an MSIS event. See section 2.1.

RAS

The primary purpose of a RAS is to stop the LPSI pumps and to switch the HPSI and spray pumps' suction from the refueling water tank to the containment sump. RAS alone would not impact the NSSS in Modes 1, 2, and 3; however, RAS alone would cause a decreased heat removal event in Modes 4, 5, and 6. See Table 2-1. RAS in combination with SIAS (the only signal that starts LPSI/HPSI) is discussed in section 2.0. Relevant actions resulting from a RAS are listed in Table 1-4.

EFAS

Two SG emergency feedwater pumps, one turbine driven and a motor driven, are given a start signal upon the initiation of an EFAS. The function of this system is to provide cooling water to the steam generators when required (MSLB, loss of feedwater, as examples). EFAS also contains logic that will isolate emergency feedwater to a ruptured unit in the event of a feed or steam line break. Important EFAS actions are listed in Table 1-5. The advertent addition of emergency feedwater (which is relatively cool with respect to the inventory in the SG) is an increased heat removal event.

1.1 SETS OF SIGNAL COMBINATIONS

For the purposes of this study, it was postulated that, independent of cause, any combination of the ESF systems can be spuriously actuated. Mathematically, dozens of combinations of inadvertent ESFAS actuations are possible. These combinations have been reviewed, and it has been determined that the subset of combinations addressed in section 2.0 are the only ones that involve significant interfacing.

The ESFAS signals discussed in the previous section can be subclassified into two groups whose systems interface among each other or affect a common system. One such group affects the reactor coolant system (RCS) and consists of the MSIS, EFAS, SIAS and CIAS actuation systems, with the MSIS being the dominant actuation and the others being contributors. The other group affects the RCS during shutdown cooling system and consists of SIAS and RAS. The former group is discussed in sections 2.1 and 2.2.2 while the latter is examined in section 2.2.1.

TABLE 1-1

CONTAINMENT ISOLATION SYSTEM

Equipment	Valves	ESFAS Action
Containment Sump Isol.	2CV-2060-1, 2CV-2061-2	Close
Containment Vent Hdr. Isol.	2CV-2400-2, 2CV-2401-1	Close
Reactor Drain Tank Drain Isol.	2CV-2201-2, 2CV-2202-1	Close
Reactor Coolant Pump CCW Coolers Isol.	2CV-5236-1, 2CV-5255-1, 2CV-5254-2	Close
Containment Chilled Water Isol.	2SV-3851-1, 2SV-3852-1, 2CV-3850-2	Close
Reactor Coolant Pump Controlled Bleedoff Isol.	2CV-4847-2, 2CV-4846-1	Close
RCS Letdown Isol.	2CV-4823-2	Close
Quench Tank M/U Water Isol.	2CV-4690-2	Close
Quench Tank Sample Isol.	2SV-5878-1, 2SV-5871-2	Close
RCS Sample Isol.	2SV-5833-1, 2SV-5843-2	Close
Steam Generators Sample Lines Isol.	2CV-5852-2, 2CV-5859-2	Close
Regenerative Heat Ex. Isol.	2CV-4821-1	Close
Safety Injection Tank Sample Isol.	2SV-5876-2	Close

TABLE 1-2

MAIN STEAM ISOLATION SYSTEM

Equipment	Valves	ESFAS Action
SW Pump 2P4A		Start
SW Pump 2P4B		Start
SW Pump 2P4C		Start (if not B)
Aux. Cool Water Isol.	2CV-1425-1, 2CV-1427-2	Close
CCW Heat Ex. Inlet Isol.	2CV-1530-1, 2CV-1531-2	Close
CCW Heat Ex. Outlet Isol.	2CV-1543-1, 2CV-1542-2	Close
SG "A" and "B" Blowdown Isol. Valves	2CV-1016-1, 2CV-1066-1	Close
FW Htr. Drain Pump 2P8A		Stop
FW Htr. Drain Pump 2P8B		Stop
FW Main Isol.	2CV-1024-1, 2CV-1074-1 2CV-1023, 2CV-1073	Close
Containment Cool. Coils SW	2CV-1513-2, 2CV-1510-2 2CV-1511, 2CV-1519	Open
Condensate Pump 2P2C		Trip
Main Steam Isol. Valves	2CV-1010-1, 2CV-1060-2	Close
Condensate Pump 2P2A		Trip
Condensate Pump 2P2B		Trip
Condensate Pump 2P2D		Trip
SW to Emer. Pond	2CV-1560-2, 2CV-1541-1	Open
EFW PMP Discharge	2CV-1026-2, 2CV-1076-2, 2CV-1025-1, 2CV-1075-1, 2CV-1036-1, 2CV-1038-1, 2CV-1037-2, 2CV-1039-2	Close
Atmospheric Steam Dump Valves	2CV-1001, 2CV-1051	Close

TABLE 1-3

SAFETY INJECTION SYSTEM

Equipment	Valves	ESFAS Action
Charging Pump 2P36A		Start
Charging Pump 2P36B		Start
Charging Pump 2P36C		Start
Main Feed Pump Turb. L.O. Pump 2P27		Stop
Boric Acid M/U Pump 2P39A		Start
Boric Acid M/U Pump 2P39B		Start
SW Pump 2P4A		Start
SW Pump 2P4B		Start (if not A)
SW Pump 2P4C		Start (if not B)
Aux. Cool. Water Isol.	2CV-1425-1, 2CV-1427-2	Close
SW #1 ESF Header Isol.	2CV-1400-1	Open
HPSI "A" Pump 2P89A		Start
HPSI "B" Pump 2P89B		Start
HPSI "C" Pump 2P89C*		Start
SW to Emer. Pond	2CV-1541-1	Open
CCW Heat Ex. Inlet	2CV-1530-1, 2CV-1531-2	Close
CCW Heat Ex. Outlet	2CV-1543-1, 2CV-1542-2	Close
Containment Isol. Sample Line	2SV-5833-1, 2SV-5878-1	Close
RDT Drain Isol.	2CV-2202-1, 2CV-2201-2	Close
Containment Sump Isol.	2CV-2061-2, 2CV-2060-1	Close
LPSI "A" Pump 2P60A		Start
LPSI "B" Pump 2P60B		Start

*Normally in "Pull to Lock" position

TABLE 1-3 (continued)

Equipment	Valves	ESFAS Action
RWT Outlet	2CV-5630-1, 2CV-5631-2	Open
RCP Controlled Bleedoff Isol.	2CV-4847-2, 2CV-4846-1	Close
VCT Discharge	2CV-4873-1	Close
Boric Acid M/U Tank Feed Isol.	2CV-4920-1, 2CV-4921-1	Open
Letdown Isol.	2CV-4820-2	Close
RCS Sample - Cont. Isol.	2SV-5843-2	Close
Quench Tank Sample - Cont. Isol.	2SV-5871-2	Close
SIT Sample - Cont. Isol.	2SV-5876-2	Close
SG Sample - Cont. Isol.	2CV-5852-2, 2CV-5859-2	Close
SIT 2T2A Drn.	2CV-5001-1	Close
SIT 2T2A Discharge*	2CV-5003-1	Open
SIT 2T2D Drn.	2CV-5061-2	Close
SIT 2T2D Discharge*	2CV-5063-2	Open
Quench Tank Isol.	2CV-4690-2	Close
Reg. Ht. Ex. Isol.	2CV-4821-1	Close
HPSI Valves	2CV-5036-2, 2CV-5056-2, 2CV-5015-1, 2CV-5055-1, 2CV-5016-2, 2CV-5035-1 2CV-5075-1, 2CV-5076-2	Open
SIT 2T2B Drn.	2CV-5021-1	Close
SIT 2T2B Discharge*	2CV-5023-1	Open
LPSI Valves	2CV-5057-2, 2CV-5037-1, 2CV-5017-1, 2CV-5077-2	Open
SIT 2T2C Drn.	2CV-5041-2	Close
SIT 2T2C Discharge*	2CV-5043-2	Open
Boric Acid Tanks Recirc. Valves	2CV-4903-2, 2CV-4915-2	Close

*When the RCS pressure is above 2000 psig these valves are locked open with the power supply breakers tagged.

TABLE 1-3 (continued)

Equipment	Valves	ESFAS Action
Boric Acid M/U Pump Discharge	2CV-4916-2	Open
VCT M/U Valve	2CV-4941-2	Close
SW Hdr. #2 ESF Hdr. Isol.	2CV-1406-2	Open
Diesel Generator 2DG1		Start
Diesel Generator 2DG2		Start
SW to Emerg. Pond	2CV-1560-2	Open

TABLE 1-4

RECIRCULATION SYSTEM

Equipment	Valves	ESFAS Action
LPSI "A" Pump 2P60A		Stop
LPSI "B" Pump 2P60B		Stop
LPSI "A" Pump Recirc.	2CV-5123-1	Close
LPSI "B" Pump Recirc.	2CV-5124-1	Close
Containment Sump Suction Isol. Valve	2CV-5649-1, 2CV-5650-2	Open
SW to S/D Heat Ex.	2CV-1453-1, 2CV-1456-2	Open
Containment Sump Suction Isol.	2CV-5647-1, 2CV-5648-2	Open
RWT Outlet	2CV-5630-1, 2CV-5631-2	Close-Permissive
Safety Injection Pump Recirc. Isol.	2CV-5628-2	Close
CSS Pump Recirc.	2CV-5673-1	Close
HPSI Recirc.	2CV-5127-1, 2CV-5128-1, 2CV-5626-1	Close

TABLE 1-5

EMERGENCY FEEDWATER SYSTEM

Equipment	Valves	ESFAS Action
SW Pump 2P4A		Start (if not 2P4B)
SW Pump 2P4B		Start (if not 2P4A)
SW Pump 2P4C		Start
EFW Motor Driven 2P7B		Start
EFW Pump Turbine Stm. Isol.	2CV-0340-2	Open
EFW Flush Line Isol.	2CV-0714-1, 2CV-0798-1	Close
EFW Pump Suct. from SW Hdr.	2CV-0716-1, 2CV-0711-2	Open-Permissive
EFW Pump Suct.	2CV-0789-1	Open
EFW Pump Suct.	2CV-0795-2	Open
EFW Pump Discharge	2CV-1025-1, 2CV-1026-2, 2CV-1075-1, 2CV-1076-2, 2CV-1038-1, 2CV-1037-2, 2CV-1036-1, 2CV-1039-2	Open

2.0 ANALYSIS OF ESFAS ACTUATION SCENARIOS RELATED TO CHAPTER 15 OF THE UPDATED ANO-UNIT 2 FSAR

2.1 EVENT DESCRIPTIONS RELATED TO OPERATION IN MODES 1 AND 2

Spurious ESFAS Transient Impact

Spurious ESFAS combinations were chosen to maximize the impact on the NSSS with respect to the following:

1. Increased heat removal from the RCS.
2. Decreased heat removal from the RCS.
3. Increased RCS inventory.
4. Decreased Reactor Coolant Flow.

The initial conditions are Mode 1 or 2 (hot full power or hot zero power critical). A discussion of ESFAS combinations for each of these categories follows:

2.1.1 Increased Heat Removal ESFAS Combinations

Spurious EFAS causes an increase in heat removal from the RCS due to the initiation of full emergency feedwater (EFW) flow to the steam generators. EFW flow is approximately 7% of full power main feedwater flow and will continue until the operator resets EFAS or overrides EFW components.

If SIAS occurs in combination with EFAS, additional cooling of the RCS will occur due to the injection of borated water to the RCS by the charging pumps (RCS pressure above HPSI/LPSI shutoff head). None of the other ESFAS combinations with EFAS and/or SIAS will result in additional heat removal from the RCS.

With the plant operating at full power, the main feedwater control system will regulate main feedwater flow and maintain steam generator level. The primary effect of EFW initiation will be a reduction in feedwater enthalpy. This event has been previously analyzed and is in section 15.1.10 of the updated FSAR. Additionally, an excess feed at 160% of nominal has been analyzed, the results of which bound the inadvertent EFAS.

For initial plant conditions at hot zero power, scoping calculations indicate the opening of a dump valve results in a more severe cooldown than the inadvertent EFAS.

Combined EFAS/SIAS events at full power or at hot zero power with the reactor critical result in smaller power excursions than if each occurs independently. This is due to the decrease in reactivity caused by the boration resulting from charging flow with the suction of the charging pumps aligned to the boric acid makeup tank (BAMT). The charging pump suction is automatically aligned to the BAMT on SIAS.

2.1.2 Decreased Heat Removal ESFAS Combinations

A review of Tables 1-1 through 1-5 indicates that any combination of ESFAS which includes MSIS will cause a decrease in heat removal by the steam generators due to the termination of main steam and feedwater flow. The resulting reactor coolant heatup and expansion will dominate the other effects from CIAS and SIAS (i.e., letdown isolation and charging initiation). In addition, EFAS will be automatically generated subsequent to main feedwater termination. Therefore, any combination of SIAS with MSIS will also include EFAS.

MSIS actuation would be similar to the loss of load/loss of condenser vacuum (LOL/LOCV) presented in section 4A.7.1.2 of the updated FSAR. The LOL/LOCV is more limiting as it assumes instantaneous termination of main feedwater and main steam flow, whereas a MSIS would cause a rampdown of these parameters. The prime effect of this rampdown is to decrease the rate of increase of RCS pressure and lower the resultant peak pressure. The inclusion of a SIAS with MSIS would have a small impact on the peak pressure. EFAS earlier than required would only help mitigate the transient as it would assist in the plant cooldown.

If a loss of offsite electrical power (LOP) occurs as a result of turbine trip during a spurious MSIS/SIAS, the event scenario would include reactor trip from the Core Protection Calculators (CPCs) due to the coastdown of the reactor coolant pumps. If LOP occurred prior to the high pressurizer pressure trip, the maximum RCS pressure would be lower due to the earlier CPC trip. This event would be nearly identical to the Loss of AC power analysis presented in section 15.1.9 of the updated FSAR. If LOP occurred after reactor trip, the influence on maximum RCS pressure and minimum DNBR would be negligble. In either case, the CPC or high pressurizer pressure trips will insure that the minimum DNBR remains above the specified acceptable fuel design limit (SAFDL).

2.1.3 Increasing RCS Inventory ESFAS Combination

An SIAS would add inventory to the RCS via the charging pumps. Initial pressure is above the HPSI/LPSI shutoff head. If at hot full power, the highly borated charging flow would cause core power and RCS temperatures to decrease, thus resulting in a contraction of the reactor coolant. This contraction would be sufficient to accommodate the volume addition. In addition, as previously mentioned, SIAS results in removal of the secondary plant from service and hence, a reactor trip. A large decrease in volume is associated with the trip.

At hot zero power, this large contraction would not occur. However, the pressurizer is programmed to be at a lower level. The operator would have at least 30 minutes to terminate charging flow before the pressurizer went solid.

2.1.4 Decreased Reactor Coolant Flow

As discussed in section 1.0, an inadvertent CIAS could result in tripping the RCPs on loss of component cooling water. Loss of four reactor coolant pumps is analyzed in section 4A.7.1.5 of the updated FSAR and results in no SAFDL violation.

Conclusion

Based on preliminary calculations and FSAR/Reload Safety Analysis reports, inadvertent ESFAS combinations will be no more severe than previously analyzed FSAR events.

2.2 EFFECTS AND EVALUTIONS OF SPURIOUS ESFAS ACTUATION DURING SUB-CRITICAL PLANT OPERATING MODES 3, 4, 5, and 6

An evaluation of plant response following spurious actuation of various combinations of ESFAS signals during plant operation in Modes 3-6 has been conducted. The worst-case scenarios have been identified and examined in detail. The results of the evaluation are presented in two parts. Section 2.2.2.1 reviews and examines a postulated worst-case scenario for operating Modes 3, 4, 5, and 6 in which the Shutdown Cooling System (SDCS) and/or SG's and the Low Temperature Overpressure Protection (LTOP) system are in operation. Section 2.2.2.2 covers operating Modes 3 and 4 with RCS cooling via the steam generator (SG) alone. During Mode 4, protection against overpressure is provided by the LTOP system or the pressurizer safety valves. LTOP is not required in Mode 3.

2.2.1.1 Introduction

The plant's response to spurious ESFAS signals during shutdown cooling system operation has been reviewed. For a spurious ESFAS event during shutdown cooling, the principle consideration is the adequacy of the Low Temperature Overpressure Protection (LTOP) system in controlling the pressure transient initiated by the signal combinations tabulated in Table 2-1. The effect of other signals (e.g., CSAS), occuring in conjunction with these combinations does not alter the LTOP transient. (A spurious CIAS can initiate a loss of CCW to the RCPs, but this is a previously defined scenario).

The limiting-case ESFAS signal combination during Shutdown Cooling System operation involves SIAS and RAS. The LTOP system ensures that the pressure transient resulting from this combination does not violate the Pressure-Temperature (P-T) limits given in the Technical Specifications.

The evaluation of spurious ESFAS signals during shutdown cooling system (SDCS) operation includes a review of the applicable plant operating modes before the detailed various signal combinations of Table 2-1. After evaluating the various signal combinations of Table 2-1, the design of the LTOP system is described and the capability of the LTOP system to mitigate and control the limiting-case pressure transient is evaluated.

2.2.1.2 Plant Operating Modes

Operation of the shutdown cooling system is permissible in Mode 4 with pressurizer pressure less than about 300 psia. A steam generator loop can also be used to remove heat from the Reactor Coolant System (RCS) in this mode. (See Tech Spec 3/4.4.1.3). SDCS operation is required in Modes 5 and 6.

2.2.1.3 Detailed Review of ESFAS Scenarios

MSIS

With a steam generator and the SDCS in operation in Mode 4 and the RCS in a water solid condition, a spurious MSIS will decrease the heat transfer from the primary to the secondary system, resulting in a small increase in the RCS pressure due to the thermal expansion of the reactor coolant.

The shutdown cooling system prevents significant heat-up of the RCS and minimizes the pressure change. Opening the main steam isolation valve(s) (MSIV) re-establishes steam flow to the steam bypass system.

RAS

RAS stops the LPSI pumps and causes a loss of shutdown cooling flow. This results in a heat-up and expansion of the reactor coolant and an increase in RCS pressure. The RAS pressure transient is enveloped by the one for the worst-case full safety injection initiation from a water solid condition. A loss of shutdown cooling flow produces a mild pressure transient with respect to the safety injection transient.

MSIS-RAS

If the Shutdown Cooling System is in operation with the steam generator in Mode 4, and an RAS is combined with an MSIS, the result will be a decrease in heat removal by the steam generator(s) and a loss of shutdown cooling. The heat-up of the RCS will be more rapid than for an RAS alone and this will result in a more aggressive pressure transient than the one discussed above. However, the MSIS-RAS pressure transient is easily enveloped by the one for the worst-case full safety injection from a water solid condition.

SIAS

Section 5.2.2.4 of the FSAR discusses the design modifications which were added to provide protection from inadvertent overpressurization during low temperature and system solid conditions. The modification was the addition of LTOP system. Each relief valve has the capacity to accommodate a worst-case full safety injection initiation from a water solid condition.

The spurious SIAS not only pressurizes the RCS, it can also cause a cooldown and contraction of the reactor coolant. After the LTOP system operates, flow from the HPSI and charging pumps passes through the core and out the LTOP system, increasing the RCS heat removal rate. The cooling of the reactor coolant tends to reduce the steady-state pressure of the RCS after the relief valves have opened.

The potential for a pressurization/cooldown transient depends upon the time after reactor shutdown. When the SDCS is placed in operation in order to finish the cooldown of the plant after reactor shutdown, the flowrate through the shutdown cooling heat exchanger(s) (SDCHX) is limited so as not to exceed the maximum cooldown rate specified in Tech Spec 3/4.4.9. HPSI and charging pump flow potentially can increase the RCS cooldown rate requiring operator action to limit cooling by the shutdown cooling system to prevent an excessive cooldown rate.

SIAS-MSIS

If the shutdown cooling system is in operation with the steam generator(s) in Mode 4 and an MSIS is combined with SIAS, the resulting pressure transient is essentially the same as an SIAS alone. This is because the pressurization due to the HPSI and charging pumps is more rapid than the pressurization due to a decrease in steam generator heat removal in Mode 4. The MSIS will decrease the heat transfer from the primary to secondary system, resulting in a small increase in RCS pressure due to the thermal expansion of the reactor coolant. However, the shutdown cooling system will prevent significant heat-up of the reactor coolant. In addition, if credit is taken for the cooling effect of the HPSI and charging pump flow, there is no heat-up and expansion of the reactor coolant.

SIAS-RAS

This combination of two spurious ESFAS signals in Mode 4 without the steam generators in operation, in Mode 5, and in Mode 6 with the reactor vessel head on produces the limiting-case pressure transient. SIAS dominates the pressure increase from time zero until the LTOP system operates. This already has been pointed out for SIAS-MSIS. The capacity of the LTOP system can accommodate the HPSI pumps' and charging pumps' flow and relieve the volume expansion of the reactor coolant due to the loss of decay heat removal. Therefore, currently installed relief capacity can accommodate this pressure transient.

Depending upon the time after reactor shutdown, it is possible for an SIAS-RAS to result in a pressurization/cooldown transient despite the loss of shutdown cooling flow caused by RAS stopping the LPSI pumps. The cooling effect of SIAS has been discussed in the previous subsection. Since the RAS stops the LPSI pumps, the cooldown will be less rapid than for the case of SIAS alone.

SIAS-RAS-MSIS

This combination of three ESFAS signals produces the limiting-case pressure transient in Mode 4 when part of the decay heat load is being removed by the steam generators (SDCS also is in operation). The SIAS dominates the pressure transient from time zero until the relief valves lift. Afterward, the loss of heat removal becomes more important. However, the LTOP system can accommodate full safety injection and the volume expansion of the reactor coolant due to the loss of RCS heat removal. For the potential cooldown case, see the discussion for SIAS.

EFAS

With the steam generators in operation with the SDCS in Mode 4, a spurious EFAS will decrease any plant heatup operation in progress or increase the cooldown rate in a cooldown operation. The cooldown rate is not expected to exceed the cooldown limits.

SIAS-EFAS

The pressure transient is dominated by the SIAS. Since EFAS increases heat removal by the steam generators when they are in operation in Mode 4, the pressure transient is enveloped by the one for SIAS.

If the cooling effect of the HPSI and charging flows after the LTOP system operates is considered, the increased heat removal with EFAS may require operator action to limit cooling by the shutdown cooling system to prevent an excessive cooldown rate.

SIAS-RAS-EFAS

Since EFAS acts to increase decay heat removal by the steam generators when they are in operation in Mode 4, the pressure transient for this combination is enveloped by the one for SIAS-RAS. The cooldown transient is enveloped by the one for SIAS-EFAS.

Conclusion

This review of the ESFAS signals has shown that the combinations of RAS-SIAS or RAS-SIAS-MSIS have the greatest potential for affecting normal plant operation in Mode 4 with the shutdown cooling system in operation, and Mode 5, and Mode 6 with the reactor vessel head on. The principle consideration is the adequacy of the Low Temperature Overpressure Protection (LTOP) system in controlling the resulting pressure transient. The discussion which follows develops the conditions associated with these most limiting signal combinations and discusses the response of the LTOP system.

2.2.2 Evaluation of Limiting Case Events For Modes 3, 4, 5, and 6

2.2.2.1 Evaluation of Cases with SDCS and/or SG's Operating

The shutdown cooling system (SDCS) is assumed to be in operation with one or both LPSI pumps running. The LPSI pump miniflow recirculation line isolation valves (2CV-5123 and -5124) are closed, while the miniflow isolation valves (2CV-5126, -5127, -5128, and 2CV-5672, -5673 and 2CV-5628), for the HPSI and containment spray (CS) pumps are open. The reactor coolant system (RCS) is considered water solid for conservatism at a pressurizer pressure less than or equal to about 300 psia and the cold leg temperature is less than 260°F for plant cooldown or 250°F for plant heatup. The LTOP relief path isolation valves (2CV-4730, -4731, -4740, -4741) are open and the LTOP system is operable. It should be noted that a water solid RCS is an abnormal plant condition. Under these specified conditions, the pressurizer level is normally such that a steam bubble of approximately 800 $ft.^3$ exists.

The isolation valve on the letdown line off the RCS coldleg may be open for the purpose of shutdown cooling purification in Mode 4, otherwise it is already closed. If the steam generator(s) is in operation to remove part of the RCS heat in Mode 4, the main steam steam isolation valves (MSIV) are open and the steam bypass system is in operation. Steam generator level is maintained by the emergency feedwater system.

It should also be noted that under these specified condition, two of the three HPSI pumps are in the "Pull-to-Lock" condition. Therefore, only one HPSI pump would start on spurious SIAS-RAS actuation. Two HPSI pumps were considered for conservatism.

A. Sequence of Events and Systems Operation

A spurious initiation of SIAS and RAS is assumed to occur. The SIAS starts two HPSI pumps, two LPSI pumps, and closes the letdown isolation valve. The injection of mass into the RCS by the HPSI pumps begins the pressure transient.

The RAS stops the LPSI pumps, opens the isolation valves in the recirculation lines from the containment sump, and closes the isolation valves in the ECCS suction lines from the refueling water tank. Stopping the LPSI pumps results in a loss of shutdown cooling, causing a heat-up and expansion of the reactor coolant, which contributes to the pressure transient. As the RCS pressure increases above 300 psia, the SDCS suction line isolates automatically. Regardless of whether miniflow valves are open, the HPSI pumps are not dead-headed because the LTOP system pass all of the pumps' flow to the quench tank.

With the containment at normal operating pressure, opening the sump isolation valves does not affect HPSI pump suction. There is sufficient elevation head from the refueling water storage tank to provide pump suction. In fact, the refueling water tank proceeds to drain to the containment sump, because refueling water tank isolation valves are interlocked open until the containment sump isolation valves reach their fully opened position.

For RAS-SIAS-MSIS, the MSIS closes the MSIVs. Heat removal from the RCS by the steam generators decreases.

The required actions to recover from a spurious SIAS-RAS during shutdown cooling are to stop the HPSI and charging pumps, reestablish SDCS suctions, and restart the LPSI pumps. The prime consideration in the event of a spurious RAS-SIAS or RAS-MSIS-SIAS at low temperature is the ability of the LTOP system to mitigate the resulting pressure transient. The ability of the LTOP system to prevent an overpressurization of the RCS and SDCS has been reviewed. The results are summarized in the section entitled "RAS-SIAS-MSIS Pressure Transient - LTOP Applicability."

B. Summary of Results

The LTOP system provides protection from inadvertent overpressurization during low temperature and system solid conditions and can accommodate a multiple failure scenario involving a spurious RAS-SIAS or RAS-SIAS-MSIS as the initiators of a potential overpressure event. For this spurious actuation scenario, the pressure transient will not exceed 110% of the design pressure of the shutdown cooling system (SDCS). The reactor vessel and reactor coolant system (RCS) are protected against overpressurization at low temperature.

The LTOP design requires only that the operator line up the LTOP system during cooldown and isolate during heatup. An alarm circuit is provided to alert the operator if the RCS temperature drops to 260°F and any LTOP isolation valve is not fully open. No other operator action is required to prevent an overpressurization event at low temperatures. The LTOP system can be available even when the SDCS is not in operation and the SDCS suction line isolation valves are closed.

C. <u>RAS-SIAS-MSIS Pressure Transient - LTOP Applicability</u>

The LTOP system can accommodate the RAS-SIAS-MSIS pressure transient. It was noted in the sub-section discussing MSIS-RAS that the pressure transient resulting from system actuations affected by MSIS and RAS was easily enveloped by the one for a worst-case safety injection with the RCS water solid. Currently installed relief capacity can control the pressure transient resulting from the superposition pressure increases caused by SIAS and MSIS-RAS.

The pressure transient will not exceed 110% of the design pressure of the shutdown cooling system. The reactor vessel and reactor coolant system are protected against overpressurization at low temperature.

TABLE 2-1

SUMMARY OF LIMITING TRANSIENTS INITIATED BY SPURIOUS ESFAS SIGNAL(S) DURING SHUTDOWN COOLING SYSTEM OPERATION[1]

ESFAS SIGNAL(S)	TYPE OF EVENT	DOES LTOP RELIEF VALVE(S) PROVIDE ADEQUATE PROTECTION?	COMMENTS
MSIS[2]	Heat-Up	Yes	The MSIS transient does not approach the severity of the SIAS transient. The shutdown cooling system picks up the extra heat load, reducing the pressure increase.
RAS	Heat-Up	Yes	Reestablishing SDCS suction and starting a LPSI pump restores shutdown cooling.
MSIS[2]-RAS	Heat-Up	Yes	See above comments.
SIAS	Pressurization/ Cooldown[3]	Yes	The pressure reduction due to cooling effect of the HPSI pump flow through the core after the LTOP system operates is neglected. This maximizes the steady state pressure. Stopping the HPSI and charging pumps terminates the transient.
SIAS-MSIS[2]	Pressurization/ Cooldown[3]	Yes	The pressure transient is essentially the same as SIAS alone. The MSIS moderates the cooldown and increases the pressure slightly. Stopping the HPSI and charging pumps terminates the transient. Opening the MSIV reestablishes steam flow.

TABLE 2-1 (contined)

SUMMARY OF LIMITING TRANSIENTS INITIATED BY SPURIOUS ESFAS SIGNAL(S) DURING SHUTDOWN COOLING SYSTEM OPERATION[1]

ESFAS SIGNAL(S)	TYPE OF EVENT	DOES LTOP RELIEF VALVE(S) PROVIDE ADEQUATE PROTECTION?	COMMENTS
SIAS-RAS	Pressurization/ Heat-Up, or[3] Pressurization/ Cooldown	Yes[4]	For the heat-up case, HPSI pump flow removes core heat so that the SDCS design temperature is not exceeded. Restarting the LPSI pump restores shutdown cooling. Stopping the HPSI and charging pumps terminates the pressure transient. For the cooldown case, stopping the HPSI and charging pumps terminates the pressure transient as well as the cooldown.
SIAS-RAS-MSIS[2]	See above.	See above.	See above two comments.
EFAS[2]	Cooldown	Yes	Cooldown is within P-T limits - no adverse impact.
SIAS-EFAS[2]	Pressurization/ Cooldown[3]	See SIAS.	See SIAS.
SIAS-RAS-EFAS[2]	See SIAS-RAS.	See SIAS-RAS.	EFAS reduces the heat-up case. The limiting heat-up case is SIAS-RAS. Also see SIAS-RAS comments.

NOTES:

[1] Modes 4 and 5, and Mode 6 with the reactor vessel head on.

[2] Mode 4 only. MSIS and EFAS have no impact in Modes 5 and 6.

[3] Heat-up/cooldown depends on the temperature of the RWST water injected by the HPSI pump and the time after reactor shutdown. In Mode 4, an SIAS always results in a pressurization/cooldown transient.

[4] The capacity of the LTOP system mitigates and controls the pressure transient. See discussion.

2.2.2.2 Evaluation of Cases With Steam Generator Cooling Only

A. Introduction

An evaluation of plant response following spurious actuation of a combination of ESFAS signals during plant operating Modes 3 and 4 (RCS cooling via steam generators only) has been made.

The combinations of ESFAS signals reviewed are tabulated in Table 2-2. Other combinations of ESFAS signals not presented in the table were considered but they are enveloped by the combinations reviewed in detail herein. Table 2-2 illustrates the type of event expected for each of the signal(s) actuated and notes the reference which addresses the type of event postulated. The limiting event in this review is the combination SIAS-MSIS-CIAS.

B. Operating Modes and Initial Conditions

Modes 3 and 4 are hot, subcritical modes of operation covering RCS temperatures greater than 200°F (Technical Specification Table 1.1 - Operational Modes). This review assumes that RCS cooling is being effected using at least one RCS loop via a steam generator and that the RCS pressure - temperature (P-T) relationship is consistent with RCP operation. For Mode 3 (Hot Standby), the upper P-T limits are the same as the Mode 1/2 cases which are covered in the review section for spurious ESFAS signals during power operation. The initial conditions which make the P-T situation for Mode 3/4 distinct from Mode 1/2 are the following: 1) The low RCS pressure maximizes safety injection at the onset of the event. 2) The low RCS temperature maximizes the initial mass within the reactor coolant system; this means more mass is present to expand and pressurize the RCS as the temperature increases. The limiting case transient couples loss of heat removal (energy input), increased RCS inventory (mass input), and loss of or diminished RCS pressure control.

C. Sequence of Events and Systems Operation

The spurious actuation of the SIAS initiates safety injection from the HPSI pumps at a rate consistent with the delivery curves. The injection rate at 400 psia will be large for two HPSI pumps, but will decrease with increasing RCS pressure up to the shutoff head of approximately 1400 psia. LPSI pumps will start but the shutoff head for LPSI is about 200 psia and so it will not increase RCS inventory. All non-running charging pumps will start and letdown will be isolated. The cold water injection would tend to contract the RCS opposing the pressurizer level increase but the dominant effect will be the mass increase causing an increase in pressurizer level.

A Main Steam Isolation Signal (MSIS) will shut the Main Steam Isolation Valves, the upstream Atmospheric Dump Valves, and the Main Feed Isolation Valves. The MSIS results in an RCS heat-up, which causes expansion of the reactor coolant, further increasing pressurizer level.

RCS pressure increases as pressurizer level increases. Pressure will increase quickly to the HPSI pumps' shutoff head which terminates safety injection flow. Pressurizer level and pressure will continue to increase as the RCS heats up and charging flow continues. Assuming no operator action, two possibilities exist according to the heatup rate and initial RCS temperature. The RCS pressure may increase to the pressurizer safety valves' setpoint (or the LTOP setpoint if it is in service in Mode 4) followed by a heatup to the saturation temperature for the secondary safety valves' pressure setpoint or the RCS temperature may cause the secondary safeties to lift prior to lifting primary safeties. In either case, RCS heat removal will be established through the secondary safety valves which will cooldown the RCS. Either scenario is enveloped by the Loss of Condenser Vacuum, updated FSAR section 4A.7.1.2.

A Containment Isolation Actuation Signal will cause a loss of cooling water to the reactor coolant pumps. Assuming RCP trip is required, the event will still be enveloped by the Loss of Condenser Vacuum analysis, although the final RCS pressure may peak higher than the MSIS-SIAS scenario alone due to a delay in establishment of RCS flow by natural circulation. The heat generated by RCPs is a significant portion of total RCS heat load for any decay heat assumed; given that, the addition of the CIAS may mitigate the transient. If CIAS requires securing the reactor coolant pumps due to loss of CCW, pressurizer spray from the main spray will be lost. Spray may be restored using auxiliary spray or main spray after restarting the reactor coolant pumps. Additional recovery actions are discussed below.

D. Recovery Actions

Mitigation of this type of event will involve termination of the Safety Injection System operations, RCP's operation and pressurizer spray valve control, and establishing RCS heat removal.

The rate of pressurizer level increase is dependent on the RCS pressure response from the competing effects of mass input (inventory increase) and energy removal (inventory and pressure decrease). Since the HPSI termination criteria will be satisfied during the course of the transient, Safety Injection System operation may be terminated.

RCS heat removal may be satisfied by reopening the Main Steam Isolation Valves and steaming via the turbine bypass valves (TBVs) or bleeding steam through the Atmospheric Dump Valves (ADVs). These two methods for heat removal can be expected to control decay heat removal almost immediately after clearing the MSIS. Heat removal will moderate any pressure transient that ensues by minimizing or counteracting coolant expansion due to heatup.

2.2.3 Reactor Coolant Pumps

The CIAS function of isolating the containment results in closing the supply and return valves (2CV-5236, -5754, -5255) for the non-critical component cooling water (CCW) to the reactor coolant pumps (RCPs). A spurious CIAS can initiate this event (loss of CCW to the RCPs), but this is a previously defined scenario. Per FSAR section 5.5.1.3, low RCP cooling flow to each pump is alarmed in the control room. FSAR section 5.6.5.1.1 notes that the high RCP seal temperature alarm also provides a backup indication that CCW flow has decreased.

Referring to section 5.5.1.3 again, the updated FSAR notes that four reactor coolant pumps with seals of similar design to those in use at ANO-2 have been operated for up to 40 minutes with no component cooling water flow. Although there was some increase in the controlled seal leakage within the system, the mechanical seals were subsequently inspected, without finding any major damage such as broken pieces in the seals. It was concluded that a loss of CCW to the Unit 2 RCPs for up to a period of 40 minutes would not be expected to result in a loss of coolant accident due to seal failure.

TABLE 2-2

MODE 3/4 WITH STEAM GENERATOR COOLING

ESFAS SIGNAL(S)	TYPE OF EVENT	ENVELOPING ANALYSIS	COMMENTS
SIAS	Pressurization, Cooldown	HPSI self-limiting on pump shutoff head.	The cooldown is limited by the decrease in core outlet temperature which reduces RCS SG heat transfer.
SIAS-EFAS	Pressurization/ Cooldown	Same as above. Possible higher cooldown rate.	Same as above; auxiliary feed will already be in use for Modes 3/4.
EFAS	Possible Small Cooldown	Within overcooling transient scenarios; see FSAR section 15.1.10, "Excess Heat Removal Due to Secondary System Malfunction".	Increased steam generator inventory possible.
MSIS-EFAS	Heat-Up	Decrease in heat removal; see FSAR section 4A.7.1.2, "Loss of Condenser Vacuum".	Same as MSIS but moderated by possibility of initial increased auxiliary feed flow.
MSIS	Heat-Up	Decrease in heat removal; see FSAR section 4A.7.1.2.	SG inventory adequate for RCS cooling through secondary safety valves.
SIAS-MSIS	Pressurization/ Heat-Up	See MSIS.	Loss of pressurizer level control.
MSIS-CIAS	Heat-Up	See MSIS.	Loss of pressurizer pressure control.
SIAS-MSIS-CIAS	See discussion.	Loss of heat removal, assumed loss of forced circulation, increase in RCS inventory.	Loss of pressurizer level/ pressure control. Worst case scenario.