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October 15, 1985

United States Nuclear Regulatory Commission
Washington, DC 20555

ATTENTION: Mr. George W. Knighton, Chief
Licensing Branch 3
Office of Nuclear Reactor Regulation

SUBJECT: Beaver Valley Power Station - Unit No. 2
Docket No. 50-412
Final Draft Safety Evaluation Report Confirmatory Issue 34

Gentlemen:

In letter 2NRC-4-119 of August 9, 1984, Duquesne Light Company indicated that a detailed plant review would be conducted to assure that a control system failure would not result in an event which was more severe than the design basis events analyzed in the FSAR. The analysis is complete and the results are attached to this letter. This information completes the Duquesne Light Company action for Confirmatory Issue 34, which should close this Final Draft SER issue.

DUQUESNE LIGHT COMPANY

By _____
J. J. Carey
Vice President

KAT/wjs
Attachment

cc: Mr. B. K. Singh, Project Manager (w/a)
Mr. G. Walton, NRC Resident Inspector (w/a)

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ANALYSIS OF CONTROL
SYSTEM FAILURES

CONTROL SYSTEM FAILURE CONCERNS

The analyses reported in Chapter 15 of the FSAR are intended to demonstrate the adequacy of safety systems in mitigating anticipated operational occurrences and accidents.

Based on the conservative assumptions made in defining these design-basis events and the detailed review of the analysis by the staff, it is likely that they adequately bound the consequences of single control system failures.

To provide assurance that the design basis event analyses adequately bound other more fundamental credible failures, you are requested to provide the following information:

(1) Identify those control systems whose failure or malfunction could seriously impact plant safety.

(2) Indicate which, if any, of the control systems identified in (1) receive power from common power sources. The power sources considered should include all power sources whose failure or malfunction could lead to failure or malfunction of more than one control system and should extend to the effects of cascading power losses due to the failure of higher level distribution panels and load centers.

(3) Indicate which, if any, of the control systems identified in (1) receive input signals from common sensors. The sensors considered should include, but should not necessarily be limited to, common hydraulic headers or impulse lines feeding pressure, temperature, level or other signals to two or more control systems.

(4) Provide justification that any simultaneous malfunctions of the control systems identified in (2) and (3) resulting from failures or malfunctions of the applicable common power source or sensor are bounded by the analyses in Chapter 15 and would not require action or response beyond the capability of operators or safety systems.

RESPONSE TO DMW FSAR QUESTION 420.6
ON CONTROL SYSTEM FAILURE

INTRODUCTION

The evaluation consists of postulating failures which affect the major NSSS control systems and demonstration that for each failure the resulting event is within the bounds of existing accident analyses. The events which are considered are:

a) Loss of any single instrument
b) Break of any single common instrument line
c) Loss of power to all systems powered by a single power supply system (i.e. single inverter)
d) Loss of power to individual protection, control, or NIS rack

The analysis is conducted for all five major NSSS control systems:

1) Reactor control system
2) Steam dump system
3) Pressurizer pressure control system
4) Pressurizer level control system
5) Feedwater control system

The initial conditions for the analysis are assumed to be anywhere within the full operating power range of the plant (i.e. 0-100%) where applicable.

The results of the analysis indicate that, for any of the postulated events considered in a) through d) above, the condition II accident analyses given in Chapter 15 of the Beaver Valley Unit II FSAR are bounding.

LOSS OF ANY SINGLE INSTRUMENT

Table 1, Loss of Any Single Instrument, is a sensor-by-sensor evaluation of the effect on the control systems itemized above caused by a sensor failing either high or low. The particular sensor considered is given, along with the number of channels which exist, the failed channel, the control systems impacted by the sensor, the effects on the control systems for failures in both directions, and the bounding FSAR accident. Where no control action occurs or where control action is in a safe direction, no bounding accident is given.

The table clearly shows that for any single instrument failure, either high or low, the condition II events itemized in the FSAR Chapter 15 are bounding.

LOSS OF POWER

The Beavery Valley Unit II power supplies related to this question consist of four vital power busses powered by their own inverters. The protection system is divided into four protection sets, the control system into four control groups, and the nuclear instrumentation system into four NIS racks. Each of these is powered by the corresponding inverter vital bus, i.e. Inverter Vital Power Bus I supplies power to Protection Set I, Control Group 1 and NIS Rack I, and similarly for the other three busses.

Tables 2 through 5, Loss of Power to Inverters I through IV respectively, analyze the effects on the control systems caused by the most limiting failure, loss of power to an entire inverter vital bus. The control systems affected, the sensors affected, the failure direction, the control responses, and the bounding FSAR accident are given in the tables. Where no control action occurs or where control action is in a safe direction, no bounding accident is given.

Besides the loss of an inverter, there is also a chance of losing power to a single control group, protection set, or NIS rack (for example, through the failure of a fuse or circuit breaker). The consequences of a loss of power to

a control group are tabulated in Tables 6 through 9. Loss of power to a protection set is addressed in Tables 10 through 13. Finally, Tables 14 through 17 consider loss of power to the NIS racks. In each case, the data is presented in a similar manner to that for the loss of an inverter described in the previous paragraph.

Besides the loss of power to an entire control group, there is the chance of having an electrical fault on one of the control system circuit cards. The control systems are designed so that each card is used in only one control system. A circuit card failure cannot directly impact more than one control system. A failure on a control card would cause the controller to generate either an "off" or a "full on" output, depending on the type of failure. This result would be similar to having a fault in a sensor feeding the control system. Therefore, the failure of or loss of power in any control system circuit card would be bounded by the Loss of Any Single Instrument analysis described in Table 1.

The tables show that for a loss of power to any inverter, protection cabinet, control cabinet, or NIS rack, the Condition II events analyzed in the FSAR Chapter 15 are bounding.

LOSS OF COMMON INSTRUMENT LINES

Table 18, Loss of Common Instrument Lines, considers the scenario whereby an instrument line which supplies more than one signal ruptures, causing faulty sensor readings.

Two sets of sensors are located in common lines:

1) Loop steam flow (Protection Set III for each steam generator) and narrow range steam generator level (Protection Set III for each steam generator).

2) Pressurizer level (Protection Set III) and pressurizer pressure (Control Groups III or IV).

Table 18 shows that in the event of a common instrument line break, the Condition II events itemized in the FSAR Chapter 15 are bounding.

Not shown on the table since they are not part of the plant control system but are used just for protection are the RCS loop flow transmitters. There are three flow transmitters in each loop, with each transmitter having a common high pressure tap but separate and unique low pressure taps. Therefore, a break at the high pressure flow transmitter tap would result in disabling all three flow transmitters in one loop, resulting in a low flow reading for all three transmitters. This would result in a reactor trip if the plant is above the P-8 setpoint, or an annunciation if it is below P-8.

The only malfunction mode explicitly analyzed was a break in the common instrument line at the tap. Another possibility is to have a complete blockage in the sensor tap, causing the sensor to read a constant (before blockage) value. However, this last failure mode is not analyzed since it is really not a credible event. There is no anticipated agent available that would cause a tap blockage. The Reactor Coolant System piping and fittings, and the instrument impulse line tubing are all stainless steel, so no products of corrosion are expected. Also the water chemistry is of high quality, which along with high temperature operation, precludes the presence of solids in the water and assures the maintenance of the solubility of chemicals in the water. In addition, prior to startup, and during any shutdown as well, it is routine maintenance and servicing practice for instrument lines to be blown down to a canister. Since the building of sludge is a slow process, any buildup would be detected during response time testing done during shutdown. therefore, the hypothesis of the presence of a complete blockage of the sensor tap is not sufficiently credible to warrant its consideration as a design basis.

In the extremely unlikely event that a complete instrument line blockage were to occur, the condition is detectable because the reading would become static (no variations over time). In an unblocked channel, a reading would always vary somewhat due to noise (i.e. flow induced noise in flow channels) or slight controller action (i.e. cycling operation of spray and heaters in

pressurizer). By a comparison of the static channel to the redundant unblocked channels, the operator would be informed that a blockage in one channel has occurred.

CONCLUSIONS

The attached tables have illustrated that failures of individual sensors, losses of power to inverters, losses of power to individual protection, control, and auxiliary process cabinets, or breaks in common instrument lines all result in events which are bounded by FSAR Chapter 15 analyses. Therefore, the FSAR adequately bounds the consequences of these fundamental failures.

LIST OF TABLES

TABLE 1

LOSS OF ANY SINGLE INSTRUMENT

SENSOR	NUMBER OF CHANNELS	FAILED CHANNEL	SYSTEM	ASSUMED FAILURE DIRECTION	EFFECT	BOUNDING EVENT
Steam Header Pressure	1 per plant	_____	o Steam Dump (Pressure Mode Only)	Lo	Dump Valves Close. (S.G. PORV's available if needed.)	Bounding Event is Loss of External Load (FSAR 15.2.2) (if trip occurs) or no event.
				Hi	Dump valves open. (Steam dump blocked on Lo-Lo TAVG (P-12).)	Steam dump in pressure mode at hot standby or very low power only. Hence, dump valves will open for only a very short time till lo-lo TAVG (P-12) is reached. This event is bounded by Excessive Increase in Secondary Steam Flow (FSAR 15.1.3).
Loop Steam Flow	2 per loop	1 selected for control	o Feedwater Control	Lo	FW valves close if in auto mode.	If FCV in manual - no event. If FCV in auto results in decreased FW flow, bounding event is Loss of Normal FW Flow (FSAR 15.2.7)

TABLE 1 (Continued)

LOSS OF ANY SINGLE INSTRUMENT

SENSOR	NUMBER OF CHANNELS	FAILED CHANNEL	SYSTEM	ASSUMED FAILURE DIRECTION	EFFECT	BOUNDING EVENT
				Hi	FW valves open if in auto mode.	If FCV in manual - no event. If FCV in auto results in increased FW flow, bounding event is Excessive FW Flow (FSAR 15.1.2)
Loop FW Flow	2 per loop	1 selected for control	o Feedwater Control	Lo	FW valve opens if in auto mode	If FCV is manual - no event. If FCV in auto results in increased FW flow, bounding event is Excessive FW Flow (FSAR 15.1.2)
				Hi	FW valve closes if in auto mode	If FCV in manual - no event. If FCV is auto, result is decreased FW flow, bounding event is Loss of Normal FW Flow (FSAR 15.2.7)
Narrow Range Level	3 per Steam Generator (one available for control)	1 used for control (III)	o Feedwater Control	Lo	FW valve opens if in auto mode	If FCV in manual - no event. If FCV in auto results in increased FW flow, bounding event is Excessive FW Flow (FSAR 15.1.2)

TABLE 1 (Continued)

LOSS OF ANY SINGLE INSTRUMENT

					Hi	FW valve closes if in auto mode.	If FCV in manual - no event. If FCV is auto, result is decreased FW flow, bounding event is Loss of Normal FW Flow (FSAR 15.2.7)
Pressurizer Level (Control)	3 per plant	I (pos 2 or 3) III (pos 1)*	o	Pzr. Level Control	Lo	Charging flow increases. Heaters turn off (except for local control). Letdown isolated (VCT empties, charging pumps take suction from RWST.)	Bounding event is Increased Reactor Coolant Inventory (FSAR 15.5.2)
					Hi	Charging flow decreases Backup heaters on (Later, letdown isolation from interlock channel, heaters blocked from interlock channel.)	While heaters are on, no net depressurization of RCS. After heaters are blocked, decreased charging flow acts to depressurize RCS. Depressurization event is therefore bounded by Inadvertent Opening of a Pressurizer Safety or Relief Valve (FSAR 15.6.1)

TABLE 1 (Continued)

LOSS OF ANY SINGLE INSTRUMENT

Pressurizer Level (Interlock)	3 per plant	II (pos 1 or 2) III (pos 3)*	o	Pzr. Level Control	Lo	Letdown isolated. Prz. heaters blocked (except for local control).(Charging flow reduced to maintain level).	Steady-state reached at slightly high level. No event.
					Hi	No control action, get Hi level annunciation.	Not applicable
Pressurizer Pressure	2 per plant (for control)	III	o	Pzr. Pressure Control	Lo	No control action. PORV 456 and PORV 455D blocked from opening. PORV 455C available if required, closes when pressure falls below deadband.	Not applicable
					Hi	PORV 456 abd 455D open	Result is bounded by Inadvertent Opening of a Pzr. Safety or Relief Valve (FSAR 15.6.1)
Pressurizer Pressure	2 per plant (for control)	IV	o	Pzr. Pressure Control	Lo	PORV 455C blocked. Heaters turn on, spray remains off.	Heaters being on causes increase in Pzr. pressure to PORV 456 and PORV 455D actuation. No event.
					Hi	PORV 455C opens. Spray turned on.	Result is bounded by Inadvertent Opening of a Pzr. Safety or Relief Valve (FSAR 15.6.1)

TABLE 1 (Continued)

LOSS OF ANY SINGLE INSTRUMENT

TAVG	one per loop	Any	Auct. Hi	o Steam Dump (TAVG Mode) o Reactor Control o Prz. Level Control	Lo	No Control Action	Not applicable
					Hi	Rods in (safe direction). Charging flow increases until full power Prz. level is reached (if at reduced power). If reactor trips, steam dump enabled and dump valves open until steam dump blocked when Lo-lo TAVG is reached (P12).	No event unless reactor trips, then dump valves open and bounding event is Excessive Increase in Secondary Steam Flow (FSAR 15.1.3)
TAVG	one per loop	Any	Auct. Hi	o Steam Dump (Pressure Mode) o Reactor Control o Prz. Level Control	Lo	No Control Action	Not applicable
					Hi	Rods in (safe direction). Charging flow increases until full power Pzr. level is reached (if at reduced power).	Steady state reached at full power pressurizer level. No event.
Turbine Impulse Chamber Pressure	2 per turbine	III (Control)	Selected	o Steam Dump (TAVG Mode) o Reactor Control o FW Control	Lo	Rods in (safe direction), auto rod withdrawal blocked (C-5). Steam dump signaled to open but is blocked by interlock. (If reactor trip occurs, steam steam dump unblocked and dump valves modulate until no load TAVG is reached). FW Control System controls to lower (No load) setpoint.	Bounded by Loss of Normal FW Flow (FSAR 15.2.7) if reactor trips, or no event.

TABLE 1 (Continued)

LOSS OF ANY SINGLE INSTRUMENT

					Hi	Rods out until blocked by Hi flux, overpower, or over-temperature, rod stop, or until programmed TREF limit is reached. (If reactor trip occurs, steam dump unblocked and dump valves open until no load TAVG is reached. FW Control System controls to nominal Full power setpoint.	Result is bounded by Uncontrolled Rod Cluster Control Assembly Bank Withdrawal at Power (FSAR 15.4.2)
Turbine Impulse Chamber Pressure	2 per turbine	III (Control) Selected	o Steam Dump (Pressure Mode) o Reactor Control o FW Control		Lo	Rods in, (safe direction) auto rod withdrawal blocked (C-5), FW Control System controls to lower (No load) setpoint.	Bounded by Loss of Normal FW Flow (FSAR 15.2.7)
					Hi	Rods out until blocked by Hi flux, overpower, or over-temperature rod stop. (Steam dump valves open if required to keep steam header pressure at or below setpoint). FW Control System Controls to nominal Full Power Setpoint.	Result is bounded by Uncontrolled Rod Cluster Control Assembly Bank Withdrawal at Power (FSAR 15.4.2).
Turbine Impulse Chamber Pressure	2 per turbine	III (Control)	o Steam Dump (TAVG Mode) (Reactor Control and FW Control not Selected)		Lo	Steam dump signaled to open but is blocked by interlock. (If reactor trip occurs, steam dump unblocked and dump valves modulate until no load TAVG is reached).	Not Applicable.

TABLE 1 (Continued)

LOSS OF ANY SINGLE INSTRUMENT

					Hi	No control action (if reactor trip occurs, steam dump unblocked and dump valves open until no load T_{AVG} is reached).	Not Applicable.
Turbine Impulse Chamber Pressure	2 per turbine	III (Control)	o	Steam Dump (pressure mode) (Reactor Control and FW Control not selected).	Lo or Hi	Steam dump functions normally.	Not Applicable.
Turbine Impulse Chamber Pressure	2 per turbine	IV (Interlock) Selected	o o o	Steam Dump (TAVG Mode) Reactor Control FW Control	Lo	Rods in (safe direction), auto rod withdrawal blocked (C-5). Steam dump unblocked (if reactor trips Steam Dump system functions normally). FW Control System controls to lower (No load) setpoint.	Bounded by Loss of Normal FW Flow (FSAR 15.2.7)
					Hi	Rods out until blocked by Hi flux, overpower, or over-temperature,, rod stop, or until programmed TREF limit is reached. (If reactor trip occurs, steam dump functions normally). FW Control System controls to nominal Full power setpoint.	Result is bounded by Uncontrolled Rod Cluster Control Assembly Bank Withdrawal at Power (FSAR 15.4.2)

TABLE 1 (Continued)

LOSS OF ANY SINGLE INSTRUMENT

Turbine Impulse Chamber Pressure	2 per turbine	IV (Interlock) Selected	o o o	Steam Dump (Pressure Mode) Reactor Control FW Control	Lo	Rods in (safe direction), auto rod withdrawal blocked (C-5). Steam dump unblocked (if reactor trip occurs, steam dump functions normally). FW Control System controls to lower (No load) setpoint.	Bounded by Loss of Normal FW Flow (FSAR 15.2.7)
					Hi	Rods out until blocked by Hi flux, overpower, or over-temperature,, rod stop, or until programmed TREF limit is reached. (If reactor trip occurs, steam dump functions normally). FW Control System controls to nominal Full power setpoint.	Result is bounded by Uncontrolled Rod Cluster Control Assembly Bank Withdrawal at Power (FSAR 15.4.2)
Turbine Impulse Chamber Pressure	2 per Turbine	IV (Interlock)	o	Steam Dump (TAVG Mode) (Reactor Control and FW Control not selected).	Lo	Unblock steam dump	Not applicable
					Hi	Steam dump on turbine trip only, steam dump blocked on load rejection.	Not applicable

TABLE 1 (Continued)

LOSS OF ANY SINGLE INSTRUMENT

Turbine Impulse Chamber Pressure	2 per Turbine	IV (Interlock)	o	Steam Dump (Pressure Mode) (Reactor Control and FW Control not selected).	Lo or Hi	Steam dump functions normally.	Not applicable
Power Range Flux	1 per plant (for Control)	_____	o o	Reactor Control FW Control	Lo	Control rods withdraw (Power increases) until blocked by high flux, overtemperature or overpower rod stop. FW bypass valve closes if in auto. Subsequent SG level deviation causes valve to reopen until nominal level is restored.	Result is bounded by Uncontrolled Rod Cluster Control Assembly Bank Withdrawal at Power (FSAR 15.4.2)
					Hi	Auto and manual rod withdrawal blocked (C-2), rods in (in safe direction). If reactor trip occurs, dump valves open until no-load TAVG is reached). FW bypass valve opens if in auto. Subsequent level deviation causes valve to close until nominal SG level is restored.	Minor SG level perturbation No event.
Steamline Pressure	1 per Steamline	any	o	Steam dump	Lo	Steamline atmospheric relief valve unavailable	No event.

TABLE 1 (Continued)

LOSS OF ANY SINGLE INSTRUMENT

					Hi	Steamline atmospheric relief valve opens	Bounded by excessive increase in secondary steam flow (FSAR 15.1.3)
Condenser Available	1 per plant	_____	o	Steam Dump	Lo	No control action-steam dump blocked, condenser unavailable.	Not applicable
					Hi	No control action-steam dump unblocked, condenser available.	Not applicable
TAVG High Auctioneer	1 per plant	_____	o o o	Steam Dump Reactor Control Pzr. Level Control	Lo	Steam dump blocked (TAVG mode). Charging flow decreased until no-load level reached. Backup heaters on. Rods out, power increases until blocked by high flux, overpower, or overtemperature rod stop.	Result is bounded by Uncontrolled Rod Cluster Control Assembly Bank Withdrawal at Power (FSAR 15.4.2)
					Hi	Indentical to TAVG channel failing high, see analysis above.	See above
Steam Flow Pressure Compensator	2 per loop	Control Channel	o	Steam Flow	Lo	Identical to Loop Steam Flow channel failing low. See analysis above.	See above
					Hi	Identical to Loop Steam Flow channel failing high. See analysis above.	See above

* Signals for pressurizer level control and interlock can be obtained from different channels. Channel selection is achieved by manual 3 position switch in the control room. Resulting accident due to failed instrument is dependent on switch position. Remaining combinations of switch position and channel failure are non-events since failed channel is not selected for control.

TABLE 2

LOSS OF POWER TO INVERTER VITAL BUS 1
(LOSS OF POWER TO PROTECTION SET I, CONTROL GROUP I AND NIS RACK I)

CONTROL SYSTEMS AFFECTED	SIGNALS AFFECTED	FAILURE DIRECTION	ITEMIZED EFFECTS	BOUNDING EVENT
Steam Dump	o Steamline atmospheric relief valves (system deenergized)	Off	Steamline atmospheric relief valves not available, no control action	
Reactor Control	o None			
FW Control	o None			Bounding event is either Increased Reactor Coolant Inventory (FSAR 15.5.2) or no event.
Pressurizer Level	o Pzr. Level (if selected)	Lo	If affected level signal used for control, charging flow increases, letdown isolated, heaters blocked. Otherwise, no control action.	
	o Interlock (Bistable LB 460)	Lo		
Pressurizer Pressure	o None			

TABLE 3

LOSS OF POWER TO INVERTER VITAL BUS II
(LOSS OF POWER TO PROTECTION SET II
CONTROL GROUP II AND NIS RACK II)

CONTROL SYSTEMS AFFECTED	SIGNALS AFFECTED	FAILURE DIRECTION	ITEMIZED EFFECTS	BOUNDING EVENT
Steam Dump	o Turbine Pressure (Interlocks C-7A, C-7B)	Lo	Steam dump blocked. Steam Dump unavailable.	Bounding event is Loss of Normal FW Flow (FSAR 15.2.7). Increased charging flow has little effect in comparison.
	o C-9 (condenser available)	Lo		
Reactor Control	o None	-		
FW Control (SG 1)	o All (system deenergized)	off	Fw Valve closes. Loss of Main FW in SGI (Plant trips on low level in SG 1)	
Pressurizer Level	o Pzr. Level	Lo	Charging FCV fails full open. Charging Flow Increases. If Level signal is selected for interlock, letdown is isolated.	
	o Charging Flow Control	off		
Pressurizer Pressure	o None			

TABLE 4

LOSS OF POWER TO INVERTER VITAL BUS III
(LOSS OF POWER TO PROTECTION SET III, CONTROL GROUP III AND NIS RACK III)

CONTROL SYSTEMS AFFECTED	SIGNALS AFFECTED	FAILURE DIRECTION	ITEMIZED EFFECTS	BOUNDING EVENT
Steam Dump	o Turbine Impulse chamber pressure (T_{REF})	Lo	No control action due to C-7 interlock.	
Reactor Control	o Turbine Impulse Chamber Pressure (if selected)	Lo	Rods inserted (safe direction)	Bounding event is Loss of Normal FW Flow (FSAR 15.2.7). Increased Charging flow has little effect in comparison
FW Control	o SG2-All (System Deenergized	FW Valve Closes	Loss of main FW in SG-2. Plant trips on Low Level in SG-2. Increase decrease or no change in FW flow to SG1 and SG3, depending on actual channels selected for control.	
	o Turbine Impulse Chamber Pressure (if selected)	Lo		
	o Steam Flow (if selected)	Lo		
	o Feedwater Flow (if selected)	Lo		
	o SG level	Lo		
Pressurizer Level	o Pzr. Level (Control or Interlock)	Lo	If affected level signal used for control, charging flow increases, letdown isolated, heaters blocked. If used for interlock, heaters blocked and letdown isolated. Otherwise, channel not connected, no control action.	

TABLE 4 (Continued)

LOSS OF POWER TO INVERTER VITAL BUS III

(LOSS OF POWER TO PROTECTION SET III, CONTROL GROUP III AND NIS RACK III)

CONTROL SYSTEMS AFFECTED	SIGNALS AFFECTED	FAILURE DIRECTION	ITEMIZED EFFECTS	BOUNDING EVENT
Pressurizer Pressure	o Pzr. Pressure (PORV 456 and PORV 455D Control)	to	PORV 456 and PORV 455D stay closed. (PORV 455C available).	

TABLE 5

LOSS OF POWER TO INVERTER VITAL BUS IV
(LOSS OF POWER TO PROTECTION SET IV, CONTROL GROUP IV AND NIS RACK IV)

CONTROL SYSTEMS AFFECTED	SIGNALS AFFECTED	FAILURE DIRECTION	ITEMIZED EFFECTS	BOUNDING EVENT
Steam Dump	o All (System Deenergized) Except Condenser Available	Off/Closed	No initiating event, steam dump system unavailable. (When reactor trip occurs, steamline atmos. relief valves available).	
Reactor Control	o All (System Deenergized)	Off	Rods stay stationary.	
FW Control	o SG3 - All (System Deenergized	FW Valve Closes	Loss of main FW in SG3. (Plant trips on low level in SG3).	
	o Steam Flow (if selected)	Lo	Increase or decrease or no change	
	o Feedwater Flow (if selected)	Lo	in FW flow to other SG's depending on actual channels selected for	
	o Power Range Flux	Lo	control. FW bypass valves close	
	o Turbine Impulse Chamber Pressure (if selected)	Lo	if in auto.	
Pressurizer Level	o All (System Deenergized) except LB 460	Off	Charging flow increases, backup heater off.	Bounding event is Loss of Normal FW flow (FSAR 15.2.7). Increased charging flow and pressurizer transients have little effect in comparison.
Pressurizer Pressure	o Pzr. Pressure (Control) (PORV 455C, Spray and Heater Control)	Lo	PORV 456 stays closed. (Pressure increases mitigated by PORV 456 & PORV 455D). Variable and backup heaters remain off. Pressure decreases alarmed by PB445B).	

TABLE 6

LOSS OF POWER TO CONTROL GROUP 1

CONTROL SYSTEMS AFFECTED	SIGNALS AFFECTED	FAILURE DIRECTION	ITEMIZED EFFECTS	BOUNDING EVENT
Steam Dump	o Steamline atmospheric relief valves	Off/Closed	No initiating event, steamline atmospheric relief valves unavailable.	
Reactor Control	o None	--	No signals affected, no control action	No event.
FW Control	o None	--	No signals affected, no control action.	
Pressurizer Level	o Pressurizer Level (LB 460)	Off	No control action.	
Pressurizer Pressure	o None	--	No signals affected, no control action.	

TABLE 7

LOSS OF POWER TO CONTROL GROUP 2

CONTROL SYSTEMS AFFECTED	SIGNALS AFFECTED	FAILURE DIRECTION	ITEMIZED EFFECTS	BOUNDING EVENT
Steam Dump	o C-7A, C-7B interlocks o C-9 Interlocks	Off Off	Steam dump blocked. Steam dump unavailable.	
Reactor Control	o None	--	No signals affected, no control action.	
FW Control (S.G.1)	o All (System Deenergized)	FW Valves Close	Loss of main FW in S.G.1. (Plant trips on low level in S.G.1.)	Bounding event is Loss of Normal FW Flow (FSAR 15.2.7) (Plant trips on low level in S.G.1.) Increased charging flow has little effect in comparison.
Pressurizer Level	o Charging Flow Control	Off	Changing FCV fails open Charging flow increases.	
Pressurizer Pressure	o None	--	No control action.	

TABLE 8

LOSS OF POWER TO CONTROL GROUP 3

CONTROL SYSTEMS AFFECTED	SIGNALS AFFECTED	FAILURE DIRECTION	ITEMIZED EFFECTS	BOUNDING EVENT
Steam Dump	o None	--	No signals affected, no control action.	
Reactor Control	o None	--	No signals affected, no control action.	
FW Control (S.G.2)	o All (System Deenergized)	FW Valve Closes	Loss of main FW in S.G.2. (Plant trips on low level in S.G.2.)	Bounding event is Loss of Normal FW Flow (FSAR 15.2.7) (Plant trips on low level in S.G.2.)
Pressurizer Level	o None	--	No signals affected, no control action.	
Pressurizer Pressure	o PORV 456 and PORV 455D control.	Lo	PORV 456 and PORV 455D remain closed (PORV 455C available if needed).	

TABLE 9

LOSS OF POWER TO CONTROL GROUP 4

CONTROL SYSTEMS AFFECTED	SIGNALS AFFECTED	FAILURE DIRECTION	ITEMIZED EFFECTS	BOUNDING EVENT
Steam Dump	o All (except control permissive) (System Deenergized)	Lo	No initiating event, steam dump system unavailable. (If reactor trip occurs, steamline atmos. relief valves available.)	
Reactor Control	o All (System Deenergized)	Off	Rods stay stationary	
FW Control (S.G.3)	o All (System Deenergized	FW Valve Closes	Loss of main FW in S.G.3. (Plant trips on low level in S.G.3.)	Bounding event is Loss of Normal FW Flow (FSAR 15.2.7) since increased charging flow has little effect in comparison. (Plant trips on low S.G.3 level.)
Pressurizer Level	o All (except LB460) (System Deenergized)	Lo	Charging flow increases, letdown isolated.	
Pressurizer Pressure	o PORV 455C, spray and heater control (System Deenergized)	Off	Normal Pressure control deactivated except for PORV 455A.	

TABLE 10

LOSS OF POWER TO PROTECTION SET I

CONTROL SYSTEMS AFFECTED	SIGNALS AFFECTED	FAILURE DIRECTION	ITEMIZED EFFECTS	BOUNDING EVENT
Steam Dump	0 None	-		
Reactor Control	0 None	-		
FW Control	0 None	-		
Pressurizer Level	0 Pressurizer Level	Lo	Identical to failure low of Pressurizer Level Channel I.	See Table 1.
Pressurizer Pressure	0 None	-		

TABLE 11

LOSS OF POWER TO PROTECTION SET II

CONTROL SYSTEMS AFFECTED	SIGNALS AFFECTED	FAILURE DIRECTION	ITEMIZED EFFECTS	BOUNDING EVENT
Steam Dump	o None	-		
Reactor Control	o None	-		
FW Control	o None	-		
Pressurizer Level	o Pressurizer Level	Lo	Identical to Failure Low of Pressurizer Level Channel II.	See Table 1
Pressurizer Pressure	o None	-		

TABLE 12

LOSS OF POWER TO PROTECTION SET III

CONTROL SYSTEMS AFFECTED	SIGNALS AFFECTED	FAILURE DIRECTION	ITEMIZED EFFECTS	BOUNDING EVENT
Steam Dump	o Turbine Impulse Chamber Pressure (Control)	Lo	No control action due to C-7 interlock.	
Reactor Control	o Turbine Impulse Chamber Pressure (if selected)	Lo	If selected, Rods Inserted (Safe Direction). Auto Rod withdrawal blocked. Otherwise no control action.	Bounding Event is either Excessive FW Flow (FSAR 15.1.2). (Changing flow transient is minor in comparison), loss of normal FW Flow (FSAR 15.2.7).
	o C-5 Interlock	Lo		
FW Control	o SG level	Lo	Increase, decrease or no change in FW Flow to loops, depending on actual channels selected for control.	(Charging Flow transient is minor in comparison), increased reactor coolant inventory (FSAR 15.5.2) or no events depending on actual channels selected for control.
	o Steam Flow (if selected)	Lo		
	o Feedwater Flow (if selected)	Lo		
	o Turbine Impulse Chamber Pressurizer (if selected)	Lo		
Pressurizer Level	o Pressurizer Level	Lo	If affected level signal used for control, charging flow increases, letdown isolated, heaters blocked. If used for interlock, heaters blocked and letdown isolated. Otherwise, channel not connected, no control action.	
Pressurizer Pressure	o None	-		

TABLE 13

LOSS OF POWER TO PROTECTION SET IV

CONTROL SYSTEMS AFFECTED	SIGNALS AFFECTED	FAILURE DIRECTION	ITEMIZED EFFECTS	BOUNDING EVENT
Steam Dump	o Turbine Impulse Chamber Pressure (interlock)	Lo	Steam Dump Unblocked	
Reactor Control	o Turbine Impulse Chamber Pressure (if selected)	Lo	Rods Inserted (safe direction). Auto Rod Withdrawal Blocked.	
FW Control	o Steam Flow (if selected) o Feed Flow (if selected) o Turbine Impulse Chamber (if selected)	Lo Lo Lo	Feedwater flow can either increase, decrease or remain constant depending on channels selected.	Bounding event is either Excessive Feedwater Flow (FSAR 15.1.2), no event, or Loss of Normal Feedwater (FSAR 15.2.7).
Pressurizer Level	o None	-		
Pressurizer Pressure	o None	-		

TABLE 14

LOSS OF POWER TO NIS I

CONTROL SYSTEMS AFFECTED	SIGNALS AFFECTED	FAILURE DIRECTION	ITEMIZED EFFECTS	BOUNDING EVENT
Steam Dump	o None	-		
Reactor Control	o None	-		
FW Control	o None	-		No event
Pressurizer Level	o None	-		
Pressurizer Pressure	o None	-		

TABLE 15

LOSS OF POWER TO NIS II

CONTROL SYSTEMS AFFECTED	SIGNALS AFFECTED	FAILURE DIRECTION	ITEMIZED EFFECTS	BOUNDING EVENT
Steam Dump	o None	-		
Reactor Control	o None	-		
FW Control	o None	-		No event
Pressurizer Level	o None	-		
Pressurizer Pressure	o None	-		

TABLE 16

LOSS OF POWER TO NIS III

CONTROL SYSTEMS AFFECTED	SIGNALS AFFECTED	FAILURE DIRECTION	ITEMIZED EFFECTS	BOUNDING EVENT
Steam Dump	o None	-		
Reactor Control	o None	-		
FW Control	o None	-		No event
Pressurizer Level	o None	-		
Pressurizer Pressure	o None	-		

TABLE 17

LOSS OF POWER TO NIS IV

CONTROL SYSTEMS AFFECTED	SIGNALS AFFECTED	FAILURE DIRECTION	ITEMIZED EFFECTS	BOUNDING EVENT
Steam Dump	o None	-		
Reactor Control	o Power Range Flux	Lo	Same as failure low of Power Range Flux Channel IV	See Table I
FW Control	o Power Range Flux	Lo		
Pressurizer Level	o None	-		
Pressurizer Pressure	o None	-		

TABLE 18

LOSS OF COMMON INSTRUMENT LINES

(ASSUMED BREAK IN LINE)

SENSORS	FAILED CHANNELS	SYSTEM	FAILURE DIRECTION	EFFECT	BOUNDING ACCIDENT
Loop Steam Flow and Narrow Range Level	III	Feedwater Control	Lo Hi	If steam flow selector switched to failed channel, FW valve closes in affected S.G.(s).	Bounding event is Loss of Normal FW (FSAR 15.2.7)
Pressurizer Level (Control) and Pressurizer Pressure (PORV 456, 455D) (PORV 455C, Control)	III III IV	Prz. Level Control Prz. Pressure Control	Hi Lo	PORV's remain closed. Spray remains off and heaters turn on. If level channel selector switch in position 1 charging flow decreases. (On low level, letdown isolated from interlock channel and heaters blocked). In position 2 level signal not connected. In position 3, letdown is isolated and heaters blocked.	These effects at worst result in a depressurization which is bounded by Inadvertent Opening of a Pzr. Safety or Relief Valve (FSAR 15.6.1).