

Pennsylvania Power & Light Company
Review of Unit 2 Control System Failures
Final Report
Unit 2 Control Systems Power Supply
and Sensor Malfunctions

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Appendix G

ANALYSIS OF UNIT 2 CONTROL SYSTEMS POWER SUPPLY AND SENSOR MALFUNCTIONS

1.0 INTRODUCTION

The purpose of this appendix is to provide an analysis of the effects of Non-Safety Grade Control System Power Supply and Sensor Malfunctions with respect to plant safety for the Susquehanna Steam Electric Station, Unit 2. In summary, this was accomplished by making a detailed, one to one comparison between the non-safety grade control system power supply and sensor arrangements for the two units, respectively. The Power Feeder Tabulation and System Electrical Drawings were the primary sources of information used. In those cases in which the power supply or sensor commonalities were identical for each of the units, it was concluded that the analysis performed for Unit 1 was directly applicable to Unit 2. For those differences noted (eg, system/component being supplied powered from different sources), a separate and distinct analysis was performed utilizing the methodology delineated in Section 3.0 of this report.

The following section describes the Summary of Results and provides supporting analysis where applicable.

2.0 Summary of Results

As indicated in Section 1.0, a detailed one to one comparison was made to determine the similarity between the power supply and sensor arrangements for Unit 1 and Unit 2. The results of this comparison are segregated into two groups - Unit 2 same as Unit 1 and Unit 2 different than Unit 1. These two groups are described in detail below.

2.1 Analysis

o Unit 2 Same as Unit 1

In reviewing the Unit 2 power supply and sensor related drawings, it was determined that the following Unit 2 common power supplies and sensors (commonalities) were the same as those identified in the Unit 1 report. The only difference noted was that of the unique Unit 2 numerical identifier. The following provides a list of Unit 1 commonalities and the corresponding Unit 2 commonalities. The affected non-safety grade control systems are also shown for each of the commonalities, respectively.



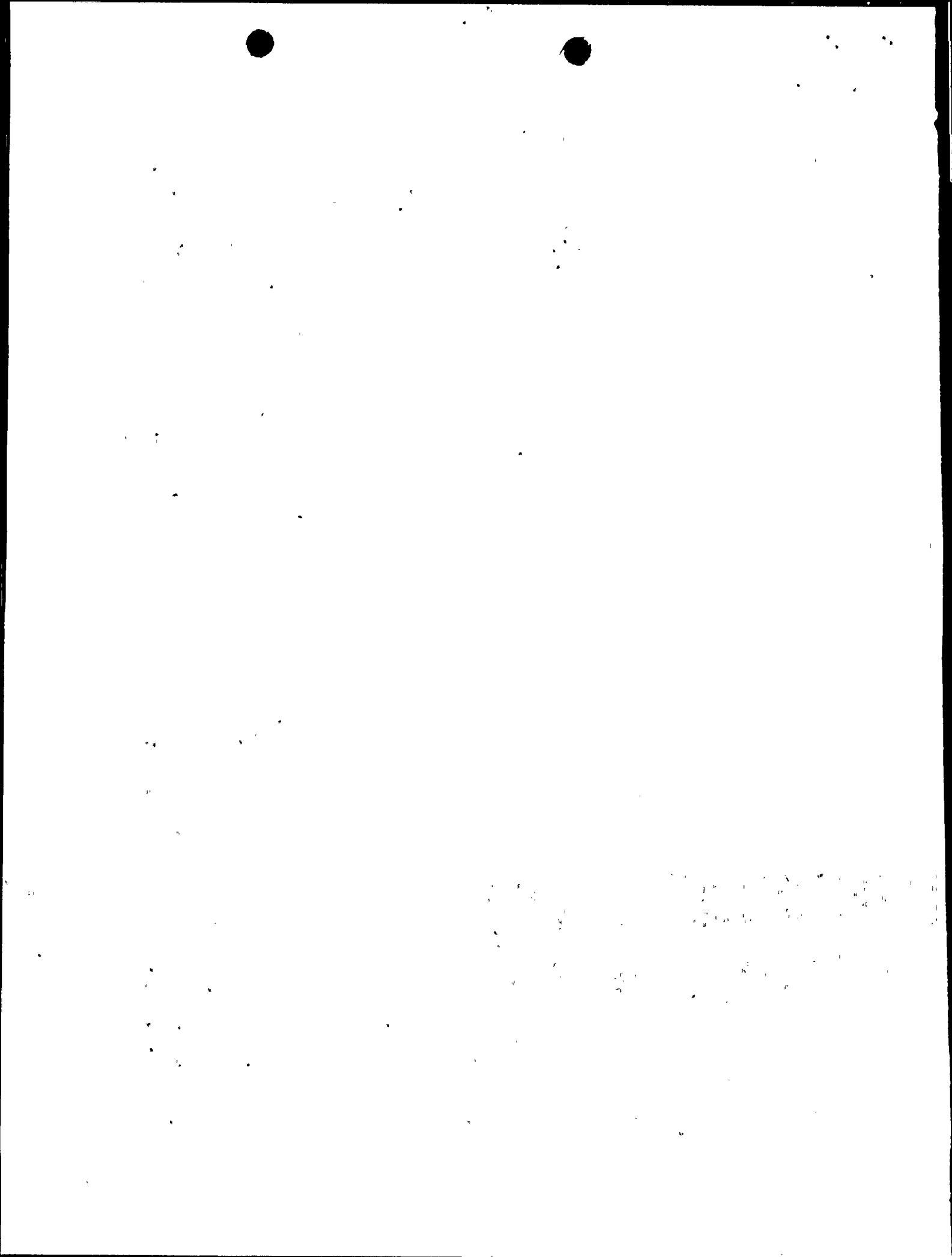
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<u>Unit 1 Commonality</u>	<u>Unit 2 Commonality</u>	<u>Affected Systems</u>
1D615 125 VDC	2D615 125 VDC	TG Recirc Feedwater
1D625 125 VDC	2D625 125 VDC	TG Recirc TIP Feedwater
1D645 125 VDC	2D645 125 VDC	TG Feedwater
1Y218 120 VAC	2Y218 120 VAC	Recirc Reactor Manual Control Nuclear Pressure Relief TG TIP RWCS Feedwater
1Y219 120 VAC	2Y219 120 VAC	RWCS Reactor Manual Control
1Y226 120 VAC	2Y226 120 VAC	RWCS Nuclear Pressure Relief
1Y629 120 VAC	2Y629 120 VAC	Recirc TG Reactor Manual Control
1Y218/219 120 VAC (Cascading Power Supply Effect)	2Y218/2Y219 120 VAC	Recirc Reactor Manual Control Nuclear Pressure Relief TG TIP RWCS Feedwater
FE 1N001, A,B,C (Feedwater Flow Element)	FE 2N001 A,B,C	Feedwater Recirc

The specific system components powered from each of the above power supplies are the same for Unit 1 and Unit 2.



o Unit 2 Different Than Unit 1

In review of the power supply and sensor arrangement for Unit 2, the following new commonalities were identified. Please note that there were no new sensor commonalities.

<u>New Unit 2 Commonality</u>	<u>Affected Systems</u>
2D614 125 VDC	Nuclear Pressure Relief Recirc
2D635 125 VDC	Feedwater TG Recirc

The 2D614 commonality arose due to the addition of the ATWS feature of Recirc Pump Trip. The 2D635 commonality is similar to the 1D635 commonality noted in the Unit 1 study with the exception that it also provides power to a portion of the Recirc system in addition to the the Feedwater and Turbine/Generator systems.

New Commonality Diagrams are contained in Attachment 1. Failure Modes and Effects Analysis (FMEA) Tables are provided in Attachment 2.

2.2 Conclusions

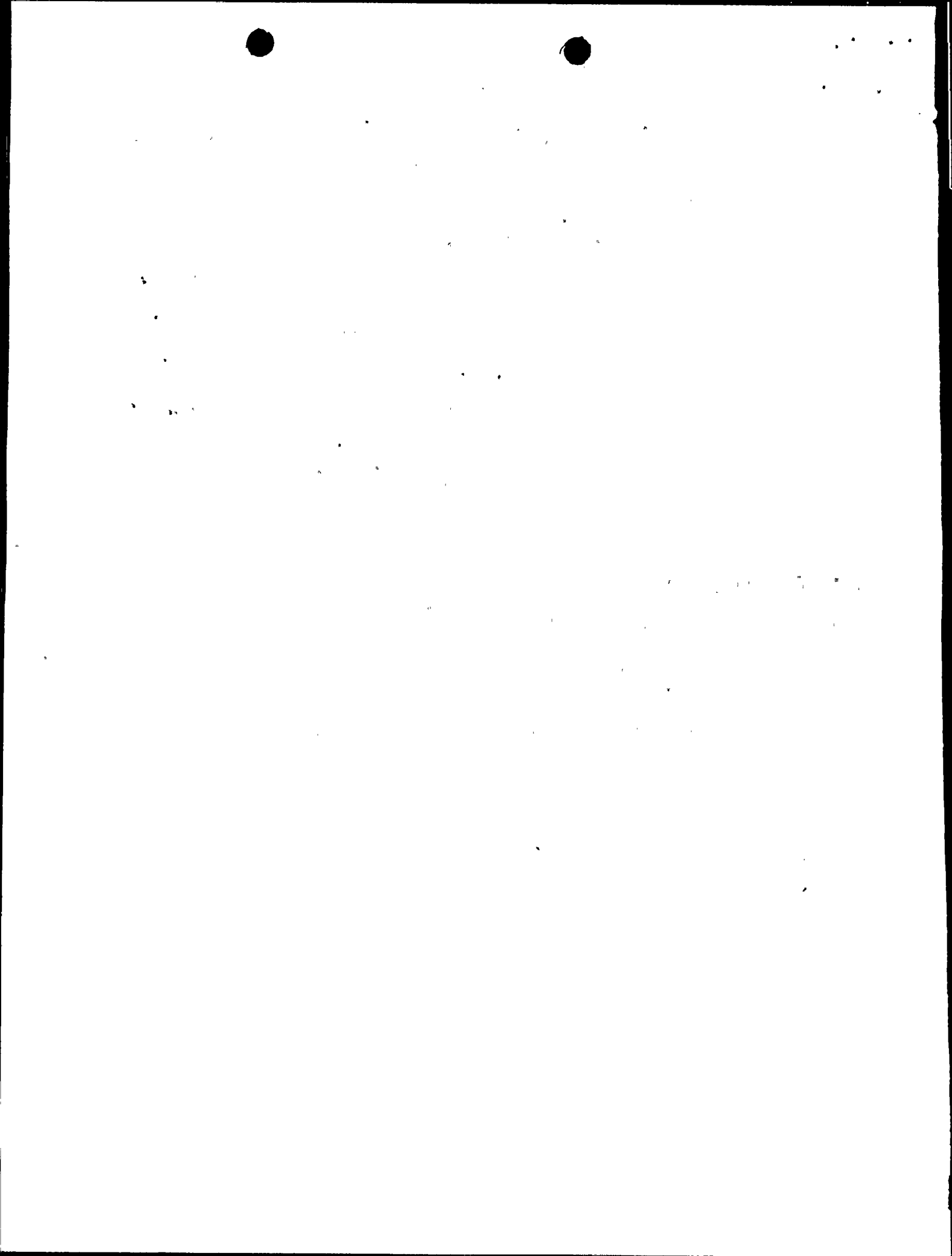
Based on the analysis provided in the FMEA's, the following conclusions have been ascertained regarding the new Unit 2 power supply commonalities.

- o The two (2) new commonalities for Unit 2 have been determined to be either bounded by Chapter 15 analysis or to not impact plant safety.
- o No recommendations for modifications or analysis are required.

The specifics associated with each of these commonalties are described below.

a. 2D614 125 VDC

The control systems involved with this power supply failure are the Nuclear Pressure Relief and Recirculation Flow Control Systems. Plant conditions are not affected by the loss of the affected portions of these control systems. In the case of the Nuclear Pressure Relief system, automatic/manual operation of the Safety Relief Valves is lost; however, they remain operable mechanically through spring set points. In addition, Division II of the Automatic Depressurization System (ADS) remains fully operable. The loss of Division I Recirc Pump Trip on ATWS does not affect plant safety conditions since Division II remains fully operable. (Division II receives power from a different power supply)



This condition and plant response are covered by Chapter 15 analysis. This condition is also within the capabilities of the operator. In addition, safety system response is not required.

b. 2D635 125 VDC

The control systems associated with this power supply failure are the Reactor Feedwater Control, Turbine/Generator, and Recirculation Flow Control Systems. This loss of power supply is quite similar to the 1D635 failure identified in the Unit 1 report. The only difference, here, is that the Recirculation Flow Control System has been added as an affected system. Specifically, the Recirculation Runback circuitry has been disabled as a result of the loss of 2D635.

In general, the plant conditions that resulted from the loss of 1D635 are identical for the loss of 2D635. In the 1D635 analysis, the loss of this power supply generated an excess feedwater flow condition due to failure of a feedwater pump to trip which resulted from the absence of a Level 8 signal from the Feedwater Flow Control System. With those conditions present, it was proven through analysis that these conditions were bounded by current Chapter 15 analysis and were within the response capabilities of plant safety systems.

In the case of 2D635, the additional loss of the Recirculation Runback circuitry does not introduce new plant conditions other than those previously described. Runback is not required from a safety perspective to mitigate the consequences on those plant conditions present. The current Chapter 15 analysis adequately bounds the plant conditions created by the non-safety grade control system failures that result from the loss of 2D635. These conditions are also within the capabilities of plant operators and safety systems.



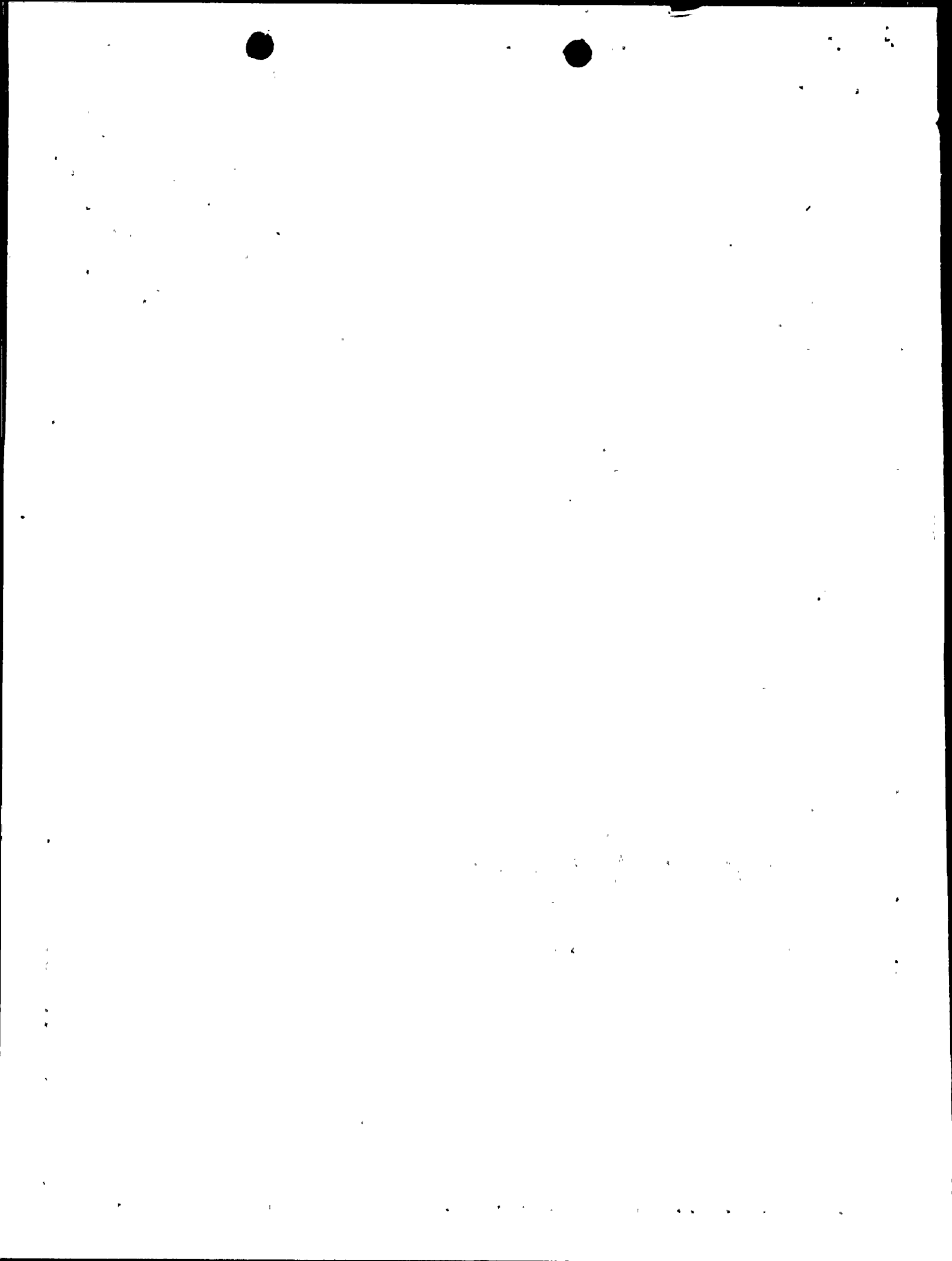
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APPENDIX G
ATTACHMENT 1

Commonality Diagrams



2D614

125 VDC
CLASS 1E

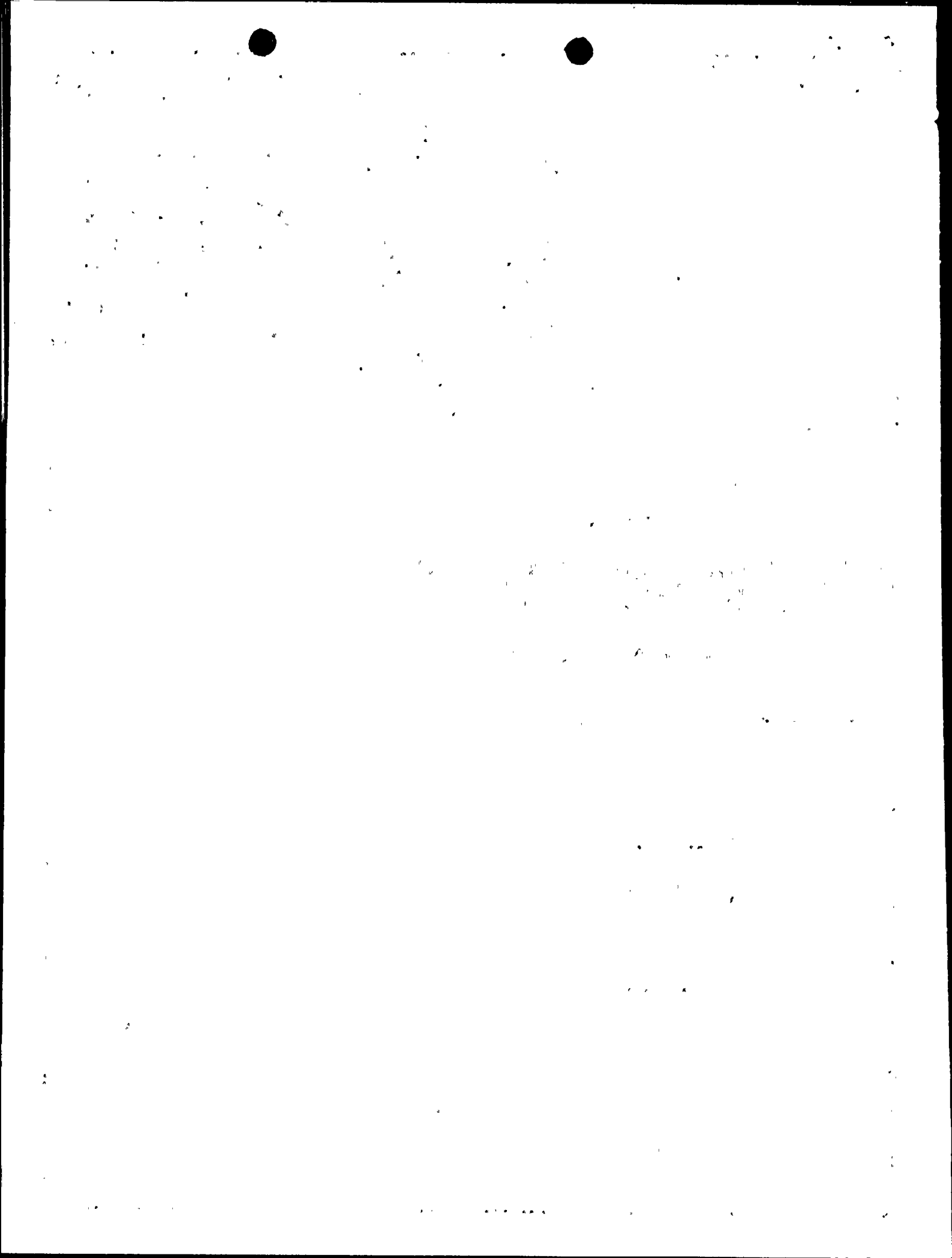
NUCLEAR
PRESSURE
RELIEF

- PSV AUTO/MANUAL INITIATION CIRCUITRY

RECIRCULATION
FLOW
CONTROL

- RECIRC. PUMP TRIP-ATWS CIRCUITRY

0	1/6/84	INITIAL RELEASE	WAK	WAK	RLS
REV.	DATE	DESCRIPTION	BY	CHK'D	APPV.
SCALE :	DESIGN :	DRAWN :			
-11-	WAK	RID			
IMPELL CORPORATION					
THE PENNSYLVANIA POWER & LIGHT COMPANY SUSQUEHANNA STEAM ELECTRIC STATION					
COMMONALITY DIAGRAM POWER SUPPLY-2D614					
JOB NO.		DRAWING NO.		REV.	
0160-017-1871		0160-017-001		0	



2D635

125 VDC
NON CLASS 1E

RECIRCULATION
FLOW
CONTROL

- RUNBACK CIRCUITRY

REACTOR
FEEDWATER
CONTROL
SYSTEM

- REACTOR WATER LEVEL-
INST. C
- FEEDWATER FLOW-
INST. B
- WIDE RANGE REACTOR LEVEL
- LEVEL B TRIP (R_x HIGH
WATER LEVEL)
- REPT C TRIP

TURBINE/
GENERATOR

- C SYSTEM-TURB. TRIP
& ALARM UNIT
- THRUST BRG WEAR DETECTOR
& LO BRG OIL PRESS
- LO. HYD. FLUID PRESS.
- EXH. HOOD HIGH TEMP
GEN. END TRIP
- UNDERVOLTAGE RELAY TO ALARM
- SHAFT PP DISCH LO PRESS
LEVEL B TRIP (R_x HIGH WATER LEVEL)

0	1/16	INITIAL RELEASE	WAC	BA	RLS
REV. DATE	DESCRIPTION		BY	CHK'D	APPV.
SCALE: <i>1/16"</i>	DESIGN: <i>WAC</i>	DRAWN: <i>FJD</i>			
IMPELLER CORPORATION					
THE PENNSYLVANIA POWER & LIGHT COMPANY SUSQUEHANNA STEAM ELECTRIC STATION					
COMMONALITY DIAGRAM POWER SUPPLY-2D635					
JOB NO.		DRAWING NO.		REV.	
0160-017-1671		0160-017-002		0	

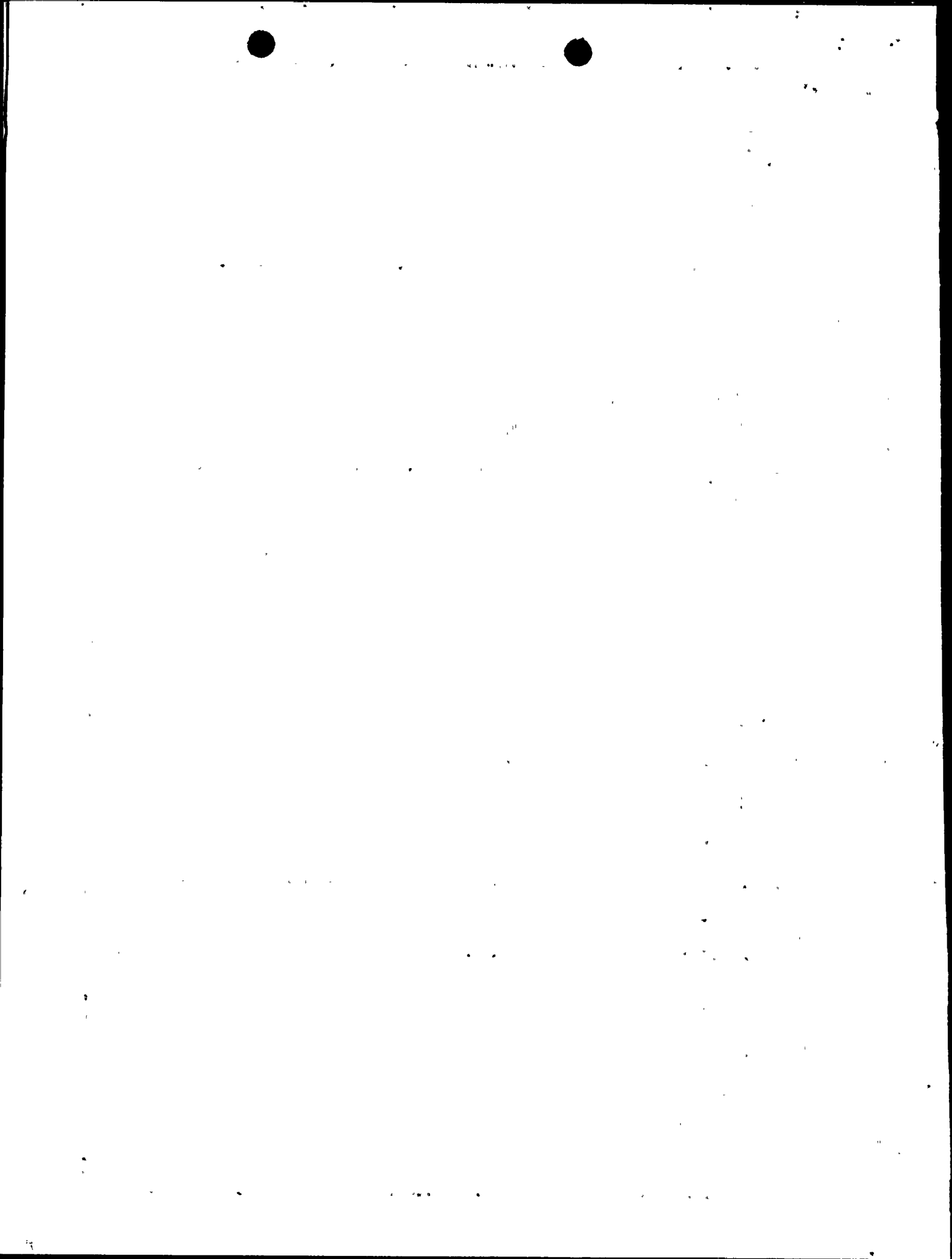
APPENDIX G
ATTACHMENT 2

Failure Modes and Effects Analyses



Common Power Supply or Sensor: <u>2D614 125 VDC</u> Control System Affected: <u>Nuclear Pressure Relief</u>	CSID: <u>0160-004-001</u> CD: <u>0160-017-001</u>	Job No. <u>0160-017-1671</u> Prepared by: <u>W. Finken</u> Date: <u>January 6, 1984</u> Checked by: <u>[Signature]</u> Approved by: <u>[Signature]</u>
Rev. <u>0</u>	Date: <u>2/1/84</u>	Date: <u>2/2/84</u>

Component Name and Number	Failure Mode	Symptoms and Local Effects Including Dependent Failures	System Inherent Compensating Provision	Summary: Effect Upon Control System	Summary: Effect Upon Plant Performance
Safety Relief Valves/PSV-B21-2F013	Off	<ul style="list-style-type: none"> . Loss of one mode of valve position indication (lights), loss of ability to manually operate valves (remote and local) . ADS Logic "A" power failure would indicate the 2D614 had been lost. 	<ul style="list-style-type: none"> . ADS valves (Div. II) remain operable (separate controls). . SRV's can still be actuated mechanically through spring set points . SRV flow monitoring and leak detection (high temperature) provide backup indication of valve position 	Loss of ability to automatically or manually operate SRV using control circuits. SRV will still operate mechanically if spring set point is reached	None



Job No. 0160-017-1671

Common Power Supply or Sensor: 20614 125 VDC

CSID: 0160-004-001

Prepared by: W. Kuban

Date: January 6, 1984

Rev. 0

Control System Affected: Recirculation Flow Control

CD: 0160-017-001

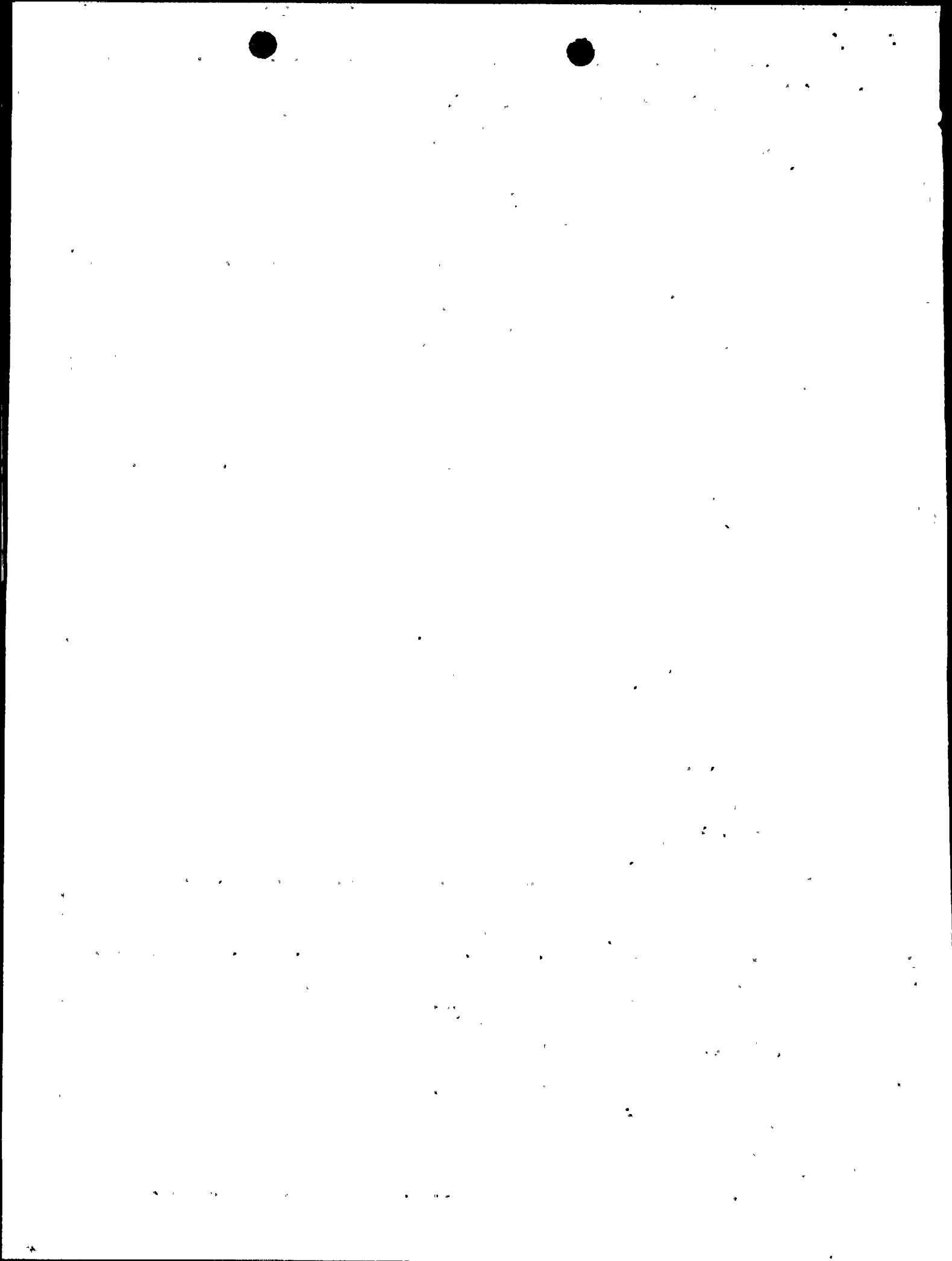
Checked by: S. Williams

Date: 2/1/84

Approved by: R. Williams

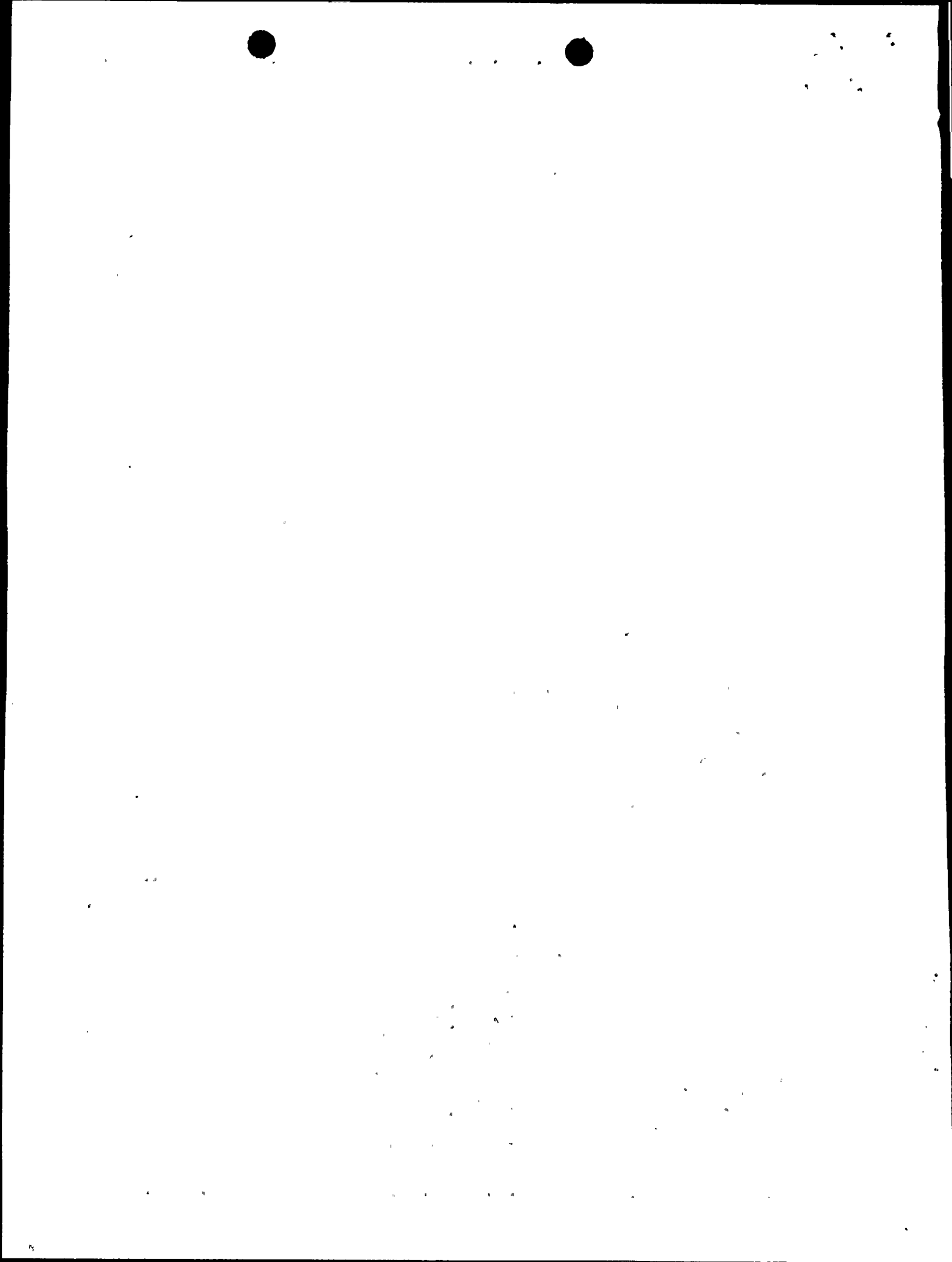
Date: 2/12/84

Component Name and Number	Failure Mode	Symptoms and Local Effects Including Dependent Failures	System Inherent Compensating Provision	Summary: Effect Upon Control System	Summary: Effect Upon Plant Performance
Recirculation pump trip ATMS - DIV1	Off	None	Division II is still fully operable and capable of tripping RPT breakers	Loss of one division of RPT breaker trip	None



Common Power Supply or Sensor:	<u>2D635 125 VDC</u>	CSID: <u>0160-004-001</u>	Job No. <u>0160-017-1671</u>
Control System Affected:	<u>Reactor Feedwater Flow Control</u>	CD: <u>0160-017-002</u>	Prepared by: <u>W. Keenan</u>
			Date: <u>January 6, 1984</u>
			Rev. <u>0</u>
			Checked by: <u>W. Keenan</u>
			Date: <u>2/1/84</u>
			Approved by: <u>W. Keenan</u>
			Date: <u>2/2/84</u>

Component Name and Number	Failure Mode	Symptoms and Local Effects Including Dependent Failures	System Inherent Compensating Provision	Summary: Effect Upon Control System	Summary: Effect Upon Plant Performance
1. Feedwater flow instrumentation: a. Feedwater flow sensor train B/C32-N002	Off	<ul style="list-style-type: none"> Flow signal from sensor B goes to zero for flow signal processing circuit 	<ul style="list-style-type: none"> Level 8 trip logic is reduced from 2/3 to 1/2 and prevents an inadvertent trip caused by a power failure 	<ul style="list-style-type: none"> In the 3 element mode: - A zero flow input signal to the flow control circuit causes an increase in speed for reactor feed pump turbine A, B, and C 	<ul style="list-style-type: none"> If Level 8 trip is reached, RFPT C will not trip due to the disabling of the trip circuit
2. Feedwater level instrumentation: a. Reactor vessel level sensor C/C32-N004C b. Reactor vessel high level alarm train C/C32-K624C	Off Alarm Armed	<ul style="list-style-type: none"> Lose C train reactor water level signal High level alarm is armed for Level 8 trip Level 8 contact in trip circuit not processed 		<ul style="list-style-type: none"> In start-up mode there is no effect Reactor vessel high level (Level 8) trip is armed in train C 	<ul style="list-style-type: none"> A Level 8 trip is possible due to the zero flow input signal to the flow control circuit
3. Reactor feed pump turbine trip (RFPT) circuit train C	Off			<ul style="list-style-type: none"> Circuits are in 1/2 logic There is no effect on the control system, providing the trip condition is not present 	<ul style="list-style-type: none"> Subsequent to Level 8 trip (if it occurs), flow imbalance in the feedwater control system is no longer present since 2 of 3 operating feedwater pumps have tripped



Job No. 0160-017-1671
 Prepared by: W. Keeler
 Date: January 6, 1984 Rev. 0
 Checked by: W. Keeler Date: 2/1/84
 Approved by: Kathleen Knie Date: 2/2/84

Common Power Supply or Sensor: 20635 125 VDC
 CSID: 0160-004-001
 Control System Affected: Pressure Regulator and T/G Control
 CD: 0160-017-002

Component Name and Number	Failure Mode	Symptoms and Local Effects Including Dependent Failures	System Inherent Compensating Provision	Summary: Effect Upon Control System	Summary: Effect Upon Plant Performance
1. Trip and Alarm switches: a. PSL-21981A3,B3/Thrust bearing wear detector and low bearing oil pressure	Fail High	Coil does not energize and fails to change state of contacts in EHC logic circuit	Circuit logic (2/3) prevents inadvertent EHC trip	Control logic circuit reduces to a 2/2 logic system	No trip of EHC occurs when power supply lost
b. PSL-20180C/Low hydraulic fluid pressure	Fail High			Level 8 trip logic is reduced from 2/3 to 1/2	No impact to overall plant performance will occur
c. PSL-210132C/Shaft pump discharge low pressure	Fail High			Loss of back-up unit protection	
d. TSHH-2019A3-C3/High exhaust hood temperature generator end	Fail Low				
e. Level 8 reactor high water level trip, train C	Armed	One third of Level 8 trip circuit armed	Level 8 trip can still trip T/G		
2. Back-up unit protection 86GD Back-up lockout relay unit protection	Off	Loss of redundant unit protection system	Primary unit protection remains activated		



Common Power Supply or Sensor: <u>20635 125VDC</u>	CSID: <u>0160-004-001</u>	Job No. <u>0160-017-1671</u>	Prepared by: <u>W. Reichen</u> Date: <u>January 6, 1984</u>
Control System Affected: <u>Recirculation Flow Control</u>	CD: <u>0160-017-002</u>	Rev. <u>0</u> Date: <u>2/1/84</u>	Checked by: <u>W. Reichen</u> Approved by: <u>R. W. [unclear]</u>

Component Name and Number	Failure Mode	Symptoms and Local Effects Including Dependent Failures	System Inherent Compensating Provision	Summary: Effect Upon Control System	Summary: Effect Upon Plant Performance
1. Feedwater system control of reactor recirculation system runback circuitry - recirculation flow loop A: a. Feedwater low flow: 1. FSL-20604A1 2. FSL-20604B1 3. FSL-20604C1 b. Feedwater high level: 1. LSHH-20317A2 2. LSHH-20317B2 3. LSHH-20317C2 4. LSHH-20305A2 5. LSHH-20305B2 6. LSHH-20305C2 c. Condensate pump low discharge pressure: 1. PSL-20507A 2. PSL-20507B 3. PSL-20507C 4. PSL-20507D d. Circulating water pump trip circuit: 1. COIL 52X1-10105	Off	None, runback will not occur if conditions are present	Runback circuit (Speed limiter #2) Only mitigates effect of other plant transients (eg. loss of feedwater) to minimize plant trips that could result from these transients	Loss of runback capability (speed limiter #2) for Recirc pumps in the event of Feedwater transient or loss of vacuum	In the event that Feedwater transient or loss of vacuum occurs, plant may trip - indirectly due to runback not occurring