

# **Human Factors Verification and Validation Scenarios**

**Revision 1**

**Non-Proprietary**

**March 2017**

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**REVISION HISTORY**

Revision	Date	Page	Description
0	December 2014	All	First Issue
1	March 2017	x (Table of Contents)	Terminology changed. (anticipated transient without trip -> anticipated transient without scram) S_MES/KP-160186M Section 4.1 Major Operator Errors deleted. R_352-8205(61)
		xi (Acronym and Abbreviations)	Terminology changed. (anticipated transient without trip -> anticipated transient without scram) S_MES/KP-160186M
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A6 (Appendix A 1.3.2)	Description added to ensure failure criteria R_352-8205(69)		
A8-A9 (Appendix A 1.3.2)	Reference to Attachment 5 added. R_352-8205(76)		

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		E39 (Appendix E Attachment 5)	Attachment 5 Guidance when difficulties occur during simulation or testing modified. R_352-8205(76R)

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		F8 (Appendix F 1.3)	Description for briefing before scenario added. R_352-8205(76)
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		G7-G8 (Appendix G 1.3)	Description for briefing before scenario added. R_352-8205(76)
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## **ABSTRACT**

The purpose of this technical report, Human Factors Verification and Validation Scenarios, is to identify the operational conditions and scenarios that are used in the human-system interface (HSI) task support verification, design verification, and integrated system validation and to provide detailed scenarios suitable for use on a full-scope simulator.

The scenarios that are described in this technical report contain a sampling of operational conditions and a summary of the Advanced Power Reactor 1400 probabilistic risk assessment.

**TABLE OF CONTENTS**

<b>1.</b>	<b>PURPOSE.....</b>	<b>1</b>
<b>2.</b>	<b>SCOPE .....</b>	<b>2</b>
2.1.	Applicable Documents .....	2
<b>3.</b>	<b>SAMPLING OF OPERATIONAL CONDITIONS FOR THE INTEGRATED SYSTEM VERIFICATION.....</b>	<b>3</b>
3.1.	Plant Conditions.....	3
3.2.	Types of Personnel Tasks.....	5
3.3.	Situational Factors or Error-Forcing Contexts .....	7
<b>4.</b>	<b>SUMMARY OF THE APR1400 PROBABILISTIC RISK ASSESSMENT .....</b>	<b>8</b>
4.1.	Total Core Damage Frequency of Initial Events .....	8
4.2.	Analysis of Significances .....	8
<b>5.</b>	<b>APR1400 HUMAN FACTORS VERIFICATION AND VALIDATION SCENARIOS .....</b>	<b>9</b>
5.1.	Small Break Loss-of-Coolant Accident with Computer-Based Procedure and Human-System Interface Display Failure .....	10
5.2.	Anticipated Transient without Scram with Ovation Distributed Control System Failure .....	12
5.3.	Excessive Steam Demand Event with Alarm Server Failure.....	13
5.4.	Loss of All Feedwater .....	14
5.5.	Station Blackout.....	15
5.6.	Steam Generator Tube Rupture .....	16
5.7.	Main Control Room FIRE .....	17
Appendix A	Small Break Loss-of-Coolant Accident with Computer-Based Procedure and Human-System Interface Display Failure (ISV-1) .....	A1
Appendix B	Anticipated Transient without Scram with Ovation Distributed Control System Failures (ISV-2).....	B1
Appendix C	Excessive Steam Demand Event with Alarm Server Failure (ISV3).....	C1
Appendix D	Loss of All Feedwater (ISV4).....	D1
Appendix E	Station Blackout (ISV5) .....	E1
Appendix F	Steam Generator Tube Rupture (ISV6) .....	F1
Appendix G	Main Control Room Fire (ISV7) .....	G1

**ACRONYMS AND ABBREVIATIONS**

AAC	alternate alternating current
ACU	air cleaning unit
AOP	abnormal operating procedure
AFWP	auxiliary feedwater pump
ATWS	anticipated transient without scram
BOL	beginning of life
BTP	Branch Technical Position
CBP	computer-based procedure
CCW	component cooling water
CCWP	component cooling water pump
CHG	charging
CMF	common mode failure
CRS	control room supervisor
CVCS	chemical and volume control system
DBA	design basis accident
DCS	distributed control system
DG	diesel generator
EDG	emergency diesel generator
EO	electrical operator
EOP	emergency operating procedure
ESWP	essential service water pump
FW	feedwater
GOP	general operating procedure
HA	human action
HSB	hot standby
HSI	human system interface
Hx	heat exchanger
I&C	instrumentation and control
IC	initial condition
ISV	integrated system validation
L/D	letdown
LDP	large display panel

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LOAF	loss of all feedwater
LOCA	loss-of-coolant accident
LOOP	loss of offsite power
LPMS	loose part monitoring system
MCR	main control room
MD	motor driven
MF	mitigating function
MFWP	main feedwater pump
NRC	U.S. Nuclear Regulatory Commission
OER	operating experience review
PM	preventive maintenance
PME	predictive maintenance engineer
POP	plant operating procedure
PRA	probabilistic risk assessment
PZR	pressurizer
RCS	reactor coolant system
RO	reactor operator
RPCS	reactor power cutback system
RSR	remote shutdown room
RTP	return to power
SBO	station black out
SBLOCA	small break loss-of-coolant accident
SG	steam generator
SGTR	steam generator tube rupture
SI	safety injection
SIAS	safety injection actuation signal
SM	shift manager
SRO	senior reactor operator
STA	shift technical advisor
SUFWP	start-up feedwater pump
Tavg	average temperature
TD	turbine driven
TO	turbine operator
TS	trade secret

VCT            volume control tank  
V&V            verification and validation

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## **1. PURPOSE**

The purpose of this technical report, Human Factors Verification and Validation Scenarios, is to identify the operational conditions and scenarios that are used in the human-system interface (HSI) task support verification, design verification, and integrated system validation (ISV). The verification and validation (V&V) scenarios are detailed scenarios that are suitable for use on a full-scope simulator.

## **2. SCOPE**

The V&V scenarios, which are described in Section 5 of this report, include the following information to reasonably assure that the important dimensions of performance are addressed and to allow the scenarios to be accurately and consistently presented in repeated trials:

- Description of the scenario and any pertinent prior history necessary for personnel to understand the state of the plant at the startup of the scenario
- Initial conditions: Precise definition of the plant's functions, processes, systems, component conditions, and performance parameters (e.g., similar to the initial conditions at shift turnover)
- Events (e.g., failures) that occur during the scenario and their initiating conditions (e.g., based on time, parameter value)
- Precise definition of workplace factors (e.g., environmental conditions, such as low levels of illumination)
- Needs for task support (e.g., procedures, technical specifications)
- Staffing level
- Details of communication content between control room personnel and remote personnel (e.g., load dispatcher via telephone)
- Scripted responses for test personnel who act as plant personnel in the scenarios

### **2.1. Applicable Documents**

1. NUREG-0711, "Human Factors Engineering Program Review Model," Rev. 3, U.S. Nuclear Regulatory Commission, 2012.
2. NUREG-0800, "Standard Review Plan," Rev. 2, U.S. Nuclear Regulatory Commission, 2007.
3. NUREG-0700, "Human-System Interface Design Review Guidelines," Rev. 2, U.S. Nuclear Regulatory Commission, 2002.
4. NUREG/CR-6393, "Integrated System Validation: Methodology and Review Criteria," U.S. Nuclear Regulatory Commission, 1997.
5. APR1400-E-I-NR-14008-P, "Human Factors Verification and Validation Implementation Plan," Rev. 1, KHNP, February 2017.
6. BTP 7-19, "Guidance for Evaluation of Diversity and Defense-in-Depth in Digital Computer-Based Instrumentation and Control Systems," Rev. 6, U.S. Nuclear Regulatory Commission, July 2012.



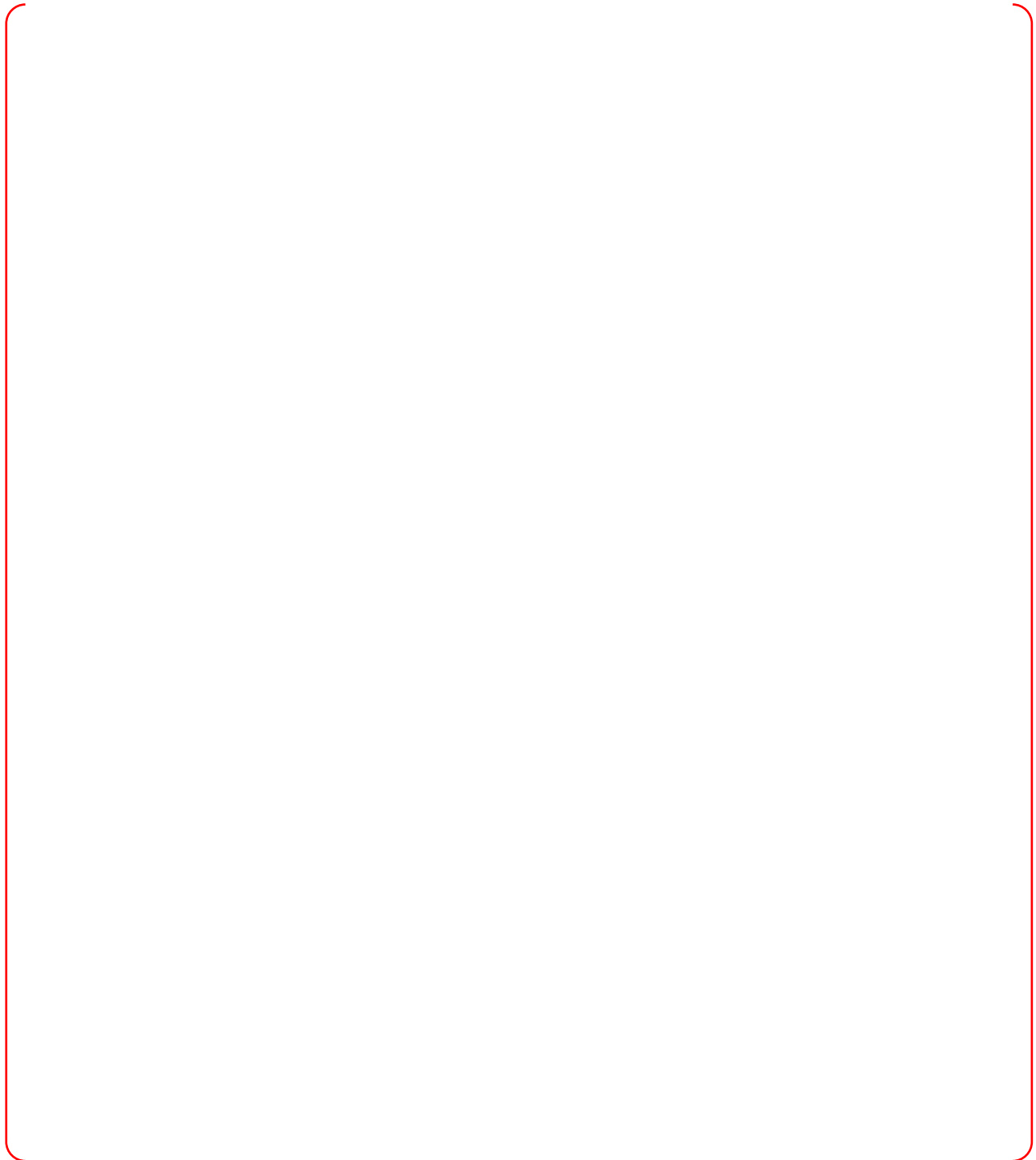
**3. SAMPLING of OPERATIONAL CONDITIONS for THE INTEGRATED SYSTEM VERIFICATION**

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**3.1. Plant Conditions**

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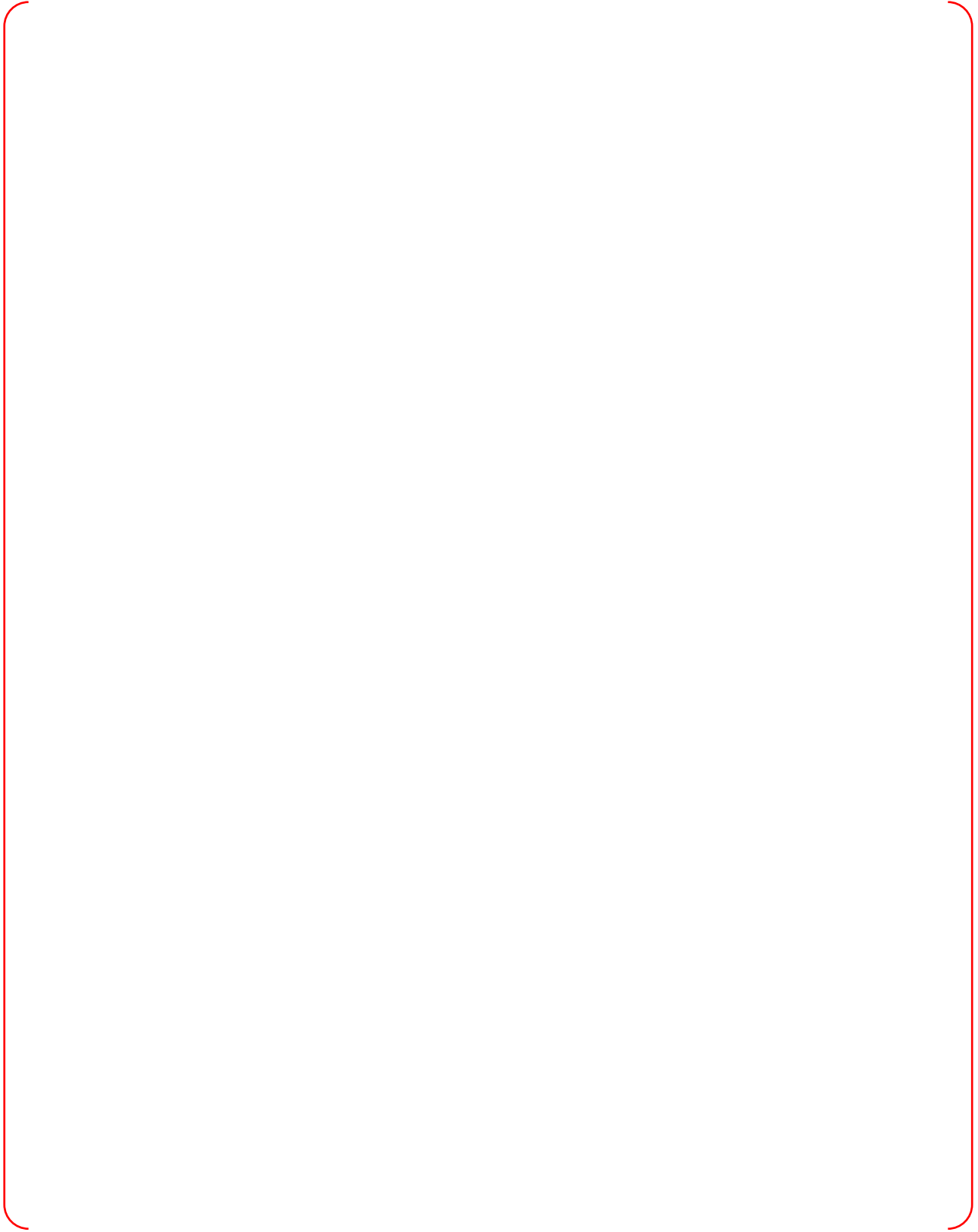


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**3.2. Types of Personnel Tasks**

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**3.3. Situational Factors or Error-Forcing Contexts**

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**4. SUMMARY OF THE APR1400 PROBABILISTIC RISK ASSESSMENT**

**4.1. Total Core Damage Frequency of Initial Events**

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**4.2. Analysis of Significances**

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**5. APR1400 HUMAN FACTORS VERIFICATION AND VALIDATION SCENARIOS**

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**5.1. Small Break Loss-of-Coolant Accident with Computer-Based Procedure and Human-System Interface Display Failure**

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**TS**



**5.2. Anticipated Transient without Scram with Ovation Distributed Control System Failure**

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**5.3. Excessive Steam Demand Event with Alarm Server Failure**

**TS**



**5.4. Loss of All Feedwater**

**TS**



**5.5. Station Blackout**

**TS**



**5.6. Steam Generator Tube Rupture**

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**5.7. Main Control Room FIRE**

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## **APPENDIX A**

# **Small Break Loss-of-Coolant Accident with Computer-Based Procedure Failure and Human-System Interface Display Failure**

## **ISV-1**



## TABLE OF CONTENTS

<b>1.</b>	<b>OVERVIEW.....</b>	<b>A4</b>
<b>1.1.</b>	<b>HUMAN FACTORS VERIFICATION AND VALIDATION OBJECTIVES .....</b>	<b>A4</b>
<b>1.2.</b>	<b>SCENARIO OVERVIEW .....</b>	<b>A5</b>
<b>1.3.</b>	<b>PERFORMANCE MEASURES .....</b>	<b>A6</b>
<b>1.3.1.</b>	<b>IMPORTANT HUMAN ACTIONS (IHA).....</b>	<b>A6</b>
<b>1.3.2.</b>	<b>PRIMARY TASKS.....</b>	<b>A6</b>
<b>1.4.</b>	<b>OTHER PERFORMANCE MEASURES.....</b>	<b>A10</b>
<b>1.5.</b>	<b>LIST OF IMPORTANT HUMAN ACTIONS.....</b>	<b>A11</b>
<b>1.6.</b>	<b>APPLICABLE OPERATIONAL CONDITION SAMPLING .....</b>	<b>A11</b>
<b>2.</b>	<b>FACILITATORS INFORMATION .....</b>	<b>A13</b>
<b>2.1.</b>	<b>SCENARIO TIMELINE .....</b>	<b>A13</b>
<b>2.2.</b>	<b>PROCEDURE FLOW PATH .....</b>	<b>A15</b>
<b>2.3.</b>	<b>EMERGENCY PLAN .....</b>	<b>A15</b>
<b>2.4.</b>	<b>TECHNICAL SPECIFICATIONS.....</b>	<b>A15</b>
<b>2.5.</b>	<b>SCENARIO TERMINATION CRITERIA.....</b>	<b>A15</b>
<b>2.6.</b>	<b>ANTICIPATED SCENARIO LENGTH.....</b>	<b>A15</b>
<b>3.</b>	<b>SIMULATOR EXERCISE EVALUATION .....</b>	<b>A16</b>
<b>3.1.</b>	<b>EVALUATION PREPARATION.....</b>	<b>A16</b>
<b>3.2.</b>	<b>EVALUATION.....</b>	<b>A17</b>
<b>3.2.1.</b>	<b>EVENT-1 RUN ESW PUMP 02A.....</b>	<b>A17</b>
<b>3.2.2.</b>	<b>EVENT-2 SG1 DOWNCOMER RADIATION MONITOR MALFUNCTION .....</b>	<b>A18</b>
<b>3.2.3.</b>	<b>EVENT-3 SBLOCA + SIAS AUTOMATIC ACTUATION FAILURE .....</b>	<b>A19</b>
<b>3.2.4.</b>	<b>EVENT 4 COMPUTER BASED PROCEDURE SYSTEM (CBP) FAILURE .....</b>	<b>A34</b>
<b>3.2.5.</b>	<b>EVENT-5 LOSS OF ALL OPERATOR CONSOLE DISPLAYS AND LDP WITH RESULTING RCS COOLDOWN AT THE SAFETY CONSOLE .....</b>	<b>A42</b>
<b>3.3.</b>	<b>DEBRIEF .....</b>	<b>A46</b>
<b>3.3.1.</b>	<b>POST EXERCISE EVALUATION .....</b>	<b>A46</b>
<b>3.3.2.</b>	<b>DATA ACQUISITION .....</b>	<b>A46</b>
<b>ISV-1 ATTACHMENT 1 - TRENDING PARAMETERS.....</b>		<b>A47</b>
<b>ISV-1 ATTACHMENT 2 - SBLOCA MALFUNCTIONS.....</b>		<b>A50</b>

**ISV-1 ATTACHMENT 3 - SHIFT TURNOVER SHEET.....A51**  
**ISV-1 ATTACHMENT 4 - ANTICIPATED DIALOG.....A52**  
**ISV-1 ATTACHMENT 5 - GUIDANCE WHEN DIFFICULTIES OCCUR DURING  
SIMULATION OR TESTING.....A53**

**1. OVERVIEW**

**1.1. Human Factors Verification and Validation Objectives**

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**1.2. Scenario Overview**

**TS**



**1.3. Performance Measures**

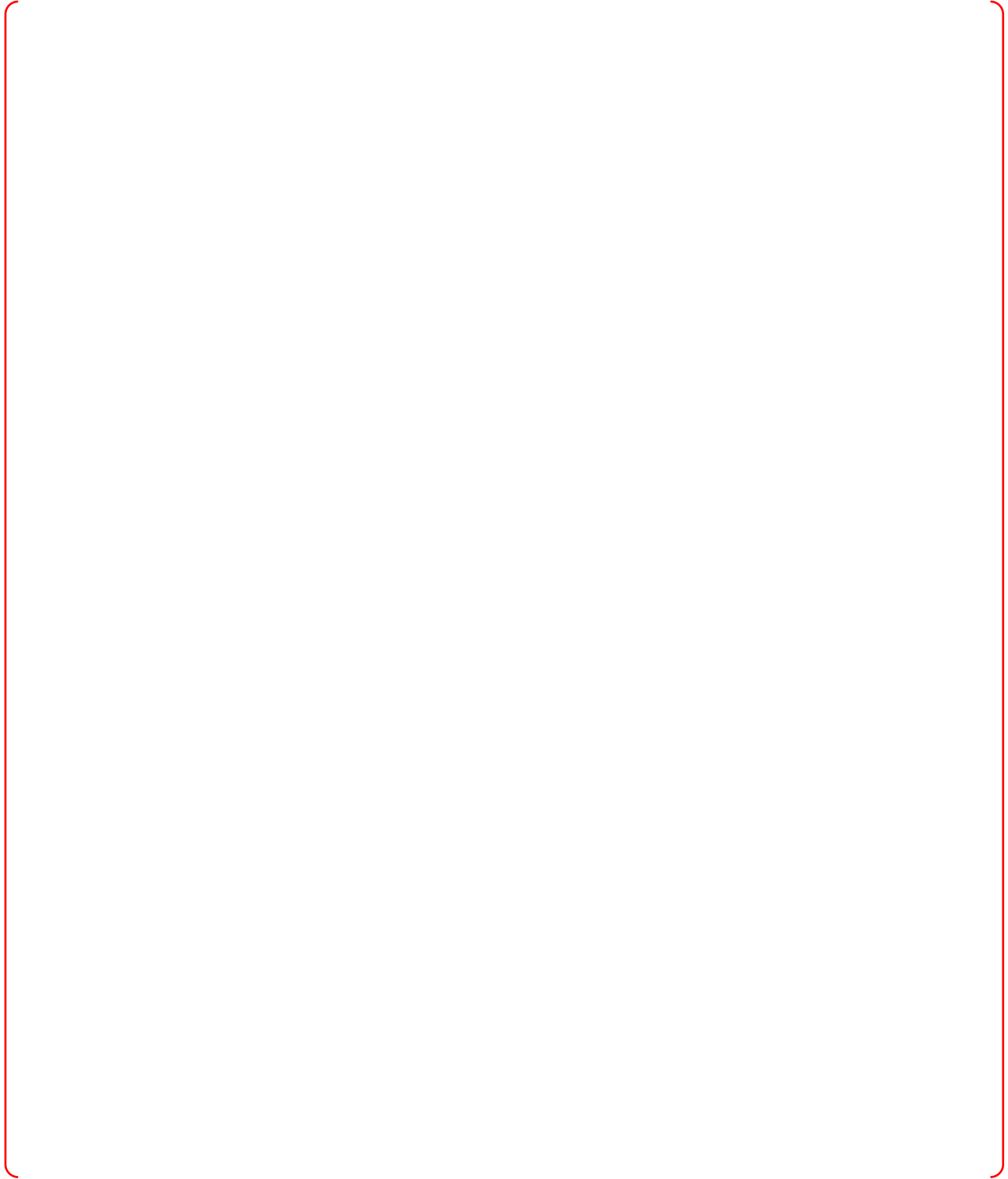
**1.3.1. Important Human Actions (IHA)**

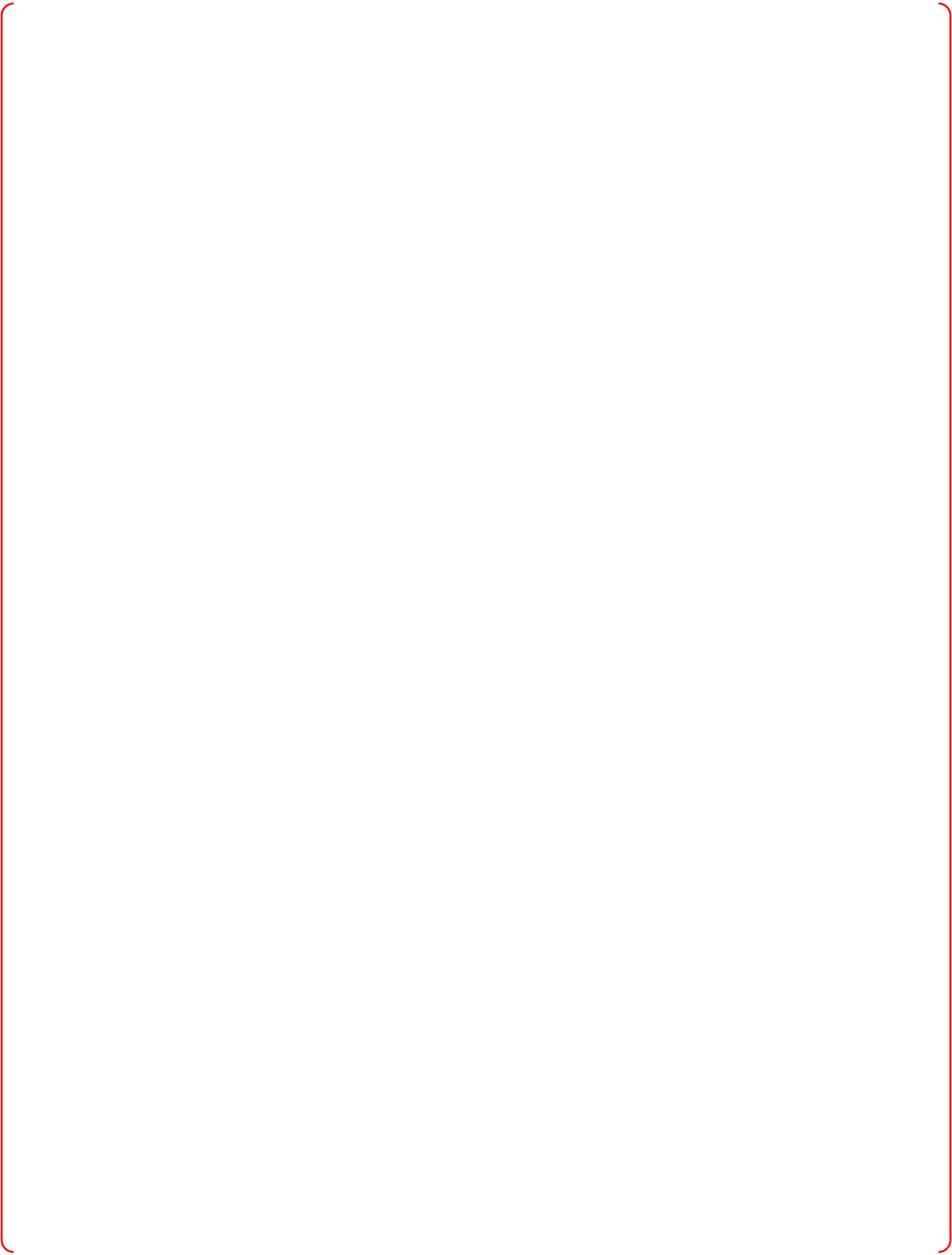
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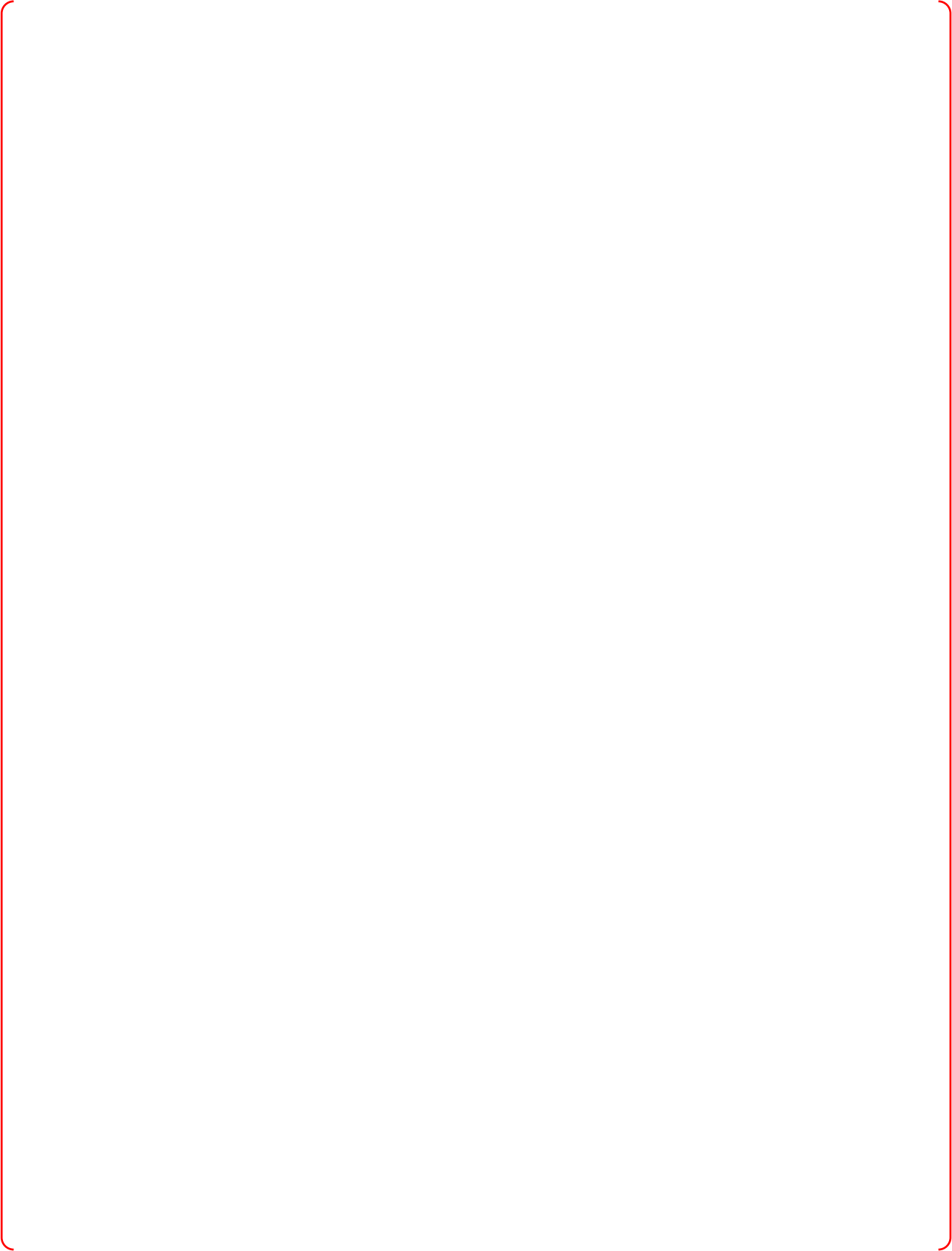
**1.3.2. Primary Tasks**

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**1.4. Other Performance Measures**

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**1.5. List of Important Human Actions**

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**1.6. Applicable Operational Condition Sampling**

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**2. FACILITATORS INFORMATION**

**2.1. Scenario Timeline**

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**2.2. Procedure Flow path**

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**2.3. Emergency Plan**

[ ] TS

**2.4. Technical Specifications**

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**2.5. Scenario Termination Criteria**

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**2.6. Anticipated Scenario Length**

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**3. SIMULATOR EXERCISE EVALUATION**

**3.1. Evaluation Preparation**

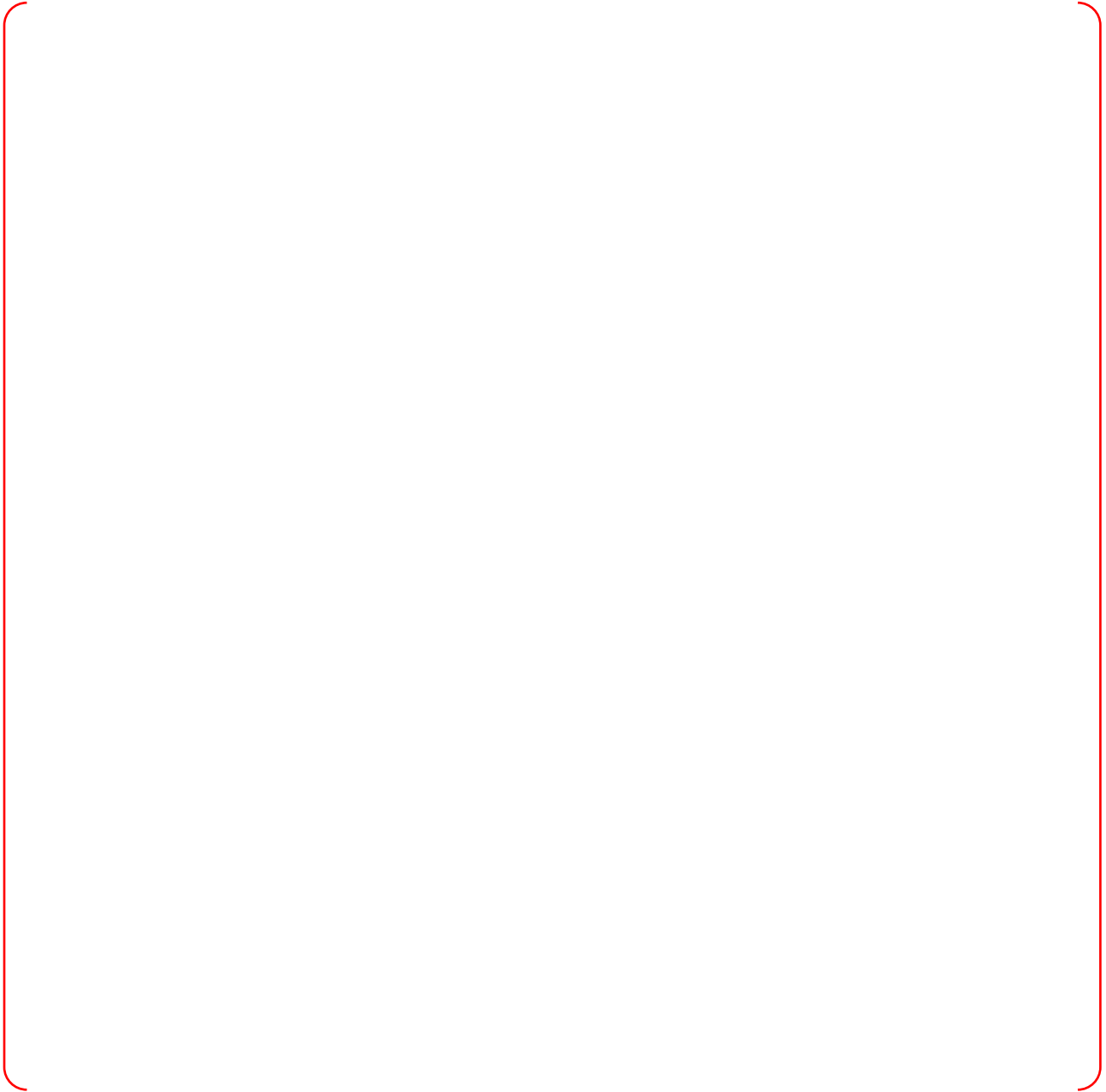
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**3.2. Evaluation**

**3.2.1. Event-1 Run ESW Pump 02A**

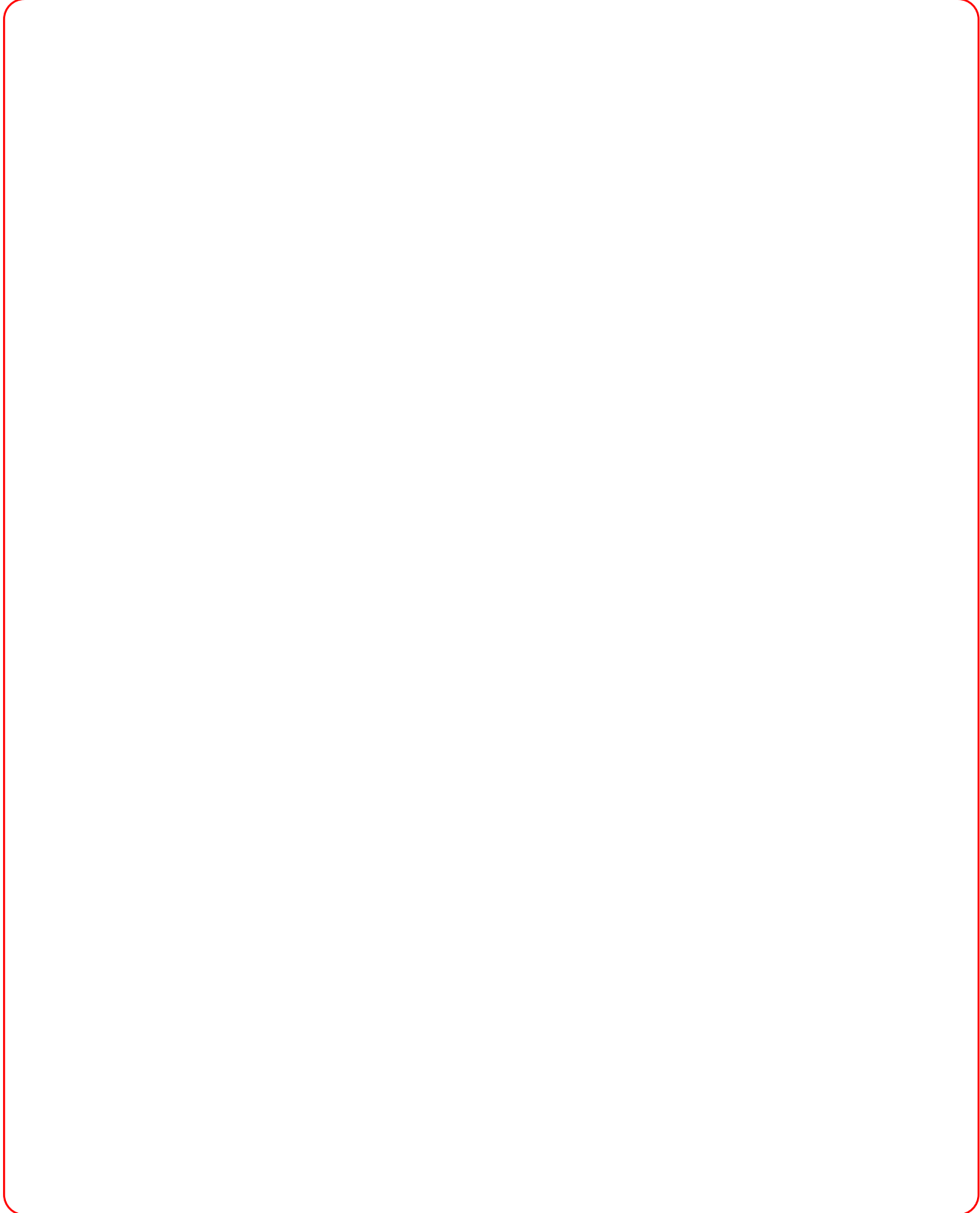
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**3.2.2. Event-2 SG1 Downcomer Radiation Monitor Malfunction**

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**3.2.3. Event-3 SBLOCA + SIAS Automatic Actuation Failure**

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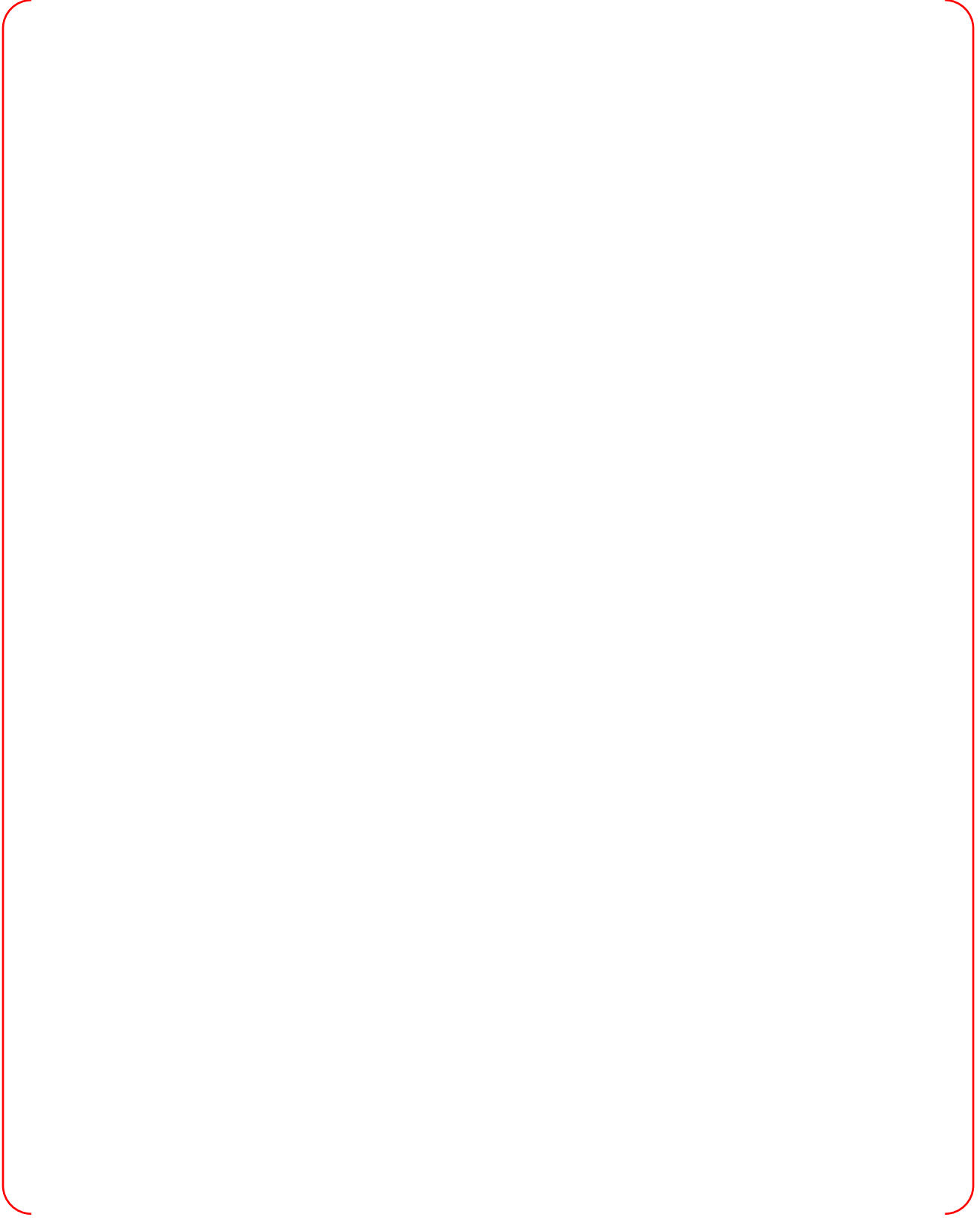




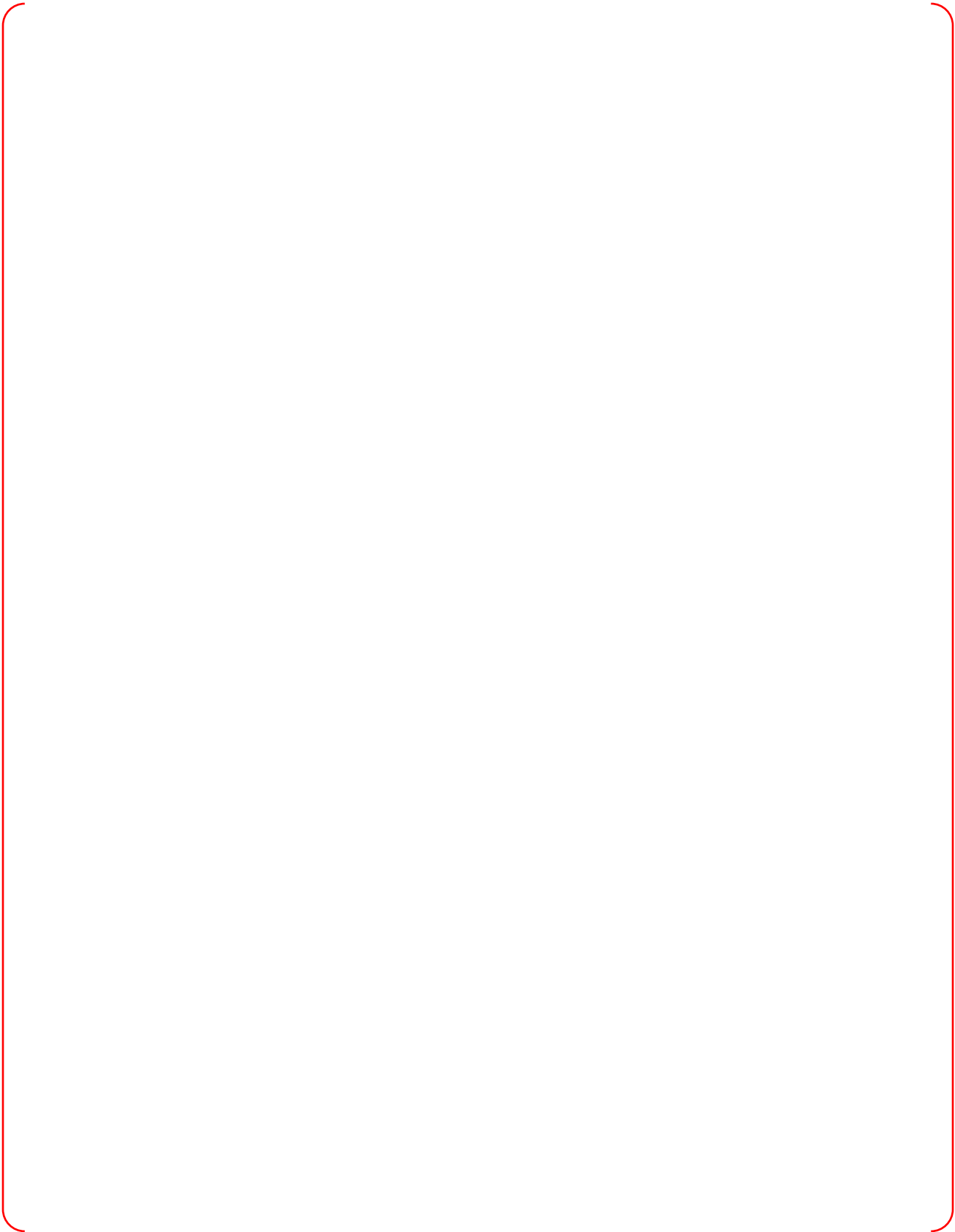


**3.2.4. Event 4 Computer Based Procedure System (CBP) Failure**

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**3.2.5. Event-5 Loss of all Operator Console Displays and LDP with resulting RCS Cooldown at the Safety Console**

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**3.3. Debrief**

**3.3.1. Post Exercise Evaluation**

**TS**



**3.3.2. Data Acquisition**

**TS**



**ISV-1 Attachment 1 - Trending Parameters**

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**ISV-1 Attachment 2 - SBLOCA Malfunctions**

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**ISV-1 Attachment 3 - Shift Turnover Sheet**

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**ISV-1 Attachment 4 - Anticipated Dialog**

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**ISV-1 Attachment 5 - Guidance When Difficulties Occur during Simulation or Testing**



## **APPENDIX B**

# **Anticipated Transient without Trip with Distributed Control System Failures**

## **ISV-2**

**TABLE OF CONTENTS**

<b>1.</b>	<b>OVERVIEW.....</b>	<b>B3</b>
1.1.	Human Factors Verification and Validation Objectives .....	B3
1.2.	Scenario Overview .....	B4
1.3.	Performance Measures .....	B5
1.4.	Other Performance Measures .....	B9
1.5.	List of Important Human Actions .....	B10
1.6.	Applicable Operational Condition Sampling.....	B10
<b>2.</b>	<b>FACILITATORS INFORMATION .....</b>	<b>B11</b>
2.1.	Scenario Timeline .....	B11
2.2.	Procedure Flowpath .....	B12
2.3.	Emergency Plan.....	B12
2.4.	Technical Specifications.....	B12
2.5.	Scenario Termination Criteria.....	B12
2.6.	Anticipated Scenario Length.....	B12
<b>3.</b>	<b>SIMULATOR EXERCISE EVALUATION .....</b>	<b>B13</b>
3.1.	Evaluation Preparation .....	B13
3.2.	Evaluation .....	B13
3.2.1.	Event 1 Enter Mode 2 and achieve criticality .....	B13
3.2.2.	Event-2 Charging Control Valve (CV-212P) Fails Close .....	B14
3.2.3.	Event-3 Start a Turbine Driven Main Feedwater Pump (TDMFWP) and stop the Start-up Feedwater Pump (SUFWP).....	B16
3.2.4.	EVENT-4 Pressurizer Spray Valve Fails Open With ATWT .....	B16
3.2.5.	EVENT-5 ATWT.....	B17
3.2.6.	EVENT-6 RCS Ovation DCS Failures (common mode failures) .....	B24
3.3.	Debrief .....	B25
	<b>ISV-2 ATTACHMENT 1 - TRENDING PARAMETERS .....</b>	<b>B26</b>
	<b>ISV-2 ATTACHMENT 2 - MALFUNCTION LIST.....</b>	<b>B29</b>
	<b>ISV-2 ATTACHMENT 3 - SHIFT TURNOVER SHEET .....</b>	<b>B30</b>
	<b>ISV-2 ATTACHMENT 4 - ANTICIPATED DIALOG .....</b>	<b>B31</b>
	<b>ISV-2 ATTACHMENT 5 - GUIDANCE WHEN DIFFICULTIES OCCUR DURING SIMULATION OR TESTING.....</b>	<b>B33</b>

**1. OVERVIEW**

**1.1. Human Factors Verification and Validation Objectives**

**TS**

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**1.2. Scenario Overview**

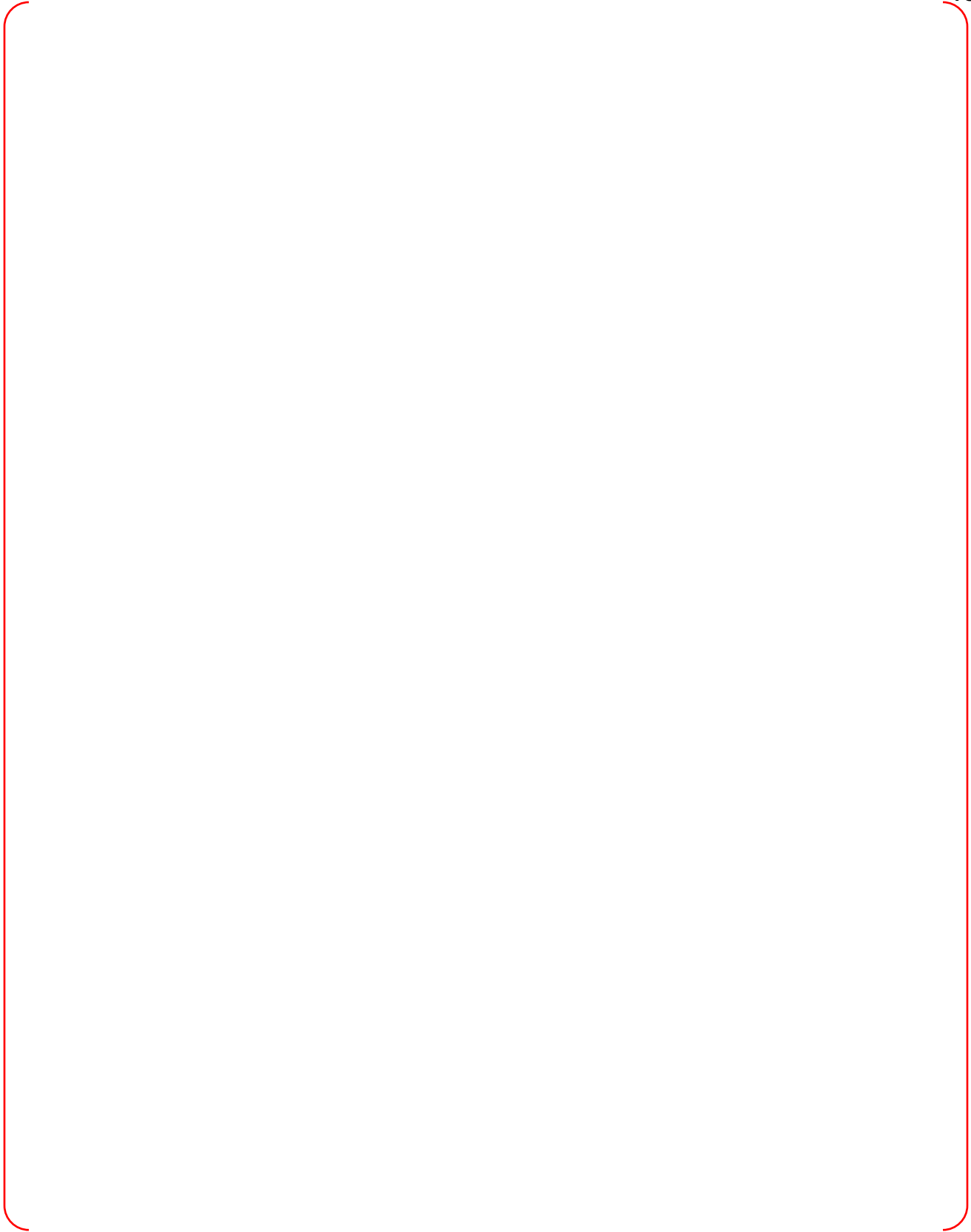
**TS**





**1.3. Performance Measures**

**TS**



TS



TS



TS



**1.4. Other Performance Measures**

**TS**



**1.5. List of Important Human Actions**

**TS**

**1.6. Applicable Operational Condition Sampling**

**TS**

**2. FACILITATORS INFORMATION**

**2.1. Scenario Timeline**

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**2.2. Procedure Flowpath**

**TS**



**2.3. Emergency Plan**

**TS**



**2.4. Technical Specifications**

**TS**



**2.5. Scenario Termination Criteria**

**TS**



**2.6. Anticipated Scenario Length**

**TS**






**3. SIMULATOR EXERCISE EVALUATION**

**3.1. Evaluation Preparation**

**TS**



**3.2. Evaluation**

**3.2.1. Event 1 Enter Mode 2 and achieve criticality**

**TS**



TS



**3.2.2. Event-2 Charging Control Valve (CV-212P) Fails Close**

TS





**3.2.3. Event-3 Start a Turbine Driven Main Feedwater Pump (TDMFWP) and stop the Start-up Feedwater Pump (SUFWP)**

TS

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**3.2.4. EVENT-4 Pressurizer Spray Valve Fails Open With ATWT**

TS

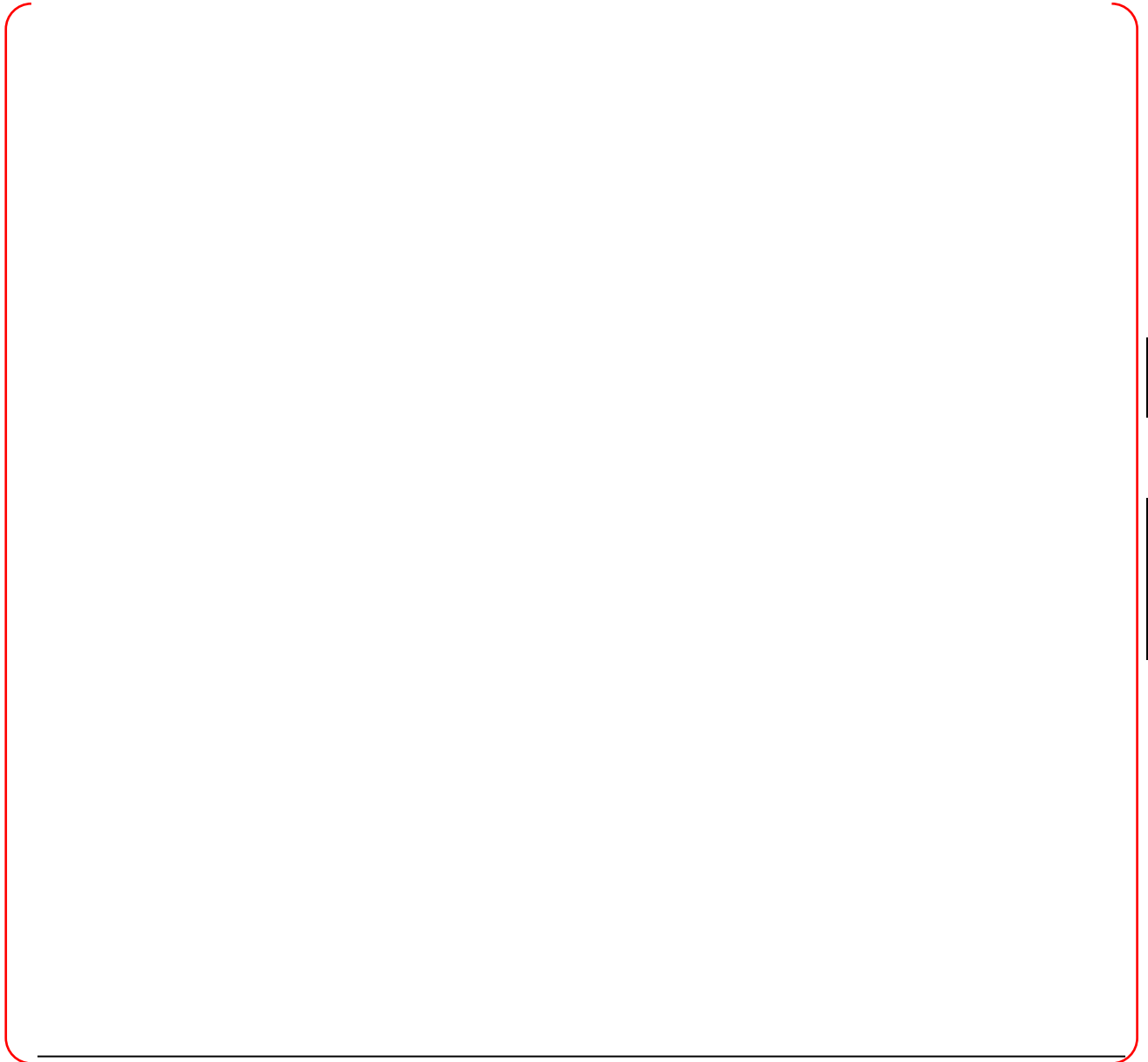
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**3.2.5. EVENT-5 ATWT**

TS

















TS



**3.2.6. EVENT-6 RCS Ovation DCS Failures (common mode failures)**

TS



TS



**3.3. Debrief**

**3.3.1 Post Exercise Evaluation**

TS



**3.3.2 Data Acquisition**

TS



**ISV-2 ATTACHMENT 1 - TRENDING PARAMETERS**

TS









**ISV-2 ATTACHMENT 2 - MALFUNCTION LIST**

TS



**ISV-2 ATTACHMENT 3 - SHIFT TURNOVER SHEET**

TS



**ISV-2 ATTACHMENT 4 - ANTICIPATED DIALOG**

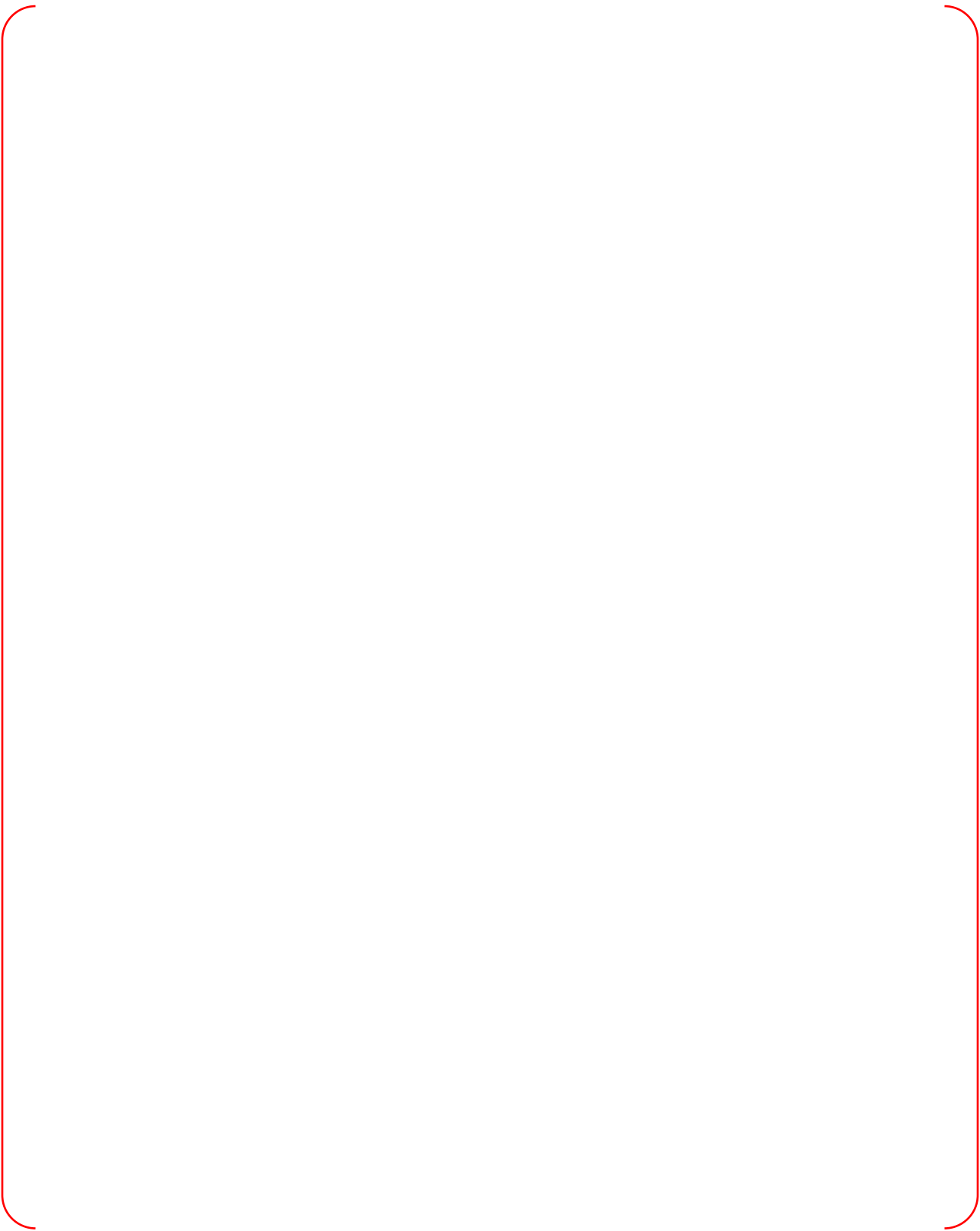
TS



**TS**



**ISV-2 Attachment 5 – Guidance When Difficulties Occur During Simulation or Testing**



## **APPENDIX C**

# **Excessive Steam Demand Event with Alarm Server Failures**

## **ISV-3**

**TABLE OF CONTENTS**

<b>1.</b>	<b>OVERVIEW.....</b>	<b>C3</b>
1.1	Human Factors Verification and Validation Objectives .....	C3
1.2	Scenario Overview.....	C4
1.3	Performance Measures .....	C5
1.4	Other Performance Measures .....	C9
1.5	List of Important Human Actions.....	C10
1.6	Applicable Operational Condition Sampling .....	C10
<b>2.</b>	<b>FACILITATORS INFORMATION .....</b>	<b>C12</b>
2.1	Scenario Timeline .....	C12
2.2	Procedure Flowpath.....	C13
2.3	Emergency Plan .....	C13
2.4	Technical Specifications .....	C13
2.5	Scenario Termination Criteria .....	C13
2.6	Anticipated Scenario Length.....	C13
<b>3.</b>	<b>SIMULATOR EXERCISE EVALUATION.....</b>	<b>C14</b>
3.1	Evaluation Preparation .....	C14
3.2	Evaluation .....	C14
3.2.1	Event 1 Control rod partial movement surveillance test .....	C14
3.2.2	Event-2 CVCS letdown Heat Exchanger tube leak .....	C15
3.2.3	Event-3 Rapid power decrease in response to LPMS alarms.....	C16
3.2.4	Event-4 Two MFWPs Trip with Automatic Initiation Failure of RPCS.....	C17
3.2.5	Event-5 Alarm Server A and B Failures .....	C18
3.2.6	Event-6 Main Steam Line 2B Break IRC .....	C20
3.3	Debrief .....	C29
3.3.1	Post Exercise Evaluation .....	C29
3.3.2	Data Acquisition .....	C30
	<b>ISV-3 ATTACHMENT 1 - TRENDING PARAMETERS.....</b>	<b>C31</b>
	<b>ISV-3 ATTACHMENT 2 - MALFUNCTION LIST.....</b>	<b>C34</b>
	<b>ISV-3 ATTACHMENT 3 - SHIFT TURNOVER SHEET .....</b>	<b>C35</b>
	<b>ISV-3 ATTACHMENT 4 - ANTICIPATED DIALOG .....</b>	<b>C36</b>
	<b>ISV-3 ATTACHMENT 5 - GUIDANCE WHEN DIFFICULTIES OCCUR DURING SIMULATION OR TESTING.....</b>	<b>C38</b>

**1. OVERVIEW**

**1.1 Human Factors Verification and Validation Objectives**

TS





1.2 Scenario Overview

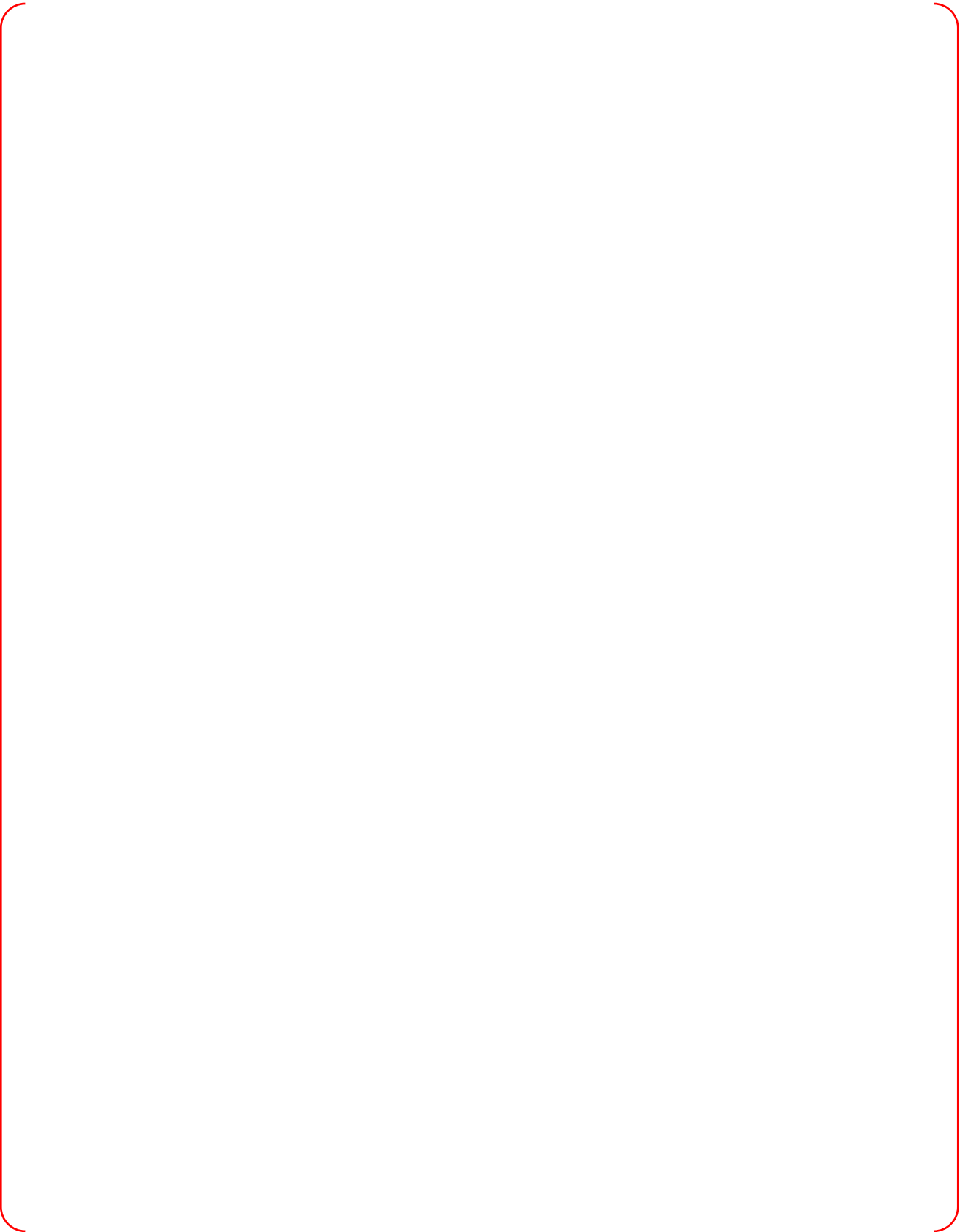
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**1.3 Performance Measures**

TS









**1.4 Other Performance Measures**

TS



**1.5 List of Important Human Actions**

TS

**1.6 Applicable Operational Condition Sampling**

TS





**2. FACILITATORS INFORMATION**

**2.1 Scenario Timeline**

TS



[ ] TS

**2.2 Procedure Flowpath**

[ ] TS

**2.3 Emergency Plan**

[ ] TS

**2.4 Technical Specifications**

[ ] TS

**2.5 Scenario Termination Criteria**

[ ] TS

**2.6 Anticipated Scenario Length**

[ ] TS

**3. SIMULATOR EXERCISE EVALUATION**

**3.1 Evaluation Preparation**

TS



**3.2 Evaluation**

**3.2.1 Event 1 Control rod partial movement surveillance test**

TS



TS



**3.2.2 Event-2 CVCS letdown Heat Exchanger tube leak**

TS

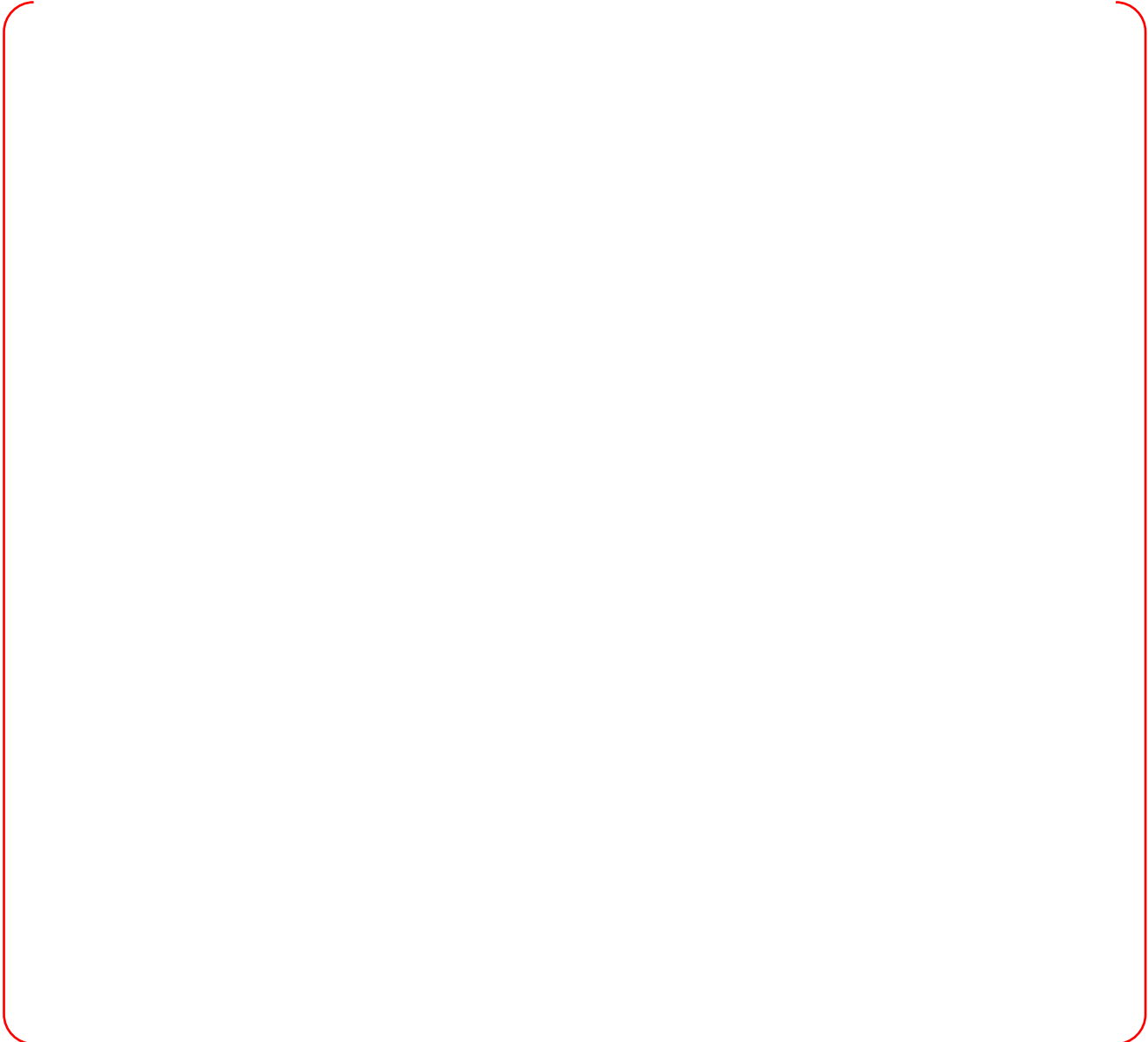


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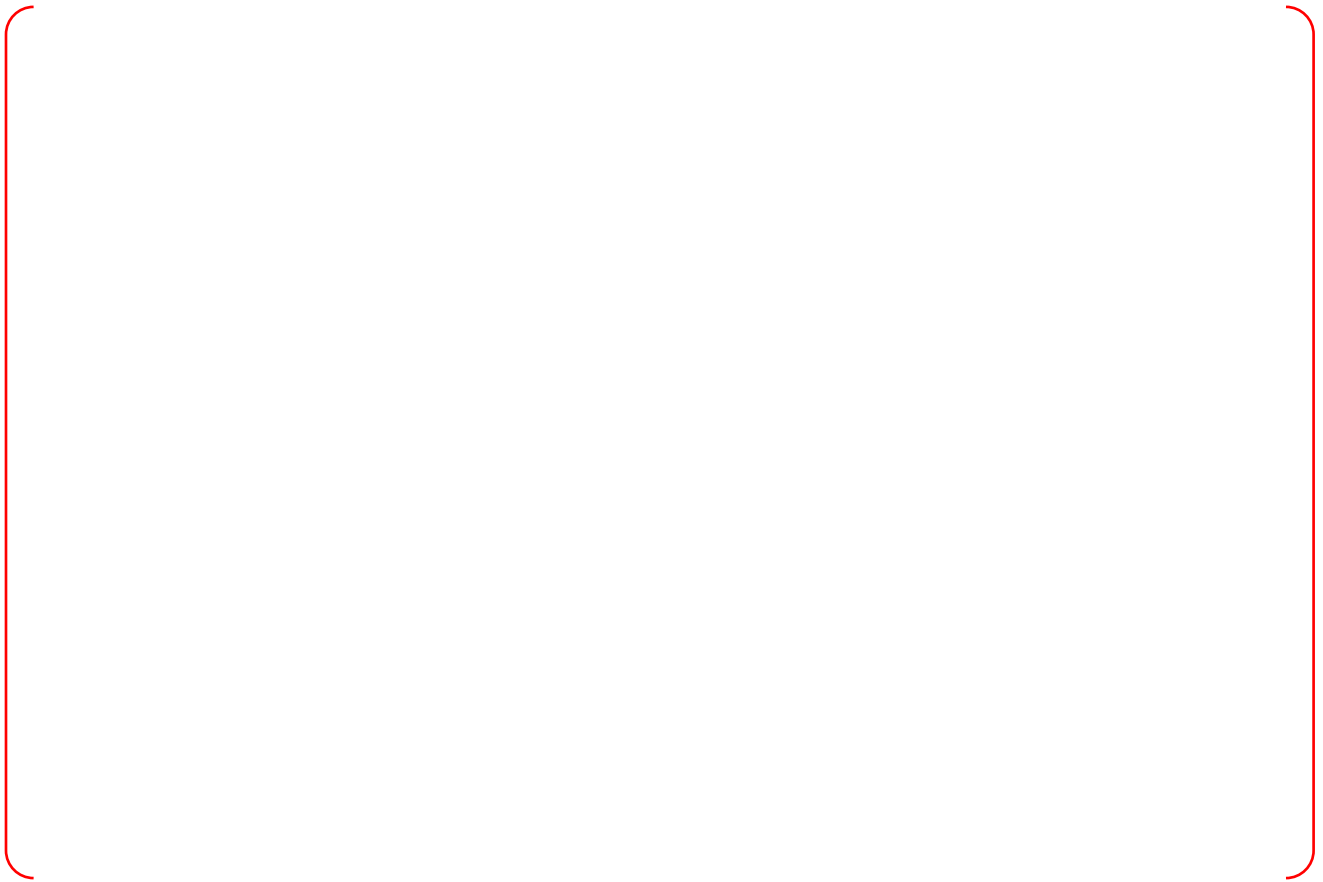


**3.2.3 Event-3 Rapid power decrease in response to LPMS alarms**

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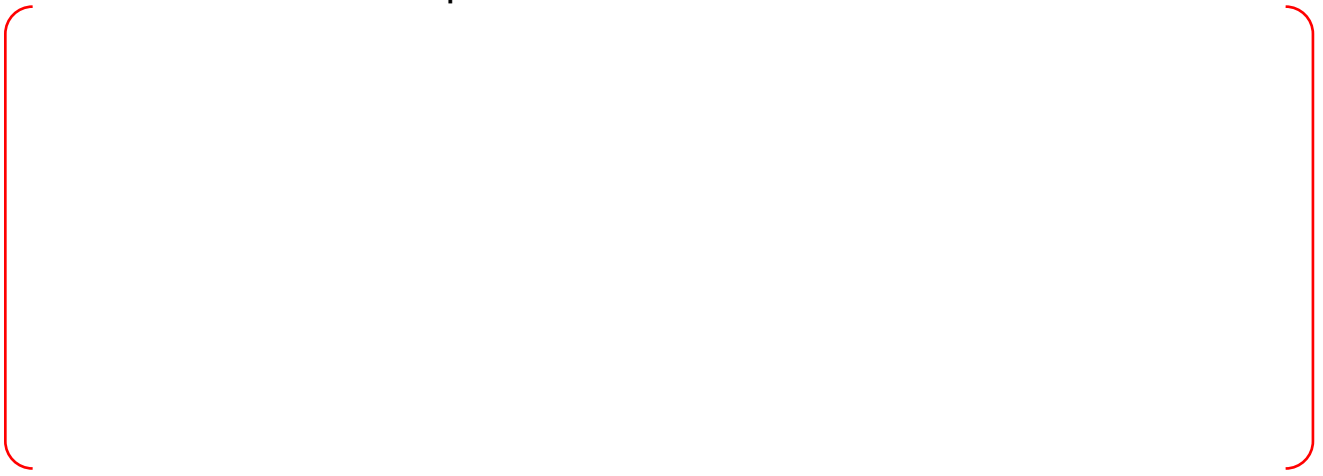


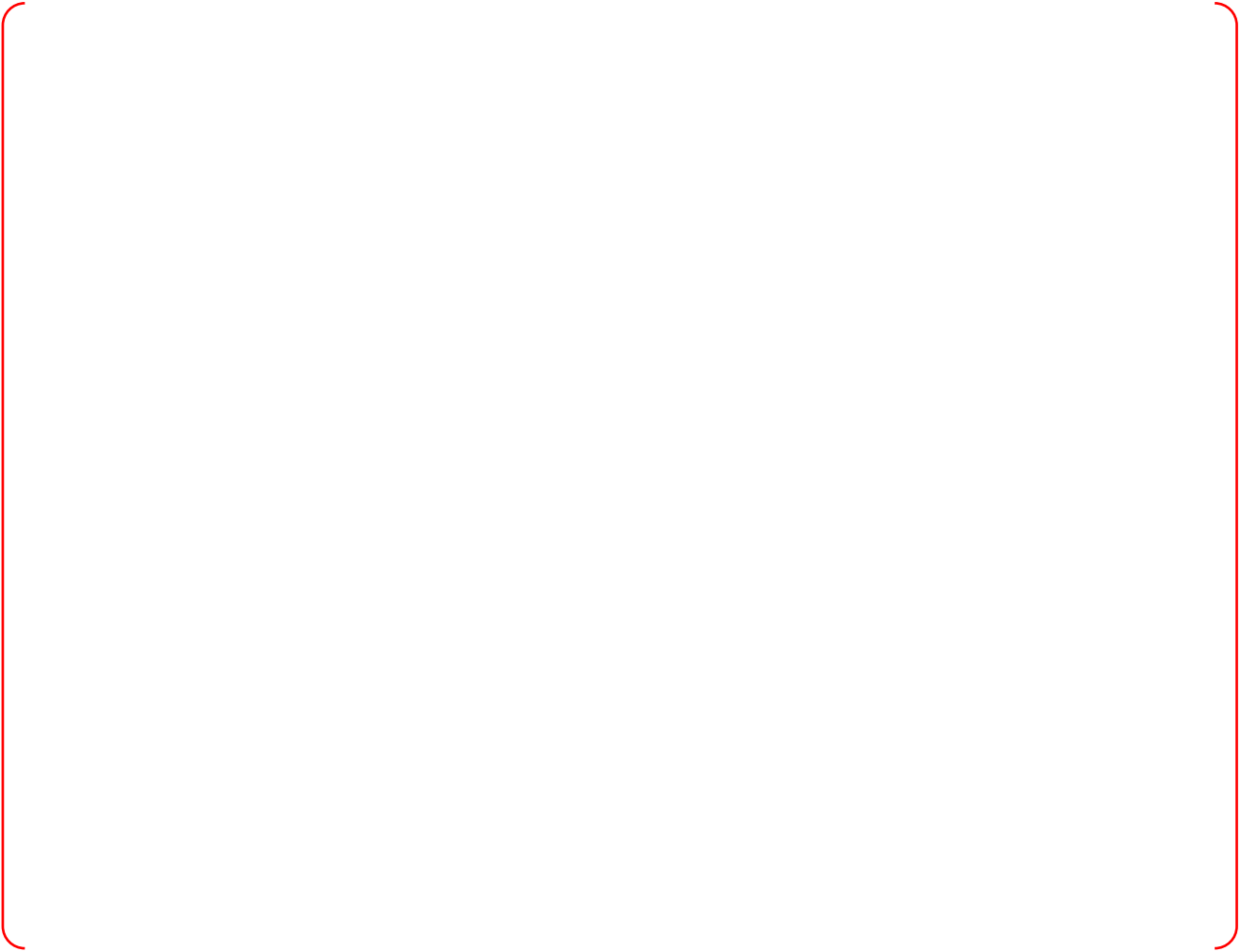
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**3.2.4 Event-4 Two MFWPs Trip with Automatic Initiation Failure of RPCS**

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**3.2.5 Event-5 Alarm Server A and B Failures**





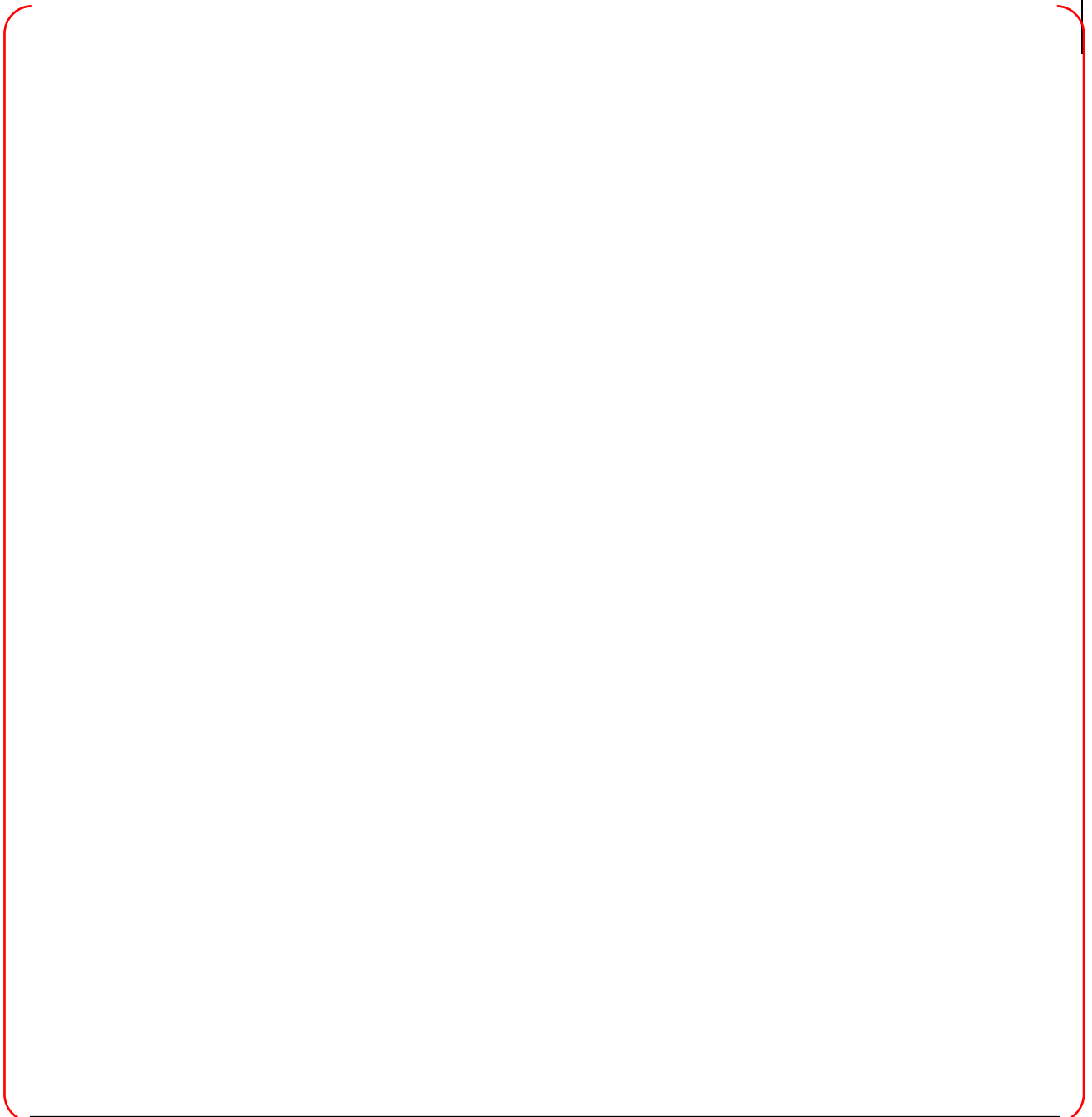


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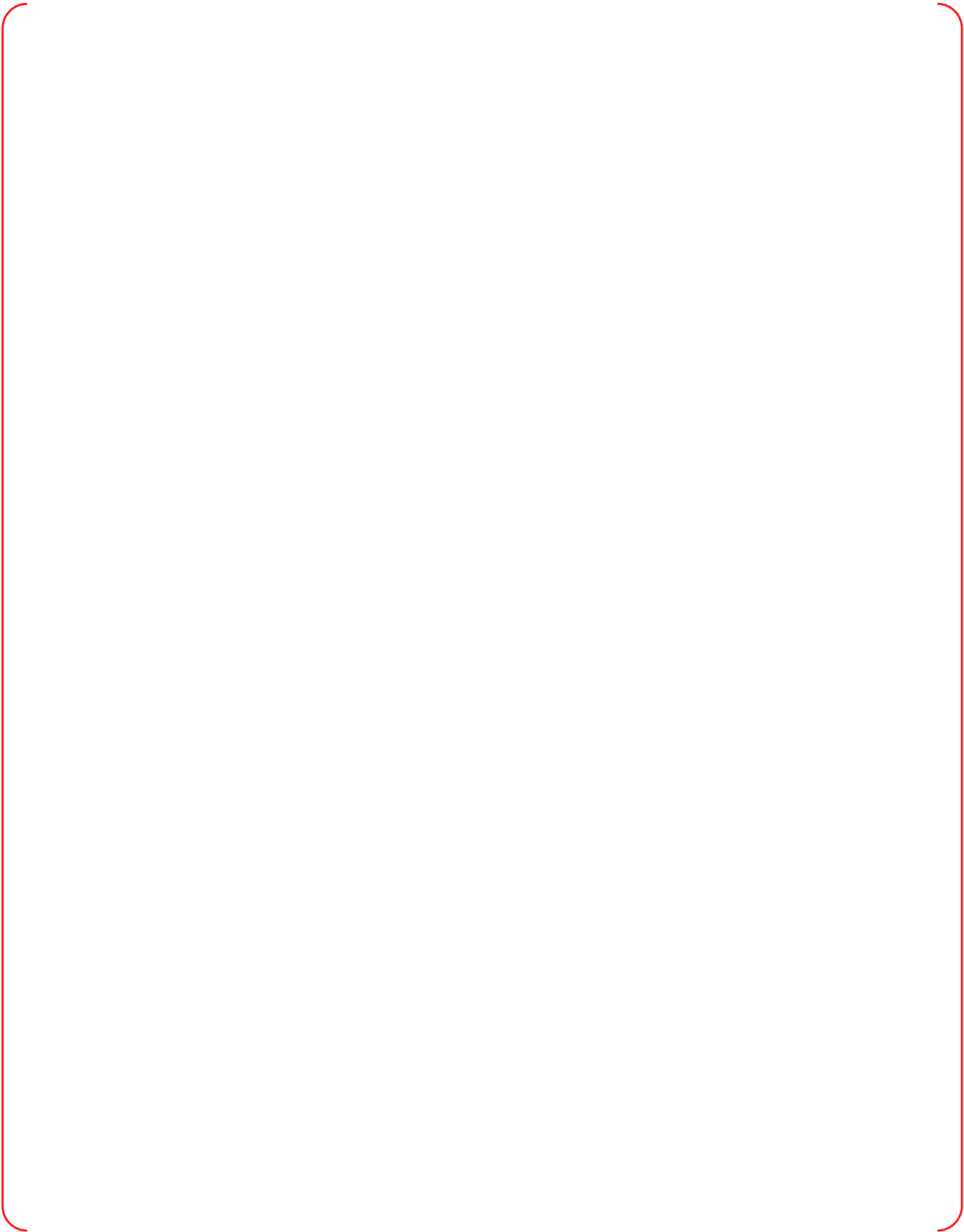


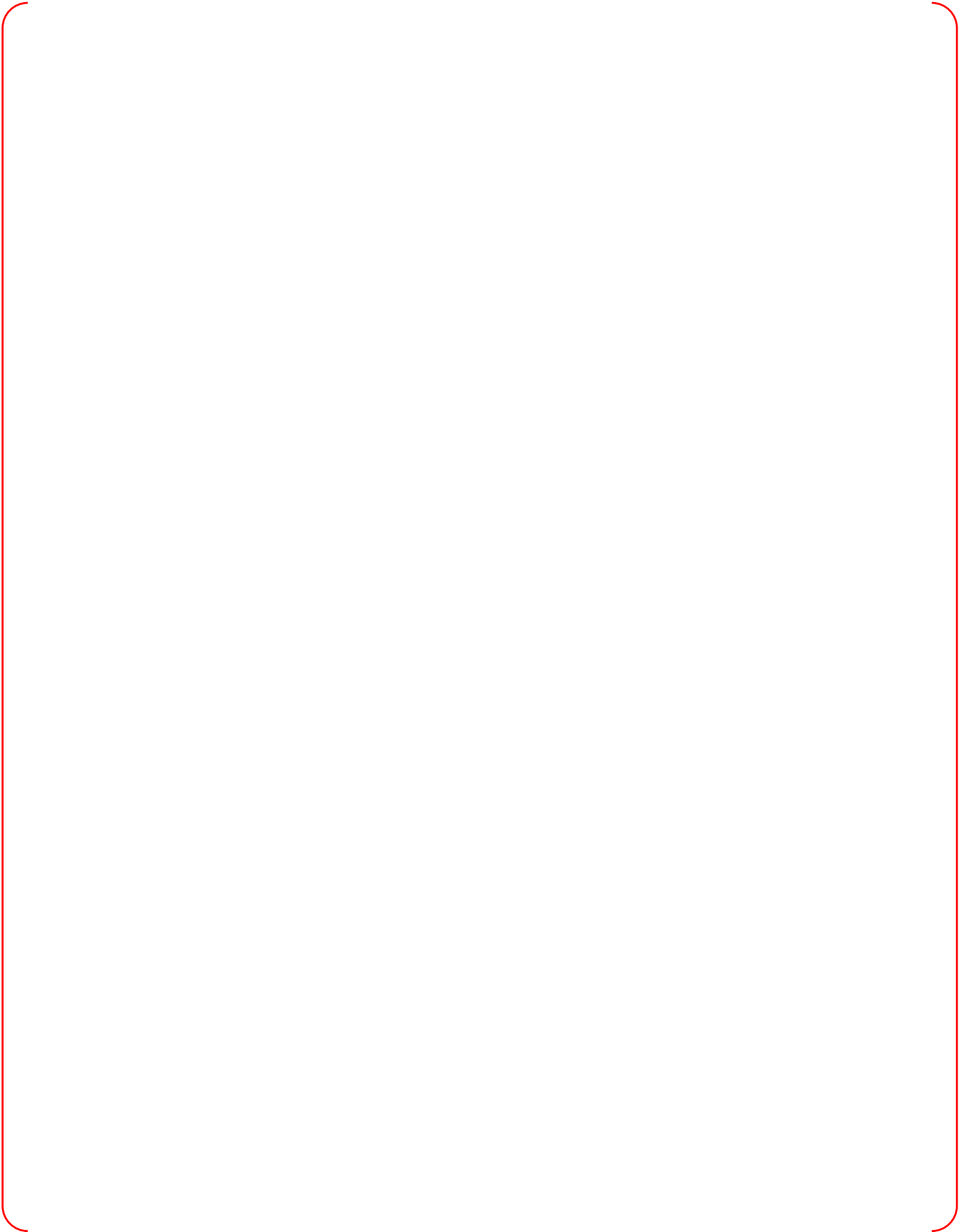
**3.2.6 Event-6 Main Steam Line 2B Break IRC**

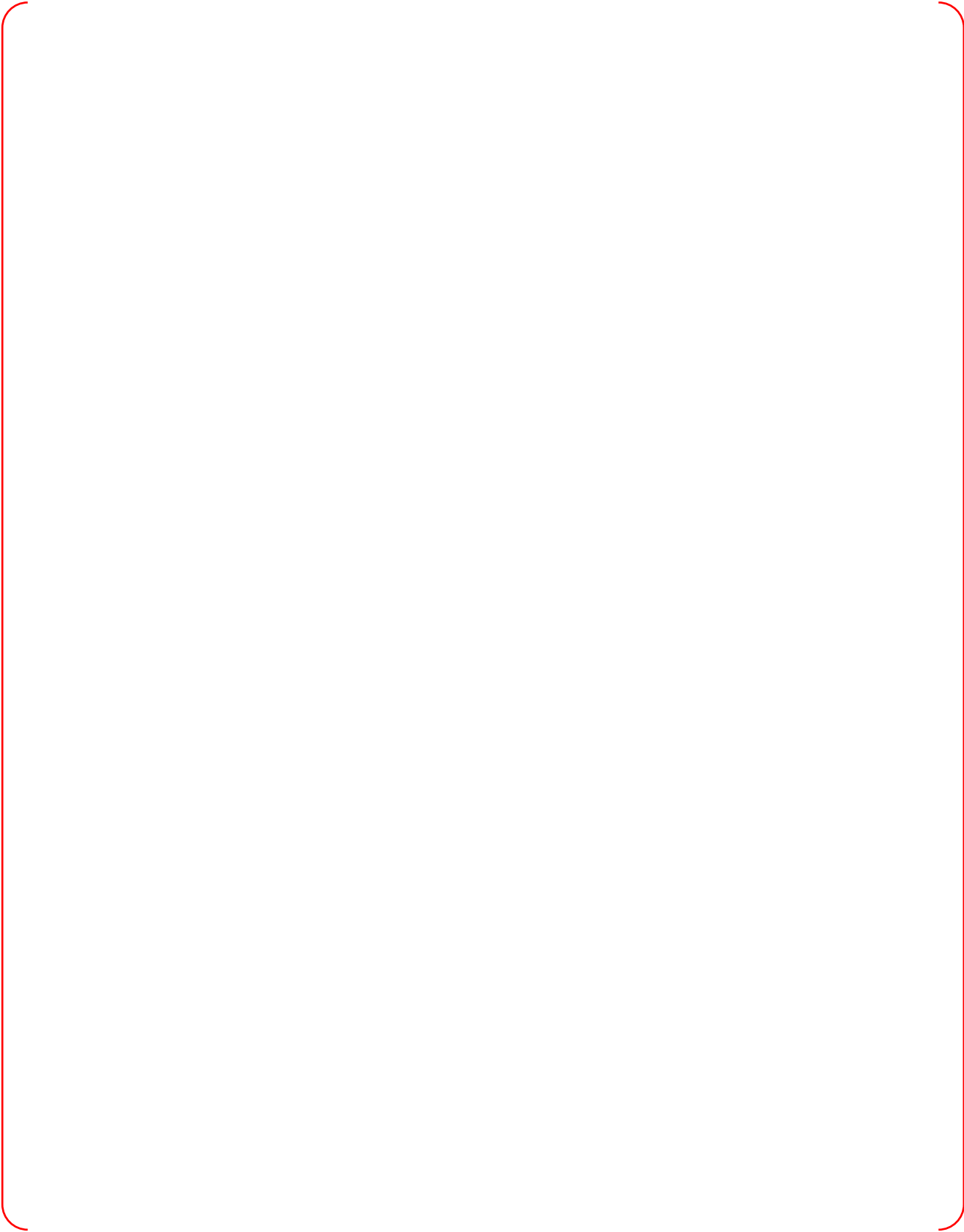
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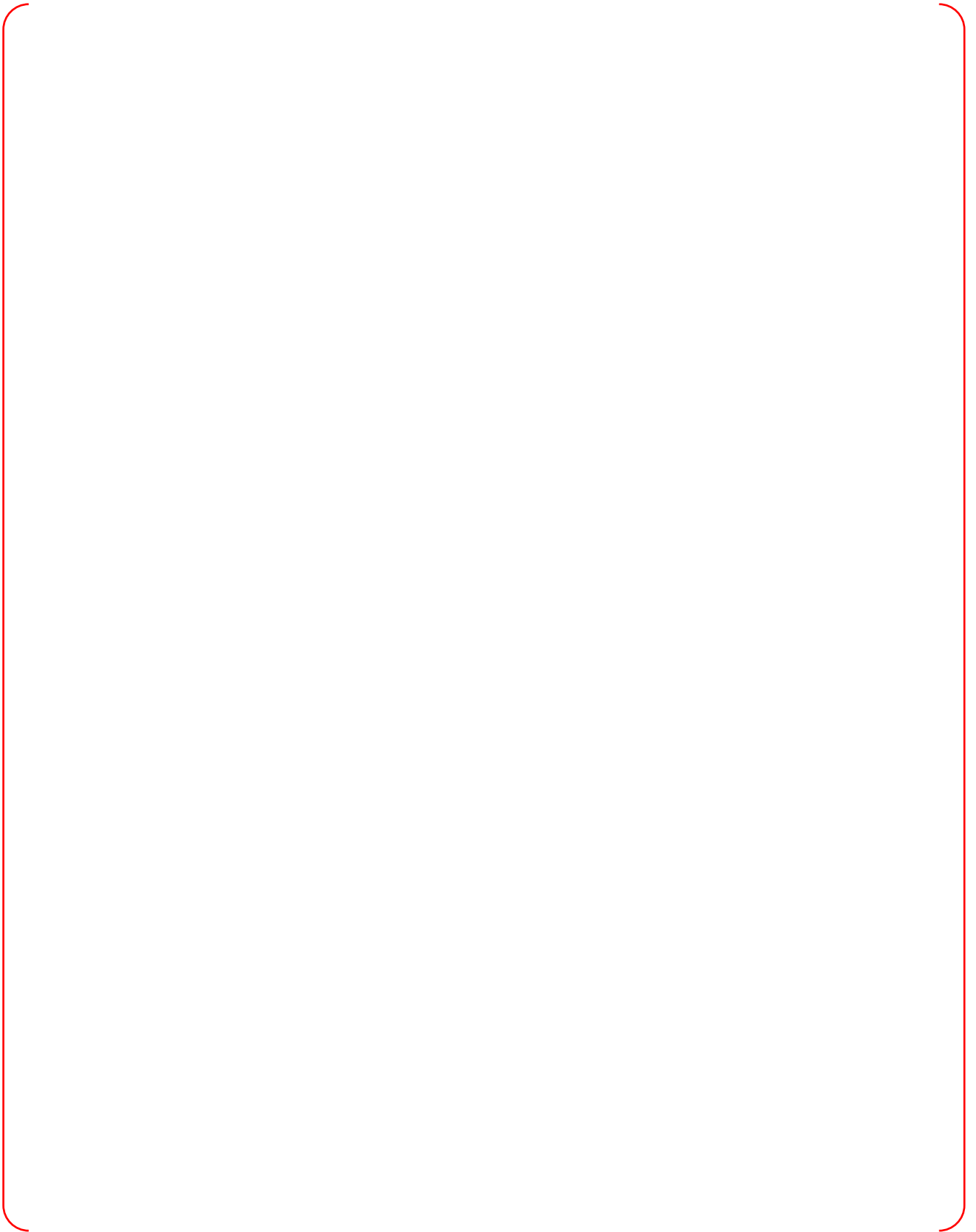






















**3.3 Debrief**

**3.3.1 Post Exercise Evaluation**



**3.3.2 Data Acquisition**

TS



**ISV-3 ATTACHMENT 1 - TRENDING PARAMETERS**

TS







**ISV-3 ATTACHMENT 2 - MALFUNCTION LIST**

TS



**ISV-3 ATTACHMENT 3 - SHIFT TURNOVER SHEET**

TS





ISV-3 ATTACHMENT 4 - ANTICIPATED DIALOG

TS





**ISV-3 ATTACHMENT 5 - GUIDANCE WHEN DIFFICULTIES OCCUR DURING SIMULATION OR TESTING**

TS

## **APPENDIX D**

### **Loss of All Feedwater**

#### **ISV-4**

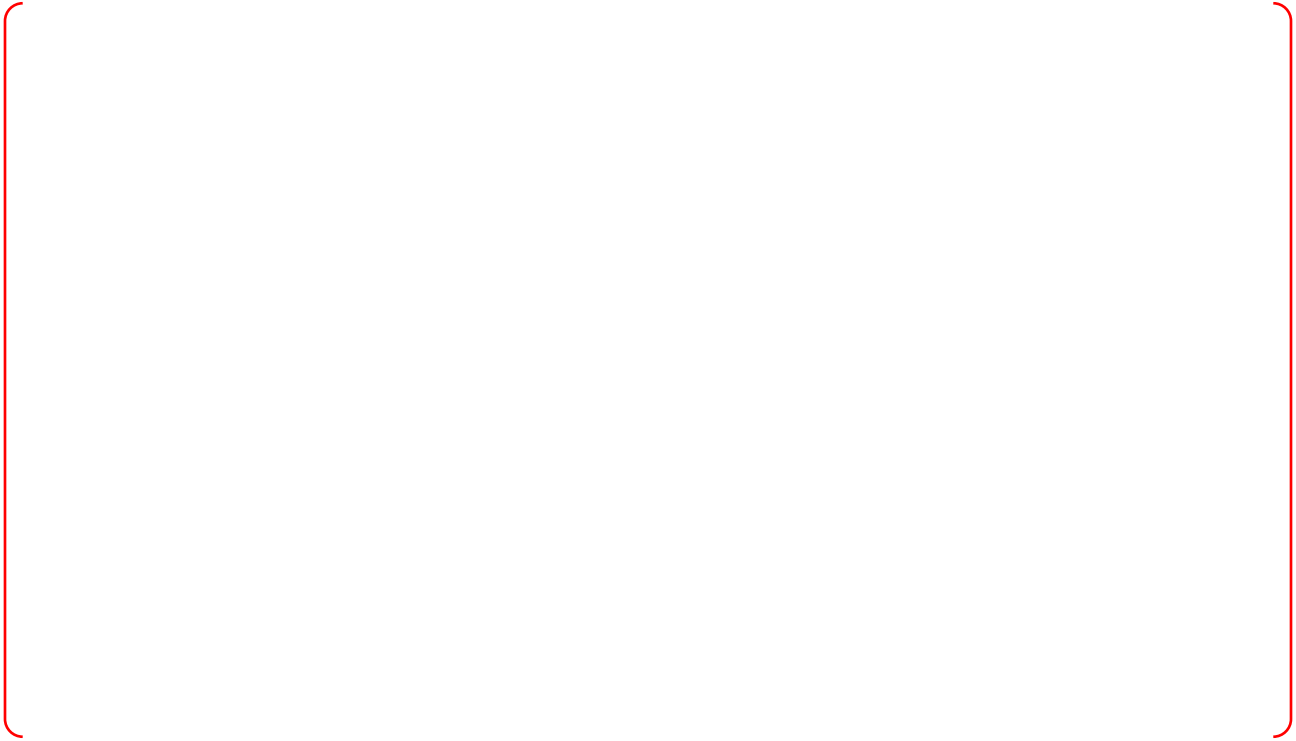
## **TABLE OF CONTENTS**

<b>1.</b>	<b>OVERVIEW.....</b>	<b>D3</b>
1.1	Human Factors Verification and Validation Objectives .....	D3
1.2	Scenario Overview.....	D4
1.3	Performance Measures .....	D5
1.4	Other Performance Measures .....	D8
1.5	List of Important Human Actions.....	D9
1.6	Applicable Operational Condition Sampling .....	D9
<b>2.</b>	<b>FACILITATORS INFORMATION .....</b>	<b>D10</b>
2.1	Scenario Timeline .....	D10
2.2	Procedure Flowpath.....	D11
2.3	Emergency Plan .....	D12
2.4	Technical Specifications .....	D12
2.5	Scenario Termination Criteria .....	D12
2.6	Anticipated Scenario Length.....	D12
<b>3.</b>	<b>SIMULATOR EXERCISE EVALUATION.....</b>	<b>D13</b>
3.1	Evaluation Preparation .....	D13
3.2	Evaluation .....	D14
3.2.1	Event 1 CVCS Letdown Line Leak Upstream Control Valve CV-201P/Q.....	D14
3.2.2	Event 2 13.8kV SW-02M, SW-02N BUS FAULT .....	D16
3.2.3	Event 3 MD AFWP 2A and 2B Trip, Loss Of All Feedwater (LOAF) .....	D23
3.3	Debrief .....	D33
3.3.1	Post Exercise Evaluation.....	D33
3.3.2	Data Acquisition .....	D33
	<b>ISV-4 ATTACHMENT 1 - TRENDING PARAMETERS.....</b>	<b>D34</b>
	<b>ISV-4 ATTACHMENT 2 - MALFUNCTION LIST.....</b>	<b>D37</b>
	<b>ISV-4 ATTACHMENT 3 - SHIFT TURNOVER SHEET .....</b>	<b>D38</b>
	<b>ISV-4 ATTACHMENT 4 - ANTICIPATED DIALOG.....</b>	<b>D39</b>
	<b>ISV-4 ATTACHMENT 5 - GUIDANCE WHEN DIFFICULTIES OCCUR DURING SIMULATION OR TESTING.....</b>	<b>D40</b>

**1. OVERVIEW**

**1.1 Human Factors Verification and Validation Objectives**

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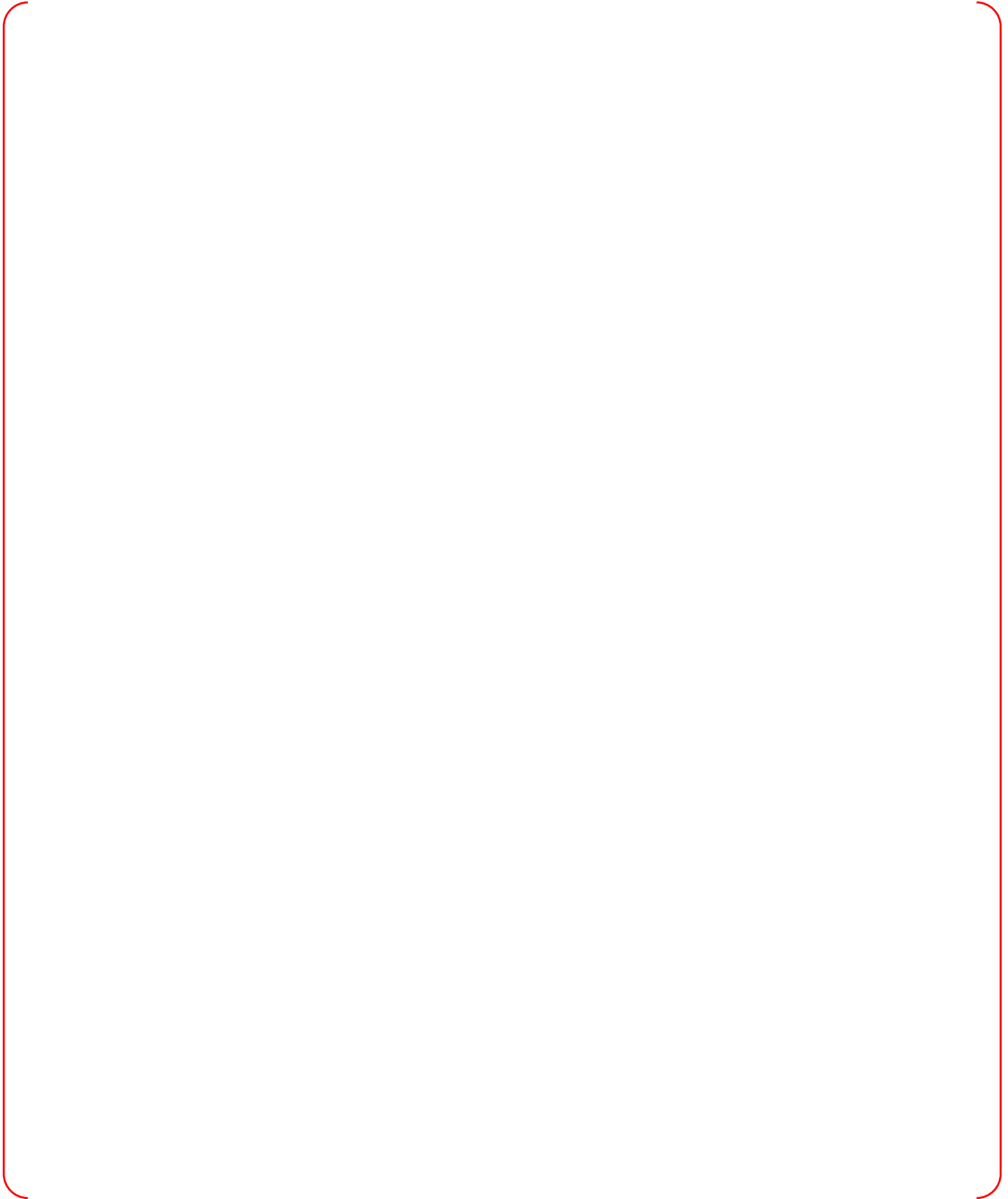
**1.2 Scenario Overview**

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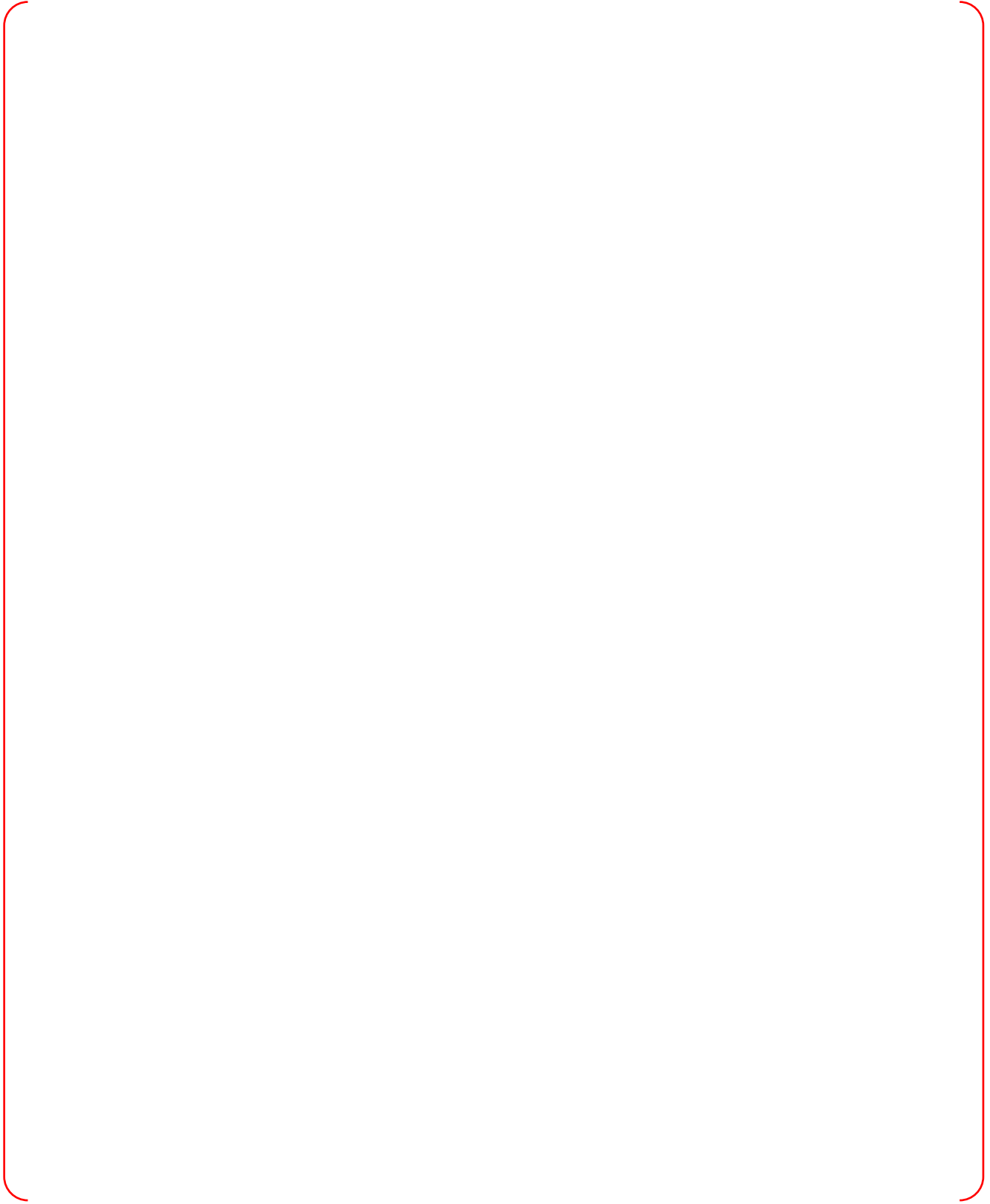
**1.3 Performance Measures**

**TS**

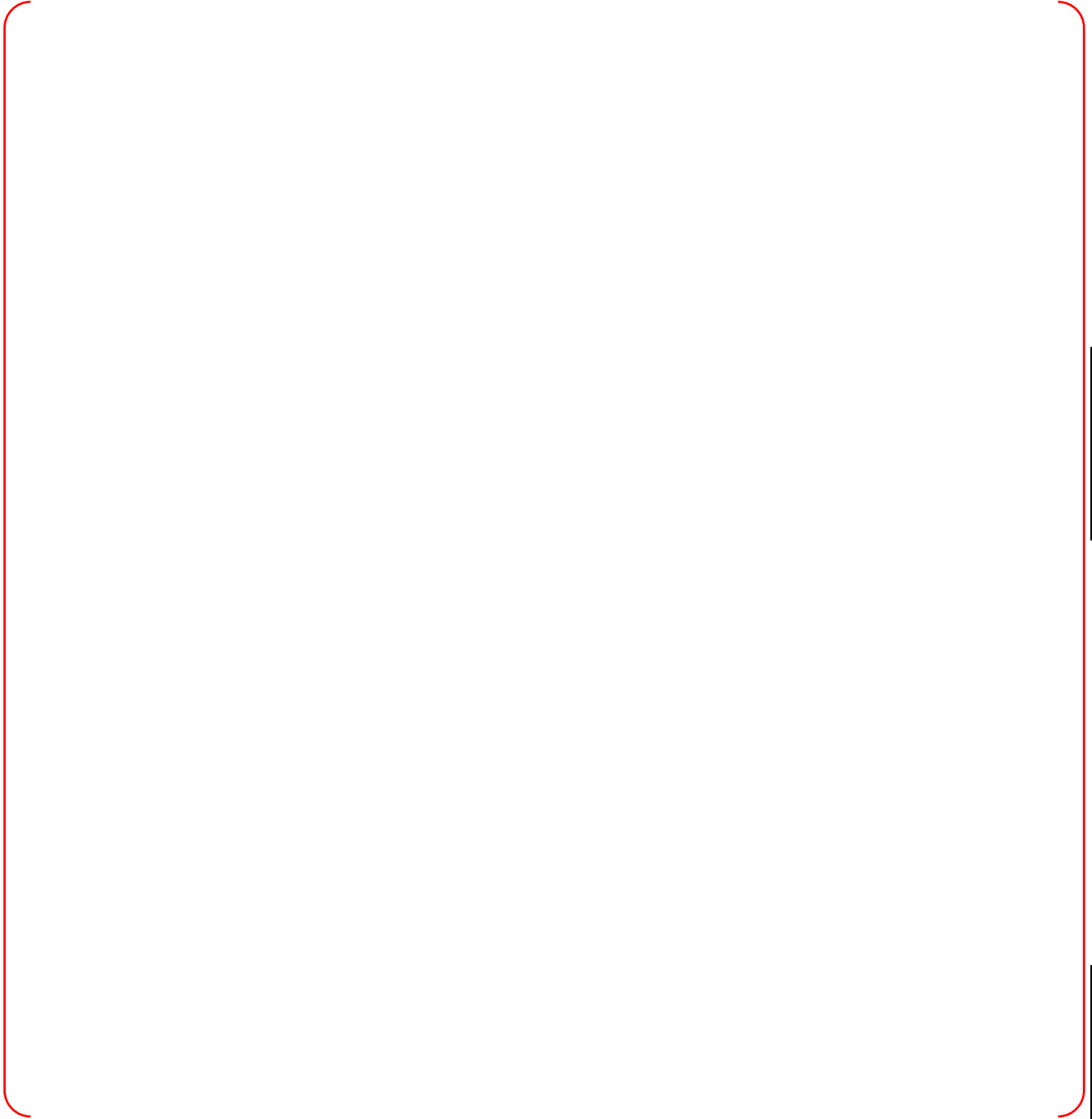




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**1.4 Other Performance Measures**

**TS**



**1.5 List of Important Human Actions**

**TS**



**1.6 Applicable Operational Condition Sampling**

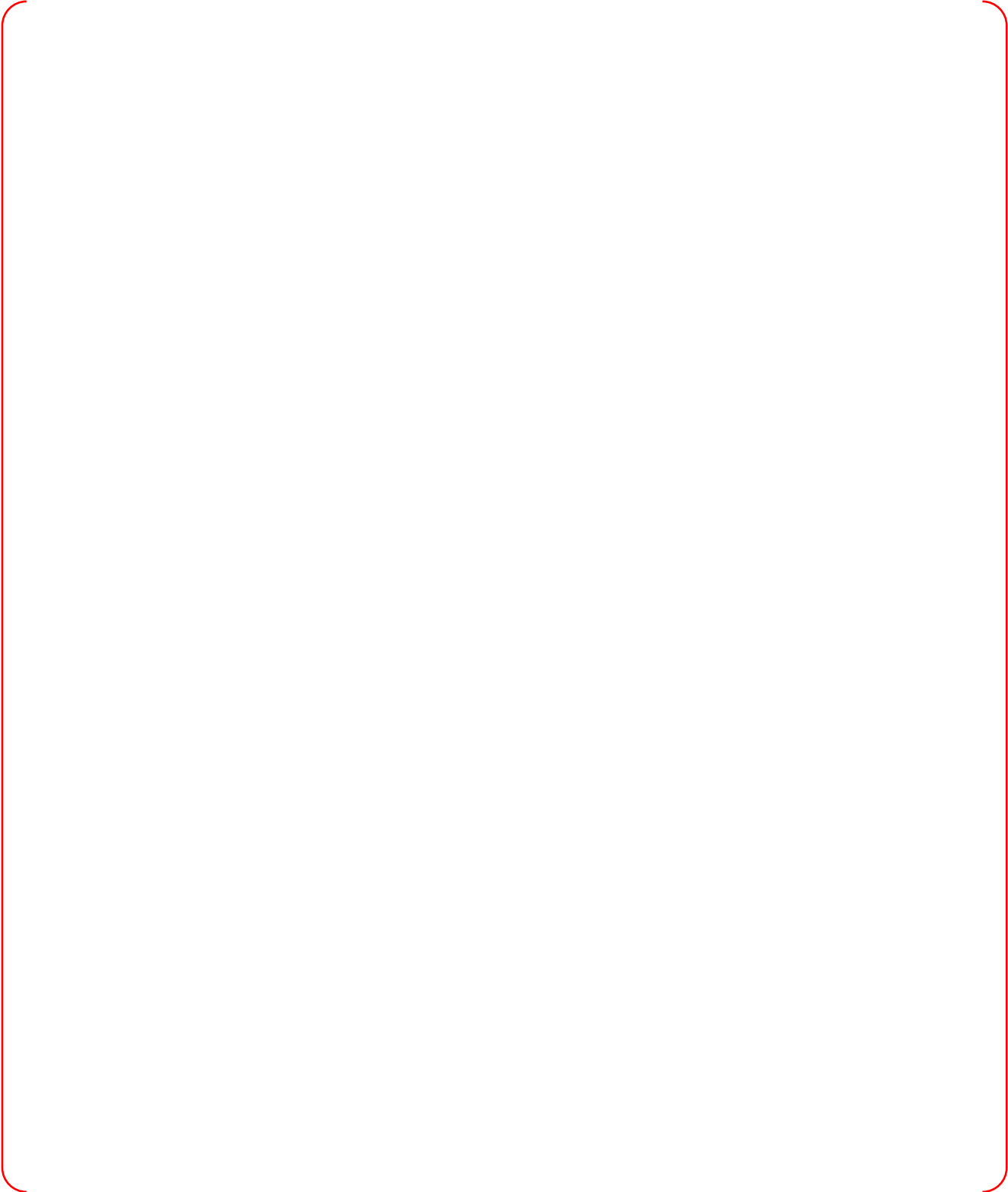
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**2. FACILITATORS INFORMATION**

**2.1 Scenario Timeline**

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**2.2 Procedure Flowpath**

**TS**



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**2.3 Emergency Plan**

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)

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**2.4 Technical Specifications**

TS  
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(  
**2.5 Scenario Termination Criteria**

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**2.6 Anticipated Scenario Length**

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**3. SIMULATOR EXERCISE EVALUATION**

**3.1 Evaluation Preparation**

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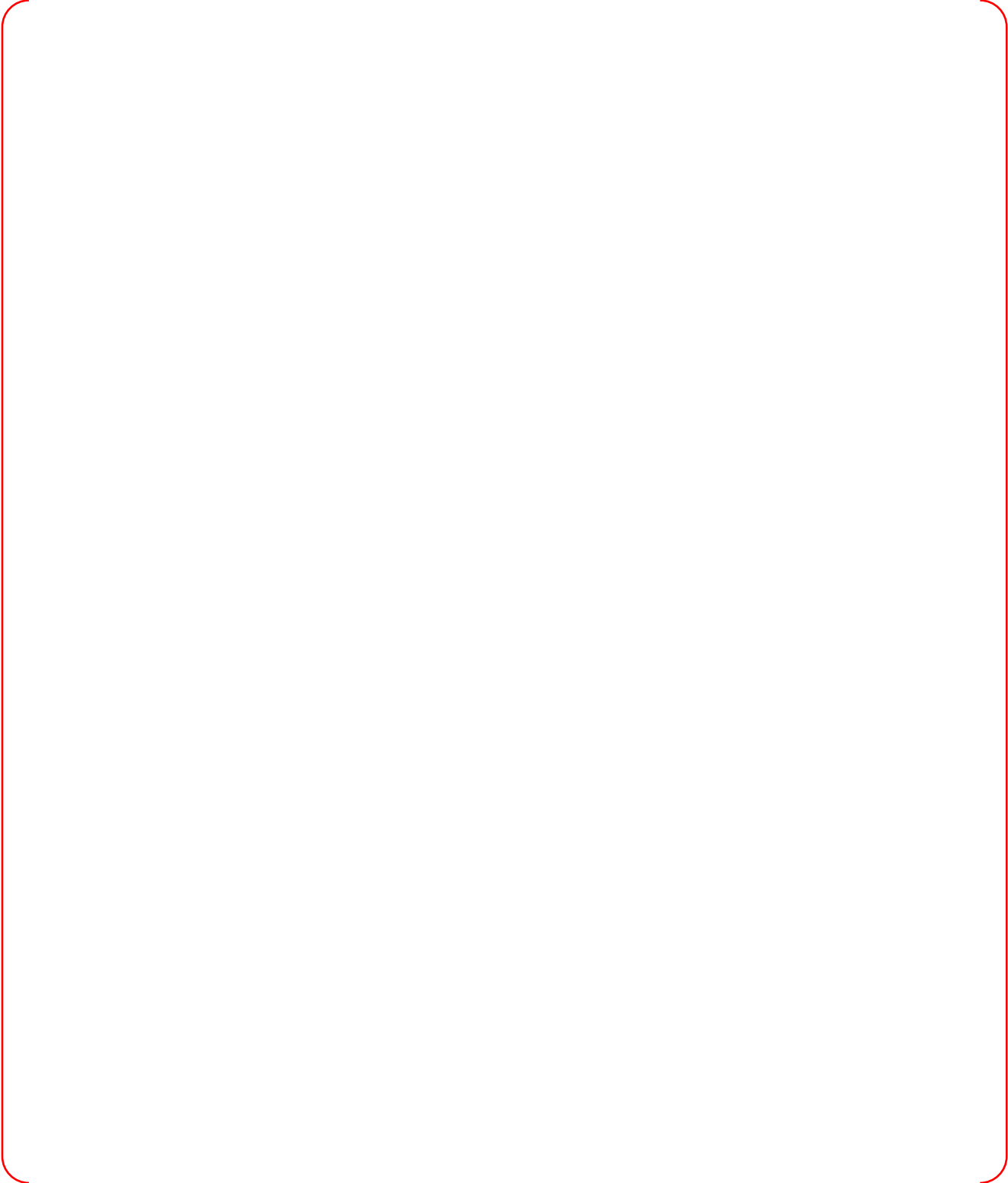


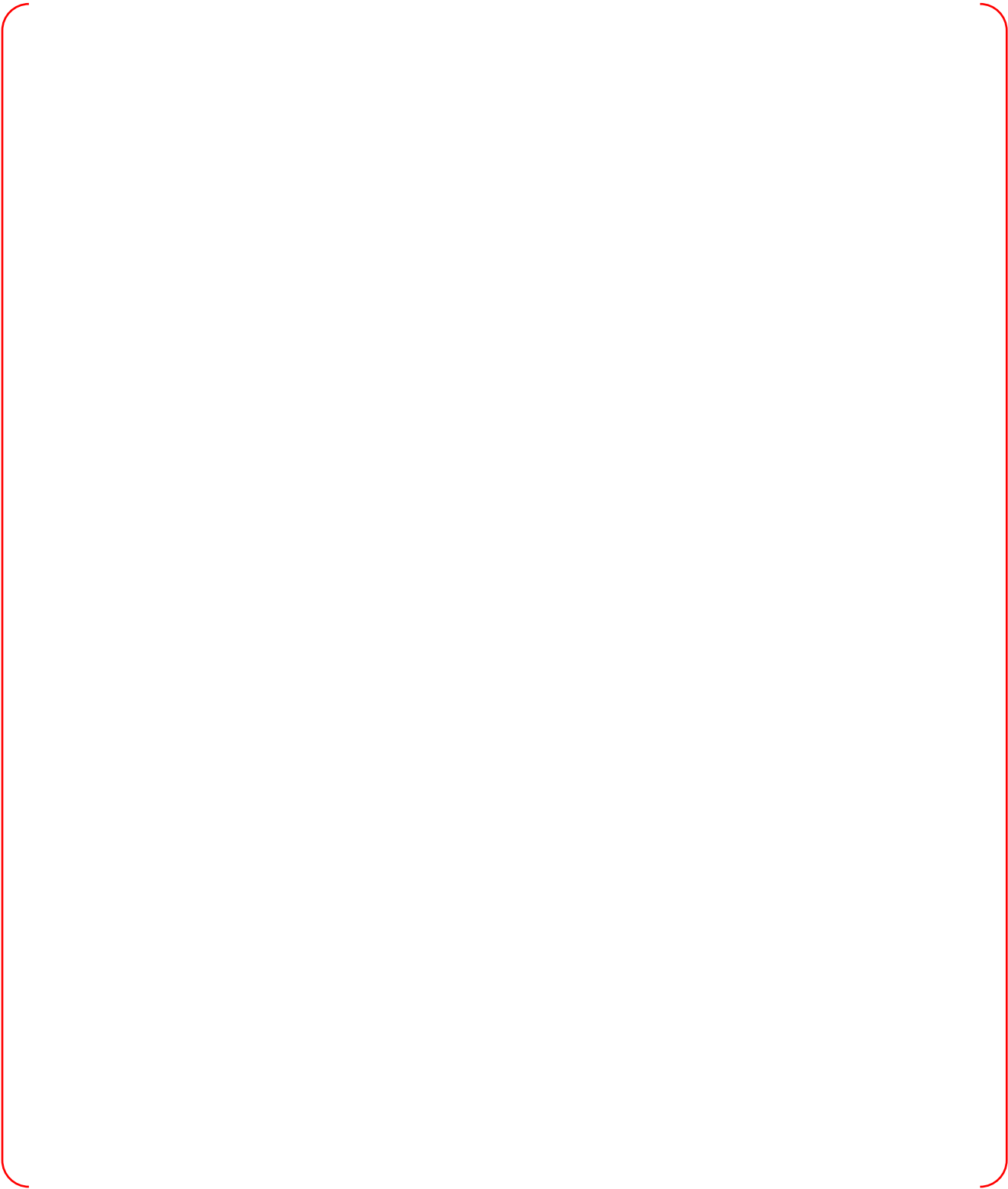


**3.2 Evaluation**

**3.2.1 Event 1 CVCS Letdown Line Leak Upstream Control Valve CV-201P/Q**

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**3.2.2 Event 2 13.8kV SW-02M, SW-02N BUS FAULT**

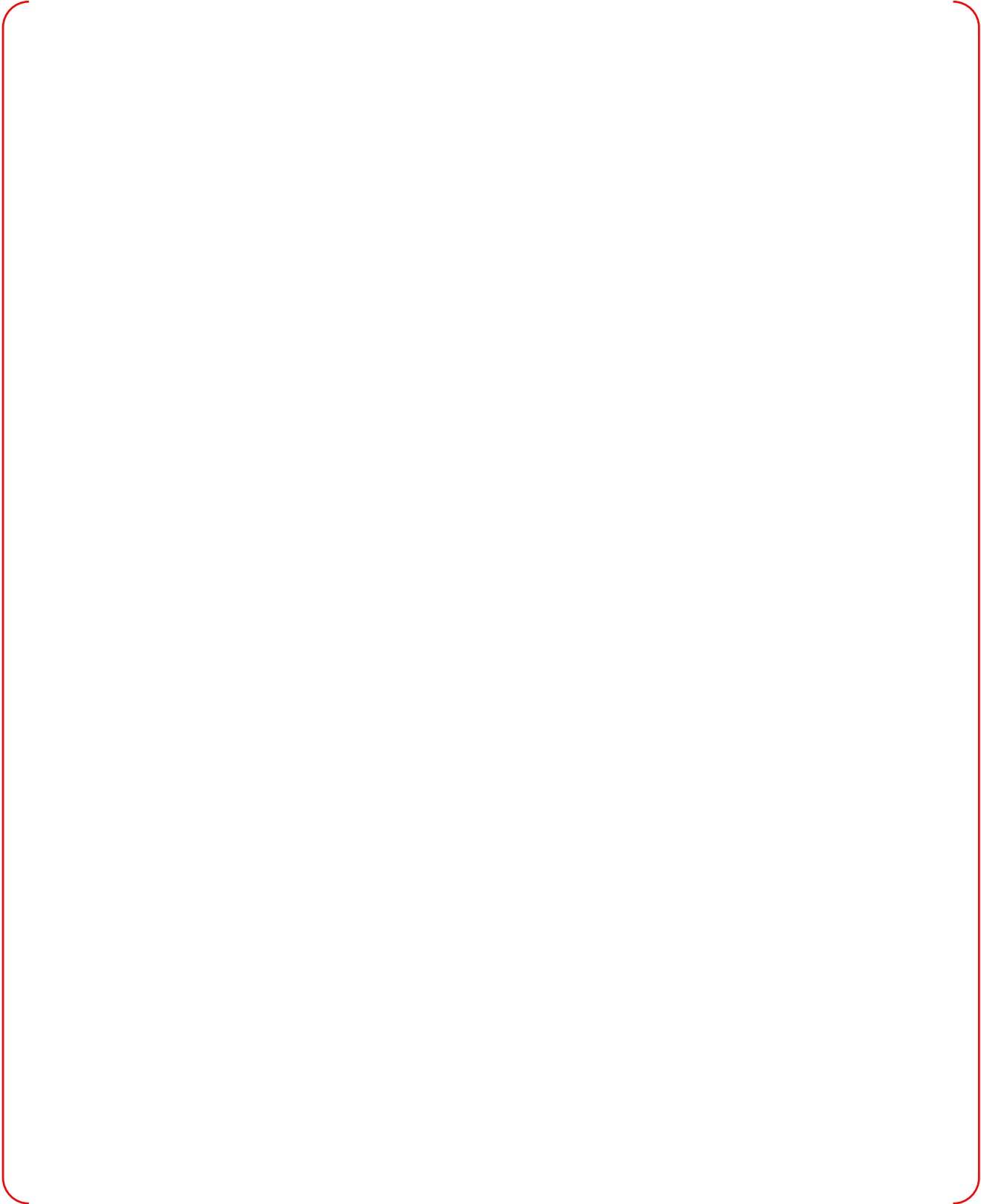
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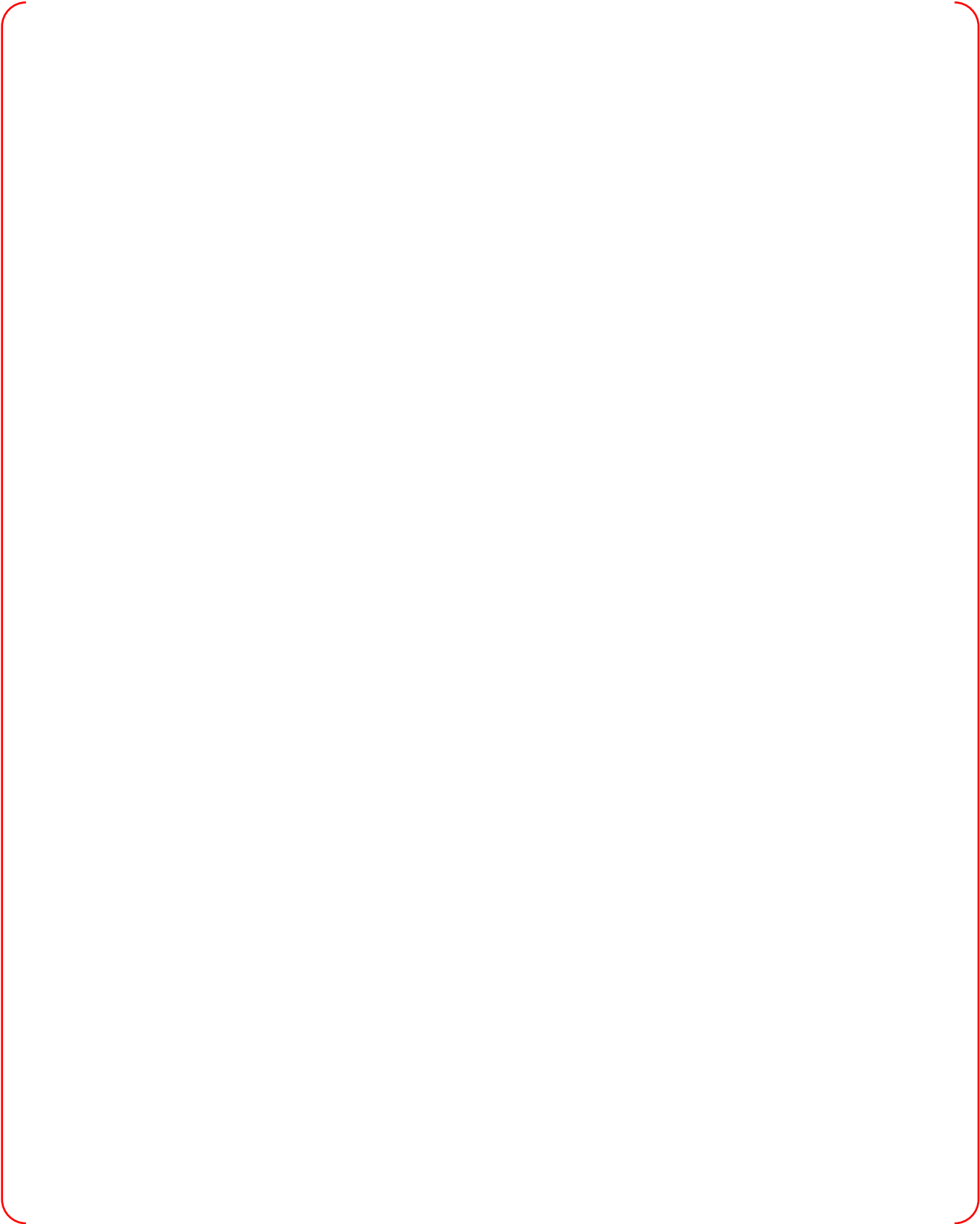
**3.2.3 Event 3 MD AFWP 2A and 2B Trip, Loss Of All Feedwater (LOAF)**

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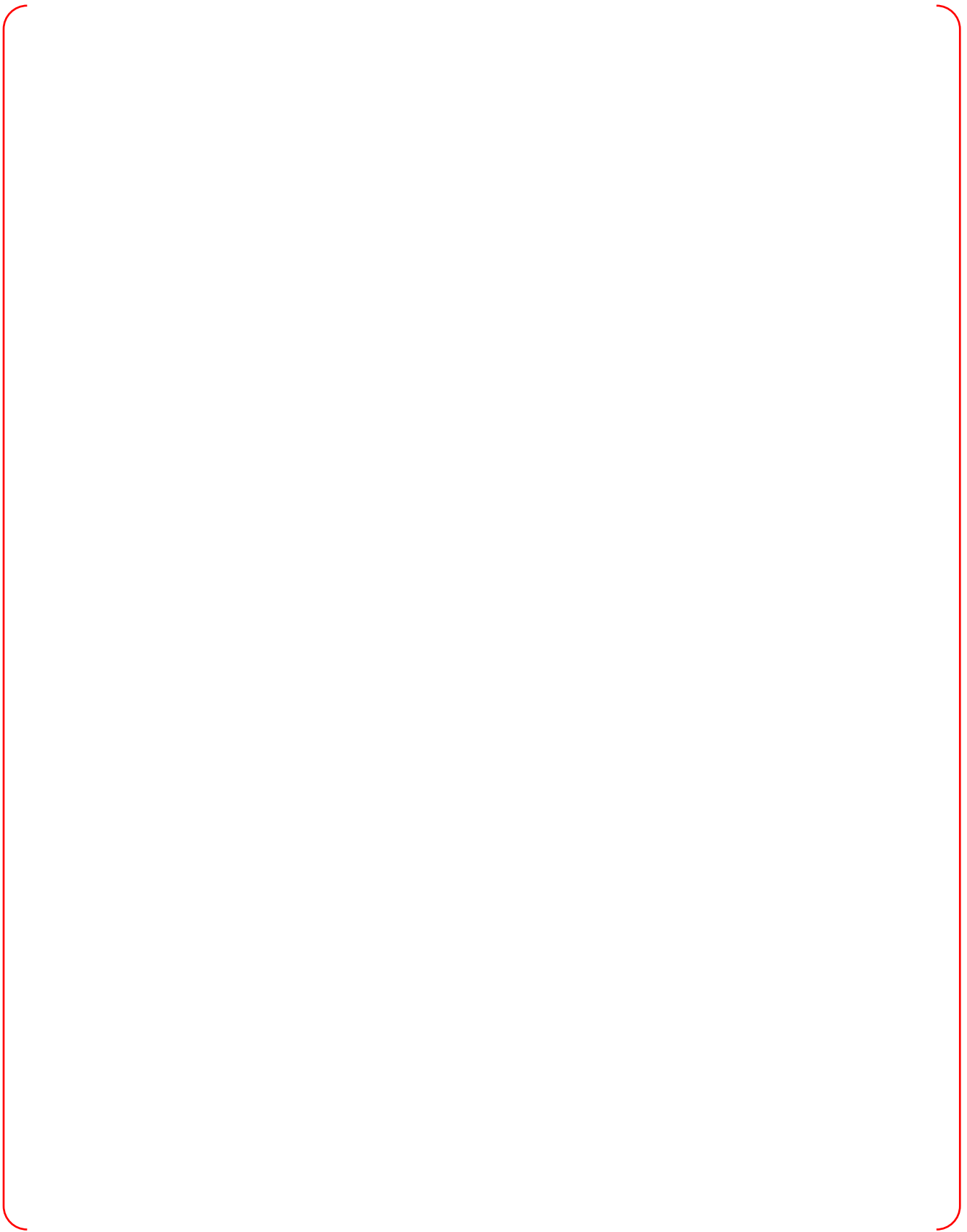
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**3.3 Debrief**

**3.3.1 Post Exercise Evaluation**

**TS**



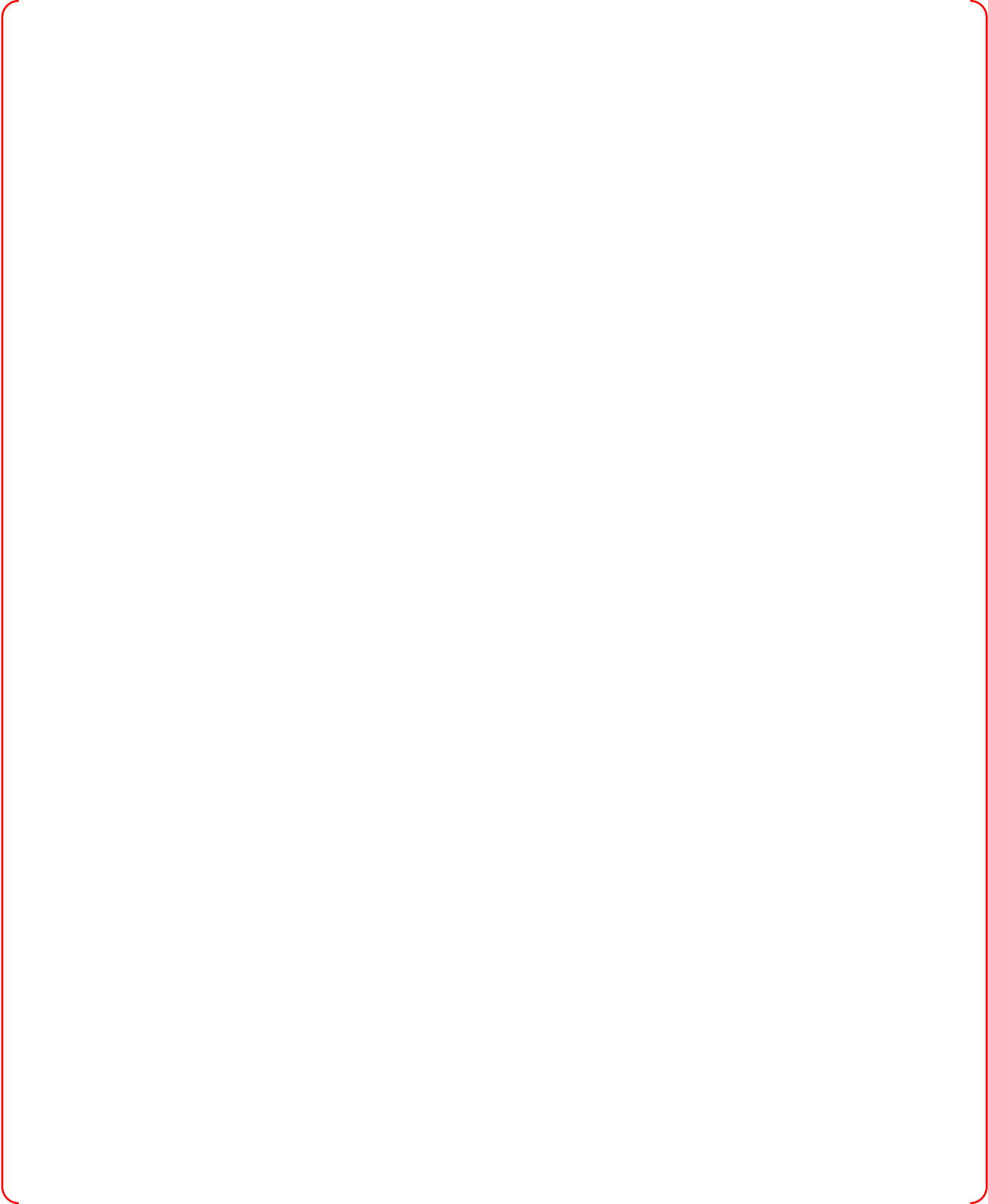
**3.3.2 Data Acquisition**

**TS**



**ISV-4 ATTACHMENT 1 - TRENDING PARAMETERS**

TS







**ISV-4 ATTACHMENT 2 - MALFUNCTION LIST**

**TS**

A large, empty rectangular box with rounded corners and a thin red border, intended for the content of the malfunction list.



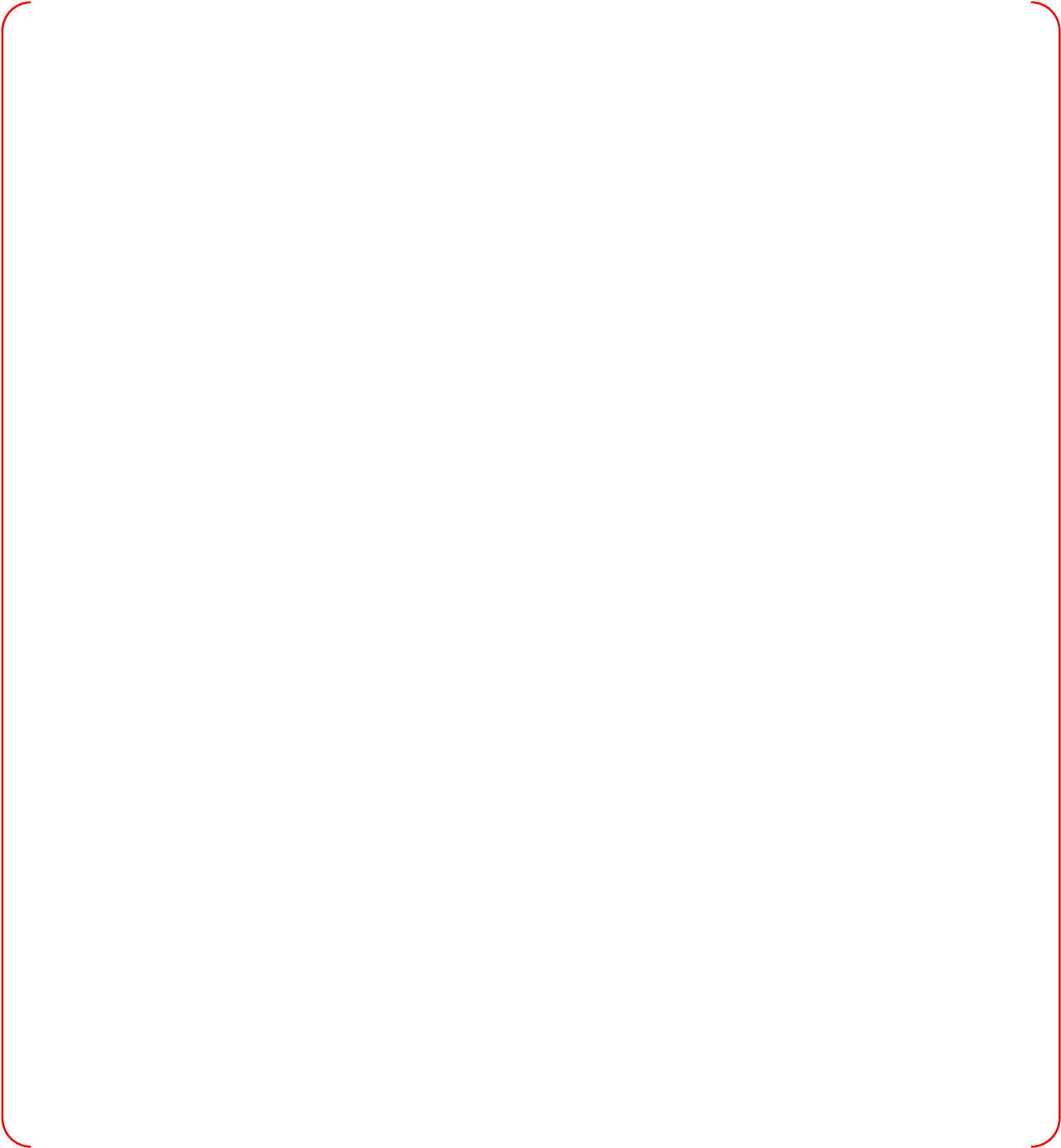
**ISV-4 ATTACHMENT 3 - SHIFT TURNOVER SHEET**

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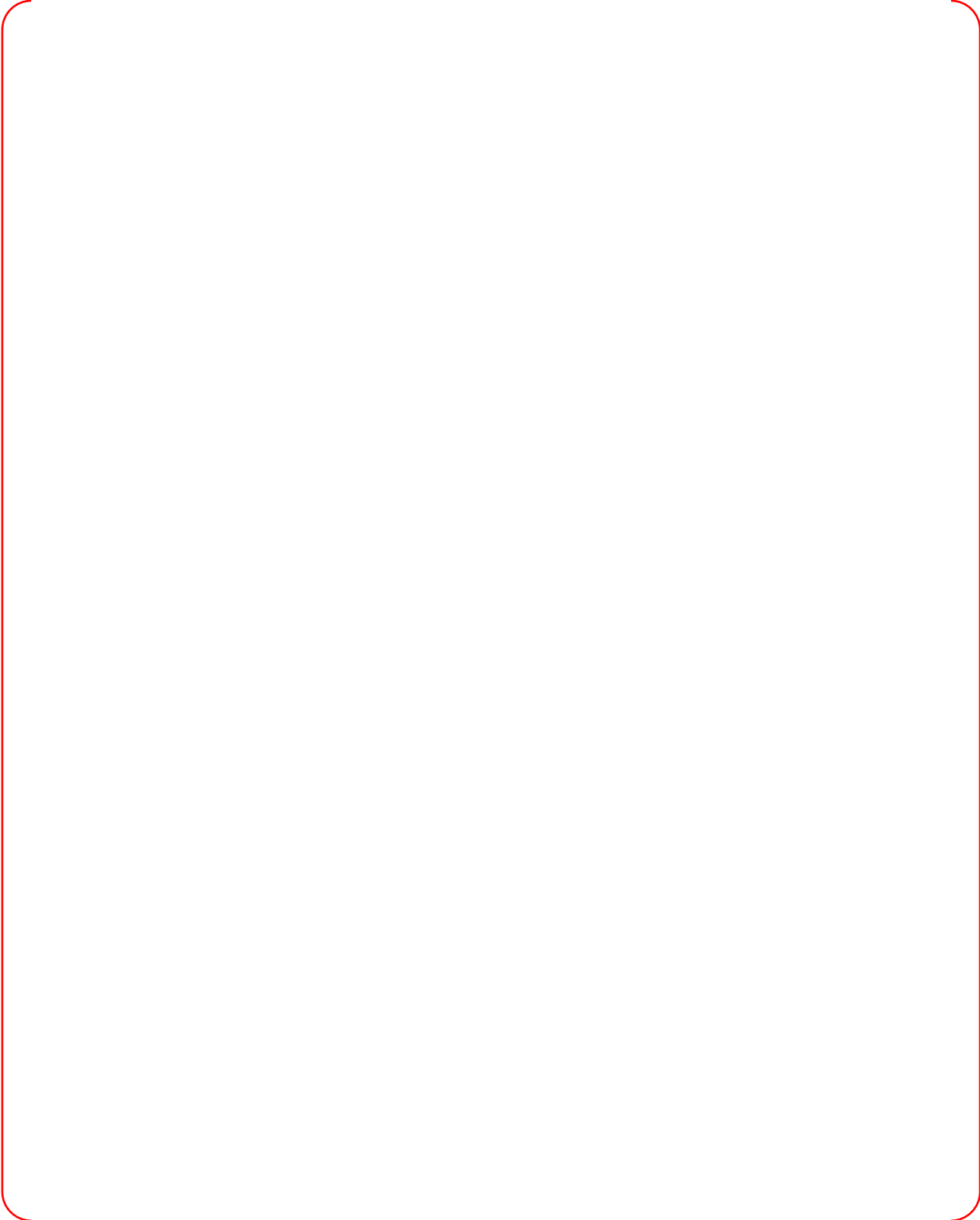


**ISV-4 ATTACHMENT 4 - ANTICIPATED DIALOG**

TS



**ISV-4 ATTACHMENT 5 - GUIDANCE WHEN DIFFICULTIES OCCUR DURING SIMULATION OR TESTING**



## **APPENDIX E**

### **Station Black Out**

#### **ISV-5**

**TABLE OF CONTENTS**

<b>1.</b>	<b>OVERVIEW.....</b>	<b>E3</b>
1.1	Human Factors Verification and Validation Objectives .....	E3
1.2	Scenario Overview.....	E4
1.3	Performance Measures .....	E5
1.4	Other Performance Measures .....	E8
1.5	List of Important Human Actions.....	E9
1.6	Applicable Operational Condition Sampling .....	E9
<b>2.</b>	<b>FACILITATORS INFORMATION .....</b>	<b>E11</b>
2.1	Scenario Timeline .....	E11
2.2	Procedure Flowpath.....	E12
2.3	Emergency Plan .....	E12
2.4	Technical Specifications .....	E12
2.5	Scenario Termination Criteria .....	E12
2.6	Anticipated Scenario Length.....	E12
<b>3.</b>	<b>SIMULATOR EXERCISE EVALUATION.....</b>	<b>E13</b>
3.1	Evaluation Preparation .....	E13
3.2	Evaluation .....	E14
3.2.1	Event 1 Equipment Rotation -- Charging Pump from 1A to 1B .....	E14
3.2.2	Event-2 CVCS VCT LT-227 Fails Low .....	E14
3.2.3	Event-3 Deaerator Level Controller LIK-0318NO1 Fails Low .....	E15
3.2.4	EVENT-4 100% to 75% Power Operation and Severe Weather (Tornado Warning) .....	E16
3.2.5	Event-5 Loss of Offsite Power .....	E17
3.2.6	EVENT-6 Station Black Out.....	E26
3.3	Debrief .....	E31
3.3.1	Post Exercise Evaluation .....	E31
3.3.2	Data Acquisition .....	E31
	<b>ISV-5 ATTACHMENT 1 - TRENDING PARAMETERS.....</b>	<b>E32</b>
	<b>ISV-5 ATTACHMENT 2 - MALFUNCTION LIST.....</b>	<b>E35</b>
	<b>ISV-5 ATTACHMENT 3 - SHIFT TURNOVER SHEET .....</b>	<b>E36</b>
	<b>ISV-5 ATTACHMENT 4 - ANTICIPATED DIALOG .....</b>	<b>E37</b>
	<b>ISV-5 ATTACHMENT 5 - GUIDANCE WHEN DIFFICULTIES OCCUR DURING SIMUMLATION OR TESTING.....</b>	<b>E39</b>

**1. OVERVIEW**

**1.1 Human Factors Verification and Validation Objectives**

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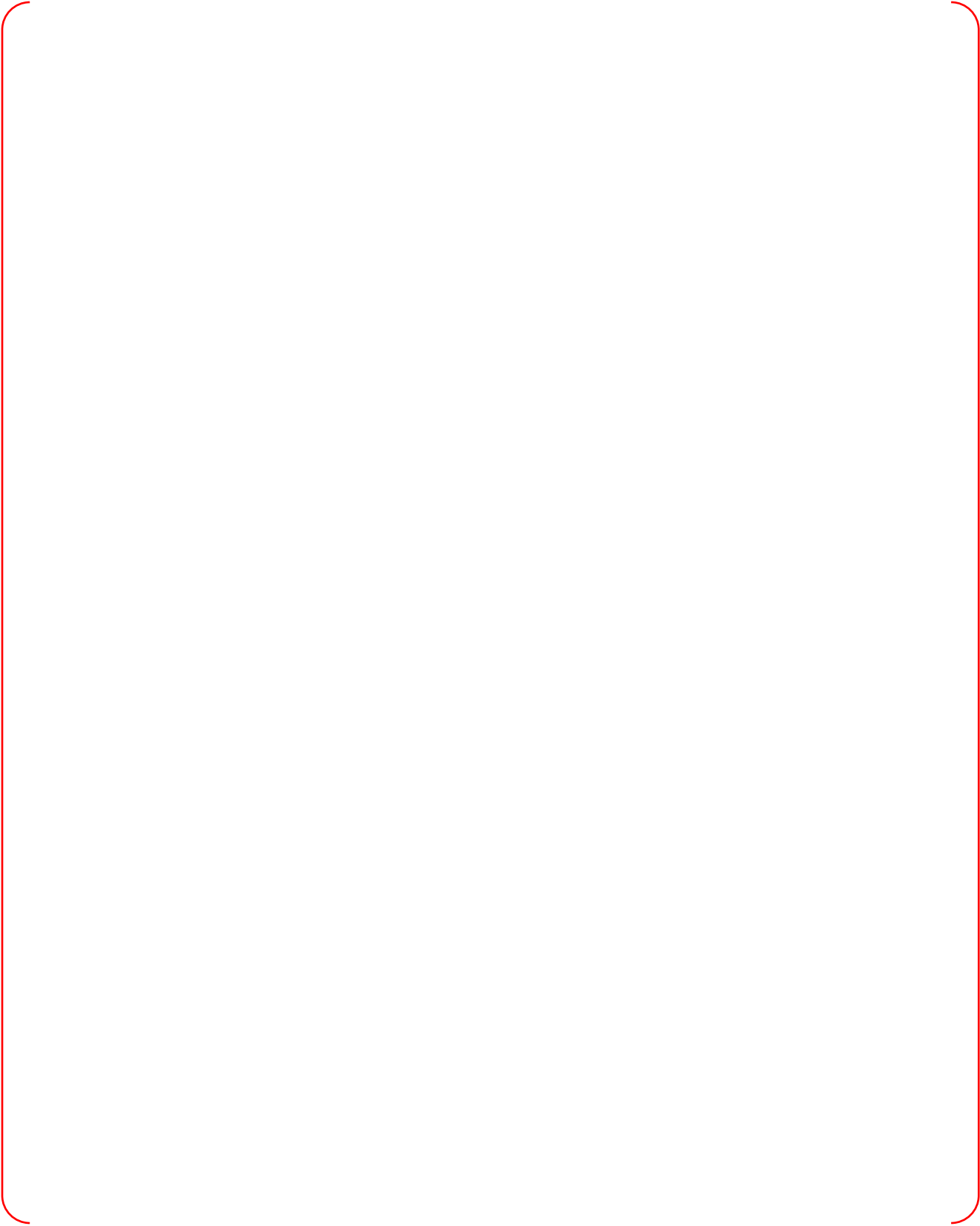
**1.2 Scenario Overview**

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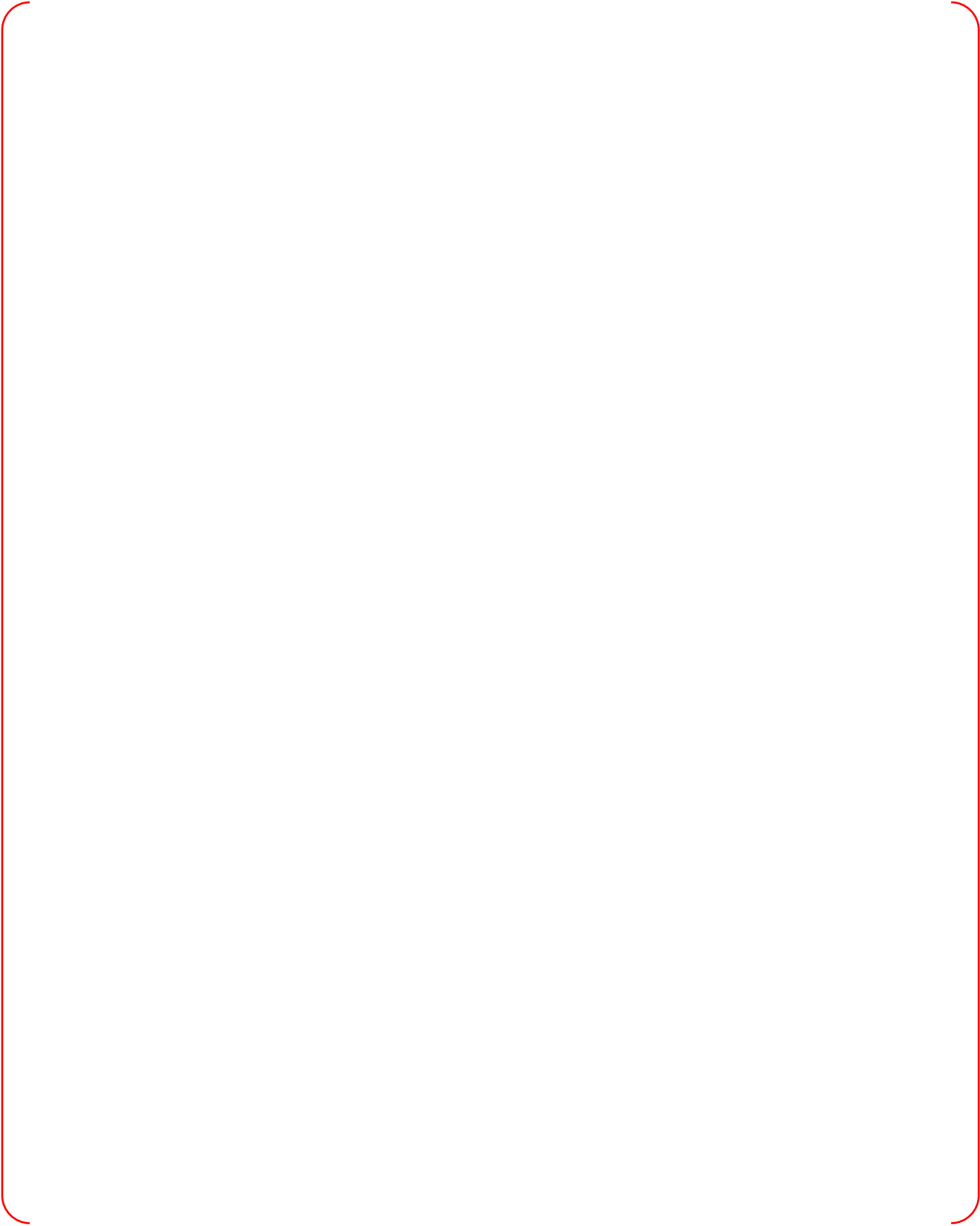


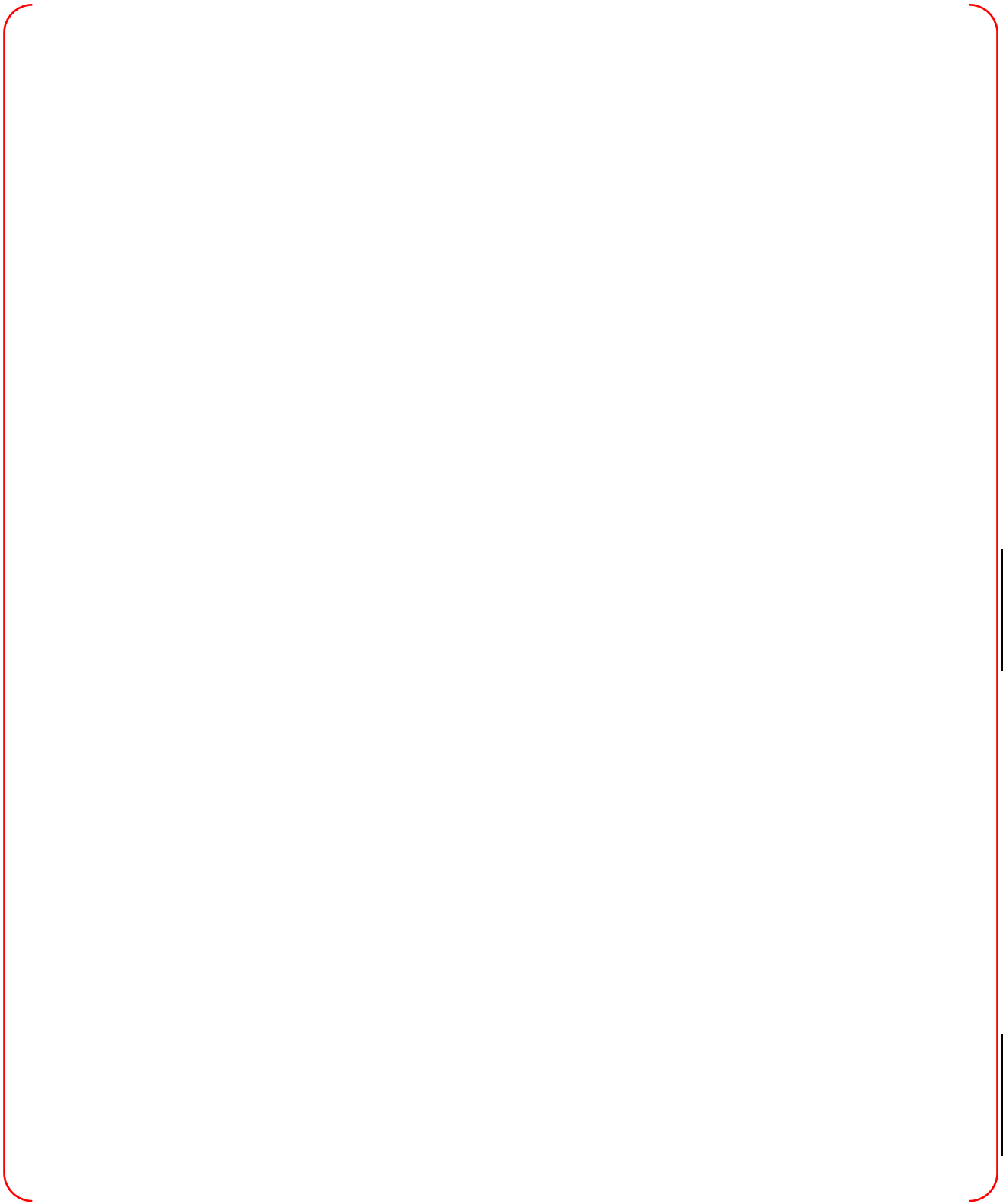
**1.3 Performance Measures**

TS









**1.4 Other Performance Measures**

TS



**1.5 List of Important Human Actions**

TS

**1.6 Applicable Operational Condition Sampling**

TS



**2. FACILITATORS INFORMATION**

**2.1 Scenario Timeline**

TS



TS



**2.2 Procedure Flowpath**

TS



**2.3 Emergency Plan**

TS



**2.4 Technical Specifications**

TS



**2.5 Scenario Termination Criteria**

TS



**2.6 Anticipated Scenario Length**

TS



**3. SIMULATOR EXERCISE EVALUATION**

**3.1 Evaluation Preparation**

TS





**3.2 Evaluation**

**3.2.1 Event 1 Equipment Rotation -- Charging Pump from 1A to 1B**

TS



**3.2.2 Event-2 CVCS VCT LT-227 Fails Low**

TS



TS



**3.2.3 Event-3 Deaerator Level Controller LIK-0318NO1 Fails Low**

TS



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**3.2.4 EVENT-4 100% to 75% Power Operation and Severe Weather (Tornado Warning)**

TS



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**3.2.5 Event-5 Loss of Offsite Power**

TS

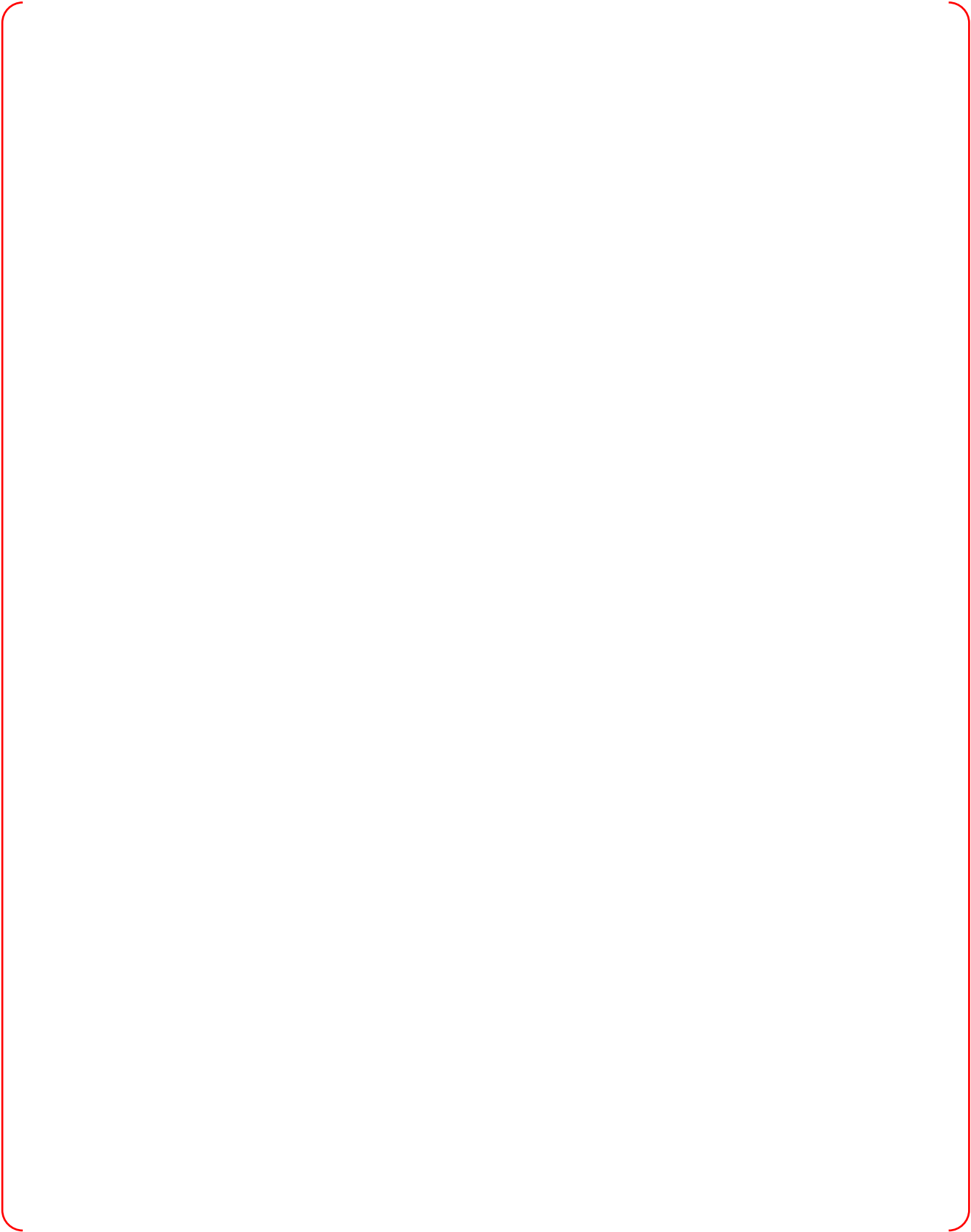


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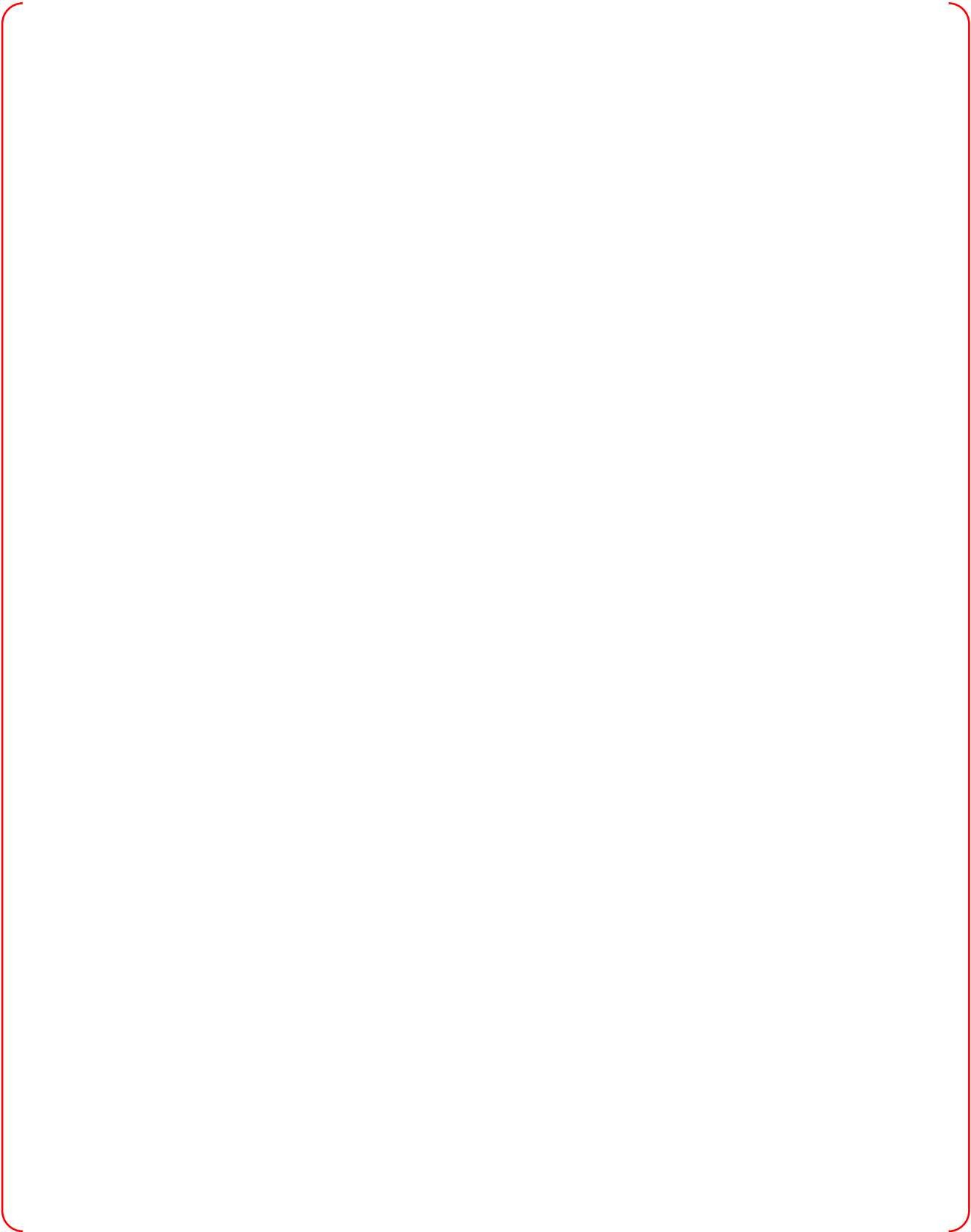


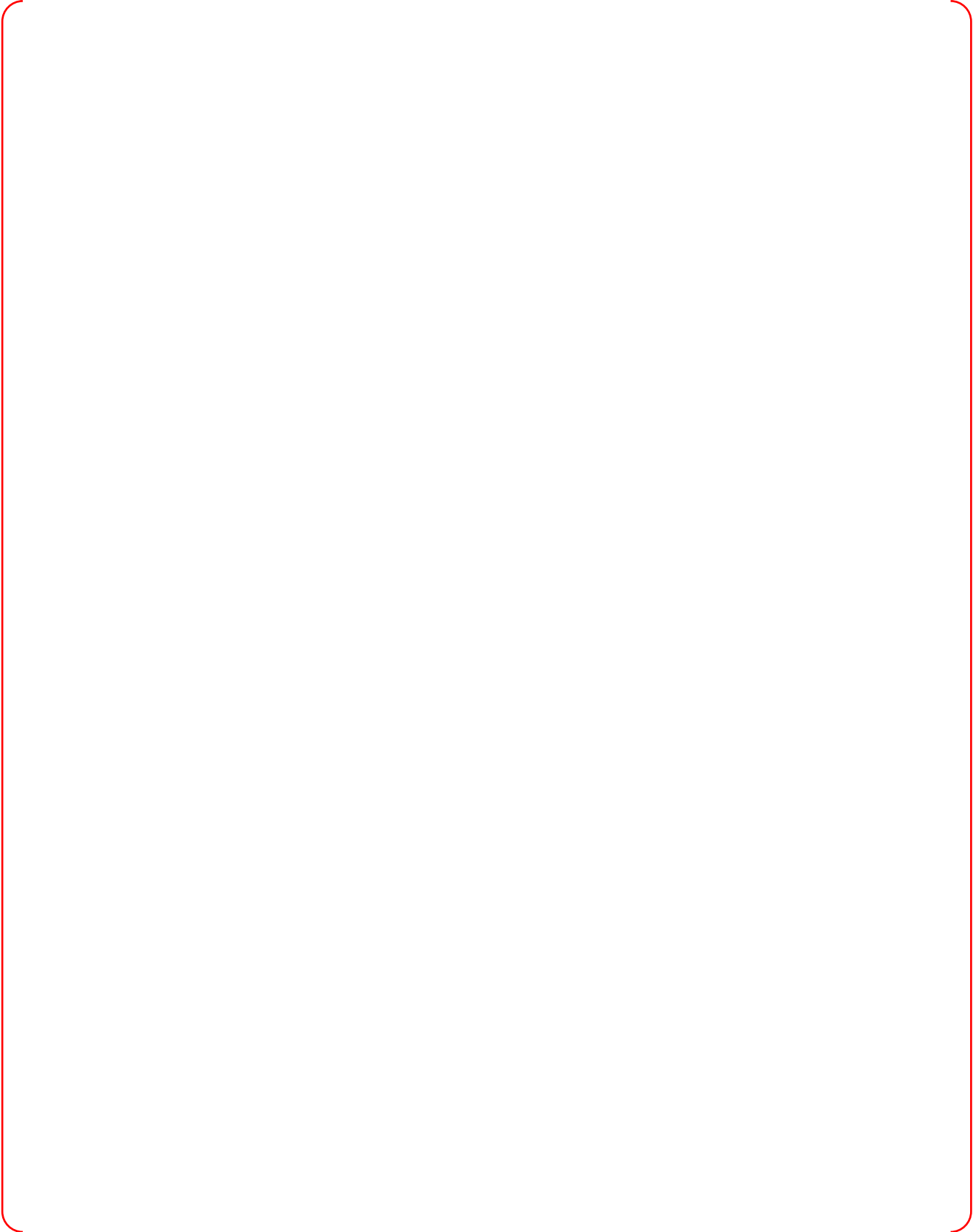
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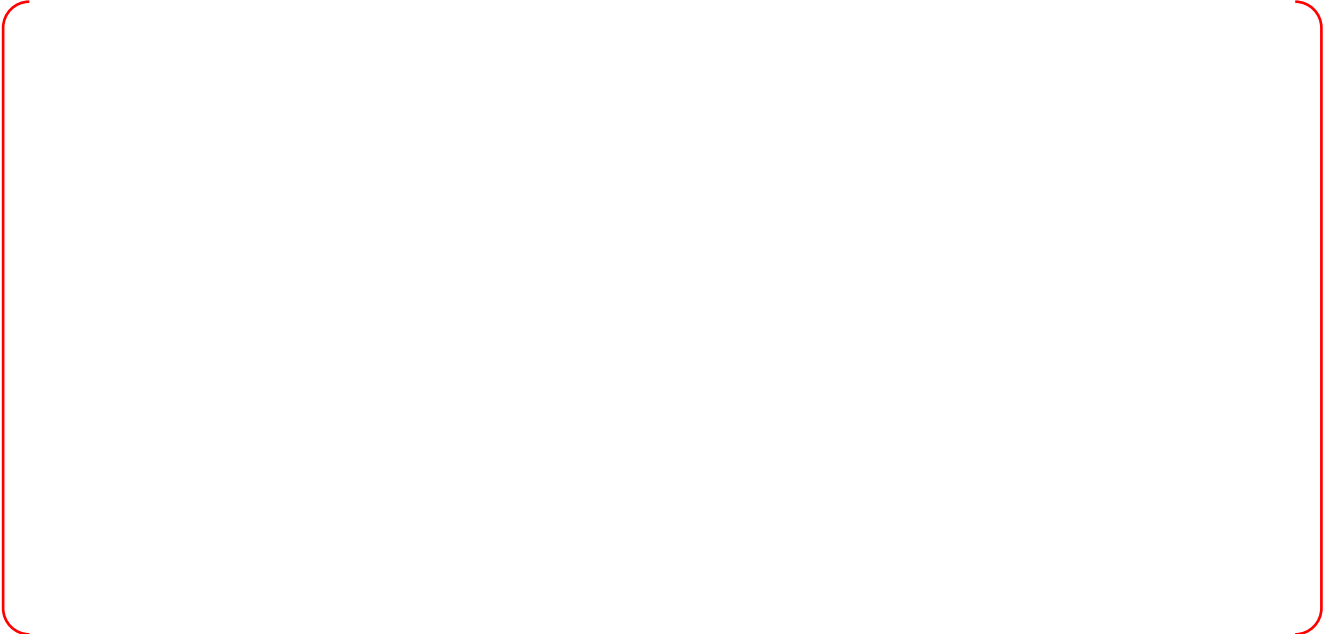




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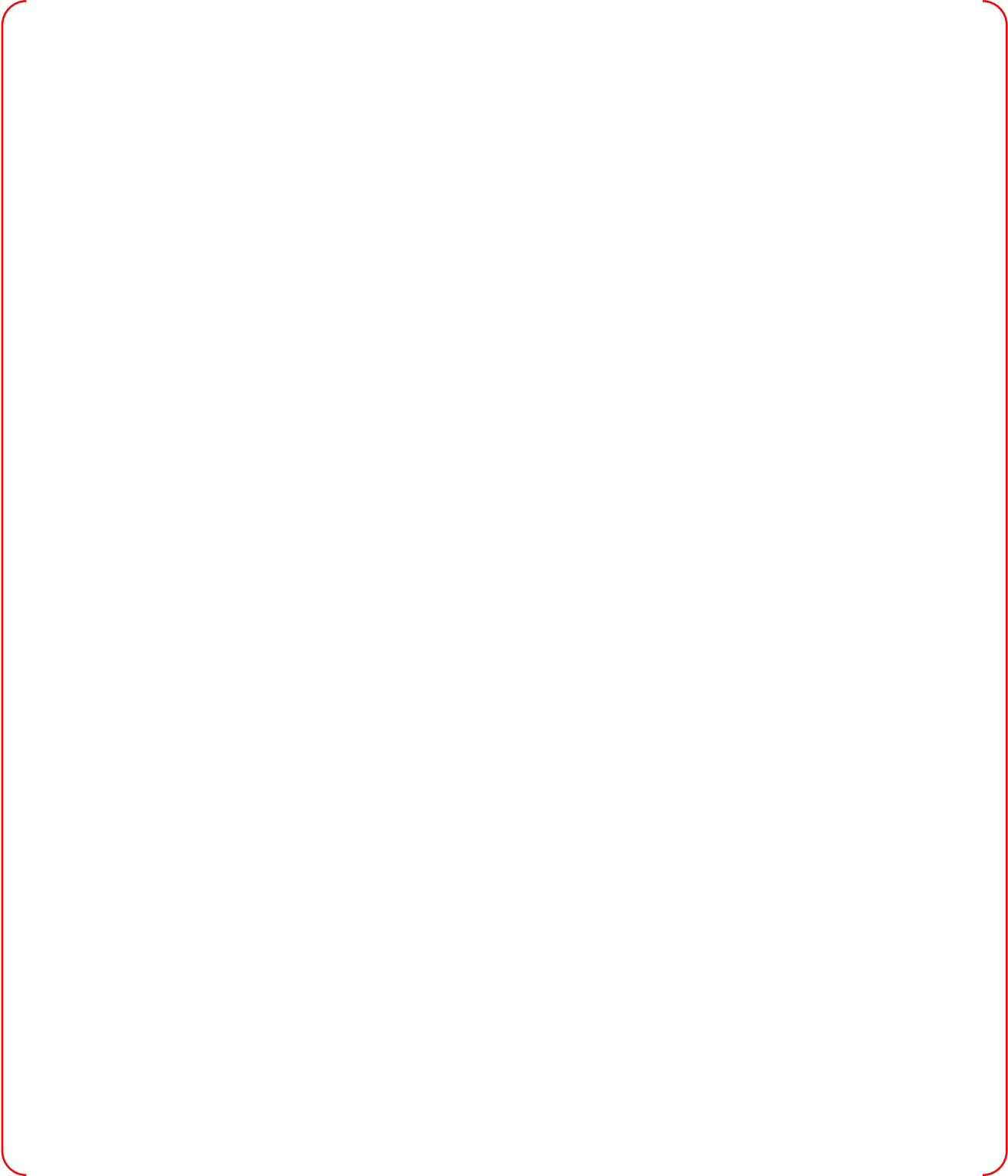




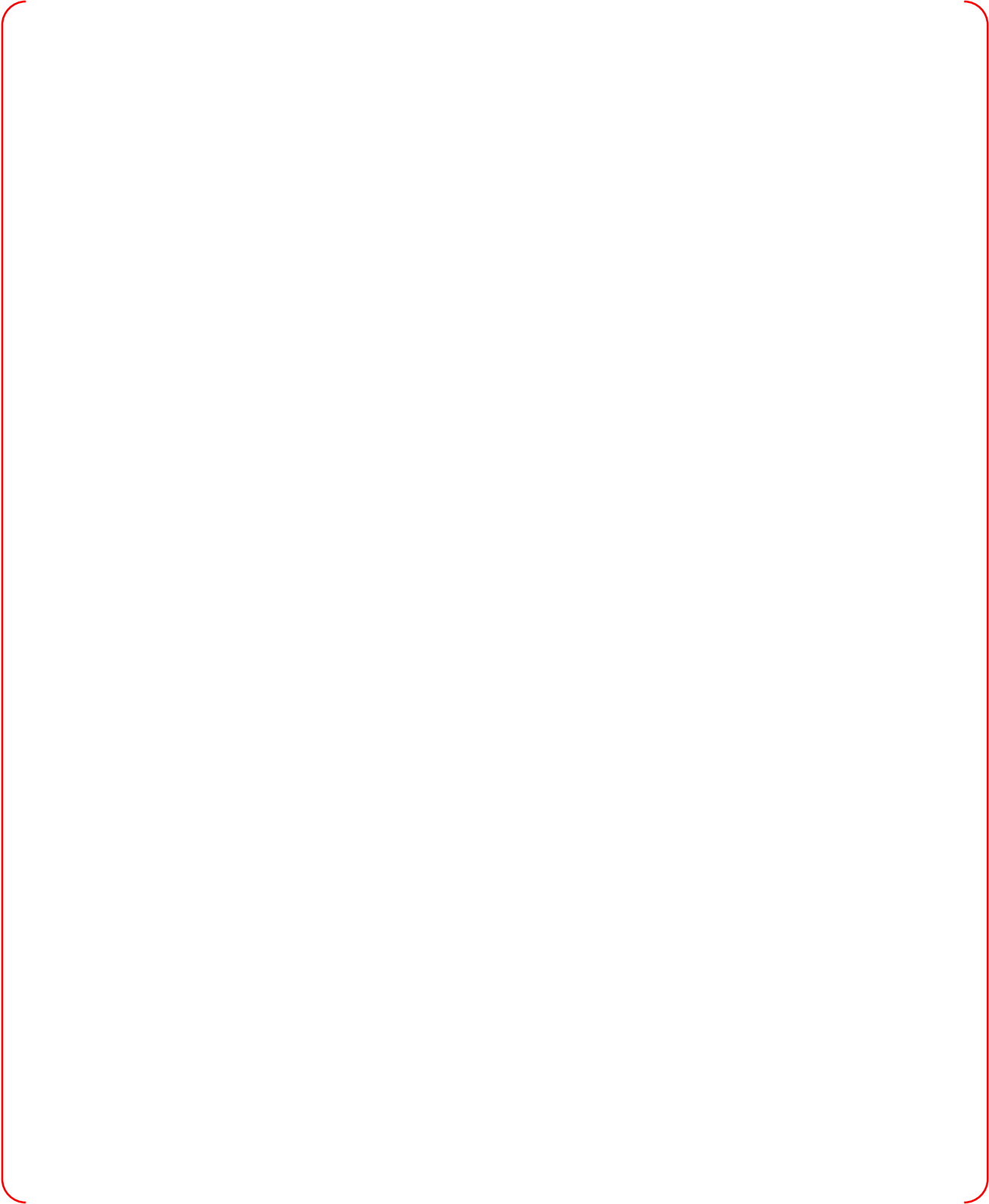


3.2.6 EVENT-6 Station Black Out

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**3.3 Debrief**

**3.3.1 Post Exercise Evaluation**

TS

**3.3.2 Data Acquisition**

TS

**ISV-5 ATTACHMENT 1 - TRENDING PARAMETERS**

TS







**ISV-5 ATTACHMENT 2 - MALFUNCTION LIST**

TS

A large, empty rectangular area enclosed by a red bracket on the left and right sides, intended for the content of the malfunction list.

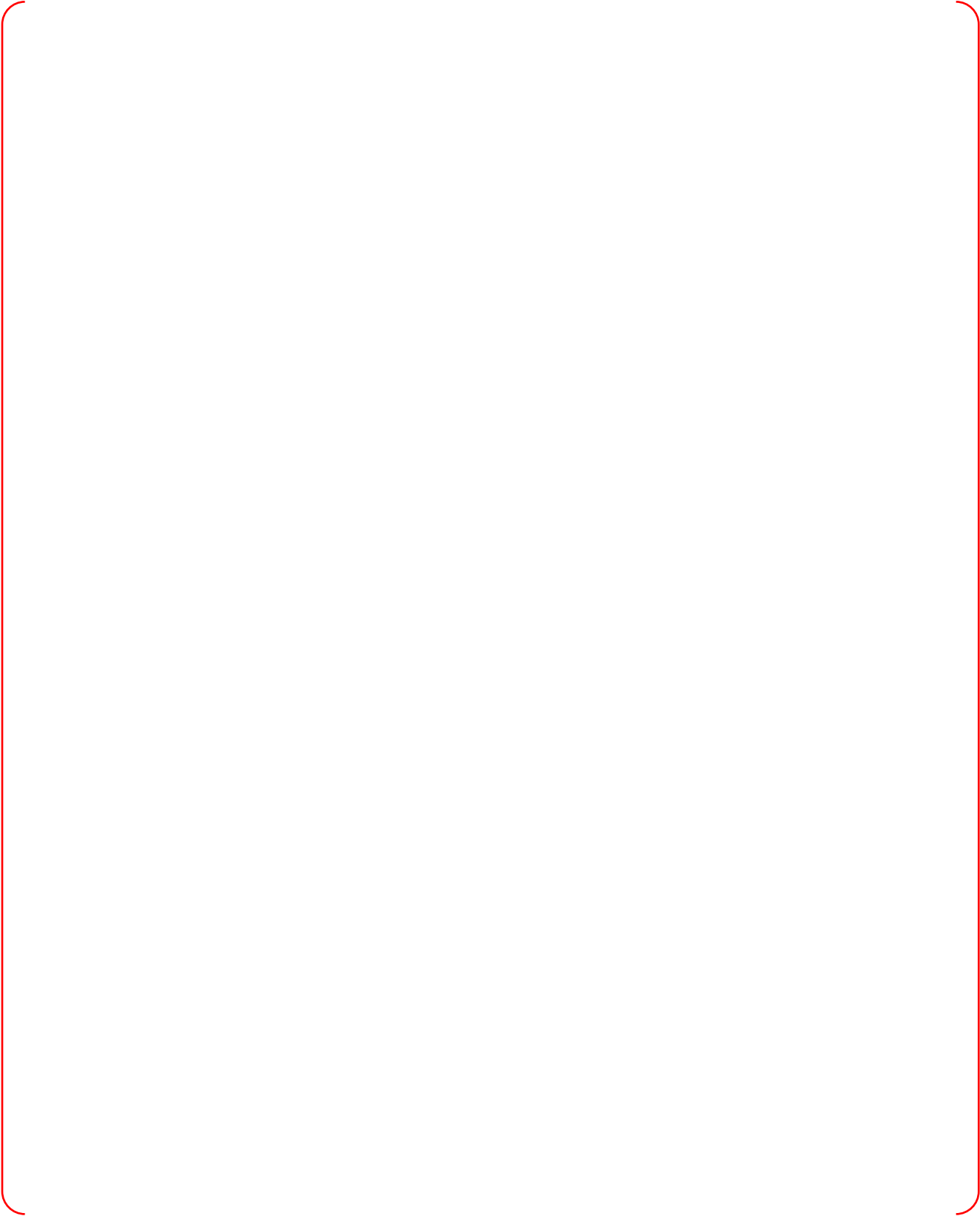
**ISV-5 ATTACHMENT 3 - SHIFT TURNOVER SHEET**

TS



**ISV-5 ATTACHMENT 4 - ANTICIPATED DIALOG**

TS





TS



**ISV-5 ATTACHMENT 5 - GUIDANCE WHEN DIFFICULTIES OCCUR DURING SIMUMLATION OR TESTING**



## **APPENDIX F**

### **Station Black Out**

#### **ISV-6**

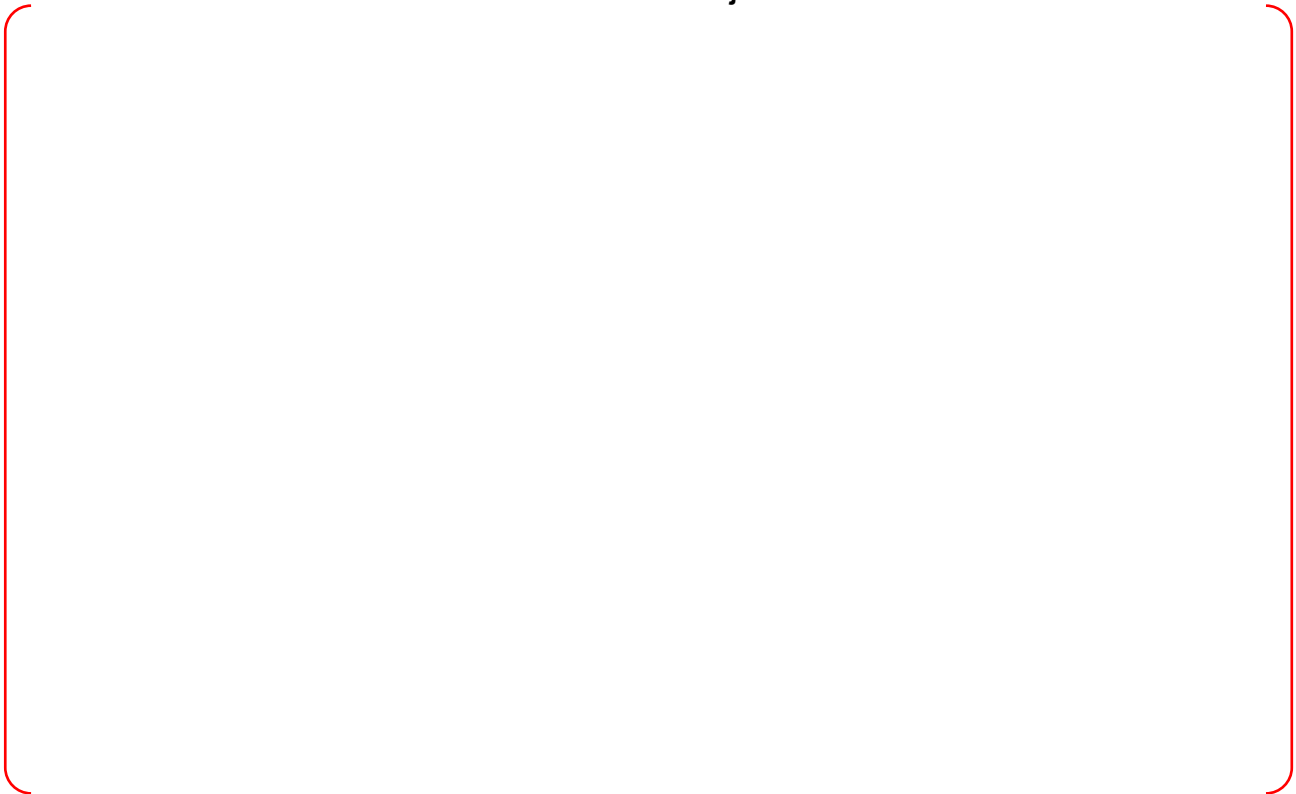
**TABLE OF CONTENTS**

<b>1.</b>	<b>OVERVIEW.....</b>	<b>F3</b>
1.1	Human Factors Verification and Validation Objectives .....	F3
1.2	Scenario Overview.....	F4
1.3	Performance Measures .....	F5
1.4	Other Performance Measures .....	F9
1.5	List of Important Human Actions.....	F10
1.6	Applicable Operational Condition Sampling .....	F10
<b>2.</b>	<b>FACILITATORS INFORMATION .....</b>	<b>F11</b>
2.1	Scenario Timeline .....	F11
2.2	Procedure Flowpath.....	F12
2.3	Emergency Plan .....	F12
2.4	Technical Specifications .....	F12
2.5	Scenario Termination Criteria .....	F12
2.6	Anticipated Scenario Length.....	F12
<b>3.</b>	<b>SIMULATOR EXERCISE EVALUATION.....</b>	<b>F13</b>
3.1	Evaluation Preparation .....	F13
3.2	Evaluation .....	F14
3.2.1	Event 1 Equipment Rotation -- CCWP from 1A & 1B to 2A & 2B .....	F14
3.2.2	Event-2 Condenser A Left Hotwell Tube Leak.....	F15
3.2.3	Event-3 100% to 75% Power Operation.....	F16
3.2.4	EVENT-4 RRS Tavg Fail Low .....	F17
3.2.5	Event-5 Steam Generator Tube Leak with Secondary Radiation Monitor Failures.....	F18
3.2.6	Event 6 Steam Generator Tube Rupture (SGTR) .....	F20
3.3	Debrief .....	F38
3.3.1	Post Exercise Evaluation .....	F38
3.3.2	Data Acquisition .....	F39
<b>ISV-6 ATTACHMENT 1 - TRENDING PARAMETERS.....</b>		<b>F40</b>
<b>ISV-6 ATTACHMENT 2 - MALFUNCTION LIST.....</b>		<b>F43</b>
<b>ISV-6 ATTACHMENT 3 - SHIFT TURNOVER SHEET .....</b>		<b>F44</b>
<b>ISV-6 ATTACHMENT 4 - ANTICIPATED DIALOG.....</b>		<b>F45</b>
<b>ISV-6 ATTACHMENT 5 – GUIDANCE WHEN DIFFICULTIES OCCUR DURING SIMULATION OR TESTING.....</b>		<b>F47</b>

**1. OVERVIEW**

**1.1 Human Factors Verification and Validation Objectives**

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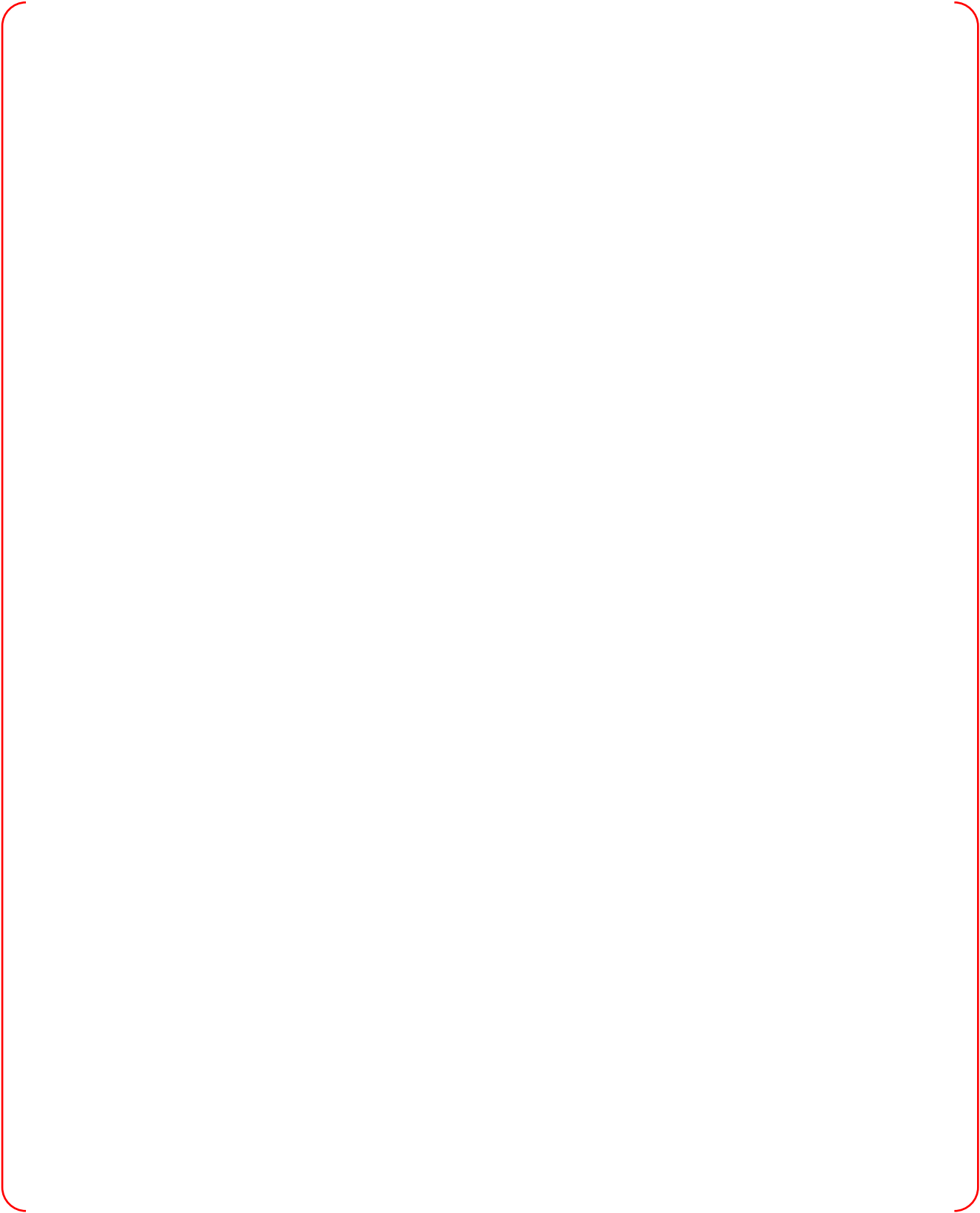
1.2 Scenario Overview

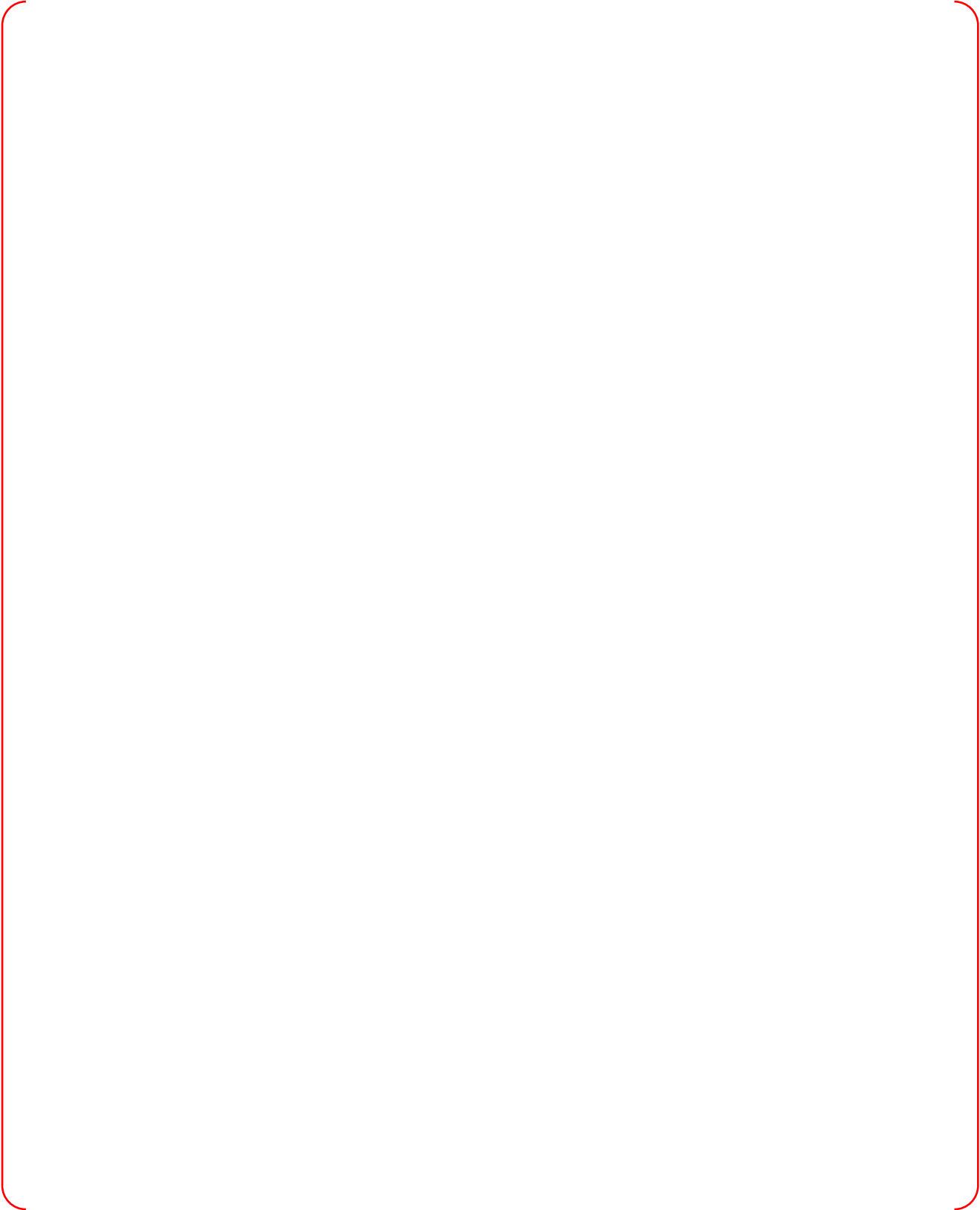
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**1.3 Performance Measures**

**TS**







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1.4 Other Performance Measures

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**1.5 List of Important Human Actions**

**TS**

**1.6 Applicable Operational Condition Sampling**

**TS**

**2. FACILITATORS INFORMATION**

**2.1 Scenario Timeline**

TS



**TS**



**2.2 Procedure Flowpath**

**TS**



**2.3 Emergency Plan**

**TS**



**2.4 Technical Specifications**

**TS**



**2.5 Scenario Termination Criteria**

**TS**



**2.6 Anticipated Scenario Length**

**TS**



**3. SIMULATOR EXERCISE EVALUATION**

**3.1 Evaluation Preparation**

TS



**3.2 Evaluation**

**3.2.1 Event 1 Equipment Rotation -- CCWP from 1A & 1B to 2A & 2B**

**TS**





**3.2.2 Event-2 Condenser A Left Hotwell Tube Leak**

TS



TS



**3.2.3 Event-3 100% to 75% Power Operation**

TS



3.2.4 EVENT-4 RRS Tavg Fail Low

TS



TS

**3.2.5 Event-5 Steam Generator Tube Leak with Secondary Radiation Monitor Failures**

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3.2.5

3.2.5

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**3.2.6 Event 6 Steam Generator Tube Rupture (SGTR)**

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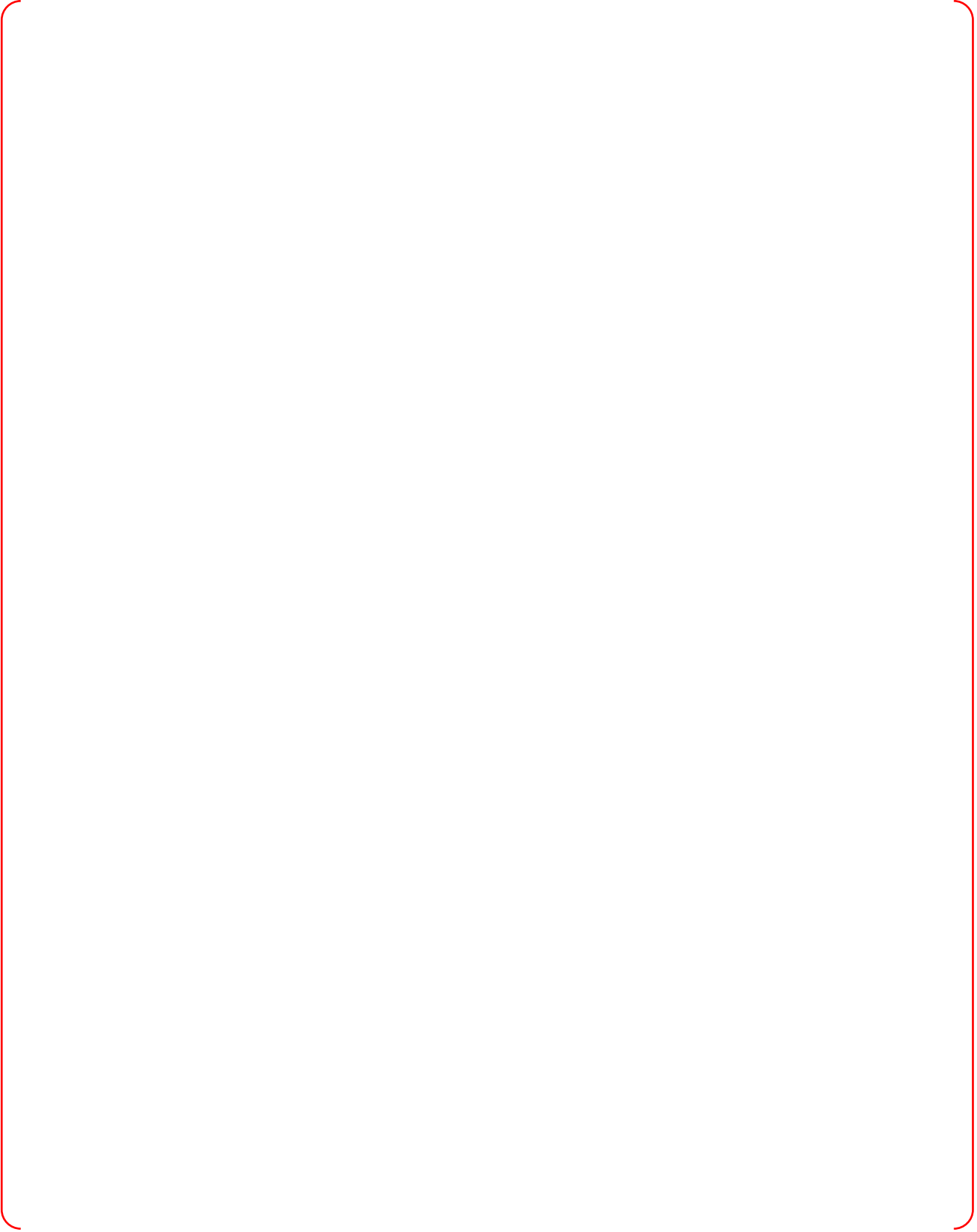










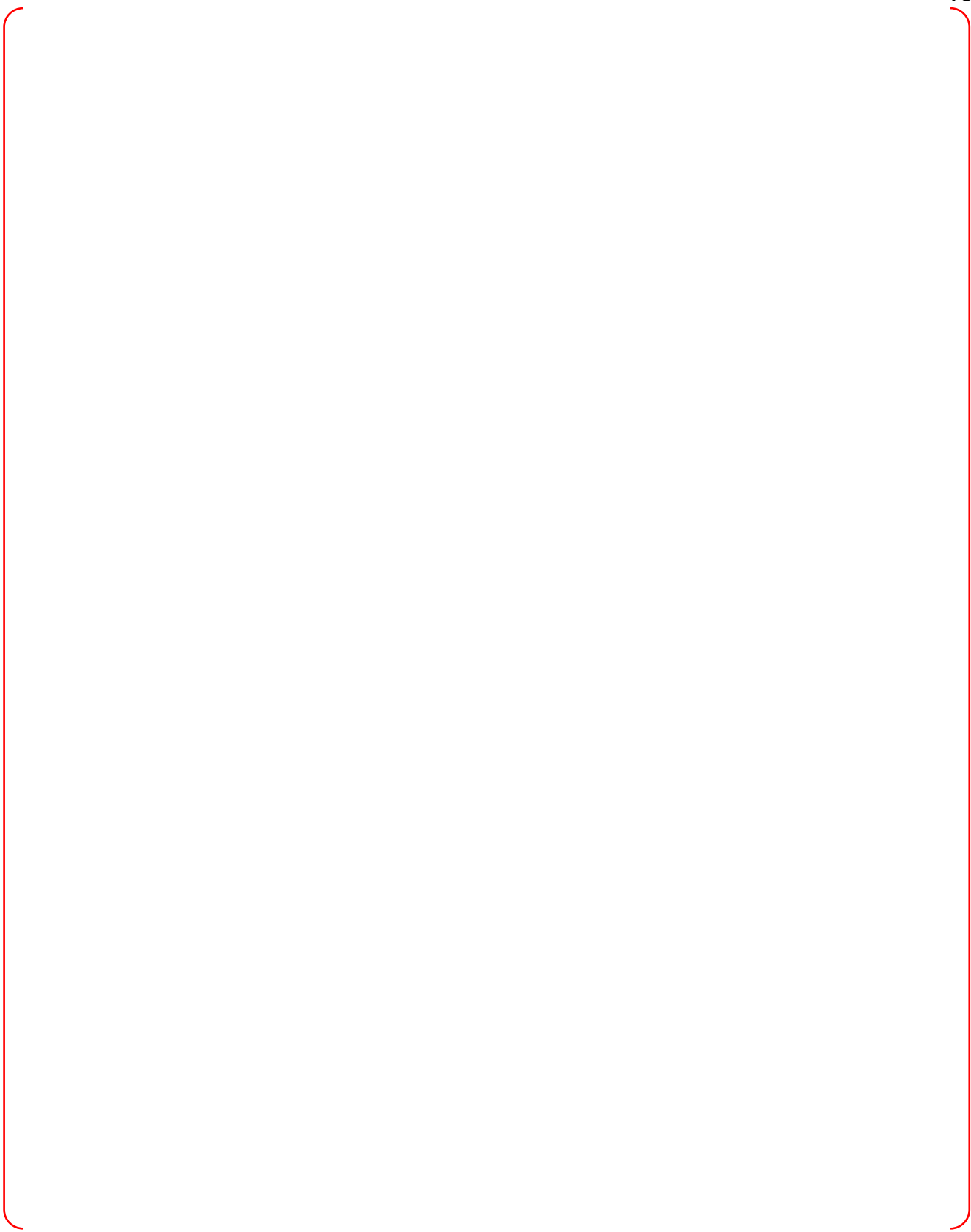












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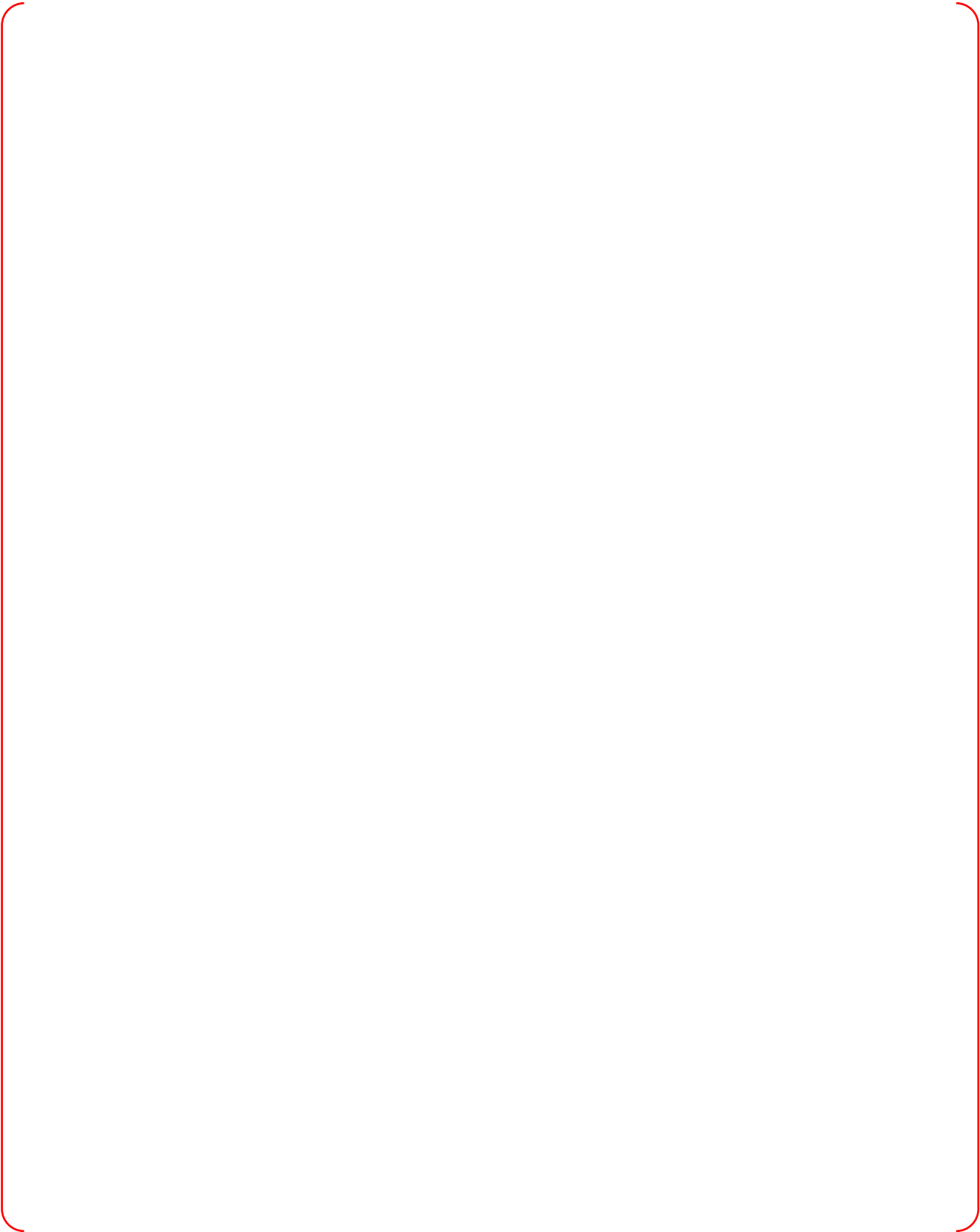
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**3.3 Debrief**

**3.3.1 Post Exercise Evaluation**

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TS



**3.3.2 Data Acquisition**



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**ISV-6 ATTACHMENT 1 - TRENDING PARAMETERS**

TS







**ISV-6 ATTACHMENT 2 - MALFUNCTION LIST**

TS



**ISV-6 ATTACHMENT 3 - SHIFT TURNOVER SHEET**

TS



**ISV-6 ATTACHMENT 4 - ANTICIPATED DIALOG**

TS

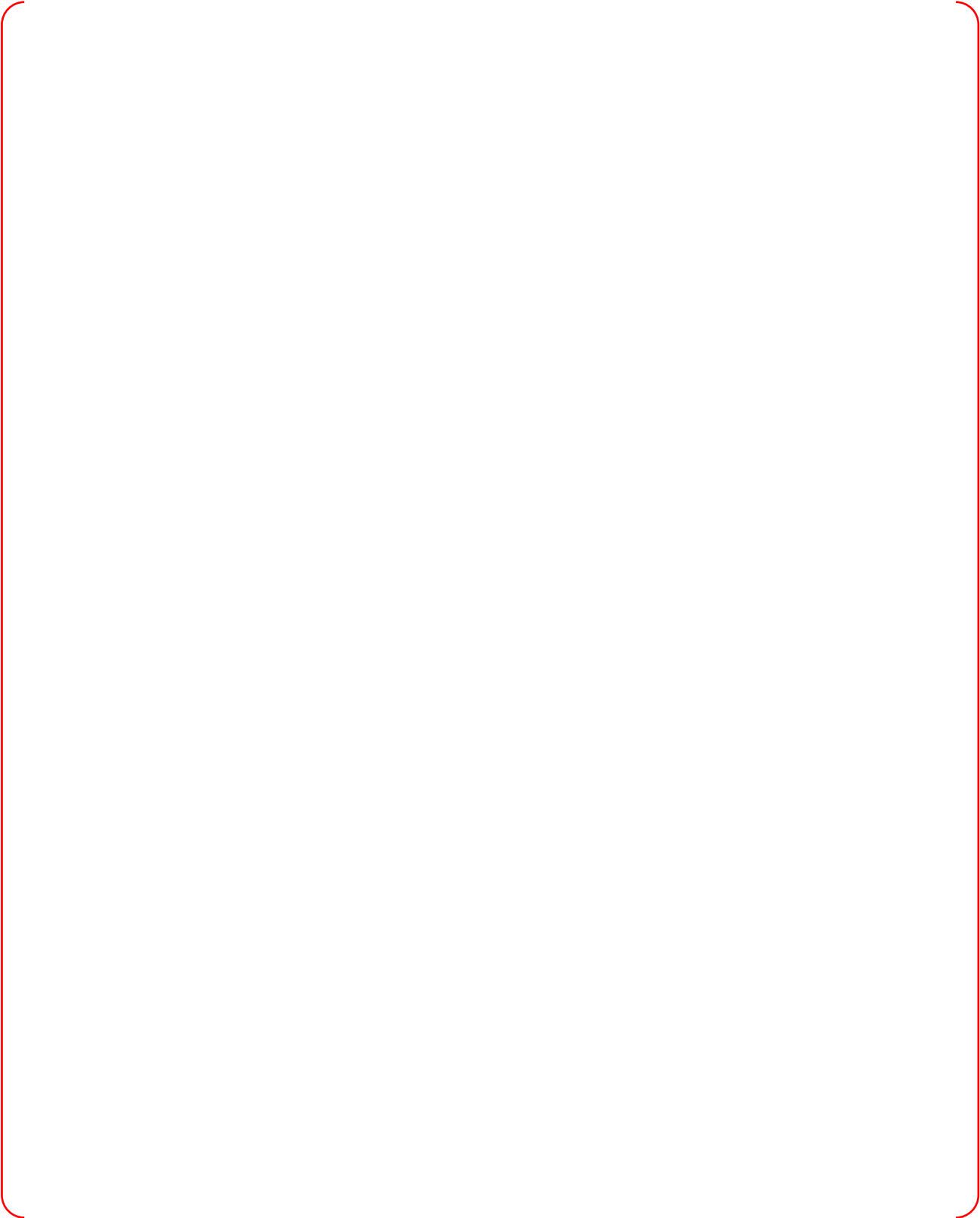


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**ISV-6 ATTACHMENT 5 – GUIDANCE WHEN DIFFICULTIES OCCUR DURING SIMULATION OR TESTING**



## **APPENDIX G**

### **Main Control Room Fire**

**ISV-7**

## **TABLE OF CONTENTS**

<b>1.</b>	<b>OVERVIEW.....</b>	<b>G3</b>
1.1	Human Factors Verification and Validation Objectives .....	G3
1.2	Scenario Overview.....	G4
1.3	Performance Measures .....	G5
1.4	Other Performance Measures .....	G9
1.5	List of Important Human Actions .....	G10
1.6	Applicable Operational Condition Sampling .....	G10
<b>2.</b>	<b>FACILITATORS INFORMATION .....</b>	<b>G11</b>
2.1	Scenario Timeline .....	G11
2.2	Procedure Flowpath .....	G12
2.3	Emergency Plan.....	G12
2.4	Technical Specifications .....	G12
2.5	Scenario Termination Criteria .....	G12
2.6	Anticipated Scenario Length .....	G12
<b>3.</b>	<b>SIMULATOR EXERCISE EVALUATION.....</b>	<b>G13</b>
3.1	Evaluation Preparation .....	G13
3.2	Evaluation.....	G14
3.2.1	Event 1 MFWP B Vibration High and associated 100% to 75% Power Operation .....	G14
3.2.2	Event 2 Charging line leak on the Regenerative Hx Outlet IRC, with containment radiation monitors failed low.....	G15
3.2.3	Event-3 Downpower from 75% to Hot Standby followed by a cooldown to Mode 4 .....	G16
3.2.4	Event-4 Steam Generator 2 FW Master controller fails low .....	G17
3.2.5	Event 5 Fire in the MCR with Required RCS Cooldown from the RSR .....	G18
<b>3.3</b>	<b>Debrief .....</b>	<b>G20</b>
3.3.1	Post Exercise Evaluation.....	G20
3.3.2	Data Acquisition.....	G20
<b>ISV-7 ATTACHMENT 1 - TRENDING PARAMETERS.....</b>		<b>G21</b>
<b>ISV-7 ATTACHMENT 2 - MALFUNCTION LIST.....</b>		<b>G24</b>
<b>ISV-7 ATTACHMENT 3 - SHIFT TURNOVER SHEET .....</b>		<b>G25</b>
<b>ISV-7 ATTACHMENT 4 - ANTICIPATED DIALOG .....</b>		<b>G26</b>
<b>ISV-7 ATTACHMENT 5 - GUIDANCE WHEN DIFFICULTIES OCCUR DURING SIMULATION OR TESTING.....</b>		<b>G27</b>

**1. OVERVIEW**

**1.1 Human Factors Verification and Validation Objectives**

TS



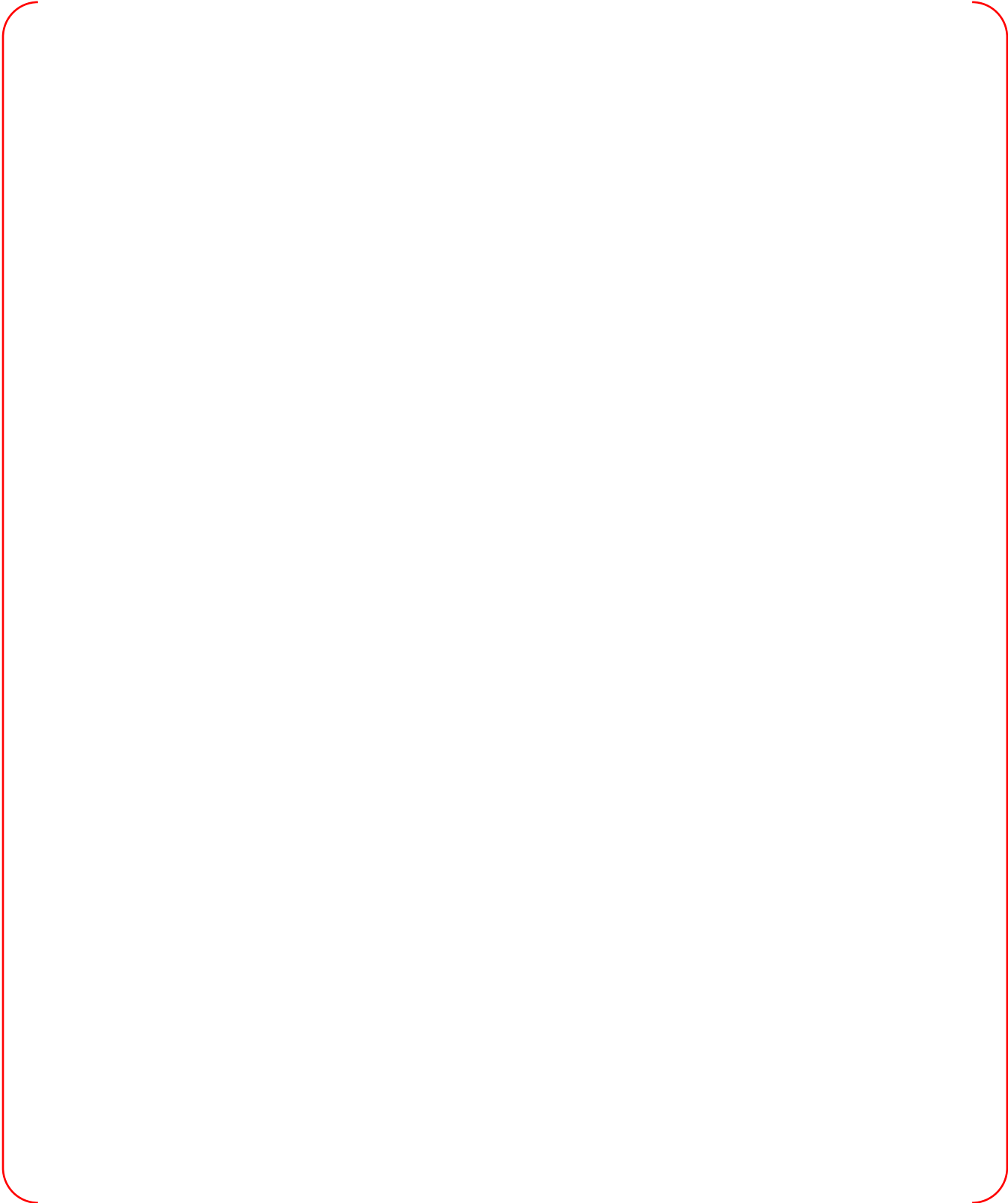
1.2 Scenario Overview

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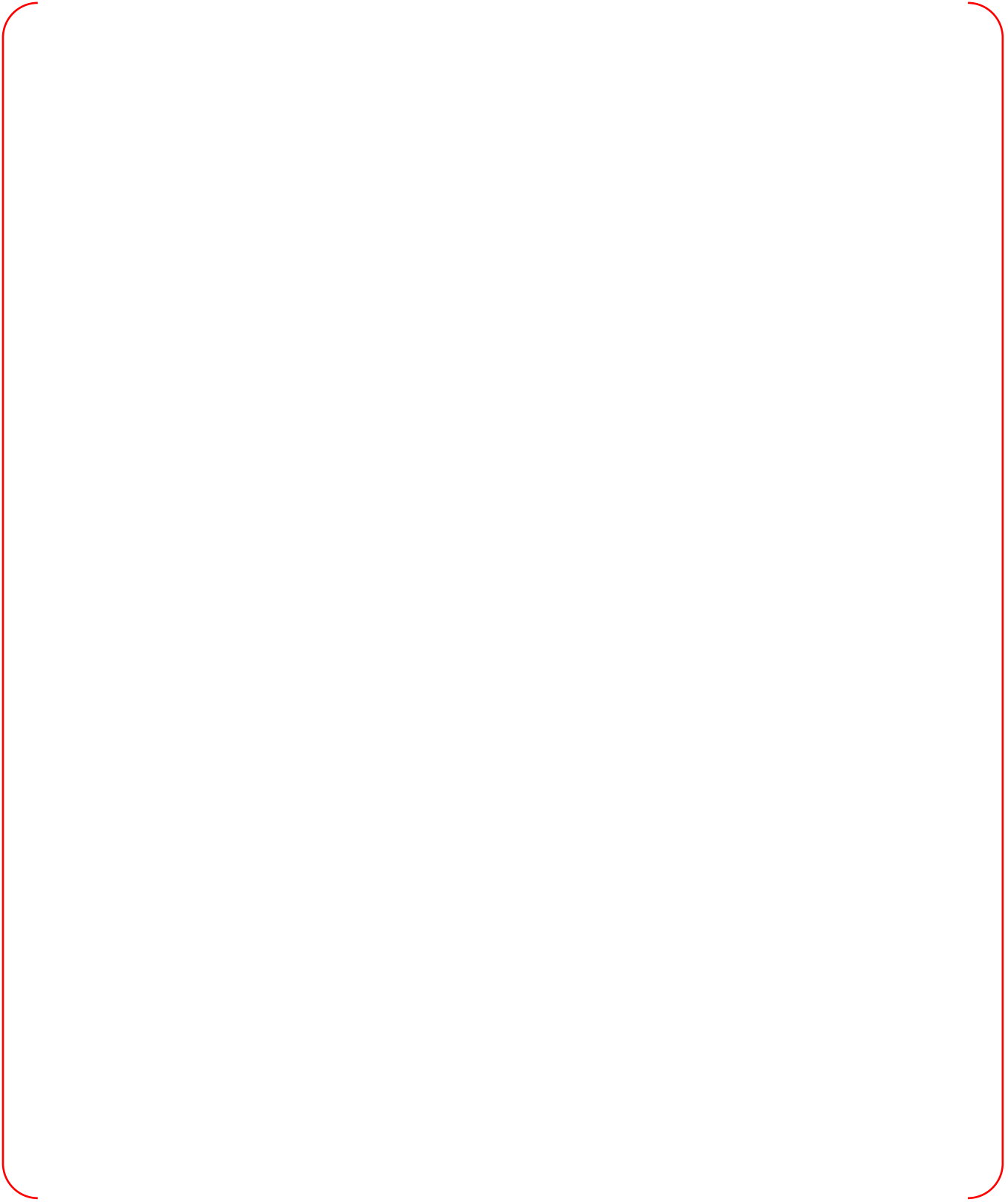


**1.3 Performance Measures**

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**1.4 Other Performance Measures**

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**1.5 List of Important Human Actions**

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**1.6 Applicable Operational Condition Sampling**

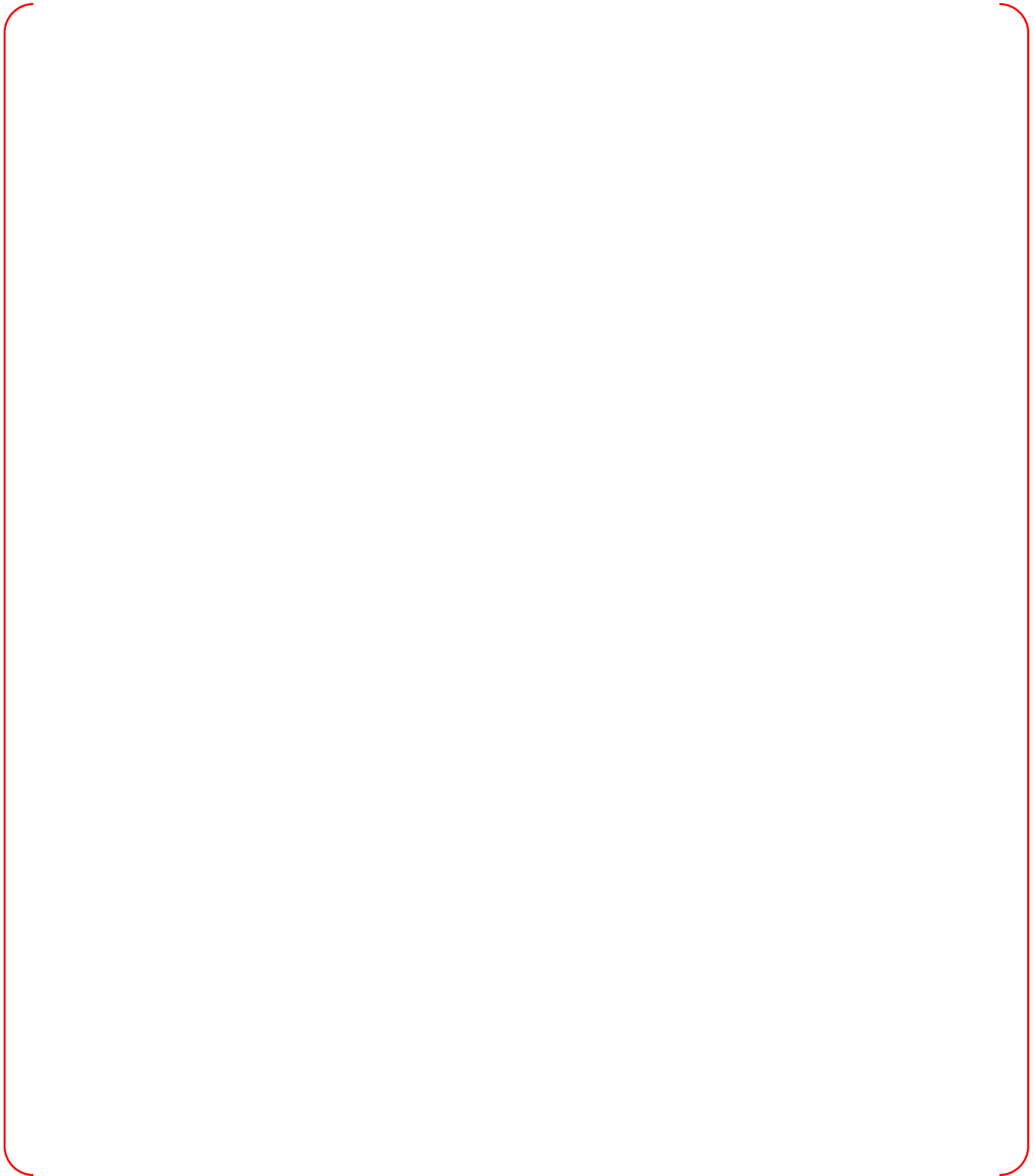
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**2. FACILITATORS INFORMATION**

**2.1 Scenario Timeline**

TS



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**2.2 Procedure Flowpath**

TS



**2.3 Emergency Plan**

TS



**2.4 Technical Specifications**

TS



**2.5 Scenario Termination Criteria**

TS



**2.6 Anticipated Scenario Length**

TS



**3. SIMULATOR EXERCISE EVALUATION**

**3.1 Evaluation Preparation**

TS



**3.2 Evaluation**

**3.2.1 Event 1 MFWP B Vibration High and associated 100% to 75% Power Operation**

TS

TS

**3.2.2 Event 2 Charging line leak on the Regenerative Hx Outlet IRC, with containment radiation monitors failed low**

TS



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**3.2.3 Event-3 Downpower from 75% to Hot Standby followed by a cooldown to Mode 4**

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**3.2.4 Event-4 Steam Generator 2 FW Master controller fails low**

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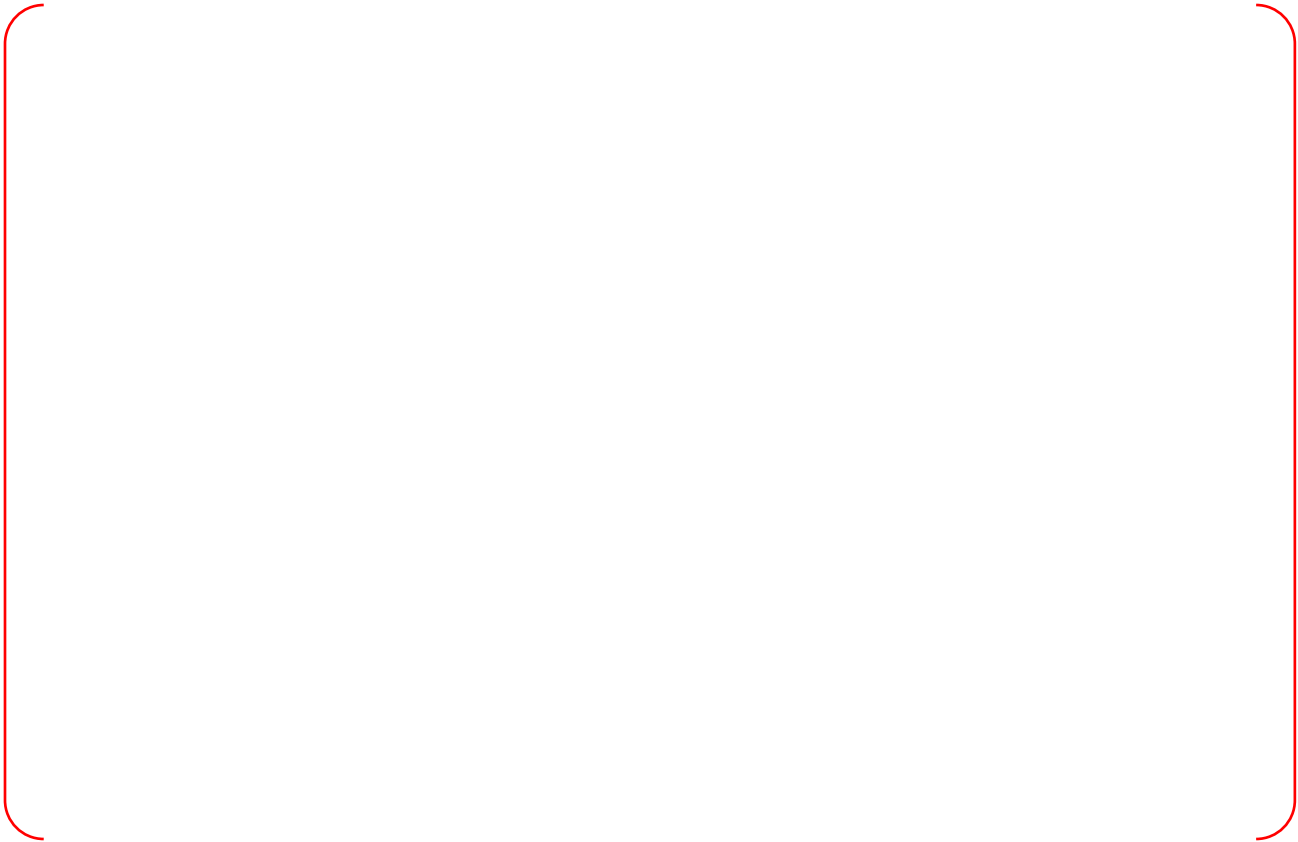
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**3.2.5 Event 5 Fire in the MCR with Required RCS Cooldown from the RSR**

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**3.3 Debrief**

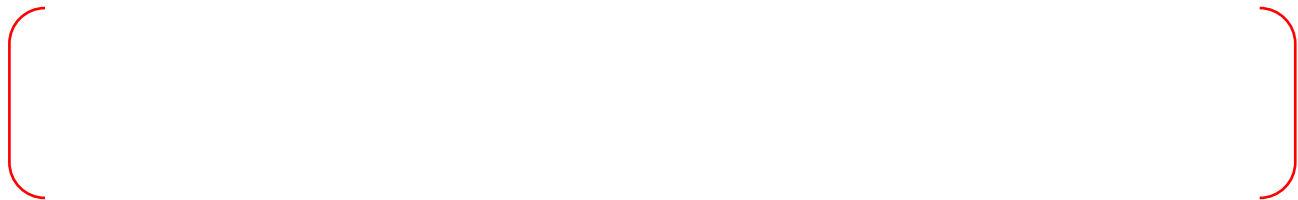
3.3.1 Post Exercise Evaluation

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3.3.2 Data Acquisition

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**ISV-7 ATTACHMENT 1 - TRENDING PARAMETERS**

TS



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**ISV-7 ATTACHMENT 2 - MALFUNCTION LIST**

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**ISV-7 ATTACHMENT 3 - SHIFT TURNOVER SHEET**

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**ISV-7 ATTACHMENT 4 - ANTICIPATED DIALOG**

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**ISV-7 ATTACHMENT 5 - GUIDANCE WHEN DIFFICULTIES OCCUR DURING SIMULATION OR TESTING**

