

Human Factors Verification and Validation Scenarios

Revision 2

Non-Proprietary

January 2018

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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)
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		A4 (Appendix A 1.1)	Description for briefing before scenario added. R_352-8205(76)
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		A8-A9 (Appendix A 1.3.2)	Reference to Attachment 5 added. R_352-8205(76)

Revision	Date	Page	Description
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		A53 (Appendix A Attachment 5)	Attachment 5 Guidance when difficulties occur during simulation or testing added. R_352-8205(76)
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Revision	Date	Page	Description
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		C3 (Appendix C 1.1)	Description for briefing before scenario added. R_352-8205(76)
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		E3 (Appendix E 1.1)	Description for briefing before scenario added. R_352-8205(76)
		E4 (Appendix E 1.2)	Description for briefing before scenario added. R_352-8205(76)
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Revision	Date	Page	Description
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		F47 (Appendix F Attachment 5)	Attachment 5 Guidance when difficulties occur during simulation or testing modified. R_352-8205(76R)
		G3 (Appendix G 1.1)	Description for briefing before scenario added. R_352-8205(76)
		G4 (Appendix G 1.2)	Description for briefing before scenario added. R_352-8205(76)
		G7-G8 (Appendix G 1.3)	Description for briefing before scenario added. R_352-8205(76)
		G11-G12 (Appendix G.2.1)	Editorial correction and description for freezing simulator deleted. R_352-8205(72)
		G20 (Appendix G.3.3.1)	Editorial correction and NASA-TLX added to post exercise evaluation. R_352-8205(72)

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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

1.	PURPOSE.....	1
2.	SCOPE	2
2.1.	Applicable Documents	2
3.	SAMPLING OF OPERATIONAL CONDITIONS FOR THE INTEGRATED SYSTEM VERIFICATION.....	3
3.1.	Plant Conditions.....	3
3.2.	Types of Personnel Tasks.....	5
3.3.	Situational Factors or Error-Forcing Contexts	7
4.	SUMMARY OF THE APR1400 PROBABILISTIC RISK ASSESSMENT	8
4.1.	Total Core Damage Frequency of Initial Events	8
4.2.	Analysis of Significances	8
5.	APR1400 HUMAN FACTORS VERIFICATION AND VALIDATION SCENARIOS	9
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

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. 2, KHNP, January 2018.
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.

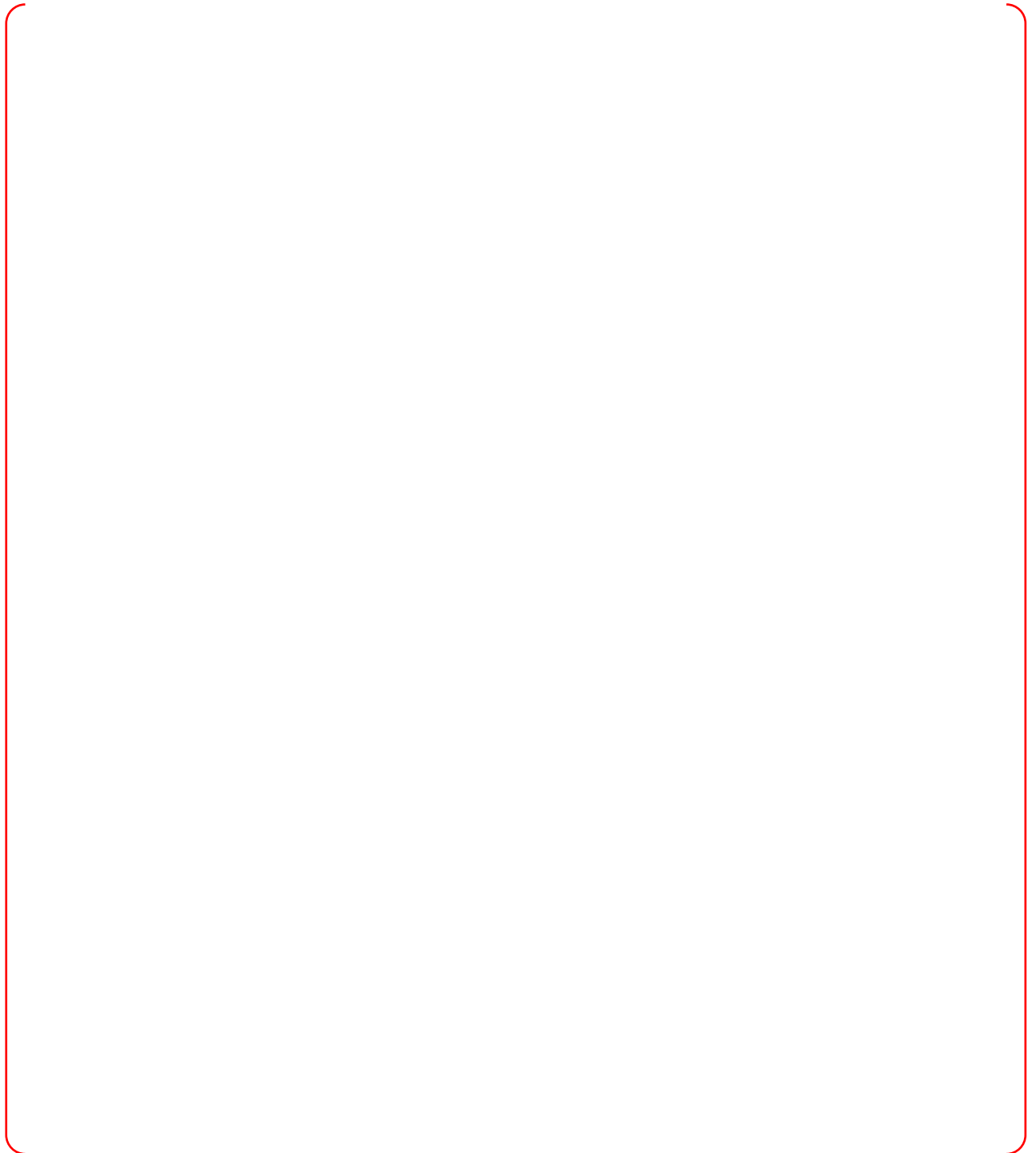
3. SAMPLING of OPERATIONAL CONDITIONS for THE INTEGRATED SYSTEM VERIFICATION

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3.1. Plant Conditions

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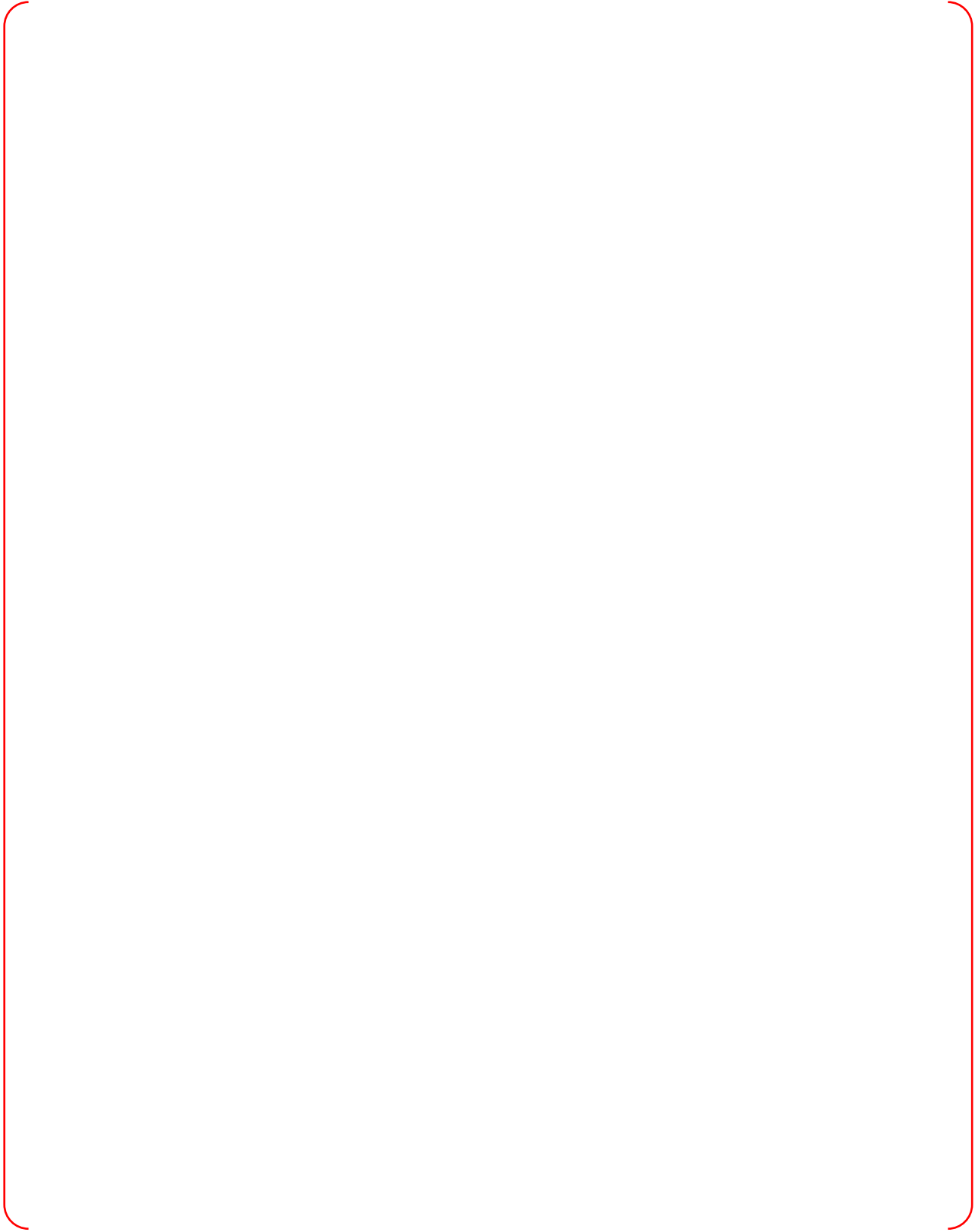


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3.2. Types of Personnel Tasks

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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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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

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5.4. Loss of All Feedwater

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5.5. Station Blackout

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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

1.	OVERVIEW.....	A3
1.1.	Human Factors Verification and Validation Objectives	A3
1.2.	Scenario Overview	A4
1.3.	Performance Measures	A5
1.3.1.	Important Human Actions (IHA).....	A5
1.3.2.	Primary Tasks	A5
1.4.	Other Performance Measures	A9
1.5.	List of Important Human Actions	A10
1.6.	Applicable Operational Condition Sampling.....	A10
2.	FACILITATORS INFORMATION	A12
2.1.	Scenario Timeline	A12
2.2.	Procedure Flow path	A14
2.3.	Emergency Plan.....	A14
2.4.	Technical Specifications	A14
2.5.	Scenario Termination Criteria.....	A14
2.6.	Anticipated Scenario Length.....	A14
3.	SIMULATOR EXERCISE EVALUATION	A15
3.1.	Evaluation Preparation	A15
3.2.	Evaluation	A16
3.2.1.	Event-1 Run ESW Pump 02A.....	A16
3.2.2.	Event-2 SG1 Downcomer Radiation Monitor Malfunction	A17
3.2.3.	Event-3 SBLOCA + SIAS Automatic Actuation Failure	A18
3.2.4.	Event 4 Computer Based Procedure System (CBP) Failure	A33
3.2.5.	Event-5 Loss of all Operator Console Displays and LDP with resulting RCS Cooldown at the Safety Console.....	A41
3.3.	Debrief	A45
3.3.1.	Post Exercise Evaluation.....	A45
3.3.2.	Data Acquisition	A45
	ISV-1 ATTACHMENT 1 - TRENDING PARAMETERS.....	A46
	ISV-1 ATTACHMENT 2 - SBLOCA MALFUNCTIONS.....	A49
	ISV-1 ATTACHMENT 3 - SHIFT TURNOVER SHEET.....	A50
	ISV-1 ATTACHMENT 4 - ANTICIPATED DIALOG.....	A51
	ISV-1 ATTACHMENT 5 - GUIDANCE WHEN DIFFICULTIES OCCUR DURING SIMULATION OR TESTING.....	A52

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

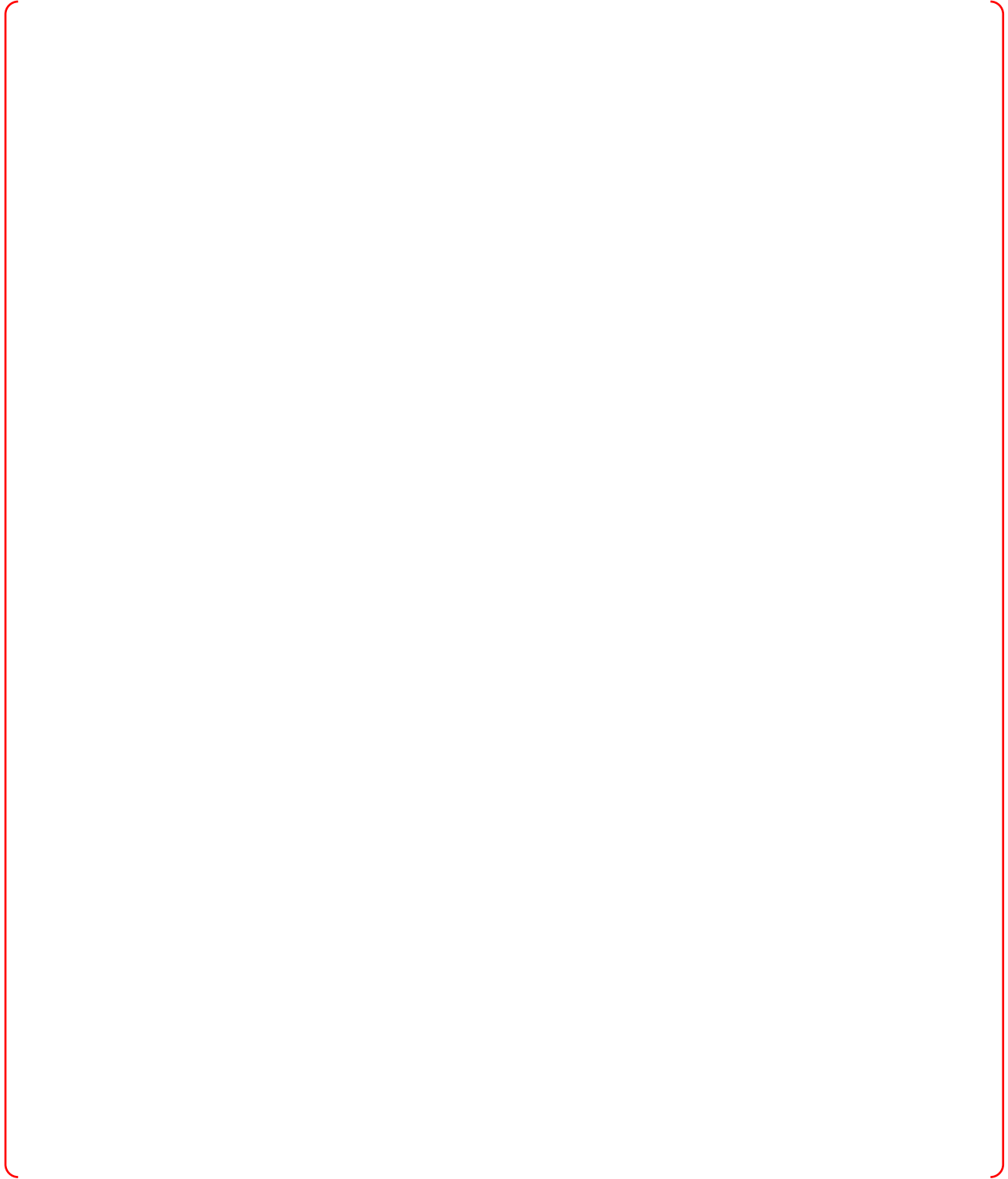
1.3.1. Important Human Actions (IHA)

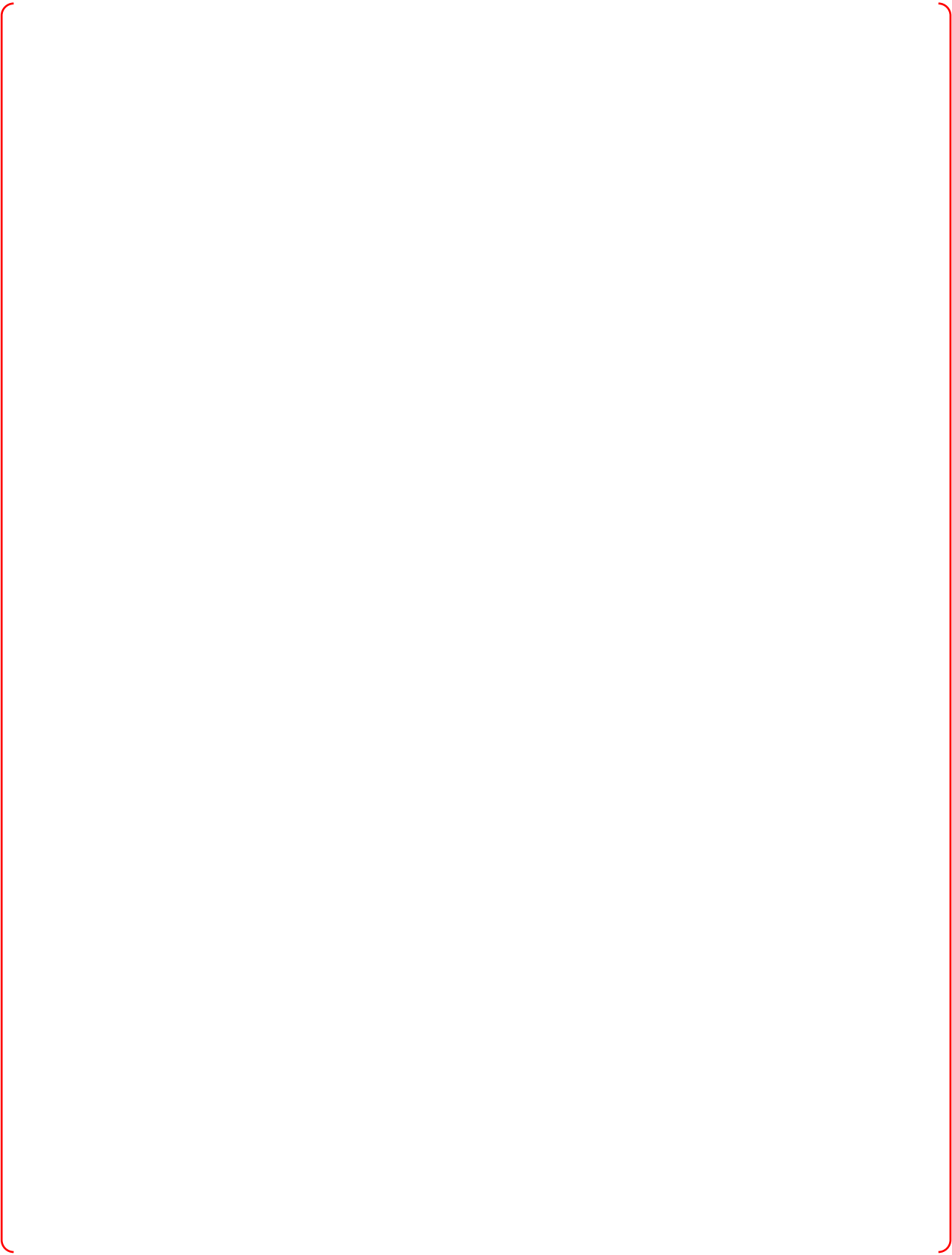
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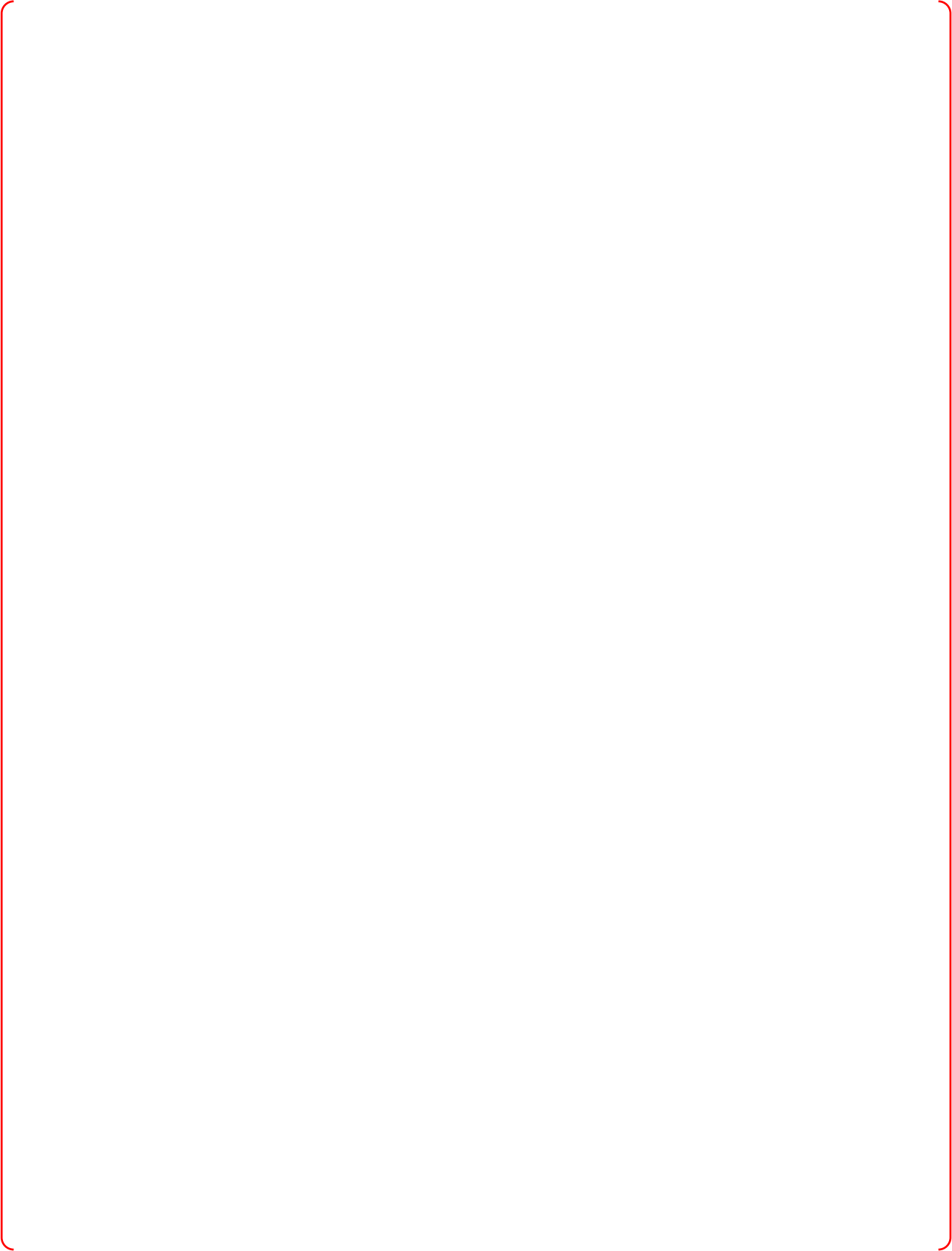
1.3.2. Primary Tasks

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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

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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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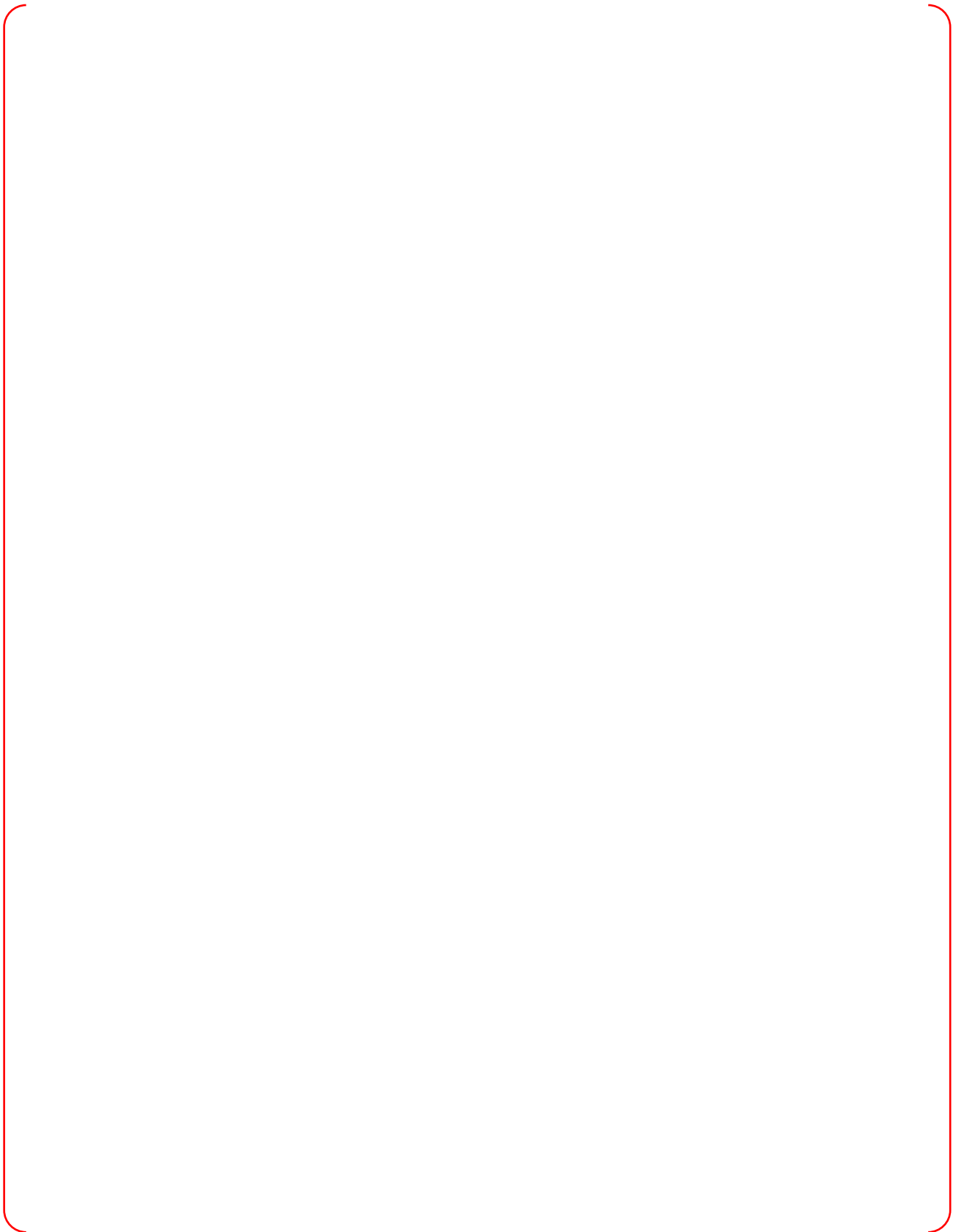
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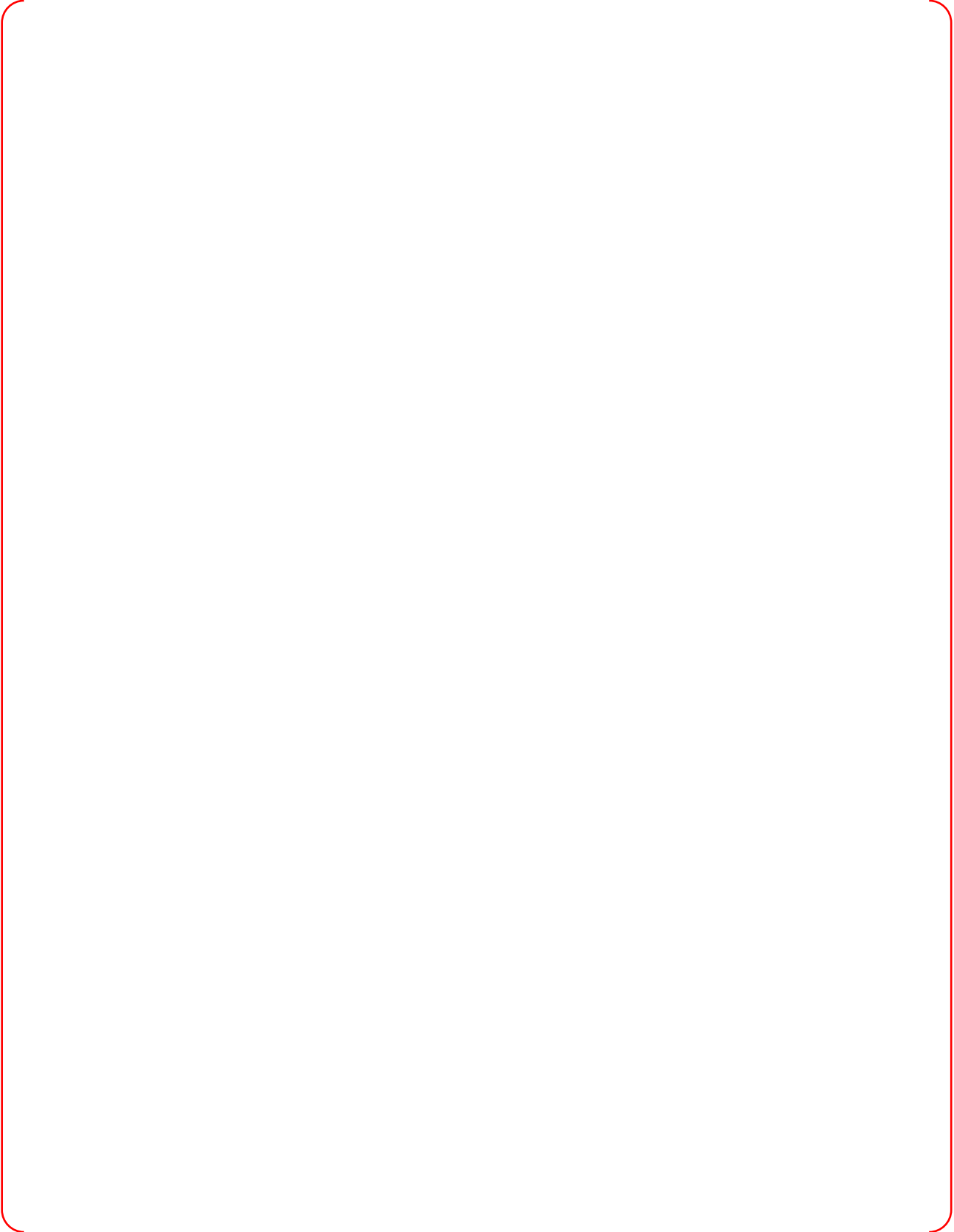
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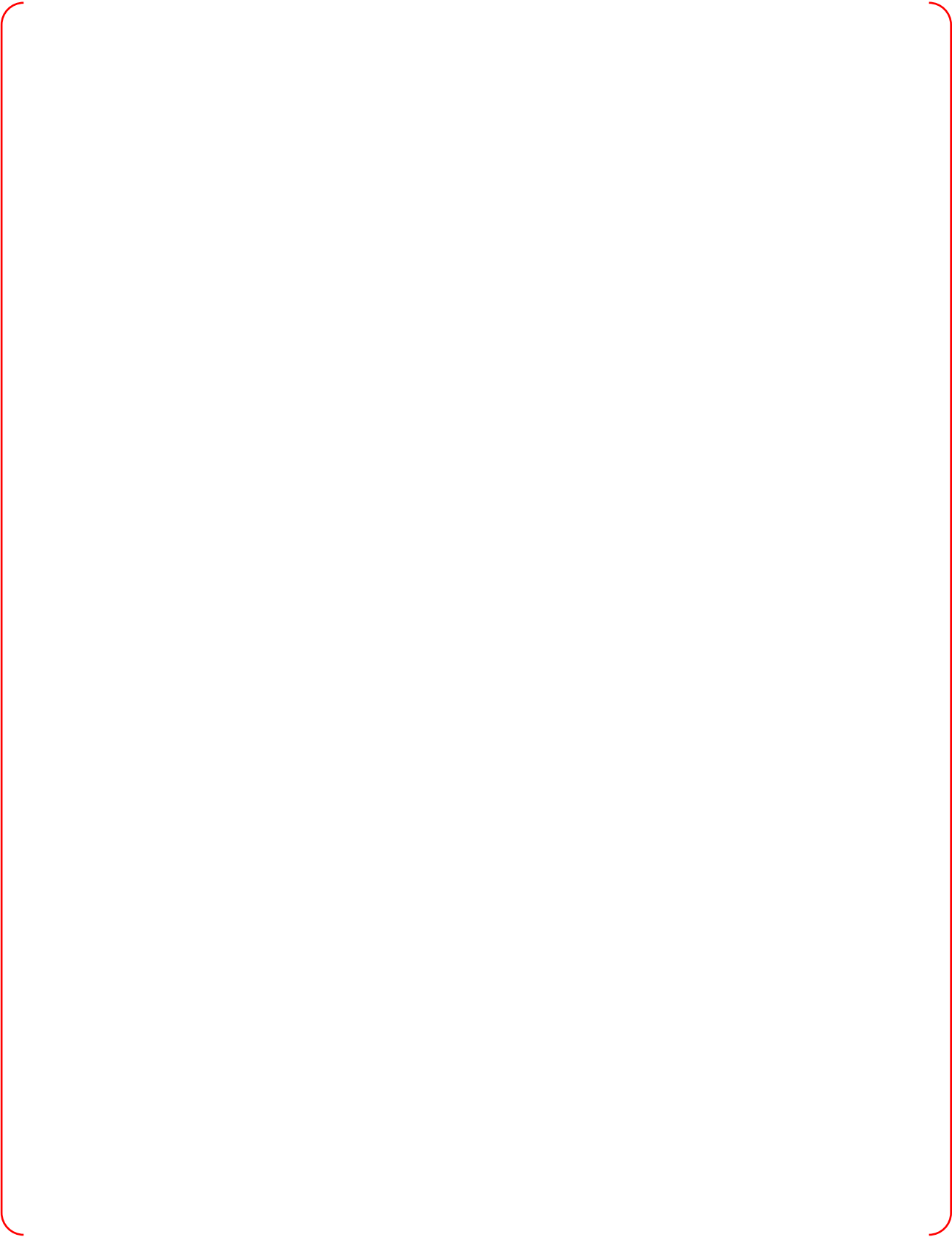
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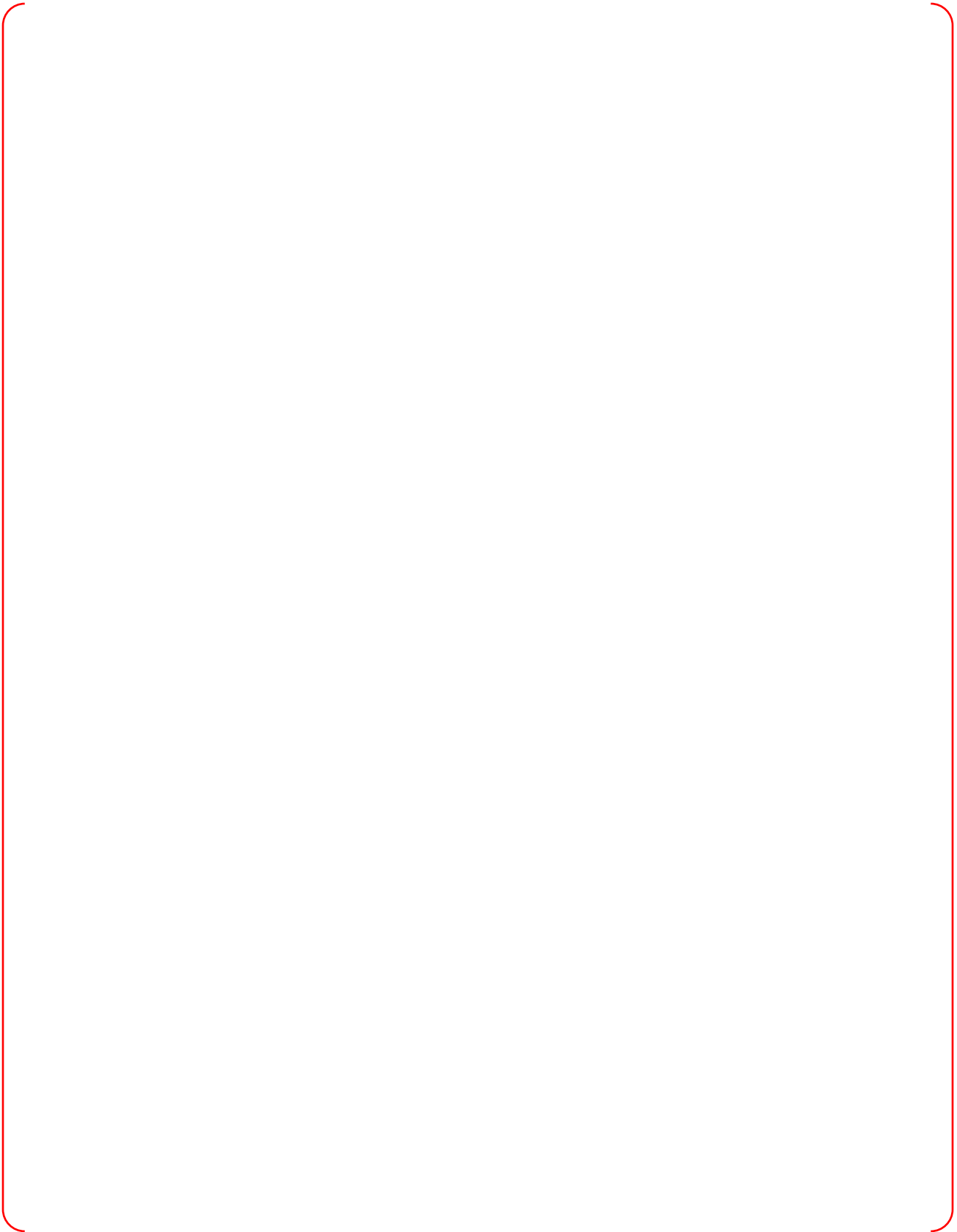


3.2.4. Event 4 Computer Based Procedure System (CBP) Failure

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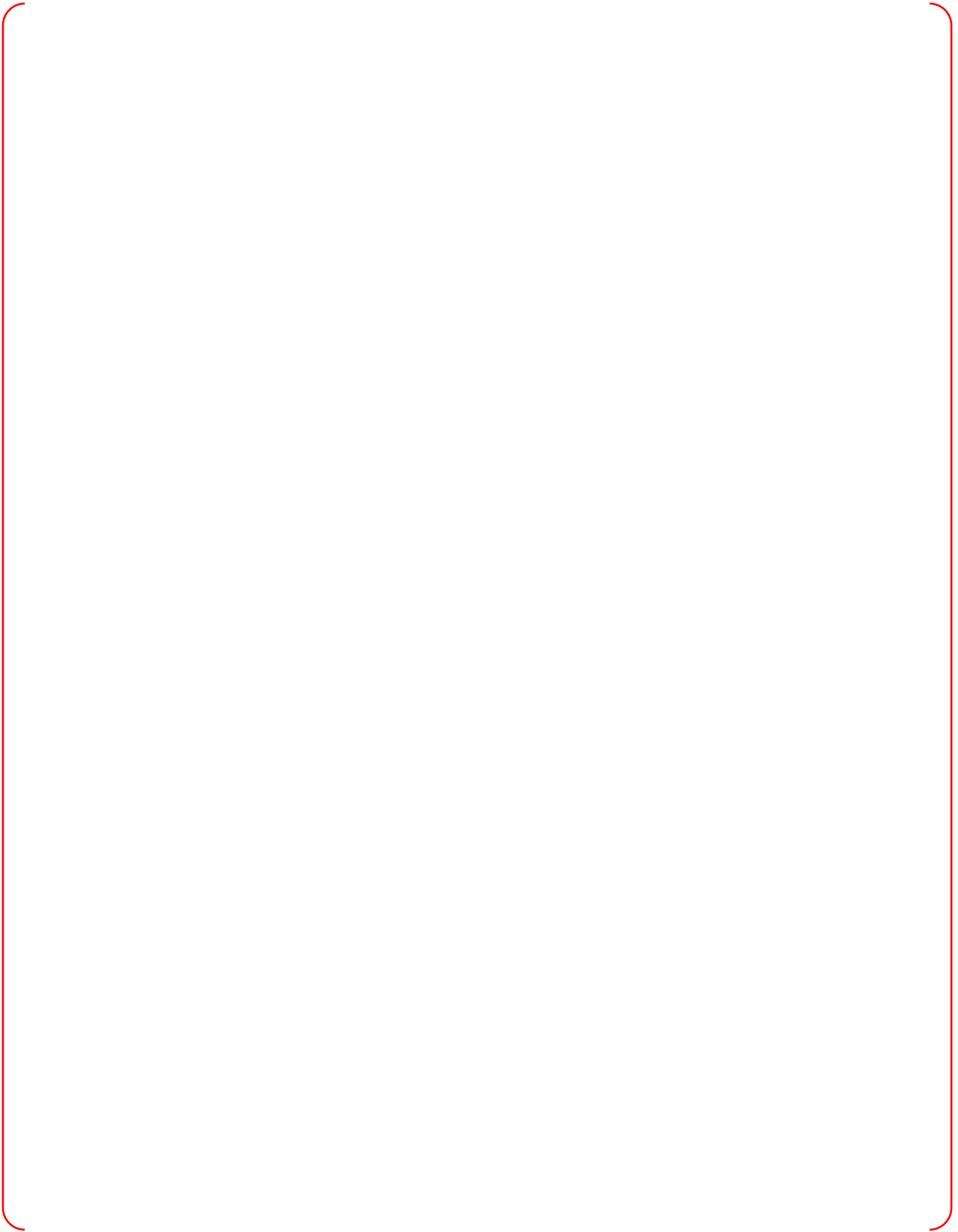
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3.2.5. Event-5 Loss of all Operator Console Displays and LDP with resulting RCS Cooldown at the Safety Console

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3.3. Debrief

3.3.1. Post Exercise Evaluation

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3.3.2. Data Acquisition

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ISV-1 Attachment 1 - Trending Parameters

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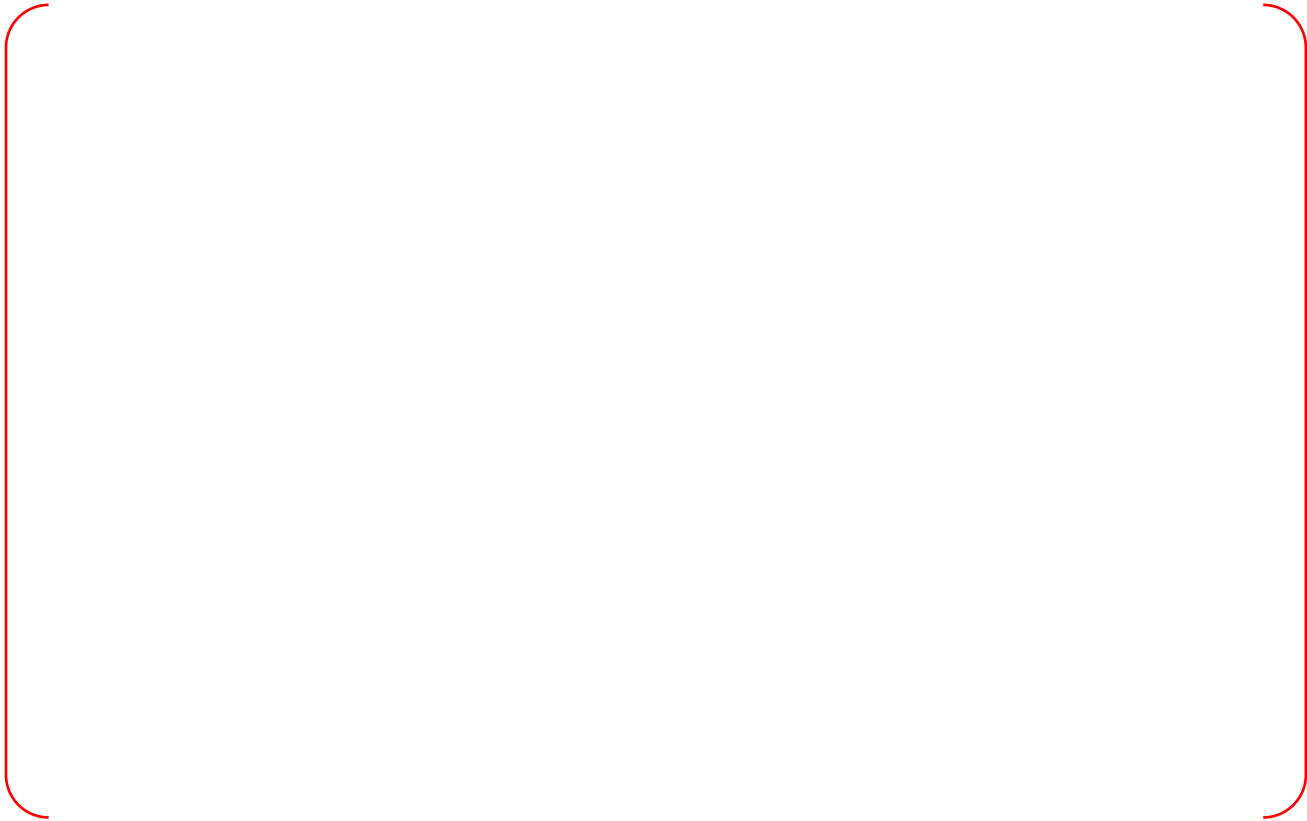
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ISV-1 Attachment 2 - SBLOCA Malfunctions

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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

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APPENDIX B

Anticipated Transient without Trip with Distributed Control System Failures

ISV-2

TABLE OF CONTENTS

1.	OVERVIEW.....	B3
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
2.	FACILITATORS INFORMATION	B11
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
3.	SIMULATOR EXERCISE EVALUATION	B13
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
	ISV-2 ATTACHMENT 1 - TRENDING PARAMETERS	B26
	ISV-2 ATTACHMENT 2 - MALFUNCTION LIST.....	B29
	ISV-2 ATTACHMENT 3 - SHIFT TURNOVER SHEET	B30
	ISV-2 ATTACHMENT 4 - ANTICIPATED DIALOG	B31
	ISV-2 ATTACHMENT 5 - GUIDANCE WHEN DIFFICULTIES OCCUR DURING SIMULATION OR TESTING.....	B33

1. OVERVIEW

1.1. Human Factors Verification and Validation Objectives

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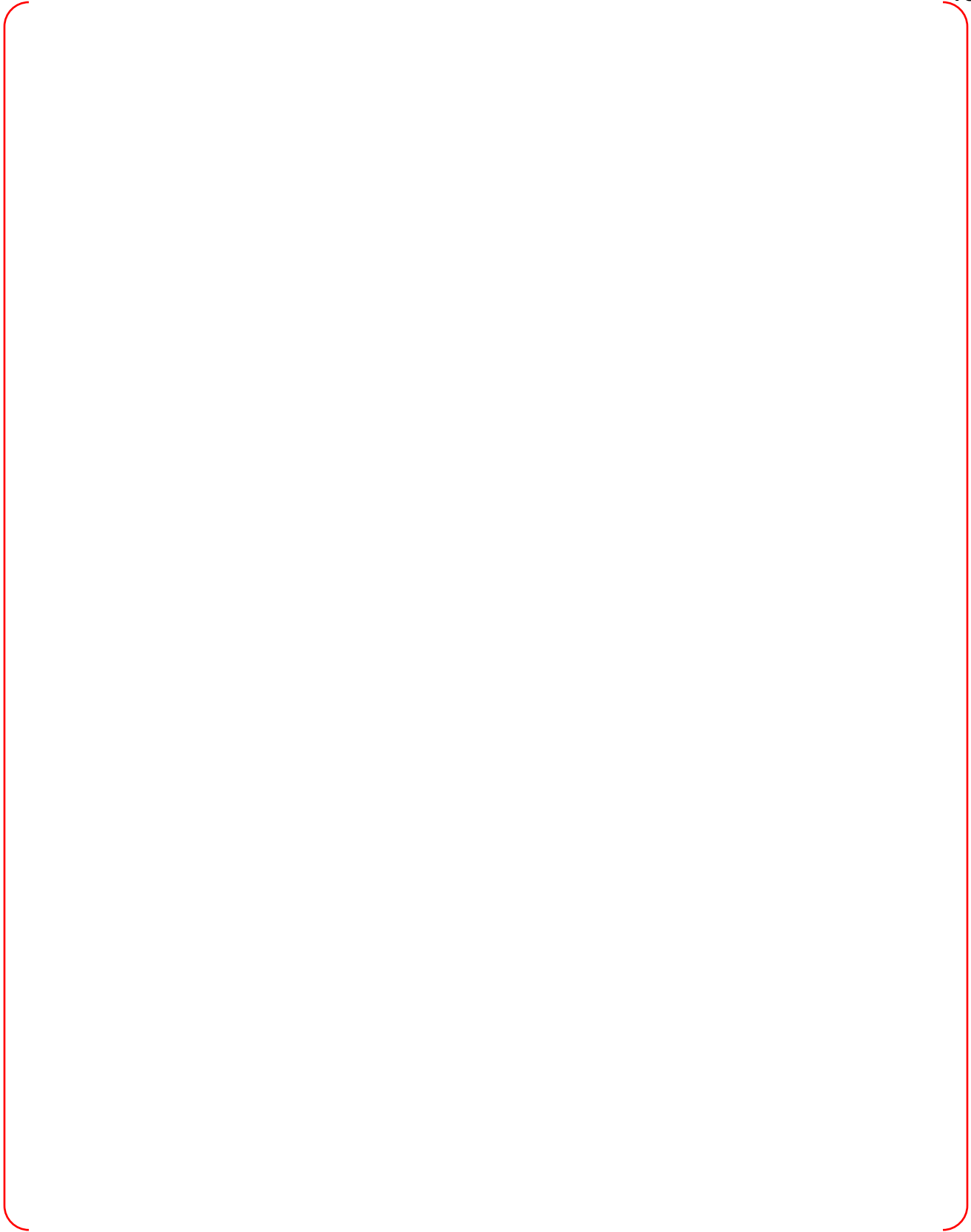
1.2. Scenario Overview

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1.3. Performance Measures

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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 Flowpath

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2.3. Emergency Plan

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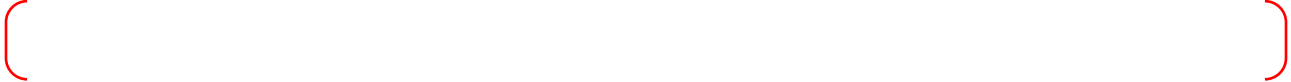
2.4. Technical Specifications

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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 Enter Mode 2 and achieve criticality

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

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

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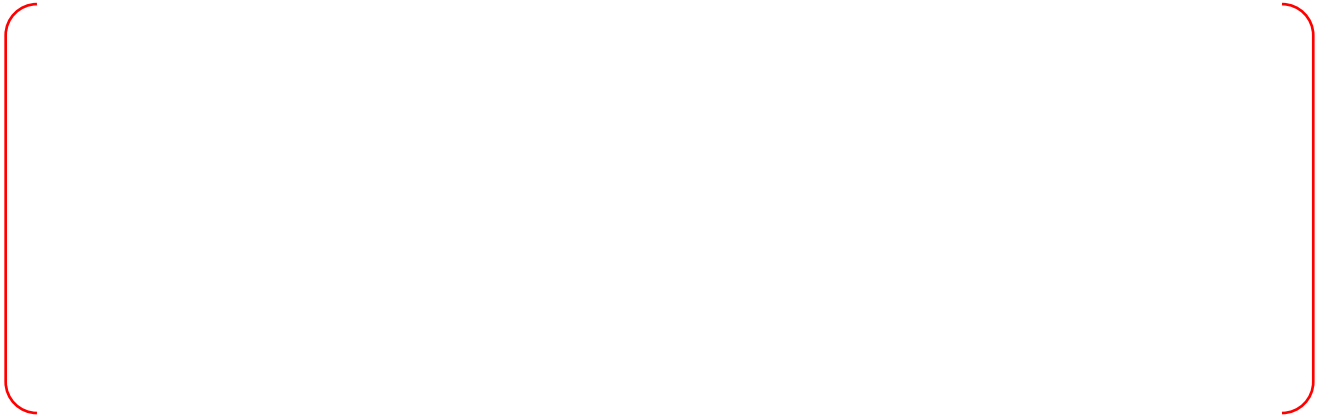


3.2.4. EVENT-4 Pressurizer Spray Valve Fails Open With ATWT

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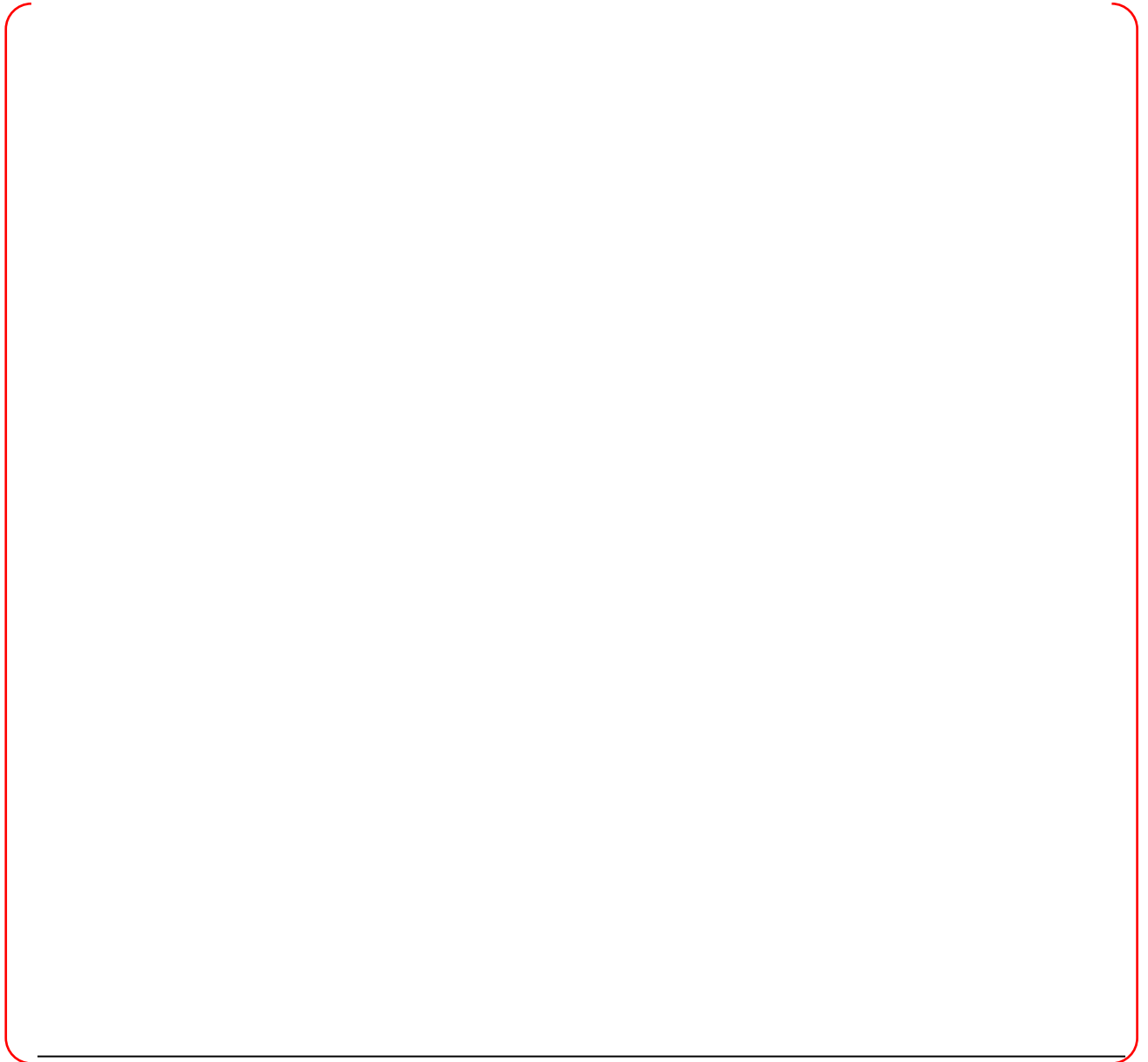


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3.2.5. EVENT-5 ATWT

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

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3.3. Debrief

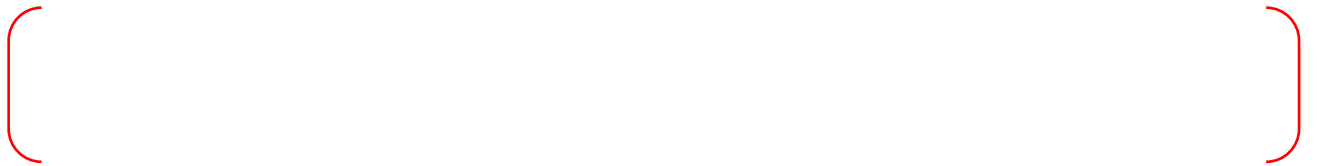
3.3.1 Post Exercise Evaluation

TS



3.3.2 Data Acquisition

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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

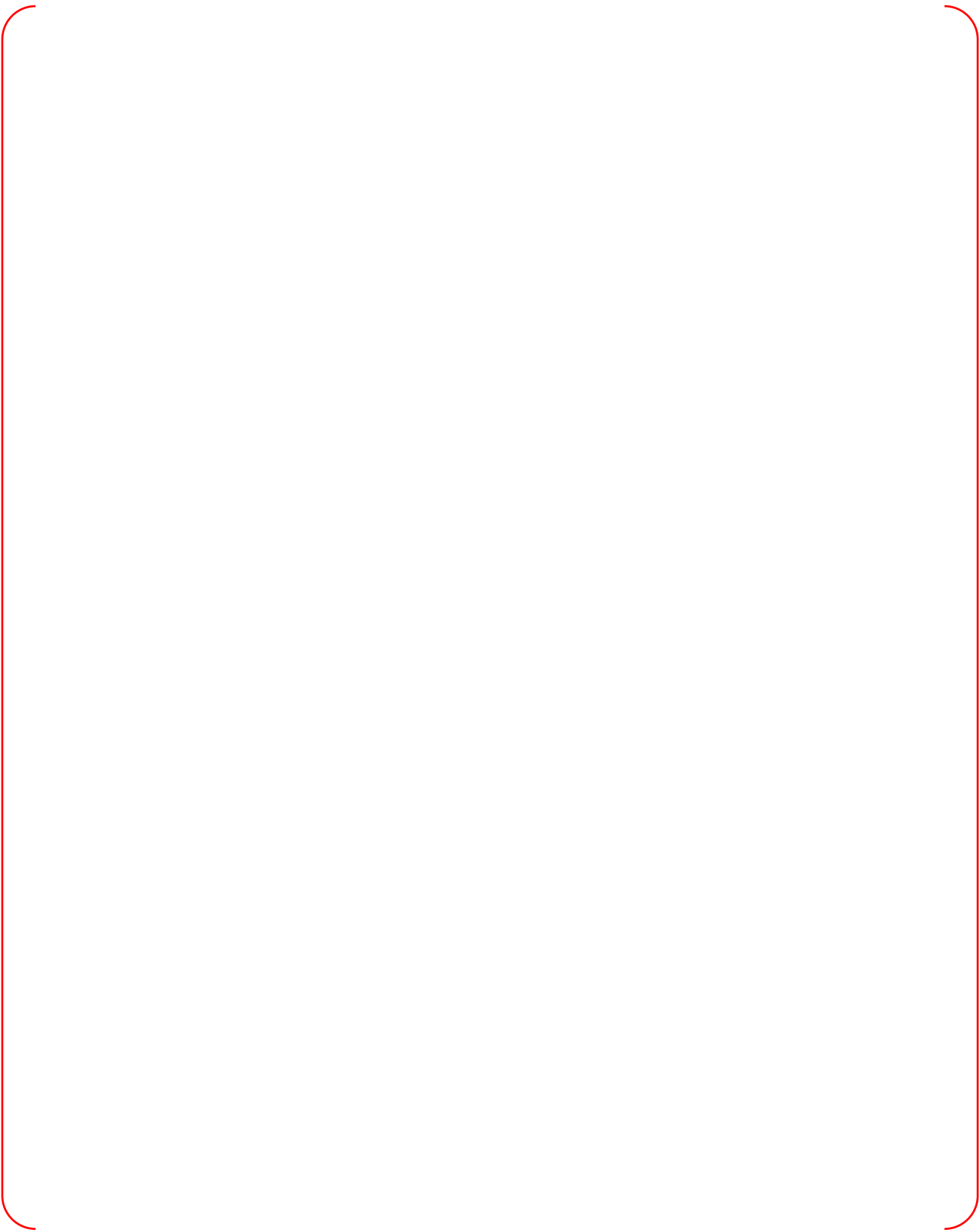


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ISV-2 ATTACHMENT 5 – GUIDANCE WHEN DIFFICULTIES OCCUR DURING SIMULATION OR TESTING

TS



APPENDIX C

Excessive Steam Demand Event with Alarm Server Failures

ISV-3

TABLE OF CONTENTS

1.	OVERVIEW.....	C3
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
2.	FACILITATORS INFORMATION	C12
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
3.	SIMULATOR EXERCISE EVALUATION.....	C14
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
	ISV-3 ATTACHMENT 1 - TRENDING PARAMETERS.....	C31
	ISV-3 ATTACHMENT 2 - MALFUNCTION LIST.....	C34
	ISV-3 ATTACHMENT 3 - SHIFT TURNOVER SHEET	C35
	C35
	ISV-3 ATTACHMENT 4 - ANTICIPATED DIALOG	C36
	ISV-3 ATTACHMENT 5 - GUIDANCE WHEN DIFFICULTIES OCCUR DURING SIMULATION OR TESTING	C38

1. OVERVIEW

1.1 Human Factors Verification and Validation Objectives

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1.2 Scenario Overview

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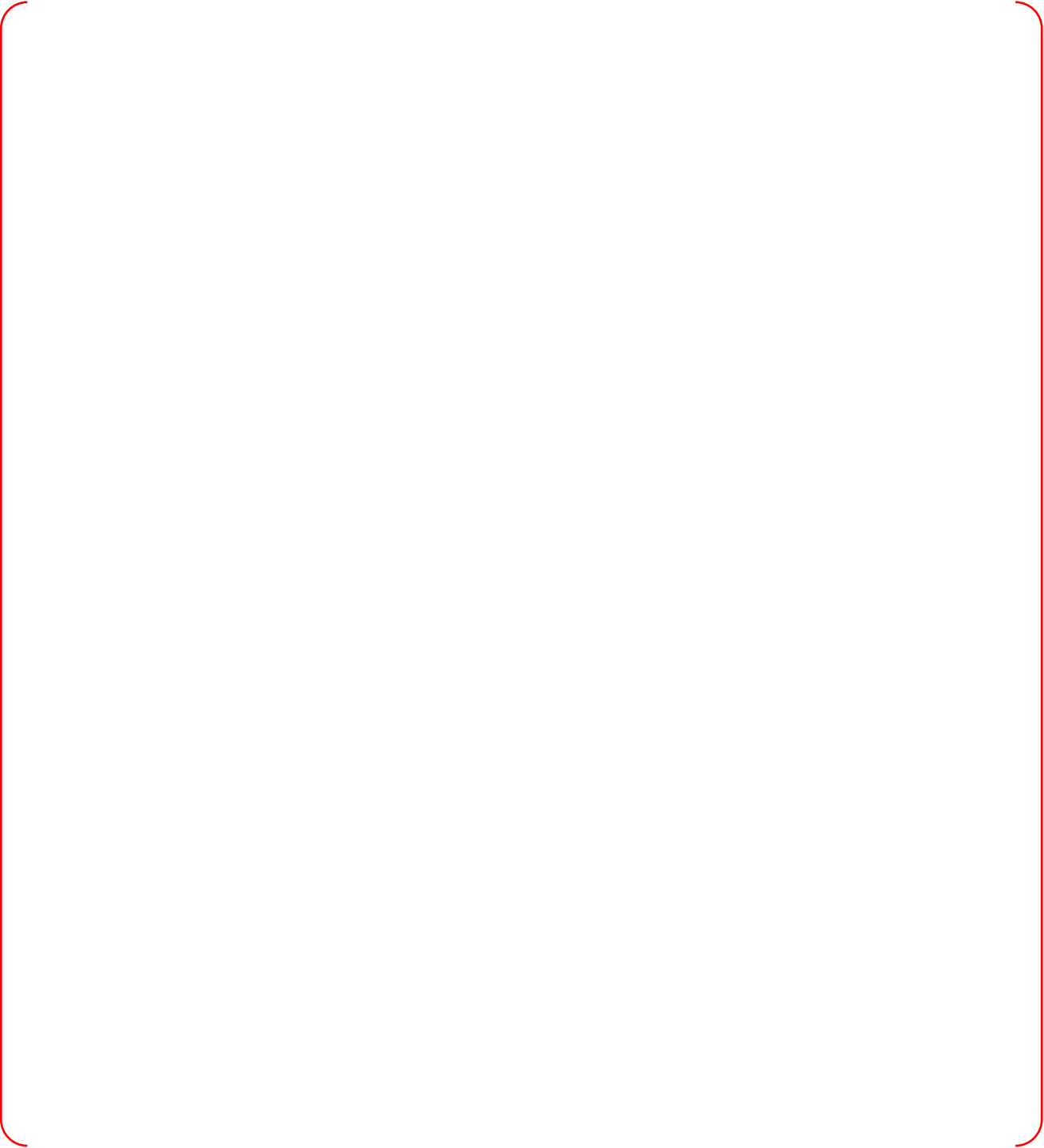
1.3 Performance Measures

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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



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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

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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

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

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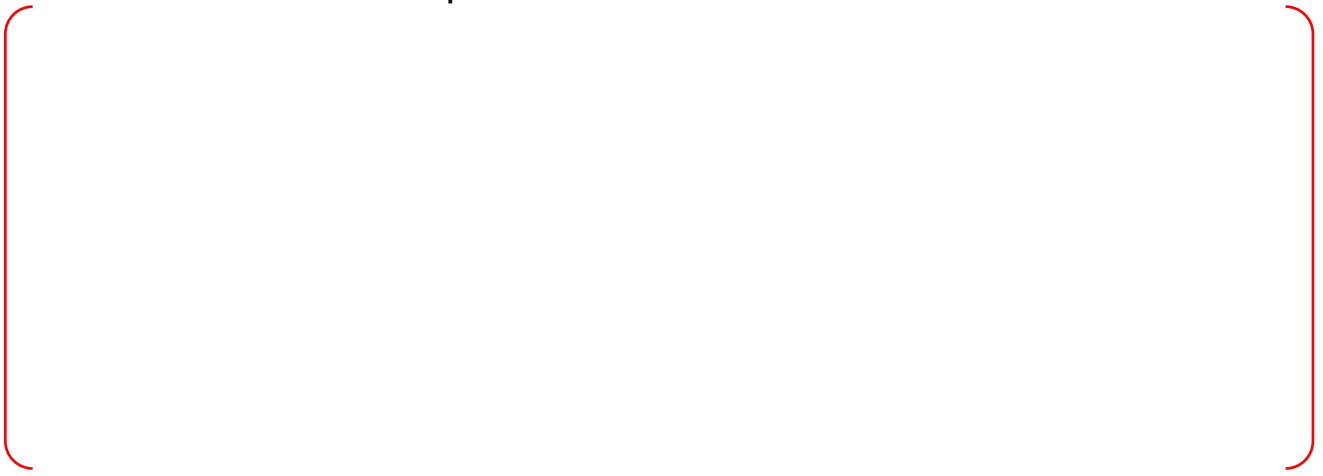


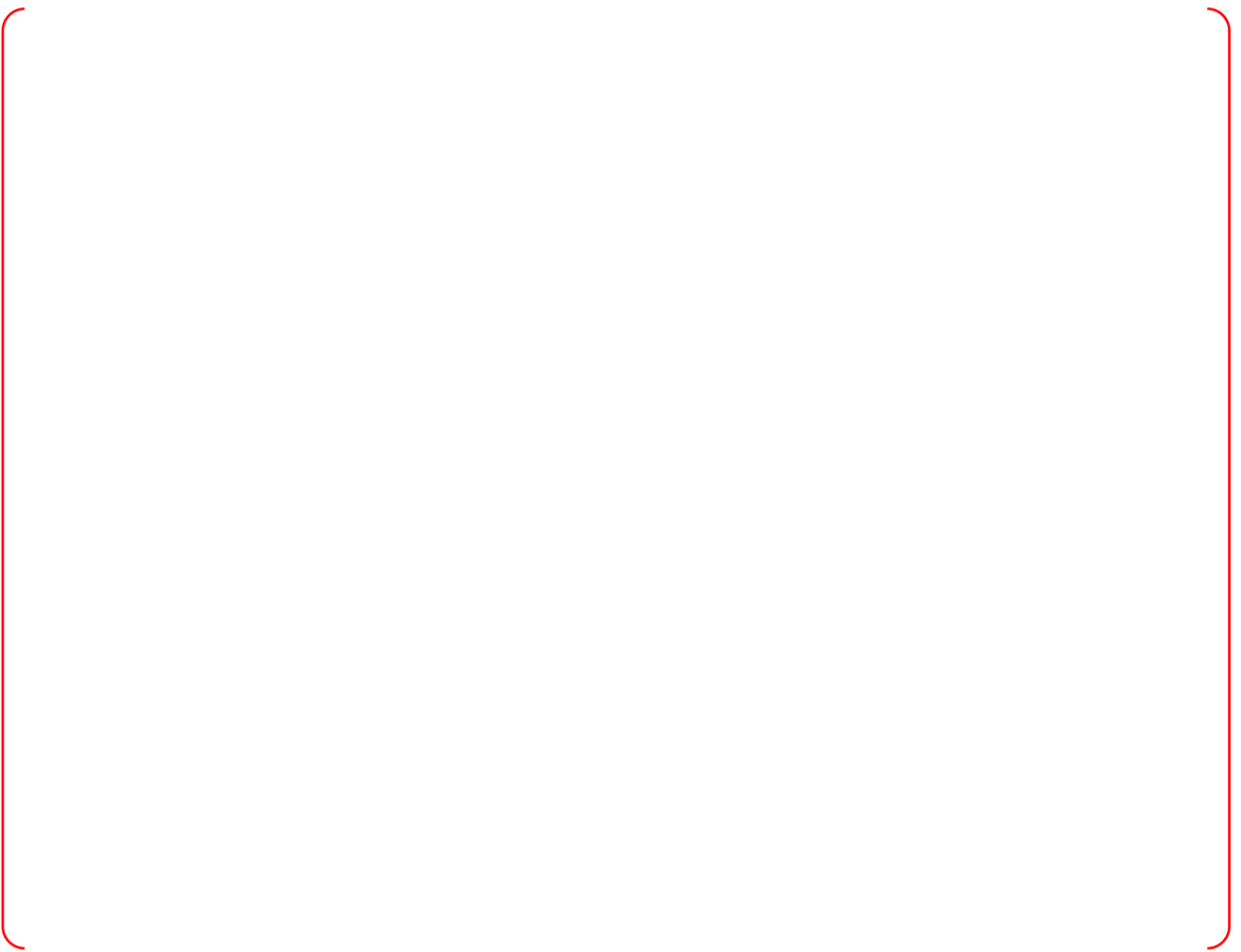
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3.2.4 Event-4 Two MFWPs Trip with Automatic Initiation Failure of RPCS

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3.2.5 Event-5 Alarm Server A and B Failures



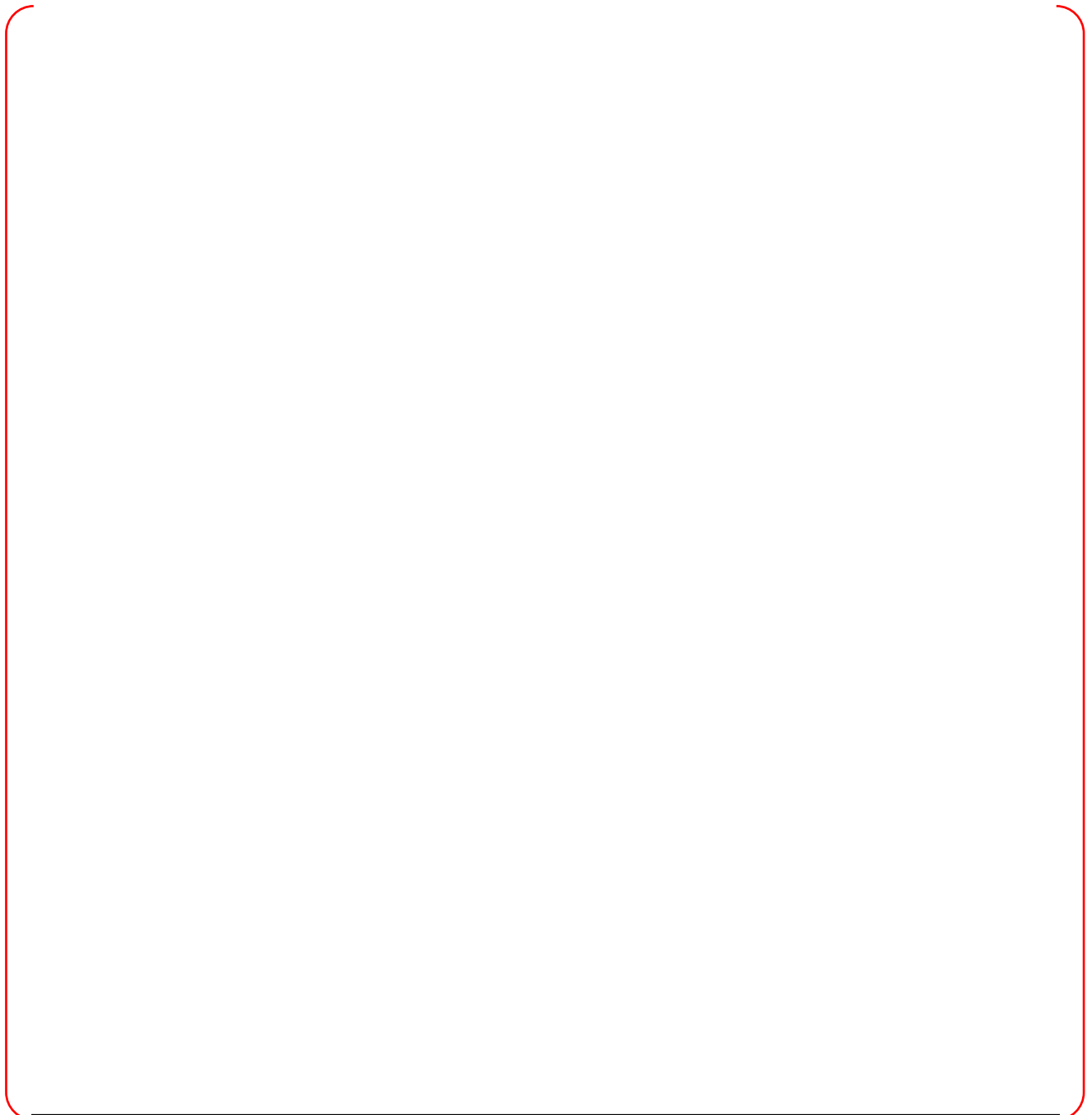


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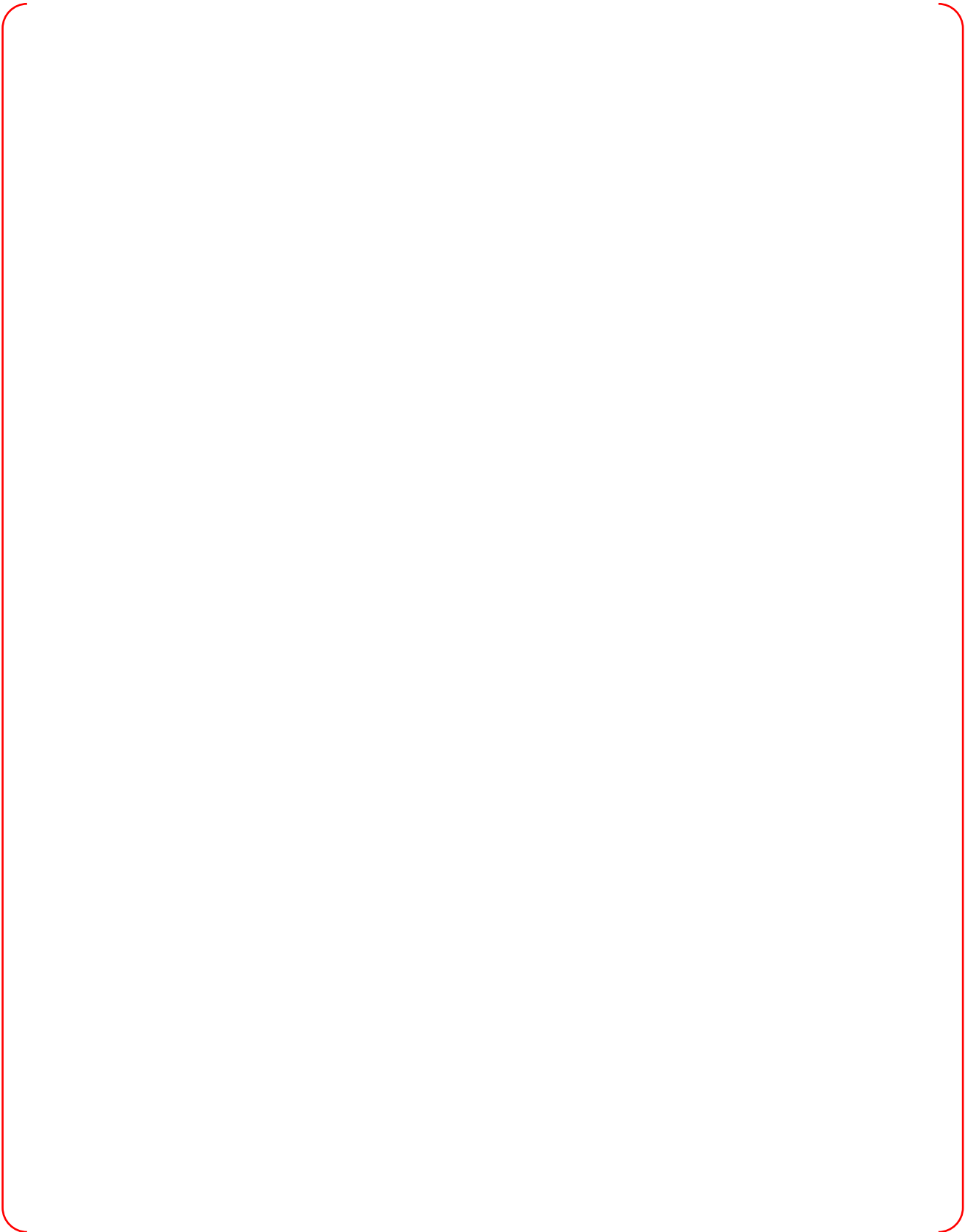


3.2.6 Event-6 Main Steam Line 2B Break IRC

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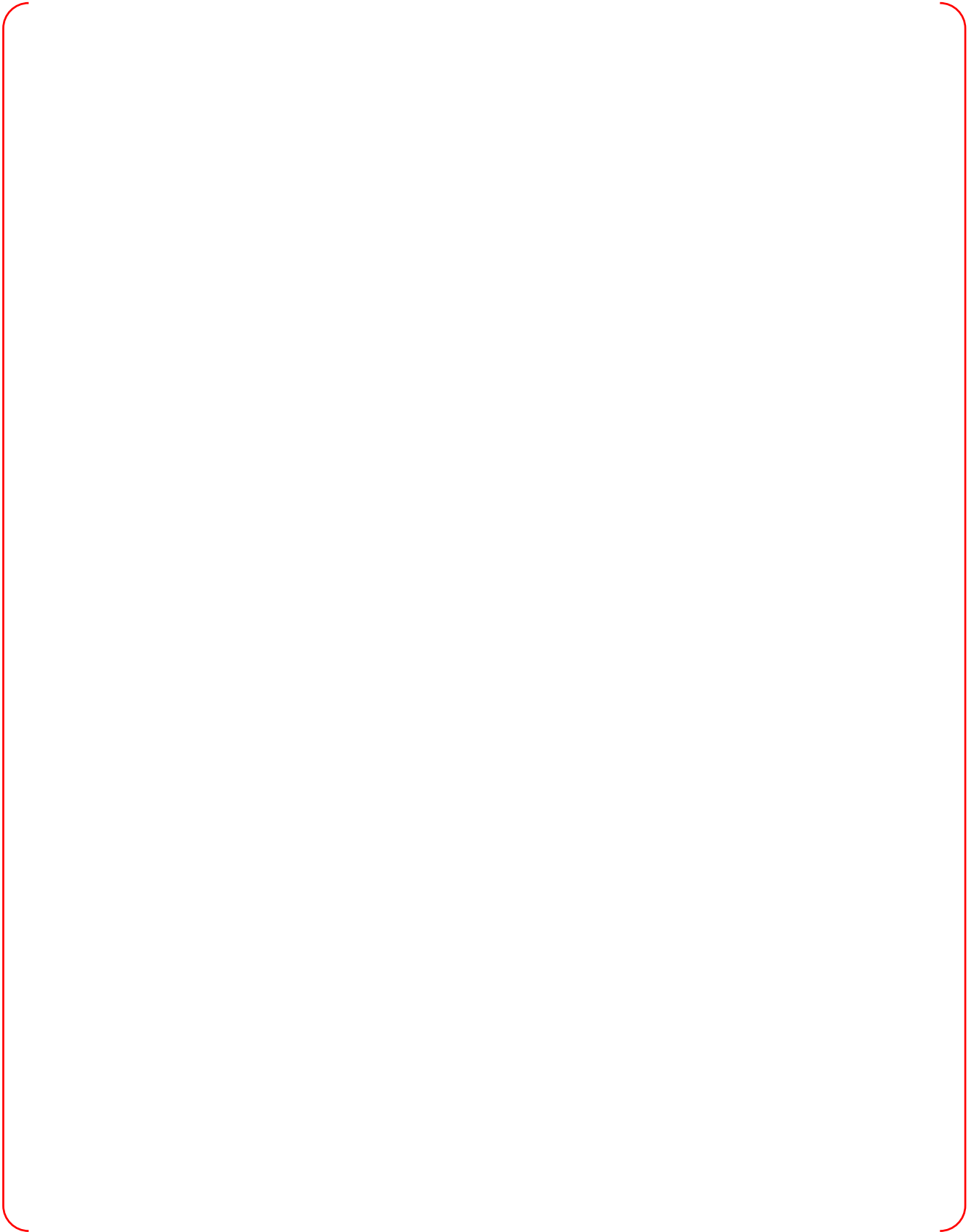


















3.3 Debrief

3.3.1 Post Exercise Evaluation



3.3.2 Data Acquisition

TS



ISV-3 ATTACHMENT 1 - TRENDING PARAMETERS

TS







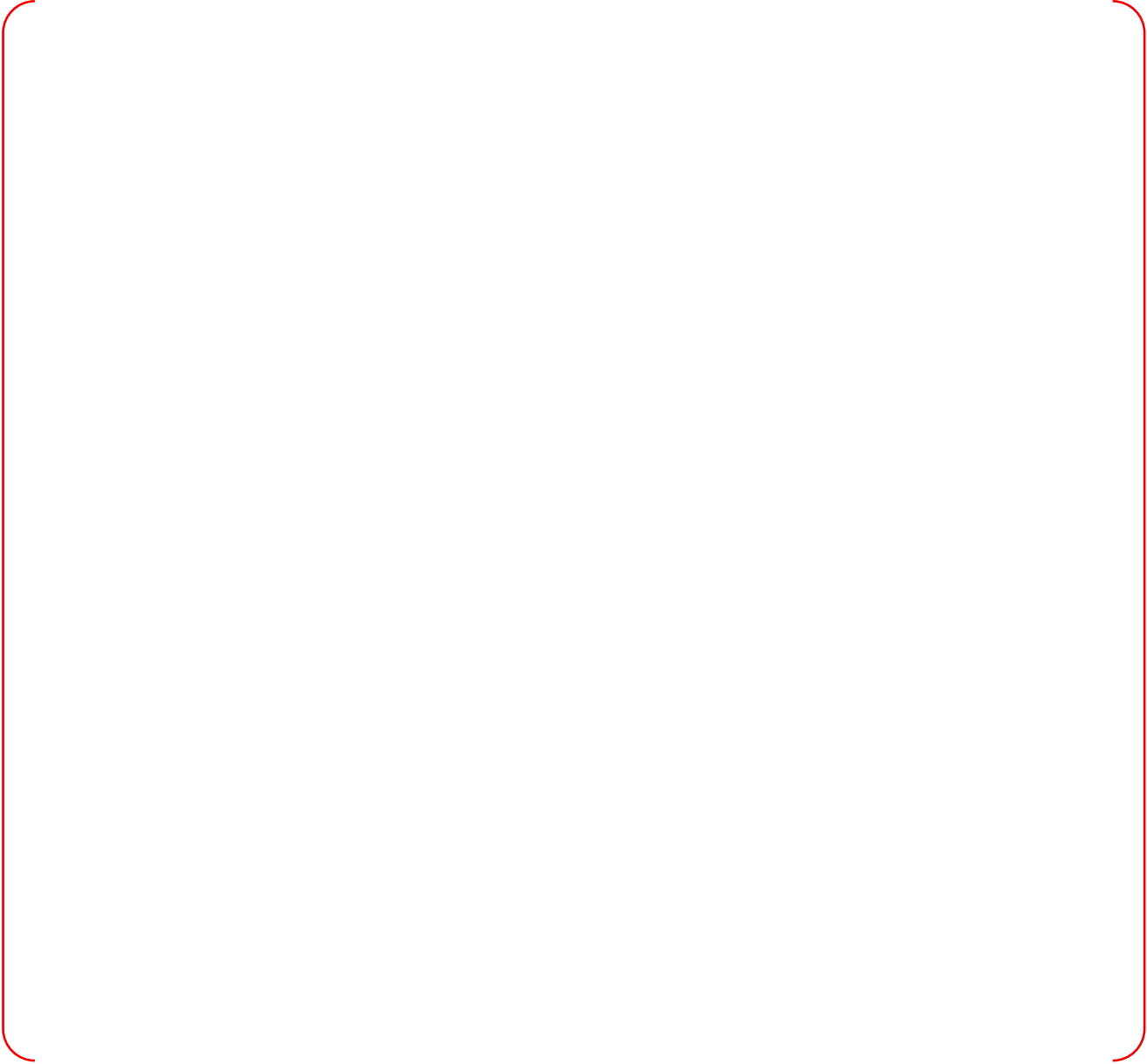
ISV-3 ATTACHMENT 2 - MALFUNCTION LIST

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

1.	OVERVIEW.....	D3
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
2.	FACILITATORS INFORMATION	D10
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
3.	SIMULATOR EXERCISE EVALUATION.....	D13
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
	ISV-4 ATTACHMENT 1 - TRENDING PARAMETERS.....	D34
	ISV-4 ATTACHMENT 2 - MALFUNCTION LIST.....	D37
	ISV-4 ATTACHMENT 3 - SHIFT TURNOVER SHEET	D38
	ISV-4 ATTACHMENT 4 - ANTICIPATED DIALOG.....	D39
	ISV-4 ATTACHMENT 5 - GUIDANCE WHEN DIFFICULTIES OCCUR DURING SIMULATION OR TESTING.....	D40

1. OVERVIEW

1.1 Human Factors Verification and Validation Objectives

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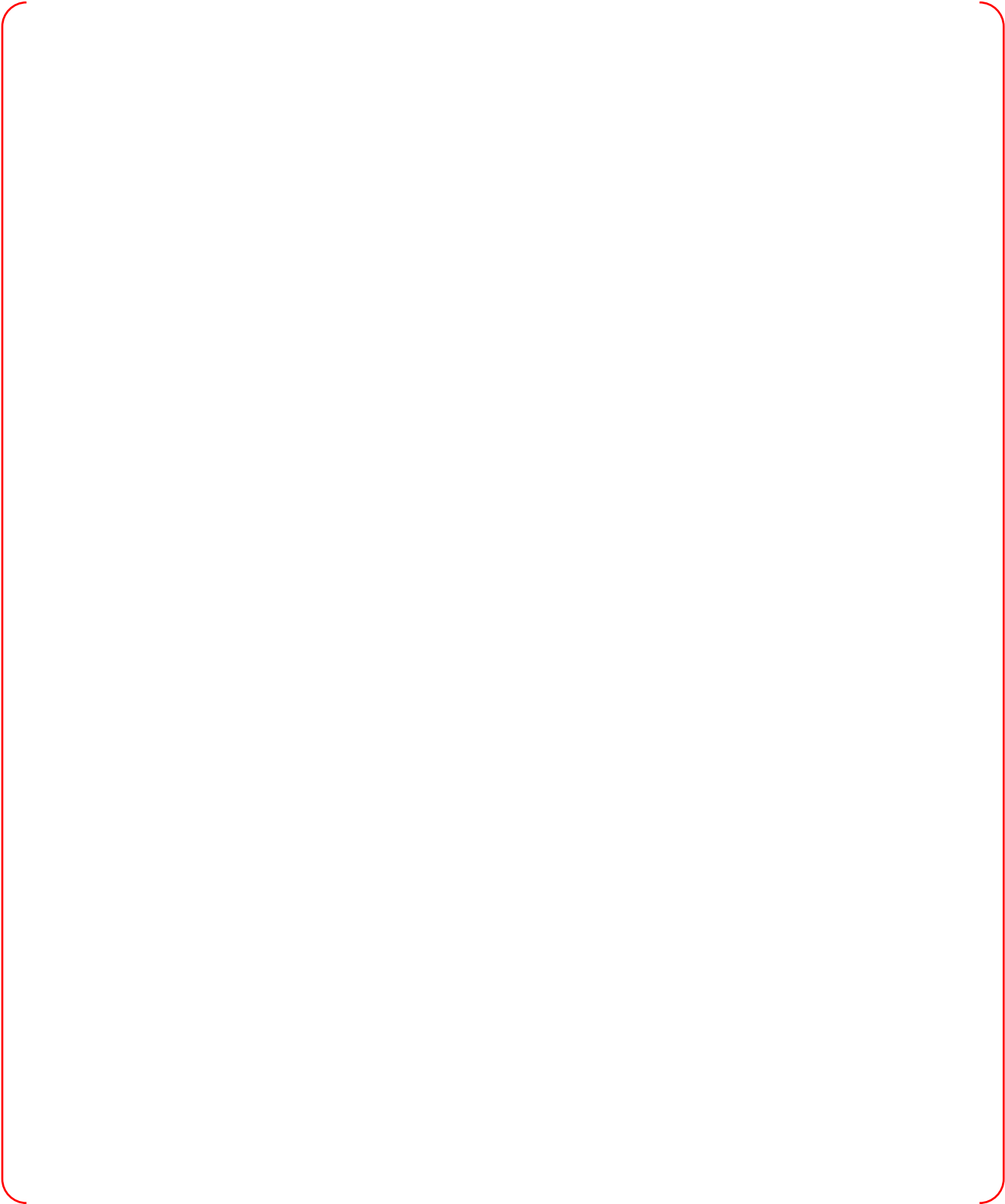
1.2 Scenario Overview

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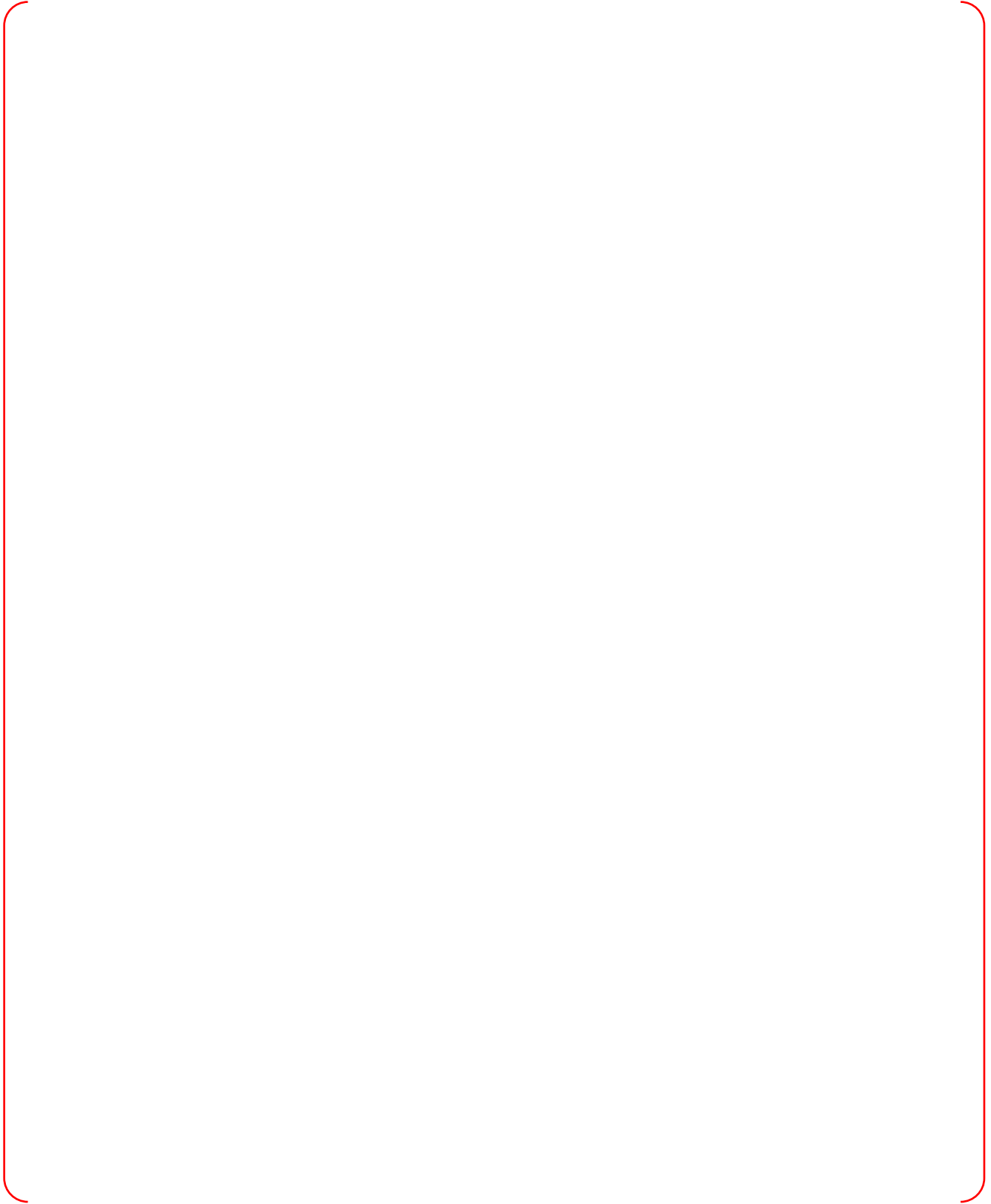


1.3 Performance Measures

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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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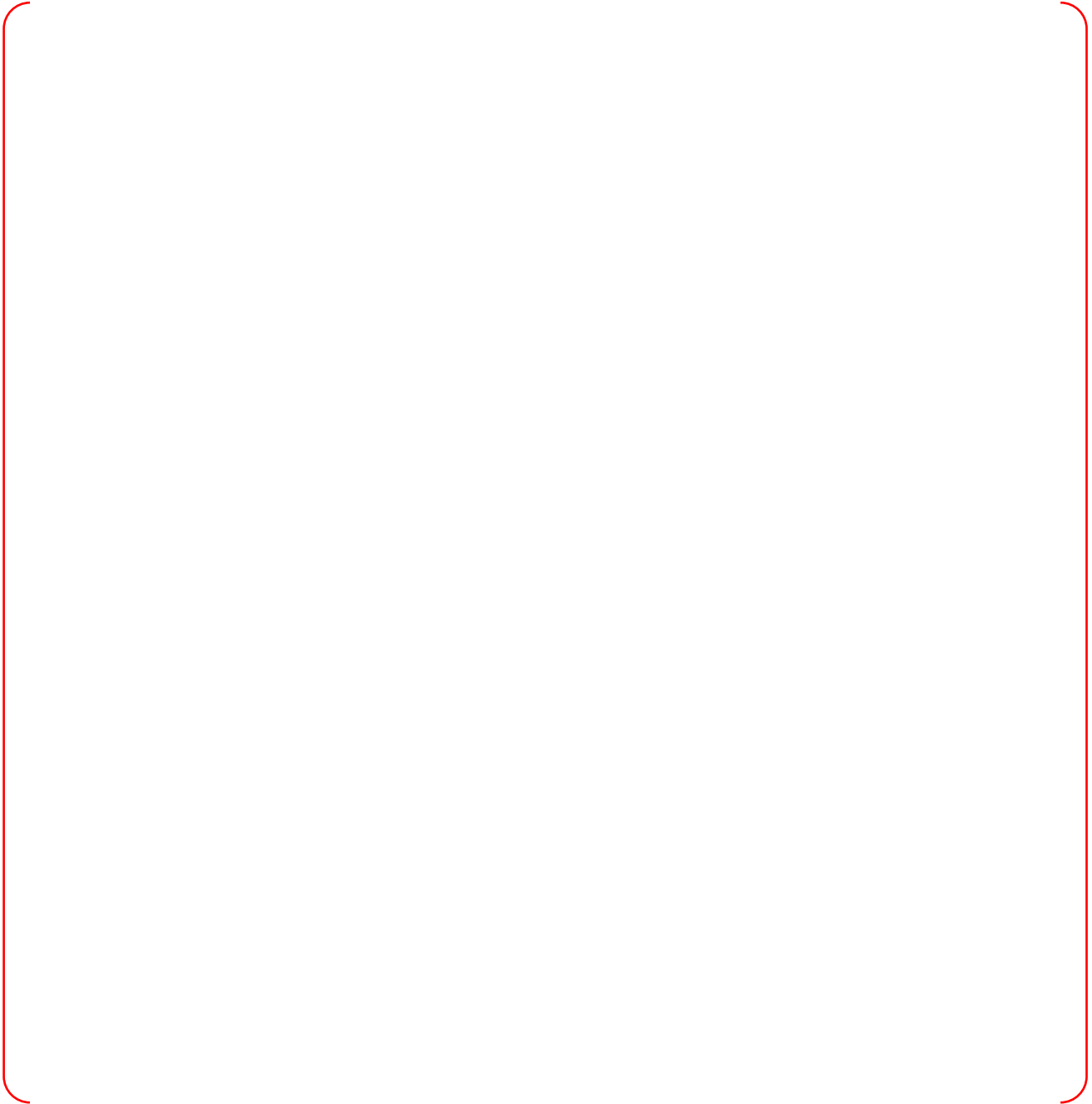
2. FACILITATORS INFORMATION

2.1 Scenario Timeline

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2.2 Procedure Flowpath

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2.3 Emergency Plan

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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

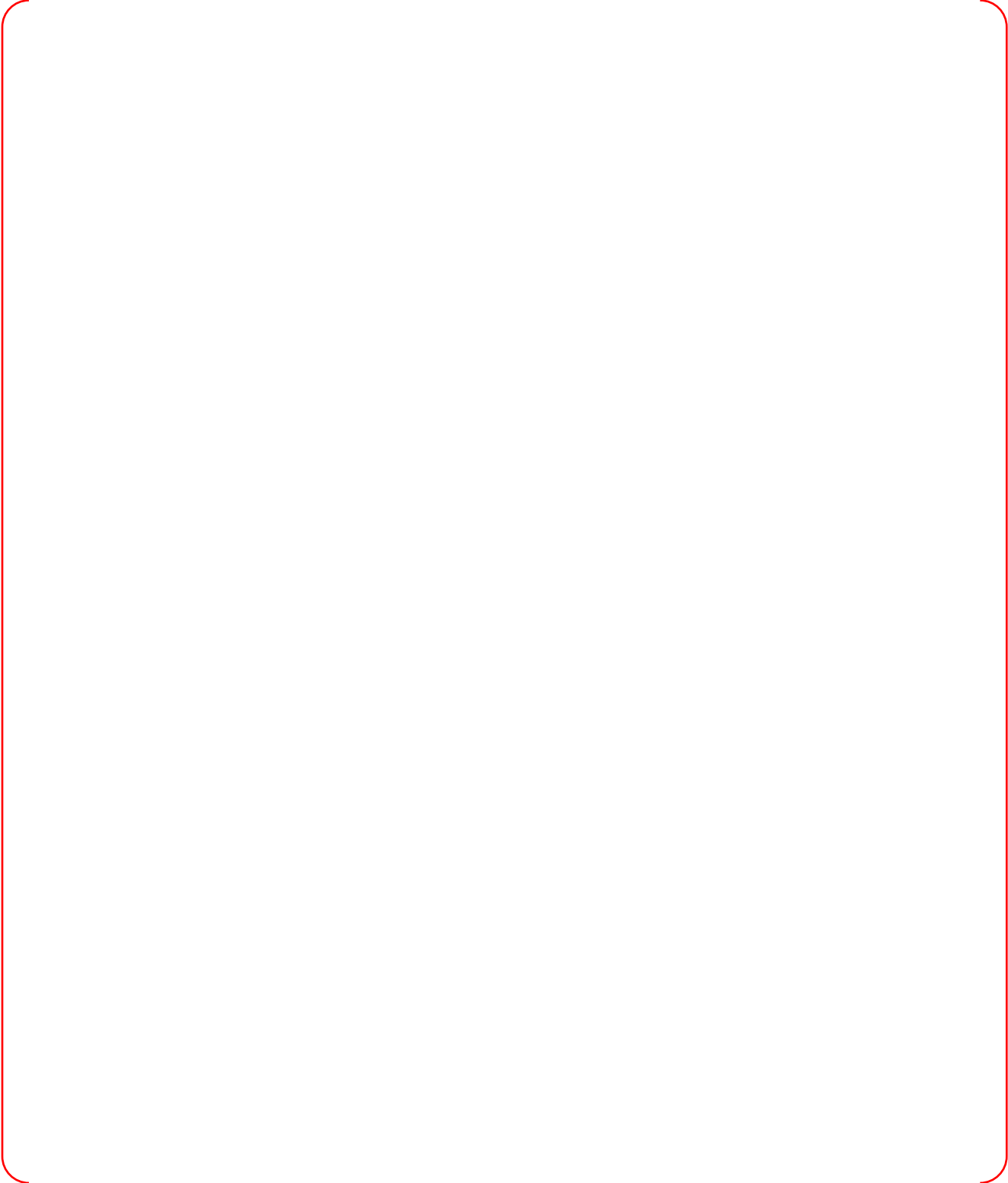
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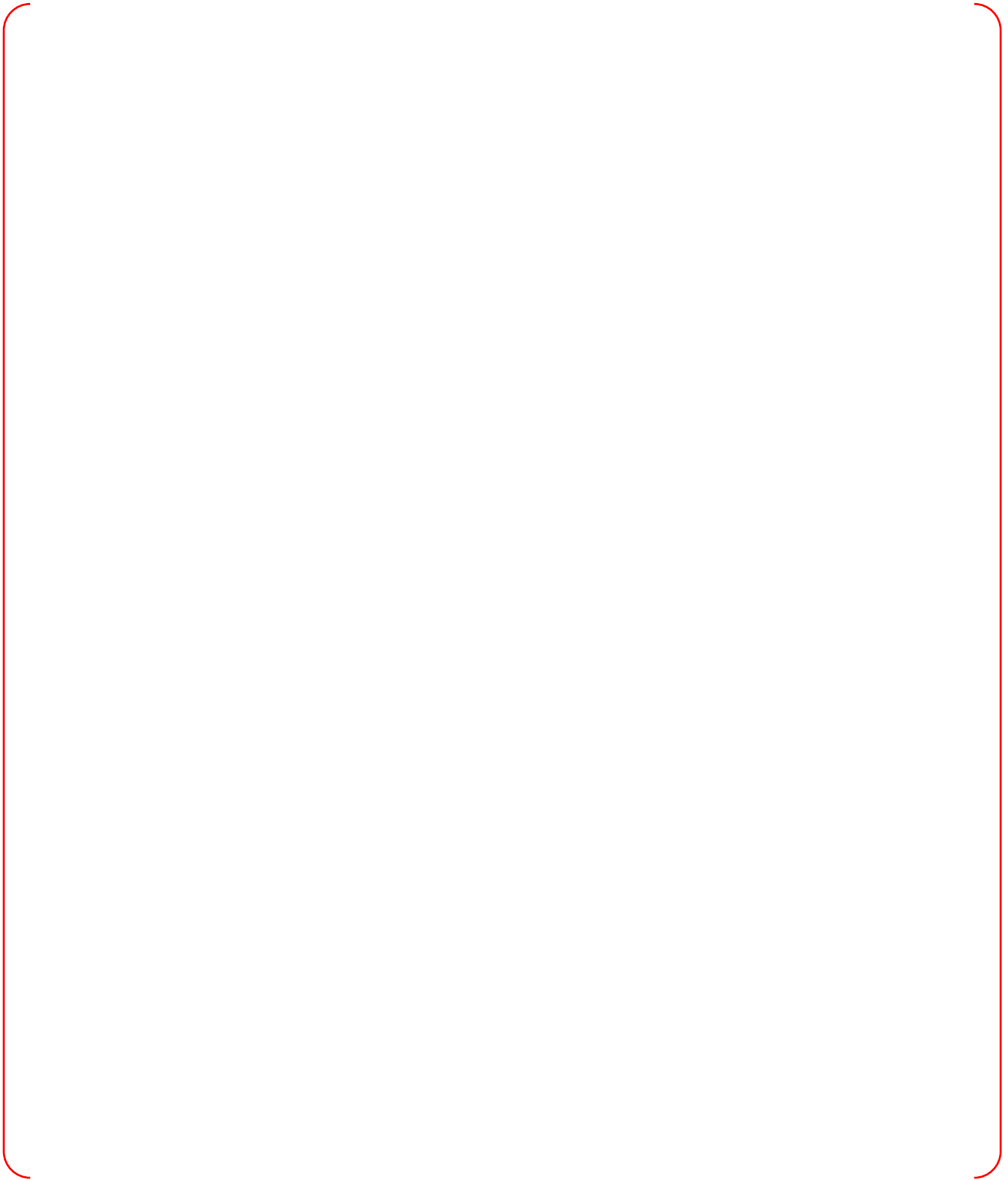


3.2 Evaluation

3.2.1 Event 1 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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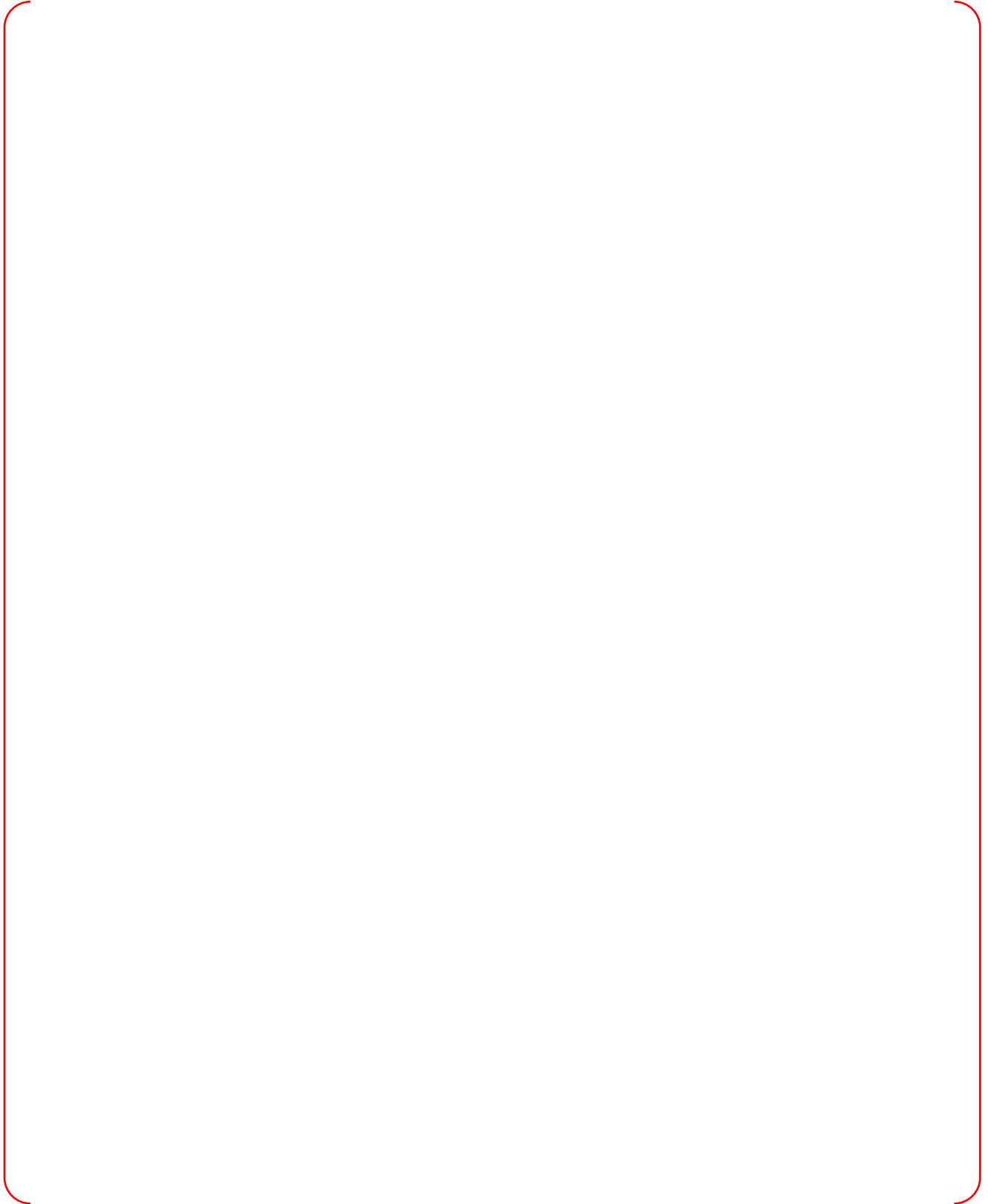




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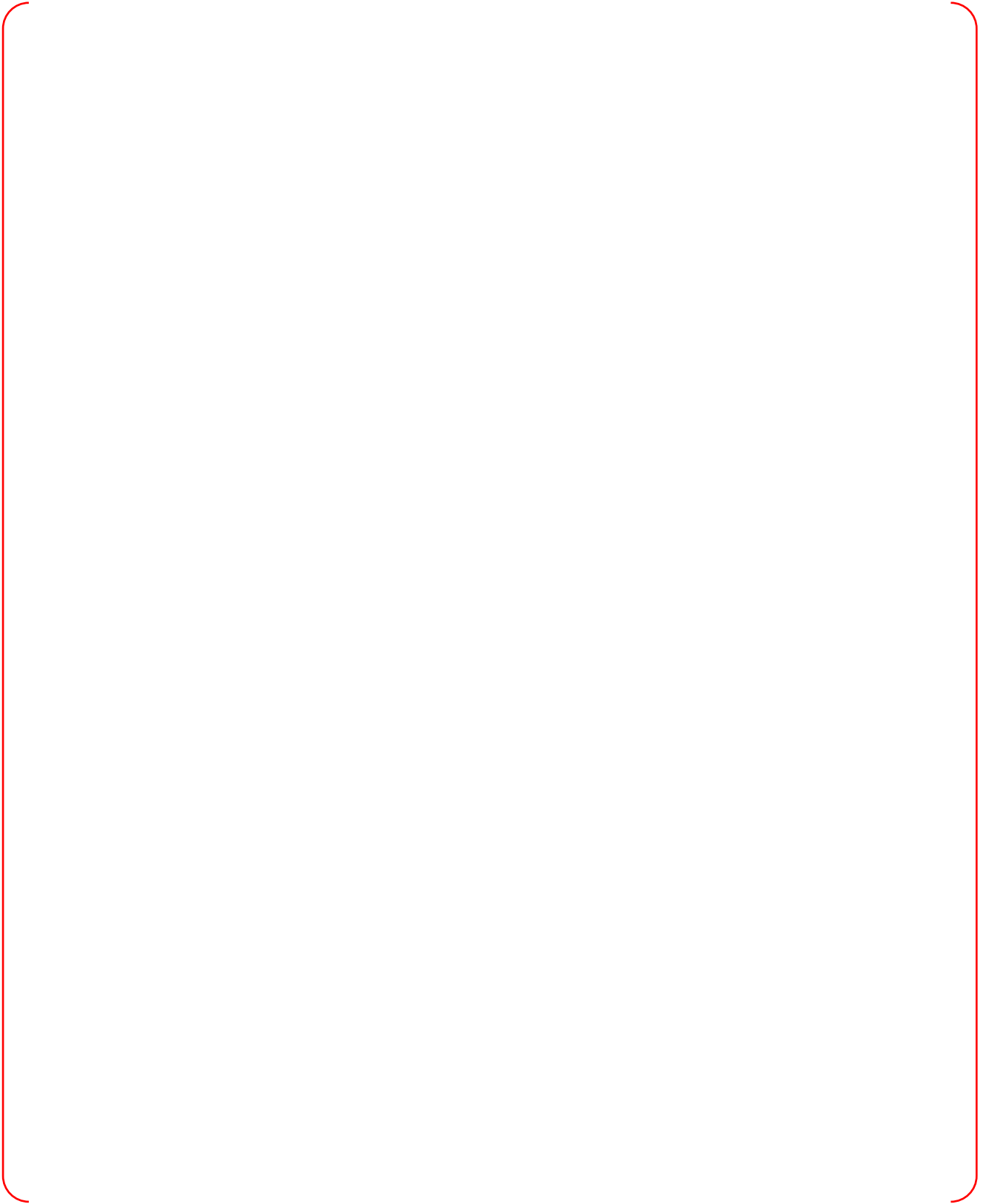


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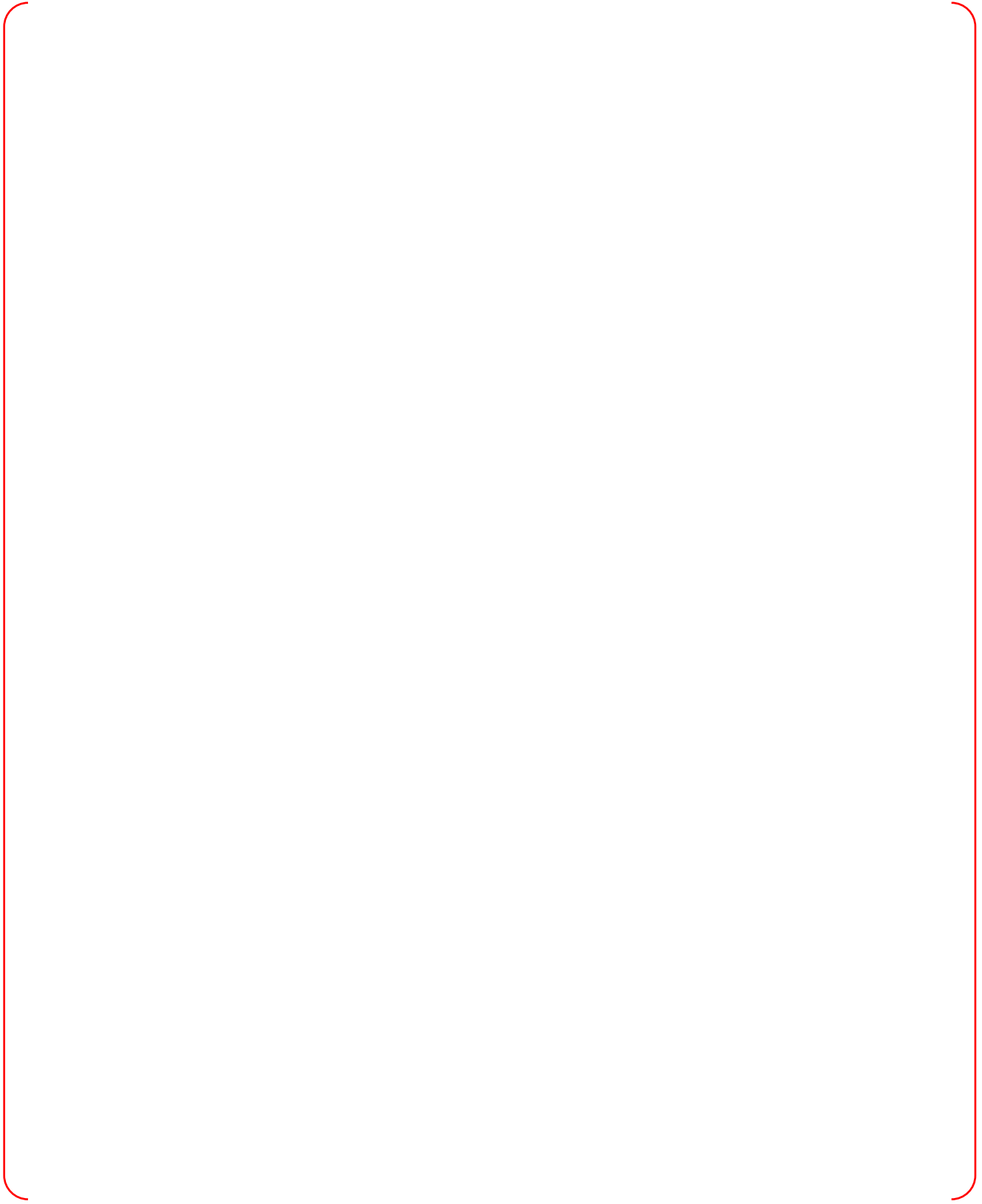


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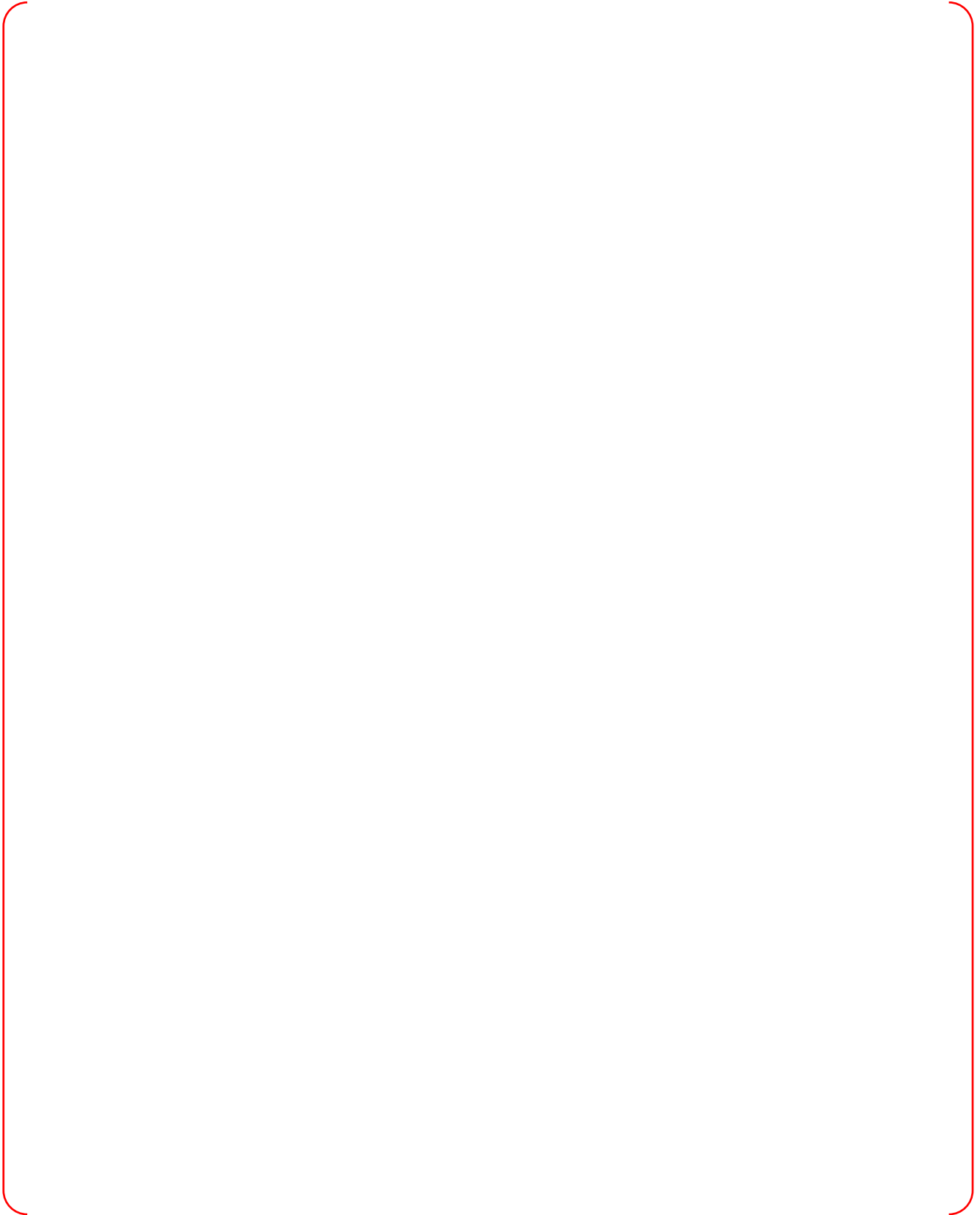
3.2.3 Event 3 MD AFWP 2A and 2B Trip, Loss Of All Feedwater (LOAF)

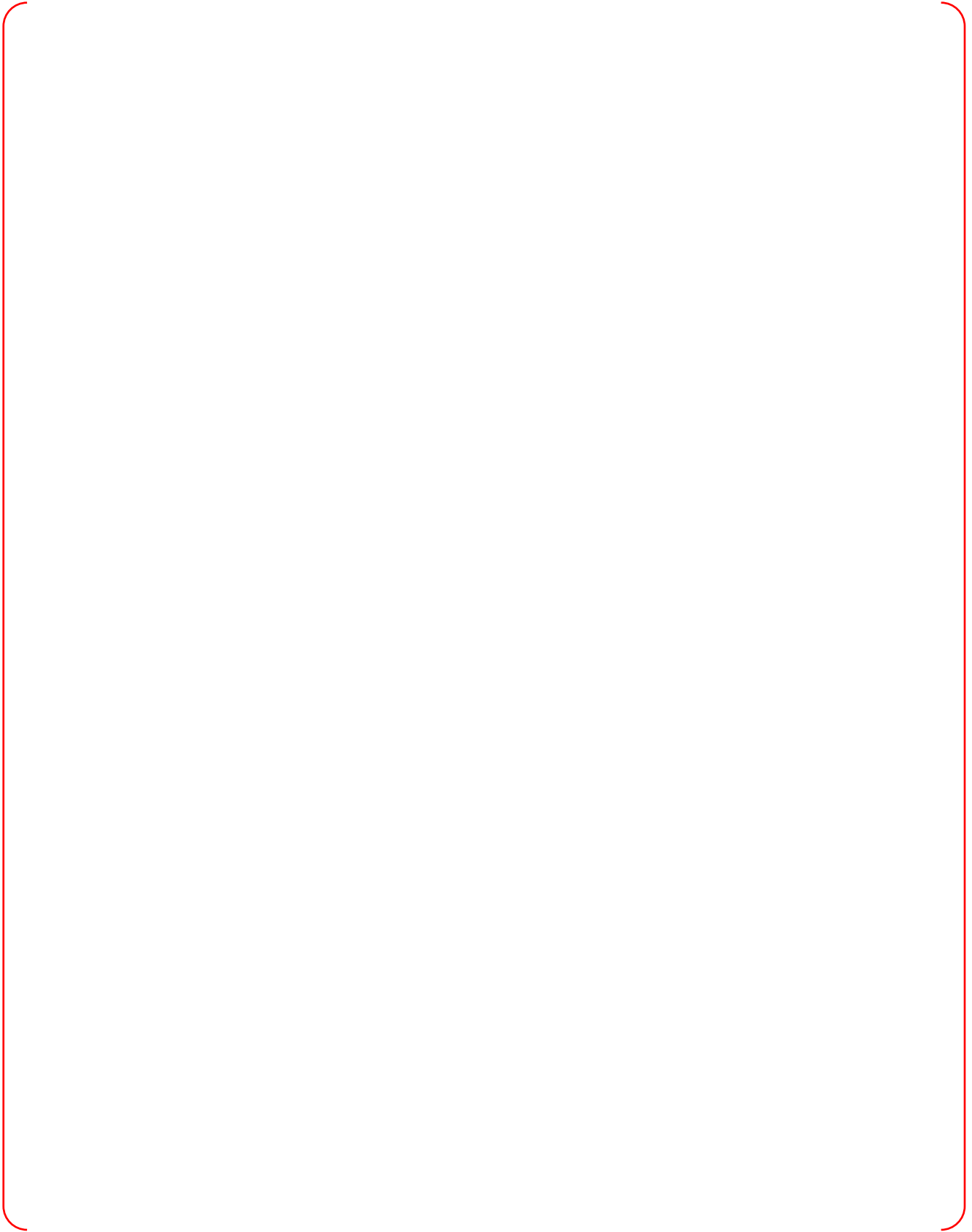
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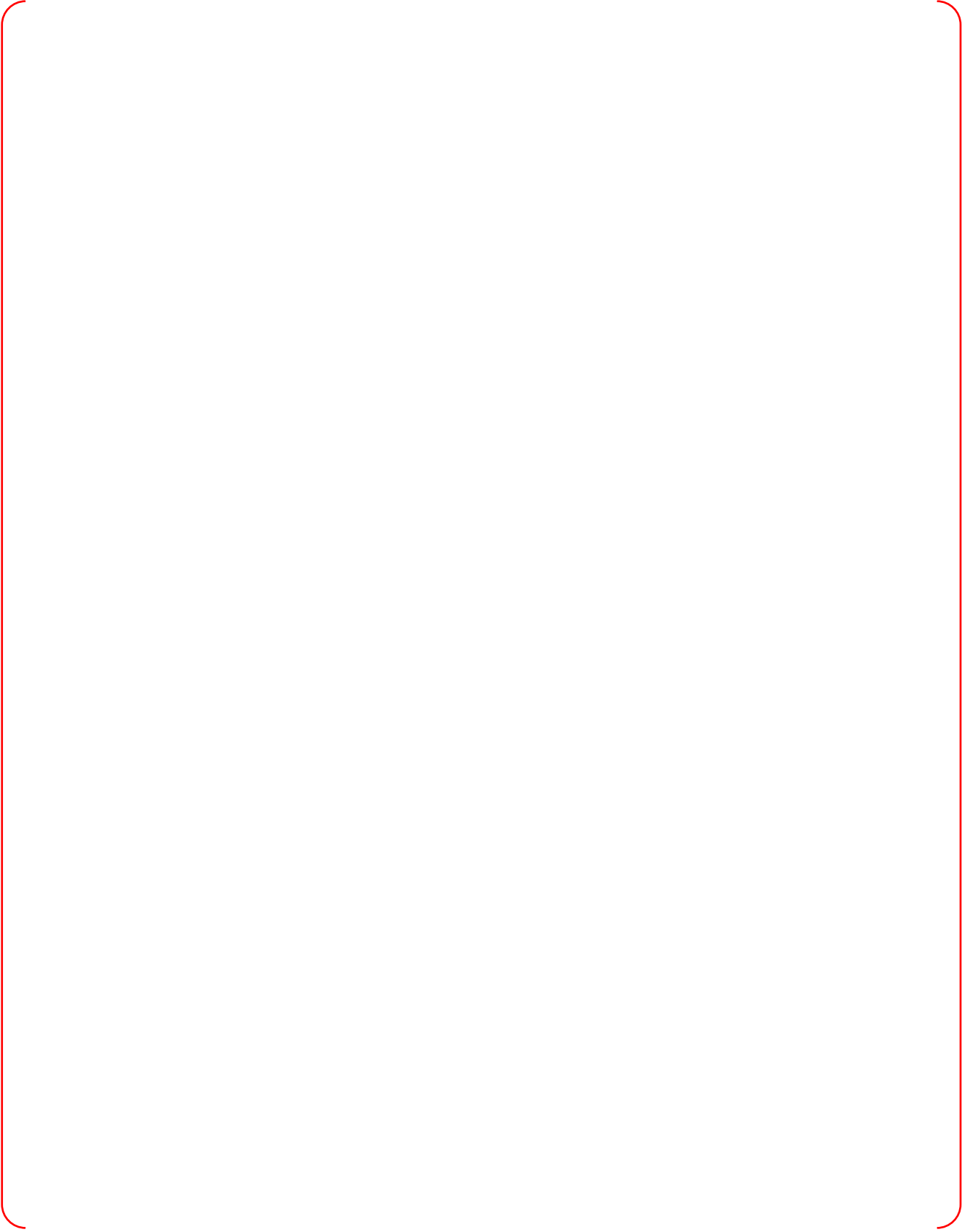
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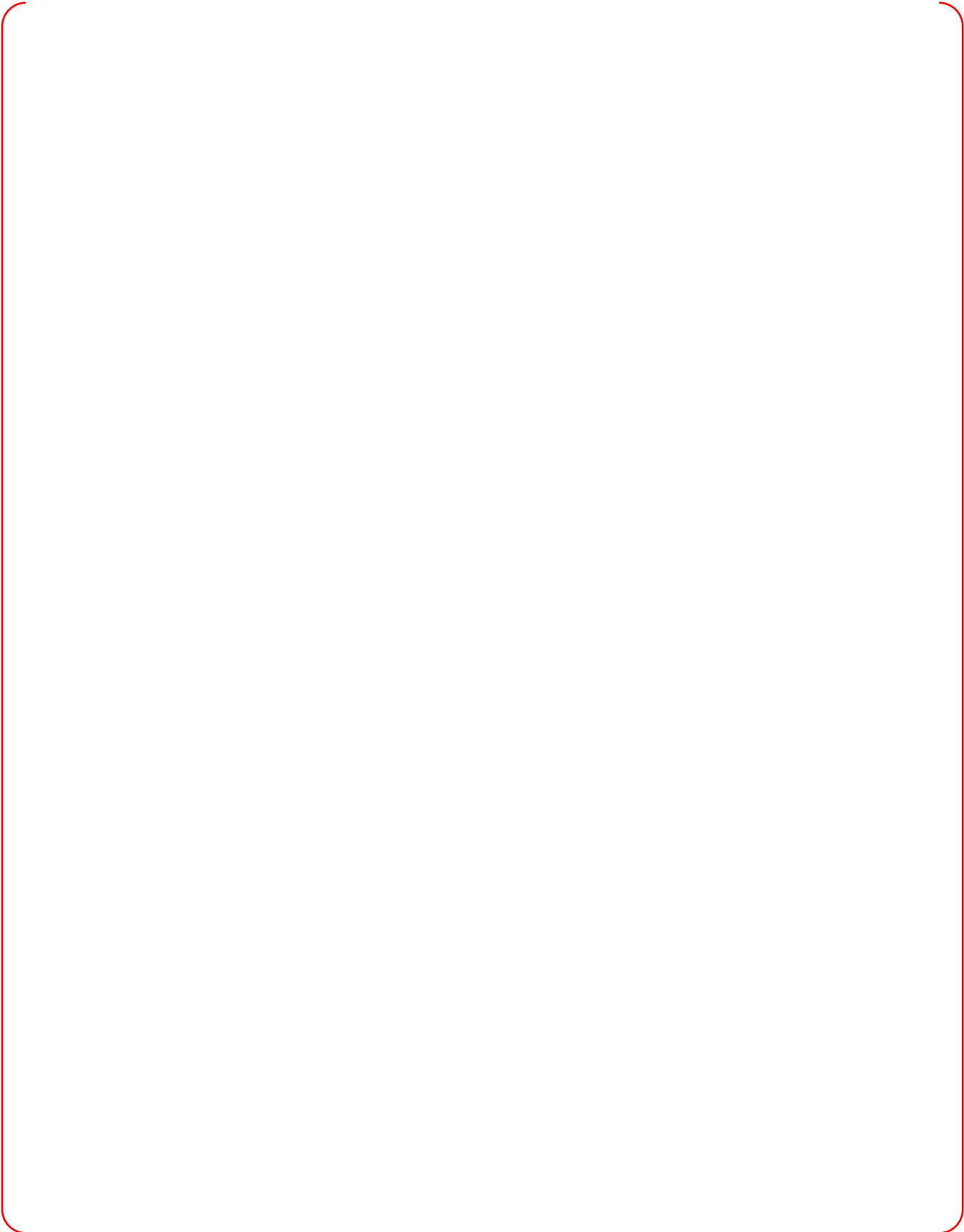




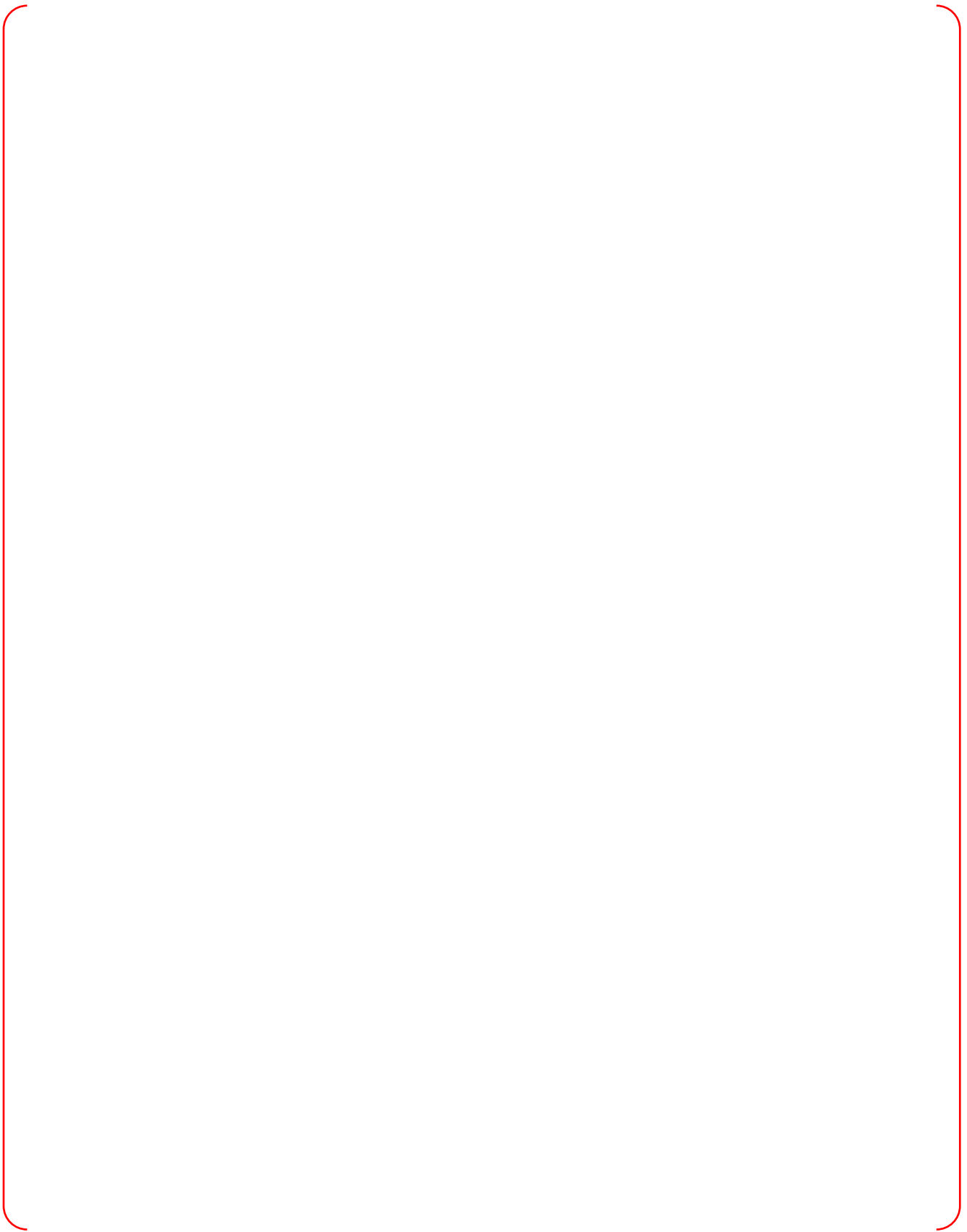




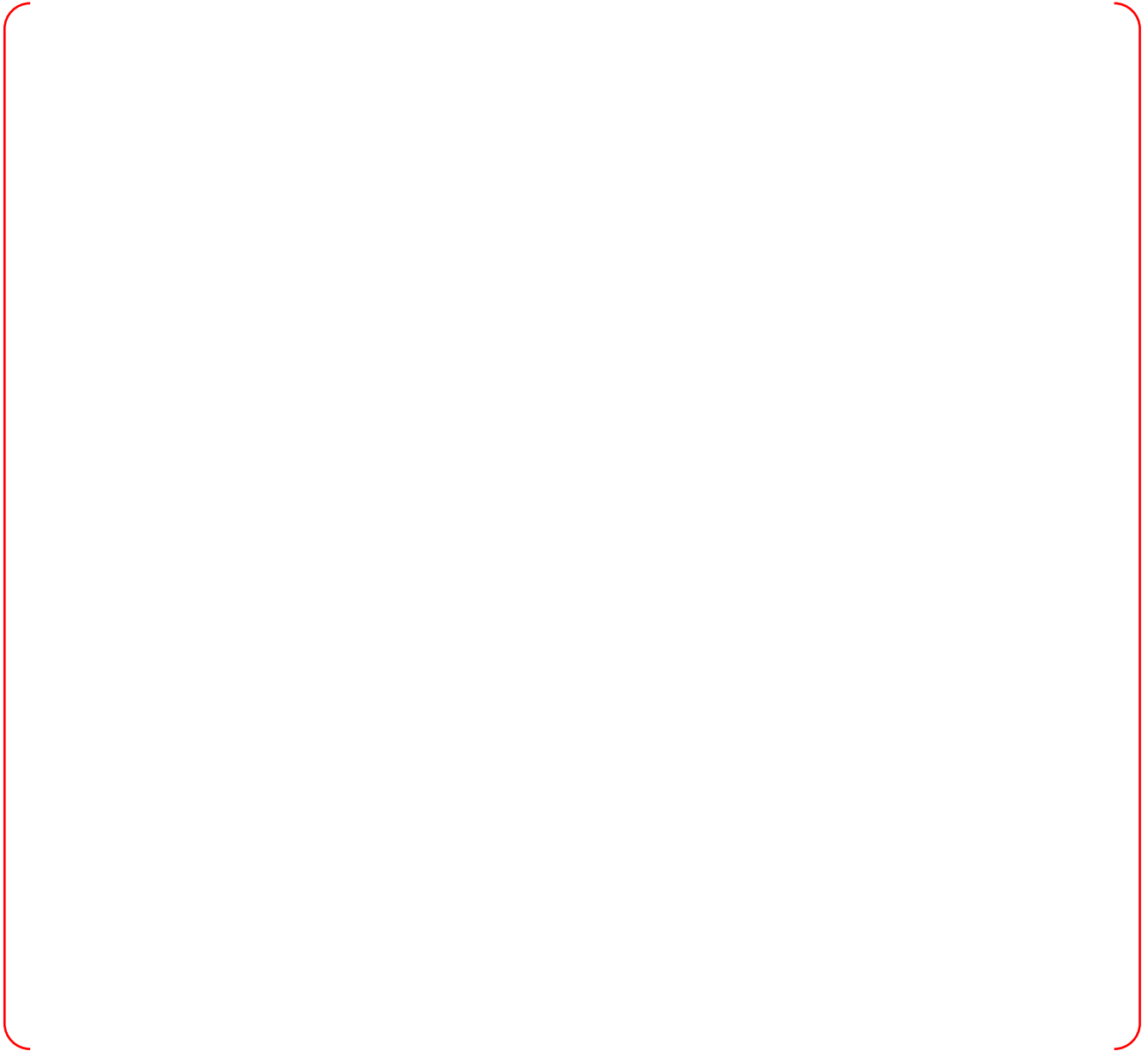




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3.3 Debrief

3.3.1 Post Exercise Evaluation

TS



3.3.2 Data Acquisition

TS

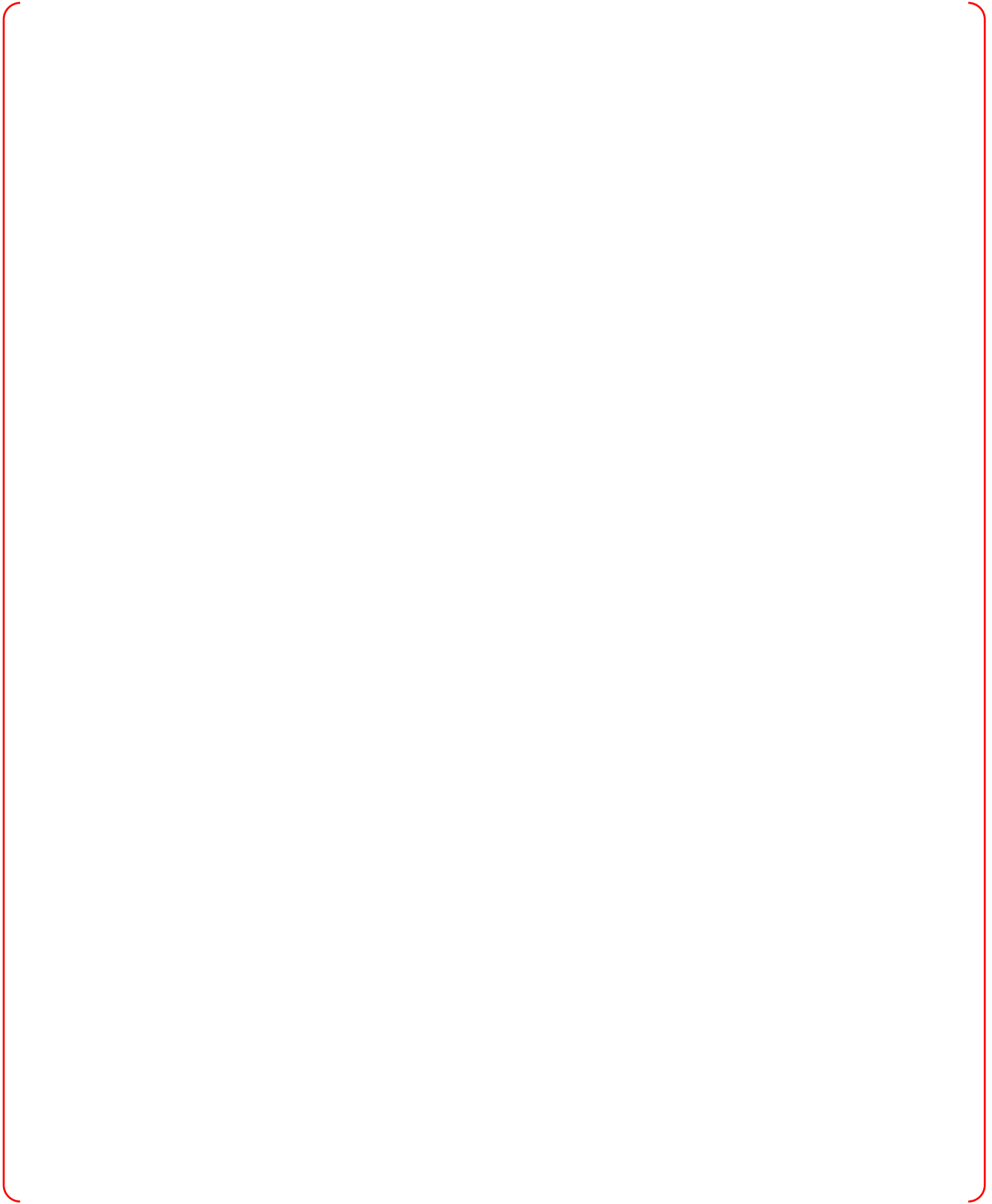


ISV-4 ATTACHMENT 1 - TRENDING PARAMETERS

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ISV-4 ATTACHMENT 2 - MALFUNCTION LIST

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ISV-4 ATTACHMENT 3 - SHIFT TURNOVER SHEET

TS

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ISV-4 ATTACHMENT 4 - ANTICIPATED DIALOG

TS



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

TS



APPENDIX E

Station Black Out

ISV-5

TABLE OF CONTENTS

1. OVERVIEW..... E3

1.1 Human Factors Verification and Validation ObjectivesE3

1.2 Scenario Overview.....E4

1.3 Performance MeasuresE5

1.4 Other Performance MeasuresE8

1.5 List of Important Human Actions.....E9

1.6 Applicable Operational Condition SamplingE9

2. FACILITATORS INFORMATION E11

2.1 Scenario Timeline E11

2.2 Procedure Flowpath.....E12

2.3 Emergency PlanE12

2.4 Technical SpecificationsE12

2.5 Scenario Termination CriteriaE12

2.6 Anticipated Scenario Length.....E12

3. SIMULATOR EXERCISE EVALUATION..... E13

3.1 Evaluation PreparationE13

3.2 EvaluationE14

3.2.1 Event 1 Equipment Rotation -- Charging Pump from 1A to 1BE14

3.2.2 Event-2 CVCS VCT LT-227 Fails LowE14

3.2.3 Event-3 Deaerator Level Controller LIK-0318NO1 Fails LowE15

3.2.4 EVENT-4 100% to 75% Power Operation and Severe Weather (Tornado Warning)E16

3.2.5 Event-5 Loss of Offsite PowerE17

3.2.6 EVENT-6 Station Black Out.....E26

3.3 DebriefE31

3.3.1 Post Exercise EvaluationE31

3.3.2 Data AcquisitionE31

ISV-5 ATTACHMENT 1 - TRENDING PARAMETERS..... E32

ISV-5 ATTACHMENT 2 - MALFUNCTION LIST..... E35

ISV-5 ATTACHMENT 3 - SHIFT TURNOVER SHEET E36

ISV-5 ATTACHMENT 4 - ANTICIPATED DIALOG E37

**ISV-5 ATTACHMENT 5 - GUIDANCE WHEN DIFFICULTIES OCCUR DURING
SIMUMLATION OR TESTING..... E39**

1. OVERVIEW

1.1 Human Factors Verification and Validation Objectives

TS



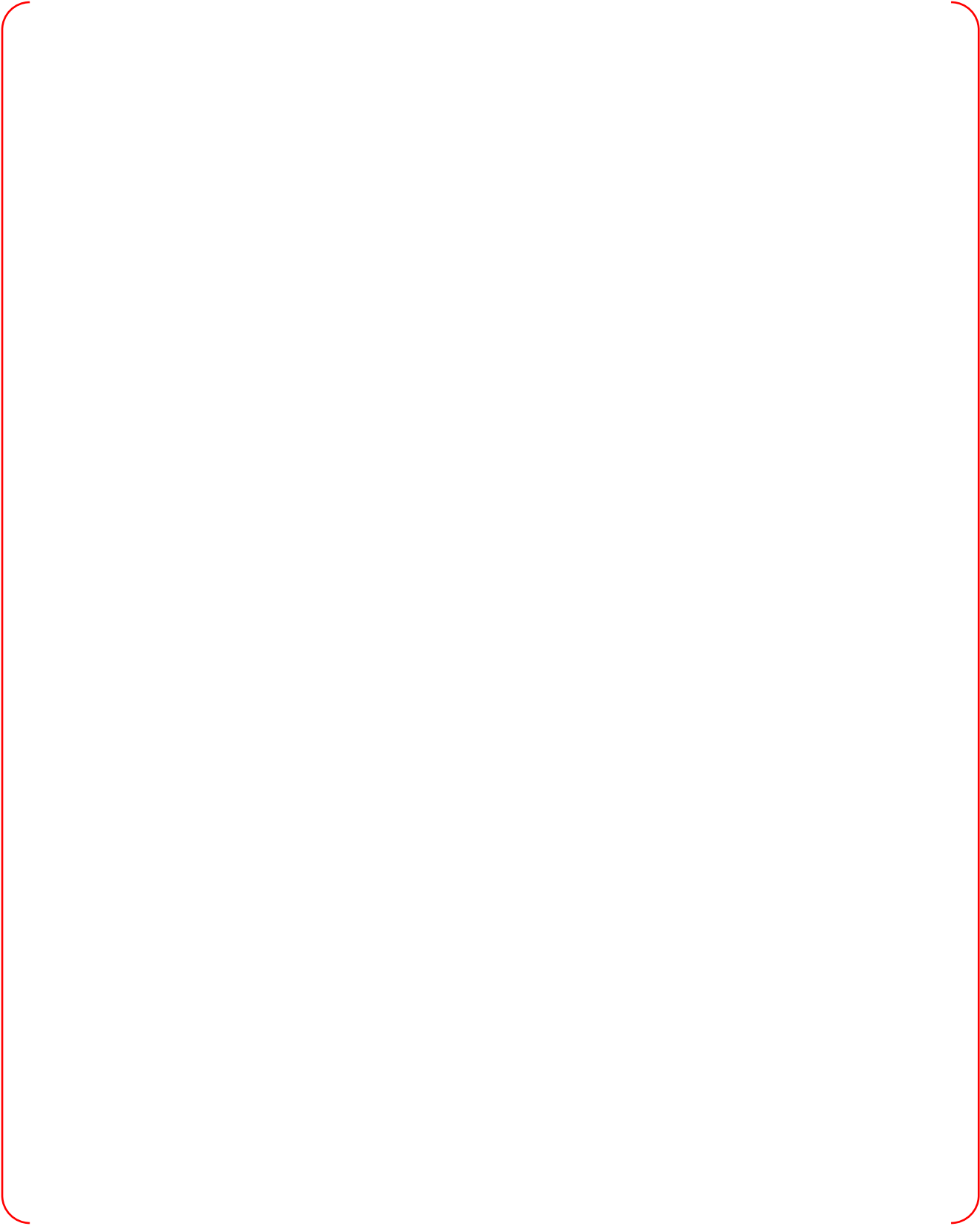
1.2 Scenario Overview

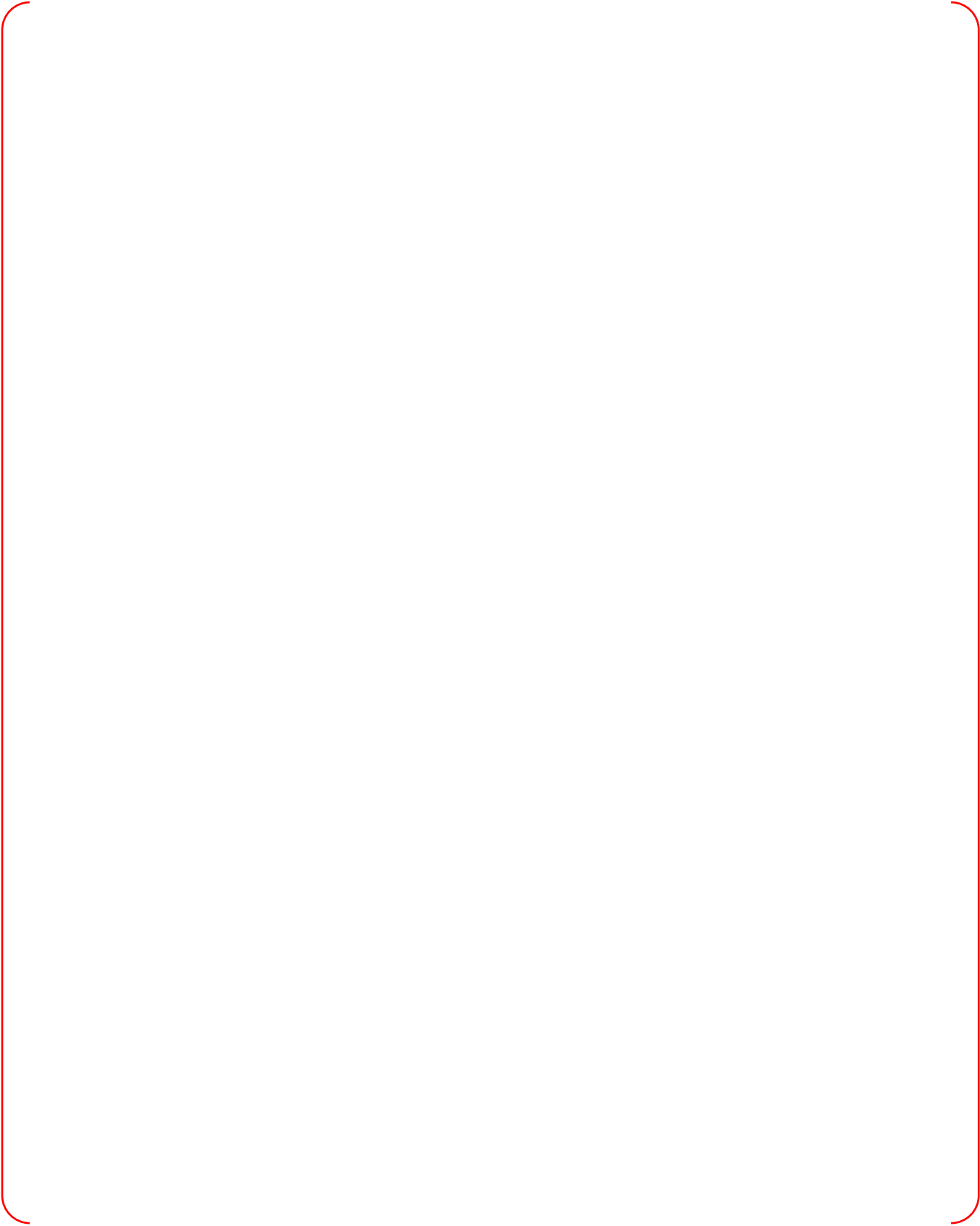
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1.3 Performance Measures

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1.4 Other Performance Measures

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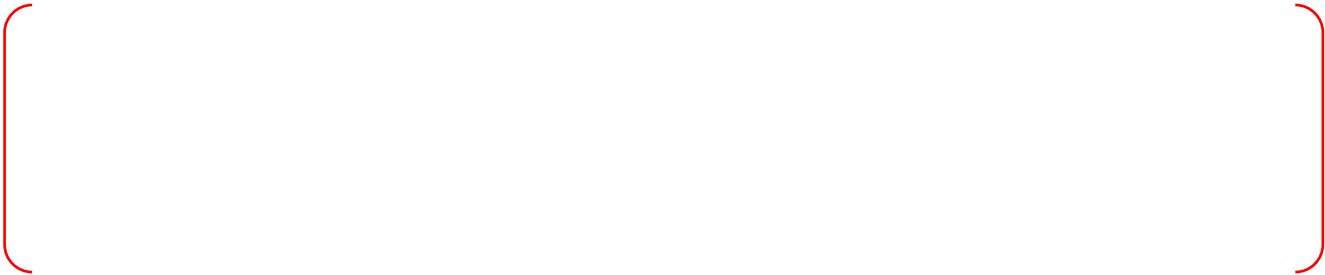


1.5 List of Important Human Actions

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1.6 Applicable Operational Condition Sampling


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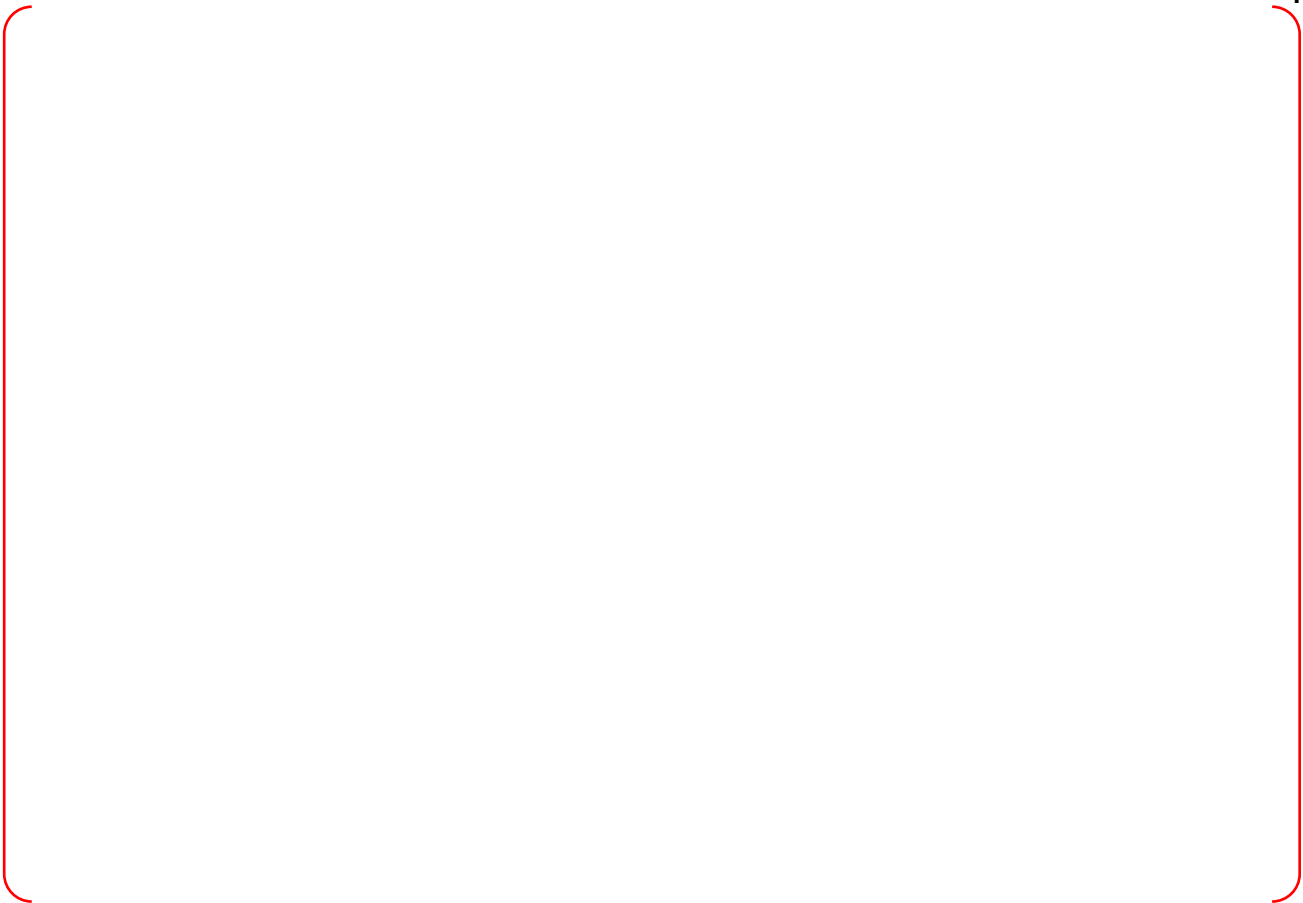
2. FACILITATORS INFORMATION

2.1 Scenario Timeline

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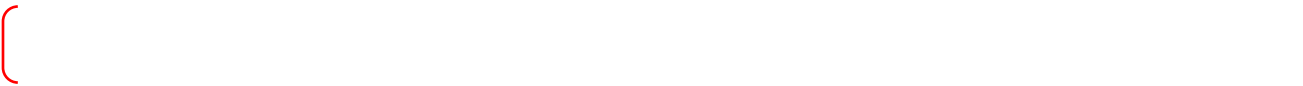
2.2 Procedure Flowpath

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2.3 Emergency Plan

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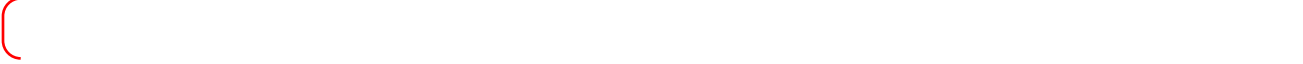
2.4 Technical Specifications

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

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

TS



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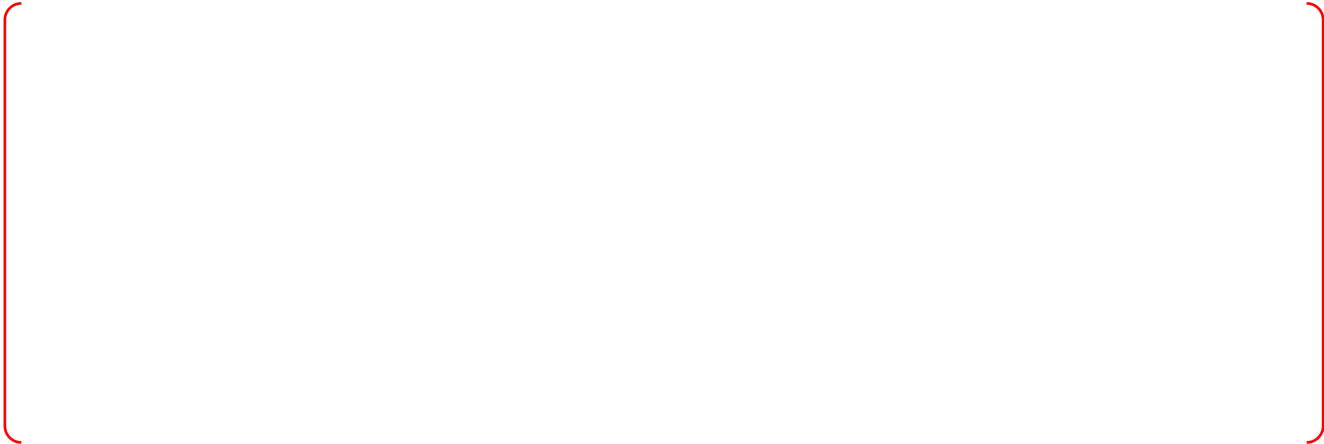


3.2.5 Event-5 Loss of Offsite Power

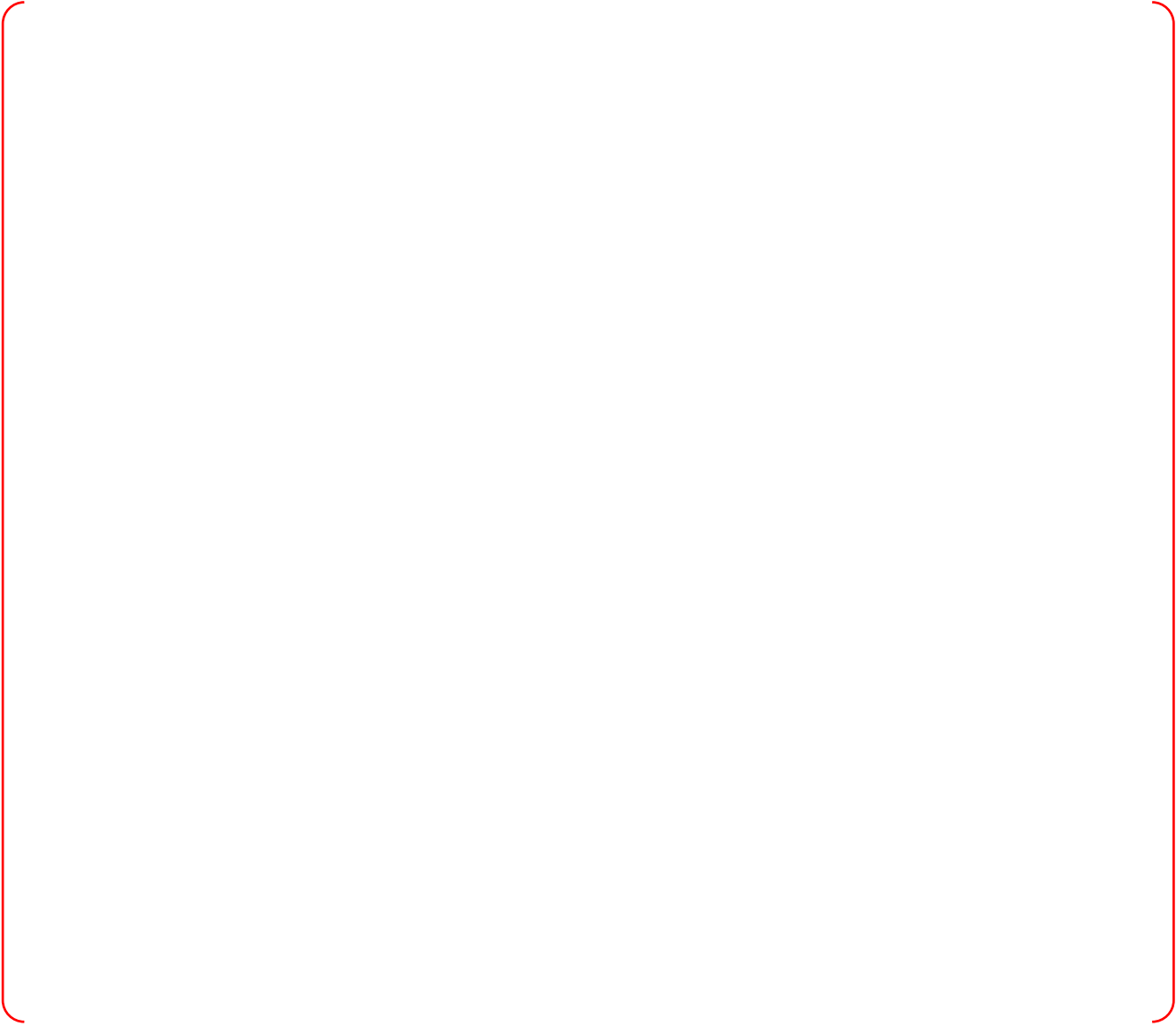
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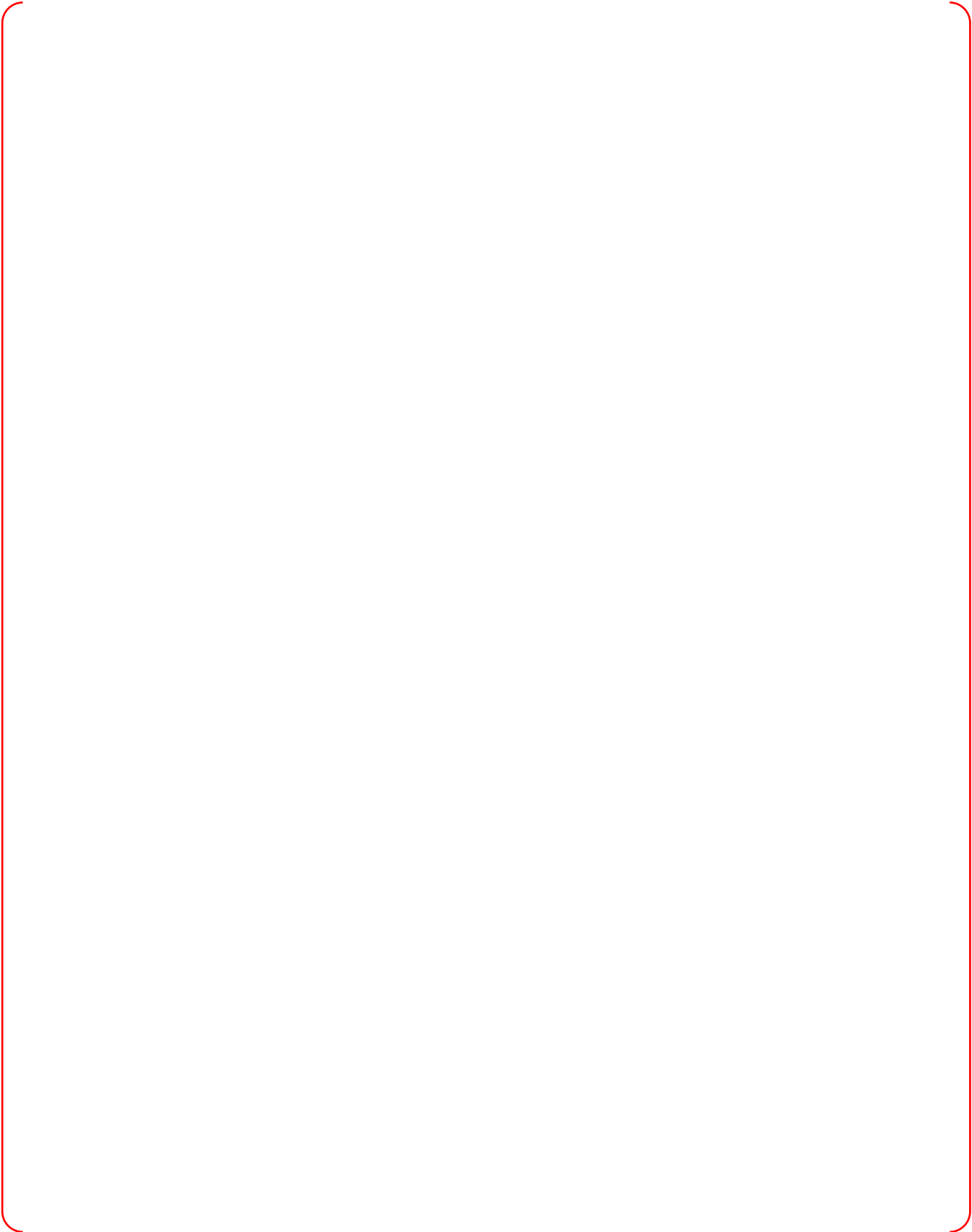


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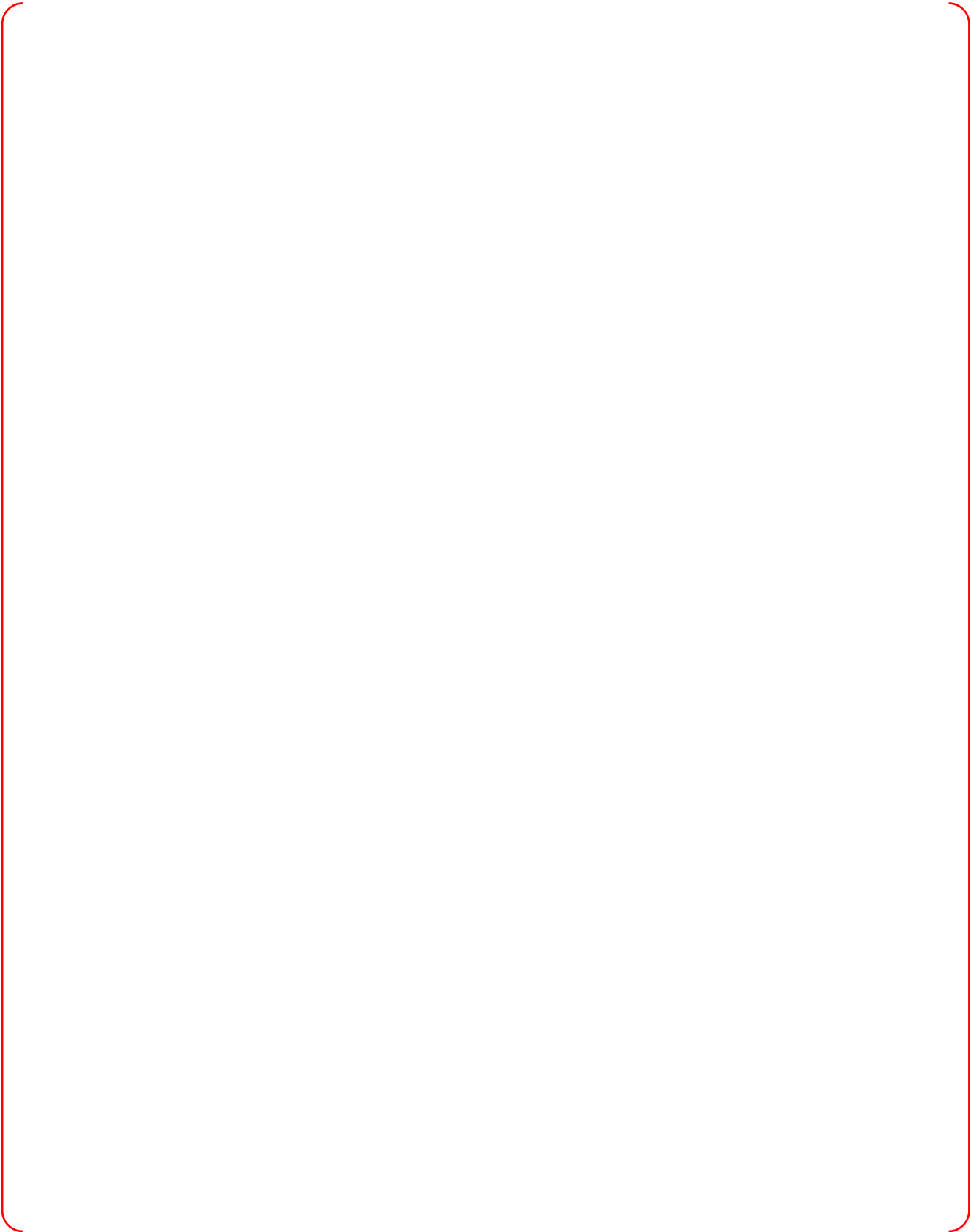


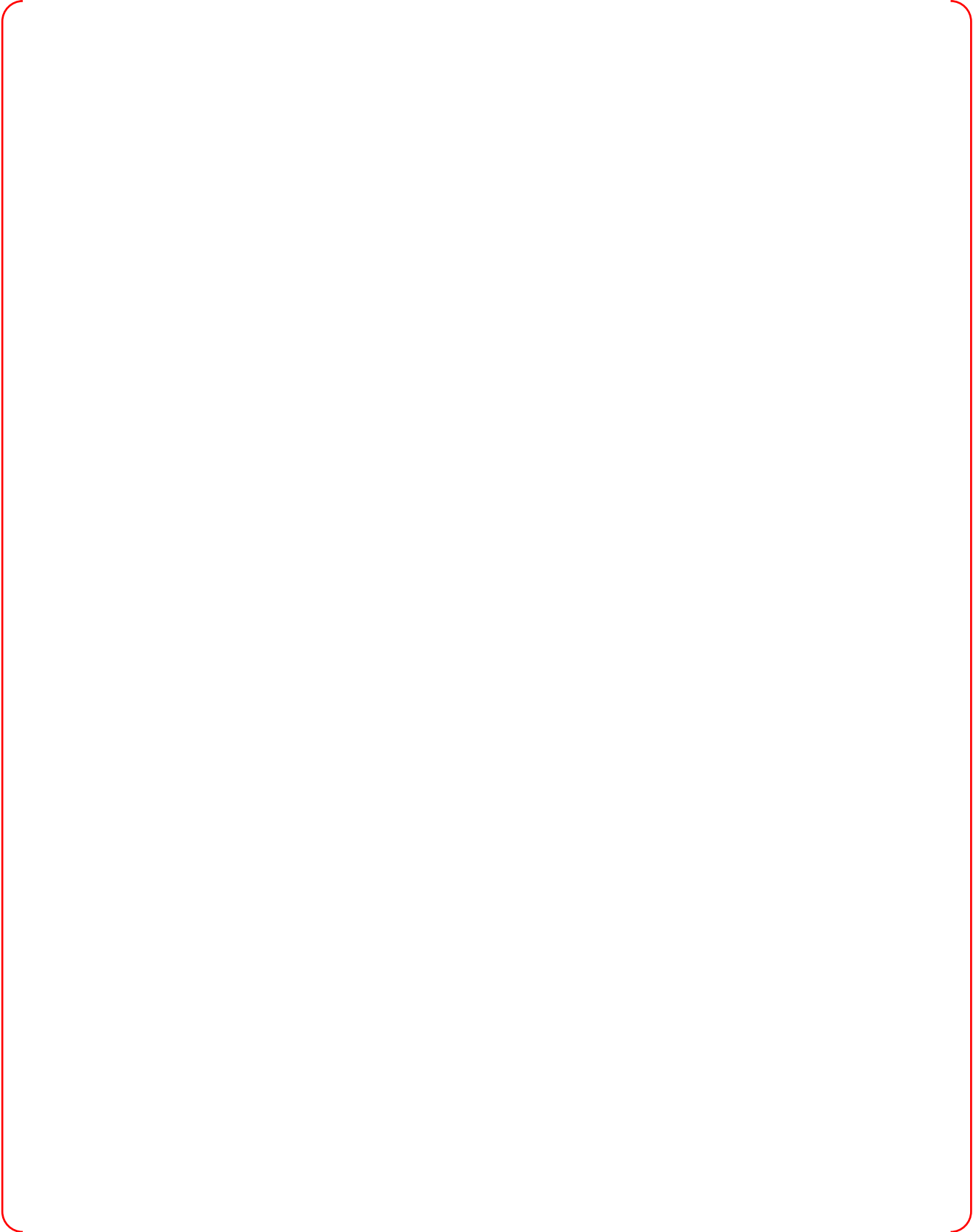
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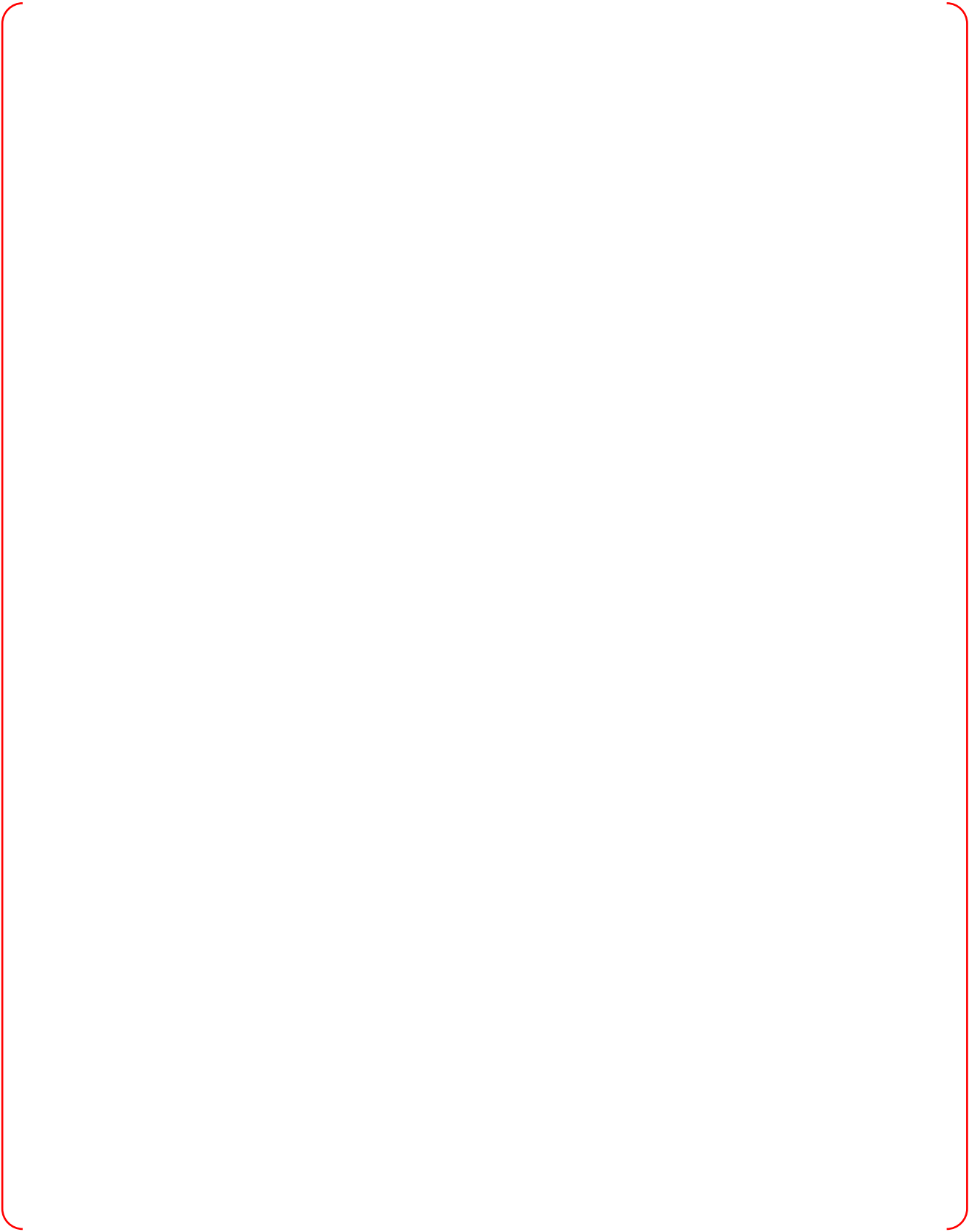


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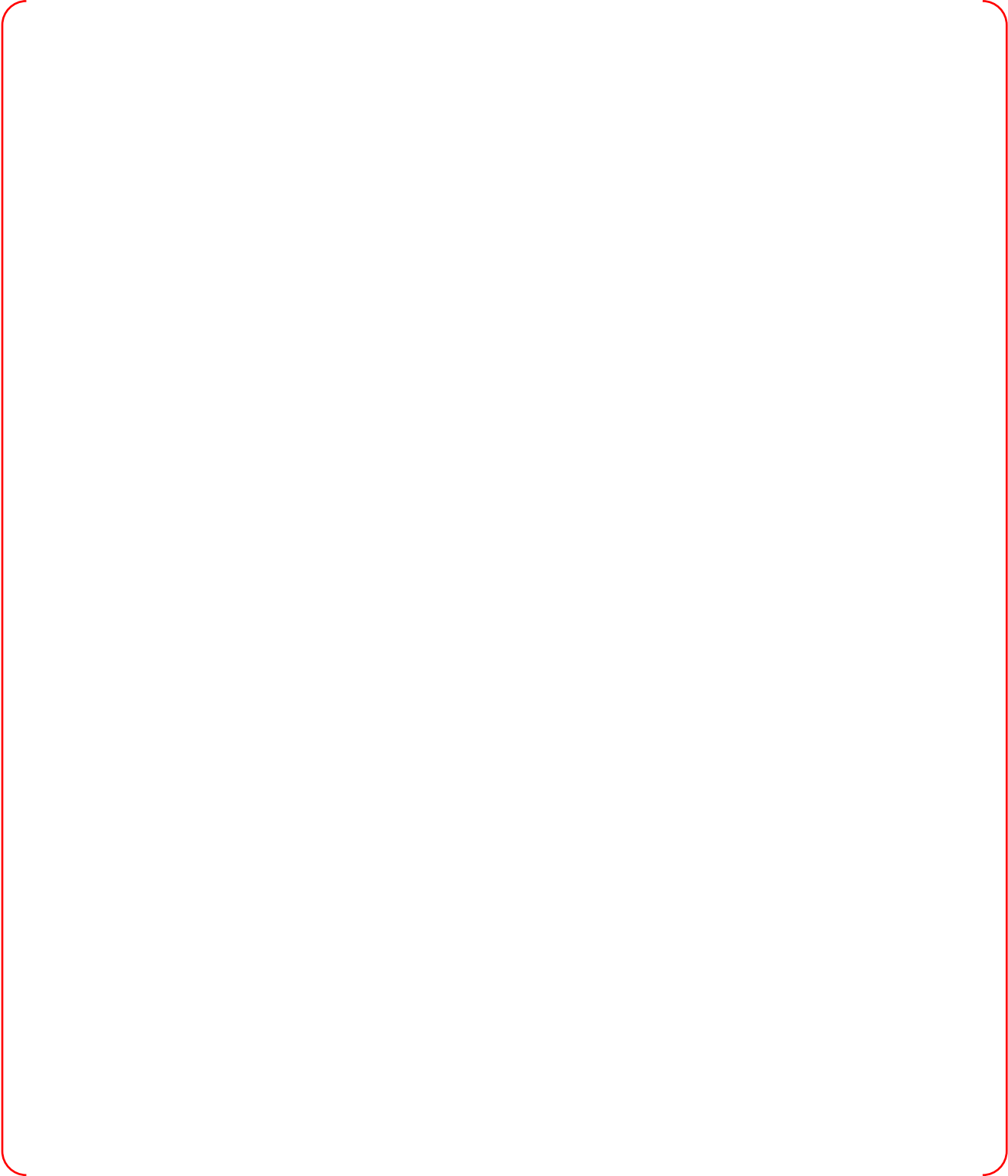




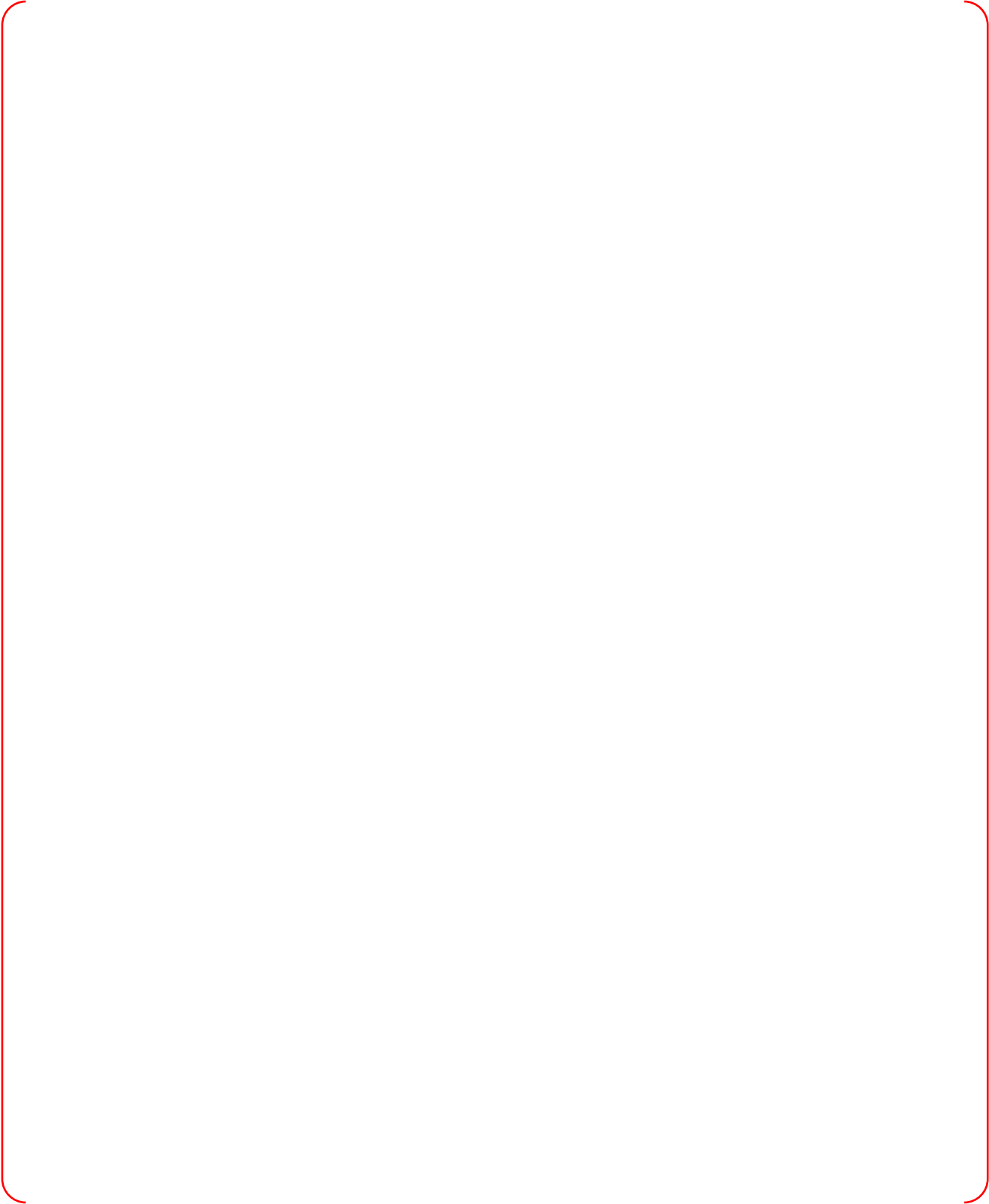


3.2.6 EVENT-6 Station Black Out

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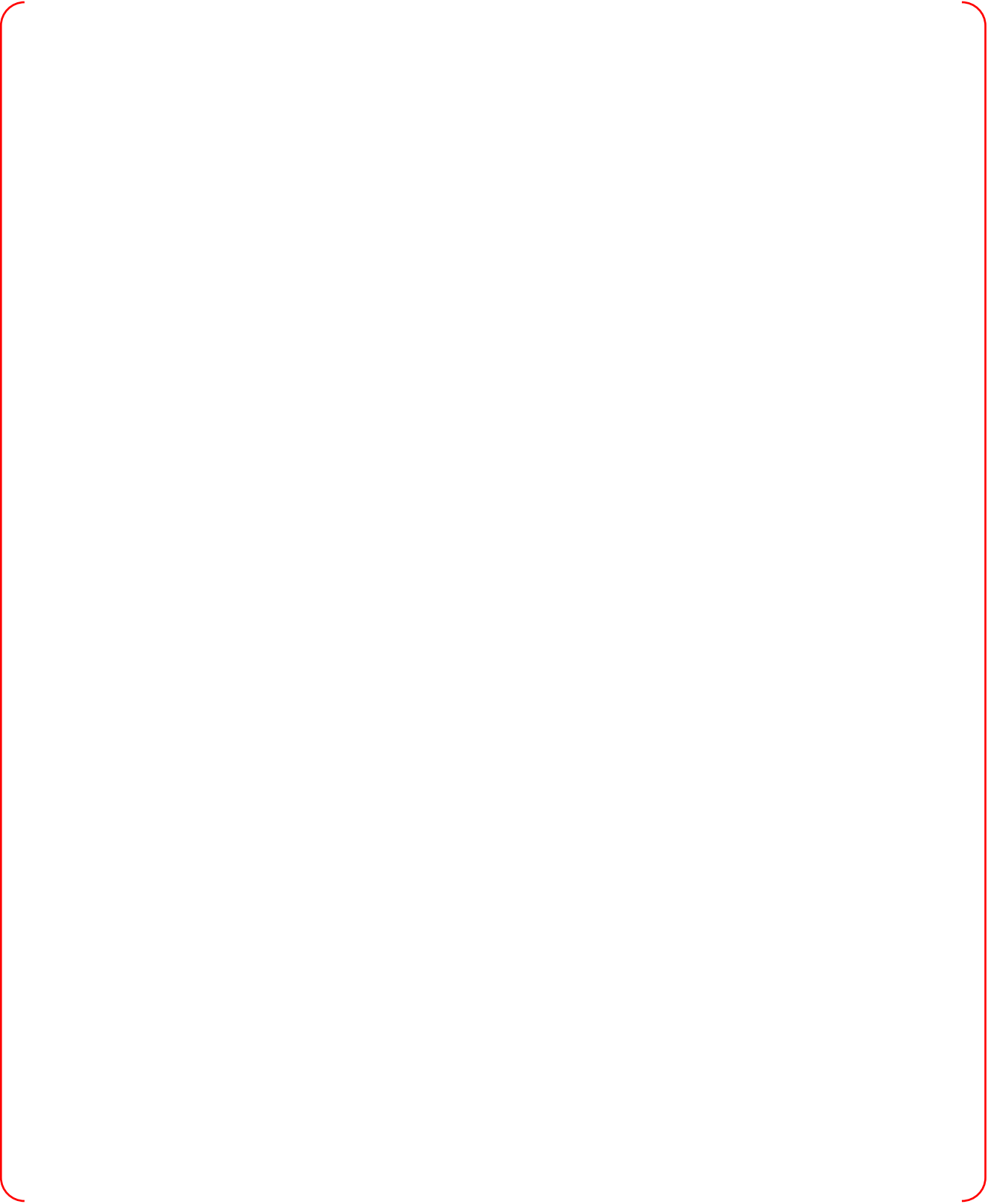
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3.3 Debrief

3.3.1 Post Exercise Evaluation

TS

3.3.2 Data Acquisition

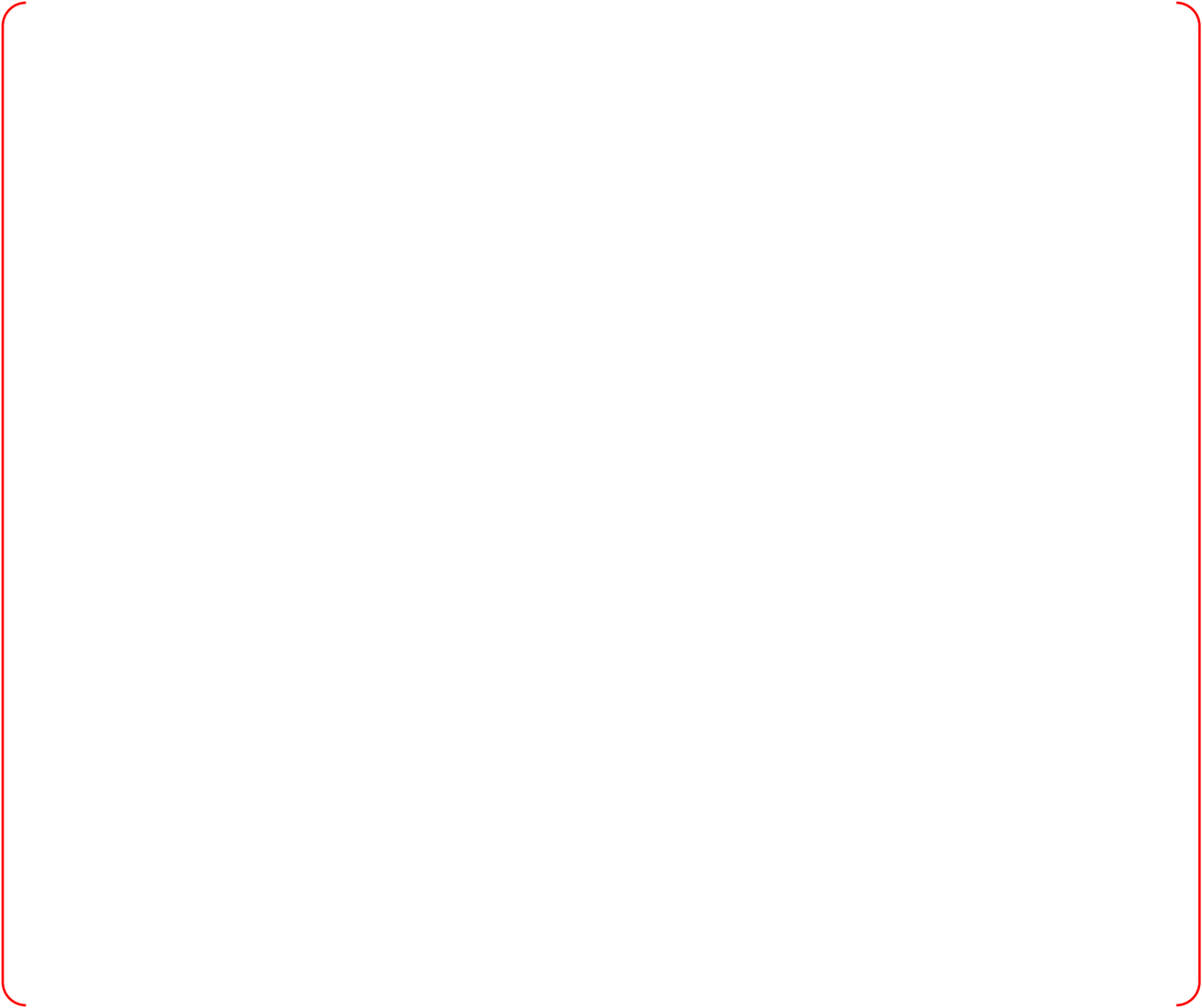
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ISV-5 ATTACHMENT 1 - TRENDING PARAMETERS

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ISV-5 ATTACHMENT 2 - MALFUNCTION LIST

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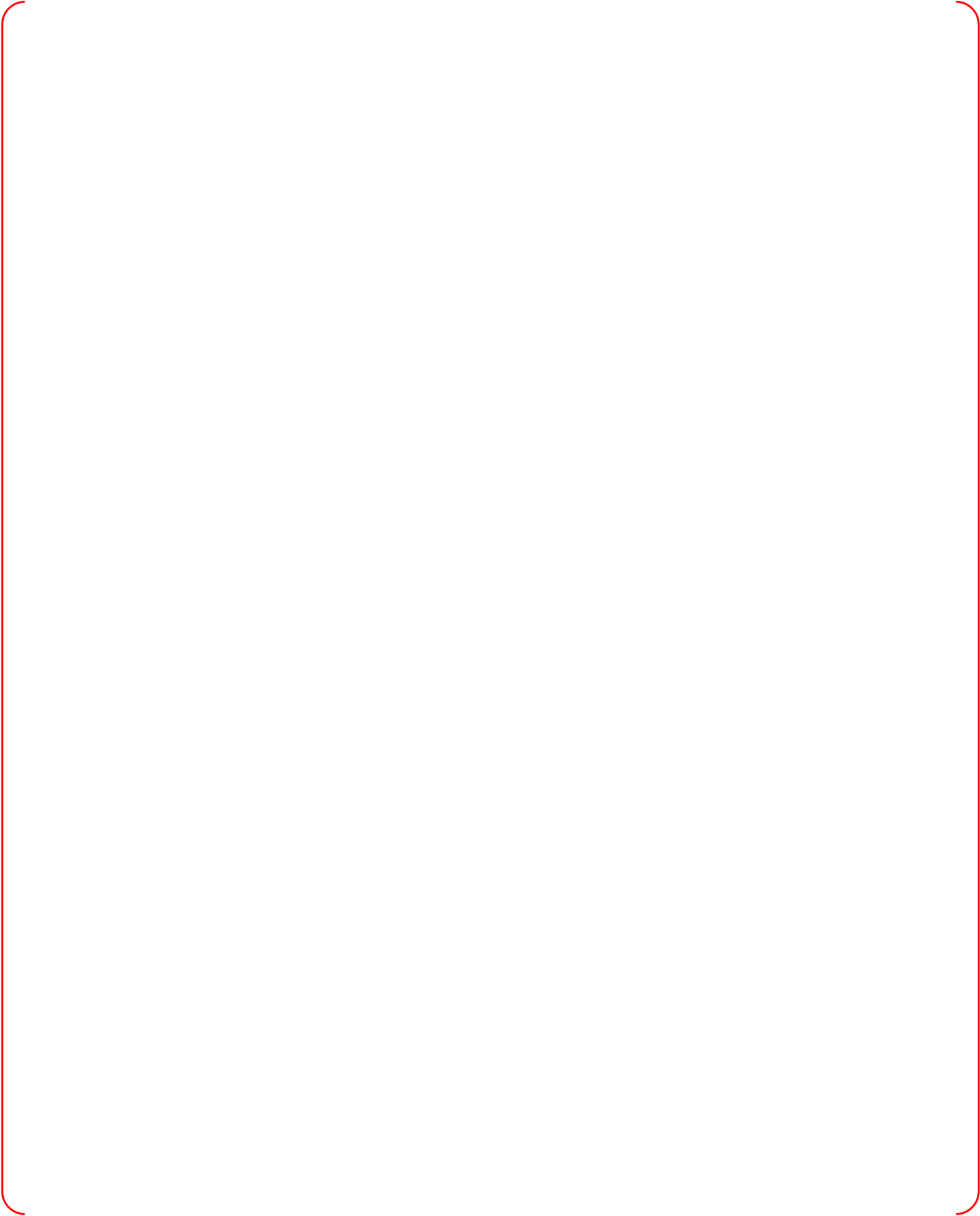
ISV-5 ATTACHMENT 3 - SHIFT TURNOVER SHEET

TS



ISV-5 ATTACHMENT 4 - ANTICIPATED DIALOG

TS





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

TS



APPENDIX F

Station Black Out

ISV-6

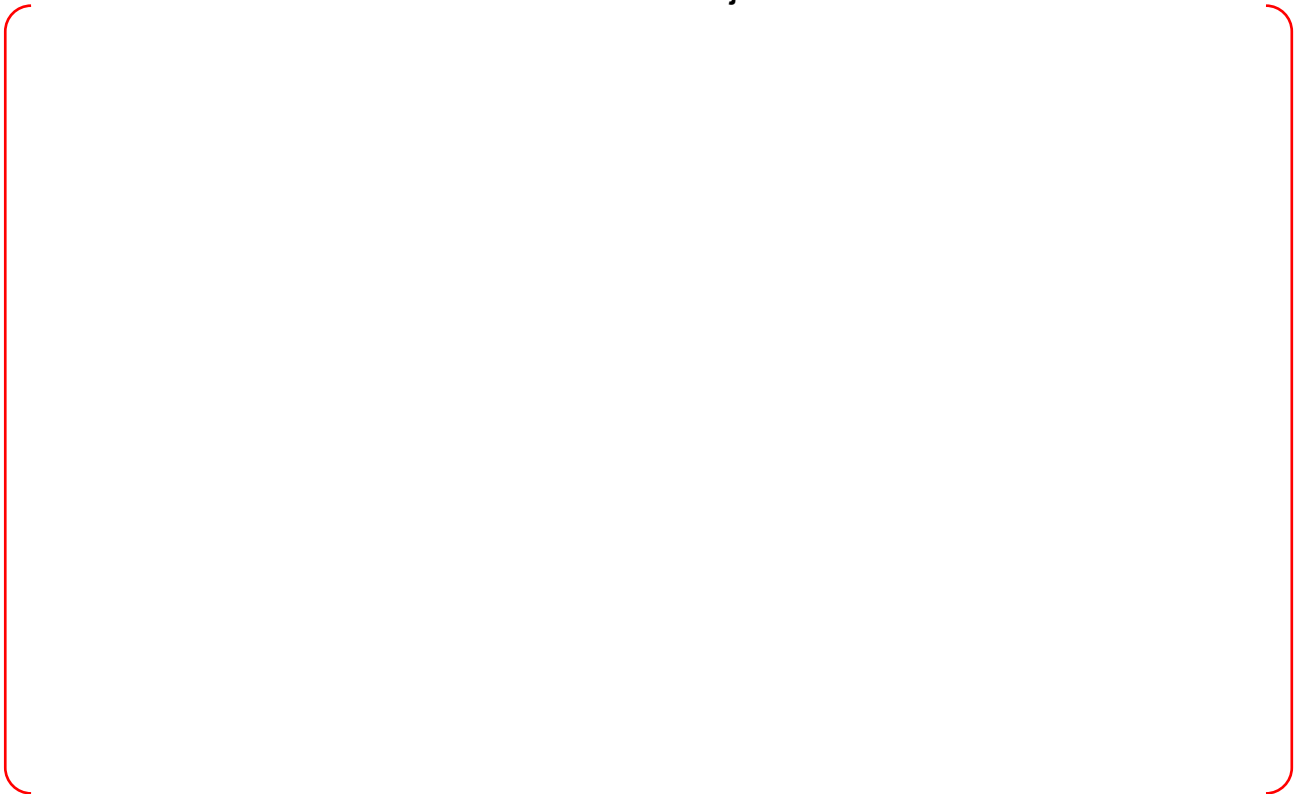
TABLE OF CONTENTS

1.	OVERVIEW.....	F3
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
2.	FACILITATORS INFORMATION	F11
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
3.	SIMULATOR EXERCISE EVALUATION.....	F13
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 Tavq 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
	ISV-6 ATTACHMENT 1 - TRENDING PARAMETERS.....	F40
	ISV-6 ATTACHMENT 2 - MALFUNCTION LIST.....	F43
	ISV-6 ATTACHMENT 3 - SHIFT TURNOVER SHEET	F44
	ISV-6 ATTACHMENT 4 - ANTICIPATED DIALOG.....	F45
	ISV-6 ATTACHMENT 5 – GUIDANCE WHEN DIFFICULTIES OCCUR DURING SIMULATION OR TESTING.....	F47

1. OVERVIEW

1.1 Human Factors Verification and Validation Objectives

TS



1.2 Scenario Overview

TS



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 -- 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

TS



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3.2.6 Event 6 Steam Generator Tube Rupture (SGTR)

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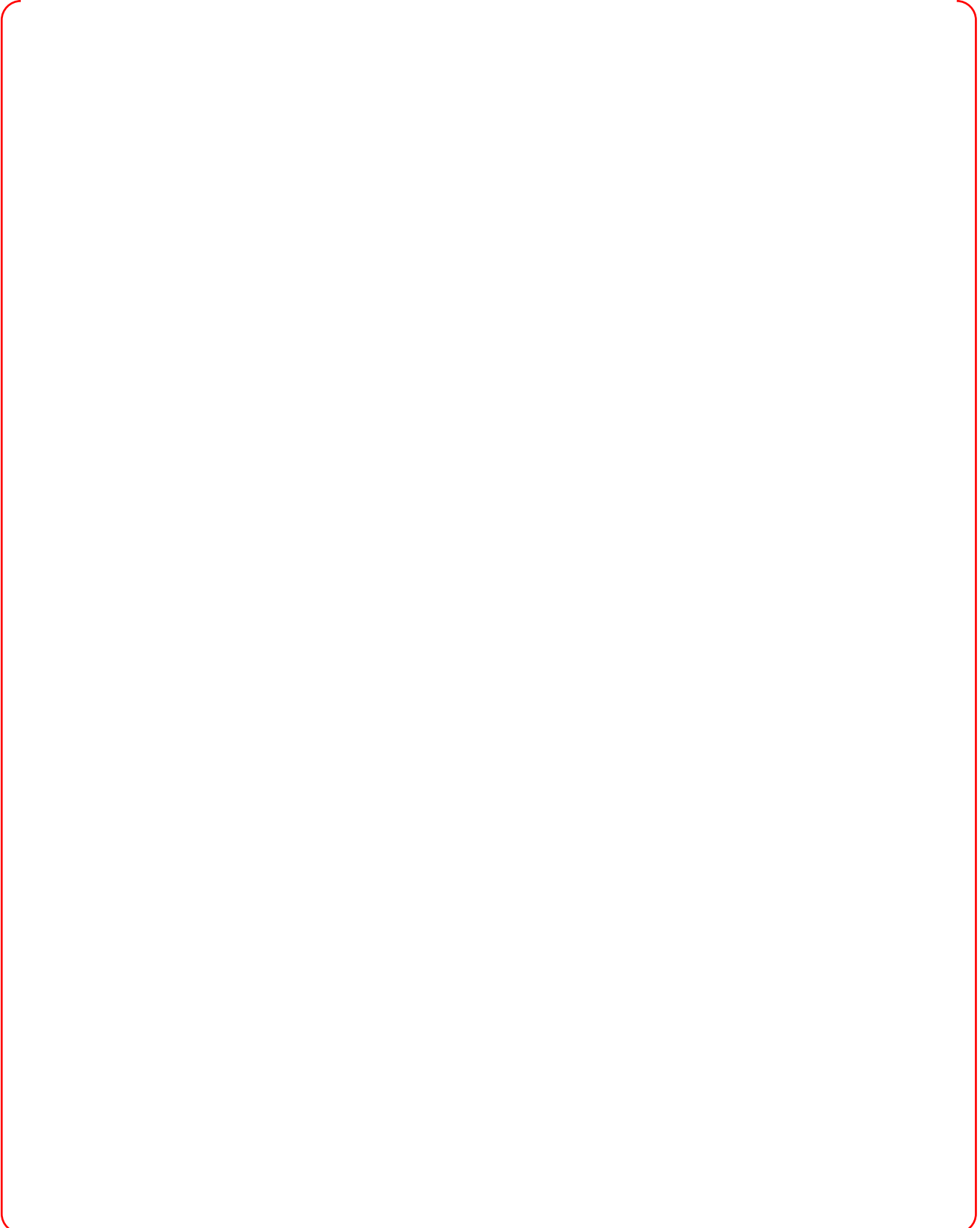








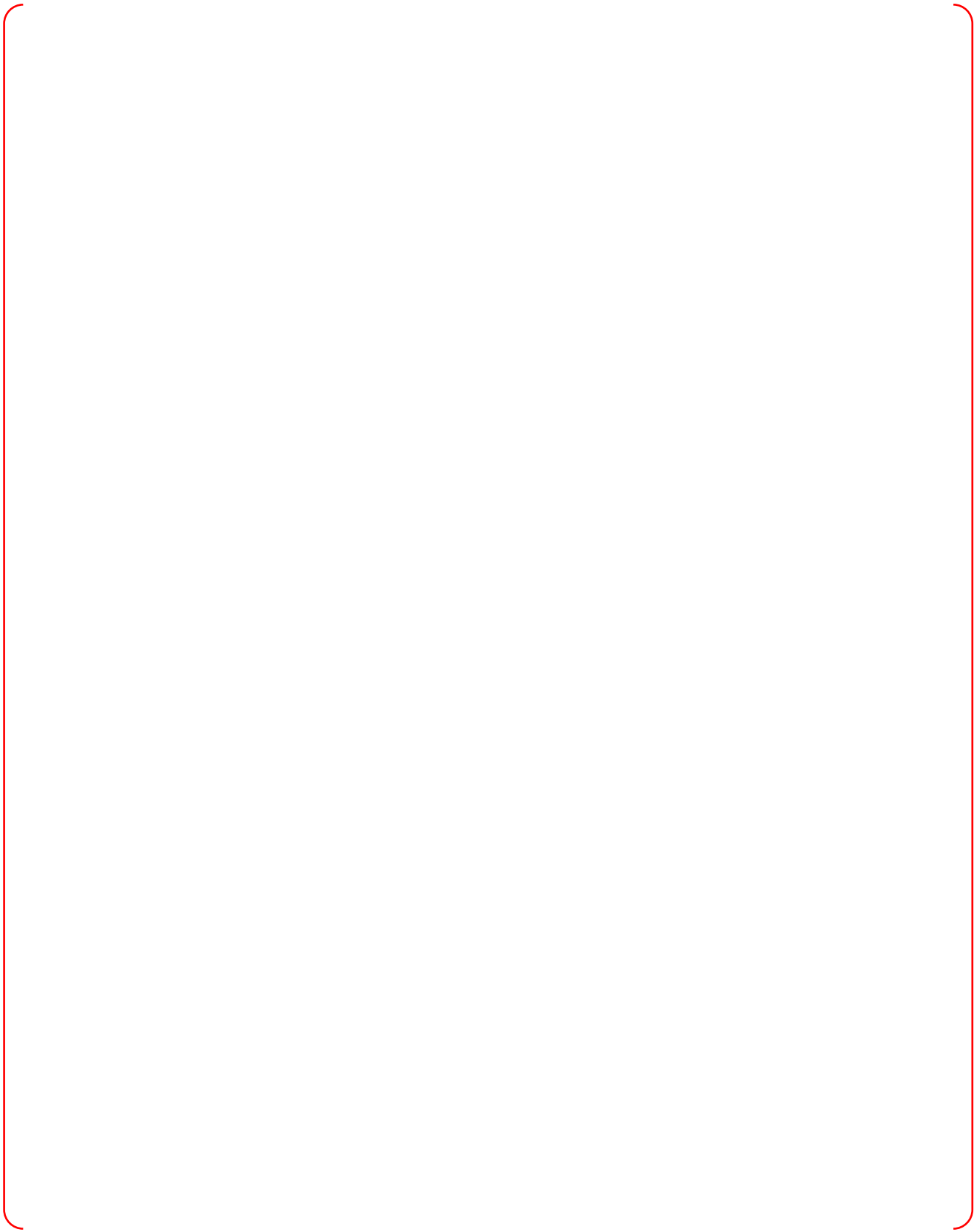


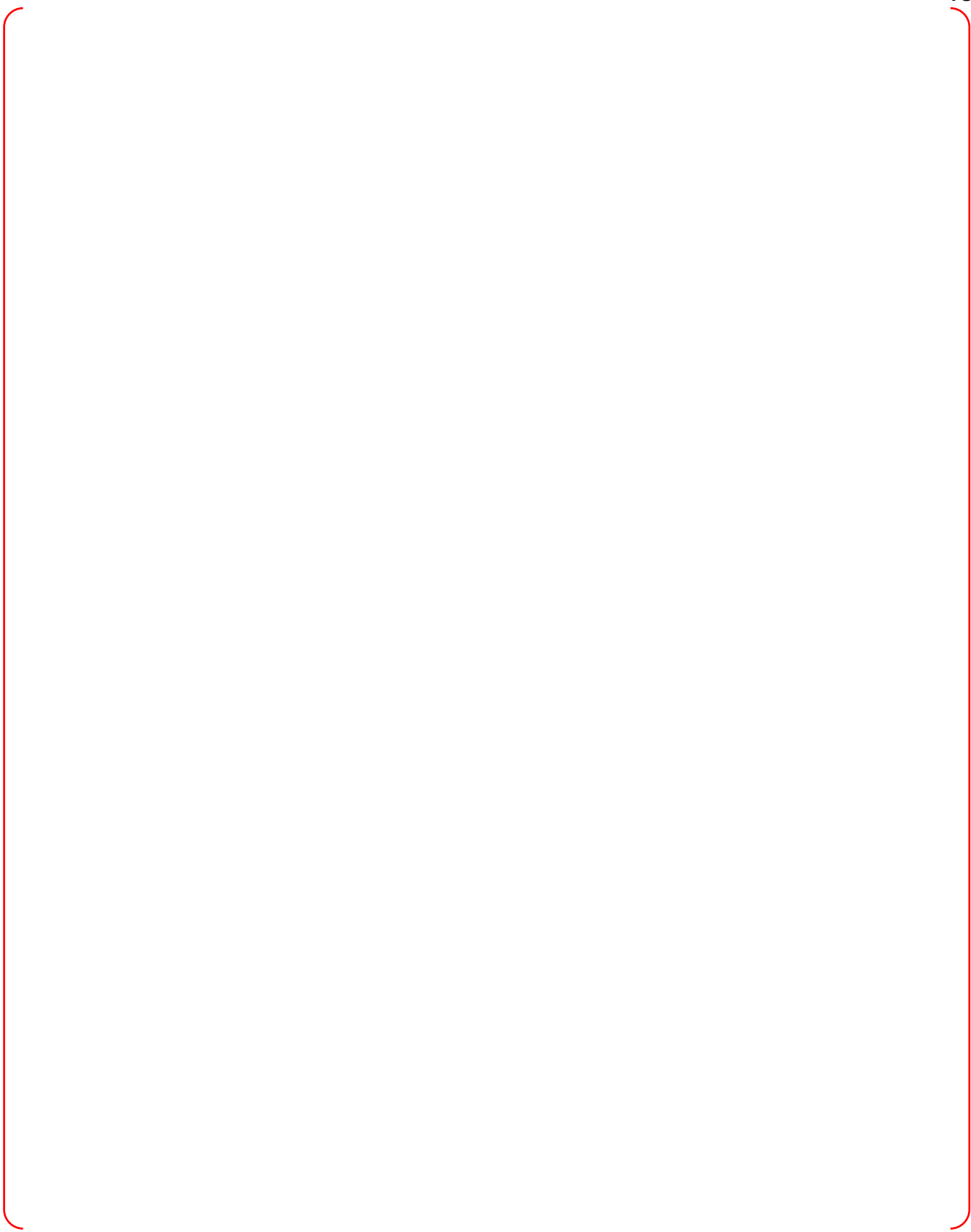






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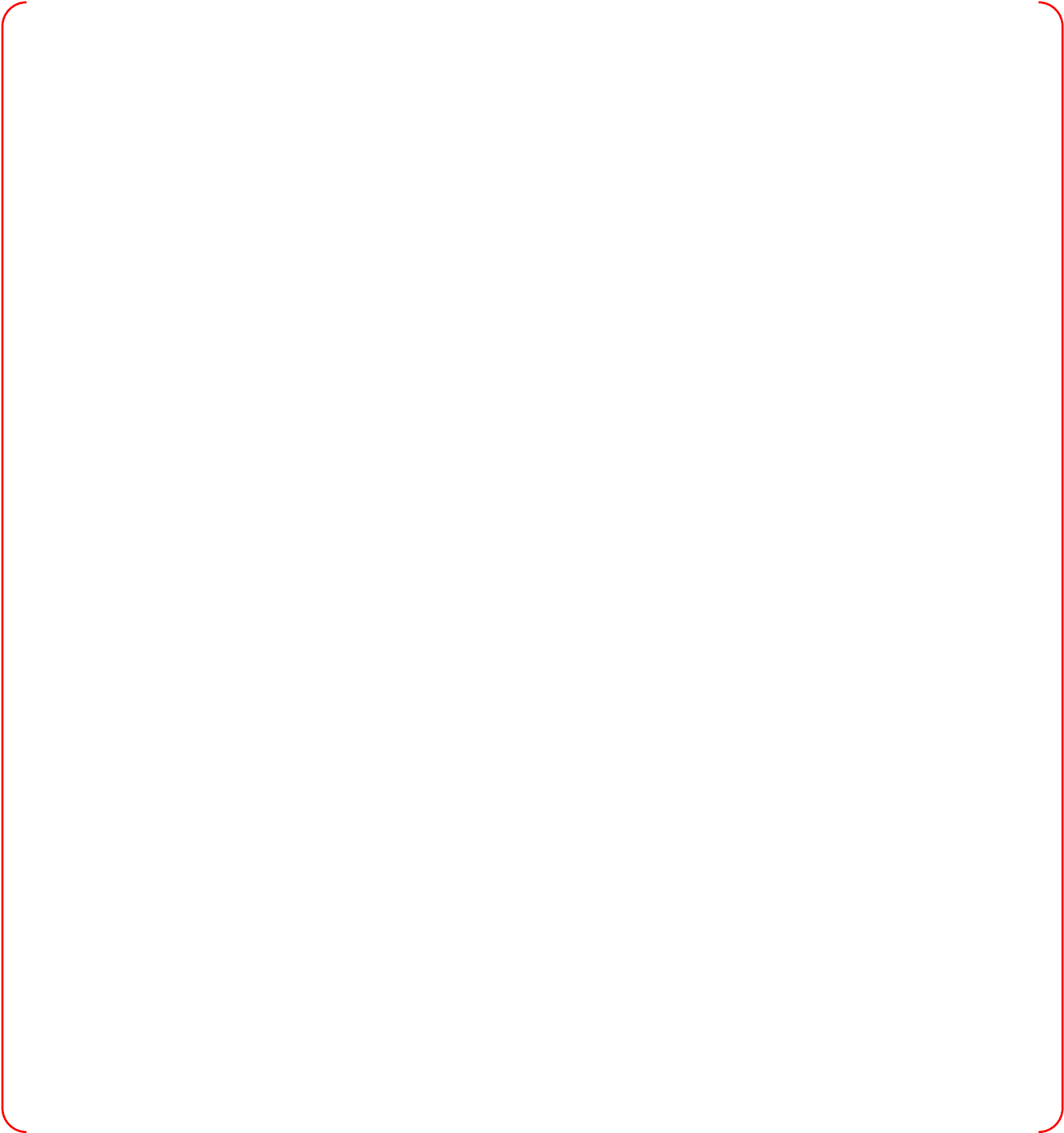








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3.3 Debrief

3.3.1 Post Exercise Evaluation

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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

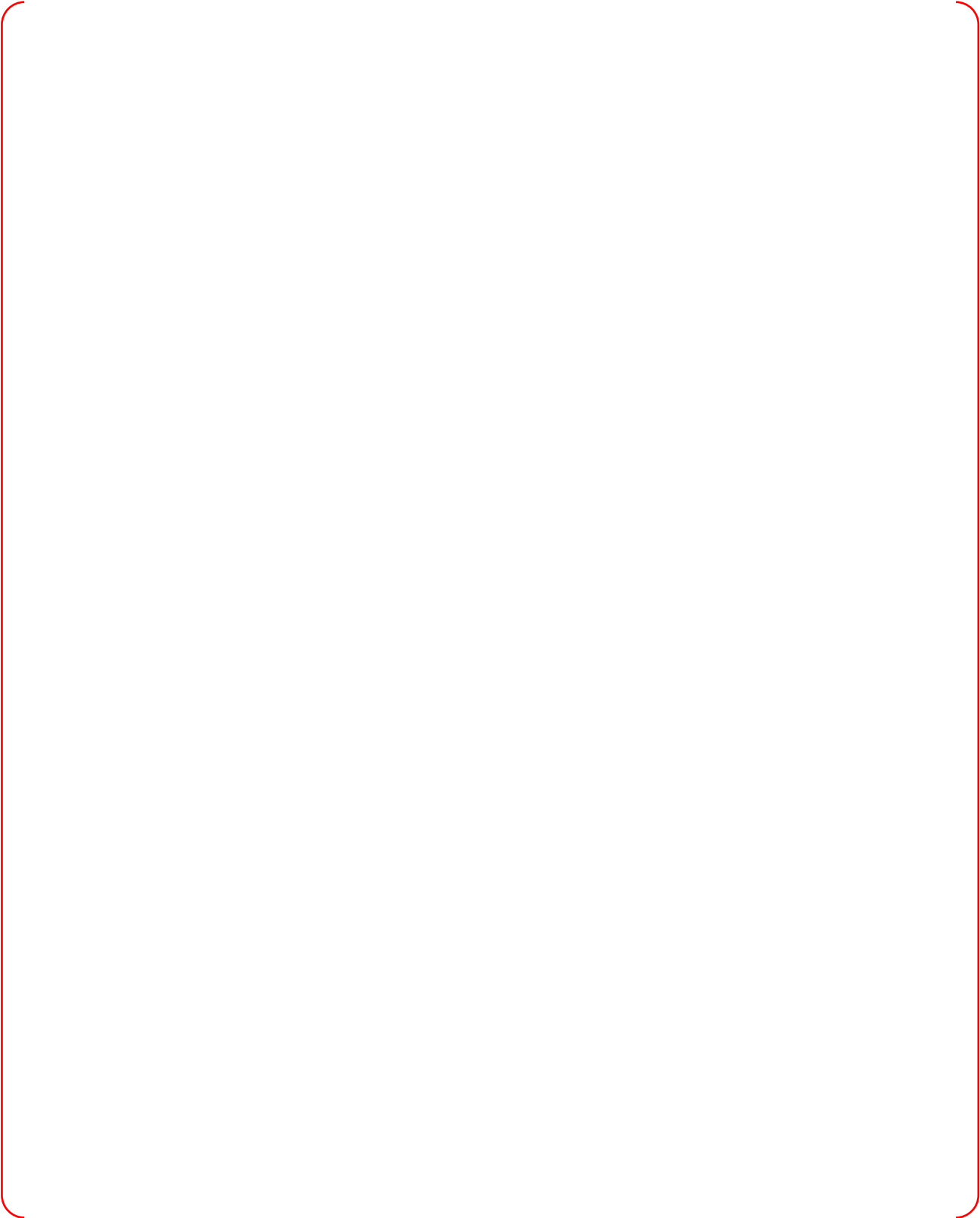


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ISV-6 ATTACHMENT 5 - GUIDANCE WHEN DIFFICULTIES OCCUR DURING SIMULATION OR TESTING

TS



APPENDIX G

Main Control Room Fire

ISV-7

TABLE OF CONTENTS

1.	OVERVIEW.....	G3
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
2.	FACILITATORS INFORMATION	G11
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
3.	SIMULATOR EXERCISE EVALUATION.....	G13
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
3.3	Debrief	G20
3.3.1	Post Exercise Evaluation.....	G20
3.3.2	Data Acquisition.....	G20
	ISV-7 ATTACHMENT 1 - TRENDING PARAMETERS.....	G21
	ISV-7 ATTACHMENT 2 - MALFUNCTION LIST.....	G24
	ISV-7 ATTACHMENT 3 - SHIFT TURNOVER SHEET	G25
	ISV-7 ATTACHMENT 4 - ANTICIPATED DIALOG	G26
	ISV-7 ATTACHMENT 5 - GUIDANCE WHEN DIFFICULTIES OCCUR DURING SIMULATION OR TESTING.....	G27

1. OVERVIEW

1.1 Human Factors Verification and Validation Objectives

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1.2 Scenario Overview

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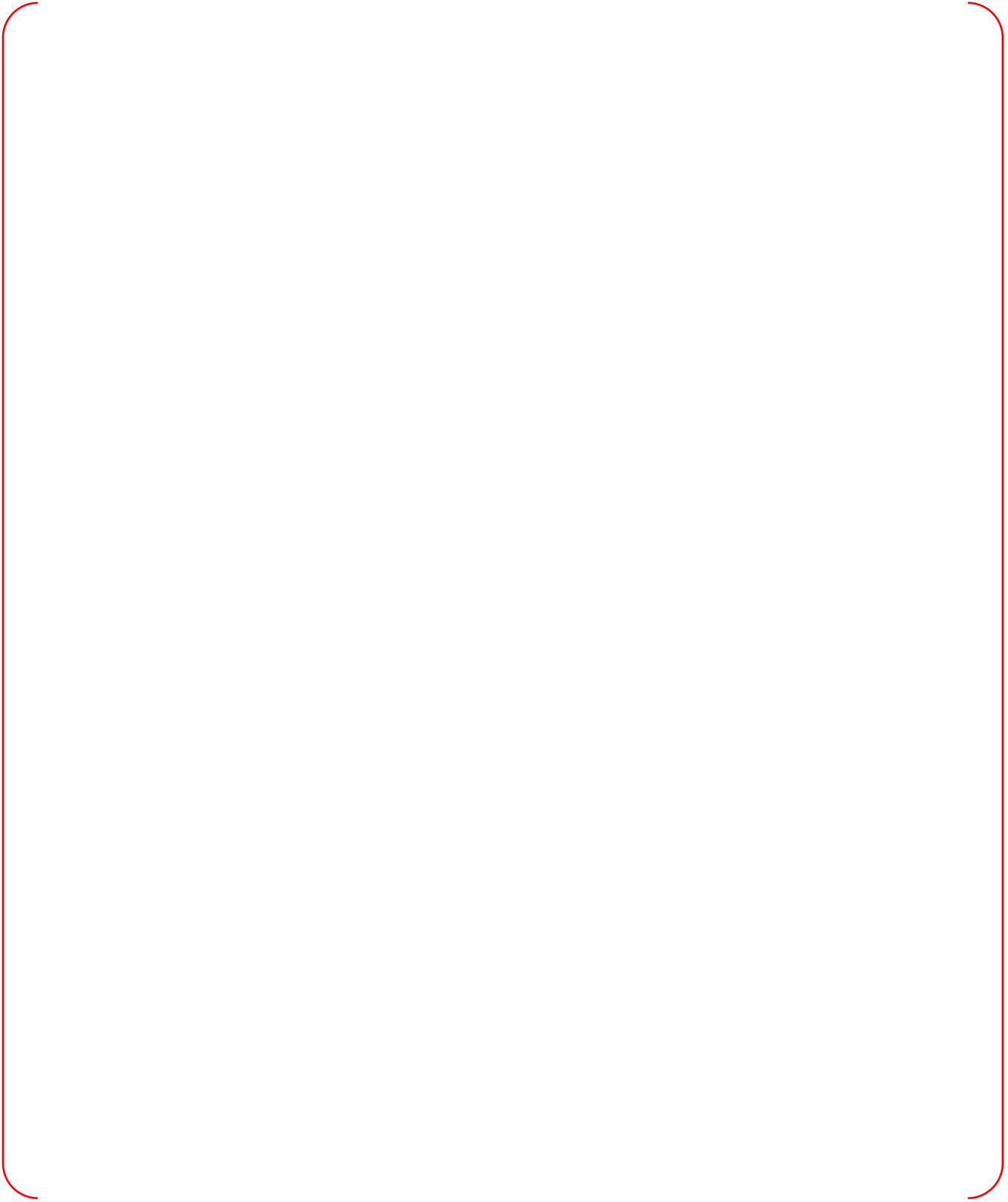


1.3 Performance Measures

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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

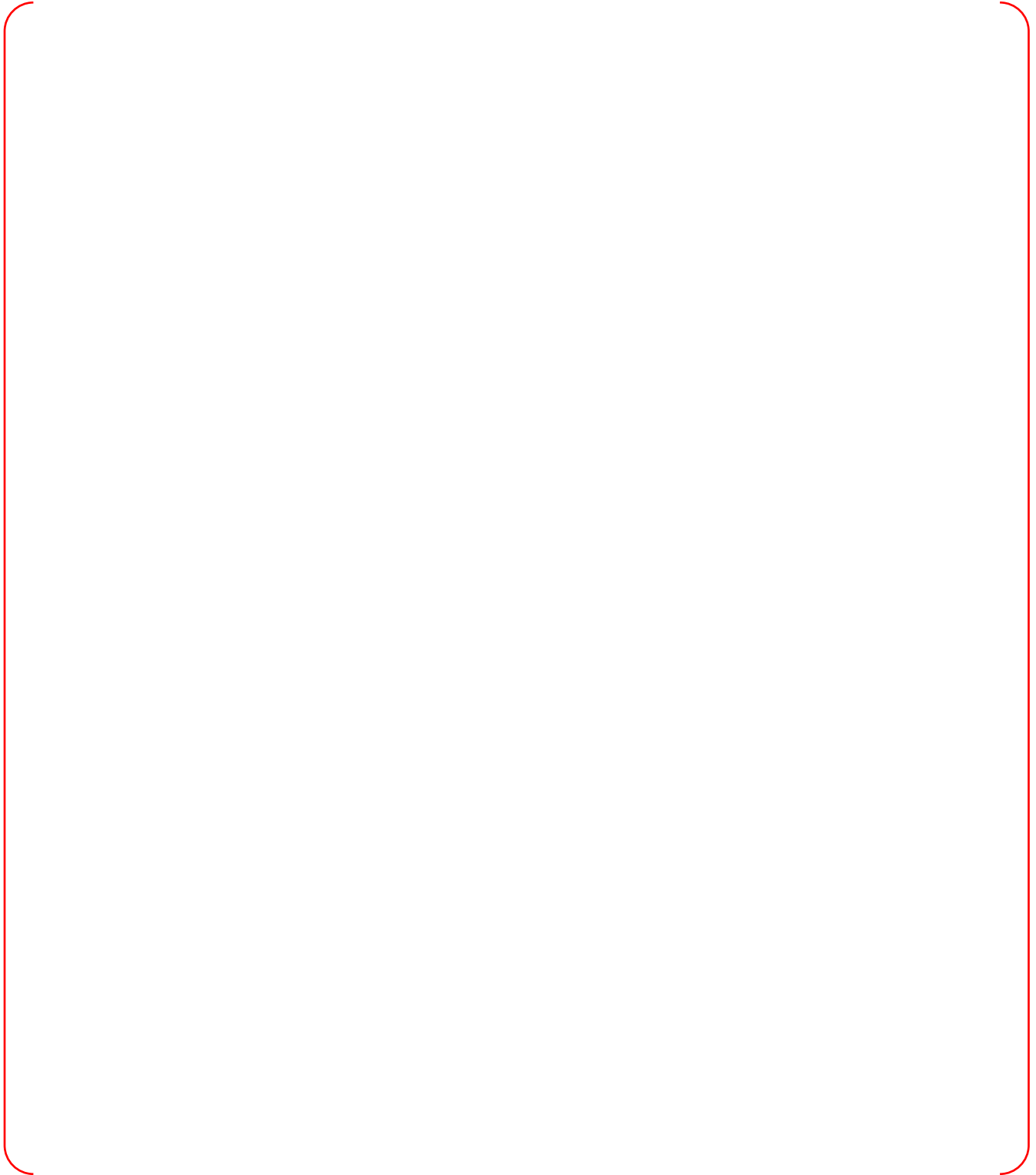
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2. FACILITATORS INFORMATION

2.1 Scenario Timeline

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2.2 Procedure Flowpath

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2.3 Emergency Plan

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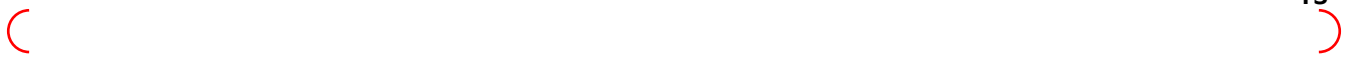
2.4 Technical Specifications

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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

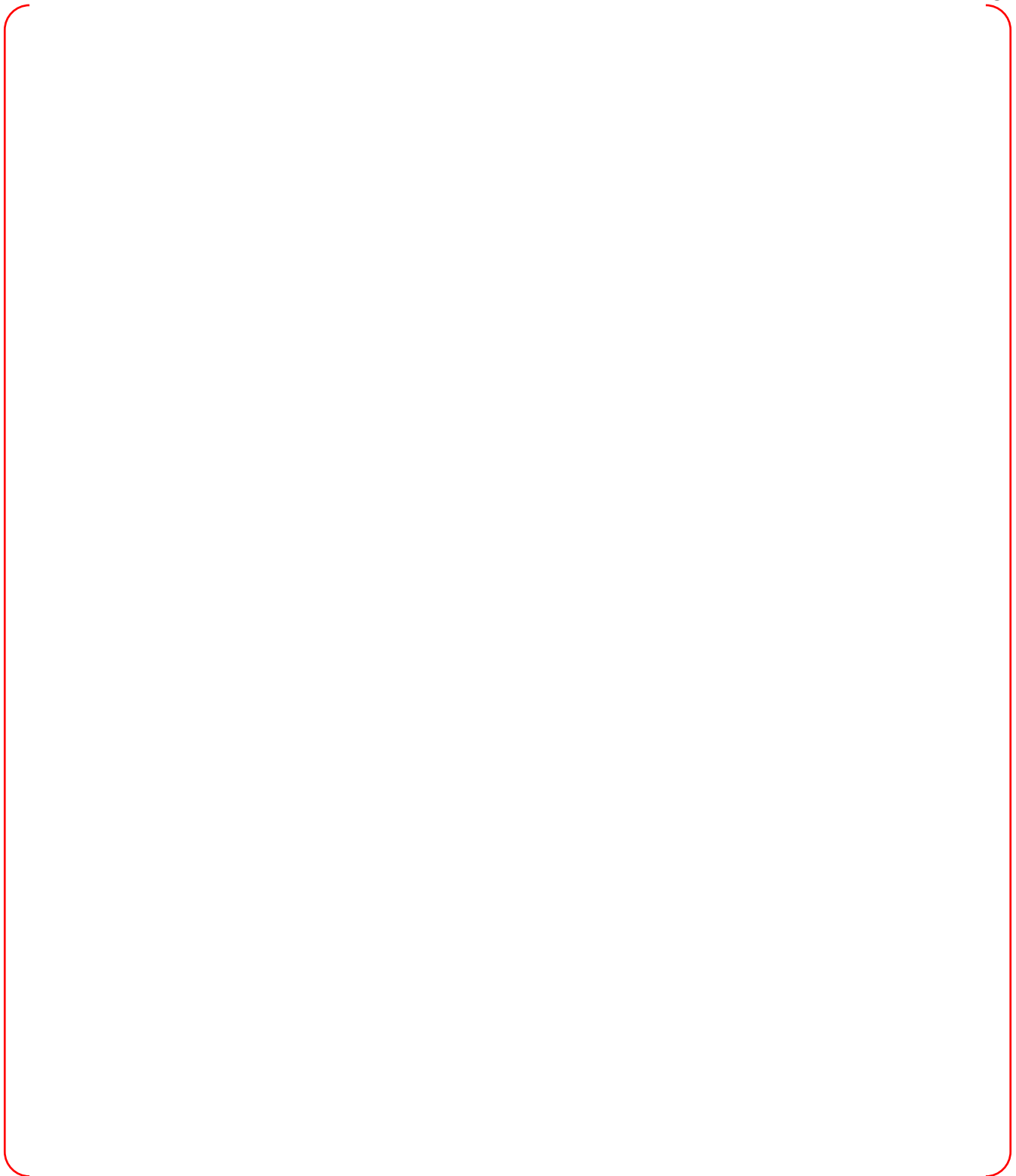
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3.2 Evaluation

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

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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

TS



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

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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

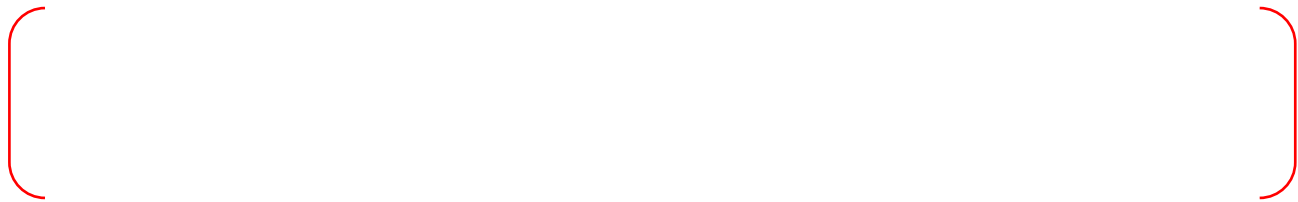
3.3.1 Post Exercise Evaluation

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3.3.2 Data Acquisition

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ISV-7 ATTACHMENT 1 - TRENDING PARAMETERS

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ISV-7 ATTACHMENT 2 - MALFUNCTION LIST

TS



ISV-7 ATTACHMENT 3 - SHIFT TURNOVER SHEET

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A large, empty rectangular area defined by a thin red line with rounded corners. This area is intended for the content of the 'SHIFT TURNOVER SHEET'.

ISV-7 ATTACHMENT 4 - ANTICIPATED DIALOG

TS



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

TS

