

# **The Development of The PRiSE, A Significance Determination Process (SDP) Tool**

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# Outline

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- Introduction
- Features of ROP/SDP
- Introduction of the PRiSE
- Display of the PRiSE
- Conclusions



# Introduction

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- A table-based Significance Determination Process (SDP) of the Reactor Oversight Process (ROP) has been provided by the USNRC to determine the safety significance of resident inspection findings
- After a preliminary screening (the Phase 1 of SDP) of inspection findings, an assessment process is conducted to obtain a risk approximation and to help the inspectors determine the risk significance (the Phase 2 of SDP)

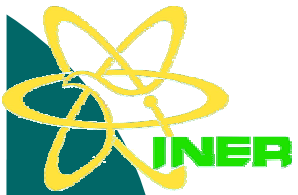


## Features of ROP/SDP

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- Implemented by NRC since 2000
- Make the **oversight process** more **objective**, **predictable**, **consistent**, and **risk-informed**
- Reduce unnecessary regulatory burden
- Integrate **inspection**, **assessment**, and **enforcement** processes
- Utilize objective indicators of performance





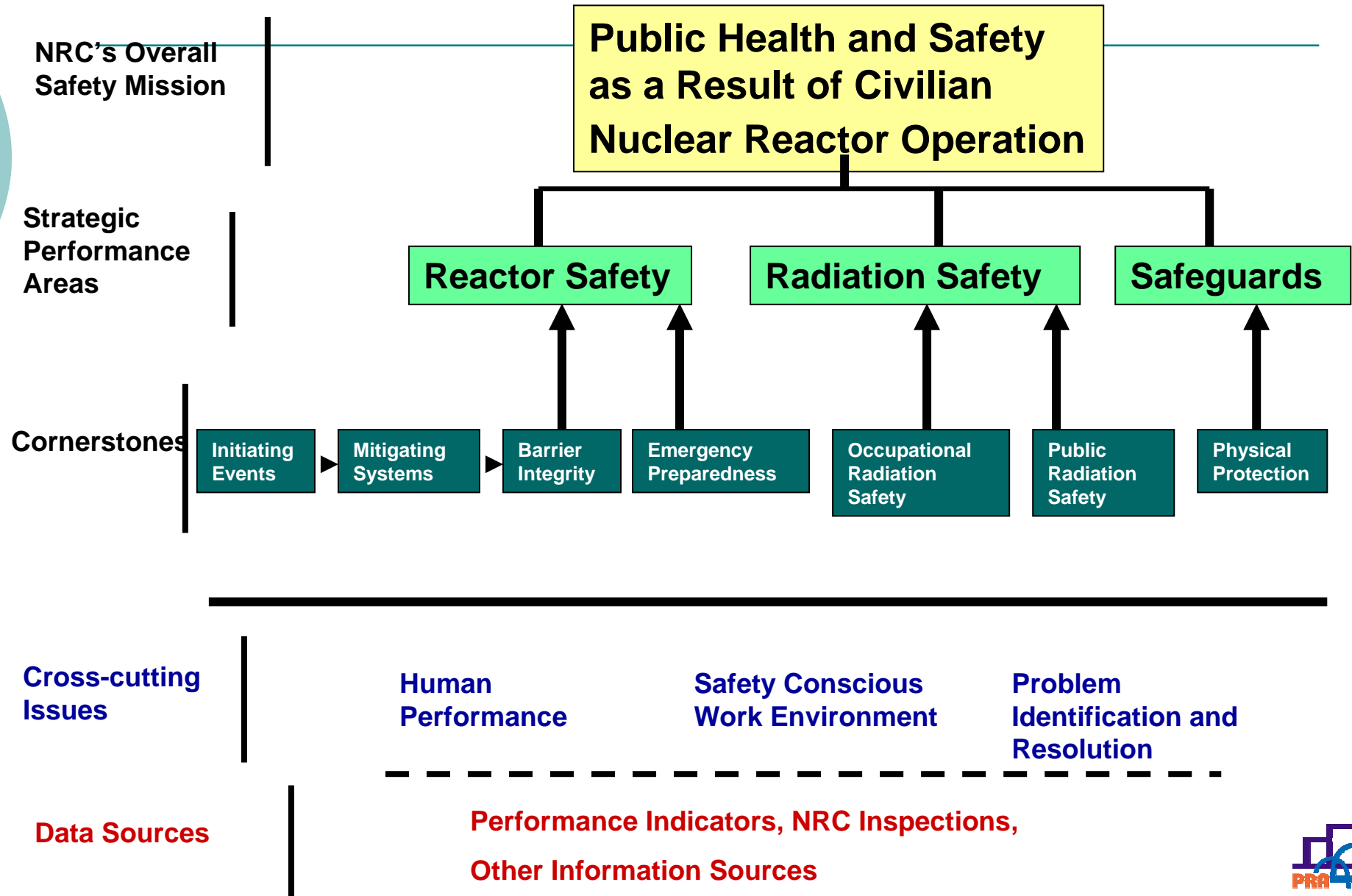
## Features of ROP/SDP

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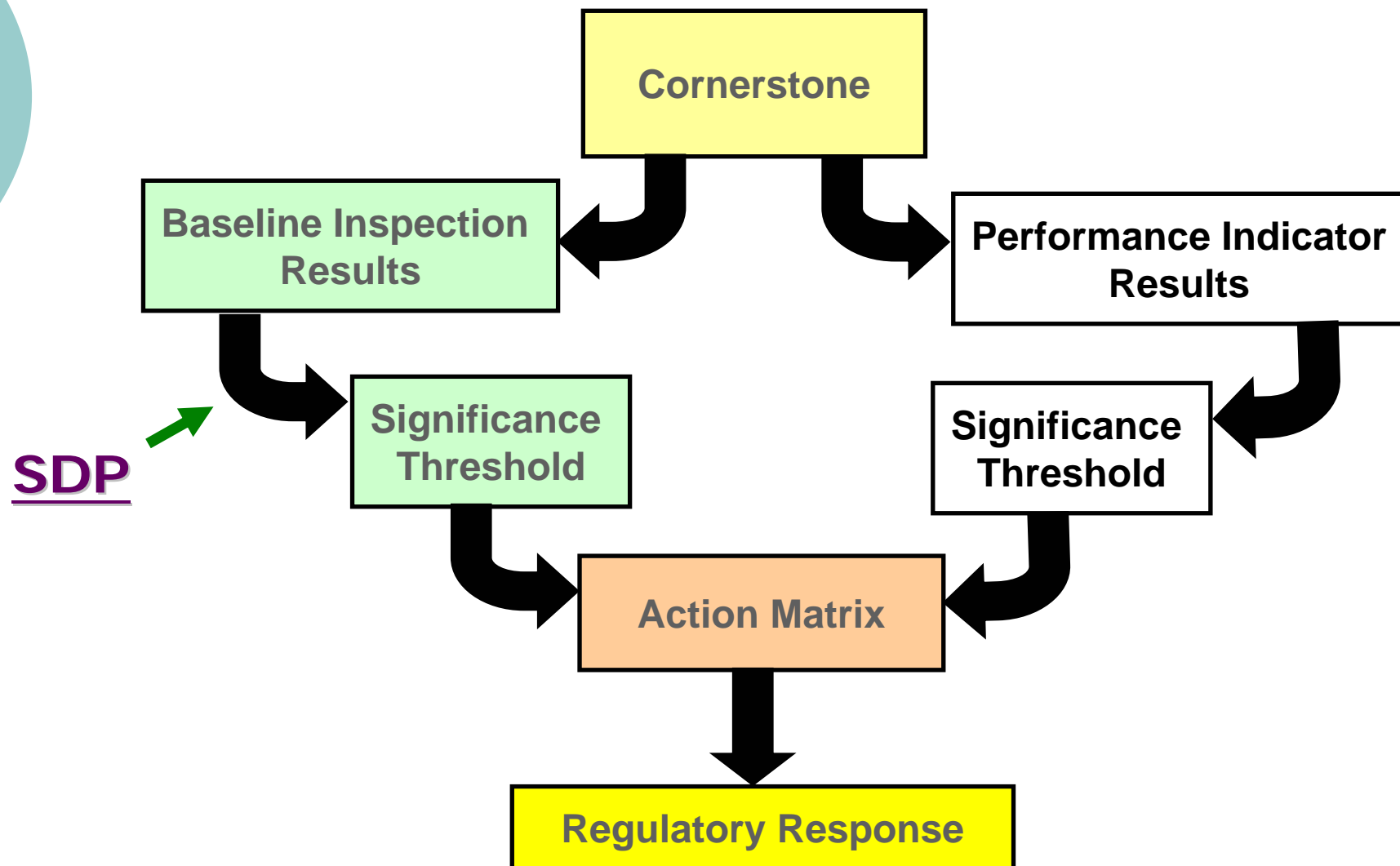
- Utilize inspections focused on key safety areas
- Apply greater regulatory attention to facilities with performance problems while maintaining a base level of regulatory attention on plants that perform well
- Respond to violations in a predictable and consistent manner that reflects the safety significance of the violations.



# Reactor Oversight Process (ROP)



# Assessing Performance and Responses



# Levels of Significance Associated with Performance Indicators and Inspection Findings

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- Green - very low risk significance (for PIs: Within peer performance)
- White - low to moderate risk significance
- Yellow - substantive risk significance
- Red - high risk significance

$\Delta\text{CDF} < 1\text{E-}6$
$1\text{E-}6 < \Delta\text{CDF} < 1\text{E-}5$
$1\text{E-}5 < \Delta\text{CDF} < 1\text{E-}4$
$\Delta\text{CDF} > 1\text{E-}4$



# Significance Determination Process (SDP)

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- Objectives
  - To characterize the safety significance of inspection findings for the NRC Reactor Oversight Process (ROP), using risk insights as appropriate
  - To provide all stakeholders an objective and common framework for communicating the potential safety significance of inspection findings
  - To provide a basis for timely assessment and/or enforcement actions associated with an inspection finding
  - To provide inspectors with plant-specific risk information for use in risk-informing the inspection program



# Inspection Manual Chapter (IMC) 0609

## Appendices for SDP

App.	Purpose
A	<b>Power operation</b>
B	Emergency Preparedness
C	Occupational Radiation Safety
D	Public Radiation Safety
E	Physical Protection

App.	Purpose
F	Fire Protection and Post-Fire Safe Shutdown
G	Shutdown Safety
H	Containment Integrity
I	Operator Re-qualification and Performance
J	SG Tubes Integrity



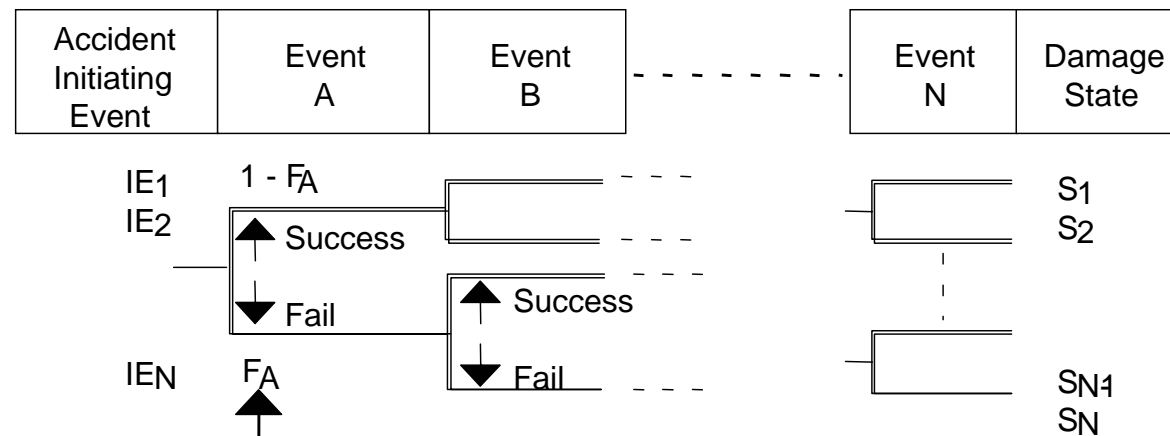
# SDP for Power Operation

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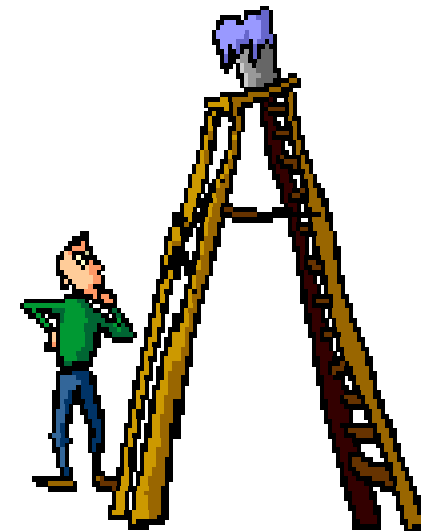
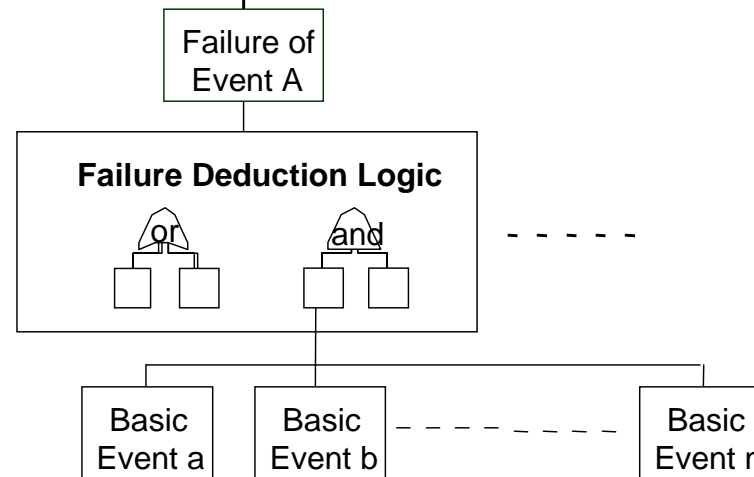
- Phase 1  
Characterization and Initial Screening of Findings,  
conducted by resident inspector
- Phase 2  
Risk Significance Estimation and Justification Using  
the Site Specific Risk-Informed Inspection  
Notebook, conducted by resident inspector
- Phase 3  
Risk Significance Estimation Using Any Risk Basis  
That Departs from the Phase 1 or 2 Process,  
usually conducted by SRA

# Scenario-based PRA Logic

## Scenario Level Event Tree Analysis



## System Level Fault Tree Analysis







# Power Operation Phase 2 SDP

$$\text{Risk} \sim P_{\text{Initiating}} \cdot P_{\text{Mitigation}} \cdot P_{\text{Consequence}}$$

$\underbrace{\hspace{10em}}_{\text{CDF (App. A)}} \qquad \underbrace{\hspace{10em}}_{\text{LERF (App. H)}}$

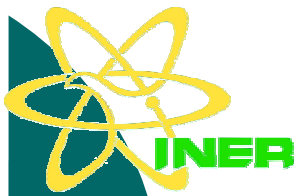
Steps (exercising on “tables”):

1. Circle the accident sequences affected by the performance insufficiency found through inspection
2. Evaluate the increase in initiating event likelihood ( $\Delta P_{\text{Initiating}}$ ) caused by performance insufficiencies
3. Evaluate the degradation in Mitigating Capabilities ( $\Delta P_{\text{Mitigation}}$ ) caused by Performance Insufficiencies
4. Sum up (simply counting rule) the P's in all the affected accident sequences to get the increase in CDF ( $\Delta \text{CDF}$ )

# PRiSE

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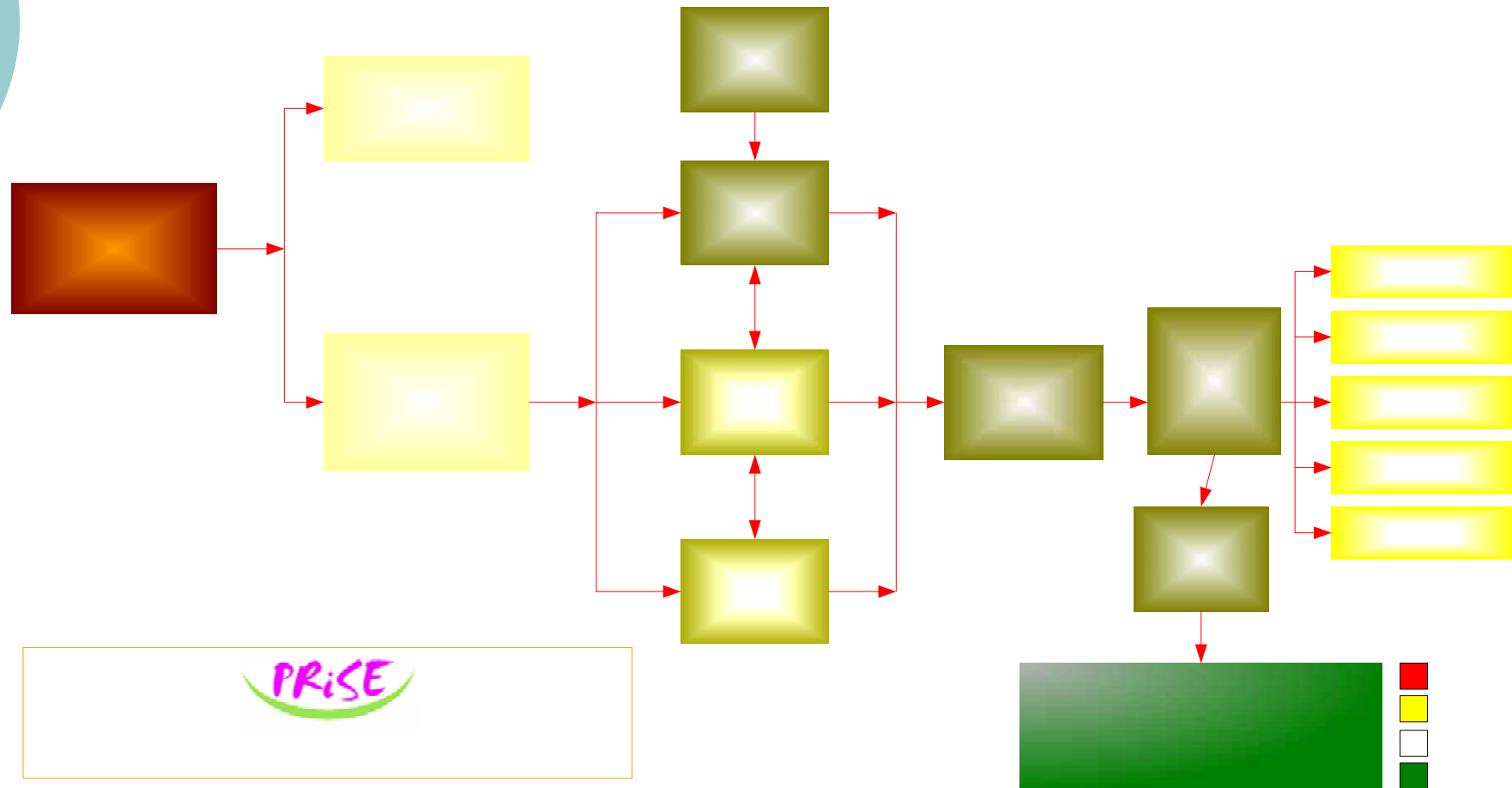
- A “PRA Model Based Risk Significance Evaluation Tool” to perform Phase 2 SDP assessment for TAEC
- Developed by PRA group of INER
- A plant-specific tool
  - For BWR-4, BWR-6 and PWR
  - Use plant-specific living PRA model
  - Obtain  $\Delta$ CDF by resolving PRA model
- Adopt a high performance risk engine (i.e. INERISKEN) developed by INER
- Provide risk significance in SDP context



# A Comparison between IMC 0609 and PRiSE

US NRC IMC 0609 Appendix A			PRiSE
Step	Purpose	Reference	
1.1~1.2	Screening Analysis	Phase 1 Table	Same Criteria by Program
2.1	Initiators and System Dependency	Phase 2 Table 2	Well-Addressed in PRA Model
2.2	Initiating Event Likelihood	Phase 2 Table 1	Input Duration
2.3	Remaining Mitigation Capability	Phase 2 Table 3,5	System Unavailable or Component Failure
2.4	Risk Significance	Phase 2 Table 4,6	$\Delta\text{CCDF} \times (\text{Duration}/365)$
2.5	External Initiating Events	Phase 3	Plant-Specific PRA Model Seismic, Flood, Typhoon
2.6	LERF	Appendix H	Plant-Specific LERF Model

# PRiSE Flow Chart





# Features of the PRiSE

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- Calculations based on plant-specific PRA model
  - CDF and  $\Delta$ CDF
  - Minimum Cut Sets
  - Importance results (F-V, RAW and RRW)
- User-friendly interface
- Detail displays of risk index
- For Internal events at Power only

# Safety-Related System Status

System Change

[Operating Status]
[Initiating Event]
[Component]
[Summary of Change]
[Main Menu]

Front Line System

☐ RCIC
☐ HPCS
☐ ADS
☐ LPCS

RHR

☐ RHR System
☐ Train
☐ RHR-A
☐ RHR-B
☐ RHR-C

SBLC

☐ SBLC System
☐ Train
☐ SBLC-A
☐ SBLC-B

Support System

☐ COND
☐ CSTXR
☐ SGTS
☐ FIRE WATER

ECW

☐ ECW System
☐ Train
☐ ECW-A
☐ ECW-B
☐ ECW-C

EChW

☐ EChW System
☐ Train
☐ EChW-A
☐ EChW-B

Power Supply

☐ 345KV
☐ D/G I
☐ 69KV
☐ D/G II
☐ BUS A5
☐ D/G III
☐ D/G 5

A3

☐ Bus A3
☐ MCC
☐ C3A
☐ C3B
☐ C3C
☐ C3D

A4

☐ Bus A4
☐ MCC
☐ C4A
☐ C4B
☐ C4C
☐ C4D

P & ID

Front Line System

RCIC
LPCS
HPCS
LPCI
RHR S/D Cooling
RHR S/P Cooling
RHR CTMT Spray
SBLC

Support System

ECW
EChW-A
EChW-B
Condensate
CST Transfer
SGTS
FIRE WATER

Power Supply

A3 Bus & D/G I
A4 Bus & D/G II
A5 Bus & D/G III
D/G 5

Status

System	Remark	Times of Increase

Clear All Change

System P&ID

Front Line System

Support System

Power Supply

System Change Detail

Reactor Core Isolation Cooling System  
( RCIC )

☐ RCIC System Unavailable

☒ RCIC Failure Rate Increase by 5 Times

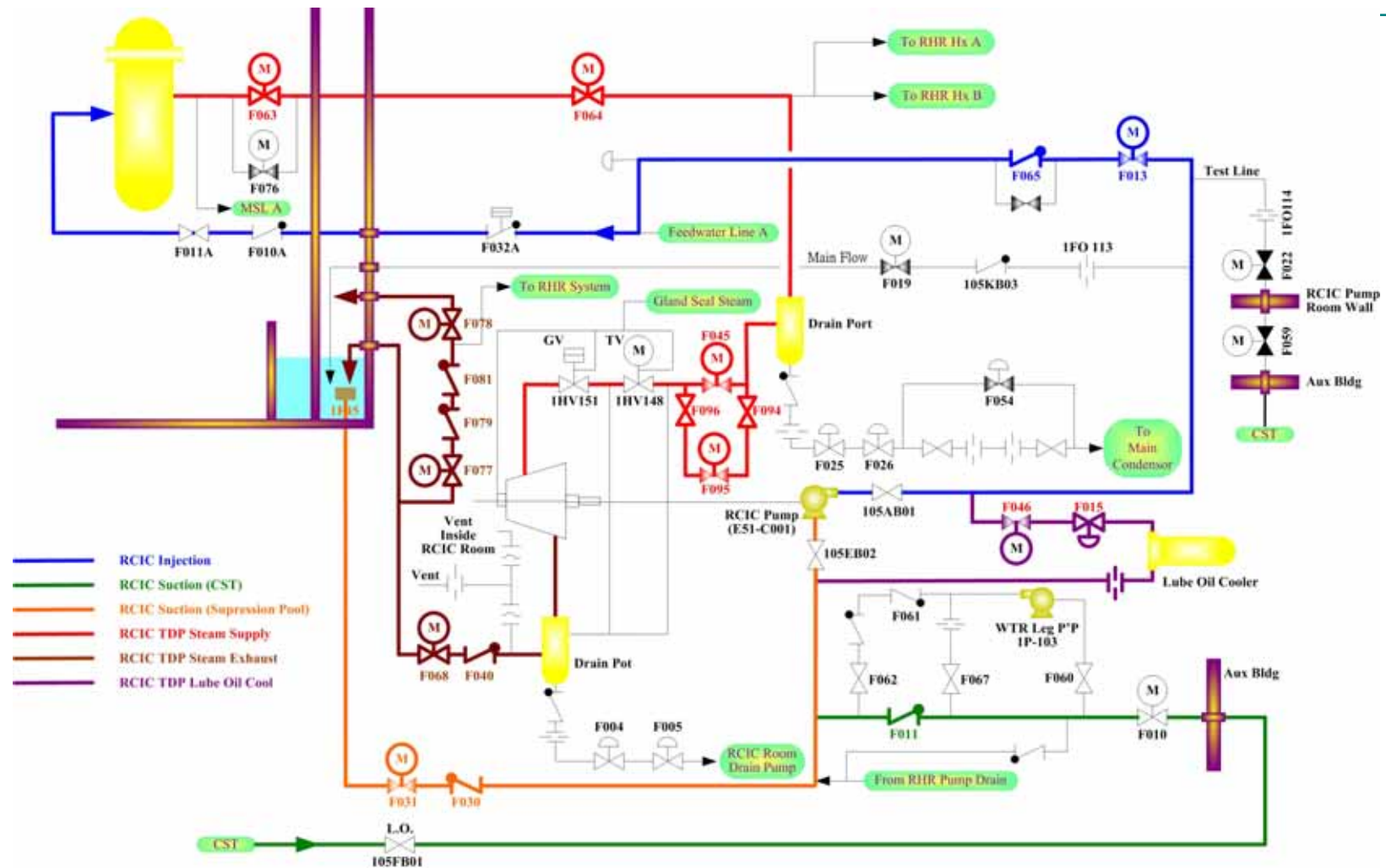
Confirm Change & Quit

Not Selected & Quit

System Fail

System Degraded

# Display of SSCs Modeled in PRA



P&ID of Reactor Core Isolation Cooling (RCIC)



# Reflect Inspection Finding by Frequency Change of Initiating Event

**Initiating Event Frequencies Change**

**【Operating Status】**  
**【Initiating Event】**  
**【Component】**  
**【Summary of Change】**

Description	Original	Modified	Times of Increase
▶ IE : LARGE LOCA	3.00E-05	1.20E-04	4
IE : BYPASS LOCA	1.70E-07		
IE : RPV RUPTURE	2.70E-07	5.40E-07	2
IE : INTERMEDIATE LOCA	4.00E-05		
IE : SMALL LOCA	3.83E-03		
IE : MAIN CONDENSER ISOLATION TRANSIENT	2.15E-01		
IE : MSIVS CLOSED TRANSIENT	3.06E-02		
IE : MAIN STEAM NOT ISOLATION TRANSIENT	1.35E+00		
IE : LOSS OF OFFSITE POWER	3.15E-02		
IE : INADVERTENT OPEN OF ONE S/RV (IORV)	4.68E-02		
IE : LOSS-OF-FEEDWATER	6.10E-02		
IE : LOSS OF 480V MCC 1C4C	2.01E-04		
IE : LOSS OF COMPRESSED AIR	2.20E-04		
IE : LOSS OF DC BUS 1RDC	6.70E-04		
IE : LOSS OF DC BUS 1GDD	6.70E-04		
IE : VLOCA AT LPCI INJECTION LINE A	4.28E-08		
IE : VLOCA AT LPCI INJECTION LINE B	4.28E-08		
IE : VLOCA AT LPCI INJECTION LINE C	3.29E-06		
IE : VLOCA AT RHR S/D COOLING SUCTION	1.52E-07		
IE : VLOCA AT RHR HEAD SPRAY INJECTION	3.29E-06		
IE : VLOCA AT RHR S/D COOLING INJECTION LINE A	7.66E-06		
IE : VLOCA AT RHR S/D COOLING INJECTION LINE B	7.66E-06		
IE : VLOCA AT LPCS INJECTION	3.29E-06		
IE : VLOCA INDUCED LARGE LOCA OUTSIDE CTMT	9.23E-09		
IE : VLOCA INDUCED LARGE LOCA INSIDE CTMT	9.44E-10		

**All Initiating Events in PRA Model**

Clear All Change

Refresh Frequencies

Save New Case

Modify Case

**Previous Cases**

Title :

Create Name : Administrator

Create Time : 2004/02/24 下午 02:48:50

Description : a typhoon





# Reflect the Inspection Findings on SSCs Reliability

**Component Change**  
[Operating Status] [Initiating Event] [Component] [Summary of Change]

Component :  All Modified change to :    
System :  Times of Increase ? Times :

**Component List**

Description	Original	Modified	Times of Increase
▶ HPCS PUMP SUCTION CHECK VALVE F002 FAILS TO OPEN	2.92E-04		
HPCS PUMP SUCTION CHECK VALVE F016 FAILS TO OPEN	2.92E-04		
HPCS PUMP DISCHARGE CHECK VALVE F024 FAILS TO OPEN	2.92E-04		
HPCS INJECTION CHECK VALVE F005 FAILS TO OPEN	1.25E-04		
HPCS INJECTION CHECK VALVE F005 FAILS TO REOPEN	1.25E-04		

All SSCs Modeled in PRA Listed by Search Criteria

**Status**

Description	Original	Modified	Times of Increase
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# List of Changes

Summary of Change

Operating Status

Initialing Event

Component

Summary of Change

Estimation

Main Menu

System Operating Status

System	Remark	Times of Increase
RCIC	RCIC Failure Rate Increase by	5

Status of Safety-Related Systems

Initiating Event Frequencies

Description	Original	Modified	Times of Increase
IE : LARGE LOCA	3.00E-05	1.20E-04	4
IE : RPV RUPTURE	2.70E-07	5.40E-07	2

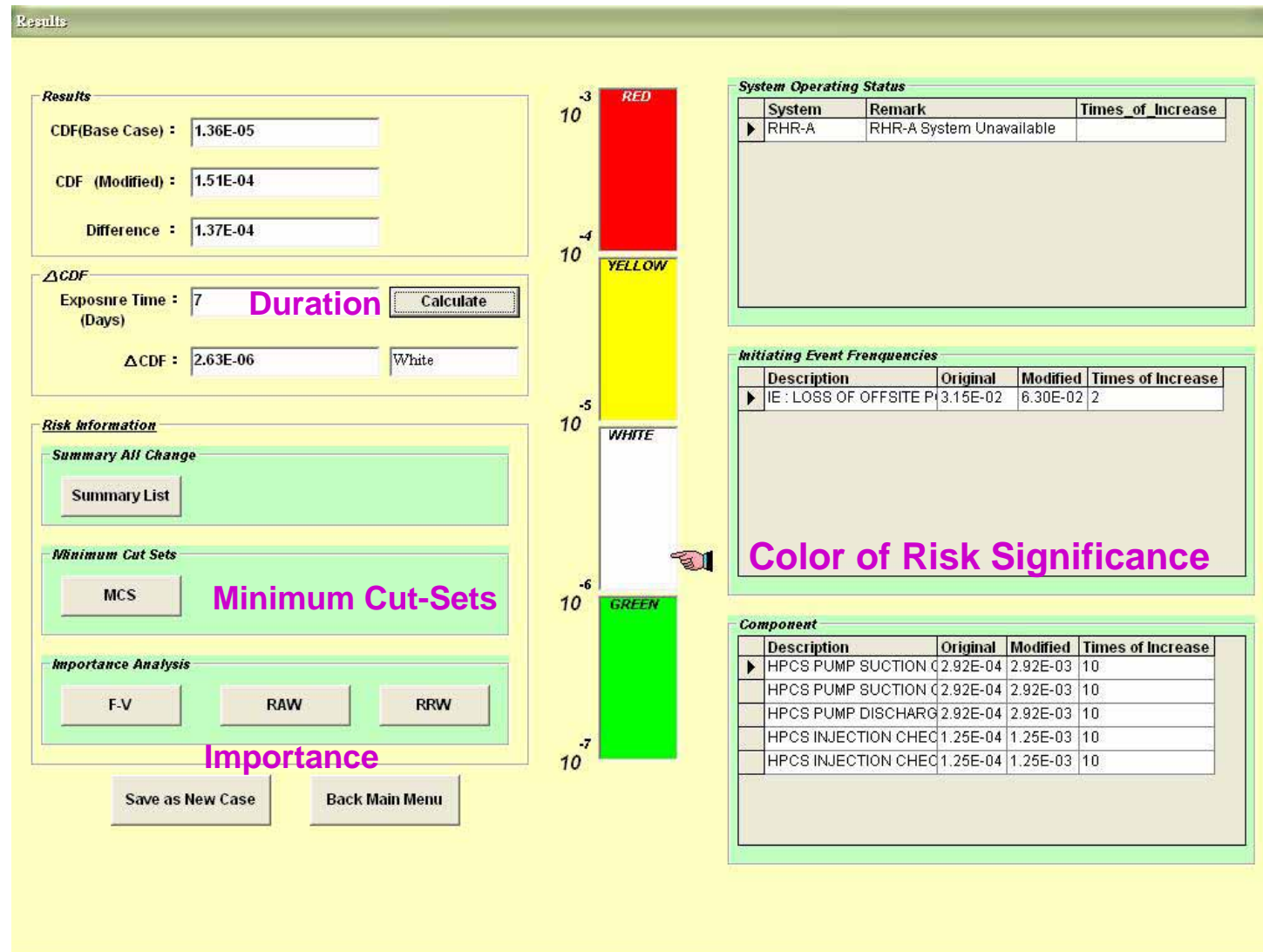
Initiating Events

Component

Description	Original	Modified	Times of Increase
CHECK VALVE E12-F031A F	2.92E-04	2.92E-03	10
CHECK VALVE E12-F050A F	2.92E-04	2.92E-03	10
CHECK VALVE E12-F031B F	2.92E-04	2.92E-03	10
CHECK VALVE E12-F031C F	2.92E-04	2.92E-03	10
CHECK VALVE F050B FAILS	2.92E-04	2.92E-03	10
CHECK VALVE E12-F019 FA	2.92E-04	2.92E-03	10
CHECK VALVE E12-F041A F	1.25E-04	1.25E-03	10
CHECK VALVE E12-F041B F	1.25E-04	1.25E-03	10
CHECK VALVE E12-F041C F	1.25E-04	1.25E-03	10

Status of SSCs

# Significance Determination Results



# Minimum Cut Sets

MCS								
Ranking	Frenquence						Ranking	Frenquence
1	1.09E-06	AAA-T3	CHAZGJ-1VC-13A/	HR-FIRE-WTR-E03	SDTFFAILLOOP		1	1.09E-06
2	7.12E-07	AAA-T5	BYWZ125-12BAT				Initiating Event / Description	
3	6.60E-07	AAA-E51-RCIC	AAA-T3	CHAZGJ-1VC-13A/	HR-FIRE-WTR-E03	HR-GT-F	AAA-T3	IE : LOSS OF OFFSITE POWER
4	5.84E-07	AAA-T5	CHAZGJ-1VC-13A/	HR-CX/FR			CHAZGJ-1VC-13A/B	CHILLER 1VC-13A/B (C.C.F) FAILS T
5	5.40E-07	AAA-R					HR-FIRE-WTR-E03	OPERATOR FAILS TO INJECTION FII
6	3.68E-07	AAA-T3	BYWZ125-12BAT				SDTFFAILLOOP	BOTH 345 & 69 KV SWYD OR TRAN
7	3.20E-07	AAA-T3	CHAAAGJ-1VC-13A	CHABGJ-1VC-13B	HR-FIRE-WTR-E03	SDTFFAI		
8	2.36E-07	AAA-E51-RCIC	AAA-T5	HR-ADS-INI-E03	PMECE22-1P45	PTANE5		
9	2.12E-07	AAA-T3	HR-FIRE-WTR-E03	PMAZE1H-1P4A/B	SDTFFAILLOOP			
10	2.12E-07	AAA-T3	HR-FIRE-WTR-E03	PMAZGJ-1VC-16A/	SDTFFAILLOOP			
11	1.93E-07	AAA-E51-RCIC	AAA-T3	CHAAAGJ-1VC-13A	CHABGJ-1VC-13B	HR-FIRE		
12	1.71E-07	AAA-T5	CHAAAGJ-1VC-13A	CHABGJ-1VC-13B	HR-CX/FR	HR-NCH		
13	1.70E-07	AAA-O						
14	1.51E-07	AAA-T5	HR-ADS-INI-E03	PMAZE1H-1P4A/B				
15	1.50E-07	AAA-E51-RCIC	AAA-T5	HR-ADS-INI-E03	PMAZE22-1P45	PTANE5		
16	1.28E-07	AAA-E51-RCIC	AAA-T3	HR-FIRE-WTR-E03	HR-GT-RCIC-INO	OSP-REI		
17	1.28E-07	AAA-E51-RCIC	AAA-T3	HR-FIRE-WTR-E03	HR-GT-RCIC-INO	OSP-REI		
18	1.27E-07	AAA-E51-RCIC	AAA-T3	DG-RECOV30M	DGEA4KV-1RG1	DGEB4K		
19	1.22E-07	AAA-E51-RCIC	AAA-T3	HR-ADS-INI-E03	PMECE22-1P45	PTANE5		
20	1.19E-07	AAA-E51-RCIC	AAA-T1B	HR-ADS-INI-E03	PMECE22-1P45	PTANE5		
21	1.17E-07	AAA-S1	HR-ADS-INI-LOCA	PIRCE22-INJ				
22	1.13E-07	AAA-T5	HR-CX/FR	HR-NCHW-RECOV	PMAZGJ-1VC-16A/			
23	1.13E-07	AAA-T5	HR-CX/FR	HR-NCHW-RECOV	PMAZE1H-1P4A/B			
24	1.09E-07	AAA-E51-RCIC	AAA-T3	DG-RECOV30M	DGEZ4KV-RG1/GGHR-DG5			
25	1.01E-07	AAA-T2	BYWZ125-12BAT	PMENCG-1P5				
26	9.54E-08	AAA-E51-RCIC	AAA-T3	CHAZGJ-1VC-13A/	HR-FIRE-WTR-E03	HR-GT-F		
27	9.48E-08	AAA-T5	HR-CX/FR	PMAZE12-1P-49AE				
28	9.28E-08	AAA-T5	CHAZGJ-1VC-13A/	HR-ADS-INI-E03	HR-NCHW-RECOV			
29	8.71E-08	AAA-E51-RCIC	AAA-T3	CHAZGJ-1VC-13A/	HR-FIRE-WTR-E03	HR-GT-F		
30	8.27E-08	AAA-T2	CHAZGJ-1VC-13A/	HR-CX/FR	HR-NCHW-RECOV	PMENCC		

Back Result



# Importance Information

F-V  
RAW  
RRW

F-V

Ranking	Event Name	Description	FV Value	Event Probability
1	AAA-T3	IE : LOSS OF OFFSITE POWER	5.34E-01	3.15E-02
2	HR-FIRE-WTR-E03	OPERATOR FAILS TO INJECTION FIRE WATER INTO RPV	4.33E-01	7.60E-01
3	AAA-E51-RCIC	RCIC SYSTEM RELIABILITY CHANGE	4.27E-01	5.00E+00
3	AAA-E51-RCIC	RCIC SYSTEM RELIABILITY CHANGE	4.27E-01	5.00E+00
4	AAA-T5	IE : LOSS-OF-FEEDWATER	2.70E-01	6.10E-02
5	OSP-RECOV30M	OFFSITE POWER NOT RECOVERED IN 30 MIN.	2.64E-01	1.87E-01
6	HR-GT-RCIC-INO	OPERATOR FAILS TO START GAS TURBINE IN 30 MIN.	2.63E-01	3.61E-01
7	PTANE51-1P46	RCIC PUMP 1P46 FAILS TO START	2.54E-01	2.79E-02
8	HR-ADS-INI-E03	OPERATOR FAILS TO INITIATE ADS IN TRANSIENT	2.25E-01	4.36E-03
9	CHAZGJ-1VC-13A/B	CHILLER 1VC-13A/B (C.C.F) FAILS TO START (ECHW)	2.07E-01	2.93E-03
10	SDTFFAILLOOP	BOTH 345 & 69 KV SWYD OR TRANSFORMERFAILED GIVEN LOOP	1.99E-01	1.56E-02
11	HR-NCHW-RECOV	OPERATOR FAILS TO RECOVER NCHW FOR ECHW HEAT LOAD	1.57E-01	1.19E-01
12	CHABGJ-1VC-13B	CHILLER 1VC-13B FAILS TO START (ECHW)	1.45E-01	2.93E-02
13	HR-CX/FR	HR-CSTXFR-E03 ,HR-FIRE-WTR-E03	1.24E-01	2.74E-02
14	CHAAGJ-1VC-13A	CHILLER 1VC-13A FAILS TO START (ECHW)	1.21E-01	2.93E-02
15	DG-RECOV30M	D/G NOT RECOVERED IN 30 MIN.	7.92E-02	9.36E-01
16	BYWZ125-12BAT	BATTERY DIV.1&2 FAIL DUE TO COMMON CAUSE	7.58E-02	1.17E-05
17	PMECE22-1P45	HPCS PUMP 1P-45 FAILS TO RUN 24 HR	6.67E-02	6.38E-03
18	HR-DG5-RCIC-INO	OPERATOR FAILS TO HOCKUP TO DG5 IN 30 MIN.	5.92E-02	1.02E-01
19	AAA-T2	IE : MAIN STEAM NOT ISOLATION TRANSIENT	5.87E-02	1.35E+00
20	PMAZEH-1P4A/B	ECW PUMPS 1P4A, B COMMON CAUSE FAIL TO START	5.65E-02	5.67E-04
21	DGEB4KV-1GG1	DIESEL GENERATOR 1GG1 FAILS TO RUN	4.03E-02	8.18E-02
22	PMACE22-1P45	HPCS PUMP 1P-45 FAILS TO START	4.01E-02	4.05E-03
23	PMENCG-1P5	MOTOR-DRIVEN PUMP CG-1P5 FAILS TO RUN	3.84E-02	6.38E-03
24	PMAZGJ-1VC-16A/B	MOTOR-DRIVEN PUMP 1VC-16A/B (C.C.F) FAILS TO START	3.78E-02	5.67E-04
25	DGEA4KV-1RG1	DIESEL GENERATOR 1RG1 FAILS TO RUN	3.44E-02	5.50E-02
26	AAA-T1B	IE : MSIVS CLOSED TRANSIENT	3.23E-02	3.06E-02
27	PMAE12-1P-49A	PUMP(MOTOR DRIVEN) E12-1P-49A FAILS TO RUN	3.21E-02	6.38E-03
28	AAA-R	IE : RPV RUPTURE	3.09E-02	5.40E-07
29	PMEBEH-1P4B	MOTOR-DRIVEN PUMP 1P-4B FAILS TO RUN	2.87E-02	6.38E-03

Back Result



# Conclusions

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- A window-based tool with the SDP context to help the resident inspectors of Taiwan's nuclear regulatory body to perform the Phase 2 SDP assessment at power of the ROP has been completed
- The inspectors should have basic PRA knowledge
- All the SDP calculations can be done within one minute
- Milestones of trial versions accomplished
  - Kuosheng NPP – BWR 6, Mark III (June 2004)
  - Chinshan NPP – BWR 4, Mark I (September 2004)
  - Maanshan NPP – 3-LOOP PWR (December 2004)



## Conclusions (cont.)

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- Possible future incorporation of evaluation capabilities for LERF at power, external event, and shutdown
- The regulatory body in Taiwan (i.e. TAEC) may need to contemplate on an appropriate action matrix that formulates responses to the SDP evaluation results

# Opinion

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Comments proposed by Professor George Apostolakis (MIT Professor, Former ACRS Chairman) toward the presentation of PRiSE at the 26th Annual Meeting of the Chung-Hwa Nuclear Society, Taiwan, December 21, 2004

This computer tool replaces the table that the USNRC has developed for performing Phase 1 and 2 (and Part of Phase 3) of the SDP. I have expressed the view in the past that these tables are awkward, so I was very pleased to see that INER is developing PRiSE. What facilitated the development of PRiSE was the use of the INERISKEN engine, which solves the PRA model in less than a minute. In my opinion, the key to this effort is the credible assessment of how inspection findings affect quantitatively the various PRA quantities, such as initiating-event frequencies and component failure rates. I would like to learn more about this assessment in the future.