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

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Third TAEC-USNRC Technical Exchange Meeting
NRC, Washington D.C., USA
May 31, 2005

Outline

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

Introduction

- 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)

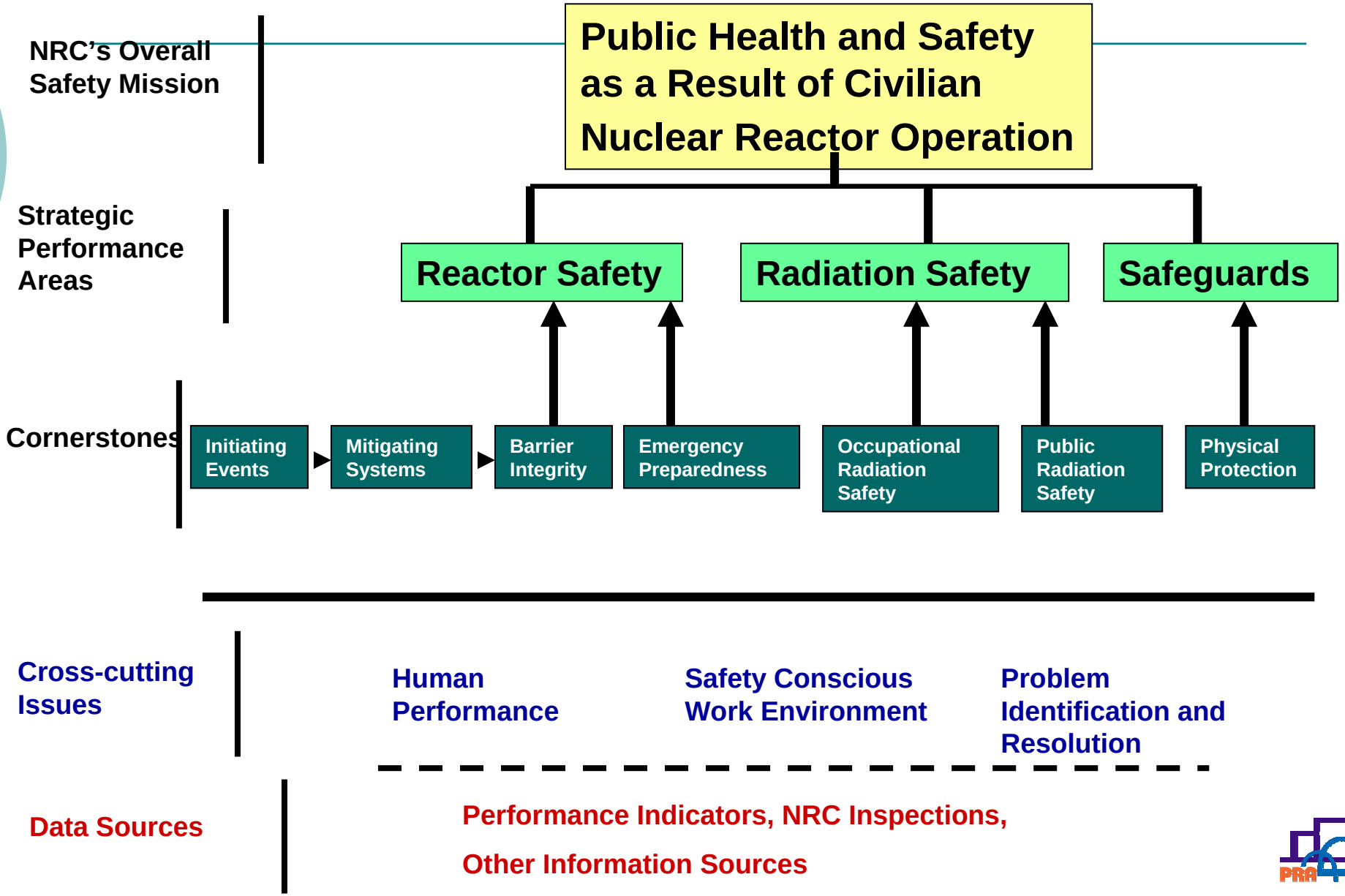
Features of ROP/SDP

- 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

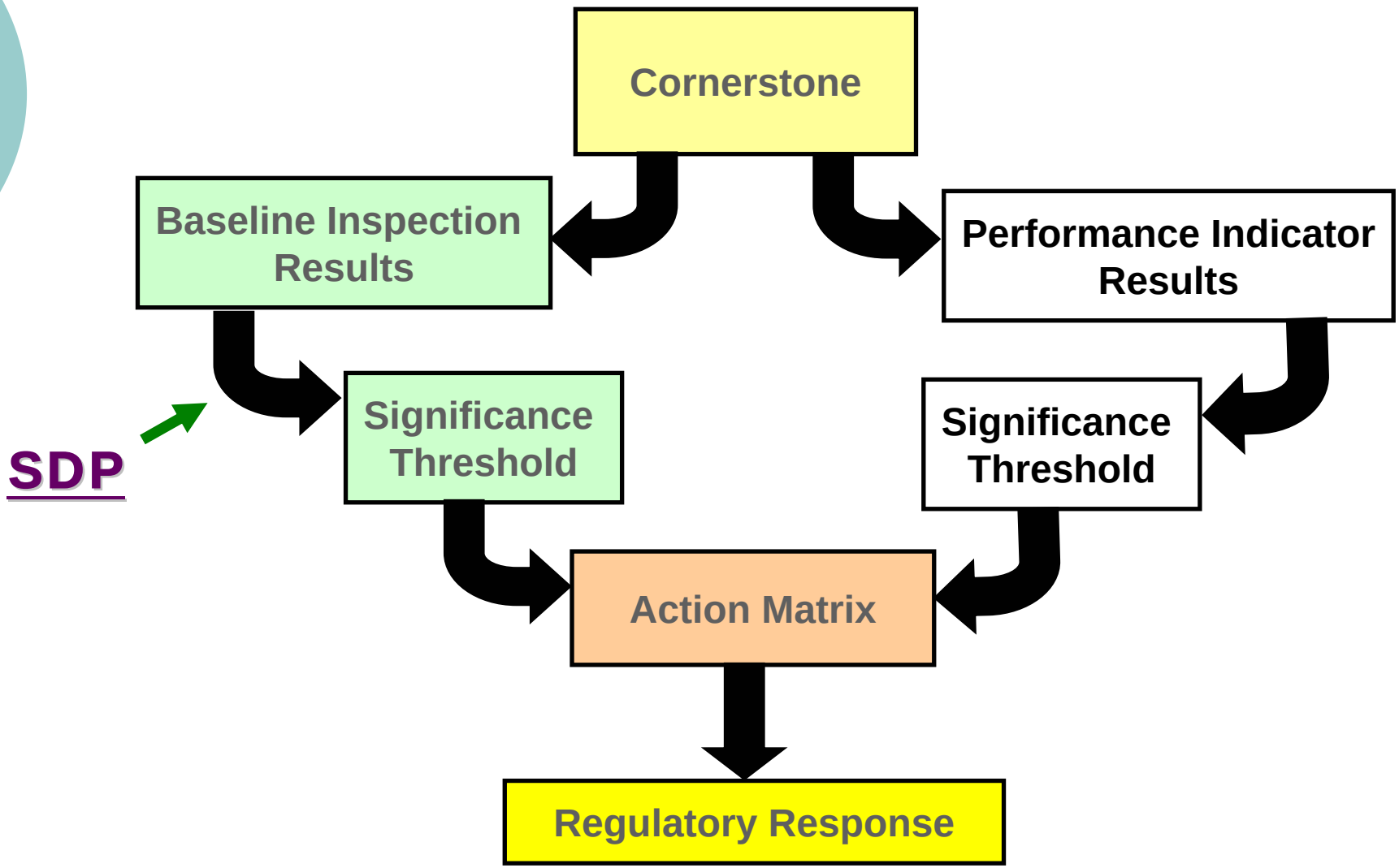
Features of ROP/SDP

- 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)

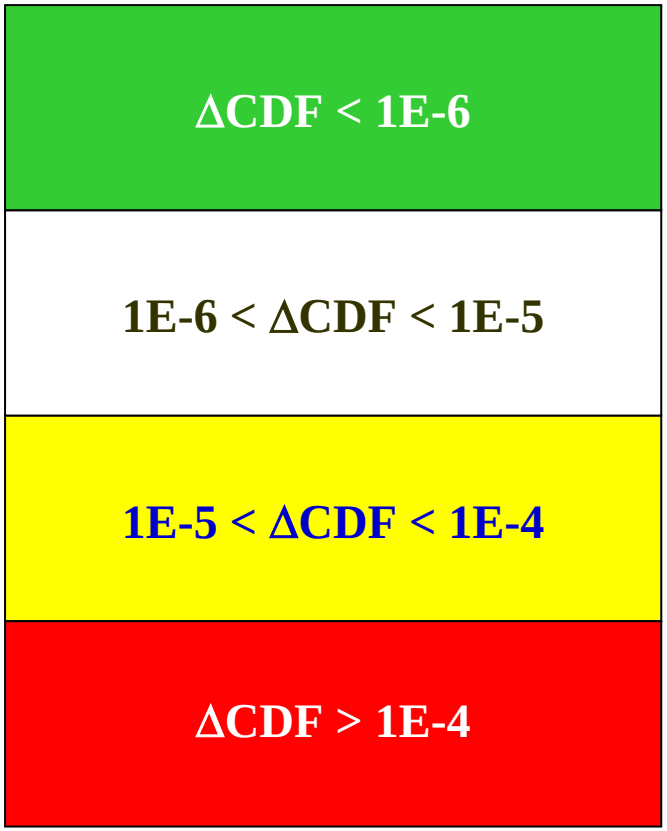


Assessing Performance and Responses



Levels of Significance Associated with Performance Indicators and Inspection Findings

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



Significance Determination Process (SDP)

- 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	**Power operation**
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

- Phase 1

  Characterization and Initial Screening of Findings, conducted by resident inspector

- Phase 2

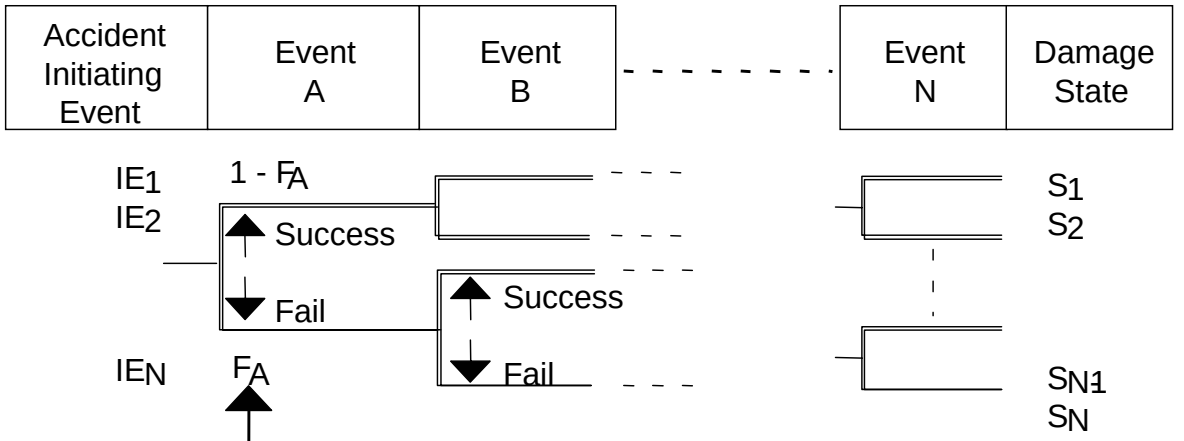
  Risk Significance Estimation and Justification Using the Site Specific Risk-Informed Inspection Notebook, conducted by resident inspector

- Phase 3

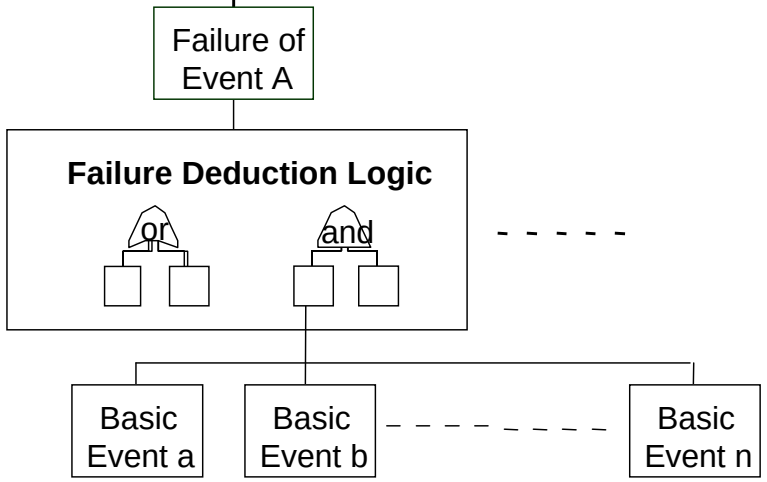
  Risk Significance Estimation Using Any Risk Basis That Departs from the Phase 1 or 2 Process, usually conducted by SRA

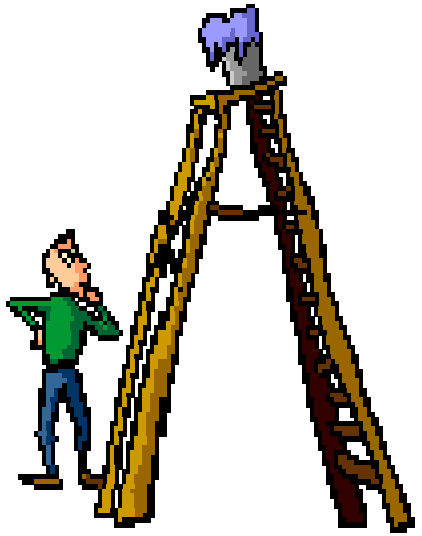
Scenario-based PRA Logic

Scenario Level Event Tree Analysis



System Level Fault Tree Analysis





Power Operation Phase 2 SDP

$$\text{Risk} \sim \underbrace{P_{\text{Initiating}} \bullet P_{\text{Mitigation}}}_{\text{CDF (App. A)}} \bullet \underbrace{P_{\text{Consequence}}}_{\text{LERF (App. H)}}$$

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 ($\triangle P_{\text{Initiating}}$) caused by performance insufficiencies
3. Evaluate the degradation in Mitigating Capabilities ($\triangle P_{\text{Mitigation}}$) 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 ($\triangle$CDF)

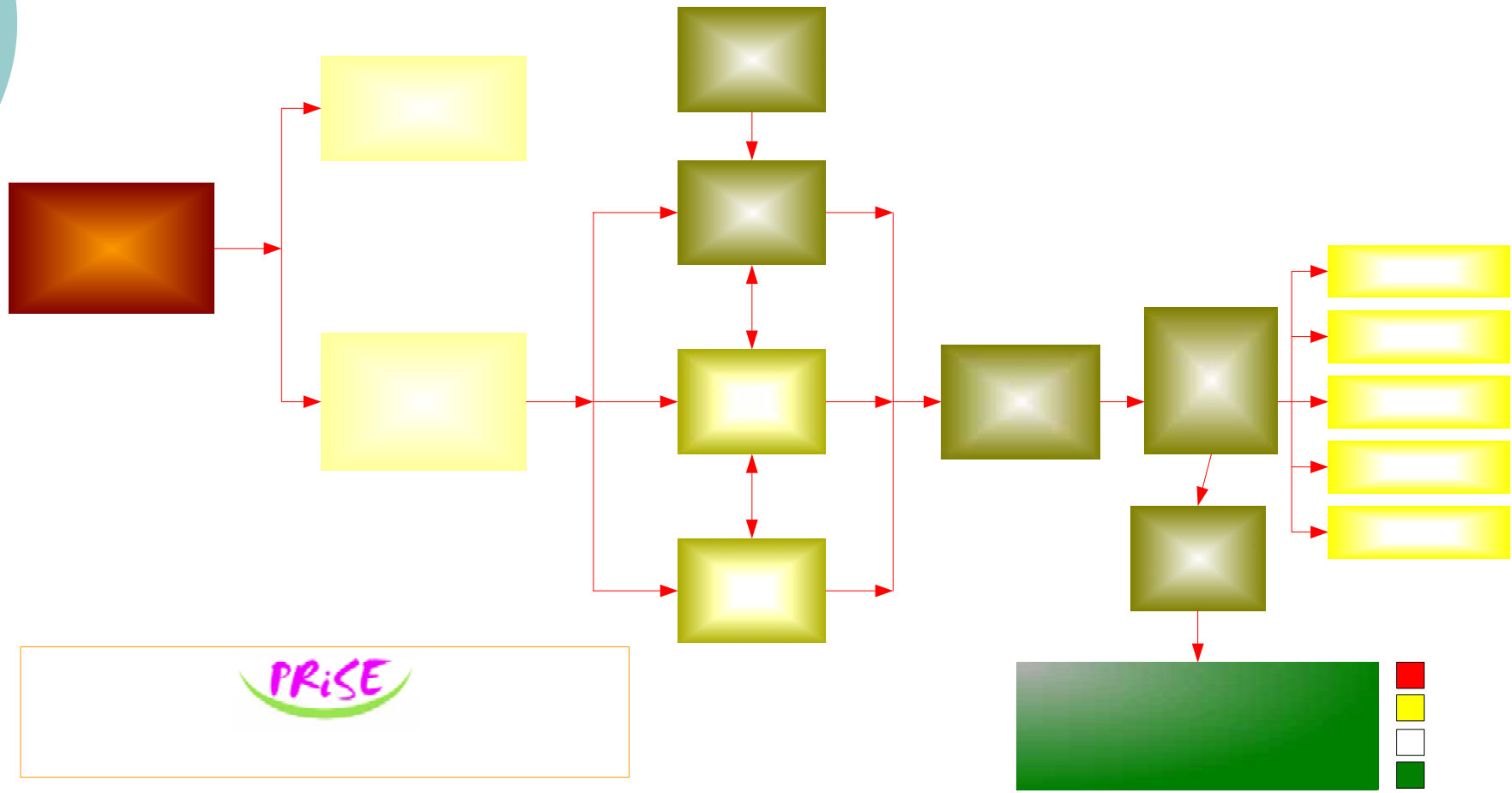
PRiSE

- 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 ΔCDF 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	ΔCCDF $\times$ (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

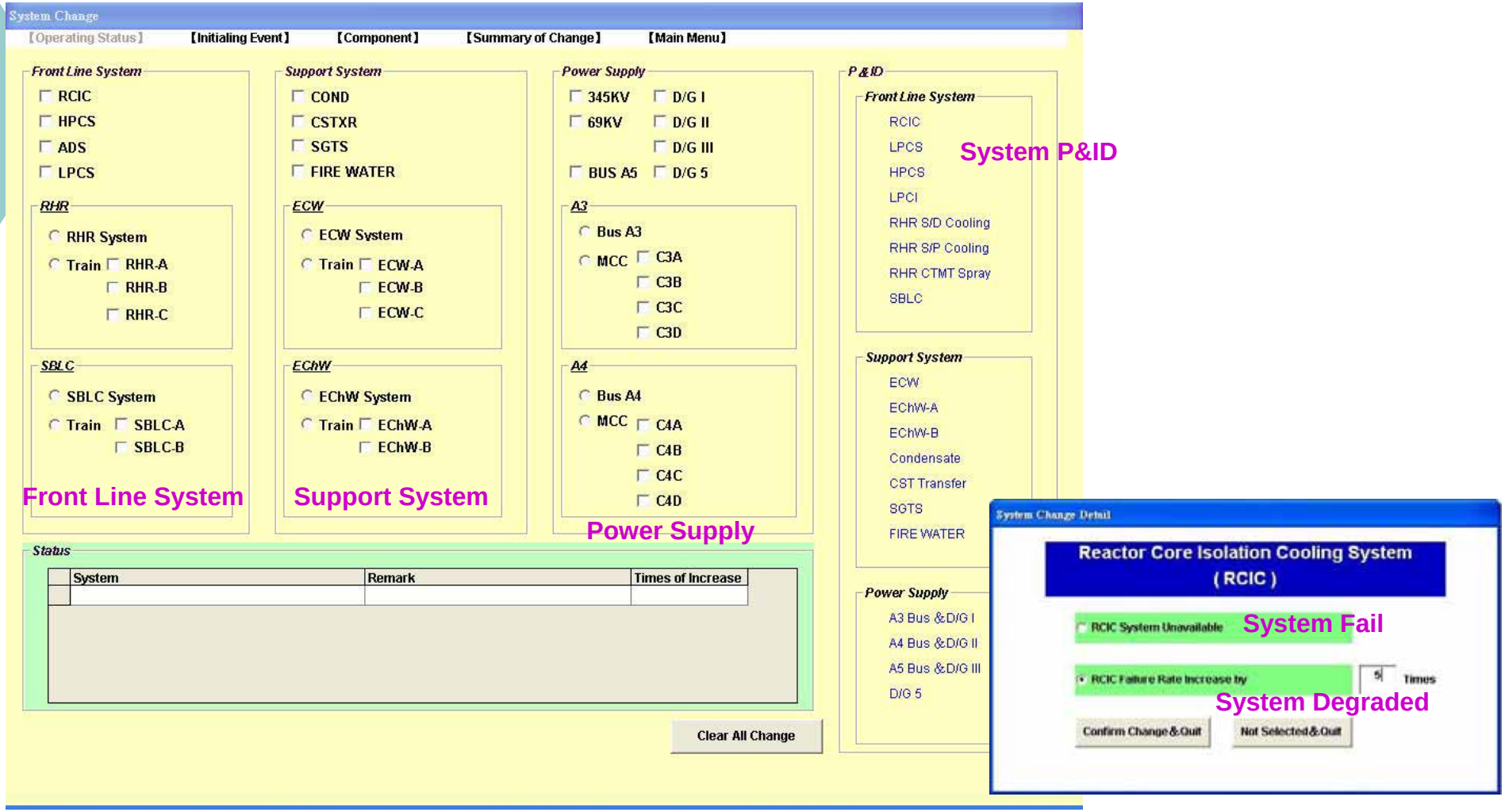
PRiSE Flow Chart



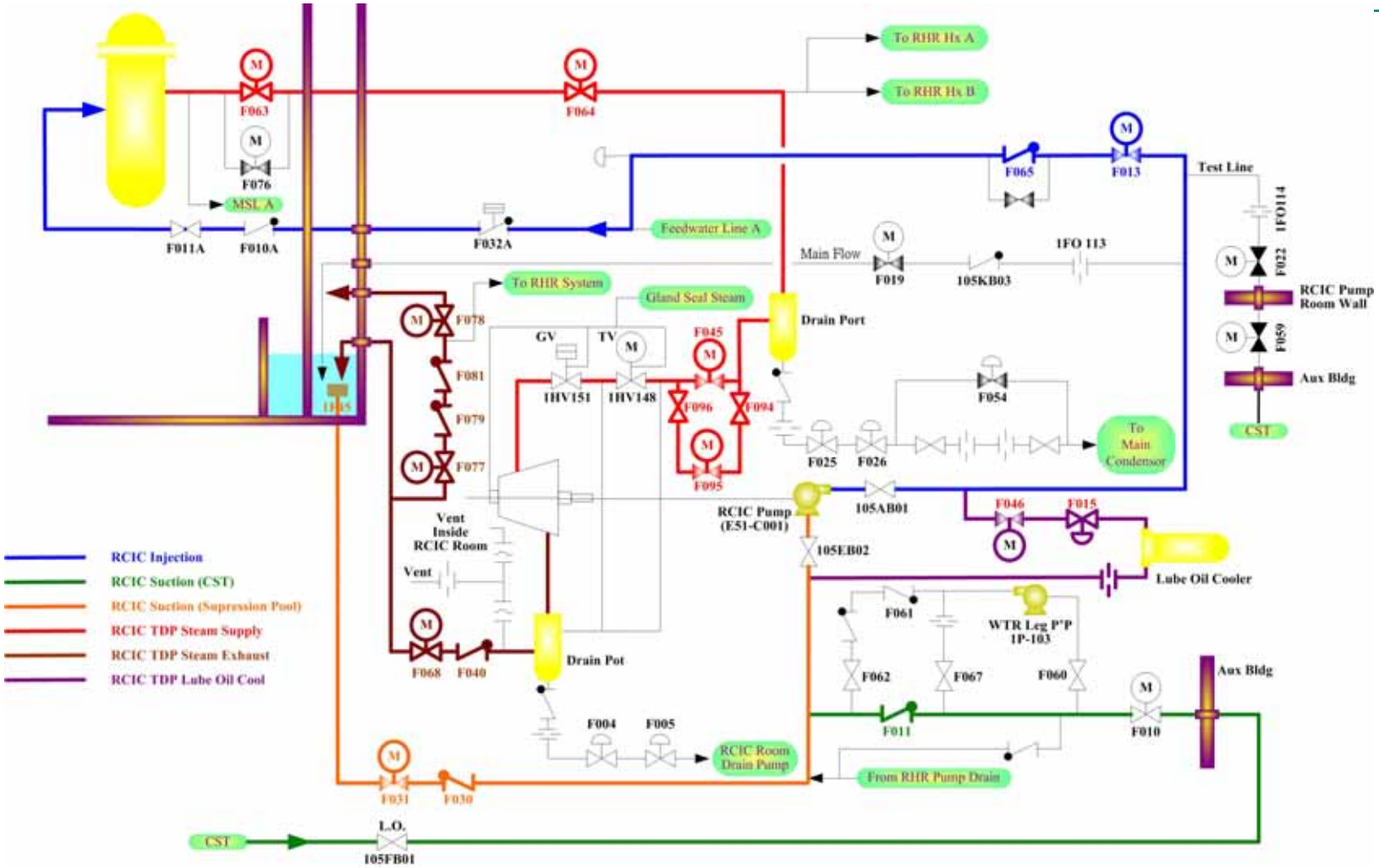
Features of the PRiSE

- Calculations based on plant-specific PRA model
  - CDF and ΔCDF
  - 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

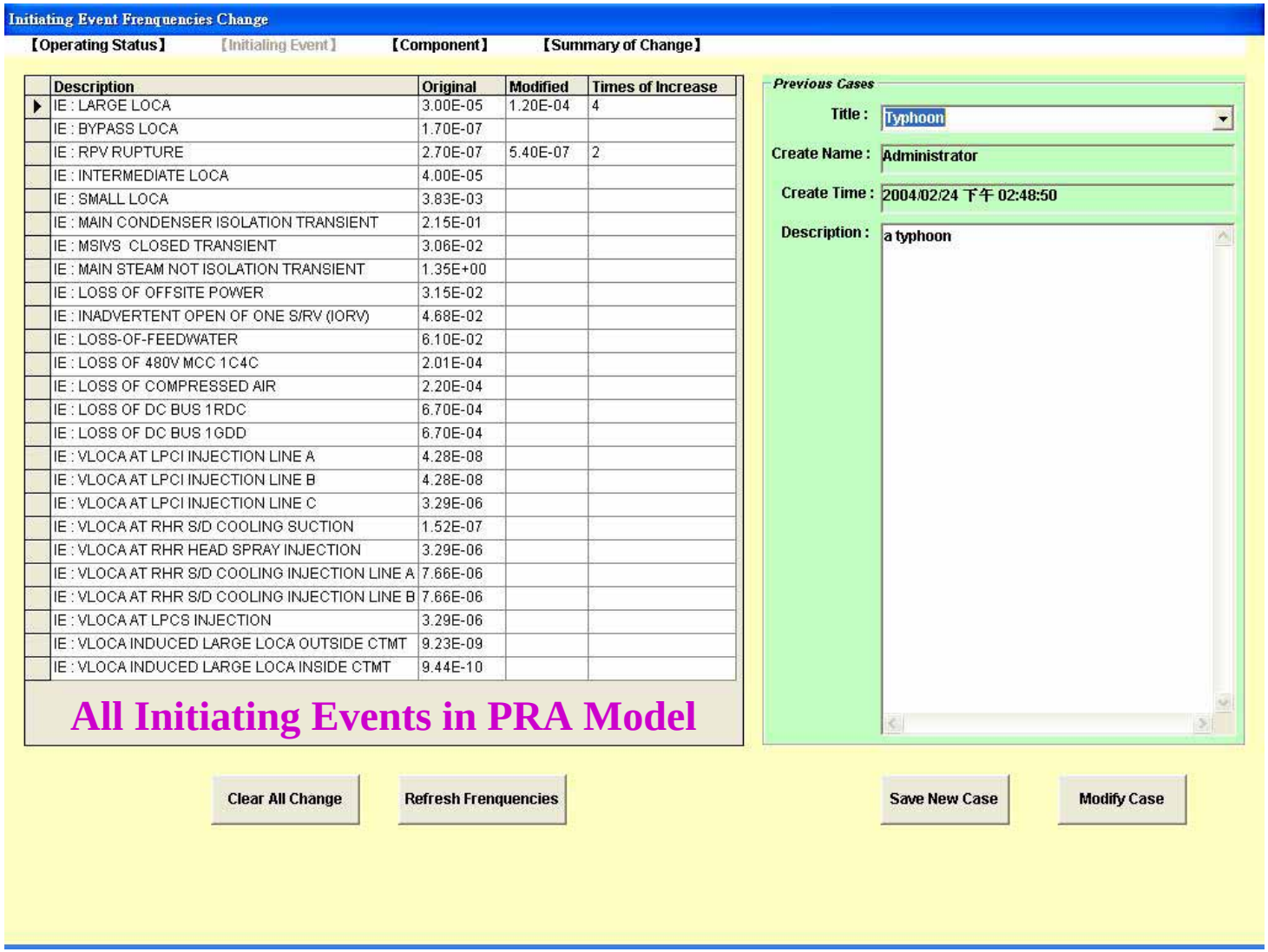


Display of SSCs Modeled in PRA

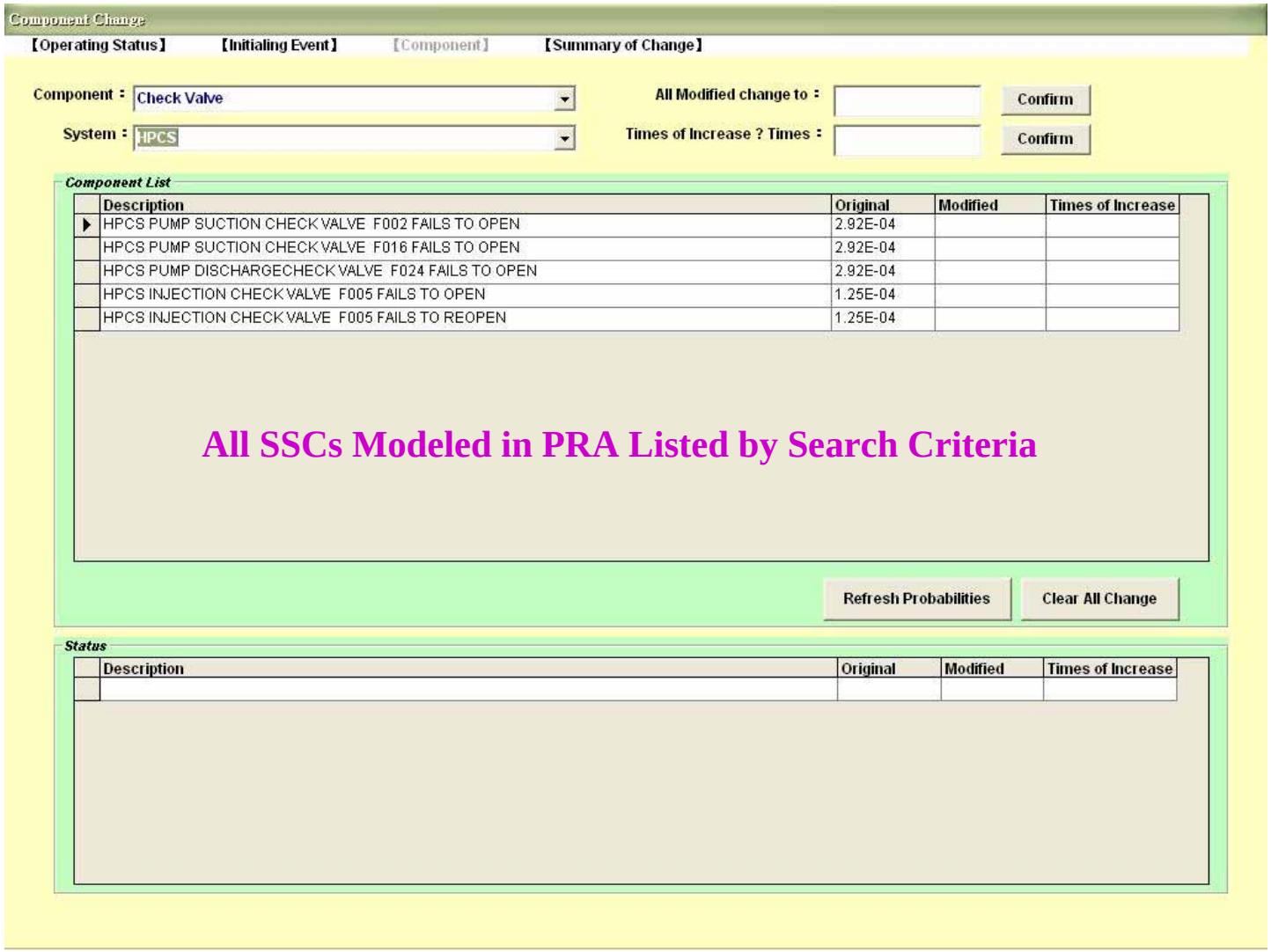


P&ID of Reactor Core Isolation Cooling (RCIC)

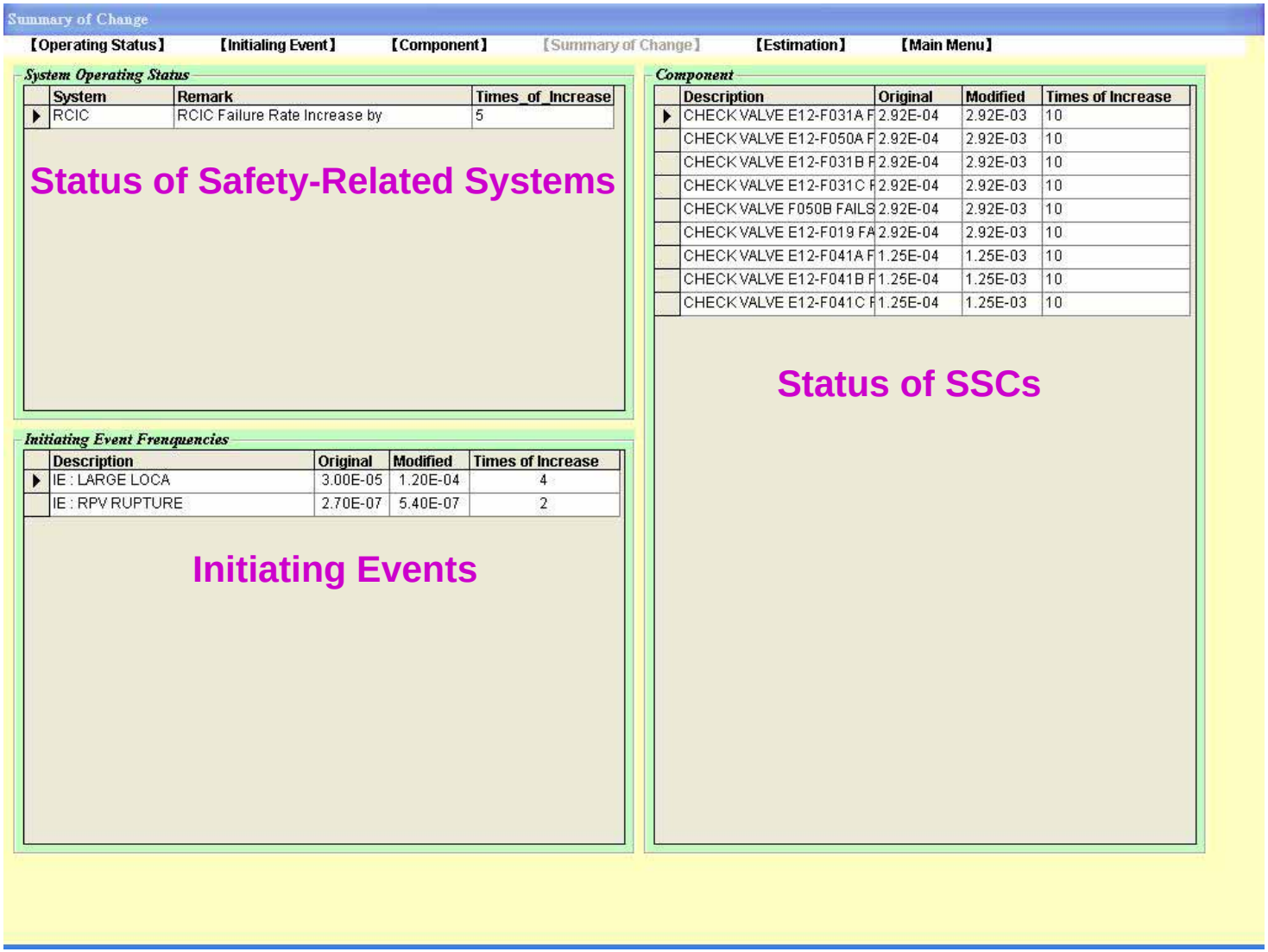
Reflect Inspection Finding by Frequency Change of Initiating Event



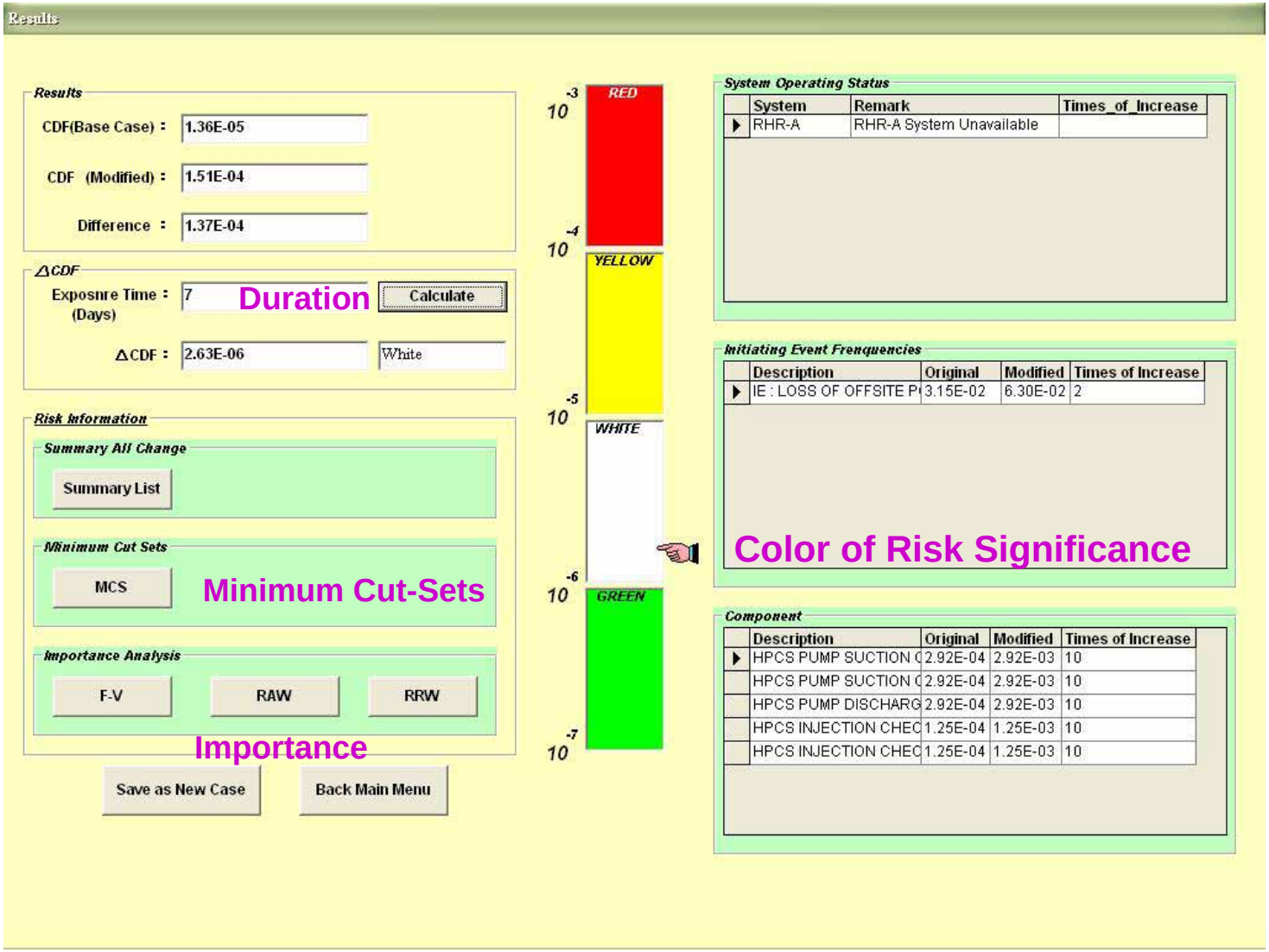
Reflect the Inspection Findings on SSCs Reliability



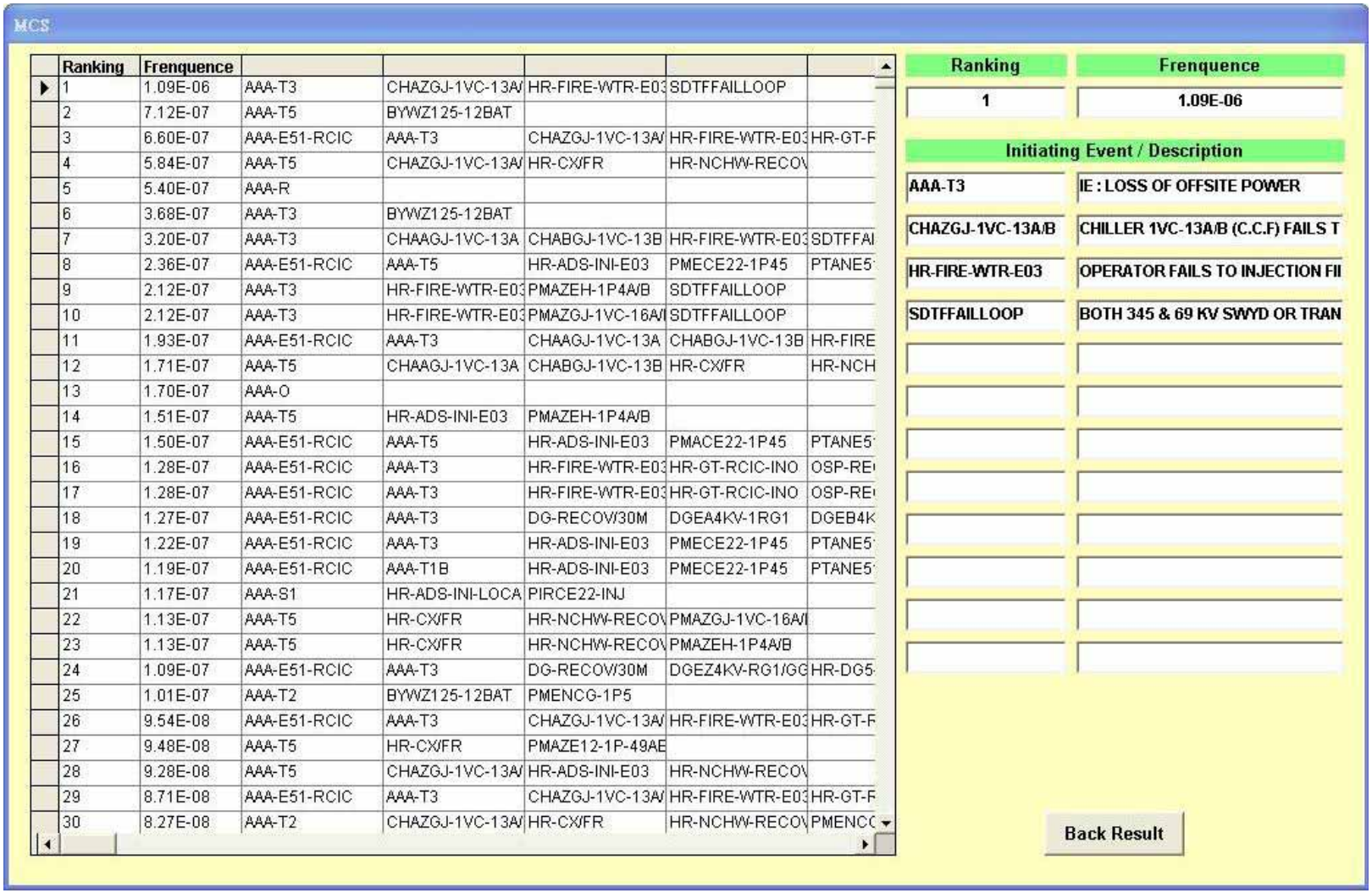
List of Changes



Significance Determination Results



Minimum Cut Sets



Ranking	Frenquence					
1	1.09E-06	AAA-T3	CHAZGJ-1VC-13A/	HR-FIRE-WTR-E03	SDTFFAILLOOP	
2	7.12E-07	AAA-T5	BYWZ125-12BAT			
3	6.60E-07	AAA-E51-RCIC	AAA-T3	CHAZGJ-1VC-13A/	HR-FIRE-WTR-E03	HR-GT-F
4	5.84E-07	AAA-T5	CHAZGJ-1VC-13A/	HR-CX/FR	HR-NCHW-RECOV	
5	5.40E-07	AAA-R				
6	3.68E-07	AAA-T3	BYWZ125-12BAT			
7	3.20E-07	AAA-T3	CHAAGJ-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	PMAZEH-1P4A/B	SDTFFAILLOOP	
10	2.12E-07	AAA-T3	HR-FIRE-WTR-E03	PMAZGJ-1VC-16A/I	SDTFFAILLOOP	
11	1.93E-07	AAA-E51-RCIC	AAA-T3	CHAAGJ-1VC-13A	CHABGJ-1VC-13B	HR-FIRE
12	1.71E-07	AAA-T5	CHAAGJ-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	PMAZEH-1P4A/B		
15	1.50E-07	AAA-E51-RCIC	AAA-T5	HR-ADS-INI-E03	PMACE22-1P45	PTANE5
16	1.28E-07	AAA-E51-RCIC	AAA-T3	HR-FIRE-WTR-E03	HR-GT-RCIC-INO	OSP-RE
17	1.28E-07	AAA-E51-RCIC	AAA-T3	HR-FIRE-WTR-E03	HR-GT-RCIC-INO	OSP-RE
18	1.27E-07	AAA-E51-RCIC	AAA-T3	DG-RECOV/30M	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/I	
23	1.13E-07	AAA-T5	HR-CX/FR	HR-NCHW-RECOV	PMAZEH-1P4A/B	
24	1.09E-07	AAA-E51-RCIC	AAA-T3	DG-RECOV/30M	DGEZ4KV-RG1/GG	HR-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

Importance Information

F-V
RAW
RRW

F-V

Ranking	Event Name	Description	FV Value	Event Probility
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	PMEAE12-1P-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

- 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.)

- 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

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.