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August 13, 2001

MEMORANDUM TO: Mark Satorius, Chief
Performance Assessment Section
Inspection Program Branch
Division of inspection Program Management
Office of Nuclear Reactor Regulation

FROM: Donald E. Hickman
Inspection Program Branch
Division of Inspection Program Management
Office of Nuclear Reactor Regulation

SUBJECT: REACTOR OVERSIGHT PROCESS SUMMARY OF PUBLIC MEETING HELD ON JULY 13, 2001 OF THE NRC/INDUSTRY WORKING GROUP ON SAFETY SYSTEM UNAVAILABILITY

On July 13, 2001a public meeting was held at the NRC Headquarters, Two White Flint North, Rockville, MD of the NRC/Industry Working Group on Safety System Unavailability. An agenda, attendance list, and information exchanged at the meeting are attached.

Attachments:

1. List of Participants
2. Agenda
3. NRC/Industry Working Group Meeting Minutes of May 16, 2001
4. ASP Evaluation of Significant Fault Exposure related Operating Events
5. Equipment unavailability/unreliability Due to Design Deficiency
6. Risk Based Performance indicator Development Summary of Reliability Indicators

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DATE:	8/ 13 /01					

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Public Meeting
List of Participants
July 13, 2001

NAME	AFFILIATION
Rick Rasmussen	NRC
Steve Floyd	NEI
Michael Johnson	NRC
Tom Houghton	NEI
Don Hickman	NRC
David Hembree	INPO
Roger Huston	LSS
Deann Raleigh	LIS, Scientech
Robin Ritzman	PSEG
Alan Madison	NRC
Tony Pietrangelo	NEI
Patricia A. Loftus	Exelon
Mike Gallagher	Exelon
Wade Warren	Southern Nuclear
Hossein Hamzehee	NRC
Tom Boyce	NRC
Steve Alexander	NRC
Ken Heffner	Progress Energy
Serita Sanders	NRC
Patrick Baranowsky	NRC
Ralph Goode	TVA
Mark Burzynski	TVA

Attachment 1

NRC/INDUSTRY WORKING GROUP MEETING ON SAFETY SYSTEM UNAVAILABILITY

JULY 13, 2001

AGENDA

1. Introduction
2. Review of minutes of last meeting
3. Definition of risk/safety significant functions to be included in SSU
4. Proposal to exclude shutdown unavailable hours from SSU
5. Replacement for t/2 where it is used in lieu of a reliability indicator
6. How to handle support system unavailability
7. Credit for operator recovery actions for other than maintenance and for support systems
8. Treatment of design deficiencies
9. How to establish thresholds
10. Use of default hours
11. Implementation phase-in
12. RES presentation on reliability indicators

Attachment 2

NRC/INDUSTRY WORKING GROUP MEETING
ON SAFETY SYSTEM UNAVAILABILITY
MAY 16, 2001

MEETING MINUTES

On May 16, 2001, Mike Johnson, Chief of IIPB, and Don Hickman of IIPB hosted an all-day public meeting of the Safety System Unavailability (SSU) Task Force (SSUTF) held at NRC headquarters. Steve Alexander, IQPB, represented maintenance rule (MR) interests. Hossein Hamazehee and Pat Baranowski represented RES/DRAA/OERAB. Tony Petrangelo and Tom Houghton represented the Nuclear Energy Institute (NEI). Other principal participants included representatives from INPO, Exelon, Southern Nuclear, Duke Power, and the industry group that is working on the consolidated data collection project. Reporters from McGraw-Hill and Scientech observed. The main topic was finding a common definition (including data to be collected and method of calculation) of SSU that would remain meaningful for the ROP (the SSU PIs), the MR, the PRA, and for INPO/WANO reporting. The group reviewed and discussed a "strawman" proposal by NEI in detail and several associated issues as delineated on the attached agenda.

The following comprise the principal results of the meeting:

1. The group agreed to the work towards development of a standard definition for unavailability (UA).

2. The group proposed that the risk/safety-significant functions to be tracked for unavailability be defined as:

> "those functions needed to be performed to satisfy the PRA success criteria, as defined for high-safety-significant (HSS) structures, systems and components (SSCs), per the industry guidance for 10 CFR 50.65, the Maintenance Rule, NUMARC 93-01, Revision 3."

All participants/interested parties were to present this definition to their respective organizations and report back at the July 13 meeting of the SSUTF.

3. The group discussed whether the UA definition should include UA while critical and UA while shutdown. As a result of concerns regarding differences in risk significance associated with shutdown and critical states, the group proposed to include only UA while critical. As an action, all participants will consider the ramifications of not counting HSS UA during shutdown, as one possible measure in normalizing the UA calculation. for all users, including MR, PRA, ROP, and INPO/ WANO. Representatives are to report their organizations' positions on this proposition at the July 13 meeting.

4. The group considered the following question: If T/2 (default estimate of unknown fault exposure time) *that is used in place of a reliability indicator* were not to be included among unavailable hours (i.e., the numerator of the SSU fraction), what other tools might be available and usable to meet PRA, ROP, and INPO/WANO needs (note that MR does not use T/2)?

The group proposed two principal candidates for replacement of T/2:

4.a Reliability ROP performance indicators (PIs) for monitored systems in terms of numbers of functional failures per so many valid demands

Attachment 3

during a specified period. OERAB was to present a conceptual description of such PIs at the July 13 meeting. (Longterm fix) Also, NEI requested that OERAB give a few examples from the Phase I RBPI Report at the July 13 meeting.

4.b Some sort of significance determination process (SDP) for SSU to supplement planned and unplanned unavailable hours and provide some alternative reliability insight. (possible near-term measure).

To validate the proposed measure of eliminating T/2 in UA calculations, OERAB was to review significant T/2 events (i.e., T/2 longer than 336 hours) and compare results with SDP results of the same events. NRR was to provide the example events to OERAB for their comparison. Status report due at July i3 meeting.

5. Handling of support system unavailability and its impact on SSU was discussed. The group proposed that unavailability PIs be developed for the two most HSS support systems, i.e., component cooling water (CCW) and service water (SW) systems or their equivalents (in addition to standby/ emergency electric power systems). One or two other HSS support systems may be added to the list if any should be identified. (Longterm)

5.a Until Action No. 5 above is completed, licensees should continue to cascade unavailability of proximate support systems onto SSU of their supported, front-line monitored systems.

5.b (Longterm) When CCW and SW PIs are implemented, cascading would be discontinued entirely for purposes of ROP and INPO/ WANO reporting. MR does not typically cascade (except possibly for ROP PI systems) and PRA must cascade interdependencies.

5.c NRC to consider, for the near term, cascading unavailability of CCW and SW only. Status by the July 13 meeting of the SSU focus group.

6. The group considered crediting operator recovery actions (ORAs) in reducing SSU charged in various situations. Note that these are general principles. Circumstances that do not exactly correspond to those described below will be dispositioned on a case-by-case basis.

6.a For testing, the group proposed to adopt (reaffirm) the treatment proposed by NEI in its strawman and as expressed in NEI 99-02, Page 28, and also NUMARC 93-01 language.

6.b For maintenance activities other than testing, specifically maintenance that may disable an automatic function (e.g.,standby/ auto-start), certain ORAs may be credited when manual operation is available *(and/or in use).*

6.c ORAs may be credited in such situations provided that the manual operation and the ORAs meet all the criteria for ORAs creditable for testing.

6.d Treatment of ORAs for support systems and auto start failures with manual operation available will
require further discussion.

7. The group discussed the treatment of design deficiencies. As a preliminary step, it was resolved to have the equipment reliability staff provide input based on industry operating experience. They are to evaluate counting certain design deficiencies against SSU and SS reliability versus use of an SDP. Cognizant parties are to have a strawman proposal on this issue reviewed by their organizations to present to the July 13 meeting.

8. Conceptual proposals on thresholds and implementation/phase-in are to be developed by all stakeholders and discussed at the July 13 meeting.

9. NEI requested RES to make a brief presentation of the reliability indicators developed in the draft Phase-1 RBPI development report at the July 13 meeting.

ASP Evaluation of Significant Fault Exposure-related Operating Events

Plant	T/2 Fault Expo. duration (hours)	SDP finding[1]	ASP finding (delta CDF)	Operating event	Comment
Millstone 2	335	white	2.20E-06 (white)	Inoperable speed control on TDAFW pump.	
Joseph M. Farley 2	515	green	5.80E-07 (green)	TDAFW pump trip on auto start.	ASP finding is green because this is not a risk significant function; i.e., manual initiation was available.
Joseph M. Farley 2	668.9	Not available	6.30E-08 (green)	Failure of MDAFW pump (Train 1) room cooler to start.	
Hope Creek 1	336	not available	2.10E-06 (white)	Diode failure in power supply to EDG (Train 2) voltage regulator. [1]	
Palo Verde 3	984.1	Not available	4.80E-06 (white)	Valve failed to open on HPI pump (Train 2) due to MCC failure. [1]	
Prairie Island 2	340.5	Not available	1.20E-06 (white)	EDG (Train 1) voltage regulator failed. [1]	
Quad Cities 1	1889	green	1.60E-06 (white)	HPCI potential failure due to auxiliary oil pump. [1]	Unable to obtain SDP results to determine reason for difference between ASP and SDP colors
Quad Cities 2	161.87	Not available	2.00E-08 (green)	MOV on RHR (Train 1) failed to close during ST due to breaker problem.	
Turkey Point 3	268.7	Not available	2.20E-06 (white)	Failed speed control on EDG (Train 2). [1]	

Note:

(1) The calculated changes in CDF are based on the available event-related information and the use of plant-specific SPAR models (Rev. 2QA). Additional information would be needed in order to compare the ASP results with SDP.

Attachment 4

Large Fault Exposure Time Treatment In Phase-1 RBPIs (1999 Data)

Event Description	SSUPI	SSUPI*	RBPI	Comment
WE 4-L Plant 1: FET of 342 hr (AFW DD pump)	White	White	Green (UR)	RBPI is green because failure was treated in reliability PI and use of Bayesian update.
BWR 3/4 Plant 18: FET of 3550 hr (HPCI TDP)	Yellow	Yellow	White (UA)	RBPI is white because of the use of plant-spec. threshold value.
BWR 3/4 Plant 19: FET of 987 hr (RCIC TDP)	Yellow	White	White (UR)	RBPI is white because failure was treated in reliability PI and use of Bayesian update.

Note: * indicates that only fault exposure time was included in the unavailability calculation; i.e., unavailable hours due to planned/unplanned activities were not included.

Acronyms:

PI = performance indicator
SDP = significance determination process
ASP = accident sequence precursor
CDF = core damage frequency
FET = fault exposure time
TDAFW = turbine-driven auxiliary feed water
AFW = auxiliary feed water
MDAFW = motor-driven auxiliary feed water
EDG = emergency diesel generator
HPI = high pressure injection
MCC = motor control center
HPCI = high pressure coolant injection
MOV = motor-operated valve
RHR = residual heat removal
ST = surveillance test
SPAR = standardized plant analysis risk
NRR = Nuclear Reactor Regulation
UA = unavailability indicator
UR = unreliability indicator

Equipment Unavailability/unreliability Due to Design Deficiency

Summary of results based on the review of operating experience:

Based on a review of the operating experience, the equipment failures due to design deficiency can be categorized as follows:

Category 1: Failures that are discovered during surveillance tests: These failures should be included in the equipment unreliability/unavailability indicators. Examples of this type are failures due to material deficiencies, sub-component sizing/settings, lubrication deficiencies, and environmental protection problems.

Category 2: Failures that cannot be discovered during normal surveillance tests: These failures are usually of longer fault exposure time. These failures are amenable to evaluation through SDP/ASP process. Examples of this type are failures due to pressure locking/thermal binding of isolation valves or inadequate component sizing/settings under accident conditions (not under normal test condition).

The results of the operating experience review are summarized below:

- A review of the ASP events for the period of 1992 through 1997 indicated that:
  - Approximately 20% of the ASP events involved aspects of design deficiency (i.e., 17 out of 75 ASP events over six years)
  - Approximately 50% of the ASP events involving design deficiency were not discovered through surveillance tests (i.e., 9 out of 17 ASP events over six years). These events fall under the second category described above.

- Percentages of failures of the following components associated with design deficiency for the period of 1987 through 1995 are shown below. These failures were all discovered during surveillance tests.
  - Turbine-driven pumps: 7%
  - Motor-driven pumps: 3%
  - Air-operated valves: 5%
  - Motor-operated valves: 5%

- A review of the operating experience during 1995 indicated that Approximately 30% of the CCF events in 1995 were due to design deficiency issues (i.e., 18 out of 61 CCF events). These CCF events were all captured during surveillance tests, and had similar characteristics to category one above.

Attachment 5

Risk-Based Performance Indicator Development

Summary of Reliability Indicators

SSUPI Working Group

July 13, 2001

Attachment 6

Risk-Based Performance Indicator - Reliability Indicators

What Are RBPI Reliability Indicators?

- They include failure to function on demand and failure to continue functioning following a successful demand.
- They are based on risk-significant functions not design-basis functions
  - More consistent with risk studies; e.g., PRAs/IPEs
  - More consistent with technical framework in 99-007
- Reliability indicators replace the use of fault exposure time for failure on demand situations; e.g., T/2
  - If the failure is not due to a known pre-existing condition; i.e., it is not in a failed state prior to a demand

Risk-Based Performance Indicator - Reliability Indicators

How Are reliability indicators Calculated?

- Total number of failures on demand and total number of demands during the monitoring period are used
- Use of a prior based on industry operating experience, which is Consistent with PRA/IPE approach

$$P = \frac{n + a}{d + a + b}$$

Where: n = number of failures on demand over monitoring period
d = number of demands over monitoring period
a , b: parameters of industry prior that will be derived from industry experience. Examples are provided in Phase-1 RBPI report.

- Failure to run during the mission time (usually 24 hours) is also included in the reliability indicators:

$$P = \lambda T \qquad \lambda = \frac{n + a}{t + b}$$

Where: λ = failure rate
T = mission time (i.e., 24 hrs)
n = number of failures during monitoring period
t = monitoring period
a , b: parameters that will be derived from industry experience. Examples are provided in Phase-1 RBPI report

- Reliability data will be provided by licensees.

Risk-Based Performance Indicator - Reliability Indicators

Benefits of Using Reliability Indicators:

- They indicate equipment performance more appropriately than the use of T/2 of fault exposure time in unavailability indicators
  - Use of risk-significant functions
  - Demand failures in reliability indicators allow for proper treatment of T/2 FET
  - Long-term unavailabilities associated with design issues are still part of the unavailability indicators, but plant-specific models/thresholds are used.

Risk-Based Performance Indicator Development
Summary of Reliability Indicators

Back-Up Information

Summary of RBPI development Results

Table ES-1 Summary of Phase-1 Risk-Based Performance Indicators

Safety Cornerstone	Existing PIs	Proposed RBPIs			
Initiating Event	- Unplanned Scram - LONHR - Unplanned Reactor Power Changes	- General Transient - LOFW - LOHS			
		PWR at Power	**BWR at Power**	**Shutdown**	**Fire**
Mitigating System	- EPS (UA) - RHR (UA) - PWR AFW (UA) HPI (UA) - BWR HPCS/HPCI (UA) RCIC/IC (UA) - Safety system functional failures	- EPS (UR&UA) - AFW-MDP (UR&UA) - AFW-TDP (UR&UA) - HPI (UR&UA) - PORV (UR) - RHR (UR&UA) - SWS (UR&UA) - CCW (UR&UA) - AOV (UR) - MOV (UR) - MDP (UR)	- EPS (UR&UA) - HPCS/HPCI (UR&UA) - RCIC/IC (UR&UA) - RHR (UR&UA) - SWS (UR&UA) - AOV (UR) - MOV (UR) - MDP (UR)	- *Time in High/Medium/Low Risk-Significant Configurations	- *Fire Suppression System (UR&UA)
Barriers	- RCS Specific Activity - RCS Identified Leak Rate	- *CIV (UR&UA)	- *Drywell Spray (MarkI)(UR&UA) - *CIV (Mark III) (UR&UA)	None	None

* Requires data that are not currently reported.

Note: The emergency preparedness, occupational radiation safety, public radiation safety, and physical protection cornerstones of safety are not included in the Phase-1 RBPI scope.

Table 3.1.2-3 PWR Mitigating System RBPIs

RBPIs & Example Thresholds for WE 4-Lp Plant 22					
Mitigating System	Baseline Train Unavailability or Unreliability	Green/White 95th %ile	Green/White ΔCDF =1E-6	White/Yellow ΔCDF =1E-5	Yellow/Red ΔCDF =1E-4
Auxiliary Feedwater	(MDP Train Unreliability) 8.7E-3	2.1E-2	9.8E-3	1.8E-2	5.4E-2
	(TDP Train Unreliability)1.9E-1	3.4E-1	2.0E-1	2.9E-1	Not Reached
	(MDP Train Unavailability) 1.1E-3	2.5E-3	3.7E-3	2.8E-2	2.5E-1
	(TDP Train Unavailability) 4.6E-3	1.8E-2	2.1E-2	1.7E-1	Not Reached
Component Cooling Water	(Unreliability) 1.6E-2	4.7E-2	2.0E-1	6.5E-1	Not Reached
	(Standby Train Unavailability)	4.4E-2	7.8E-1	Not Reached	Not Reached
Emergency AC Power	(Unreliability) 4.2E-2	1.0E-1	4.3E-2	5.5E-2	1.3E-1
	(Unavailability) 9.7E-3	1.9E-2	1.3E-2	3.9E-2	3.0E-1
High Pressure Injection (Includes CVC trains)	(SI Unreliability) 9.7E-3	2.1E-2	8.8E-1	Not Reached	Not Reached
	(SI Unavailability) 4.2E-3	1.6E-2	Not Reached	Not Reached	Not Reached
	(CVC Unreliability) 5.9E-2	1.9E-1	4.3E-1	Not Reached	Not Reached
	(CVC Standby Train Unav) 5.4E-2	1.7E-1	Not Reached	Not Reached	Not Reached
Power Operated Relief Valves	(System Unreliability) 3.2E-2	6.8E-2	5.7E-2	2.6E-1	Not Reached
Residual/Decay Heat Removal	(Unreliability) 1.7E-2	3.8E-2	3.8E-2	1.3E-1	4.7E-1
	(Unavailability) 7.3E-3	2.4E-2	9.3E-2	8.8E-1	Not Reached[1]
Service Water	(Unreliability) 3.2E-2	9.4E-2	1.3E-1	2.1E-1	3.2E-1
	(Standby Train Unav) 2.7E-2	9.0E-2	Not Reached	Not Reached	Not Reached
AOVs	Component Class Unreliability	N/A	Increase 2.2X	Increase 13X	Increase 106X
MOVs	Component Class Unreliability	N/A	Increase 2.4X	Increase 11X	Increase 39X
MDPs	Component Class Unreliability	N/A	Increase 1.2X	Increase 3.2X	Increase 16X

Summary of RBPI development Results

Validation and Verification:

- The purpose of this effort was to show that RBPIs can be calculated using readily available data and risk models consistent with current ROP philosophy
  - Feasibility of the process was demonstrated through these calculations
- RBPIs for full power, internal events were tested by evaluating plant-specific data for 23 plants over three-year period (1997-1999)
  - Rev 3i SPAR models with industry average reflecting 1996 performance were used for baseline
  - EPIX database was used for unreliability
- Validation and Verification effort showed that RBPIs provide:
  - More precise accounting for risk-significant design features of plants
  - More plant-specific thresholds
  - More appropriate accounting for risk impact of FET

Table 5.3-3 Plant Performance Bands for Mitigating System Unreliability RBPIs (1997 - 1999)[e]

Plant	EPS	HPI/ HPCI/ HPCS	AFW/ RCIC	RHR[a]	SWS	CCW	PORV
PWRs							
WE 4-Lp Plant 1	< baseline (G)[b]	No data[c]	< baseline (G)	< baseline (G)	No data	No data	No data
WE 4-Lp Plant 2	< baseline (G)	No data	< baseline (G)	< baseline (G)	No data	No data	No data
CE Plant 2	< baseline (G)	< baseline (G)	< baseline (G)	< baseline (G)	No data	No data	No data
CE Plant 3	< baseline (G)	< baseline (G)	< baseline (G)	< baseline (G)	No data	No data	No data
CE Plant 4	< baseline (G)	< baseline (G)	< baseline (G)	< baseline (G)	< baseline (G)	No data	< baseline (G)
CE Plant 5	< baseline (G)	< baseline (G)	< baseline (G)	No data	No data	< baseline (G)	No data
B&W Plant 4	< baseline (G)	< baseline (G)	< baseline (G)	< baseline (G)	< baseline (G)	< baseline (G)	NA
B&W Plant 5	< baseline (G)	< baseline (G)	< baseline (G)	< baseline (G)	< baseline (G)	< baseline (G)	NA
B&W Plant 6	< baseline (G)	< baseline (G)	< baseline (G)	< baseline (G)	< baseline (G)	< baseline (G)	NA
WE 2-Lp Plant 5	< baseline (G)	< baseline (G)	< baseline (G)	< baseline (G)	No data	< baseline (G)	< baseline (G)
WE 2-Lp Plant 6	< baseline (G)	No data	< baseline (G)	< baseline (G)	< baseline (G)	No data	< baseline (G)
CE Plant 12	< baseline (G)	< baseline (G)	< baseline (G)	< baseline (G)	NA	< baseline (G)	No data
WE 4-Lp Plant 22	< baseline (G)	< baseline (G)	< baseline (G)	< baseline (G)	< baseline (G)	< baseline (G)	< baseline (G)
WE 4-Lp Plant 23	< baseline (G)	< baseline (G)	1.5E-2 (MDP) (W) (0.13)[d]	< baseline (G)	< baseline (G)	< baseline (G)	< baseline (G)
BWRs							
BWR 3/4 Plant 5	< baseline (G)	< baseline (G)	< baseline (G)	< baseline (G)	No data	NA	NA
BWR 3/4 Plant 6	< baseline (G)	< baseline (G)	< baseline (G)	< baseline (G)	No data	NA	NA
BWR 3/4 Plant 8	< baseline (G)	< baseline (G)	< baseline (G)	< baseline (G)	No data	NA	NA
BWR 5/6 Plant 2	< baseline (G)	< baseline (G)	< baseline (G)	< baseline (G)	< baseline (G)	NA	NA
BWR 3/4 Plant 11	< baseline (G)	< baseline (G)	< baseline (G)	< baseline (G)	No data	NA	NA
BWR 3/4 Plant 15	< baseline (G)	< baseline (G)	< baseline (G)	< baseline (G)	No data	NA	NA
BWR 3/4 Plant 16	< baseline (G)	< baseline (G)	< baseline (G)	< baseline (G)	No data	NA	NA
BWR 3/4 Plant 18	< baseline (G)	< baseline (G)	< baseline (G)	< baseline (G)	No data	NA	NA
BWR 3/4 Plant 19	< baseline (G)	< baseline (G)	< baseline (G)	< baseline (G)	No data	NA	NA

a. Reflects pump data. Valve data still need to be collected and evaluated.
b. "< baseline" indicates that there were not enough failures to result in a train unreliability greater than the baseline.
c. "No data" indicates that either EPIX has no data on this system, or the RADS data load of the EPIX file did not include this system.
d. The 0.13 probability indicates that there is only a 13% chance that performance is at its baseline value.