August 1, 2000

EA-00-128

Mr. Oliver D. Kingsley
President, Nuclear Generation Group
Commonwealth Edison Company
ATTN: Regulatory Services
Executive Towers West III
1400 Opus Place, Suite 500
Downers Grove, IL 60515

SUBJECT: QUAD CITIES REGULATORY CONFERENCE SUMMARY

Dear Mr. Kingsley:

The NRC staff met with Commonwealth Edison and Quad Cities Nuclear Power Station representatives on July 19, 2000, in the Region III office. This meeting was a Regulatory Conference concerning the failure of the Unit 2 injection valve for the safe shutdown makeup pump to operate properly on January 19, 2000. The results of NRC inspections on this issue were documented in Quad Cities Inspection Reports 50-254/2000001; 50-265/2000001 and 50-254/2000005; 50-265/2000005. The conference was open to public observation.

The conference focused on the risk to the safe operation of the Quad Cities plant from fires because the safe shutdown makeup system was considered a mitigating system for certain fire scenarios. Application of the Significance Determination Process and the risk achievement worth methodology were utilized during the conference to determine the risk significance of the Unit 2 injection valve failure. Based on the information presented during the conference, the NRC concluded that the failure of the Unit 2 injection valve for the safe shutdown makeup pump represented an issue of very low safety significance (GREEN). No violations of NRC requirements were identified as a result of the information provided during the conference. Enclosure 1 contains a list of attendees at the conference. Enclosure 2 contains the handout provided by Commonwealth Edison during the meeting. Enclosure 3, "Commonwealth Edison Response to NRC Inspection Report EA-00-128, Issue 1R13.2," contains information, provided to the NRC in advance of the conference, which describes Commonwealth Edison's view of the risk associated with the Unit 2 injection valve failure.

In accordance with 10 CFR 2.790 of the NRC's "Rules of Practice," a copy of this letter and its enclosure will be available **electronically** for public inspection in the NRC Public Document Room **or** from the *Publicly Available Records (PARS) component of NRC's document system (ADAMS). ADAMS is accessible from* the NRC Web site at http://www.nrc.gov/NRC/ADAMS/index.html (the Public Electronic Reading Room).

Should you have any questions regarding this conference or the NRC conclusions, please contact Mr. Mark A. Ring (630-829-9703), the Region III Projects Branch Chief for Quad Cities.

Sincerely,

/RA/

Geoffrey E. Grant, Director
Division of Reactor Projects

Docket Nos. 50-254; 50-265
License Nos. NPF-29; NPF-30

Enclosures:
1. List of Attendees
2. ComEd Meeting Handout
3. ComEd Response

cc w/encl:
D. Helwig, Senior Vice President, Nuclear Services
C. Crane, Senior Vice President, Nuclear Operations
H. Stanley, Vice President, Nuclear Operations
R. Krich, Vice President, Regulatory Services
DCD - Licensing
J. Dimmette, Jr., Site Vice President
G. Barnes, Quad Cities Station Manager
C. Peterson, Regulatory Affairs Manager
M. Aguilar, Assistant Attorney General
State Liaison Officer, State of Illinois
State Liaison Officer, State of Iowa
Chairman, Illinois Commerce Commission
W. Leech, Manager of Nuclear
MidAmerican Energy Company

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SRI Quad Cities
DRP
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JRK1
BAH3

Enclosure 1

Regulatory Conference for Quad Cities Nuclear Power Station

Partial List of Attendees:

NRC

M. Dapas, Deputy Director, Division of Reactor Projects, Region III
J. Grobe, Director, Division of Reactor Safety, RIII
T. Reis, Office of Enforcement
B. Clayton, RIII Enforcement Officer
D. Coe, Chief, Operating Reactors Section, NRR
M. Parker, Senior Risk Analyst, RIII
M. Ring, Chief, Branch 1, DRP, RIII
K. Walton, Resident Inspector, Quad Cities

Commonwealth Edison

C. Peterson, Regulatory Assurance Manager, Quad Cities
W. Burchill, Chief Engineer, Risk Management, ComEd
E. Jebsen, Risk Management Engineer, Quad Cities
T. Hanley, Operations Support Manager, Quad Cities
M. Lesniak, Director, Licensing & Compliance, ComEd

Enclosure 2

COMMONWEALTH EDISON
Regulatory Conference Handout

ComEd Evaluation of Fire Risk Due to Quad Cities SSMP Unavailability January 19-21, 2000

Presentation to
NRC Region III
Lisle, IL
July 19, 2000

Determination of Fire Risk Due to SSMP Unavailability

- NRC Inspection Module 0609, Appendix A, Attachment 1, Step 2.5 states
  - "If the licensee's current risk analysis for their plant incorporates external initiating events and the equipment or function being evaluated has been assigned a risk importance measure (e.g., RAW), based on this analysis, that would result in its unavailability causing an increase in core damage frequency [ΔCDF] of greater that 1E-6/yr, then identify the core damage scenarios of concern and provide this input for a Phase 3 analysis.".

Summary of Risk Determination

- SSMP was unavailable 47 hr & 43 min
- Unit 2 Base Fire CDF = 7.1 E-5/yr
- Unit 2 SSMP RAW = 2.7
- $\Delta CDF = \Delta T_U \times (RAW - 1) \times CDF_0$

  $= (2/365) \times (2.7 - 1.0) \times 7.1\ E\text{-}5/yr$

  $= 6.6\ E\text{-}7/yr$
- ΔCDF is less than the fire risk significance screening criterion of < E-6/yr

Conclusion of Risk Determination

- Because the Quad Cities SSMP Unavailability during January 19-21, 2000 produced an increase in fire risk which is less than the screening criterion stated in NRC Inspection Module 0609, no further risk evaluation is required.

SSMP Unavailability Determination

- SSMP unavailability was due to Valve 2-2901-8 maintenance
- Valve 2-2901-8 must open once when injection is required to Unit 2 (remain closed when injection is required to Unit 1)
- Valve 2-2901-8 was stroked successfully several times between 8/31/99 and 1/19/00

SSMP Unavailability Determination

- On 1/19/00 Valve 2-2901-8 failed to open during a test following several successful valve operations
- Failure was due to a loose yoke bushing caused by failure of anti-rotation staking
- Valve 2-2901-8 was repaired in 47 hr & 43 min and returned to service on 1/21/00

SSMP Unavailability Determination

- SSMP unavailability was limited to 2 days because Value 2-2901-8
  - demonstrated operability during numerous tests from 8/31/99 to 1/19/00
  - was manually torqued closed after its last operation prior to 1/19/00
  - is required only to remain closed for Unit 1 injection (this function is unaffected by the staking failure)

SSMP Unavailability Determination

- SSMP unavailability was limited to 2 days because Value 2-2901-8 (cont'd.)
  - is required to open only once to provide injection to Unit 2
  - failed to open on 1/19/00 because of staking failure only after several successful openings
  - was repaired to eliminate the known failure mechanism and returned to service on 1/21/00

Fire Risk Factors

- The Quad Cities Unit 2 base fire CDF is reported in the revised IPEEE submitted to NRC in May, 1999 to be 7.1 E-5/yr
- The SSMP RAW (risk achievement worth) was determined to be 2.7 using the Quad Cities Unit 2 fire PRA reported in the revised IPEEE by setting the SSMP maintenance unavailability to "True"

Fire Risk Scenerios with SSMP Unavailable

- 6 scenerios produce 95% of the change in fire risk due to SSMP unavailability
- There was an insignificant change in the relative risk ranking of 5 of these scenerios with SSMP unavailable compared to the base case with SSMP available
- The 6th scenerio had a significant change in relative risk ranking but contributes only 6% of total fire CDF

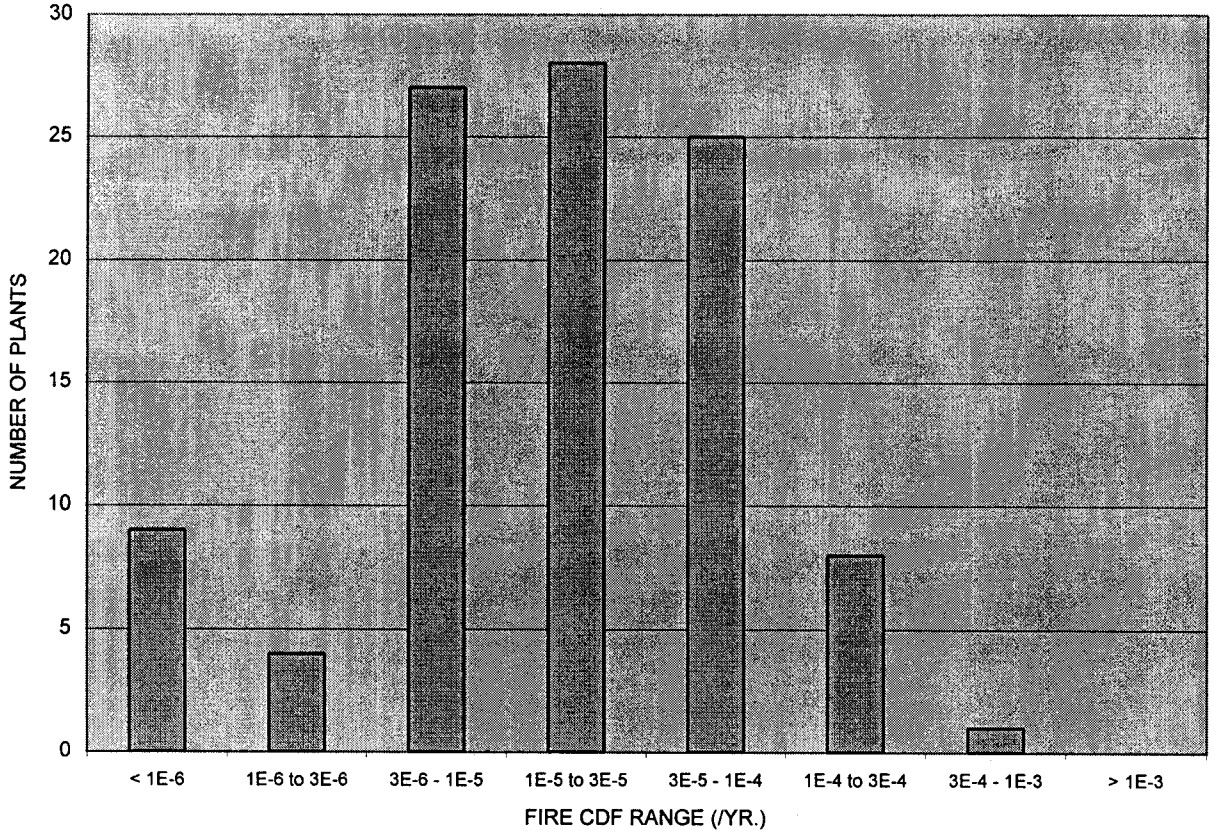
Conclusions Relative to Risk Insights

- There are no new risk insights provided by the fire risk profile with SSMP unavailable
- SSMP unavailability for short periods of time is acceptable, i.e. produces an acceptable change in fire risk

Disagreement with Fire Risk Screening Criterion

- ComEd disagrees with the fire risk screening criterion of $\Delta CDF < E\text{-}6/yr$ stated in NRC Inspection Module 0609
- The criterion is based on examination of internal events risk analyses statistics
- The criterion is overly conservative for application to fire risk based on examination of fire risk analysis statistics

FIRE PRA RESULTS



Characteristics of Fire Risk Analysis Statistics

- Most reported fire risk CDFs (EPRI Report TR-112933) are in the range 3 E-6/yr to 1 E-4/yr
- The largest concentration of reported fire risk CDFs are in the range 1 E-5/yr to 3 E-5/yr
- These values are higher than reported internal events CDFs due to conservative fire modeling methods

Conclusions Relative to Fire Risk Screening Criterion

- Reported fire risk results are acceptable because of the known conservatisms in fire risk analyses
- However, the magnitude of these results should not be compared to risk significance criteria based on internal events analyses
- The fire risk screening criterion should be $\Delta CDF < E\text{-}5/yr$ or higher

Enclosure 3

COMMONWEALTH EDISON RESPONSE TO

NRC INSPECTION REPORT EA-00-128, ISSUE 1R13.2

NRC INSPECTION REPORT

The NRC issue relative to the "risk due to internal fire initiating events given the Unit 2 SSMP injection valve failure that occurred on January 19, 2000" is stated on pages 7-8 of the NRC Inspection Report for the period April 5 - May 16 which was transmitted to ComEd by NRC letter EA-00-128 dated 6/14/00.

The NRC Inspection Report states "The safe shutdown makeup pump [SSMP] was assumed to be unavailable for one month." The Report states that an SDP Phase 3 analysis was done "with the assistance of regional and headquarters' risk analysts" because "information required to perform the Phase 2 fire SDP was not readily available." The analysis determined the risk increase using the following equation:

1/12[CDF(RAW-1)]

where

1 (in the numerator of 1/12) = the SSMP one month unavailability assumed by the NRC

12 = this is not defined in the NRC inspection report; however, based on the report's stated result of the calculation, it is assumed to be the number of months in one year

CDF = annual average fire risk reported in ComEd's revised IPEEE (6.6E-5/yr)

RAW = SSMP risk achievement worth reported to the NRC by the ComEd Quad Cities Risk Management Engineer (3.9)

The result is reported to be 1.5E-5 per year, which the NRC Inspection Report states "is near the threshold of a white/yellow issue." The definition of this threshold is not stated in the NRC Inspection Report. However, it is assumed to be the white/yellow threshold equal to 1E-05/yr stated on p. A2-2 of NRC Inspection Manual 0609, Appendix A, Attachment 2.

The NRC Inspection Report concludes that "the inspectors recommend that the NRC continue to evaluate this issue via the Phase 3 SDP."

ComEd QUESTIONS/COMMENTS ON THE INSPECTION REPORT

Conclusions

ComEd disagrees with the SSMP unavailability stated in the Inspection Report, providing a justification for a smaller number. ComEd has also calculated a Unit-2-specific value for the risk achievement worth (RAW) of the SSMP for Unit 2 fire risk. Combining these, and using the Unit-2-specific fire risk yields a risk impact below the NRC Staff

boundary between GREEN and WHITE. Therefore, ComEd concludes that this issue "screens to GREEN." ComEd also disagrees with the NRC Staff criterion of ΔCDF > 1E-6/yr. for fire risk, and we present a justification for an alternative criterion. Finally, as requested, ComEd provides the core damage scenarios of concern with the SSMP unavailable, forming conclusions about their significance.

SSMP Unavailability

ComEd disagrees with the value of SSMP unavailability stated by the NRC Inspection Report. The SSMP unavailability was less than 2 days, not one month as stated in the NRC Inspection Report. The basis for this conclusion is described as follows.

If the Safe Shutdown Make-up Pump (SSMP) system is required to inject to either Unit 1 or Unit 2, the SSMP 1(2)-2901-8 valves are required to perform certain functions. A particular unit's 8 valve is required to open to allow full system flow to the affected unit and the opposite unit valve is required to remain closed to prevent flow diversion to the non-affected unit. There is no requirement for the valve to cycle open more than once. Specifically, the 2-2901-8 valve is required to open once when injection is required to Unit 2 and is required to remain closed when flow is required to Unit 1.

The 2-2901-8 valve was stroked successfully for testing on several occasions between 8/31/99 and 1/19/00. During stroking for maintenance on 1/19/00, the 2-2901-8 valve failed and could not be operated either electrically or manually. The valve failed because the "staking" of the yoke bushing failed. The failure of the staking allowed the bushing to rotate during valve operation. After several successful valve operations, the bushing came partially out of the bottom of the yoke, became cocked and prevented further valve operation. Because of the repeated successful valve operations prior to failure, and the requirement for only a single operation for core protection during a fire, the 2-2901-8 valve is deemed to have been capable of performing its design function to open until the time of failure on 1/19/00.

When the SSMP system is required to inject to Unit 1, the 2-2901-8 valve must be closed to prevent diversion of flow to Unit 2. The 2-2901-8 valve is a normally closed valve and is not required to operate in this event. (Prior to the failure on 1/19/00, the 2-2901-8 valve had been manually torqued closed after the last electrical operation.) The yoke bushing is staked to prevent rotation of the bushing during valve operation. Since 2-2901-8 valve operation is not required for injection to Unit 1, failure of the staking, as long as the valve is initially closed, has no impact on the capability of the valve to remain closed.

Based on the above discussion, the 2-2901-8 valve was capable of performing its close function to support injection to Unit 1 and its open function to support injection to Unit 2 until its failure on 1/19/00. The 2-2901-8 valve was repaired and returned to service on 1/21/00. Total duration of the valve out-of-service (OOS) for repairs is 17 minutes short of 2 days, that is, 47 hours and 43 minutes.

SSMP Importance in Fire Risk

The RAW of 3.9 stated in the NRC Inspection Report is the result of a sensitivity calculation that had been done by a ComEd contractor with the Unit 1 model, using a relatively high truncation limit and a screening technique (a quantification "ones run") which double counts some cutsets. Since the event occurred on Unit 2, ComEd performed an additional calculation. For this calculation, ComEd set the maintenance term for the SSMP in the Unit 2 fire IPEEE to "True" within the fault tree, rather than assigning it a value of 1.0. ComEd then used that fault tree with the Unit 2 model and performed a requantification, generally using the same truncation limit, 1E-9/yr., as had been used for the base case. The resultant CDF is 1.9E-4/yr. Dividing by the Unit 2 base case CDF of 7.1E-5/yr. yields an RAW of 2.7. Therefore, a unit-specific, more precise calculation yields an RAW smaller than the value of 3.9 stated in the NRC Inspection Report.

SDP Entry Condition and Risk Significance Criterion

The NRC Inspection Report states in "Background" that the risk significance of SSMP failure [unavailability] was determined using the SDP for internal events to be "of very low risk (GREEN)" as reported in a previous NRC inspection report. It continues to state that "the NRC determined that the failure needed to be evaluated in terms of increase in core damage frequency due to fire initiating events." However, it does not explain precisely how the NRC entered the SDP for consideration of fire initiating events.

In particular, it does not mention using NRC Inspection Module 0609, Appendix A, Attachment 1, Step 2.5 which states "If the licensee's current risk analysis for their plant incorporates external initiating events and the equipment or function being evaluated has been assigned a risk importance measure (e.g., RAW), based on this analysis, that would result in its unavailability causing an increase in core damage frequency [ΔCDF] of greater that 1E-6/yr, then identify the core damage scenarios of concern and provide this input for a Phase 3 analysis." ComEd assumes that entry into the SDP relative to the risk significance of SSMP unavailability due to fire initiating events followed this instruction.

ComEd disagrees with the use of the criterion of ΔCDF > 1E-6/yr stated in NRC Inspection Module 0609, Appendix A, Attachment 1, Step 2.5. Note that this disagreement is specific to analysis of fire initiating events, not "internal" events. Use of 1E-6 as a screening criterion for temporary risk increases for internal events is considered reasonable, based on review of internal events PRA results for most nuclear plants. Typical internal-events results fall in such a range that an increase of 1E-6 is not considered negligible.

An examination of results from fire PRAs indicates that ΔCDF of 1E-6/yr is an overly conservative criterion for risk significance. Figure 1 provides a histogram of the fire CDFs reported by U.S. nuclear utilities (EPRI Report TR-112933, "IPEEE Fire Review," June, 1999). ComEd adjusted the EPRI data to account for the recent revisions to the Quad Cities and Dresden Fire IPEEE results. This figure shows that most fire CDFs are in the range 3E-6/yr to 1E-4/yr with the largest concentration being in the range 1E-5/yr to 3E-5/yr. One reason that fire CDFs are reported in this CDF range is that conservative methods for determining fire initiation frequencies and fire propagation and impact

modeling are used in fire PRAs. Because this conservatism is known to exist, these fire CDF values are considered to be acceptable. However, they can not be fairly compared to CDFs reported from internal events PRAs or to the risk significance criterion of $\Delta CDF >$ 1E-6/yr., which is based on results from internal events PRAs.

An alternative risk significance criterion is to use a CDF increase of greater than a factor of 2. This criterion has been widely used for on-line risk monitoring. Based on the results shown in Figure 1, this would correspond to a ΔCDF of 2E-5/yr to 6E-5/yr for the largest concentration of reported fire CDFs. This indicates that using a criterion of $\Delta CDF >$ 1E-6/yr is overly conservative and that a criterion of $\Delta CDF >$ 1E-5/yr or higher would be more appropriate.

Risk Significance Determination

ComEd disagrees with the risk increase due to SSMP unavailability stated by the NRC Inspection Report. Primarily because the SSMP unavailability was less than 2 days, not one month as stated in the NRC Inspection Report, but also because the RAW is smaller than first believed, the risk increase (as measured by ΔCDF) is less than 1E-6/yr. Thus, although ComEd has reservations about use of this metric for fire risk, the risk significance criterion stated in NRC Inspection Module 0609, Appendix A, Attachment 1, Step 2.5 was not exceeded. The basis for this conclusion is described as follows.

The equation for risk increase stated in the NRC Inspection Report is readily derived from the example stated on p. A2-4 of NRC Inspection Manual 0609, Appendix A, Attachment 2. This example provides the equation for the ΔCDF produced by a "simple unavailability," i.e., the unusual unavailability of a single SSC (structure, system or component) beyond its nominal value already considered in calculating the base CDF. The example gives the equation for ΔCDF as

$$\Delta CDF = [T_0/(T_0 + T_1)] \times CDF_0 + [T_1/(T_0 + T_1)] \times CDF_1 - CDF_0$$

where

T_0 = time when the SSC is at its nominal unavailability

T_1 = time when the SSC experiences an unusual unavailability

$T_0 + T_1$ = one year

CDF_0 = base CDF considering nominal unavailabilities

CDF_1 = CDF during the time the SSC experiences an unusual unavailability

Noting that $CDF_1 = RAW \times CDF_0$, this equation simplifies to

$$\Delta CDF = [T_1/(T_0 + T_1)] \times (RAW - 1) \times CDF_0$$

which is the equation stated in the NRC Inspection Report.

The ΔCDF associated with SSMP unavailability is determined using T_1 = 2 days, $T_0 + T_1$ = 365 days = 1 year, RAW = 2.7, and CDF_0 = 7.1E-5/yr. The ΔCDF is calculated to be 6.6E-7/yr, which is below the risk significance criterion of ΔCDF > 1E-6/yr stated in NRC Inspection Module 0609, Appendix A, Attachment 1, Step 2.5. Notwithstanding ComEd's disagreement with this risk significance criterion stated above, the SSMP unavailability is not risk significant even using this criterion.

Alternative Risk Significance Determination

An alternative method of determining the risk significance of a temporary condition is provided by EPRI Report TR-105396, "PSA Applications Guide," August 1995. This Guide defines the risk significance of a temporary condition using the incremental conditional core damage probability (ICCDP) although this term is not explicitly used in the Guide. The term ICCDP is defined as

$$ICCDP = (CDF_1 - CDF_0) \times T_1 = (RAW - 1) \times CDF_0 \times T_1$$

where the terms are the same as previously defined. ICCDP is the incremental change in the probability of core damage during the time T_1 and is a dimensionless number. Comparison of this equation for ICCDP to the equation for ΔCDF above shows that they are arithmetically equal if T_1 is expressed in units of years since $T_0 + T_1$ = one year. However, the units of ICCDP and ΔCDF are different, and they have different meanings.

The Guide states that the risk of conditions with an ICCDP less than E-6* "are considered non-risk significant" and that conditions with an ICCDP greater than E-5 are "potentially risk significant." For ICCDP between E-6 and E-5 the Guide states "other non-quantitative arguments may apply which could still justify the increase as non-risk significant." The ICCDP associated with SSMP unavailability determined using T_1 = 2 days = (2/365) yr, RAW = 2.7, and CDF_0 = 7.1E-5/yr is 6.6E-7. This shows that the condition is non-risk significant according to the EPRI "PSA Applications Guide."

Significant Fire Scenarios with SSMP Unavailable

The Quad Cities NRC Resident has requested that ComEd "identify the core damage scenarios of concern [with SSMP unavailable] and provide this input for a Phase 3 analysis" as specified in NRC Inspection Module 0609, Appendix A, Attachment 1, Step 2.5. Although over 140 individual scenarios contribute to this risk increase, the top three scenarios contribute over 85% of the risk increase:

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* The E-6 criterion was based on assuming that the aggregate risk of a credible number of temporary conditions over the course of a year, each of which had an ICCDP < E-6, would have a small enough impact on the annual average CDF such that the NRC's surrogate safety goal of CDF < E-4/yr would not be violated.

- FZ086B – RFP 2A&B Large Fire (45%)
- FZ086D – RFP 2A Small Fire w/o Suppression (22%)
- FZ091G – Bus 23/24 Large Fire (20%)

The remaining dominant scenarios comprising the top 95% of the risk increase are:

- FZ031A – Unit 2 RB Southeast Corner Room (2B RHR) (6%)
- FZ066C – 250 VDC Turbine Building MCC (1%)
- FZ061A – Old Computer Room (1%)

Table 1 lists details for the individual scenarios comprising the top 95% of the change in CDF.

- The 2A/2B reactor feed pump large fire remained the most important scenario, with a CDF increase of approximately 5 for that scenario.
- The 2A reactor feed pump small fire went to scenario #2 from scenario #4 in significance, with an increase of a factor of 7.
- The Bus 23/24 large fire went from scenario #8 to scenario #4, with a factor increase of 7.
- The 2B RHR room fire went from scenario #34 to scenario #6, with a factor increase of 23. (The initiating event for this scenario is turbine trip with bypass. Review of cutsets shows CCDP is dominated by loss of FW and loss of long term condensate makeup. Fire in this zone results in loss of HPCI and RCIC. The additional loss of SSMP increases this vulnerability to loss of FW makeup.)
- The turbine building 250VDC MCC went from scenario #35 to scenario #18 with a factor increase of 5.
- The old computer room went from scenario #28 to scenario #19 with a factor increase of 3.

Therefore, the risk profile does not change significantly, perhaps with the exception of the 2B RHR pump room. But the fire CDF increase for this room is only 6% of the total fire CDF increase due to the unavailability of the SSMP.

ComEd concludes that the risk profile during the time that the SSMP is unavailable to Unit 2 is consistent with the base case. No new risk insights result from the SSMP being unavailable. Given the nature and the magnitude of this risk profile, unavailability of SSMP for small amounts of time is acceptable.

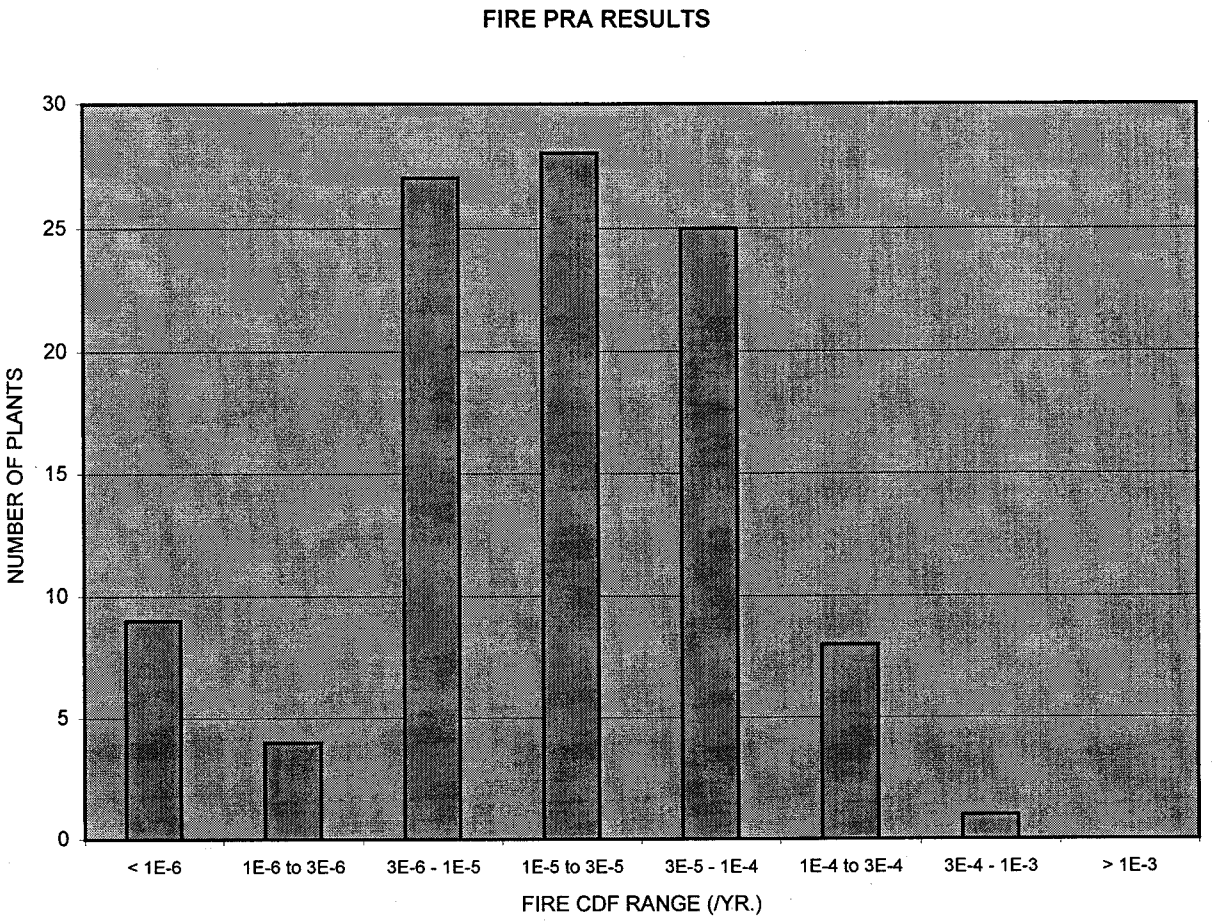

Figure 1 Histogram of Fire CDFs Reported by U.S. Nuclear Utilities (Based on Figure 4-1 of EPRI Report TR-112933, "IPEEE Fire Review," June, 1999, adjusted to account for the recent revisions to the Quad Cities and Dresden Fire IPEEE results.)

Table 1
DETAILS OF Unit 2 CORE DAMAGE SCENARIOS DUE TO FIRE WITH SSMP UNAVAILABLE

ZONE	Scenario	Scenario Description	Zone Description	Ignition Frequency	Non-Suppression Probability	Severity Factor	CCDP	CDF	CDF Increase	Cum %
FZ086	B	RFP 2A&B Large Fire	Unit 2 Turbine Building Ground Floor (North)	2.87E-03		1.80E-01	1.25E-01	6.47E-05	5.36E-05	45%
FZ086	D	RFP 2A Small Fire w/o Suppression	Unit 2 Turbine Building Ground Floor (North)	1.43E-03	2.00E-01	8.20E-01	1.25E-01	2.95E-05	2.56E-05	67%
FZ091	G	Bus 23/24 Large Fire	Unit 2 Mezzanine Floor (North)	1.12E-03		2.00E-01	1.23E-01	2.75E-05	2.42E-05	87%
FZ031	A		Unit 2 RB Southeast Corner Room (2B RHR)	1.79E-03			4.03E-03	7.21E-06	6.91E-06	93%
FZ066	C	250 VDC Turbine Building MCC	Unit 2 DC Panel Room	1.95E-03		1	8.22E-04	1.60E-06	1.32E-06	94%
FZ061	A		Old Computer Room	3.13E-03			4.84E-04	1.52E-06	1.10E-06	95%