June 14, 2002

MEMORANDUM TO:	Mark A. Cunningham, Chief Probabilistic Risk Analysis Branch Division of Risk Analysis & Applications Office of Nuclear Regulatory Research
THRU:	Mary T. Drouin, Section Leader Probabilistic Risk Analysis Branch Division of Risk Analysis & Applications Office of Nuclear Regulatory Research
FROM:	Alan S. Kuritzky **/RA/** Probabilistic Risk Analysis Branch Division of Risk Analysis & Applications Office of Nuclear Regulatory Research
SUBJECT:	TRANSMITTAL OF PRELIMINARY STAFF AND CONTRACTOR COMMENTS ON EPRI EXPERT ELICITATION MEETING ON THE PROBABILITY OF LOOP GIVEN LARGE LOCA

By letter dated April 27, 2002, the Nuclear Energy Institute (NEI) forwarded to the staff the results of an EPRI expert elicitation meeting on determining the probability of a loss of offsite power (LOOP) given a large-break loss of coolant accident (LOCA) (ADAMS accession number ML021270019). This report was initially discussed during a public meeting between the staff and stakeholders on May 2, 2002 (ADAMS accession number ML021430342). During that meeting, the staff agreed to review and provide comments on the EPRI expert elicitation report at the next scheduled public meeting (June 20, 2002). Both the staff and its contractor (Brookhaven National Laboratory) have performed a preliminary review of the report, and the comments are attached. To facilitate discussion on this topic at the upcoming public meeting on June 20, 2002, these comments are being entered into the ADAMS public library.

Attachment: As stated

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Attachment

Comments on the EPRI Expert Elicitation Meeting on the
Probability of LOOP Given Large LOCA

Jim Lazevnick, NRR/DE/EEIB
Gerardo Martinez-Guridi, Brookhaven National Laboratory
June 13, 2002

The following comments pertain to the *Results of Expert Elicitation Meeting* regarding *Probability of LOOP Given Large LOCA*, dated March 20, 2002. The expert elicitation meeting report was forwarded to the NRC by NEI in a letter dated April 27, 2002. The pages of the expert panel's report were numbered consecutively to refer to them. These comments are those of the authors and are provided only for the purpose of facilitating additional discussion on this topic.

<u>Comments on "Background"</u>

B.1 Page 1, bottom paragraph. The expert panel's report mentions that the database of LOOP events given a plant trip contains between 8 and 10 events in 3415 trips from 1984 to 2001. It is considered that there are 8, not 10, LOOP events after a reactor trip. After detailed review, it was considered that the two remaining events are not consequential LOOPs.

B.2 Page 1, bottom paragraph. The expert panel's report indicates that both EPRI and Brookhaven independently determined the value of 0.003 for the conditional probability of LOOP after a reactor trip. It is noted that Brookhaven independently searched licensee event reports for the period January 1,1984 to October 31, 2001 to identify LOOP events that had happened as a consequence of a reactor trip. The list of events identified in this way was then shared with EPRI. Using this list, EPRI and Brookhaven independently estimated the value quoted in the report, i.e., 0.003. Taking into account comment B.1, the conditional probability of LOOP after a reactor trip is now estimated as 2.4E-3.

B.3 Page 2, top paragraph. As mentioned in the expert panel's report, there was one LOOP event after a major ECCS actuation from 1986 to 2001. This event happened in Salem 2 in 1986. According to LER 311/86007, there were several contributing causes to the consequential LOOP, and not just an out-of-date transient analysis. Additional electrical loads were added to the Salem Station electrical distribution system, and the block loading of safeguards equipment onto the vital busses contributed to the undervoltage condition. Hence, this event should be included in the analysis, i.e., there is 1 failure in 14 events involving a major ECCS actuation.

<u>Comments on Item 1, "Stable Grid"</u>

1.1 The expert panel concludes that the conditional loss of offsite power due to grid-centered factors given a LOCA would be the same as that for a plant trip. The expert panel did not address the effect on the safety buses of switchyard voltage sag following loss of VAR support due to the LOCA induced plant trip when combined with the additional voltage drops associated with starting and running LOCA loads. These were addressed separately in item 1 and item 3 of the report, but their combined effect was not addressed. The authors believe the combined effect results in a larger conditional LOOP probability given a LOCA than the non-LOCA plant trip. The LOCA event results in safety bus voltages that typically are significantly lower than the non-LOCA event, resulting in a smaller margin to tripping of degraded voltage relays (see comment 2 below). Small excursions below the normal minimum switchyard voltage might, therefore, trip the relays and separate the plant from offsite power. The smaller margin to tripping of the relays is also less forgiving of errors that might have been made in the plant's voltage analysis, plant configuration control, the transmission system online model, or the plant operator/grid operator protocols.

1.2 In the late 80s and early 90s the staff performed a large number of electrical distribution system functional inspections (EDSFIs). NRC Information Notices 91-29 and 91-29 supplement 1 indicated that the EDSFIs found many plants did not have degraded voltage relay setpoints set sufficiently high enough to protect all connected safety loads from inadequate voltages. As a result, the majority of plants re-evaluated their degraded voltage setpoints and moved them higher. While this provided increased protection to safety loads from inadequate voltage, it made the plants more prone to tripping of the relays due to low grid voltages. In recent reviews on plants that are changing degraded voltage setpoints the staff has noticed there is little margin between the setpoint and the expected lower limit of the plant switchyard voltage operating range, forcing licensees to use higher accuracy Type 27N electronic relays. In addition, the staff has heard comments from licensees that these lower limits of switchyard operating voltages are being seen much more frequently following deregulation.

1.3 In discussions with the staff in a May 2, 2002, public meeting, an EPRI representative indicated that the degraded voltage analyses performed by licensee's to determine degraded voltage relay setpoints were conservative in that the grid voltages would have to get near the point of grid voltage collapse before the relays would actuate. It was indicated that this is a small range and therefore not likely to happen. The authors' observations are not the same. As indicated in Comment 2 above the staff has observed that there is not a lot of margin between degraded voltage setpoints and reasonable lower limits of switchyard operating voltages. Switchyard lower voltage operating limits are typically not near the point of grid voltage collapse. This was recently reinforced during a staff visit to a transmission system independent system operator (ISO). A representative of the ISO indicated that a nuclear power plant member had just made its newly installed automatic load tap changer operational. This would allow the ISO more flexibility by not having to control the voltage around the power plant at the previously imposed higher and more limiting plant required voltage. If the plant required voltage was down near the point of grid voltage collapse, eliminating that requirement would provide little additional flexibility to the ISO. It is the staff's understanding that maintaining nuclear power plant minimum switchyard voltage requirements are often limiting, and without them the transmission system operator could control the surrounding grid voltage to lower values without danger of voltage collapse.

1.4 It was indicated during the May 2nd meeting that the expert panel's conditional LOOP probability of 0.01 should be used whether or not a plant had a means of regulating safety bus voltages (e.g. auto load tap changing transformer). The reason provided was that all the plants had done analyses to determine required voltages and degraded voltage setpoints, and the switchyards were being controlled to those voltages. The staff was told that the expert panel had a good deal of concern about errors that could be introduce into the analyses if they are not done properly. The authors agree, however, it seems that utilizing a voltage regulating means would make the chance of error in the analyses less critical by making the actuation of the degraded voltage relays less sensitive to accurate modeling of motor starting and running effects, as well as grid transient effects following LOCA and plant trip. The response of the voltage regulation and its coordination with plant-trip grid voltage, degraded voltage relays, diesel generator operation, and the like would have to be analyzed. However, overall it would seem to make the potential for a conditional LOOP following a LOCA due to degraded voltage less likely, whether due to human errors or actual degraded voltage conditions.

1.5 During the May 2nd meeting and in the expert elicitation report, credit was given to the plant operator/grid operator agreements for maintaining adequate grid voltage following a LOCA induced plant trip. The authors agree that these protocols can be a valuable tool for maintaining a low conditional LOOP probability given a LOCA, but some words of caution are in order. In many cases these protocols have only been recently instituted and therefore have not received the test of time. In some cases where agreements were already in place, deficiencies were found in the alarm values used and in plant operator responses to alarm notification. The data used in the transmission grid operator contingency models has not always been realistic. During summer stress high peak conditions transmission operators have found system generators were not necessarily capable of delivering their advertized VAR support. These observations should be appropriately considered when applying credit to the protocols.

1.6 Item 3 of the expert elicitation indicates that the ECCS pumps must sequence onto their respective safety buses without inducing an automatic transfer to the EDGs. This is related to item 1 because in some implementations the ECCS pumps are block-loaded, not sequenced, to the safety buses. The voltage drop at the safety buses when the ECCS pumps are block-loaded can be larger than when they are sequenced because of the combined impact of starting several motors. Accordingly, the probability of a consequential LOOP is expected to be higher when a block-loading scheme is used rather than a sequential loading scheme.

<u>Comments on Item 2, "Successful Bus Transfer"</u>

2.1 The expert elicitation states that at least one division of the ECCS normally is powered from the grid. This is not consistent with the authors' experience. In general, plants either operate all their safety buses directly from offsite power, or operate them all from unit auxiliary transformers connected directly to the output of the main generator. In addition, according to a Brookhaven study [Martinez-Guridi and Azarm, 1994], 34 out of 71 sites of nuclear plants normally supply their safety buses from the main generator.

2.2 The expert elicitation considers that random failures that cause a failure of the bus transfer function are included in the generic industry experience data of consequential LOOPs given a reactor trip. However, it should be noted that these generic data come from a mixture of plants, that is, about half of the population of plants transfer the source of power after a reactor trip, and the other half do not. For this reason, the authors believe that for plants that power the safety buses from the main generator during normal operation, and hence, transfer the source of power to offsite power after the reactor trips, the probability of failure of the bus-transfer function should be evaluated separately. This belief is supported by the following observations:

a) An NRC report on bus transfers [Mazumdar, 1990] identified at least 56 LERs issued between 1985 and 1989 which reported failures of bus transfer to take place. Its review of these LERs found the following main causes for these failures: “defective system design, slow sync-check relay speed..., improper relay settings, slow operation of the outgoing breaker, bad auxiliary contacts, system undervoltage, and human error.” The NRC study concludes that “the schemes that eliminate bus transfer on unit trip...have much lower probability of failure than the conventional scheme...popular in the USA in which a bus transfer is initiated at every unit trip.”

b) A failure in the transfer of power source was a contributor in three of the eight consequential LOOPs after a reactor trip. These events happened at Robinson 2 (LER 261/86-005), Dresden 2 (LER 237/90-002), and Oyster Creek 1 (LER 219/97-010).

Accordingly, for plants that power the safety buses from the main generator during normal operation, the probability of failure of the transfer of the power source should be evaluated, and added to the other contributors to a consequential LOOP due to plant-centered factors.

<u>Comments on Item 3, “Successful Pump Sequencing”</u>

3.1 The conditional probability of consequential LOOP in the expert panel’s evaluation is dominated by the contribution of human errors. Hence, to obtain estimates that are as realistic and credible as possible, the estimates of human-error probabilities should be conducted by employing commonly used techniques for human-reliability analysis.

3.2 The expert panel’s report considers a human error in the system voltage analysis. The expert panel’s report estimates a human error probability (HEP) of 0.003, and gives a reference for it (Reference 4 of the expert panel’s report). The expert panel’s report states that this HEP is based on a 0.03 probability of errors being introduced by the originator of the analysis, and a 0.10 probability that those errors are not identified and corrected when checking and verifying the analysis. While these two HEPs appear to be the result of expert judgment, the expert panel’s report does not discuss the basis or justification for such judgment.

3.3 With regard to equipment failures, the industry’s evaluation did not consider the following components that are relevant to a consequential LOOP:

a) the failure of a fault relay on the main generator’s output breakers. Consequential LOOPs at Point Beach 2 (LER 301/89-002) and at Nine Mile Point 2 (LER 410/99-010) were triggered by this failure. In both events, this failure left the plant with a single line of offsite power.

b) voltage control relay of the tap changer of the transformer that feeds the safety buses from offsite power. A consequential LOOP at Indian Point 2 (LER 247/99-015) was triggered by this failure.

In addition, and related to Comment 2.2 above, for plants that are powered by the main generator during normal operation, and that transfer power source after the reactor trips, the components involved in the transfer are not included in the industry’s evaluation.

Comment on Item 4, "Other Issues"

4.1 The expert elicitation is concerned with human errors involving the control of the plant's configuration. The expert panel's report gives as an example a 1997 event. It is surmised that the expert panel's report refers to a consequential LOOP at Oyster Creek 1 (LER 219/97-010). According to this LER, the cause of the sustained low voltage on the emergency buses was that the start-up transformer's voltage regulators were set to control output voltage lower than the worst-case voltage assumed in the degraded grid study. The licensee's study assumed that the voltage regulators would be in neutral, i.e., providing no regulation for the start-up transformers. The voltage regulators were actually set to reduce voltage. The expert panel's report considers that the HEP of this error is low, and that it can be enveloped by the HEPs presented in the expert panel's report item 3. However, this failure mode is different, and hence, not enveloped by these HEPs. Accordingly, at least for the human error identified in the event at Oyster Creek 1, an HEP may need to be assessed, and included in the probabilistic model, for an operator or team from the plant's staff setting the voltage regulators incorrectly, or when the design requirements are not properly translated into these regulators.

Comment on the Concluding Section, "Probability of LOOP Given Large LOCA"

C.1 The expert panel's report obtains a value of 0.01 for the total probability of consequential LOOP, and states that this result is likely to have a much higher confidence limit than one based on the 14 events involving full ECCS actuation. The basis for asserting that this estimate has such high confidence was not found in the expert panel's report. In fact, several of the dominant contributors to the probability appear to be estimated by expert judgment, and as mentioned in the comments above, in some cases the basis for such judgment was not found in the expert panel's report.

References

1. EPRI, "Probability of LOOP Given Large LOCA - Results of Expert Elicitation Meeting," dated March 20, 2002. Report forwarded to the NRC by NEI in a letter dated April 27, 2002.

2. Martinez-Guridi, G., Azarm, M.A., "Reliability Assessment of Electrical Power Supply to Onsite Class 1E Buses at Nuclear Power Plants," Brookhaven National Laboratory Technical Report L-2505, June 1994.

3. Mazumdar, S., "Operational Experience on Bus Transfers," AEOD/E90-05, June 1990.