January 28, 2011

MEMORANDUM TO: Gary L. Shear, Deputy Director
Division of Reactor Projects
Region III

FROM: John R. Jolicoeur, Acting Deputy Director **/RA/**
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

SUBJECT: TASK INTERFACE AGREEMENT (TIA) – EVALUATION OF FLOODING LICENSING BASIS AT PRAIRIE ISLAND NUCLEAR GENERATING PLANT (PINGP) (TIA 2011-007)

The Office of Nuclear Reactor Regulation (NRR) staff has reviewed the enclosed "Draft Task Interface Agreement – Evaluation of Flooding Licensing Basis at Prairie Island Nuclear Generating Plant (TIA 2010-xxx)," provided by Region III for NRR review. Please note that by enclosing Region III's draft TIA, it becomes publicly available; this action was agreed upon between Region III and NRR via email (Agencywide Documents Access and Management System (ADAMS) Accession No. ML110240448). The NRR staff's position is provided within the body of this memorandum. Where appropriate, the NRR staff references information contained in the enclosure to support the NRR position.

The NRR staff concurs with the overall conclusion reached in Region III's draft TIA that the licensee must include the flow from all ruptured pipes in performing the flooding analysis associated with a high energy line break (HELB). The basis for NRR's conclusion is provided below.

Licensee Position

The licensee's position, as described in "Licensing Bases for Prairie Island Nuclear Generating Plant Turbine Building Internal Flooding," dated July 16, 2010 (ADAMS Accession No. ML102100198) is that water sources from the pipe that suffered the HELB should be included as a source of flooding, but water sources from piping adjacent to the HELB pipe that may be subjected to damage from pipe whips do not need to be considered. The licensee's assessment is focused on PINGP's response to the Giambusso letter (ADAMS Accession No. ML102100067) concerning the potential for flooding safety-related equipment resulting from a HELB. In responding to paragraph 9.29.15 of the Giambusso letter, concerning flooding potential from HELBs, PINGP discussed flooding from the HELB-ruptured pipe itself in a specific system in the Auxiliary Building. In its March 17, 1973, response contained in Final Safety Analysis Report (FSAR) Amendment 31 (ADAMS Accession No. ML102100175), PINGP did not

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provide a discussion or consideration of other sources of water from a secondary rupture due to pipe whip. In fact, there is no discussion of any adjacent or target pipe, or pipe whip in the flooding paragraph. The licensee subsequently concluded that the Atomic Energy Commission (AEC) approved the PINGP response through the staff's safety evaluation report (SER) and, therefore, accepted the premise that consequential flooding from the secondary pipe rupture is not required to be analyzed.

Discussion

Supplement 1 to the PINGP Units 1 and 2 SER, dated March 21, 1973, which addressed the issues contained in the Giambusso letter responses, provides some information on what the AEC expected. An excerpt on page 2 states:

> A summary of criteria and requirements that were incorporated in our request is set forth below:
>
> (1) Protection of equipment necessary to shut down the reactor and maintain it in safe shutdown condition, assuming a concurrent and unrelated single active failure of protected equipment, should be provided from all the effects resulting from ruptures in pipes carrying high-energy fluid, up to and including a double-ended rupture of such pipes, where the temperature and pressure conditions of the fluid exceed 200F and 275 psig. Breaks should be assumed to occur in those locations specified in the "pipe-whip criteria." The rupture effects on equipment to be considered include pipe whip, structural (including the effects of jet impingement) and environmental.

The regulatory assessment does not specifically discuss the secondary rupture effects on the adjacent piping, but it does state that the HELB effects on equipment should be considered, including pipe whip and environmental effects.

Appendix I of the Updated Safety Analysis Report (USAR) provides a description of PINGP's compliance with the HELB criteria. For example, Figures I.3.2-3/4, "Feedwater Isometric - Unit 1/Unit-2," identify two break points outside containment for each unit: FW1-B1 and -B4 for Unit 1 and FW2-B1 and -B4 for Unit 2. The enclosure states that there are no whip restraints on the 16-inch feedwater lines in the area of the break points. Thus, a broken feedwater line can be assumed to whip into any structure or component in the vicinity of the break.

An example was provided in the enclosure where there are several fluid containing pipes adjacent to the feedwater lines that range in size from 4 inches to 14 inches in nominal pipe diameter, some carrying an unlimited supply of water until isolated. The enclosure also states that the licensee determined the length of pipe allowed to whip is between approximately 15 and 20 feet. Further, in most instances the distance between the feedwater pipe and the target pipe is less than 10 feet. Section I.2.1, "Pipe Rupture Induced Loads" of USAR Appendix I, states:

> If a whipping pipe was capable of impacting adjacent pipes of equal or greater nominal pipe size and equal or heavier wall thickness, the adjacent pipe was

> considered to be free from rupture. Protection from a pipe wall whip was not provided if pipe rupture occurred in such [a] manner that the unrestrained pipe movement of either end of the ruptured pipe, in any possible direction about a plastic hinge formed at the nearest pipe whip restraint, cannot impact any structure, system or component required to survive the accident.

The first sentence of the above paragraph can be restated as follows: if a whipping pipe is capable of impacting an adjacent pipe of smaller pipe size and smaller or lighter wall thickness, the adjacent pipe is considered to be ruptured. Therefore, the adjacent cooling water pipe is assumed to be ruptured.

Since the ruptured feedwater pipe whips into, and causes the rupture of, the cooling water pipe, both failed pipes are considered as the event to be analyzed, including the consequences of flooding with both ruptured pipes as simultaneous sources of flood water.

The licensee performed an analysis that indicates, in some cases, that a HELB in the Turbine Building could actuate the fire protection sprinkler system. Since the HELB causes the actuation of the fire protection sprinkler system, this flow should also be considered as a source of flooding water.

The enclosure notes that in the flooding review results section of the USAR (subparagraph I.5.5.3), it is stated that: “Piping systems in the Design Class I area of the Auxiliary Building were reviewed for the effects of flooding due to HELB and Non-HELB events.”

In the USAR discussion of the Auxiliary Building, the HELB event that is discussed only considers the initial pipe break source of water. No discussion of pipe whip or jet impingement exists in this section. The HELB flooding event discussed in the USAR is that event resulting from a steam generator blowdown piping failure. The USAR further states that the response times from failures of other non-Class I piping systems are bounded by this failure. There is no discussion of piping systems in the Turbine Building whose failure could impact Class I components. Based on a review of the USAR, the licensee did not exclude Turbine Building HELBs in its analysis, but rather concluded that these events were not limiting. For example, Table I.3.2-1 in Appendix I of the USAR identifies HELB locations in the Turbine Building. In addition, Section I.3.1 describes the Turbine Building as a structure requiring evaluation. Section I.3.I discusses the Class I aisle (in the Turbine Building) that houses safety-related equipment (auxiliary feedwater and electrical components). The section further states that there are no high energy line systems within the Class I aisle and that the Turbine Building is vented through corridors, grates, stairways, etc. Based on the above, the licensee’s assessment appears to conclude that the Turbine Building was evaluated and no adverse issues related to HELB were identified.

The licensee’s position is that, because there was no documented discussion in the USAR that a pipe rupture caused by a whipping high energy pipe should be included as a source of flooding water in addition to the already ruptured high energy line, this does not need to be considered. The NRR staff’s position is that it is the licensee’s responsibility to identify situations where a pipe can whip into another pipe and rupture the target pipe. Therefore, the licensee’s contention that there is no discussion of this scenario in the USAR is not justified.

The following references from the USAR address the requirements for protecting components from flooding events.

Section I.5.2, “Pipe Whip,” of the USAR Appendix I states:

> Restraints are provided to prevent pipe whip where there is a possibility that whip following a pipe rupture would damage structures, systems or components that are required to mitigate the consequences of that pipe rupture.

Section 12.2.5.1, “Protection for Class I Items,” of the USAR states:

> The Class I items are protected against damage from:
>
> a. Rupture of a pipe or tank resulting in serious flooding or excessive steam release to the extent that Class I function is impaired….

As noted in the enclosed draft TIA, flooding that results from a HELB in the Turbine Building, taking into account the flow contributions from both ruptured pipes, could result in damage to components and systems required to mitigate the HELB, including the emergency diesel generators, the station batteries, and the auxiliary feedwater system.

Conclusion

Based on the discussion above, the NRR staff concludes that if a ruptured high energy line can whip and strike another fluid-filled line which meets the criteria for being ruptured by a whipping high energy line, the second (target) pipe must also be assumed to rupture. There is no basis for not including the water contribution from the target pipe rupture in the facility’s flooding analysis. Therefore, the NRR staff’s position is that the fluid from the target pipe must also be included in the flooding analysis at PINGP. Further, if the HELB can also result in actuation of the fire sprinkler system, then the water from that system must also be included in the flooding analysis at PINGP.

Enclosure:
As stated

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Enclosure:
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November XX, 2010

MEMORANDUM TO: Thomas B. Blount, Deputy Director
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

FROM: Gary L. Shear, Deputy Director
Division of Reactor Projects
Region III

SUBJECT: DRAFT TASK INTERFACE AGREEMENT – EVALUATION OF FLOODING LICENSING BASIS AT PRAIRIE ISLAND NUCLEAR GENERATING PLANT (TIA 2010-xxx)

This Task Interface Agreement (TIA) documents the regulatory position as determined through consultation between Region III and the Office of Nuclear Reactor Regulation regarding the internal flooding licensing basis at Prairie Island Nuclear Generating Plant, Unit 1 and 2 (PINGP). Specifically, this TIA evaluates the flooding licensing basis for high energy line breaks (HELB) outside of the containment, and specifically in the turbine building.

Background

PINGP is a pre-General Design Criteria (GDC) Plant. In addition, the original operating license application for PINGP was reviewed by the Atomic Energy Commission (AEC) before the Standard Review Plan (SRP) and Regulatory Guides for seismic design (RG 1.29) and their criteria were implemented.

PINGP has several non-seismically qualified, high energy lines in the turbine building that are not equipped with pipe restraints or other structural anchors. Adjacent to these high energy lines are fluid piping lines that could be impacted by pipe whips if a HELB were to occur. If a secondary rupture of the adjacent pipe occurred, large sources of water (open loop system from the Mississippi river) would flow into the turbine building, under doors and through drainage paths into safety related rooms. These possible sources of water could impact multiple trains of safety related equipment (for example the diesel generators, the batteries and the auxiliary feed water system) if they are not isolated prior to submergence of key subcomponents. This TIA establishes if the target or adjacent pipe fluid contents, or other water sources, need to be considered as part of the water sources for potential flooding. [For information: for HELB there is a pipe that ruptures, then, if there are no restraints or anchors, the pipe could whip and hit an adjacent pipe. The pipe that is impacted is called the adjacent or target pipe, and the rupture is called a secondary rupture.]

For example, one piping segment on the inlet to feedwater heaters 25A and 25B is 16-2FW-3 (a 16” diameter high energy line), and it is adjacent to several fluid piping lines. There are no pipe whip restraints on this line. These target pipes range from 4 inches to 14 inches in diameter, and some carry an unlimited supply of cooling water until isolated. The licensee determined the pipe length which would be whipped ranged between approximately 15 and 20 feet. In most cases, the distance between the high energy pipe and the target pipe was less than 10 feet and

some were less than 2 feet. For cases where the larger cooling lines were ruptured by the whipping HELB line, flow rates between 20,000 and 30,000 gpm could result. Based on limited access to the turbine building during the initial stages of the HELB (due to environmental conditions), the volume of water could impact safety related equipment, until manually isolated by the operators. There are multiple HELB pipe segments in the feedwater, condensate and main steam systems that can have the same impact of challenging safety related equipment.

In addition, the licensee's analysis determined that for several HELBs, the fire protection sprinkler system would actuate based on the high temperatures in the turbine building. The water would continue to fill the turbine building and eventually adjacent areas until manually isolated by the operators.

Licensing basis

Because of the age of the plant, there are not a lot of detailed documents that describe the specifics of the plant's flooding design and licensing basis requirements. The licensing basis is discussed in the Updated Safety Analysis Report (USAR) in Sections 6 and 12. Some source documents for the licensing basis for internal flooding included: a letter from the NRC to the licensee, and the licensee's response in 1972 describing flooding operating experience at Quad Cities; and a letter from the NRC to the licensee, and the licensee's responses in 1972 and 1973 describing high energy line breaks. This letter is referred to as the Giambusso letter (written by Mr. Giambusso of the NRC and sent to all licensees in 1972). From these two sources, additional licensing basis information was added in Appendix I to the PINGP USAR. In addition, another source document for HELBs is the NRC Generic Letter 87-11 (GL 87-11), which relaxed the requirements for postulating arbitrary intermediate breaks and leakage cracks in high energy systems. There is no issue with the licensing basis in this regard, but it is mentioned for completeness. The TIA will focus on the licensing basis documentation, including the USAR revision of record in place (revision 29) in April 2009, when the first condition report was written documenting potential flooding issues at PINGP.

USAR (general)

The USAR provides a high level summary of the required protection in Sections 6 and 12.

Section 12.2.5.1 – Protection for Class I Items

"The Class I items are protected against damage from:

a. Rupture of a pipe or tank resulting in serious flooding or excessive steam release to the extent that Class I function is impaired.

b. Pipe whip and steam/water jets following a pipe rupture of an adjacent pipe.

c. Earthquakes, by having the ability to sustain seismic accelerations adopted for the purposes of plant design without loss of function. Protection from interaction with the surrounding buildings is accomplished by providing a separating joint of sufficient size for earthquake displacements. Unless the building is designed Class I seismic design, an analysis is made to demonstrate that it will not collapse, otherwise the systems are protected locally.

d. Tornado wind loads. And

e. Missiles created from other sources such as tornado created missiles.

Section 6.1.2.8 – Engineered Safety Features Protection from Internal Flooding

"Internal flooding which could be postulated to adversely affect the performance of Engineered Safety Features was a part of the original plant design criteria. Provisions have been made for sumps and sump pumps in the Screenhouse, Turbine Building, Auxiliary Building and the Reactor Building, and sumps with level annunciation in the D5/D6 Diesel Generator Building. These provisions are intended to protect vital equipment from equipment leakage which occurs during normal plant operation. They were not originally designed as protection against large internal flooding conditions resulting from major failures of systems having relatively large capacities of water (rupture of flexible connections in the circulating water lines, cooling water header rupture or main feedwater break).

These buildings do however have the capacity to accommodate large internal floods since it takes time to increase the water levels to an elevation where nuclear safety related equipment is located. It has been shown by various studies that the operating staff has enough time to isolate the cause of the flooding before safety related equipment function would be lost."

It should be noted that USAR Section 12 was created from Appendix B of a previous revision to the USAR in October of 1972, and was in the original Final Safety Analysis Report (FSAR) submitted to the AEC (Amendment 7, dated January 28, 1971). The current wording of Section 12.2.5.1 (a) and (b) has not changed from the FSAR submittal. The USAR is clear that protection must exist to prevent the loss of function.

USAR (Appendix I – Postulated Pipe Failure Analysis Outside of Containment)

HELB and Flooding

"This Appendix includes information on NSP's [Northern States Power] response to the Giambusso letters and NSP's subsequent application of GL 87-11 criteria." [Introduction to Appendix I, PINGP USAR]

There is a specific subparagraph (I.5.5.1) for HELB-induced flooding:

"The requirement to determine the flooding effects of high energy line breaks was specified in the original HELB requirements letter, A Giambusso (AEC) to AV Dienhart (NSP), "Request for Additional Information Concerning a Postulated Steam Pipe Break Outside of Containment," December 12, 1972. (Ref 1) Paragraph 9.29.15 in the letter's attachment states, "A discussion should be provided of the potential for flooding safety related equipment in the event of failure of a feedwater line or any other high energy fluid line."

> To obtain clarification on several aspects of the December 12, 1972, letter, a meeting was held with the AEC staff on January 4, 1973. Meeting minutes were transmitted in letter, A Giambusso (AEC) to AV Dienhart (NSP), January 11, 1973. The AEC response to Request 9.29.7b(3) concerning cracks in high energy pipes reads in part, "The critical size is taken to be one half the pipe diameter in length and one half the wall thickness in width." (Ref. 2)
>
> PINGP's later commitment to implementing the high energy pipe break and leakage crack criteria in NRC Branch Technical Position MEB 3-1, as attached to NRC Generic Letter 87-11, Relaxation in Arbitrary Intermediate Pipe Rupture Requirements, (Ref. 4) is discussed in Sections I.1 and I.2. When adopting the relief offered by Generic Letter 87-11, PINGP used only the applicable equations in MEB 3-1 and nothing more."

The above USAR discussion is focused on the crack criteria and the use of the GL 87-11 relaxation criteria. No discussion on pipe whip exists in this section.

In the flooding review results section of the USAR (subparagraph I.5.5.3), it is stated that:

> "Piping systems in the Design Class I area of the Auxiliary Building were reviewed for the effects of flooding due to HELB and Non-HELB events."

In the discussion of Auxiliary building, the HELB event that was discussed only considered the pipe break source of water. No discussion on pipe whip or jet impingement exists in this section. The HELB event was from steam generator blowdown piping and the USAR indicates that response times from failures of other non-Class I piping system is bounded by this failure. There is no discussion of piping systems in the turbine building that could impact Class I components. Based on the USAR references, the licensee did not exclude turbine building HELBs in their analysis, but rather they concluded that they were not limiting. For example, the tables in the back of Appendix I included a list of turbine building HELBs. Also, Section I.3.1 describes the turbine building as a structure requiring evaluation. Section I.3.I discusses the Class I aisle (in the turbine building) that houses safety-related equipment (auxiliary feedwater , electrical components) and mentions that there are no high energy line systems within the Class I aisle and that the turbine building is vented through corridors, grates, stairways, etc. In summary, the licensee's assessment appears to conclude that the turbine building was evaluated and there were no issues.

Pipe Whip

In section 1.2, "Features for Protection Against the Effects of HELB Events", pipe whip and jet impingement are discussed. The adjacent pipe damage is discussed specifically:

> "If a whipping pipe was capable of impacting adjacent pipes of equal or greater nominal pipe size and equal or heavier wall thickness, the adjacent was considered to be free from rupture." [USAR Appendix I, Section I.2.1, Revision 29, April 2009]

Region III's position is that the converse is equally true: if the adjacent piping does not meet the thickness and size requirements, then the pipe should be considered ruptured, unless specific analysis indicates that damage would not occur. There is a concluding statement on pipe whip in Appendix I, Section 1.2.1:

> "restraints installed on high energy piping systems preclude any functional damage to required equipment in the Shield Building Annulus, Auxiliary Building, and other structures."

No USAR discussion of HELBs in the turbine building exists in this section. However, as in the flooding section above, since HELBs in the turbine building are discussed in the other sections of the USAR Appendix I, one should conclude that where the licensee believed whip restraints were needed, they were installed.

Licensee Position

The licensee's position is that water sources from the pipe that suffered the HELB should be included as a source of flooding; however, water sources from piping adjacent to the HELB pipe that may be subjected to damage from pipe whips do not need to be considered.
The licensee's assessment is focused on PINGP's response to the Giambusso letter concerning the potential for flooding safety-related equipment resulting from the HELB. In answering paragraph 9.29.15 of the Giambusso letter, concerning flooding potential from HELBs, PINGP discussed flooding from the HELB-ruptured pipe itself in a specific system in the Auxiliary Building. In its response, PINGP did not provide a discussion or consideration of other sources of water from a secondary rupture due to pipe whip. In fact, there is no discussion of any adjacent or target pipe, or pipe whip in the flooding paragraph. The licensee subsequently concluded that AEC approved the PINGP response through the staff's safety evaluation report (SER); and therefore, accepted the premise that consequential flooding from the secondary pipe rupture is not required to be analyzed.

Based on the thought process above, the licensee does not consider the fire projection sprinklers a water source since there was no specific discussion in the Giambusso discussion.

Regulatory Evaluation

The USAR established the licensing basis in Sections 6 and 12 for flooding (Section 12- "The Class I items are protected against damage from rupture of a pipe or tank resulting in serious flooding or excessive steam release to the extent that Class I function is impaired.") Section 6 notes that internal flooding, which could be postulated to adversely affect the performance of Engineered Safety Features, was a part of the original plant design criteria. It further suggests that the turbine building was a building for which protection is designed to mitigate the consequences of flooding.

The PINGP licensing basis for HELB impacts on adjacent piping resides in Section 12 ("Class I items are protected against damage from: Pipe whip and steam/water jets following a pipe rupture of an adjacent pipe"). The type of damage is discussed in USAR Appendix I. If the pipe is not restrained and is capable of striking a smaller diameter pipe with a smaller wall thickness than the target or adjacent pipe, one should conclude that the target or adjacent pipe is ruptured (unless an analysis shows this not to be the case). Since the pipe ruptures, water will flow out of the pipe just as it flows into rooms, under doors and into sumps. These are expected to happen as a part of the original initiating event. ("In general, facility design takes into consideration any consequential failures that are deemed credible." Inspection Manual Chapter, Part 9900 NRC guidance). Consequential effects are part of the licensing basis, if they are

credible. Regardless whether it is specifically stated or not, the USAR licensing basis for flooding establishes the requirement to assume from the pipe rupture that the natural consequence is water flowing. One could conclude that the reason that these consequential effects from the secondary rupture were not discussed or evaluated in Appendix I was not that they were assumed not to occur, but where the licensee believed the potential did exist to impact the safety function (needed to reach and maintain safe shutdown), whip restraints were provided ("Restraints installed on high energy piping systems preclude any functional damage to required equipment in the Shield Building Annulus, Auxiliary Building, and other structures"). It does not appear that an adequate evaluation was completed on the potential impact of pipe whips and secondary ruptures in the turbine building as would be needed based on the USAR description in Sections 6 and 12.

The NRC position is that the evaluation of one piping system identified in the licensee's response to the Giambusso letter, absent a discussion on pipe whip, does not constitute the licensing basis of the plant, and is narrowly focused on a specific evaluation. For example, there is no discussion in the response as to whether pipe restraints were in place on this system. The licensing basis uses USAR Sections 6 and 12 with the knowledge that, without an analysis or restraints, a HELB-induced pipe whip will rupture the adjacent pipe (pursuant to the thresholds discussed in Appendix I), causing consequential impacts for which class I components must be afforded protection.

Staff Guidance

In the SER dated March 21, 1973 for the Giambusso letter responses provides some information on what the NRC expected. The Page 2 excerpt:

> "A summary of criteria and requirements that were incorporated in our request is set below:
>
> Protection of equipment necessary to shut down the reactor and maintain it in safe shutdown condition, assuming a concurrent and unrelated single active failure of protected equipment, should be provided from all the effects resulting from ruptures in pipes carrying high-energy fluid, up to and including a double-ended rupture of such pipes, where the temperature and pressure exceed 200F and 275 psig. Breaks should be assumed to occur in those locations specified in the "pipe-whip criteria". The rupture effects on equipment to be considered include pipe whip, structural (including the effects of jet impingement) and environmental."

The regulatory assessment does not specifically discuss the secondary rupture affects on the adjacent piping, but it does say the HELB effects on equipment needs to be considered including pipe whip and environmental effects. Therefore, the regulatory position taken in this TIA is consistent staff guidance which existed in the timeframe.

Conclusion

The consequential effects from HELBs are part of the licensing basis. If pipe whip restraints are not installed on a pipe that must be postulated to rupture, then adjacent pipes could be subject to rupture, unless an analysis is provided which indicates it would not rupture. Furthermore if the adjacent/target pipe is determined to rupture, then all consequential environmental effects of

that rupture should be considered. This includes water sources from the adjacent/target pipe and sprinklers which may actuate based on temperatures. These water sources must be considered in evaluating whether the required Class I equipment is adequately protected.