ArevaEPRDCPEm Resource

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Sent: Wednesday, June 09, 2010 12:07 PM
To: Tesfaye, Getachew
Cc: ROMINE Judy (AREVA NP INC); VAN NOY Mark (EXT); CORNELL Veronica (EXT); SLAY Lysa M (AREVA NP INC)
Subject: DRAFT RAI 354 Supplement 2 response
Attachments: RAI 354 Supplement 2 Response US EPR DC - DRAFT.pdf

Getachew,

On May 20, a draft response for RAI 354 questions 03.06.02-33 thru 40 was provided. Attached are draft responses for 03.08.05-20, 21; 03.06.02-32, 03.06.02-41 and 42. In RAI 354 Supplement 1 dated June 3, 2010, a final submittal date of July 7, 2010 was provided to allow time for the staff to review and interact as necessary to resolve any remaining questions. Let me know if the staff has any questions on this material.

Thanks,

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Response to

Request for Additional Information No. 354(4106,4107,4220), Revision 0, Supplement 2

3/16/2010

U. S. EPR Standard Design Certification
AREVA NP Inc.
Docket No. 52-020
SRP Section: 03.08.02 - Steel Containment
SRP Section: 03.08.05 - Foundations
SRP Section: 03.06.02 - Determination of Rupture Locations and Dynamic Effects Associated with the Postulated Rupture of Piping

Application Section: FSAR Ch 3

QUESTIONS for Structural Engineering Branch 2 (ESBWR/ABWR Projects) (SEB2)

Question 03.08.05-20:

Follow-up to RAI 155, Question Nos. 03.08.05-13

Regarding part (A) of the RAI, the staff notes that the FSAR generally requires that concrete exposed to aggressive environments will meet the applicable requirements of ACI 349-01, Chapter 4 “Durability Requirements” or ASME, Section III, Division 2, Article CC-2231.7 “Durability.” However, FSAR Section 3.8.5.6.1 is not explicit about the need to follow specific durability requirements.

To resolve part (A) of the RAI, confirm whether the items listed below will be implemented.

1. Evaluation of aggressive environments will be determined in accordance with ACI 349-01 Chapter 4 or ASME Section III, Division 2, Article CC-2231.7, where applicable.
2. In the case of aggressive environments, and in addition to the use of epoxy rebar proposed by the FSAR in aggressive environments, the concrete durability requirements (special cement types, maximum water-to-cement ratios, minimum compressive strengths, etc.) of ACI 349-01 Chapter 4 or ASME Section III, Division 2, Article CC-2231.7 will be followed, where applicable.
3. This information will be incorporated into the relevant sections of the FSAR including FSAR Section 1.8, Table 1.8-2, COL Item 3.8-11.

Regarding part (B) of the RAI response, it states that “Dewatering systems, if used, mitigate potentially aggressive groundwater effects, minimize seepage, and decrease long-term structure maintenance. Dewatering systems perform no safety-related function and are not classified as Category 1.” The staff requests that these statements be included in the FSAR. In addition, since the dewatering systems are not classified as seismic Category I, the staff also requests that the FSAR clearly explain that if dewatering systems are utilized, they should not be relied upon to lower existing groundwater levels to meet assumed design conditions (e.g., maintain water level below a certain elevation assumed in design). AREVA should be aware that if the dewatering systems are used to meet assumed design conditions, then these systems need to be classified as Seismic Category I or further technical justification needs to be provided to justify otherwise.

Response to Question 03.08.05-20:

The requirements for concrete durability in aggressive environments will be explicitly referenced by the U.S. EPR FSAR. The use of dewatering systems to mitigate the potentially aggressive groundwater effects will not be relied upon as an alternative for lowering the existing groundwater levels to meet assumed design conditions for safety-related structures. The U.S. EPR FSAR will be updated to remove this item.

U.S. EPR FSAR Tier 2, Section 3.8.5.6.1 will be updated as follows:

- Concrete exposed to aggressive environments, as defined in ACI 349-01, Chapter 4, shall meet the durability requirements of ACI 349-01 Chapter 4 or ASME Section III, Division 2, Article CC-2231.7, as applicable. In addition, epoxy coated reinforcing steel will be considered, on a site-specific basis, for use in foundations subjected to aggressive environments. For epoxy coated reinforcing steel, the required splice length is increased in accordance with ACI 349-01 specifications.

U.S. EPR FSAR Tier 2, Section 1.8, Table 1.8-2, COL Item 3.8-11 and Section 3.8.5.6.1 will be updated as follows:

> “A COL applicant that references the U.S. EPR design certification will evaluate the use of epoxy coated rebar for foundations subjected to aggressive environments, as defined in ACI 349-01, Chapter 4. In addition, the waterproofing system of Seismic Category I foundations subjected to aggressive environments will be evaluated for use in aggressive environments. Also, the concrete of Seismic Category I foundations subjected to aggressive environments will meet the durability requirements of ACI 349-01, Chapter 4 or ASME, Section III, Division 2, Article CC-2231.7, as applicable.”

Impact on FSAR

U.S. EPR FSAR Tier 2, Section 3.8.5.6.1 and Section 1.8, Table 1.8-2, COL Item 3.8-11 will be revised as described in the response and indicated on the enclosed markup.

Question 03.08.05-21:

Follow-up to RAI 155, Question Nos. 03.08.05-14

The staff finds that the information provided in the response to Items 1 and 2 of this RAI is acceptable. However, the applicant is requested to incorporate the information for both items in FSAR Section 3.8.5.6.1.

The response to Item 3 of this RAI indicates that moisture alone does not necessarily cause structural concrete deterioration. It further states that COL applicants are required to identify aggressive environments, free moisture with sufficient hydraulic gradient to potentially erode or otherwise cause deterioration of the structure, and provide mitigating measures on a site-specific basis as provided by U.S. EPR FSAR Tier 2, Section 1.8, Table 1.8-2, Item 3.8-11. Finally, it is pointed out that a waterproofing membrane is not required where groundwater chemistry or hydraulic gradient do not warrant its use.

The staff notes that past operating plant experience has identified numerous cases of unexpected degradation of below grade foundations. In addition, past designs of seismic Category I foundations at nuclear power plants and other current licensing applicants provide some form of waterproofing systems to protect foundations. The use of waterproofing systems has always been recognized as a good engineering practice to prevent degradation of foundations. Therefore, the staff requests that AREVA explain why these considerations do not apply to the EPR and to demonstrate that omission of waterproofing systems is not detrimental to the structure for the entire life of the plant.

Also, the staff notes that Section 3.8.5.6.1 of the FSAR indicates that the waterproofing membrane will be required for sites with a high water table. This section implies that for a low water table, waterproofing may not be utilized. If waterproofing membranes will not be used for seismic Category I structures because of the assumed low water table, then AREVA is requested to describe the plant program that will monitor the ground water table for the entire 60 year period of the plant which will ensure that the initial low water table assumption is maintained. Identify the required elevation below all foundations that constitutes a sufficiently low ground water table. Also, discuss how potential aggressive chemicals that may occur in the soils above the low ground water level will be precluded from degrading the foundations due to rain infiltration and/or moisture in the soil.

Response to Question 03.08.05-21:

AREVA is no longer specifying the use of a geosynthetic membrane embedded within a mud mat as the only form of waterproofing for the U.S. EPR. Figure 3.8-117 will be removed from the FSAR. Instead, a waterproofing system is required for all Seismic Category I foundations below grade. The requirement of a waterproofing system is not a function of water table elevation. This is defined in U.S. EPR FSAR Tier 2, Section 3.4.2. The waterproofing system of Seismic Category I foundations subjected to aggressive environments, as defined according to ACI 349-01, Chapter 4, shall be evaluated for use in such environments. U.S. EPR FSAR Tier 2, Section 3.8.5.6.1 will be updated to clarify this.

FSAR Impact:

U.S. EPR FSAR Tier 2, Table 1.8-2 and Sections 2.5.4.5, 3.8.5.4.1, 3.8.5.5.1 and 3.8.5.6.1 will be revised and Figure 3.8-117 will be removed as described in the response and indicated on the enclosed markup.

Question 03.06.02-32:

Follow-up to RAI 222, Question No. 03.06.02-20 and RAI 107, Question No. 03.06.02-2

The response from AREVA concerning RAI 222, 03.06.02-20 is not adequate. In the response, AREVA revised the EPR FSAR Tier 2 Section 3.6.2.1.1.4 to discuss how the US EPR design and the separation and redundancy method are used to mitigate the effects of pipe rupture of high energy lines.

i) It is not clear to the staff how AREVA is intended to apply the method of separation and redundancy. The applicant is requested to clarify whether the separation and redundancy method is used

   a) when the source of the postulated pipe failure is one of the essential systems that is separated and redundant.

   b) when the target of the postulated pipe failure is one of the essential systems that is separated and redundant

ii) In particular, the revised FSAR indicated that "For outside containment, each redundant train is located in one of four separate Safeguard Buildings. For inside containment, this separation is often accomplished by separate compartments/rooms." It is not clear if there are cases where they are not separated by compartments inside the containment. AREVA should clarify what it meant by “often” or remove the word "often". AREVA should also clarify if these compartments and rooms are capable of resisting the effect of pipe whip and mitigating the extreme environmental effects resulting from a pipe break in the U.S. EPR. The applicant is requested to revise FSAR 3.6.2.1.1.4 to clarify aforementioned issues.

iii) AREVA stated in its response that the system train redundancy and separation of trains of essential systems are key to mitigating the effects of pipe breaks. It also stated that many essential systems are designed with 4 redundant trains, with each train capable of performing the system’s safety function. It is not clear to the staff whether each train is capable of performing 100 percent of the system's function when the separation and redundancy method is used. It is also not clear if there are still other essential systems, in addition to the "many essential systems", which may not have this separation/redundancy characteristic. The applicant is requested to address the above staff concerns.

Response to Question 03.06.02-32:

Subpart (i) to this question asks for clarification as to when the method of separation and redundancy is used, and specifically asks if the method will be used when the source is a separated and redundant essential system, or when the target is in a separated and redundant essential system.

A key point about the use of four train separation and redundancy is that it is used as a tool for evaluating the effects of breaks on essential structures, systems and components (SSC) targets. It is not used to preclude the need for break postulation and subsequent evaluation. Therefore, it doesn’t matter if the break is in essential system piping or in non-essential system piping, as long as all essential system elements impacted by the break are evaluated. The effects of either type of break are evaluated on a case-by-case basis to evaluate the capability for safe shutdown of the plant following the break. This was discussed in the third bullet of the Response to RAI 222, Supplement 3, Question 03.06.02-20, which stated:

> "If the targets are within the same train of four train redundant systems (including the broken pipe, if it is also within an essential system), then the survivability of the systems' safety functions is confirmed without the need for further target analysis or protection considerations."

To provide further clarification to U.S. EPR FSAR Tier 2, Section 3.6.2.1.1.4, the following sentence will be added to the end of the first paragraph, as shown on the attached markup:

> "Since not all essential systems have four completely separated and redundant trains capable of performing the system's safety function, all ruptures must be evaluated with the four train separation and redundancy concept providing a useful evaluation tool, where it is available."

Note that this also provides clarification for question subparts (ii) and (iii)

Subpart (ii) to this question asked for clarification of the sentence "Inside containment, this separation is often accomplished by separate compartments/rooms used for individual trains." The use of the word "often" required clarification. Also, it was asked if compartments and rooms were capable of resisting the effects of the break in order to maintain separation.

The use of the word "often" in the subject sentence was by design since inside containment, even for four train redundant systems, it is not always possible to show complete separation of the trains. There are a number of areas, however, where the trains are completely separated by the use of four separate compartments or rooms. Thus, for clarification, the sentence will be modified to state "often, but not always" as shown on the attached markup.

For all postulated breaks, the targets to be evaluated fall into the categories of SSC. Thus, each break is evaluated for nearby essential system distribution targets, such as piping, conduits, cable trays, and heating, ventilation, air conditioning (HVAC), as well as protective structures for other essential system targets beyond, and nearby essential system components (equipment). In response to the second part of the question, surrounding compartment and room structural elements are designed for all effects of the break where such structural elements are credited for separation.

To provide further clarification to U.S. EPR Tier 2, Section 3.6.2.1.1.4, the following information will be added after the word targets in the second bullet: "(equipment, piping, HVAC, electrical distribution elements and structures)".

Subpart (iii) to this question asked for clarification of the phrase "many of the U.S. EPR essential systems are designed with four redundant trains". In particular, the use of the word "many" requires clarification. Also, it was asked whether each train is capable of performing 100 percent of the system's function.

The use of the word "many" in the subject phrase was by design since not all essential systems have four trains, and not all four train essential systems have 100 percent capability of performing the safety function in each of the four trains. Thus, for clarification, the sentence will be modified to state "most, but not all."

In response to the question about the 100 percent capability of each train, this was specified in the subject sentence when it states “with each train capable of performing the system’s safety function of bringing the unit to a safe shutdown condition”.

FSAR Impact:

U.S. EPR FSAR Tier 2, Section 3.6.2.1.1.4 will be revised as described in the response and indicated on the attached markup.

Question 03.06.02-41:

Follow-up to RAI 222, Question No. 03.06.02-30 and RAI 107, Question No. 03.06.02-15

In its response to Question 03.06.02-30, AREVA stated that the seismic loadings on the whip restraint structure from the piping are excluded because there are sufficient gaps between the pipe and the structure to preclude contact during a safe shutdown earthquake, and AREVA will include self-weight seismic excitation in the appropriate load combinations. The staff finds that AREVA did not define the appropriate load combinations. The staff also notes that the loads and load combinations appropriate for the design and analysis of these restraints should be similar to those applicable to Seismic Category I structures (i.e., SRP Section 3.8.4 for miscellaneous steel structures), since the whip restraint must survive all other loads and the environment to perform its one-time restraint action to the whipping pipe anything during its design life. The applicant is requested to provide the design and analysis of whip restraint, loads and load combinations, and the Codes and Standards to be used for maintaining its structural integrity prior to a pipe break event.

Response to Question 03.06.02-41:

A paragraph will be added to U.S. EPR FSAR Tier 2 Section 3.6.2.5.1.2 to identify the applicable loads, load combinations, Codes and Standards, and acceptance criteria for whip restraints. This paragraph will identify loads for these restraints as deadweight, self-weight seismic excitation, and the one-time pipe whip force. These restraints are designed as Seismic Category I miscellaneous structures, in accordance with U.S. EPR Tier 2 Section 3.8.4, which identifies the appropriate load combinations, Codes and Standards, and acceptance criteria.

FSAR Impact:

U.S. EPR FSAR Tier 2 Section 3.6.2.5.1.2 will be revised as described in the response and indicated on the enclosed markup.

Question 03.06.02-42:

Follow-up to RAI 222, Question No. 03.06.02-31 and RAI 107, Question No. 03.06.02-17

The response from AREVA concerning RAI 3.6.2-31 is not adequate.

a) In its response to part 1 of this question related to as-designed pipe break hazards analysis, the applicant stated that, in its response to RAI 132, Supplement 1, Question 14.03.02-11, AREVA moved the pipe break hazards analyses ITAAC to a structure ITAAC, EPR FSAR Tier 1, Table 2.1.1-4, Nuclear Island ITAAC. As discussed in the staff's RAI and the applicant's RAI response, the pipe break hazards analysis needed to be performed for applicable postulated pipe failures for all the piping systems which are within the scope of SRP Section 3.6.2. In addition, GDC 4 requires that all SSCs important to safety be designed to accommodate the effects of postulated piping failures, including appropriate protection against the dynamic and environmental effects of postulated failure. It should be noted that Nuclear Island (NI) as defined in EPR FSAR Tier 1, Section 2.1.1 consists of the structures supported by the NI common basemat and the NI common basemat itself. It is not piping system related. Therefore, the staff determines that it is not proper to include the pipe break hazards analysis ITAAC in the structure ITAAC, Table 2.1.1-4, Nuclear Island ITAAC. The applicant is requested to address this staff's concern.

b) In its response to part 2 of this question related to as-built pipe break hazards analysis, the applicant stated that the inspection of the as-installed configuration of the pipe break analysis protection features will be performed against construction drawings such that they agree with the construction drawings. The staff found this not acceptable. It should be noted that as-built reconciliation is to be performed using the as-built information against as-designed pipe break hazards analysis report (as opposed to construction drawings). For an example, as a result of piping reanalysis caused by differences between the design configuration and the as-built configuration, or a change is required in pipe parameters, such as major differences in pipe size, wall thickness, and routing, the highest stress or CUF locations may be shifted. As a result, the initially determined break locations may be changed and therefore, the dynamic effects from the new (as-built) break locations are not mitigated by the original pipe whip restraints and jet shields. Therefore, an acceptable as-built pipe break hazards analysis reconciliation is to reconcile the as-built configuration against the as-designed pipe break hazards analysis and to confirm that all SSCs that are important to safety be designed to accommodate the dynamic and environmental effects of postulated pipe failures or are protected from these effects (e.g., by proper design of jet shields and pipe whip restraints) as required by the regulation. The applicant is required to address this staff's concern.

c) In its response to Part 4 of this question related to the closure milestone of the as-designed pipe break hazards analysis report, the applicant referred to EPR FSAR, Tier 2, Table 1.8.2, COL Information Item 3.6-2. The applicant also stated that ITAAC for the pipe break hazards analysis has been established and COL applicant is responsible for the closure of the ITAAC as well as the closure milestone for the COL Information Item 3.6-2. The staff noted that COL Information Item 3.6-2 does not specifically refer to as-designed pipe break analysis. The applicant is therefore, requested to revise that COL Information Item to clearly refer to the as-designed pipe break analysis. In addition, the FSAR needs to make it clear that it is the COL applicant's responsibility to address whether it will follow the standard ITAAC closure schedule as set forth in NRC regulation, 10 CFR 52.99 or to propose a plant specific closure schedule that will make the final as-designed pipe break hazards analysis report available for NRC staff review.

Response to Question 03.06.02-42:

(a) A new U.S. EPR Tier 1. Section 3.8, “Pipe Break Hazards,” will be added. U.S. EPR FSAR Tier 1, Section 2.1.1 ITAAC 3.4 regarding pipe break hazards analysis will be moved to the new U.S. EPR Tier 1, Section 3.8.

(b) U.S. EPR Tier 1, Table 2.1.1-4, ITAAC 3.4 regarding pipe break hazards analysis will be revised to specify reconciliation to the as-designed pipe break hazards analysis. This ITAAC will be relocated to the new U.S. EPR Tier 1. Section 3.8.

(c) U.S. EPR Tier 2, Table 1.8-2 COL Items 3.6-1 and 3.6-2 for pipe break hazards analysis will be revised to specify reconciliation to the as-designed pipe break hazards analysis.

FSAR Impact:

U.S. EPR FSAR Tier 1, Section 2.1.1 and Table 2.1.1-4, ITAAC 3.4 and U.S. EPR Tier 2, Table 1.8-2 will be revised as described in the response and indicated on the enclosed markup. U.S. EPR Tier 1, Section 3.8 will be added as described in the response and indicated on the enclosed markup.

U.S. EPR Final Safety Analysis Report Markups

3.1b Decoupling of SB 2/3 and FB internal structures from their outer external hazards barrier walls, at their exterior walls along the entire wall length and the upper ceiling, and from the RSB above elevation 0 feet, 0 inches.

3.2 The NI site grade level is located between 12 inches and 18 inches below the finish floor elevation at ground entrances.

3.3 The NI structures include barriers for post-accident radiation shielding as described in Table 2.1.1-3.

03.06.02-42

3.4 Deleted.~~A pipe break hazards analysis summary exists that concludes the plant can be shut down safely and maintained in cold safe shutdown following a pipe break with loss of offsite power.~~

3.5 Deleted.~~Essential SSCs in RB, SBs and FB rooms listed in Table 2.1.1-6 are protected from the dynamic effects of pipe breaks.~~

3.6 ~~Portions of NI Seismic Category I structures located below grade elevation are protected from external flooding by waterstops, water tight seals and waterproofing.~~ NI Seismic Category I structural walls or floors having exterior penetrations located below grade elevation are protected against external flooding by watertight seals.~~Portions of Seismic Category I structures that are located below grade elevation and exposed to aggressive soil or groundwater conditions will use waterstops, water tight seals, and waterproofing materials as required to mitigate deterioration.~~

3.7 The NI structures have key design dimensions that are confirmed after construction.

4.0 Interface Requirements

There are no interface requirements for the NI Structures.

5.0 Inspections, Tests, Analyses, and Acceptance Criteria

Table 2.1.1-4 lists the NI ITAAC.

Table 2.1.1-4—Nuclear Island ITAAC (~~3~~ 4 Sheets)

03.06.02-42

	Commitment Wording	Inspections, Tests, Analyses	Acceptance Criteria
3.4	Deleted.~~A pipe break hazards analyses summary exists that concludes the plant can be shut down safely and maintained in cold safe shutdown following a pipe break with loss of offsite power.~~	Deleted.~~A pipe break hazards analysis will be performed.~~	Deleted.~~A pipe break hazards analyses summary exists that concludes the plant can be shut down safely and maintained in cold safe shutdown following a pipe break with loss of offsite power and confirms whether:~~ ~~–Piping stresses in the RCB penetration area are within allowable stress limits.~~ ~~–Pipe whip restraints and jet shield designs can mitigate pipe break loads.~~ ~~–Loads on safety-related SSCs are within design load limits.~~ ~~–SSCs are protected or qualified to withstand the environmental effects of postulated failures.~~
3.5	Deleted.~~Essential SSCs in RCB, SBs and FB rooms listed in Table 2.1.1-6 are protected from the dynamic effects of pipe breaks.~~	Deleted.~~a. An analysis of essential SSCs in the rooms listed in Table 2.1.1-6 will be performed to determine the protective features required for the dynamic effects of pipe breaks.~~ ~~b. An inspection of as-installed features providing protection for essential systems and components from the effects of piping failures versus construction drawings of protective features identified in the analysis of part (a) will be performed.~~	Deleted.~~a. Essential SSCs in rooms listed in Table 2.1.1-6 are protected from the dynamic effects of pipe breaks.~~ ~~b. Essential SSCs in rooms listed in Table 2.1.1-6 are protected from the dynamic effects of pipe breaks and the features providing protection conform to the construction drawings.~~

3.8 Pipe Break Hazards

1.0 Description

Plant features provide the capability to shut the plant down in the event of a pipe break.

2.0 Design Features

A pipe break hazards analysis summary exists that concludes the plant can be shut down safely and maintained in cold safe shutdown following a pipe break with loss of offsite power.

3.0 Inspections, Tests, Analyses, and Acceptance Criteria

Table 3.8-1 lists the piping hazards analysis ITAAC.

03.06.02-42

Table 3.8-1—Piping Hazard Analysis ITAAC

	Commitment Wording	Inspections, Tests, Analyses	Acceptance Criteria
1.0	A pipe break hazards analyses summary exists that concludes the plant can be shut down safely and maintained in cold safe shutdown following a pipe break with loss of offsite power.	a. A pipe break hazards analysis will be performed. **{{DAC}}**	a. A pipe break hazards analyses summary exists that concludes the plant can be shut down safely and maintained in cold safe shutdown following a pipe break with loss of offsite power and confirms whether: – Piping stresses in the RCB penetration area are within allowable stress limits. – Pipe whip restraints and jet shield designs can mitigate pipe break loads. – Loads on safety-related SSCs are within design load limits. – SSCs are protected or qualified to withstand the environmental effects of postulated failures. **{{DAC}}**
		b. Inspections of as-built features for protection against pipe break will be performed. Analyses will be performed to reconcile deviations with the as-designed pipe break hazards analysis.	b. Reconciliation of deviations to the as-designed pipe break hazards analysis have been performed and conclude that the plant can be shut down safely and maintained in cold safe shutdown following a pipe break with loss of offsite power.

03.06.02-42

Table 1.8-2—U.S. EPR Combined License Information Items
Sheet 14 of 53

Item No.	Description	Section	~~Action Required by COL Applicant~~	~~Action Required by COL Holder~~
3.5-9	A COL applicant that references the U.S. EPR design certification will describe controls to confirm that unsecured maintenance equipment, including that required for maintenance and that are undergoing maintenance, will be either removed or seismically supported when not in use to prevent it from becoming a missile.	3.5.1.1.3	~~Y~~	
3.6-1	A COL applicant that references the U.S. EPR design certification will perform the pipe break hazards analysis and reconcile deviations in the as-built configuration to the as-designed ~~this~~ analysis.	3.6.1		~~Y~~
3.6-2	A COL applicant that references the U.S. EPR design certification will perform the pipe break hazards analysis and reconcile deviations in the as-built configuration to the as-designed ~~this~~ analysis.	3.6.2.1		~~Y~~
3.6-3	A COL applicant that references the U.S. EPR design certification will confirm that the design LBB analysis remains bounding for each piping system and provide a summary of the results of the actual as-built plant specific LBB analysis, including material properties of piping and welds, stress analyses, leakage detection capability, and degradation mechanisms.	3.6.3		~~Y~~
3.6-4	A COL applicant that references the U.S. design certification will provide diagrams showing the final as-designed configurations, locations, and orientations of the pipe whip restraints in relation to break locations in each piping system.	3.6.2.5.1		~~Y~~
3.6-5	A COL applicant that references the U.S. EPR design certification will implement the ISI program as augmented with NRC approved ASME Code cases that are developed and approved for augmented inspections of Alloy 690/152/52 material to address PWSCC concerns.	3.6.3.3.4.1		

03.06.02-42

Table 1.8-2—U.S. EPR Combined License Information Items
Sheet 17 of 53

Item No.	Description	Section	~~Action Required by COL Applicant~~	~~Action Required by COL Holder~~
3.8-7	A COL applicant that references the U.S. EPR design certification will confirm that site-specific conditions for Seismic Category I buried conduit, electrical duct banks, pipe, and pipe ducts satisfy the requirements specified in Section 3.8.4.4.5 and those specified in AREVA NP Topical Report ANP-10264NP-A.	3.8.4.5	~~Y~~	
3.8-8	A COL applicant that references the U.S. EPR design certification will address site-specific Seismic Category I structures that are not described in this section.	3.8.4.1	~~Y~~	
3.8-9	A COL applicant that references the U.S. EPR design certification will describe site-specific foundations for Seismic Category I structures that are not described in this section.	3.8.5.1	~~Y~~	
3.8-10	A COL applicant that references the U.S. EPR design certification will evaluate site-specific methods for shear transfer between the foundation basemats and underlying soil for site-specific soil characteristics~~parameters~~ that are not within the envelope of the soil parameters specified in Section 2.5.4.2.	3.8.5.5	~~Y~~	
3.8-11	A COL applicant that references the U.S. EPR design certification will evaluate the use of epoxy coated rebar for foundations subjected to aggressive environments, as defined in ACI 349-01, Chapter 4. In addition, the waterproofing system of all Seismic Category I foundations subjected to aggressive environments will be evaluated for use in aggressive environments. Also, the concrete of Seismic Category I foundations subjected to aggressive environments will meet the durability requirements of ACI 349-01, Chapter 4 or ASME, Section III, Division 2, Article CC-2231.7, as applicable.~~A COL applicant that references the U.S. EPR design certification will evaluate and identify the need for the use of waterproofing membranes and epoxy coated rebar based on site-specific groundwater conditions.~~	3.8.5.6.1	~~Y~~	

03.08.05-20 &
03.08-05-21

Section 2.5.4.5 discusses the use of mud mats under the foundation basemats to facilitate construction. When used, the governing friction value at the interface zone is determined by a thin soil layer (soil-on-soil) under the mud mat. As indicated above, the underlying soil (expected to be compacted backfill) will have a friction angle greater than 35 degrees. Typical values of friction coefficient between concrete and dry soil and rock are in the range of approximately 0.7. Due to the interlock of concrete with soil as the concrete is placed, the friction between the mud mat and underlying soil media is generally higher than the friction resistance of soil-on-soil so that continuity of load transfer across the interface is maintained.

Earthquake induced soil pressures for the design of the U.S. EPR are developed in accordance with Section 3.5.3 of ASCE 4-98 (Reference 2). Maximum ground water and maximum flood elevations used for determining lateral soil loads for the U.S. EPR are as specified in Table 2.1-1.

A COL applicant that references the U.S. EPR design certification will reconcile the site-specific soil properties with those used for design of U.S. EPR Seismic Category I structures and foundations described in Section 3.8.

2.5.4.3 Foundation Interfaces

Foundation interfaces with underlying materials are site specific and will be addressed by the COL applicant. The COL applicant will confirm that the site soils have (1) sliding coefficient of fiction equal to at least 0.7, (2) adequate shear strength to provide adequate static and dynamic bearing capacity, (3) adequate elastic and consolidation properties to satisfy the limits on settlement described in Section 2.5.4.10.2, and (4) adequate dynamic properties (i.e., shear wave velocity and strain-dependent modulus-reduction and hysteretic damping properties) to support the Seismic Category I structures of the U.S. EPR under earthquake loading.

2.5.4.4 Geophysical Surveys

Geophysical surveys are site specific and will be addressed by the COL applicant.

2.5.4.5 Excavations and Backfill

Excavations and backfill are site-specific and will be addressed by the COL applicant. ~~The use of waterproofing membranes is site-specific as described in Section 3.8.5.6.1.~~ Mud mats may be provided under foundations for ease of construction. Mud mats may be designed as structural plain concrete elements on a site-specific basis in accordance with ACI 318 (Reference 3). ~~Embedment of waterproofing membranes within mud mats is described in Section 3.8.5.6.1.~~

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- Identification of the systems and components that are located proximate to high- or moderate-energy pipe systems, that are deemed essential to plant safety, and that are required to safely shut down the plant. The safety-related SSC which require protection from pipe rupture are listed in Section 3.2.

- Identification of the failures for which protection is being provided and design basis assumptions used in the evaluations (Section 3.6.1.1.2).

- Identification of the protection considerations that are utilized in the design to safeguard the essential equipment from the postulated failures (Section 3.6.1.2). Separation and redundancy of essential systems, methods of analyzing the dynamic and environmental effects of the postulated piping failures, and habitability of the main control room (MCR) are also addressed.

The following GDC apply to this section:

- GDC 2 as it relates to protection against natural phenomena, such as seismically-induced failures of non-seismic piping. The application of GDC 2 to this section is to incorporate environmental effects of full-circumferential ruptures of non-seismic moderate-energy piping in areas where effects are not already bounded by failures of high-energy piping. As noted in Section 3.6.1.1, the criteria used to evaluate pipe failure protection conform to the guidance in BTP 3-3 (Reference 1). Additionally, seismic classifications of SSC are provided in Section 3.2.

- GDC 4 as it relates to SSC important to safety being designed to accommodate the effects of and to be compatible with the environmental conditions associated with postulated pipe rupture. In the event of a high- or moderate-energy pipe failure within the plant, protection is provided so that essential SSC are not impacted by the adverse effects of the postulated piping failure. Also, as noted in Section 3.6.1.1, the criteria used to evaluate pipe failure protection conform to the guidance in BTP 3-3. The U.S. EPR design also prevents the dynamic effects of postulated pipe ruptures based on the application of the LBB approach as described in Section 3.6.3.

Table 3.6.1-1 lists those systems that contain high- and moderate-energy lines that are considered when determining the need for protection of essential systems.
Table 3.6.1-2 provides a listing of terminal end breaks for the high-energy systems, and provides the location for these breaks by building and room number.
Table 3.6.1-3 provides a summary of the evaluation of a subset of the terminal end breaks where there are nearby essential systems and components requiring protection.
Table 3.6.1-3 also lists the essential system targets, as well as the type of protection to be designed.

A COL applicant that references the U.S. EPR design certification will perform the pipe break hazards analysis and reconcile deviations in the as-built configuration to the as-designed ~~this~~ analysis.

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For ASME Class 1, 2, and 3 piping, breaks are postulated at terminal end locations which are determined according to the applicable piping isometrics. Intermediate breaks and cracks in ASME Class 1, 2, and 3 piping are postulated per the guidance described in the sections that follow. A COL applicant that references the U.S. EPR design certification will perform the pipe break hazards analysis and reconcile deviations in the as-built configuration to the as-designed ~~this~~ analysis.

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The pipe break hazards analysis identifies each piping run considered for break postulation. For complex systems (e.g., those containing arrangements of headers and parallel piping running between headers) the piping is included within a designated run for the purposes of break postulation. The following information will be provided in the pipe break hazards analysis report:

- A summary of the dynamic analyses applicable to high-energy piping systems, including:
  - Sketches showing the locations of the resulting postulated pipe ruptures, including identification of longitudinal and circumferential breaks; structural barriers, if any; restraint locations; and the constrained directions in each restraint.
  - A summary of the data developed to select postulated break locations, including, for each point, the calculated stress, the calculated primary plus secondary stress/stress intensity range, and the calculated cumulative usage factor as delineated in BTP 3-4.
- For failure in the moderate-energy piping systems, descriptions showing how safety-related systems are protected from spray wetting, flooding, and other adverse environmental effects.
- Identification of protective measures provided against the effects of postulated pipe failures for protection of each of the essential systems and components.
- A conclusion that the plant can be shut down safely and maintained in cold safe shutdown following a pipe break with loss of offsite power.

3.6.2.1.1 Locations of High-Energy Line Breaks and Leakage Cracks

3.6.2.1.1.1 Break Locations in Containment Penetration Areas

For the portions of fluid systems in containment penetration areas, breaks and cracks are not postulated from the containment wall up to and including the inboard and outboard containment isolation valves, when the systems meet the requirements of Subarticle NE-1120 in Section III of the ASME Boiler and Pressure Vessel Code (Reference 2), and where the additional requirements listed in Items 1 through 3 below are met.

2. ASME Code, III, Division 1 – Class 2, 3, and non-ASME Code Class Piping in Areas other than Containment Penetration Areas.

   With the exception of the portions of piping identified in Item 2 in Section 3.6.2.1.1.1 above, leakage cracks in ASME Code Class 2, 3, and non-ASME Code piping are postulated at axial locations where the stress calculated by the sum of Equations 9 and 10 from Paragraph NC/ND-3653 in Section III of the ASME Code, exceeds 0.4 times the sum of the stress limits given in NC/ND-3653.

3. Unanalyzed Non-Safety Class Piping.

   Non-safety-class piping that does not have detailed stress information has a through-wall crack postulated at axial locations that yield the most severe environmental consequences.

3.6.2.1.1.4 High-Energy Fluid Systems Separated From Essential Systems and Components

As addressed in Section 3.6.1, separation of high-energy piping from essential systems and components is an important consideration to prevent pipe ruptures from having direct effects on essential systems and components, and challenging the ability to safely shut down the unit following a pipe rupture. The U.S. EPR has extended this safety concept to include additional system train redundancy, along with separation of trains of essential systems. Specifically, most, but not all of the U.S. EPR essential systems are designed with four redundant trains, with each train capable of performing the system's safety function of bringing the unit to a safe shutdown condition. Outside of containment, each of these trains is contained in a separate Safeguard Building to complete separation. Inside containment, this separation is often, but not always accomplished by separate compartments/rooms used for individual trains. Since not all essential systems have four completely separated and redundant trains capable of performing the system's safety function, all ruptures must be evaluated with the four train separation and redundancy concept providing a useful tool, where it is available.

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This four train separation and redundancy inherently provides design basis safety function survivability for certain rupture effects with the fourth train, while postulating the required effects of concurrent pipe rupture, single failure, and one train potentially out of service for maintenance. Separation and redundancy allow safety function survivability for the dynamic effects of high-energy line breaks. Since these are direct loading effects from the broken pipe, such as jet impingement and pipe whip, the separation of trains by structures or spatial location can be shown. This methodology by itself, however, cannot always be used for environmental effects of high-energy line breaks because fluid flow between compartments is still possible within the Reactor Building.

The applied methodology for using four train separation and redundancy to demonstrate essential system function survivability for dynamic effects of a break is as follows:

- High-energy pipe breaks are postulated as described in Section 3.6.2.1.1.2.
- Essential system targets (equipment, piping, HVAC, electrical distribution elements, and structures) are identified for each break based on plant layout of these systems relative to the break location.
- If the targets are within the same train of four train redundant systems (including the broken pipe, if it is also within an essential system), then the survivability of the systems' safety functions is confirmed without the need for further target analysis or protection considerations.

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~~For essential system targets identified for a high-energy line rupture that are part of a system with complete separation and redundancy, the evaluation of such targets need only identify this separation and redundancy, as the target may be considered lost due to the rupture without having an adverse impact on essential equipment. The U.S. EPR design has many essential systems with redundant safety trains located in each of four separate Safeguard Buildings. This four train separation and redundancy allows for one train to be lost due to the rupture, while a second train is lost due to single active failure and a third is down due to normal maintenance. With the fourth train still capable of operating the system, protection for the dynamic and environmental effects of these ruptures need not be considered.~~

3.6.2.1.2 Locations of Leakage Cracks in Moderate Energy Lines

3.6.2.1.2.1 Leakage Crack Locations in Fluid Systems in Containment Penetration Areas

Leakage cracks are not postulated in those portions of moderate-energy lines that extend from the containment wall up to and including the inboard and outboard containment isolation valves where they meet the requirements of Subarticle NE-1120 in Section III of the ASME Code, and where the Level A or Level B stress calculated by the sum of Equations 9 and 10 from Paragraph NC-3653 does not exceed 0.4 times the sum of the stress limits given in NC-3653.

3.6.2.1.2.2 Leakage Crack Locations in Fluid Systems in Areas other than Containment Penetration Areas

With the exception of the portions of piping identified in Section 3.6.2.1.2.1, leakage cracks are postulated at the following locations:

1. Through-wall cracks are postulated in piping located adjacent to safety-related SSC except:

With the pipe break jets and whips characterized per the sections above, there is still a need to design pipe whip restraints which have been assumed in the rupture analysis, or to design structural barriers between the break and potential essential system targets. Both of these types of structural designs are for essential system protection purposes.

3.6.2.5.1.2 Pipe Whip Support Design

Pipe whip supports are typically only designed for the restraint of a whipping pipe following a postulated high-energy line break, and are typically separate from the other system pipe supports which are designed for other design basis loadings. Whip restraints are typically designed for a one-time accident event; so they are designed to undergo deformation as long as the whipping pipe is fully restrained for the entire time of the blowdown event. Similarly, the whip restraint has gaps to allow for the free thermal and seismic movements of the pipe at that location, so that the restraint does not affect the parameters of the design basis piping analysis. If a support is designed as both a standard pipe support and a pipe whip restraint, the design of the support meets the design criteria of a standard pipe support for loadings using the appropriate loading combinations.

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Whip restraints which are not also standard pipe supports are designed as Seismic Category I miscellaneous structures in accordance with Section 3.8.4. The loadings to be applied to these restraints are self-weight, seismic self-weight excitation, and the one-time whipping load from the broken pipe. The load combinations, Codes and Standards, and acceptance criteria are defined in Section 3.8.4, as supplemented by the guidance and requirements in this section.

The calculation of design loads to be utilized in the design of pipe whip supports is described in Section 3.6.2.4.3. For a whip restraint near the first elbow upstream of a circumferential break, or near a longitudinal break, a static analysis calculation can be performed using the maximum jet discharge force multiplied by a factor of 1.1 for rebound effects, and a factor of 2.0 for a dynamic load factor. With this design load, a typical whip restraint usually consists of crushable, energy-absorbing material. The allowable capacity of such a crushable material is limited to 80 percent of its rated energy dissipating capacity, as determined by dynamic testing, at loading rates within plus or minus 50 percent of the specified design loading rate. The rated energy dissipating capacity is not greater than the area under the load-deflection curve from Figure 3.6.2-1 of SRP 3.6.2.

3.6.2.5.2 Structural Barrier Design

Structural barriers are used for high-energy line break protection purposes in order to provide separation between safety trains of essential systems, and to provide shields between rupture effects and an essential system component. The dynamic effects of a

~~Waterproofing membranes used under or within the NI Common Basemat Structure foundation basemat will be evaluated on a site-specific basis, as described in Section 3.8.5.6.~~

3.8.5.1.2 Emergency Power Generating Buildings Foundation Basemats

Each EPGB foundation basemat supports a building superstructure and associated equipment. At the super-structure and foundation basemat interface, heavily reinforced concrete shear walls function as bearing walls to transfer loads from floors and the roof. Each foundation basemat is embedded approximately five feet into the supporting soil and has overall dimensions of approximately 178 feet long by 94.5 feet wide by 6 feet thick. In the areas of the two diesel fuel oil storage tanks, the foundation basemat reduces in width from 94.5 feet to 42 feet.

Figure 3.8-89 illustrates the general arrangement plan, which also shows the primary shear walls at column lines A, C, E, G and J in the east-west direction, and column lines 11, 13, 17 and 19 in the north-south direction. Additional figures, provided in Appendix 3E, illustrate both the shear walls at the super-structure and foundation basemat interface and the foundation basemat reinforcement.

Figures 3.8-93 and 3.8-94 provide section views of the EPGB structure, which further clarify the relationship between the superstructure and the foundation basemat. Isometric views of the GT STRUDL model representing the overall structure are provided in Section 3.7.2.

3.8.5.1.3 Essential Service Water Buildings Foundation Basemats

The reinforced concrete foundation basemat for each ESWB supports the superstructure and water basin. At the super-structure and foundation basemat interface, heavily reinforced concrete shear walls function as bearing walls to transfer loads from the floors and the roof. Each foundation basemat is embedded approximately 21~~22~~ feet into the supporting soil and has overall dimensions of approximately 164 feet by 108 feet wide by 6 feet thick.

Figures 3.8-101 and 3.8-102 provide cross-sections of the ESWB in each direction, illustrating the superstructure which bears on the foundation basemat. Figure 3.8-95 provides the general arrangement plan, which also illustrates the primary shear walls at column lines A, B, D and F in the east-west direction, and column lines 1, 2, 4 and 5 in the north-south direction. Additional figures provided in Appendix 3E illustrates both the shear walls at the super-structure and foundation basemat interface and the foundation basemat reinforcement. Isometric views of the GT STRUDL model representing the overall structure are provided in Section 3.7.2.

comprise the building structures being supported, as well as by equipment supported directly on the foundations. Intersecting concrete walls also serve to stiffen the foundation basemat slabs to increase resistance to bending moments resulting from soil pressures under the slabs. Foundations are analyzed for the various factored loads and load combinations identified in Section 3.8.5.3.

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Seismic Category I foundation basemat structures transfer vertical loads from the buildings to the subgrade by direct bearing of the basemats on the subgrade. Horizontal shears, such as those produced by wind, tornados, and earthquakes are transferred to the subgrade by friction along the bottom of the foundation basemat, shear key, or by passive earth pressure ~~(or both)~~. ~~Waterproofing membranes used under or within the Seismic Category I foundations will be evaluated on a site-specific basis, as described in Section 3.8.5.6.~~

Design and analysis procedures for Seismic Category I foundations are the same as those described in Sections 3.8.1.4 and 3.8.4.4 for the respective structures that apply loads on the foundations.

Seismic Category I concrete foundations are designed in accordance with ACI 349-01 and its appendices (GDC 1). Exceptions to code requirements specified in RG 1.142 are incorporated into the design and are accommodated in the loading combinations described in Section 3.8.5.3. In addition, the portion of the NI Common Basemat Structure foundation basemat that supports the RCB/RSB is designed in accordance with the ASME BPV Code–2004 Edition, Section III, Division 2 for support and anchorage of the concrete RCB as described in Section 3.8.1.

The design of concrete foundations for Seismic Category I structures is performed using the strength-design methods described in ACI 349-01, with the exception that a shear reduction factor of 0.85 is used as allowed in ACI 349-06 (Reference ~~39~~63). The ductility provisions of ACI 349-01 are satisfied to provide a steel reinforcing failure mode and to prevent concrete failure for design basis loadings.

Foundation design is performed for the spectrum of soil cases described in Section 3.7.1. Section 2.5 and Section 3.7 describe seismic parameters and design methods used for analyzing and designing Seismic Category I structures.

Soil-structure interaction and structure-soil-structure interaction effects are considered in the seismic analyses of Seismic Category I structures as described in Section 3.7.2. Figure 3B-1 illustrates separation distances between Seismic Category I structures upon which these interaction evaluations are based.

The NI Common Basemat Structure is designed for an average static soil bearing pressure of 14,500 pounds per square foot and a maximum static bearing pressure of foot for static loading conditions, and 10,800 pounds per square foot for dynamic loading conditions. The factors of safety against overturning, sliding, and flotation are each greater than or equal to 1.1.

3.8.5.5.3 Essential Service Water Building Foundation Basemats

Appendix 3E provides details of the design of the ESWB foundation basemats critical sections.

~~Evaluation of the ESWB foundation basemat for maximum bearing pressures under static and dynamic loading conditions, settlements, flotation, sliding, and overturning will be performed to confirm that applicable acceptance criteria are met.~~Maximum soil bearing pressures under the ESWB foundation basemat are 17,800 pounds per square foot for static loading conditions, and 28,200 pounds per square foot for dynamic loading conditions. The factors of safety against overturning, sliding, and flotation are each greater than or equal to 1.1.

3.8.5.6 Materials, Quality Control, and Special Construction Techniques

This section contains information relating to the materials, quality control programs and special construction techniques used in the fabrication and construction of Seismic Category I foundations.

3.8.5.6.1 Materials

Concrete, reinforcing steel, and structural steel materials for Seismic Category I foundations have been used in other nuclear facilities and are the same as described in Section 3.8.3.6 (GDC 1), except as follows:

- Materials for the portion of the foundation basemat that supports the RCB/RSB are the same as described in Section 3.8.1.6.
- Structural concrete used in the construction of Seismic Category I foundations has a minimum compressive strength of 4000 psi (f'_c) at 90 days.

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- Concrete exposed to aggressive environments, as defined in ACI 349-01, Chapter 4, shall meet the durability requirements of ACI 349-01 Chapter 4 or ASME Section III, Division 2, Article CC-2231.7, as applicable. In addition, epoxy coated reinforcing steel will be considered, on a site specific basis, for use in foundations subjected to aggressive environments. For epoxy coated reinforcing steel, the required splice length is increased in accordance with ACI 349-01 specifications. ~~Epoxy coated reinforcing steel will be considered, on a site-specific basis, for use in foundations when groundwater may adversely affect the long-term durability of the concrete foundation. This may be waived if the groundwater level is below the foundation level due to either natural site conditions or provision of a site-specific permanent dewatering system. For epoxy coated reinforcing steel, the required splice length is increased in accordance with ACI 349-01 specifications.~~

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- The waterproofing system of all below-grade Seismic Category I structures subjected to aggressive environments, as defined according to ACI 349-01, Chapter 4, shall be evaluated for use in such environments. ~~Use of waterproofing membrane, a textured geo-synthetic material, will be considered on a site-specific basis for use around foundations on sites with a high water table. Where this material is used under Seismic Category I foundations it will be embedded within the mud mat as shown in Figure 3.8-117—Geosynthetic Water Proofing Membrane.~~

The waterproofing system will provide adequate frictional characteristics, μ ≥ 0.7, at its interface with concrete. This characteristic will be demonstrated by vendor testing. The contact surface between the waterproofing system and the concrete will be finished in accordance with manufacturer recommendations.

~~The textured waterproofing membrane will provide adequate frictional characteristics, m>0.7, at its interface with concrete. This characteristic will be demonstrated by vendor testing. The contact surface between the membrane and the concrete will be finished in accordance with manufacturer recommendations. The membrane is not a safety-related component as its failure would not result in core melt or a release of radioactivity to the environment.~~

A COL applicant that references the U.S. EPR design certification will evaluate the use of epoxy coated rebar for foundations subjected to aggressive environments, as defined in ACI 349-01, Chapter 4. In addition, the waterproofing system of all Seismic Category I foundations subjected to aggressive environments will be evaluated for use in aggressive environments. Also, the concrete of Seismic Category I foundations subjected to aggressive environments will meet the durability requirements of ACI 349-01, Chapter 4 or ASME, Section III, Division 2, Article CC-2231.7, as applicable.

~~A COL applicant that references the U.S. EPR design certification will evaluate and identify the need for the use of waterproofing membranes and epoxy coated rebar based on site-specific groundwater conditions.~~

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3.8.5.6.2 Quality Control

Quality control procedures for Seismic Category I foundations are the same as described in Section 3.8.3.6 (GDC 1).

3.8.5.6.3 Special Construction Techniques

Seismic Category I foundations are constructed using proven methods common to heavy industrial construction. No special, new, or unique construction techniques are used.

Modular construction methods are used to the extent practical for prefabricating portions of reinforcing and concrete formwork. Such methods have been used

Figure 3.8-117—Figure Deleted~~Geosynthetic Water Proofing Membrane~~

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