RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

3/27/2014

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 1062-7296 REVISION 4**
SRP SECTION:	**03.08.03 – Concrete and Steel Internal Structures of Steel or Concrete Containments**
APPLICATION SECTION:	**3.8.3**
DATE OF RAI ISSUE:	**11/25/2013**

QUESTION NO. 03.08.03-116:

The staff reviewed MUAP-12006-P, “Steel Concrete (SC) Wall Fabrication, Construction and Inspection," Revision 0, dated February 28, 2013, hereinafter referred to as 'the report'. The staff found that the technical information provided in the report addressed most of the request for additional Information (RAI) questions regarding steel-concrete (SC) wall fabrication, construction and inspection. However, additional information needs to be provided as discussed below to ensure the construction adequacy of the US-APWR SC walls.

1. A mockup program is important to demonstrate the adequacy of fabrication, concrete placement and inspection. However, the report provided no mockup information other than stating that the contractor (for the COLA) shall be responsible to use mockups as necessary. Therefore, the staff requests that the applicant provide details of the mockup program, such as objectives, mockup locations, post construction mockup inspections, and training for construction crew to implement the program.

2. For post-construction inspection of the concrete, no non-destructive evaluation (NDE) method except visual testing (VT) is discussed in the report. Considering the unique features of the SC walls, the staff requests that the applicant describe NDE methods, such as ultrasonic testing (UT), that will be used for post-construction concrete inspection to detect critical defects of the concrete. This should include the NDE methods to be used, critical areas to be inspected, sampling approach, the need for mockup testing, types of critical defects of the concrete, the acceptance criteria for each defect and the corresponding engineering basis. This should be considered to be part of the mockup program.

3. Because construction tolerances are important in controlling additional stresses in structural components induced by construction, the staff requests that the applicant provide the construction tolerances for the offset of the two half-length pieces of a tie bar, and the construction tolerances for the alignment of the faceplates in two adjacent SC module blocks. Also provide the bases for the tolerances.

4. Section 2.2, “Applicable Codes and Standards,” of the report lists applicable codes and standards for the construction of the US-APWR SC walls. In addition to those codes and

standards listed, the staff requests that the applicant explain why the following codes and standards are not included: ACI 301-05 - Specifications for Structural Concrete for Buildings, ACI 305.1 - Hot-Weather Concreting, ACI 306R- Cold-Weather Concreting, ACI 306.1-Standard Specification for Cold Weather Concreting, ACI 308R - Guide to Curing Concrete, ACI 308.1- Standard Specification for Curing Concrete, ANSI/AWS D1.4 - Structural Welding Code - Reinforcing Steel, and ANSI/AWS D1.8 - Structural Welding Code – Seismic Supplement.

5. Correct the following inconsistencies in the report:

a. The stud layout shown in Figure 3.1-3, “Conceptual Basemat Anchorage for SC Structure Wall,” on Page 3-4, and the stud spacing/dimension and the use of the web plate/round tie bars shown in Figure 3.5-5, “Example of Concrete Placement in the SC Structure: General Section,” on Page 3-20 are inconsistent with the corresponding details shown in MUAP-11019-P, “Containment Internal Structure: Design Criteria for SC Walls,” Revision 1. This also applies to some other figures in the report which the applicant should confirm.

b. In Figure 3.4-2, “Typical SC Structure Anchorage to Basemat,” on Page 3-12, both construction steps B and F are labeled as installation of temporary structure for SC module Tier 0. The staff requests that the applicant correct the inconsistency; otherwise, provide an explanation for the inconsistency.

c. The example of concrete placement demonstrated in Figure 3.5-3, “Example of Placement of Fresh Concrete on Hardened Concrete,” on Page 3-18 shows a concrete pour height of 20'-4". The example of concrete placement presented in Section 3.5.4.3.3, “Concrete Placement procedure Taking Concrete Lateral pressure into Account,” assumes a concrete pour height of 14'-5". However, in the response to RAI 905-6311, Question 03.08.03-71, dated May 16, 2012, the applicant indicated that the maximum wet concrete height of 10 ft would be specified to limit additional stresses/forces in steel faceplates and tie bars due to concrete placement in the SC walls. The staff requests that the applicant correct the inconsistency; otherwise, provide an explanation for the inconsistency.

d. Section 3.5.4.3.1, “Standard Practice,” Page 3-19, states that the free-fall height of concrete placement should not be greater than {[5 ft]} to avoid segregation. However, in the response to RAI 322-1999, Question 03.08.03-10, dated September 17, 2009, the free-fall height limit is specified as {3 ft}. The staff requests that the applicant correct the inconsistency and provide the basis for the height.

ANSWER:

1. Technical Report MUAP-12006 Section 3.6 Use of Mock-Ups has been developed requiring the Contractor to establish a mock up test program. The mock-up program is to be performed prior to construction with the purpose of demonstrating that the contractor proposed means and methods are capable of achieving the design criteria for the structural items. Technical Report MUAP-12006 allows the contractor to perform multiple mock ups as they need to develop the construction means and methods as part of their Risk Management program but the following two mock ups are identified as minimum mandatory:

- Placement of Self Consolidating Concrete under the SC-Wall Baseplate (i.e. ASME Section III containment liner – pressure boundary)
- Placement of Normal Concrete into a congested SC-Module where accessibility is limited

The intent of Technical Report MUAP-12006 is to document guidance and Operating Experience lessons learned to achieve successful concrete placement along with identifying the designer's intent. The criteria within Technical Report MUAP-12006 is considered minimum mandatory and supplemental to the specification and referenced standards that will control construction. COL 3.8(33) has been revised as follows to reflect this intent: "*The COL Applicant is to demonstrate construction practices, means and methods that demonstrate the ability to achieve design per the guidance provided in MUAP-12006*."

2. Additional detail has been provided in Technical Report MUAP-12006, Section 4.2.3(b) identifying post concrete placement inspections/testing and Section 4.2.3(d) identifying the sampling approach. Test methods have been evaluated and it is recommended that the Impact Echo method be used as the primary NDE method to identify and categorize concrete defects. Technical Report MUAP-12006 does not preclude other test methods or new technologies but any other test method will need to be evaluated as identified in Technical Report MUAP-12006 Section 4.2.3(c). Additional non-destructive testing may include: Probe penetration, other ultrasonic pulse velocity methods, Impulse Resonance, ultrasonic, and others as technology is developed depending upon the defect being evaluated.

   SC walls use the steel modules as formwork for the plastic concrete. As such it is anticipated that some debonding may occur between the inside face of the steel wall and concrete after set. Although bond is not considered in the structural analyses, a resulting gap may hinder external "sonic" type devices from providing definitive information regarding the quality of the concrete. The mock up program also contains criteria that a gap is to be identified/created simulating debonding between the steel wall and concrete. A process is to be demonstrated, e.g. injection of epoxy, concrete mortar, or other filler that would allow the concrete section to be evaluated by non-destructive methods, etc. to bridge the gap as opposed to cutting access ports into the steel wall allowing direct contact with the concrete.

   Technical Report MUAP-12006 has also been revised to require that the NDE examinations be demonstrated as part of the mock up testing program. The acceptance criteria are to be controlled as part of the construction specifications. The density and location of tests are to be part of the construction Quality Control program required as part of the 10CFR50 Appendix B program.

3. The "hold back" and tolerances established by the AWS D1.1 and AWS D1.6 weld program will dictate the vertical offset dimension tolerances for connection of the two ends of the tie bar and of fit-up tolerances of the faceplates of two adjacent SC module blocks.

4. The identified codes have been added to Technical Report MUAP-12006 Section 2.2 as requested.

5.a. Figures 3.1-3 and 3.5-5 have been revised to be consistent with Technical Report MUAP-11019 as requested. Also, Figure 3.5-8 through Figure 3.5-10, Figure 3.5-12

and Figure 3.5-13 have also been updated to be consistent with Technical Report MUAP-11019.

b. Figure 3.4-2 has been revised to clarify the difference between steps A and F as requested. Step F is modified to install the Steel Frame for SC structure Tier 0. This steel frame is installed as a construction aid to support the Tier 0 SC wall module and to allow adjustment of the elevation and location of SC structure Tier 0 on the temporary structure installed in step B.

c. Technical Report MUAP-12006 Figure 3.5-3 has been revised to be consistent with Technical Report MUAP-12006, Section 3.5.4.3.3 and RAI 905-6311, Question 03.08.03-71. Section 3.5.4.3.3 was revised to reflect that the concrete fill height will be controlled in accordance with ACI 347-04, Guide to Formwork for Concrete and limited to lifts that are 10 feet in height or less without specific analyses demonstrating the local geometry of the formwork is equivalently stressed at the revised height.

d. Free-fall height limit of [3'] in RAI 322-1999, Question 03.08.03-10 is superseded by Technical Report MUAP-12006 as documented in this RAI response. Technical Report MUAP-12006 has been revised to clarify that the concrete is to be placed in accordance with ACI 304 in such a manner as to prevent segregation with an additional free-fall height limit of [five (5)] feet.

Impact on DCD

DCD will be revised as indicated on the attached markup.

Impact on R-COLA

There is no impact on the R-COLA.

Impact on PRA

There is no impact on the PRA.

Impact on Technical/Topical Report

Technical Report MUAP-12006 will be revised as indicated on the attached markup.

This completes MHI's response to the NRC's question.

COL 3.8(26) *Actual total and differential settlements are dependent on site-specific conditions (e.g., soil variability, construction sequence and schedule (including basemat stiffening), loading conditions, excavation plans, and dewatering plans). The COL Applicant is to perform settlement analysis for the specific site, the in-situ soil properties, and for the specific construction schedule to verify that the site-specific total and differential settlements, and tilt, are bounded by the settlements and tilt in Table 2.0-1 of Chapter 2. If the site-specific settlements and tilt are bounded by the values in Table 2.0-1, detailed site-specific stress and gap closure verifications are not required with regard to settlement and tilt effects.*

COL 3.8(27) *The COL Applicant is to specify normal operating thermal loads for site-specific structures, as applicable.*

COL 3.8(28) *The COL Applicant is to specify concrete strength utilized in non-standard plant seismic category I structures.*

COL 3.8(29) *The COL Applicant is to provide design and analysis procedures for the ESWPT, UHSRS, and PSFSVs.*

COL 3.8(30) *When a coefficient of friction > 0.6 is used in calculating sliding resistance F_s, roughening of mud mat is required per criteria given in Section 11.7.9 of ACI 349-06 (Reference 3.8-8). If a coefficient of friction $\leq$ 0.6 is used by the COL Applicant in a pseudo-static sliding stability analysis, roughening of mud mat is not required.*

COL 3.8(31) *Site-specific stability evaluations are required to be performed by the COL Applicant for standard plant seismic category I and II structures to confirm the minimum required values in Table 3.8.5-1, unless the COL Applicant can demonstrate that the site-specific conditions for evaluating stability are enveloped by the standard plant design. The COL Applicant is to also provide the factors of safety for site-specific seismic category I structures ~~in Table 3.8.5-6~~ based on the methodology and acceptance criteria presented in Subsection 3.8.5.5.* DCD_03.07.02-217

COL 3.8(32) *Unless the COL Applicant can demonstrate by means of pseudo-static analysis that seismic induced sliding does not occur and that a safety factor against sliding $\geq$ 1.1 is achieved, site-specific seismic sliding stability analyses is to be performed using the seismic sliding stability analysis methodology described in Technical Report MUAP-12002 (Reference 3.8-82). If non-linear sliding analysis is performed, the COL Applicant is to demonstrate that resulting sliding is $\leq$ 0.75 in. for the R/B complex and $\leq$ 0.20 for the T/B.*

COL 3.8(33) *The COL applicant is to ~~provide detailed construction and inspection plans and documents in accordance with~~demonstrate construction practices, means and methods that demonstrate the ability to achieve design per the guidance provided in MUAP-12006.* DCD_03.08.03-116

2.2 Applicable Codes and Standards

Construction of SC structures shall comply with ACI 349 and ANSI/AISC N690. Construction of the SC structure steel base plate, which is a part of PCCV liner plate, and attachments to the steel base plate shall comply with ASME Section III, Division 2.

(1) American Concrete Institute (ACI)

- ACI 349-06, Code Requirements for Nuclear Safety-Related Concrete Structures
- ACI 117-10, Specification for Tolerances for Concrete Construction and Materials
- ACI 304R-00, Guide for Measuring, Mixing, Transporting, and Placing Concrete (Reapproved 2009)
- ACI 311.4R-05, Guide for Concrete Inspection
- ACI 311.5-04, Guide for Concrete Plant Inspection and Testing of Ready-Mixed Concrete
- ACI 347-04, Guide to Formwork for Concrete
- ACI 207.1R-05, Guide to Mass Concrete (Reapproved 2012)
- ACI 237R-07, Self-Consolidating Concrete
- ACI 301-05 - Specifications for Structural Concrete for Buildings
- ACI 305.1 - Hot-Weather Concreting
- ACI 306R- Cold-Weather Concreting
- ACI 306.1-Standard Specification for Cold Weather Concreting
- ACI 308R - Guide to Curing Concrete
- ACI 308.1- Standard Specification for Curing Concrete

(2) American National Standards Institute/American Institute of Steel Construction(ANSI/AISC)

- ANSI/AISC N690-1994, Specification for the Design, Fabrication and Erection of Steel Safety-Related Structures for Nuclear Facilities, Including Supplement 2 (2004), American National Standards Institute/American Institute of Steel Construction, 1994 & 2004

(3) American Society of Mechanical Engineers (ASME)

- ASME Section III, Division 2, Subsection CC, Concrete Containments (Prestressed or Reinforced), American Society of Mechanical Engineers, 2001 Edition through the 2003 Addenda
- ASME NQA-1-1994, Quality Assurance Requirements for Nuclear Power Plants
- ASME Section II, SA-516 Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service, 2001 Edition through the 2003 Addenda
- ASME Section IX Welding and Brazing Qualifications, 2001 Edition through the 2003 Addenda
- ASME Section XI, Rules for Inservice Inspection of Nuclear Power Plant Components, 2001 Edition through the 2003 Addenda

(4) American Welding Society (AWS)

- AWS D1.1 Structural Welding Code - Steel, D1.1, American Welding Society, 2006.
- AWS D1.6 Structural Welding Code - Stainless Steel, D1.6, American Welding Society, 1999
- ANSI/AWS D1.4 - Structural Welding Code - Reinforcing Steel
- ANSI/AWS D1.8 - Structural Welding Code – Seismic Supplement.

(5) American Society for Testing and Materials (ASTM)

- ASTM A572-00a, Standard Specification for High-Strength, Low-Alloy Columbium-Vanadium Structural Steel
- ASTM A108-07, Standard Specification for Steel Bar, Carbon and Alloy, Cold-Finished
- ASTM A240-04, Standard Specification for Chromium-Nickel Stainless Steel Plate, Sheet and Strip for Pressure Vessel and for General Applications
- ASTM A264-03, Standard Specification for Stainless Chromium-Nickel Steel-Clad Plate
- ASTM A513-90, Standard Specification for Electric-Resistance-Welded Carbon and Alloy Steel Mechanical Tubing
- ASTM A615-04b, Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
- ASTM A706-04b, Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement

(6) 10 CFR 50 Appendix B, Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants

(7) NUREG/CR-6486, Assessment of Modular Construction for Safety-Related Structures at Advanced Nuclear Power Plants

should be performed. The welded configurations not suitable for UT or RT shall be identified in the SC Structure Fabrication Plan and alternate NDE techniques established.

In addition to above, NDE must also be specified for:

- Welds at SC structure wall connection to basemat base plate
- Rebar splice sleeve welds

The base plate anchors the CIS SC structures to the RC structure of the basemat. Studs are welded to the base plate and VT examined. Rebar splice sleeves (weldable couplers) are also welded to the base plate to connect the anchor rebar embedded in the basemat as shown in Figure 3.1-3. The anchor rebar should be connected to the rebar splice sleeves (couplers) at site. These welds are subjected to magnetic testing. The base plate also functions as a PCCV liner plate and is thus subject to ASME Section III, Division 2 liner requirements. The thickness of the base plate is **[** 3-1/2″ **]**, and due to the thickness, preheats and post weld heat treatment (PWHT) shall be applied to the welding, butt-welded joint of the base plate. The details are shown on the welding procedure specification.

Local leak testing (LT) with vacuum box shall be performed for SC structure base plate welded joints (which are the leak boundary of PCCV) to comply with ASME code requirements.

The basemat anchorage for a typical SC structure wall (secondary shield wall) is shown in Figure 3.1-3.

Figure 3.1-3 Conceptual Basemat Anchorage for SC Structure Wall

Figure 3.4-2 Typical SC Structure Anchorage to Basemat

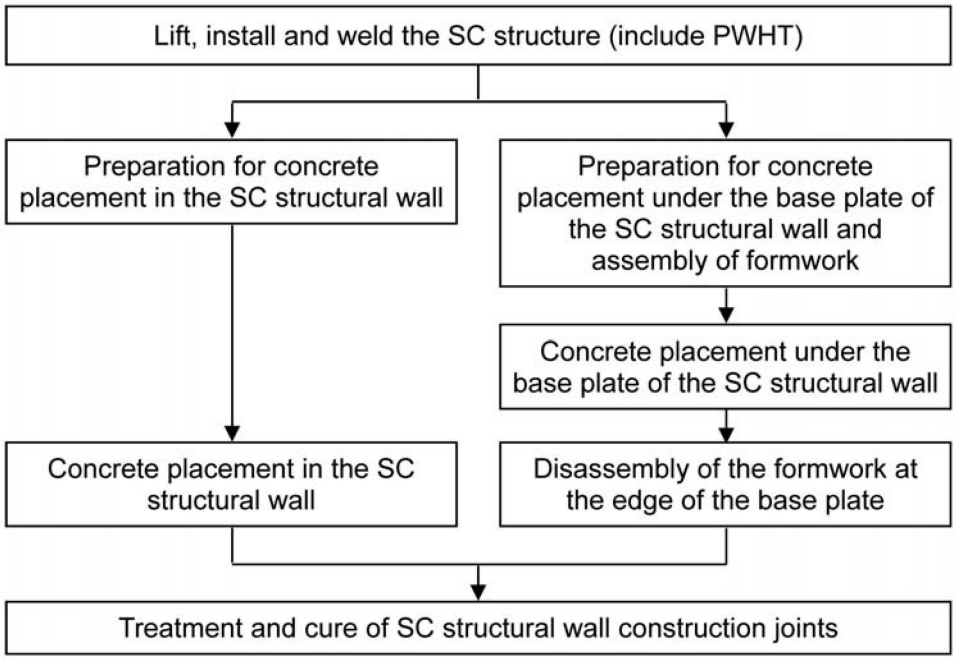

Figure 3.5-1 Flow Chart for Concrete Placement

3.5.4.2 Preparation for concrete placement

The preparation for concrete placement follows a prescribed concrete placement plan and foreign material exclusion plan prior to concrete placement.

3.5.4.3 Concrete Placement

3.5.4.3.1 Standard Practice

Concrete should be pumped into the SC structure wall through the concrete pipeline using a concrete pump source. Concrete placement should start at the point farthest from the pump source using a boom or a separately installed concrete pipeline. When the concrete is placed using a concrete pipeline, the piping which is furthest away from the concrete pump should be removed as placement gets closer to the concrete pump source. When placing on consolidated fresh concrete, concrete should be placed horizontally to prevent excessive lateral pressure from being applied to both the face and web plates of the SC structure wall as shown in Figure 3.5-2. **[**

] The next concrete layer should be placed to avoid aggregates not filling under the tie bars, as shown in Figure 3.5-3.

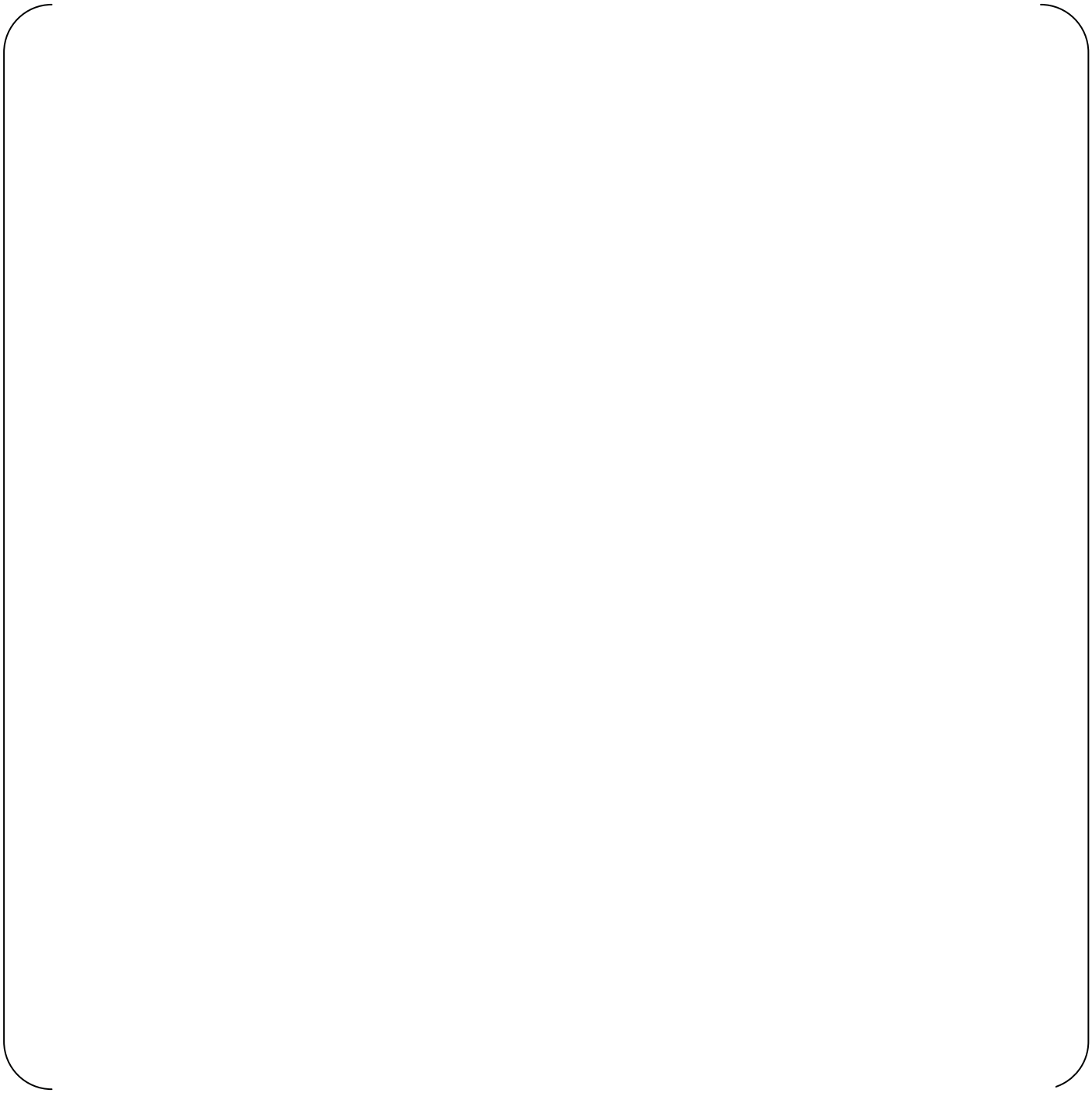

Figure 3.5-5 Example of Concrete Placement in the SC Structure: General Section

3.5.4.3.2.2 SC Structure Wall: Underside of the Base Plate

SCC should be placed under the base plate without vibration and consolidation. To avoid any dead air space under the base plate, the concrete placement should be poured in one direction to allow air to vent though opposite side.

In addition, concrete may be pumped under pressure to fill voids.

3.5.4.3.3 Concrete Placement Procedure Taking Concrete Lateral Pressure into Account

When placing concrete, the lateral pressure is maintained under design allowable values as determined using the methodology of ACI 347-04. An example for calculating lateral pressure using Zone ① of Figure 3.5-6 is shown below.

Figure 3.5-6 Sample of Lift Division Plan

3.5.4.3.3.1 Sample Calculation of Lateral Pressure and Concrete Lift Height

Table 3.5-1 Calculation Conditions (Assumptions)

Figure 3.5-8 Checking Concrete Placement in Typical SC Structure Wall

3.5.4.3.5.2 Horizontal Structural Member Section at the Intermediate SC Structure Wall

If horizontal structural members are inside of an SC structure steel modules (e.g., a stiffener to maintain SC structure modules during transportation), air vent holes should be placed in the horizontal structural member. The vent hole is used to vent air and confirm that concrete is filling the space beneath the horizontal member by ensuring that concrete comes out of the air vent hole holes during placement.

If the member is located near the concrete overlay height, concrete is placed up to approximately 8″ below the member. The concrete is left to stand until the top surface of the concrete settles sufficiently. Free water that bleeds to the top surface is absorbed with sponge or a Hydro-Sweeper. After free water is removed, the process of concrete placement proceeds to the next pour elevation or top of SC module, whichever is applicable. Figure 3.5-9 shows the process described above.

Figure 3.5-9 Concept for Placing Concrete in the Area Around a Horizontal Structural Member Section

3.5.4.3.5.5 Section With a Steel Plate at the Top of the SC Structure Wall

Concrete placement is stopped slightly below the top of the SC structure (Level A as shown below), and SCC or grout is used to fill the remaining space (to Level B) after removal of laitance. Level A is established during construction. Figure 3.5-12 summarizes the process described above.

Figure 3.5-12 Concept for Placing Concrete in a Closed Section (Other Cases)

3.5.4.3.5.6 Concrete Placement Around a Sleeve or Support Structure Anchor Assembly

Concrete is placed from one side and then consolidated. The concrete placement is confirmed by observing concrete coming out from under the sleeve to the other side.

For large sleeves (such as the main steam pipe sleeve) air vent holes should be arranged in the surface of the sleeve steel plate and in the SC face plate directly under the sleeve to vent air and confirm concrete coming out. Vibrator holes are arranged as needed to consolidate concrete. Figure 3.5-13 shows the process described above.

Figure 3.5-13 Placing Concrete Around a Sleeve

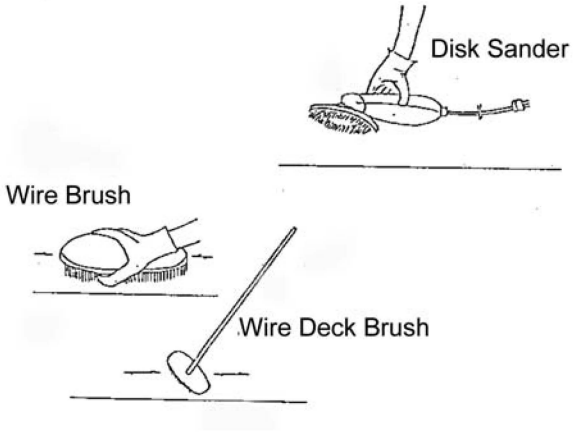

Figure 3.5-15 Tools for Construction Joint Surface Preparation

3.5.6 Curing

After concrete placement, water should be sprayed on the concrete surface to the extent that construction joint finishing is not interfered with and freezing does not occur. If when placing concrete in the winter, the surface temperature of concrete in contact with the face plate of the SC structure wall is likely to drop significantly compared to the inside temperature of the concrete, the concrete surface should be covered and the entire face plate should be covered for insulation with a sheet or an appropriate material.

3.6 Use of Mockups

Means and methods to achieve design requirements is the responsibility of the contractor. The contractor shall establish a test program, including the use of mockups, to assure that the proposed construction processes are capable of producing a structure that meets the design requirements and to proof inspection methods and procedures to document that the design criteria has been achieved. Fabrication, assembly, and erection of scaled, but equivalent, mockups are considered part of the quality control process. These mockups are to be representative of the anticipated working conditions, physical configuration, accessibility, and provide equivalent quality control accessibility that is expected to be encountered during construction. Review and examination of the mockups and their resulting lessons learned will be used to confirm the adequacy of construction means, methods, and procedures. If defects are encountered, the procedures are to be revised and the mockup repeated as appropriate to demonstrate that the required result is obtained. The major tasks that will be performed on each mockup, as a minimum, include the following:

- Field performance testing of the quality of concrete mixes,
- methods of concrete placement,
- inspections and surveillance,
- post-placement activities.

Visual inspection and physical testing during initial placement of plastic concrete and non-destructive examination (NDE) after concrete set will be performed for assessing defects that may impact structural integrity, such as crack distress, deterioration caused by honeycomb,

voids, and delaminations. The ability of proposed NDE testing programs to identify these potential defects will be demonstrated as part of the mockups and any lessons learned with the R-COLA will be made available to the supplemental-COLAs. This is to demonstrate construction quality control for concrete placement, and develop and document insights and requirements for corrective action, if required, to be used in the construction inspection program for any and all plants.

The mockup testing program will be used to demonstrate the contractor's ability to place concrete into formwork which includes, but is not exclusive to, placement of concrete into the SC-Walls. A mockup is not required in areas where established ACI placement techniques are considered standard construction practice; but, congested areas with high rebar density, load critical locations with limited access, configurations that have the potential of creating voids, or changes in concrete material properties, etc. will be demonstrated. The contractor shall identify mockups that are to be performed as part of their risk management program but the following mockups will be performed as a minimum:

- Placement of Self Consolidating Concrete under the SC-Wall Baseplate (i.e. ASME Section III containment liner – pressure boundary)
- Placement of Normal Concrete into a congested SC-Module where accessibility is limited

4.2 Concrete

Inspection and testing of concrete used within the SC structure shall be in accordance with ACI 349-06 Section 1.3, ACI 311.4R-05 and ACI 311.5-04. Concrete shall be inspected prior to, during and after placement activities to differing criteria appropriate to each respective phase. Major inspection items are shown below. Figure 4.2-1 shows typical tests and inspections during concrete placement.

4.2.1 Inspection of Concrete Materials at Acceptance (Before Use) and During Use

(a) Scope of inspection
Inspection should be performed on cement, aggregate, water and admixture.

(b) Inspection
The materials used and their quality should be checked at the specified frequency, including acceptance and during use, to ensure that the quality requirements are met.

4.2.2 Inspection of Material Properties During the Production and Placement of Concrete

(a) Scope of inspection
Inspection should be performed on mixed concrete before placement in the SC structure wall or under the base plate and hardened concrete after placement.

(b) Inspection
Immediately before placement, concrete should be measured and checked with an appropriate instrument that the quality requirements are met and the measurements are within the acceptable range.

Test cylinder specimens shall be taken during concrete placement and compressive strength shall be tested at specified test age.

4.2.3 Finish Inspection of the SC Structures After Concrete Placement

(a) Scope of inspection
Inspection should be performed on the SC structure wall filled with concrete.

(b) Inspection
Concrete is to be monitored during placement to assure that the desired configuration has been achieved. Use of pre-inspections before placement and visual observations during placement are to be performed. However, it is also anticipated that quality control of the set concrete will also be required to provide objective evidence that the concrete has been placed in accordance with the design. These requirements will be controlled in the construction specifications and will be implemented as part of the contractor's construction inspection program. Inspections and methodologies are provided as follows:

- Physical Configuration: The cross-sectional dimensions of the members of the SC structure wall filled with concrete should be measured with an appropriate instrument, such as a scale and a plummet, to ensure that the measurements are within the acceptable range for the cross-sectional dimensions.

- Impact Echo Method (IEM): It is recommended that IEM be a primary non-destructive examination (NDE) method for examining placed concrete through the walls. The IEM approach has been extensively evaluated and has a proven track record for categorizing potential concrete defects.

(c) Mockup Testing

Applicability of the recommended test method, or any other NDE test method, to confirm the ability to identify known defects is to be confirmed as part of the Section 3.6 Mockup program described above. The mockup testing is also to evaluate the test method's ability to be used directly through the steel plate of the SC-walls. If the steel plate masks the results or reduces resolution such that it cannot define the character of the potential concrete defect then criteria for cutting an access port through the SC wall directly accessing the concrete surface is to be established. It is also feasible that de-bonding between the steel plate and the filler concrete may be encountered and should be evaluated as part of the mockup program. The feasibility of injecting epoxy grout, masonry grout, a highly viscous liquid, etc. between the steel SC-plate and concrete is to be evaluated as part of the program to limit the number and size of access ports that may be required.

Voids, delaminations and cracks are to be introduced into the mockups, and the ability of the technology to identify and quantify the defects is to be assessed. It is essential that any technology be proven to be reliable before it is considered as objective evidence for acceptance of the as-built structure.

(d) Sampling Approach

A statistically-based sample acceptance program approach can be used in each of the critical areas identified for mockups in Section 3.6 to look for coarse voids, honeycombs or delaminations (Reference 5). A grid will be established for the SC-walls with a weighted consideration being provided in areas of defined critical sections. The location of the samples are to be randomly established with the application of a 95/90 sample plan to provide a confidence ("assurance") of 95% that at least 90 percent of the lots are acceptable".

The sampling would be considered acceptable if no coarse voids, honeycombs or delaminations larger than defined in the acceptance criteria were found. If a coarse voids, honeycombs or delaminations larger than defined in the acceptance criteria are identified, then additional engineering evaluations would be need to assess the extent of the condition and then corrective actions would be taken as required in the corrective action program.

(e) Acceptance Criteria

The acceptance criteria are to be established as part of detailed design and are to be included and controlled in the Construction Specifications. The SC-wall section being evaluated is required to be without defect unless it meets specific acceptance criterion within the specification. The acceptance criteria are intended to address normal construction tolerances while complying with design and minimum margin requirements. Guidance for these potential defects was obtained from ACI 117, "Standard Specifications for Tolerances for Concrete Construction and Materials" and ACI 349, "Code Requirements For Nuclear Safety Related Concrete Structures".

8.0 REFERENCES

Note: Codes and Standards identified in this document are not included as references

1. Containment Internal Structure Design and Validation Methodology, MUAP-11013, Rev. 2, Mitsubishi Heavy Industries, Ltd., February 2013.

2. Containment Internal Structure: Stiffness and Damping for Analysis, MUAP-11018, Rev. 1, Mitsubishi Heavy Industries, Ltd., February 2013.

3. Containment Internal Structure: Design Criteria for SC Walls, MUAP-11019, Rev. 1, Mitsubishi Heavy Industries, Ltd., January 2013.

4. Containment Internal Structure: Anchorage and Connection Design and Detailing, MUAP-11020, Rev. 1, Mitsubishi Heavy Industries, Ltd., February 2013.

5. NUREG 1475, Applying Statistics, United States Nuclear Regulatory Commission, February 1994.