August 18, 2010

GUIDANCE TO NRC/NRR/DSS/SRXB REVIEWERS FOR WRITING TI SUGGESTIONS FOR THE REGION INSPECTIONS

This is Revision 9 of this document. It is an interim version that we plan to update later this year when additional information is available.

Blue is used for comments and guidance in preparing the communication to the Regions. Material in black may be used "as is" or you may modify it. Choose from material in Red as appropriate, modify it, or add anything else that you believe is needed. Green is used for licensee-specific information. This means that a color printer should be used if you want a hard copy of this communication.

The following should be a memo from Anthony Ulses, the SRXB Branch Chief, if to Region II and an attachment to an email from Anthony Ulses if to Regions I, III, or IV. Addressees are:

I Michael Balazik

II Binoy Desai, Chief, Engineering Branch 1, Division of Reactor Safety, Region II, cc to Robert Berryman, Senior Reactor Inspector, Engineering Branch 1, Division of Reactor Safety, Region II

III Ann Marie Stone, cc to Caroline Tilton, Nestor Feliz-Adorno,

IV Thomas Farnholtz, cc to Matthew Young,

Warren Lyon, Jennifer Gall, Dave Beaulieu, the Project Manager (PM), and the PM's Branch Chief should be on cc for all communications.

Subject: TI 2515/177 Inspection of plant name

The attachment provides the NRR Reactor Systems Branch (SRXB) suggestions for the inspection of plant name using the guidance provided in Temporary Instruction (TI) 2515/177, "Managing Gas Accumulation in Emergency Core Cooling, Decay Heat Removal, and Containment Spray Systems, (NRC Generic Letter 2008-01)."

ATTACHMENT

OFFICE OF NUCLEAR REACTOR REGULATION (NRR) REACTOR SYSTEMS BRANCH (SRXB) SUGGESTIONS FOR THE PLANT NAME INSPECTION USING THE GUIDANCE PROVIDED IN TEMPORARY INSTRUCTION (TI) 2515/177 (REFERENCE 1)

1 BACKGROUND

Section 1 summarizes the SRXB review approach and provides information inspectors may find useful for inspections.

1.1 SRXB Review Approach

Reference 2 described the coverage the NRC staff expected licensees to provide in their responses to Generic Letter (GL) 2008-01 (Reference 3). The initial SRXB review approach was to address all shortcomings via in-depth Requests for Additional Information (RAIs) followed by recommendations to the Regions to supplement Regional plans for TI inspection coverage. However, based on feedback from the Regions and other stakeholders, we modified the review process to focus on information needed to ensure plant operability with respect to finding and addressing voids (Reference 4). This should reduce regulatory burden and appropriately utilize Regional inspector practices and knowledge. Reference 2 continues to apply and may be used for guidance in conducting TI inspections,

We focused on the following when preparing RAIs:

a. Technical Specifications (TSs) and planned response to Technical Specifications Task Force (TSTF) documentation,
b. Surveillance requirements,
c. Procedures, and
d. Corrective action program (CAP).

This was done with the intent of establishing that any remaining issues are confirmatory and the Regions can select issues to be examined further via the TI inspection.

1.2 Operability Determination

Our review and the inspections are based on guidance provided in References 5 - 7 for assessing subject system operability. The objective is to "reasonably ensure that subject system operability" is achieved and a "reasonable expectation" test applies. This means that a high degree of confidence applies but absolute assurance is not necessary. The determination can be based on analyses, test or partial test, experience, and/or engineering judgment. This is particularly applicable to determination of void transport behavior, pump response to voids, and vortexing where the reliance on judgment will vary depending upon the depth of understanding that has been developed. This is discussed further in Sections 1.4 and 1.5. Consequently, a strong reliance on engineering judgment will sometimes be necessary to support an interim finding regarding current operability[1] for these issues until improved guidance can be developed. Such guidance is expected to be available in early 2011 and will allow operability findings to be more solidly based on analyses and tests and the need for engineering judgment will be diminished although there will likely remain circumstances where solidly based engineering judgment is both appropriate and acceptable.

1.3 The Meaning of "Full of Water"

There have been issues related to the meaning of "full of water" in TSs. Reference 8 concluded that "if the licensee can conclude through an operability determination that there is a reasonable expectation that the system in question can perform its specified safety function, the system piping can be considered filled with water such that the surveillance requirement is met." A condition where there is no void is described by such words as gas-free, free-of-gas, or water-solid.

[1] "Currently operable" is a determination made on the basis of currently available information with the understanding that later information may affect the conclusion.

1.4 Void Transport and Pump Response

Assessing current operability requires addressing all aspects of the behavior. This includes but is not necessarily limited to:

1. Variation in pump flow rate and discharge head encountered.
2. Suction transport.
3. Pump ingestion.
4. Discharge effects.
5. Behavior within the reactor coolant system including delay in delivery of water.

Selected aspects of these considerations are addressed in the following subsections to Section 1.4. Development of other aspects is continuing and will be addressed in future revisions of Section 1.4.

1.4.1 Acceptance criteria for pump response to voids

Interim criteria for the void fraction entering a pump, Φ, that we will accept without further justification for not jeopardizing operability of a subject system pump, as qualified in the discussion following the table, are:

	$\% \frac{Q}{Q_{BEP}}$	**Φ for BWR Typical Pumps**	**Φ for PWR Typical Pumps**		
			Single Stage	Multi-Stage Stiff Shaft	Multi-Stage Flexible Shaft
Steady State Operation	40%-120%	0.02	0.02	0.02	0.02
Steady State Operation	< 40% or > 120%	0.01	0.01	0.01	0.01
Transient Operation	70%-120%	0.10 for ≤5 sec	0.05 for ≤20 sec	0.20 for ≤20 sec	0.10 for ≤5 sec
Transient Operation	< 70% or > 120%	0.05 for ≤5 sec	0.05 for ≤20 sec	0.05 for ≤20 sec	0.05 for ≤5 sec

where: Q = water volumetric flow rate
BEP = best efficiency point
Transient Φ is averaged over the specified time span
Instantaneous Φ < 1.7 times the listed value[2]

[2] The 1.7 represents mutual judgment of industry and SRXB representatives.

The transient operation criteria are based on the premise than full head will be recovered after the gas has passed through the pump as substantiated by pump operation experience and the judgment that the short times associated with the transients will not result in pump damage. Further, the most likely condition that would result in pump damage would be associated with an insufficient flow rate during the transient time, a condition that is not judged to occur during the listed transient times in conjunction with the $\Phi < 1.7$ criterion that precludes momentary large void fractions and precludes slug flow with respect to applying the criteria.

Meeting the steady state criteria should preclude pump damage provided pump miniflow requirements are met so that pump cooling is ensured. Further, the steady state criteria will reasonably ensure that operability requirements will be met if the difference between the pump head required to meet operability requirements and the un-degraded pump head is greater than three percent. If required pump head is within three percent of un-degraded head, then degradation due to gas should be addressed.

The pump void criteria are applicable when the upstream suction piping has a circular cross section and the velocity is generally parallel to the pipe centerline as flow enters the pump unless acceptable qualifications are provided.

1.4.2 Net positive suction head (NPSH)

NPSH margin for consideration of cavitation will be captured in design basis analyses for loss-of-coolant accidents (LOCAs). Consequently, consideration of the effect of gas on NPSH is not necessary with respect to GL 2008-01 inspections.

1.4.3 Gas movement in pipes

At low flow rates, gas may be assumed to not move in a pipe if the Froude Number, N_{FR}, is ≤ 0.31 and the average void fraction in a plane perpendicular to the pipe centerline, Φ, is ≤ 0.20, where:

$$N_{FR} = \frac{V}{\sqrt{\frac{Dg_c(\rho_L - \rho_g)}{\rho_L}}}$$

D = pipe diameter
V = liquid velocity based on total pipe flow area
g_c = gravitational constant
ρ = density
subscript L indicates liquid
subscript g indicates gas

At $N_{FR} \le 0.65$, some gas may be transported and if $N_{FR} \ge 2.0$, all gas will be carried out of a pipe with the flowing water. Time to clear gas from a pipe for $0.8 < N_{FR} < 2.0$ is a function of flow rate. Dynamic venting may not be assumed effective for $N_{FR} < 0.8$. Time to clear gas as a function of time will be addressed in a later revision of this document when we have received and evaluated test data that supports clearance behavior. In the meantime, inspectors should determine whether licensees that use dynamic venting have acceptable justification to support the effectiveness of their dynamic venting processes.

An acceptable method of determining the size of a void upstream of a pump that will not jeopardize current operability is to use the 0.5 second averaging criterion identified in Reference 9 as a starting point. The upstream void volume that will not jeopardize current operability is obtained by multiplying the void fraction given in the Section 1.4.1 table times the total volumetric flow rate times 0.5 seconds.

At present, there is no acceptable generic methodology for assessing pipe void size and void transport behavior, other than the above, and any extrapolations to conditions not addressed by the above information should be addressed on a plant-specific basis. Industry is developing a simplified conservative methodology to address gas movement that should cover the majority of cases of concern. This is scheduled for completion during calendar year 2010 and we will update our guidance as more information becomes available that provides an acceptable methodology. Industry is also considering an approach that may reduce the concern with acceptable void volumes based on the maximum void fraction that could cause a problem under any conditions. We will continue to follow this development and will incorporate results as applicable and acceptable. In the meantime, inspectors may find it necessary to rely on judgment in conjunction with other guidance provided in Subsection 1.4.3 to determine that licensees have an acceptable justification to support conclusions regarding movement of gas in pipes.

One approach that is used by licensees is to analyze gas movement by applying codes such as RELAP 5, GOTHIC, TRAC, and TRACE to perform a two-phase, two component analysis of gas movement. We have not reviewed these codes in sufficient depth to confirm they are generically acceptable but they may provide reasonably results if properly applied. For example, Region I personnel, the licensee, and Fauske Associates did an in-depth evaluation of a void issue at Millstone 3 that provided sufficient information for the Region to conclude that historic operability had been acceptably confirmed. References 10 and 11 describe two phase, two component tests and RELAP 5 analyses of the tests, respectively. Fauske Associates and the licensee also used RELAP 5 to calculate behavior in the emergency core cooling system (ECCS) flow path at Millstone 3, but these reports are not readily available. We suggest contacting Wayne Schmidt (610-337-5315) at Region I if you need additional information. RELAP 5 has also been used to calculate two phase, two component behavior in the subject systems at other facilities.

GOTHIC has been reported to be used at a number of facilities to predict gas movement associated with GL 2008-01 and other systems, such as an issue with gas accumulation in a component cooling water system.[3] GOTHIC has a broad modeling capability and is one of the most flexible thermal-hydraulic codes we have examined. It is restricted to rectangular geometries and approximations are necessary to model piping systems. We judge the modeling of cylindrical horizontal and vertical pipes to be reasonable approximations and error associated with the modeling can probably be reduced by tuning. Piping at an angle from horizontal must be addressed with care. Similarly, treatment of elbows and tees will vary with the orientation. For example, an elbow between a horizontal and a vertical pipe may have to be modeled differently than an elbow from one horizontal pipe to another for gas/water analyses. This means that single phase water tests will not provide enough data for a comparison to GOTHIC calculations of two phase water and gas with respect to tracing the gas behavior.

[3] We are aware of its use at Three Mile Island, Point Beach 1 and 2, St. Lucie 2, Catawba 1 and 2, Salem 1 and 2, and Wolf Creek.

We are aware of a broad range of comparisons between GOTHIC predictions and test data with a range of results. Most of the comparisons we have seen, including the support for our acceptance of GOTHIC for containment modeling[4], do not address gas movement under the conditions of concern here. We are not aware of any blind comparisons or any comparisons that we judge to acceptably cover plant system behavior for the plants that are the topic of our inspections. The closest coverage of plant system behavior are results provided to support ongoing inspections that include proprietary comparisons with Purdue test data[5] and preliminary comparisons to the Reference 10 test simulation of piping from the Millstone 3 refueling water storage tank (RWST). Unresolved issues associated with these tests include potential modeling inconsistency and applicability of the tests to the overall plant modeling. Consequently, plant-specific partial system tests of the type identified above for RELAP 5 are necessary to support GOTHIC predictions of gas/water behavior and any test and plant calculations must be consistently accomplished with the same code version and applicable input data.

There are at least seven cautions to observe in considering application of thermal-hydraulic codes:

1. Modeling is strongly influenced by the modeler who must have a demonstrated capability to fully understand the code, selection of input parameters, and the nodalization.

2. Some codes may not correctly model such phenomena as the kinematic shock (waterfall) that may occur downstream of the elbow from a horizontal pipe to a vertical pipe. Other codes may require in-depth modeling to address the behavior if the kinematic shock has a significant effect on downstream behavior. Any conclusions must consider such inadequacies or requirements.

3. If pump modeling is an important component of the analysis, then correct pump modeling should be verified because understanding of two phase transient pump behavior is changing as additional data are obtained.

4. There are questions regarding the correct modeling of vortex behavior associated with water level approaching the level of a drain pipe from a tank or the connection between a large pipe and a smaller suction pipe.

5. The wide variation of pipe geometries and the above considerations may necessitate that tests be conducted and compared to calculations unless previously applicable comparisons have been performed.

6. An up-to-date version of the code should be used that has a demonstrated two component (gas-liquid) analysis capability for the configurations and conditions of concern.

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[4] Blount, Thomas B., “Final Safety Evaluation For Westinghouse Electric Company (Westinghouse) Topical Report (TR) WCAP-16608-P, Revision 0, ‘Westinghouse Containment Analysis Methodology’ and Appendix A ‘Generation Of Thermal Hydraulic Information For Containments (GOTHIC) Generic Boiling Water Reactor (BWR) Mark I Model,’ and Appendix B ‘BWR [Boiling Water Reactor] Mass and Energy Release Input Calculation Methodology” (TAC No. Md2953),” ML090230143 (Package), January 27, 2009.

[5] The data were obtained from “Testing and Evaluation of Gas Transport to the Suction of ECCS (Emergency Core Cooling System) Pumps,” Westinghouse Electric Company LLC, WCAP-16631-NP, Revision 0, October 2006.

7. Predictions should be assessed with respect to basic behavior as addressed by such approaches as use of Froude number, bubble behavior correlations, and, in some cases, tests that include applicable configurations.

With respect to the need for substantiation of a code for such applications as opposed to an industry comment that it is not necessary since engineering judgment is sufficient, we disagree. Engineering judgment must be based upon a reasonable basis and applying a code that does not have such a basis is not acceptable. A reasonable basis was shown in the RELAP 5 work described above where the test data and associated analyses established what aspects of RELAP 5 could be applied and which were not appropriate. With respect to the time required to perform a validation test and the need to shut down in the event of a problem, since insufficient time would be available, the first requirement is a reasonable substantiation of operability. This can differ with respect to the time when in-depth substantiation becomes available. For example, continued operation for a short time while an acceptable code application is substantiated for justification of long term operation may be acceptable. We note that the more likely situation is that potentially significant discovered gas volumes will be immediately removed followed by immediate entry into the CAP. Gas removal mitigates immediate operability concerns and entry into the CAP addresses potential gas accumulation at the same or similar locations as well as addressing past operability concerns.

Licensees sometimes begin their analyses from the viewpoint that the tabulated acceptable void criteria may be used as a starting point and that some calculational methodology may be applied to determine acceptable void volumes throughout different locations in suction piping. If acceptable consideration is given to the combined effect of the void volumes, then this is an acceptable approach to determine short term operability when provided in procedures. However, it is not acceptable to support long term operability conclusions. Our opinion is that discovery of any non-trivial void must be removed if practical and entry into the CAP is necessary to provide an acceptably process to assess the effect of the void.

Licensees sometimes reference industry documentation that is inconsistent with the above information and such references may not be acceptable for operability or operating considerations. The best approach is one in which voids are prevented and, when voids are found, they should be much smaller than a void that could challenge operability and should be removed unless removal is impractical. In all cases where a void is found, the CAP should be entered to address the condition. Further, any void that potentially challenges operability must be removed or reduced so that it is no longer a concern.

1.5 Vortexing

NRC inspectors often encounter plant conditions where vortexing may result in entrainment of gas into systems that are required for plant operation or to respond to accident conditions. In assessing these conditions, they are finding that licensees may rely on non-conservative analysis methodologies, yet the inspectors have little guidance upon which to base their assessments. Instead, they have found that several methodologies exist to determine whether a vortex will form and contradictory results have been obtained from the different testing methods, configurations evaluated, and interpretation and extrapolation of results. Likewise, inspectors have a difficult time in determining the amount of air entrainment due to vortexing and the effect on pumps. This has led to such situations as inconsistent assessment of vortices, challenging of previously reviewed vortex analyses, potential inappropriate selection of which methodology to use, and questions regarding the impact on pump operability.

Industry has commented that vortices are categorized as Types 1 through 6 with Type 1 being a surface dimple and Type 6 having a continuous gas core that extends into the suction port. To obtain a 0.01 void fraction in the suction flow, the diameter of the gas core needs to be at least 10% of the suction port diameter. This is only obtained with a Type 6 vortex. Much of the confusion arises because it is not clear that only a Type 6 vortex of this scale would challenge pump operation. This vortex guidance must be consistent with the NEI/NRC guidance on the allowable pump inlet gas volume fraction.

We plan to develop a formal position and generic guidance regarding vortex formation and acceptable analytical methods for assessing vortex formation by 08/31/11 (TAC ME1306). The best approach is one in which plant operation prevents approaching conditions where vortexing can result in gas ingestion.

1.6 Nuclear Energy Institute (NEI) Guidance

Reference 12, "Guidelines for Effective Prevention and Management of System Gas Accumulation," ML093130090, provides excellent coverage of many aspects of the GL 2008-01 issues and extends industry guidance to cover all systems where gas accumulation may be a concern. We recommend you read this document for background information before conducting the TI inspection. NEI plans to revise Reference 12 to broaden coverage of the issues by the end of December, 2010. We are pursuing endorsing the revised document, assuming it is acceptable, by issuing a regulatory guide (RG) and regulatory issue summary (RIS) in 2012.

1.7 Accessible Versus Non-Accessible Locations and Surveillance Requirements

All locations are considered to be accessible unless actual environmental conditions constitute a hazard to personnel or are such that conducting the surveillance in the specific locations will result in an unacceptable dose. Surveillance locations in a posted high radiation area are considered to be accessible if the surveillance(s) can be conducted without exceeding an acceptable dose with respect to ALARA considerations. For example, suppose six surveillance locations are in a high radiation area and five can be completed with minimal exposure to radiation. The locations where the five surveillances are to be conducted are accessible. Consideration of such aspects as high environmental temperatures or local high temperatures that constitute a burn hazard also apply to determination of non-accessibility.

Surveillance is required for all locations of concern unless it is acceptably determined that the surveillance is not necessary to reasonably ensure operability. However, the NRC staff will allow more flexibility in determination of operability for non-accessible locations with respect to consideration of such aspects as the likelihood that gas can accumulate in the locations of concern in contrast to the impact of gas at those locations.

1.8 Surveillance Frequency and Requirements

The NRC staff is studying general surveillance requirements as part of the TSTF evaluation but, for now, the scheduled surveillance frequency should be every 31 days unless a greater surveillance frequency has been justified. Typical considerations for a greater surveillance frequency could include such items as:

1. All potential sources of gas are monitored and trended and applicable parameters remain within specified limits. Potential monitoring may include but not be limited to such items as accumulator level and pressure, reactor coolant system (RCS) leakage,

ECCS and residual heat removal (RHR) system piping pressure, RHR temperature versus saturation temperature when RHR is initiated or suction sources are changed, volume control tank pressure for unanticipated pressure drops, reactor coolant pump seal return flow rate for unanticipated increases, and level in tanks (if any) that are provided to accumulate gas from piping high points. Further, monitoring of locations where outgassing may occur when liquid passes from a high pressure region to one at lower pressure should be considered.

2. The piping is maintained at a pressure higher than that of any potential source of gas in-leakage, such as some of the ECCS discharge piping in some Westinghouse designs that are maintained at pressures greater than the RCS pressure, and no locations exist where outgassing may cause gas to accumulate during operation

Potential sources of gas that should also be considered may include failure of level instruments to indicate correct level, leakage through one or a series of closed valves, vortexing, design deficiencies that may result in gas intrusion during accidents, keep-full system malfunctions, leaks in hydraulic dampeners, and cooling of an isolated section of piping that may cause a pressure decrease.

Any location that has the potential for a gas volume to be formed should be assumed to have an acceptance criterion of zero gas unless an acceptable criterion has been specifically determined for that location.

Monitoring is not required for those potential void locations (vented or unvented) where the maximum potential accumulated gas void volume has been evaluated and determined not to challenge system operability based on the maximum acceptable void volume, location, Froude number, or other technical basis. Monitoring is not required for a potential void location that communicates with a bounding monitored potential void location in the same piping segment when the second location will show a void when the first location is full. However, any potential gas volume in unmonitored locations must be acceptably evaluated with respect to its potential contribution to the overall system response if gas accumulates in other locations. The evaluation must be documented and the total potential gas volume from such a location reduces the overall system acceptance criteria for that pipe segment. The process could require additional monitoring for these locations if gas is found at the bounding monitored potential void location. (Most material taken from Reference 12, which provides excellent insights for addressing gas concerns.)

The monitoring methodology should be documented. The documentation should include an assessment of the monitoring methodology accuracy and a justification of why the accuracy is sufficient to support a determination of operability. In the case of UT, an accuracy determination and justification is not necessary if the measurement methodology involves a relatively precise process such as determining the water level in a horizontal pipe from one side and from the other side accompanied by a circumferential measurement and suitable calculations, measuring the level in a vertical pipe, or using a widely acceptable method of measurement from the bottom or top of a horizontal pipe. These processes are expected to provide more than sufficient accuracy when compared to the uncertainty associated with the void criteria.

Failure to meet a gas volume acceptance criterion shall require (1) immediate entry into the CAP, (2) an immediate operability determination, and (3) a decreased scheduled surveillance frequency that is sufficiently short to ensure that the affected locations will remain within acceptance criteria until the cause of the failure is corrected.

1.9 Surveillances Associated with Outage and Maintenance

Any system maintenance activity that will result in a reduction in fluid inventory of a fluid system in the scope of gas accumulation management should be evaluated to determine the required fill, vent and verification inspection. The work processes should include provision for engineering review and evaluation of such evolutions. If the specific evolution has been previously evaluated and the fill, vent, and verification requirement identified, then engineering review could be limited to verifying applicability.

Some of the potential sources of gas that are of concern with outage and maintenance practices are the same as identified in Section 1.8, above. Others that should be considered include procedure errors, failure to follow procedures, ineffective fill and vent, system draining, and realignments.

Locations potentially affected by outages or maintenance operations are to be purged of gas and/or surveyed immediately upon completion of the activity and established to have no gas volumes that exceed gas volume acceptance criteria. A follow-up, completely independent surveillance of potentially affected locations and adjoining locations should be accomplished within 31 days if the scheduled surveillance frequency is greater than 31 days to ensure that the post-outage or maintenance potential impacts have been addressed. The acceptance criteria for this second surveillance should be that no gas volume acceptance criteria will be exceeded and no significant gas accumulation will have occurred since the first surveillance that was conducted upon completion of the activity. Startup of selected pumps and observation of the transient discharge pressure is an acceptable second surveillance of pump discharge piping if (1) at least one week has passed since the first test, (2) this test was conducted previously with verification that the observed transient was consistent with the previously determined volume, (3) the second surveillance established, within the sensitivity of the test, that no gas accumulated since the first test, and (4) gas volumes are less than half the gas volume acceptance criteria.

1.10 Gas Volume Acceptance Criteria

If there is no specified gas volume acceptance criterion for a location where gas may potentially exist, then the acceptance criterion is that a water-solid condition shall exist.

As discussed in Section 1.4, above, gas volume acceptance criteria are of five types:

1. Pump Inlet void fractions
2. Criteria applicable to piping upstream of pumps that may result in voids entering a pump
3. Criteria applicable to water hammer and related issues
4. Criteria applicable to RCS behavior due to injected gas
5. Criteria applicable to containment response

Water hammer effects due to potential accumulated gas or vapor must be shown to be limited to a value that does not damage piping, pipe supports, or other system components. Further, the pressure surge associated with pump starts must not result in lifting of relief valves where system pressure exceeds reseat pressure and should not result in lifting relief valves. Several industry reports have been received that address water hammer under various conditions and the NRC staff is considering the available information. We plan to complete assessment of these reports by 12/31/10.

RCS response to injected gas generally entails consideration of the potential delay in injecting water upon demand and the effect of the injected gas on RCS behavior. The potential delay is generally small with respect to other delays associated with initiation of injection and the amount of injected gas is often small in comparison to the voids that exist due to other causes. In such cases, a qualitative evaluation is often sufficient to establish operational acceptability. No generic guidance is anticipated to be necessary to address Item 4.

The same conclusions generally apply to Item 5.

1.11 **Corrective Action Program** (Taken in part from Reference 12)

The CAP should be used to resolve identified deficiencies in procedures. The final system condition should be verified to meet acceptance criteria or to be resolved by appropriate corrective action. Any voids found following completion of fill and vent activities should be recorded, tracked, and trended for evaluation of gas intrusion management effectiveness.
If the CAP is entered because of failure to meet an acceptance criterion, an immediate review should be conducted to identify other locations that are potentially affected by the observed gas intrusion mechanism and licensee inspections should be performed at the locations identified by the review. Locations where gas continues to accumulate should be evaluated for possible remedies which could prevent or minimize future gas intrusion. This could be through plant modification or operating procedure and practice changes. An important aspect of correcting such conditions is to have a clear understanding of the gas intrusion mechanism. If changes cannot be made immediately to remedy these locations, then enhanced monitoring shall be implemented to identify early onset of gas accumulation.

1.12 **Procedures** (Taken from Reference 12 with modifications)

Operating, testing, and maintenance procedures should include warnings about potential gas intrusion and / or accumulation for those evolutions that have been identified during the evaluations of the plant systems. For precursor conditions that are monitored, criteria for when action is required to evaluate gas intrusion should be included in procedures.

1.12.1 Fill and Vent Procedures

Fill and vent procedures should contain guidance on filling and venting methods to restore the systems as full based on the system configuration. Venting methods may include static venting through a valve, dynamic (flow induced) venting, and vacuum venting. Verification that the system piping is full of water following fill and vent is necessary.

Fill and vent procedures should:

1. Specify vent locations to support operating and maintenance activities, the venting method, and the criteria to determine when adequately filled.

2. Specify adequate steps that ensure the subject systems are free of accumulated gas and will perform their intended functions.

3. Be revised as necessary to incorporate operating experience and to control gas voids that may be introduced by maintenance and / or operational activities.

4. Be specific for the condition and alignment of the system at the time of the activity and any limitations on available vents from isolation boundaries.

5. Include the following:

   a. Use the appropriate fill source and fill location.

   b. Provide the proper sequencing of valve operations to maximize gas void removal. Vent sequencing from lower high points to the higher elevation high points should be accomplished unless an acceptable determination has been made that it is not necessary.

   c. Provide specific acceptance criteria for venting based on potential void locations and the duration of flow required for transfer of the void to the vent location.

   d. Include filling or backfilling instrumentation lines when applicable.

   e. Provide instructions related to system alignment and the minimum required flow rate to perform dynamic venting if necessary.

   f. Provide verification after fill and venting, and re-verification if additional venting is required, so that the piping is sufficiently full.

   g. Document void identification and quantification information, including no void present.

   h. Use the CAP if verification identifies weaknesses in prior fill and vent activities.

1.12.2 Dynamic Venting

Use of dynamic venting is an effective means to remove gas from local high points and traps in piping. It involves pumping water through the system to force accumulated gas to a location that can be vented or removed. When static fill and vent efforts are not effective in removing all trapped gas during system restoration, procedures should provide for use of dynamic venting when it is allowed by the system configuration. Dynamic venting should be performed in accordance with written procedures that consider the following:

1. Acceptability of the location to which the gas will be transported

2. Effect of transporting voids through pumps

3. Required flow rate (Froude Number) to sweep the gas from the high point

4. Time that flow should be maintained to ensure sweeping the gas

1.12.3 Vacuum Fill

Vacuum filling may be an effective method for removal of trapped gas. Vacuum fill should be done in accordance with written procedures and appropriate evaluations of the effect of vacuum on the system should be performed and documented.

1.12.4 Verification

Fill and vent procedures should include requirements for verification of effectiveness and should include quantification of any remaining gas found. If the fill and vent is performed for system restoration following maintenance on an isolated portion of the system, verification should include quantitative inspection to find gas accumulation that may be transported outside the isolation boundary once the system is restored.

1.13 Applicable systems

Select the PWR or BWR list as appropriate:

For pressurized water reactors, applicable systems will typically include:

1. Safety Injection (SI) System or ECCS. This typically includes charging pumps, high pressure coolant injection (HPCI) system, low pressure injection (LPI) system, and SI accumulators where different licensees use different nomenclature that is not listed in this report for the same function.

2. RHR, DHR, or Shutdown Cooling (SDC) System. Different licensees use different designations. Configurations typically include reactor vessel (RV) cold leg and hot leg injection, suction from the RCS, and the containment emergency sump.

3. Containment Spray (CS) System.

4. Borated Refueling Water Storage System or its equivalent with respect to potential interactions with the ECCS. (Different licensees use different designations.)

5. Chemical and Volume Control System with respect to potential interactions with the ECCS.

For boiling water reactors, this will typically include:

6. Core Spray.

7. High Pressure Coolant Injection (HPCI).

8. RHR. Functions typically include suppression pool cooling, shutdown cooling, core spray, containment cooling, decay heat removal, alternate decay heat removal, drywell / wetwell spray, suppression pool spray, ECCS keepfill system, torus spray, and low pressure core spray, depending upon the plant and the licensee’s designation of the system functions.

9. Other components of the ECCS.

2 INSPECTION GUIDANCE

The status is that licensee has provided a response to GL 2008-01 (References 14, 15, etc) that satisfies the GL objectives and NRR/SRXB has completed a response review. There are no open items that necessitate additional NRR/SRXB follow-up although SRXB plans to provide consultation to Regional or Resident Inspectors upon request. A confirmatory inspection that uses the guidance provided in Temporary Instruction (TI) 2515/177 is the only item that remains.

Selection of inspection items and the inspection depth is a Regional decision since Regional personnel have insights and knowledge that we do not possess at Headquarters, and the TI has been written to provide this flexibility. Our suggestions are based on a selective review of the licensee's responses to the GL and those responses may not fully cover the licensee's capabilities. Our suggestions are provided for your consideration and we have not attempted to cover all aspects of the TI. You should treat the suggestions as supplementary information that may not be necessary in light of your knowledge of the actual plant condition, and you should follow the TI in whatever depth you believe is appropriate.

In general, we suggest that your inspection in response to the TI

Select one of the following three or provide your own suggestion:

be minimal since the licensee has provided an in-depth response to the GL that addresses the issues.

or

be an in-depth inspection because the licensee's response to the GL resulted in many confirmatory items that need to be addressed. We suggest that most aspects of the TI be covered with consideration of the suggestions we provide below.

or

be based on selections from the TI guidance that you believe appropriate with consideration of the suggestions we provide below.

Based upon the information we have reviewed, we suggest you consider including the following when planning the TI 2515/177 inspection:

The following should be included in all inspection suggestions documents unless there are no commitments:

- Verify that the licensee has completed or has acceptable plans for addressing commitments identified in the GL responses. We suggest that you plan to follow up to reasonably ensure outstanding commitments are acceptably addressed.

The following should be included in all PWR inspection suggestions documents:

- Many PWR licensees have found that flashing can occur in RHR suction lines when initiating RHR while the lines are at an elevated temperature. Verify that the licensee has acceptably addressed this issue if applicable to its design and operation. Note that steam bubbles do not transport like a gas. Rather, they collapse once submerged into the flow stream if the flow stream temperature is less than the saturation temperature, a process that will be accompanied by a flow stream temperature increase. Conversely, instant flashing due to a pressure decrease will result in a rapid temperature decrease.

Depending on the information provided in the licensee's GL response and our review, the following should be considered for inclusion in our suggestions to the Regions:

- Verify that one or more procedures (1) include acceptable methods for determining void volume, (2) acceptably address a methodology for void removal, (3) have been covered in training, and (4) ensure that the licensee enters the CAP whenever voids are discovered following refill operations. TI Sections 04.01, 04.03, Reference 2 Sections 3.3.2, 3.5.1, 3.5.2, 3.5.3, 3.5.4

- Selectively verify the acceptability of the CAP process for addressing issues pertinent to GL 2008-01 and, if applicable CAP processes have been performed, then selectively verify the acceptability of the licensee's response to the identified issues. TI Sections 04.01, 04.02, 04.03c5, 04.04; Reference 2 Sections 3.4.6, 3.6

- Verify the acceptability of the licensee's processes for monitoring and trending such parameters as void volumes, accumulator level and temperature, reactor coolant system (RCS) leakage, and ECCS discharge pressure and temperature to ensure that pre-cursor parameters are addressed and that entry into the CAP will be accomplished if acceptable trending criteria are not met. See Sections 1.8 and 1.9, above, for guidance. TI Sections 04.01, 04.02e Exclude any items that do not apply, such as accumulators for BWRs.

- Verify the acceptability of the licensee's methodology for predicting void behavior and the impact on subject system operability. Pay particular attention to the licensee's determination of acceptable void volumes with respect to void volume, void transport, and pump response to voids. See Section 1.4, above, for guidance. The licensee should be consistent with the Reference 9 or the Section 1.4 criteria or should provide a justification for any differences. TI Sections 04.01, 04.02f, 04.03d; Reference 2 Sections 3.3.2, 3.4.3, 3.4.4

- Selectively verify the acceptability of the licensee's review relative to the plant configuration, walkdowns, and commitments for planned walkdowns. TI General Guidance, TI Sections 04.02c and d, 04.04; Reference 2 Sections 3.4.5, 3.4.6, 3.4.7

- Selectively verify that the licensee has acceptably performed hardware modifications, such as installing additional vent valves in upper pipe elevations and that the vent valve installation process reasonably ensures that the opening inside the pipe is sufficiently close to the upper elevation of the pipe to accomplish the venting purpose. TI Section 04.04, Reference 2 Section 3.4.8

- If training is acceptably addressed, but interim training is not covered, then: Training is stated to be accomplished at a future date. Verify that the existing applicable training background ensures that personnel are aware of gas-related concerns and will respond accordingly. TI Section 04.02c, Reference 2 Section 3.7.

- If TSTF information, such as a commitment date, is not adequate, then: Verify that the licensee has committed to assess the technical specification task force (TSTF) traveler and to implement appropriate changes in TSs within one year or less of the TSTF being issued. TI Section 04.01, Reference 2 Section 3.3.4

- If “accessible locations” is based on a broad statement such as containment and posted high radiation areas rather than actual radiation or thermal access considerations, then: Verify that the meaning of “accessible locations” is consistent with actual accessibility and that coverage of inaccessible locations is acceptable. TI Section 04.02c, Reference 2 Section 3.3.2

- If the licensee did not adequately identify the applicable systems, then: Verify that the licensee considers all systems that should be covered consistent with the GL. Select either the PWR or the BWR item that follows. For pressurized water reactors (PWRs) this will typically include:

  - Safety Injection (SI) System or ECCS. This typically includes charging pumps, the high pressure coolant injection (HPCI) system, the low pressure injection (LPI) system, and SI accumulators. (Different licensees use different nomenclature that is not listed in this report for the same function.)

  - Residual Heat Removal (RHR), DHR, or Shutdown Cooling (SDC) System. Different licensees use different designations. Configurations typically include reactor vessel (RV) cold leg and hot leg injection, suction from the reactor coolant system (RCS), and the containment emergency sump.

  - Containment Spray (CS) System.

  - Borated Refueling Water Storage System or its equivalent with respect to potential interactions with the ECCS. (Different licensees use different designations.)

  - Chemical and Volume Control System (CVCS) with respect to potential interactions with the ECCS.

  For boiling water reactors (BWRs) this will typically include:

  - Core Spray.

  - High Pressure Coolant Injection (HPCI).

  - Residual Heat Removal (RHR). Functions typically include suppression pool cooling, shutdown cooling, core spray, containment cooling, decay heat removal, alternate decay heat removal, drywell / wetwell spray, suppression pool spray, ECCS keepfill system, torus spray, and low pressure core spray, depending upon the plant and the licensee’s designation of the system functions.

  - Other components of the ECCS.

  TI General Guidance, Reference 2 Section 3.1

- With respect to surveillance frequency and requirements, see Sections 1.8 and 1.9, above, for guidance. If the licensee did not adequately address surveillances, then: Verify that areas not covered by TSs and TS Bases, such as not providing surveillance requirements (SRs) for ECCS suction piping and not ensuring a void assessment at high points that are not equipped with a vent, are identified and the process of ensuring adequate coverage is identified. See Sections 1.8 and 1.9, above, for guidance. And / or, if the licensee uses a surveillance frequency that is greater than every 31 days and it is not acceptably justified, then: Since the licensee uses a surveillance frequency of greater than 31 days, verify that the surveillance frequency is acceptably justified. See Sections 1.8 and 1.9, above, for guidance. TI Section 04.01, Reference 2 Section 3.3.2

- If the licensee did not adequately identify potential gas intrusion mechanisms, then: Verify that the licensee has addressed the potential gas intrusion mechanisms. Depending on the plant, these typically include such items as SI accumulators, the RCS, dissolved gas coming out of solution, gas issues associated with the containment emergency sump, the refueling water storage tank, gas issues that may be caused by level instrumentation error, valve leakage, and operations such as shutdown, restart, and maintenance. TI Section 04.02e, Reference 2 Section 3.4.2 Exclude any items that do not apply, such as accumulators for BWRs.

3 REFERENCES

3.1 General References

1. **The Temporary Instruction:** "Managing Gas Accumulation in Emergency Core Cooling, Decay Heat Removal, and Contain Spray Systems (NRC Generic Letter 2008-01)," Temporary Instruction 2515/177, ML082950666, June 9, 2009.

2. **NRR expectations for licensee GL responses:** Ruland, William H., "Preliminary Assessment of Responses to Generic Letter 2008-01, 'Managing Gas Accumulation in emergency Core Cooling, Decay Heat Removal, and Containment Spray Systems,' and Future NRC Staff Review Plans," NRC letter to James H. Riley, Nuclear Energy Institute, ML091390637, May 28, 2009.

3. **The Generic Letter (GL):** "Managing Gas Accumulation in Emergency Core Cooling, Decay Heat Removal, and Containment Spray Systems," NRC Generic Letter 2008-01, ML072910759, January 11, 2008.

4. **Guidance for NRR Reactor Systems Branch (SRXB) reviews:** "July 2009 Review Guidance Update," ML092460591, July 17, 2009.

3.2 Guidance for assessing operability

5. "NRC Regulatory Issue Summary 2005-20: Revision to Guidance Formerly Contained in NRC Generic Letter 91-18, 'Information to Licensees Regarding Two NRC Inspection Manual Sections on Resolution of Degraded and Nonconforming Conditions and on Operability,'" ML052020424, September 26, 2005.

6. "NRC Regulatory Issue Summary 2005-20, Rev. 1, Revision to NRC Inspection Manual Part 9900 Technical Guidance, 'Operability Determinations & Functionality Assessments for Resolution of Degraded or Nonconforming conditions Adverse to Quality or Safety,'" ML073440103, April 16, 2008.

7. "Operability Determinations & Functionality Assessments for Resolution of Degraded or Nonconforming conditions Adverse to Quality or Safety," NRC Inspection Manual, Part 9900: Technical Guidance, Attachment to Reference 6, April 16, 2008.

8. **The Technical Specification meaning of "full:"** "Task Interface Agreement - Emergency Core Cooling Systems (ECCS) Voiding Relative to Compliance with Surveillance Requirements (SR) 3.0.1.1, 3.5.2.3, and 3.5.3.1 (TIA 2008-03)," ML082560209, October 21, 2008.

9. **Void criteria the NRC staff will accept without further justification:** "Revision 2 to NRC Staff Criteria for Gas Movement in Suction Lines and Pump Response to Gas," ML090900136, March 26, 2009. This reference is replaced by Section 1.4, above, and revisions are expected as additional information is obtained by industry and made available to NRR.

3.3 Additional references for void transport behavior

10. "Test Results for the Millstone-3 Gas-Water Transport Tests," Fauske Associates, LLC, FAI/09-22, ML091170150, March, 2009.

11. "Post-Test Analysis of the FAI Millstone 3 RWST ¼ Scale Gas Entrainment Test," Fauske Associates, Inc., FAI/09-44, Rev. 0, ML091910460, March 13, 2009.

3.4 Additional NEI guidance

12. Riley, James H., "Issuance of NEI 09-10, Revision 0, Guidelines for Effective Prevention and Management of System Gas Accumulation," Communication from NEI Director of Engineering, ML093130090, October 30, 2009.

13. Riley, James H., "Industry Guidance – Evaluation of Unexpected Voids or Gas Identified in Plant ECCS and Other Systems," Letter from NEI Director of Engineering, ML091800416, ML091800418, June 18, 2009.

3.5 Plant-Specific References

14.… GL 2008-01 licensee responses and any other applicable documents