Transactions of the Korean Nuclear Society Autumn Meeting
Pyeongchang, Korea, October 30-31, 2014

Development of Inspection Guideline for Gas Accumulation in the Safety Systems

Seung Hun Yoo*, Kwang-Won Seul, Young-Seok Bang, Jun Soo Lee
Korea Institute of Nuclear Safety, 62 Gwahak-ro, Yuseong-gu, Daejeon
**Corresponding author: k720ysh@kins.re.kr*

1. Introduction

Gas accumulation in the piping system can cause water hammer, gas binding in pumps which may result in pump cavitation, and inadvertent relief valve actuation that may damage pumps, valves, piping, and supports. Therefore, gas accumulation in the safety systems including Emergency Core Cooling System (ECCS) has been dealt with one of significant safety issues in the operating nuclear power plant. The Nuclear Regulatory Commission (NRC) in the United States has published twenty Information Notices, two Generic Letters, and one NUREG report related to this issue. Gas accumulation of approximately sixty events was reported for ten years since Generic Letter 2008-01was issued [1]. It has been considered that gas accumulation occurred since the beginning of commercial nuclear power plant operation and may occur in the currently operating plants. Gas accumulation in the safety systems is the condition that did not consider in Accident Analysis of Final Safety Analysis Report or Technical Specification and may finally result in degradation or loss of the safety functions. It is necessary and important to identify the status of gas accumulation in the operating plants. NRC issued a temporary inspection manual to provide background information and guidance for NRC inspectors on March, 2010 [2]. In this paper, Draft of inspection guideline for gas accumulation in the safety systems, which may give key precursors to prevent and to manage gas intrusion effectively, is proposed.

2. Draft of Inspection Guideline

2.1 Objective

The objective of this document is to provide guidance for KINS inspectors to verify that the onsite documentation, system and licensee actions are appropriately equipped to monitor and manage gas accumulation and to confirm that the safety systems are operable if the safety functions are required.

2.2 Scope of Inspection

This document provides technical guidance to inspect gas intrusion and accumulation in the Emergency Core Cooling, Decay Heat Removal, and Containment Spray Systems.

2.3 Specific Guidance for Design

The purpose of this section is to verify that design and design documentation is consistent with reasonably assuring that the safety systems are operable consistent with applicable requirements.

A. Verify that the licensee has isometric drawings that describe the safety system configurations, select one or more drawings that describe regions where voids may accumulate, and verify that the licensee has acceptably confirmed the accuracy of the drawings.
   1. High point vents are identified.
   2. High points that do not have vents are acceptably recognizable.
   3. Other areas where gas can accumulate and potentially impact safety system operability are acceptably described in the drawings or in referenced documentation.
   4. Horizontal pipe lines that exceed specified criteria should be identified.
   5. All pipes and fittings are clearly shown.
   6. The drawings should be up-to-date with respect to recent hardware changes.

B. Verify that Piping and Instrumentation Diagrams (P&IDs) accurately describe the safety systems. The P&IDs should be up-to-date with respect to recent hardware changes. Any discrepancies between as-built configurations, the isometric drawings and the P&IDs should be documented.

C. Walkdowns for the selected area in the safety system should be performed in order to confirm the appropriation of the system design and installation. High points without vents should be identified and it should be confirmed that gas does not accumulate in those high points. Procedures for gas monitoring and prevention should be reviewed.
   1. Walkdowns does not need to access high radioactive area during operation. It is possible to be performed during overhaul period according to ALARA principle.
   2. It is not necessary to remove pipe insulation to determine pipe slope if the insulation is tightly wrapped and in good condition or the insulation thickness has been acceptably determined by such methods as boring holes and measuring insulation thickness.
   3. If the piping to be inspected is the underground piping or the wall penetrating piping, it is possible to select alternative inspection locations or to decide inspection according to engineering judgment.

4. It is not necessary to walk down sections of piping that are usually void such as a containment spray discharge pipe provided the pipe configuration has been acceptably established as not having traps where water could accumulate that could cause a water hammer concern.

D. It is necessary for inspectors to confirm that the licensee actions to identify gas intrusion and accumulation were appropriate or not. The potential region for gas accumulation is followed.
   1. Leakage from accumulators, vent valves, or RCS
   2. Dissolved gas can come out of solution due to a pressure reduction
   3. Inadvertent draining, system realignments, and incorrect maintenance and testing procedures
   4. Failure of level instruments to indicate the correct level for tanks

E. Selectively verify the acceptability of the licensee's review of applicable documents, including calculations, engineering evaluations, and vendor technical manuals, with respect to gas accumulation. The documentation can provide the following contents.
   1. Vent requirements
   2. Keep-full systems
   3. Aspects where pipes are normally void such as some spray piping inside containment.
   4. Void control during system realignments due to actuations and tests.
   5. The effect of debris on strainers in containment emergency sumps and its impact on NPSH requirements

2.4 Specific Guidance for Testing

The purpose of this section is to verify that selected procedures are acceptable for testing associated with power operation, shutdown operation, maintenance, and subject system modifications, void determination and elimination methods, and post-event evaluation.

A. Review the procedures used for conducting surveillances and determination of void volumes to reasonably ensure that the void acceptance criteria are satisfied and will be reasonably ensured to be satisfied until the next scheduled void surveillance.

B. Review the procedures used for filling and venting following conditions which may have introduced voids into the safety systems to verify that the procedures acceptably address testing for such voids and provide acceptable processes for their reduction or elimination.

C. General considerations are followed
   1. Gas intrusion prevention, refill, venting, monitoring, trending, evaluation, and void correction activities are acceptably controlled by approved operating procedures.
   2. Procedures should reasonably ensure the system does not contain voids that may jeopardize operability.
   3. Procedures should reasonably establish that the void acceptance criteria are satisfied and will be reasonably ensured to be satisfied until the next scheduled void surveillance.

D. Surveillance and Void Detection
   1. Specified surveillance frequencies should be consistent with Technical Specification's requirements.
   2. Surveillances may be conducted by ultrasonic testing (UT), venting, or by other methods when the other methods are acceptably established to achieve the needed accuracy.
   3. Surveillance procedures should include up-to-date acceptance criteria.
   4. Measured void volume uncertainty should be considered when comparing test data to acceptance criteria.
   5. Venting procedures and practices should utilize criteria such as adequate venting durations and observing a steady stream of water.
   6. An effective sequencing of void removal steps should be followed to ensure that gas does not move into previously filled system volumes.
   7. Surveillances should be conducted at any location where a void may form, including high points, dead legs, and locations under closed valves in vertical pipes.
   8. The licensee should ensure that systems are not pre-conditioned by other procedures that may cause a system to be filled, such as by testing, prior to the void surveillance.

E. Filling and Venting
   1. Revisions to fill and vent procedures to address new vents or different venting sequences should be acceptably accomplished.
   2. Fill and vent procedures should provide instructions to modify restoration guidance to address changes in maintenance work scope or to reflect different boundaries from those assumed in the procedure.

F. Void Control
   1. Void removal methods such as venting, dynamic void removal, and vacuum refill should be acceptably addressed by approved procedures.
   2. When gas enters the suction of an operating safety system pump requires follow-up to reasonably ensure the pump has not been damaged.

3. Application of the Inspection Guideline

The proposed inspection guideline was applied for gas accumulation inspection for Hanbit Unit 6 on May,

2014. The draft was modified and supplemented in detail based on the result of the site inspection.

4. Conclusions

Gas accumulation in the safety systems has been dealt with one of significant safety issues in the operating nuclear power plants. In order to identify the status of the accumulated gas, we proposed the draft of inspection guideline for gas accumulation in the safety systems. The proposed guideline provides specific inspection contents for safety system design and testing. This draft was modified and improved based on the result of the site inspection for Hanbit Unit 6. We think that this draft can be used to establish the regulatory position and procedure for gas accumulation inspection by KINS inspectors. It is considered that the regulatory requirement and evaluation methodology should be prepared based on the operating experience of Korean nuclear power plants to prevent and manage gas accumulation in the future.

REFERENCES

[1] NRC Generic Letter 2008-01, Managing Gas Accumulation in Emergency Cooling, Decay Heat Removal, and Containment Spray Systems, ML072910759, January 11, 2008

[2] NRC Inspection Manual, Managing Gas Accumulation in Emergency Cooling, Decay Heat Removal, and Containment Spray Systems (NRC Generic Letter 2008-01), Temporary Instruction 2515/177, Revision 1, March 17, 2011