Introduction to Loss of Large Area Analysis

Mee Jeong Hwang, Heoksoon Lim*, Myungsu Kim*

Korea Atomic Energy Research Institute, 989-111, Daedeok-daero, Youseong-Gu, Daejeon
*Korea Hydro Nuclear Power, Central Research Institute, 1312-70, Youseong-daero, Youseong-Gu, Daejeon**

mjhwang@kaeri.re.kr

1. Introduction

New U.S. licensed commercial nuclear power plant operators are required to provide a LOLA (Loss of Large Area) analysis as per the U.S. Code of Federal Regulations, 10CFR50.54(hh)(2). To better understand how the LOLA analysis, which would typically be considered more of a safety issue rather than a security problem, has come to be incorporated into security requirements for new NPPs within the U.S., a brief chronological history of LOLA is provided. After the September 11, 2001, the NRC conducted a series of assessments of commercial aircraft impacts on NRC-licensed facilities using state-of-the-art structure and fire analyses. These insights and concerns did prompt the concept of LOLA and the application of relevant mitigation strategies into NRC licensing and security requirements. As a result of these initial post 9-11 assessments in February 2002, the NRC issued an interim safeguards and security compensatory measures order. In "Interim Compensatory Measures for High Threat Environment," Section B.5.b (not publically available) of this order, current NPP licensees had to adopt mitigation strategies using readily available resources to maintain or restore reactor core cooling, containment, and spent fuel pool (SFP) cooling capabilities to cope with a LOLA due to large fires and explosions from any cause, including beyond-design basis threat (BDBT) aircraft impacts. However these B.5.b measures did not specify the measure to be taken. Therefore, in this paper, we are introducing the LOLA and a LOLA analysis methodology.

2. LOLA History and Regulation

2.1 Chronological History of LOLA

After the September 11, 2001 terrorist attacks within the U.S., the NRC in conjunction with U.S. Department of Energy (DOE) national laboratories (e.g., SNL) conducted a series of assessments of commercial aircraft impacts on NRC-licensed facilities using state-of-the-art structure and fire analyses. The results confirmed that the likelihood is low that such an incident could affect public health and safety. However, these insights and concerns did prompt the concept of LOLA and the application of relevant mitigation strategies into NRC licensing and security requirements. As a result of these initial post 9-11 assessments in February 2002, the NRC issued an interim safeguards and security compensatory measures order.
In March 2009, the NRC issued amendments to 10CFR Part 50, Part 52, and Part 73 for power reactor security requirements for operating and new reactors.

2.2 Relevant Regulations

The B.5.b requirements to address LOLA due to explosions or fires from a beyond design basis event are generically applicable to operating or new reactors. Additionally 10CFR52.80(d) provides the required submittal information on how an applicant for a combined operating license (COL) for a nuclear power plant to meet these requirements. Additionally these amendments added new security requirements which updated the NRC's security regulatory framework for licensing a new nuclear power plant.
CFR50.54(hh)(2) states the following: "Each licensee shall develop and implement guidance and strategies intended to maintain or restore core cooling, containment, and spent fuel pool cooling capabilities under the circumstances associated with loss of large areas of the plant due to explosions or fire, to include strategies in the following areas:
1. Firefighting;
2. Operations to mitigate fuel damage; and
3. Actions to minimize radiological release."

A review of the international communities' regulations and guidance did not find any publically available English-version documents regarding LOLA. However, severe accident management documentation provides guidance that is similar to LOLA strategies [5][6][7].

3. LOLA Guidance

The NRC planned to implement this in a two-phase approach. The NRC sees the B.5.b measures as a pragmatic approach which has broad applicability because it is not event specific and involves the development of mitigation strategies for both the reactor and SFP for a LOLA event due to large fires or explosions. LOLA strategies are responsive and are not preventive. This means the strategies are implemented to place the plant in a safe condition or prevent/minimize public exposure, and are not meant to preclude any security event. While the LOLA strategies were developed from a terrorist event, their applicability transcends security. A LOLA event need not necessarily be a security event such as a terrorist crashing a plane into facility, but rather it could be an external event such as an earthquake and tsunami like the Fukushima Daiichi accidents.

3.1 Nuclear Energy Institute (NEI)

Guidance (NEI 06-12) [3] was developed by the Nuclear Energy Institute (NEI) and endorsed by the U.S. Nuclear Regulatory Commission (NRC) for the development of LOLA strategies in compliance with U.S. Federal regulations. NEI has developed guidance for both existing plants and for new reactor designs. The fact that there is a distinction between strategies for existing plants and for new reactor designs is an acknowledgment by the NEI and the NRC that new plant designs could be inherently more robust against the circumstances associated with a LOLA event than existing plants. This is because new plant design features could include such features as enhanced spatial separation between trains of safety systems, passive systems, and additional new safety systems or redundancies.

3.2 U.S. Nuclear Regulatory Commission (NRC)

In October 2009, the NRC issued interim staff guidance for implementing LOLA security requirements for new nuclear reactors [1]. Within this guidance, the NRC endorses the guidelines of NEI 06-12 Revision 3 0 as an acceptable approach to meet the requirements of 10CF50.54(hh)(2) and 10CFR50.80(d). New U.S. nuclear reactor applicants (e.g., the AP1000 plants under construction at Vogtle) used this interim staff guidance to address LOLA.
In May 2013, the NRC updated its Standard Review Plan, NUREG-0800 Section 19.4 0, to incorporate the interim staff guidance (2009). Now, any new U.S. nuclear reactor COL applicants must meet NUREG-0800 Section 19.4 to address LOLA.

4. An Application of the VAI Model

However, the U.S. nuclear industry felt it was not feasible to define a 'bounding' scenario for a LOLA event. The NRC ultimately agreed with the industry's position and even adopted their guidelines for LOLA analyses 0. These guidelines do not necessarily require a VAI (Vital Area Identification)-type of analysis to inform LOLA. Never the less, a VAI-type of analysis can produce useful insights that could be used to influence LOLA strategies, but are not required by the NRC to meet regulatory requirements.
The method by which new plant designs may be evaluated for LOLA involves the evaluation of alternate means to provide a plant's safety functions against deterministically defined spatial separation and protection criteria. If a safety function at a new reactor can be provided through at least one alternate means for which at least one of the four spatial separation and/or protection criteria can be satisfied, than that alternate means can be credited as an acceptable LOLA strategy for that safety function.
Therefore, we performed a LOLA proof-of-concept analysis for the APR1400 reactor design. The purpose of this study is not to literally design LOLA strategies to explicitly avoid all rooms in the target sets that were evaluated, but to look for interesting combinations of rooms in certain target sets, and produce useful insights that can be used to influence LOLA strategies.
Table provides second-order results for Level 137 of the Auxiliary Building. From the review of the building design layout plans, the spatial location of the 'Term 2' Main Steam Valve Room for both the C and D quadrants are only separated by a single internal wall for one of the 'Term 1' results, Class 1E MCC (Motor Control Center) 06A Room. This insight may be helpful in determining how thick or reinforced this internal wall should be.
If a safety function at a new reactor can be provided through at least one alternate means, that alternate means must satisfy at least one of the four spatial separations and/or protection criteria required. If so, then that alternate means can be credited, and is an acceptable LOLA strategy for that safety function. The determination as to whether a candidate alternate means satisfies at least one of the spatial separation and protection criteria, including necessary support systems and equipment, can be assessed through the exercise of the VAI model.

Term 1	Term 1 Room	Term 2	Term 2 Room
137-A01C	Cable Spreading Area	137-A31C	Main Steam Valve Room
137-A02C	Electrical Equipment Room	137-A31C	
137-A03C	CEDM M/G Set Room	137-A31C	
137-A09C	General Access Area	137-A31C	
137-A10C	Class 1E MCC 06A Room	137-A31C	
137-A11C	Electrical Penetration Room	137-A31C	
137-A01D	Cable Spreading Area	137-A31D	Main Steam Valve Room
137-A03D	Electrical Equipment Room	137-A31D	
137-A09D	General Access Area	137-A31D	
137-A10D	Class 1E MCC 06A Room	137-A31D	
137-A11D	Electrical Penetration Room	137-A31D	
137-A12D	MUX N_2 Room	137-A31D	

5. Conclusions

For the export of Korean nuclear power plant, it would be required to analyze LOLA. Therefore, it is necessary to prepare our own guidance for a development of LOLA strategies because the phase 1 of US guidance is classified as 'NRC Safeguards Information'. Also, we proposed a method to look for interesting combinations of rooms in certain targets getting through VAI model, and produced insights that could be used to influence LOLA strategies.
The method involves the evaluation of alternate means to provide a plant's safety functions against deterministically defined spatial separation and protection criteria.

ACKNOWLEDGEMENTS

This work was supported by the Nuclear Power Core Technology Development Program of the Korea Institute of Energy Technology Evaluation and Planning (KETEP) grant funded by the Korea government Ministry of Trade, Industry and Energy. (No.2012T100201558)

REFERENCES

1. USNRC, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Editions," NUREG-0800, U.S. Nuclear Regulatory Commission, Washington D.C., USA, 2013.
2. USNRC, "Issuance of Order for Interim Safeguards and Security Compensatory Measure for Nuclear Power Plants," EA-02-026, U.S. Nuclear Regulatory Commission, Washington D.C., USA, 2002.
3. Erin Engineering, "B.5.b Phase 2 & 3 Submittal Guideline – Revision 3," NEI 06-12, Nuclear Energy Institute, Washington, D.C., USA, 2009.
4. NEI, "Diverse and Flexible Coping Strategies (FLEX) Implementation Guide – Revision 0," NEI 12-06, Nuclear Energy Institute, Washington D.C., USA, 2012.
5. IAEA, "Severe Accident Management Programmes for Nuclear Power Plants – Safety Guide," Safety Guide No., NS-G-2.15, International Atomic Energy Agency, Vienna, Austria, 2009.
6. NKS, "Severe Accident Research and Management in Nordic Countries: A Status Report," NKS-71, Nordic Nuclear Safety Research, Roskilde, Denmark, 2002.
7. NEI, "Severe Accident Mitigation Alternatives (SAMA) Analysis Guidance Document Revision A," NEI 05-01, Nuclear Energy Institute, Washington D.C., USA, 2005.
8. USNRC, "Compliance with 10CFR50.54(hh)(2) and 10CFR52.80(d) Loss of Large Areas of the Plant due to Explosions or Fires from a Beyond-Design Basis Event," DC/COL-ISG-016, U.S. Nuclear Regulatory Commission, Washington D.C., USA, 2009.
9. USGPO, "Title 10 Code of Federal Regulations, Part 50, Section 54 – General Design Criteria for Nuclear Power Plants: Conditions of Licenses," 10CFR50.54, U.S. Government Printing Office, Washington D.C., USA, 2013.
10. USGPO, "Title 10 Code of Federal Regulations, Part 52, Section 80 – Licenses, Certifications, and Approvals for Nuclear Power Plants: Contents of Applications; Additional Technical Information," 10CFR52.80, U.S. Government Printing Office, Washington D.C., USA, 2013.
11. USNRC, "Final Safety Evaluations for Vogtle Units 3 and 4 Application, Appendix 19.A: Loss of Large Area of the Plant due to Explosions or Fires," NRC ADAMS Accession No., ML110300022, U.S. Nuclear Regulatory Commission, Washington D.C., USA, 2011.