Review on the Safety Classification of Small Lines Connected to the Pressurizer Steam Space

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1. Introduction

Depending on a plant's licensing basis, the safety classification of components in small lines connected to the pressurizer steam space might be incorrect as a result of plant protection logic changes that were made after TMI. According to the NSAL-07-9[1], ANSI - N18.2[2] safety classification of some small, non-instrumentation, lines(less than 1 inch nominal pipe size) and components connected to the pressurizer steam space may be incorrect. These lines and components may currently be classified as Safety Class 2. However, an assumed rupture of one of these small lines could result in a reactor trip and emergency core cooling system (ECCS) actuation. Therefore, the lines should have been classified as Safety Class 1 whereas the Westinghouse NSSS standard design specifies the pressurizer steam space instrument line and other small lines connected to the pressurizer steam volume as Safety Class 2. The objective of this study was to determine whether small lines connected to the pressurizer steam space were consistent with their original safety classification. Therefore, a technical assessment was performed for the case of a Westinghouse-type plants in Korea.

2. Methods and Results

2.1 Issue on the safety classification of the small lines connected to the pressurizer steam space

According to the nuclear safety design criteria of ANSI-N18.2 [2], safety class 1 applies to components whose failure could cause a Condition III or Condition IV loss of coolant. Therefore, a break in a safety class 2 line should not result in a loss of coolant accident (LOCA). In other words, a break of small lines connected to the pressurizer steam space should not cause LOCA and ECCS actuation because they are safety class 2 lines.

Transition analyses performed by Westinghouse for several plants indicate that a break in a small line in the steam space of the pressurizer(having an inside diameter of 0.83 inch) could result in depressurization of the reactor coolant system. This would lead to a reactor trip relatively early in the transition and ECCS actuation between several seconds and several minutes after the occurrence of the postulated break. Although the pressurizer level may be maintained with normal charging flow for a steam space break of a pipe having an inside diameter of 0.83 inch or less, a reactor trip and ECCS actuation could still occur based on a low pressurizer pressure signal since the rate of steam discharge through the broken line may exceed the steam generation capacity of the pressurizer heater. Some small lines connected to the pressurizer steam space should have, therefore, been classified as Safety Class 1. For this reason Westinghouse recommended that the safety classification of all small lines connected to the pressurizer steam space having an inside diameter of 0.83 inch or less should be reviewed. According to the Westinghouse recommendation, one of our Westinghouse plants was reviewed on this issue.

2.2 Transition analysis of a break in a small line connected to the pressurizer steam space

Small lines connected to the pressurizer steam space include the drain lines (0.75inch) for the safety valve loop seal, the pressurizer steam sample vent line(0.75inch) and the pressurizer spray bypass line(0.75inch). Fig. 1 presents a simplified diagram of these small lines.

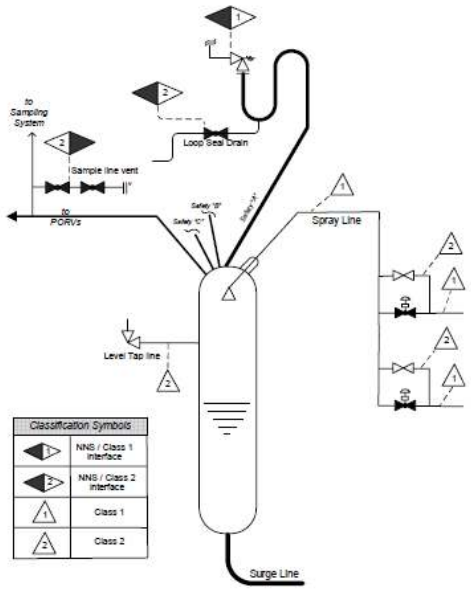

Fig. 1. Simplified diagram of the small lines connected to the pressurizer steam space for the original safety classification

The ECCS actuation signal related to the pressurizer is only low pressurizer pressure. Therefore, a transition analysis on a small line break in the steam space of the pressurizer was carried out and the behaviors both pressurizer mass (level) and pressure were reviewed

using RETRAN-3D code. A break of the instrumentation line (0.375inch) connected to the pressurizer steam space was also considered.

According to Fig. 2 and Fig. 3, both the pressurizer pressure and level dramatically decreased after a 0.75inch line break, while a 0.375inch line break resulted in only a slight transition state.

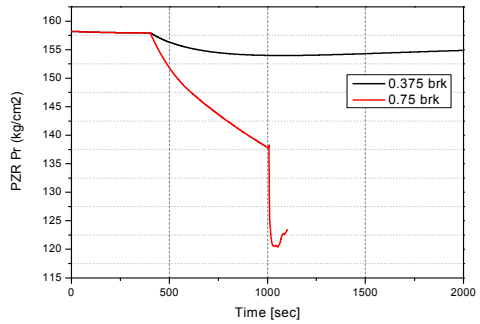

Fig. 2. Pressurizer pressure according to break of small lines

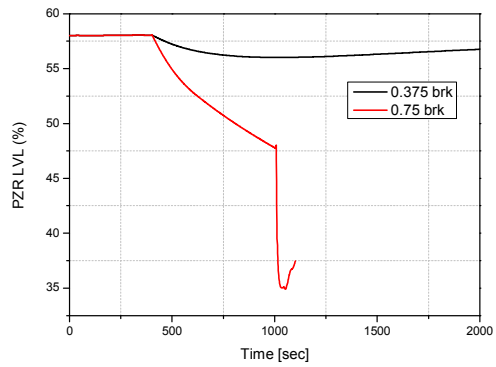

Fig. 3. Pressurizer level according to break of small lines

2.3 Discussion

To demonstrate the suitability for the safety classification of small lines connected to the pressurizer steam space, a transition analysis of a break in the small lines connected to the pressurizer steam space was performed. In the case of a 0.75inch line break, sharp decreases were shown in both the pressure and level of the pressurizer. This means that a rapid decline pressure caused ECCS actuation within several minutes regardless of the Safety Class 2 lines. Therefore, 0.75inch lines connected to the pressurizer steam space conflict with their safety classification, because Safety Class 2 lines cannot initiate the ECCS actuation signal. A 0.375inch line break showed a slow recovery after a slight decrease of the pressurizer pressure and level, respectively. This indicates that the capabilities of the pressurizer heaters to compensate the steam losses out of the break and normal charging flow are sufficient to the maintain pressure and level of the pressurizer in the event of a 0.375inch line.

According to the NSAL-07-9[1], some Westinghouse plant designs include a flow restrictor in small lines connected to the pressurizer steam space. In these cases, small break LOCA evaluations and pressurizer control performance analyses have confirmed that the resulting plant response is sufficiently recovered without ECCS actuation. These modifications and analyses have justified retaining a Safety Class 2 designation for certain small lines connected to the pressurizer steam space. The basis of these design features, where implemented, is consistent with the original design intent of allowing a reactor trip but preventing safety injection actuation following a break in a small line connected to the pressurizer steam space.

3. Conclusions

A technical evaluation was performed on the safety classification of small lines connected to the pressurizer steam space. As discussed in this study, a break of 0.75inch line could bring about ECCS actuation despite that all small lines connected to the pressurizer steam space fall in the Safety Class 2. Therefore, the safety classification of 0.75inch lines should be reviewed. However, with installation of an appropriately sized orifice, the pressurizer pressure will remain above the low pressurizer pressure signal following a break of the affected line.

Based on the findings of this study, in order to maintain consistency with the safety classification of the affected lines, some small lines (0.75inch line) connected to the pressurizer steam space could be changed from Safety Class 2 to Safety Class 1 or small lines could include a flow restrictor to reduce the rate of RCS depressurization which would occur following a break in a small line connected to the pressurizer steam space.

REFERENCES

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