Transactions of the Korean Nuclear Society Spring Meeting
Jeju, Korea, May 17-18, 2018

Introduction of Containment Liner Plate (CLP) Corrosion

Yonglak Paek[1], Sangyun Kim[1], Euisik Yoon[1] , Hun Cha[2]
[1]*Principal Researcher, Korea Institute of Nuclear Safety (KINS), South Korea*
[2]*Senior Researcher, Korea Institute of Nuclear Safety (KINS), South Korea*

**Corresponding author: PAEK@kins.re.kr*

1. Introduction

The steel liner plate has been used in the containment building for its leaktightness of Pressurized Water Reactor (PWR) nuclear power plants. This liner plate is typically 6 mm thick and is anchored to the surface of the concrete wall and dome. The liner is periodically inspected by visual examination conducted by qualified personnel during in-service inspection (ISI) in order to check flaws or degradation on the liner surface. This paper introduces the cases of the degradation of the steel liner plate found in a few nuclear power plants in S. Korea, and shows how the liner plate with reduced thickness was inspected in detail, repaired and replaced. Also, this paper includes the reduction of steel liner thickness resulted from corrosion of steel liner plate against the surface of concrete where the corroded plates were found in the construction joint of concrete exposed over a month.

2. Examination of CLP

This section shows current status and results of inspection of containment liner plate (CLP). Also, this section includes root cause analysis (RCA) for the corroded CLPs and repair of the corroded CLPs.

2.1 Current Status

In June of 2016, the corrosion on the backside of CLP in Hanbit unit 2 was found during the in-service inspection. The regulatory body, Nuclear Safety and Security Commission (NSSC), ordered the licensee to perform the extensive examination for CLPs of all operating pressurized water reactor (PWR) units. This paper covers 6 units which have the reduced thickness of CLP among the units examined by July 2017 as shown in Table 1.

Nominal thickness of CLP of all units is 6mm, and the required minimum thickness is 5.4mm, 90% of nominal thickness [1-2].

All 6 units have been operated under around 30 years excluding Hanbit #4 under around 20 years operation.

2.2 Examination Method

The thickness of CLP was measured using the ultrasonic technique. In order to examine on the invisible outside surface of CLP, the measurement along the construction joint (CJ) of concrete at intervals of vertically 5cm by circumferentially 30 cm was applied as a basic examination. Moreover, if the reduced thickness of CLP was found, the precise measurement was applied at the intervals of vertically 2.5cm by circumferentially 2cm.

Table 1: Results of the examination of CLP corrosion

Plant	Location of Corrosion	# of Corrosion Area	Min. Thickness (mm)
Hanbit #1	EL226'-3"	49	2.53
	EL218'-3"	1	2.84
Hanbit #2	EL226'-6"	135	Perforation
Hanbit #4	EL228'-7"	120	Perforation
Hanul #1	EL43.5m	7	2.75
Kori #3	EL226'-3"	133	1.12
	EL148'-3"	1	2.75
	EL128'-3"	1	5.39
	EL118'-3"	73	2.29
Kori #4	EL226'-3"	1	5.28
	EL118'-3"	10	3.31

2.3 Examples of CLP corrosion and root cause analysis

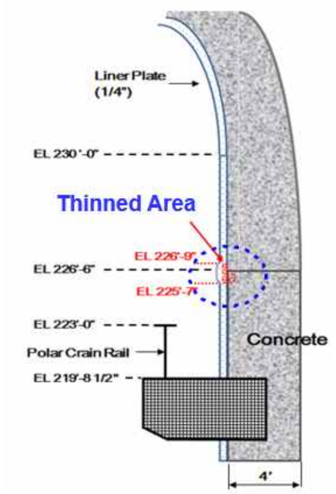

Fig. 1. Characteristic of CLP

Most of corrosion were found mainly along the CJ between cylindrical wall and dome shown in Fig. 1.

During construction of containment wall, this location had been exposed to outside environment relatively for a long time. The outside environment like chloride flown by air from the ocean can provide the condition easy to corrode steel plates. It was analyzed that this chloride and water content from the ocean nearby Nuclear power plant (NPP) would come into the gap between liner plate and concrete at the CJ during long exposure period to environment. For passive oxide film on the liner plate damaged by the lowered pH, crevice corrosion was initiated.

It was investigated that the different sources such as wood, concrete void, debris, etc. can be contributable to corrosion of CLP. These causes were similar with examples of Beaver Valley #1, North Anna #2, and D.C. Cook #2 in US [3].

Table 2 shows root causes of CLP corrosion in NPPs.

Table 2: Root causes of CLP corrosion

Plant	Location	Root cause
Hanbit #1	EL226'-3"	Long time exposure of construction joint (CJ) to outside environment (5.5 Months)
	EL218'-3"	Foreign material (wood)
Hanbit #2	EL226'-6"	Long time exposure of CJ to outside environment (16 Months) - Drop accident of dome liner plate assembly
Hanbit #4	EL228'-7"	Concrete void
Hanul #1	EL43.5m	Long time exposure of CJ to outside environment (4 Months)
Kori #3	EL226'-3"	Long time exposure of construction joint (CJ) to environment (7 Months)
	EL148'-3"	Foreign material (wood)
	EL128'-3"	Iron debris
	EL118'-3"	Long time exposure of CJ to outside environment (2.7 Months)
Kori #4	EL226'-3"	Long time exposure of CJ to outside environment (5 Months)
	EL118'-3"	Long time exposure of CJ to outside environment (2.7 Months)

2.4 Corrective Actions

The CLP corroded more than 0.6mm which was 10% of nominal thickness (6mm) of the plate were repaired instead of engineering evaluation. Actually, the base metal reduced by more than 10% of the nominal plate thickness can be justified by analysis following KEPIC MIE 3122.3. The process of repair for the replacement of CLP is shown in Fig. 2.

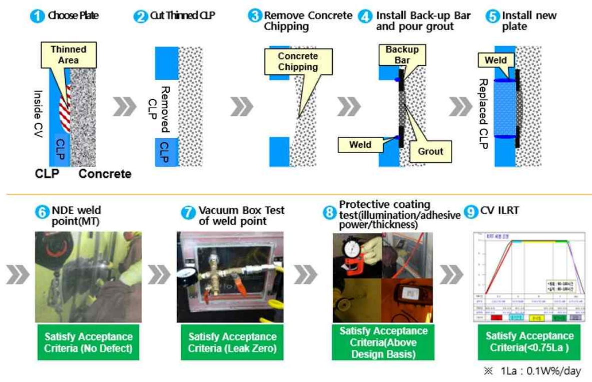

Fig. 2. Process of replacement of CLP

2.5 Actions of regulatory body

The regulatory body, NSSC, ordered the licensee to do extensive examination for CLPs of all 19 PWR units in operation after finding the corrosion on the surface of the backside of CLP in Hanbit unit 2 in June 2016.

A lot of discussions between KINS and licensee have been done on the extent and methods of examination on the CLP corrosion, analysis of root cause, repair and verification method, etc. KINS also has been performing the inspection to confirm the adequacy of the examination and repair work.

The regulatory body expected that the licensee will provide the strengthened follow-up examination plan for monitoring the soundness of CLP.

3. Conclusions

In conclusion, lessons learned from the previous actions were focused. The limitations of the current in-service inspection (ISI) program which is KEPIC MIE (equivalent to ASME IWE) were shown as following the bellows;

- Difficulties to find corrosion at the backside of CLP before showing the abnormality on the surface coating of the plate
- Focusing on visual examination on inside surface of liner plate; Measurement on the plate thickness with ultrasonic testing on very limited areas
- Necessity to complement the ISI program
- Importance of preparedness against the corrosion of CLP at the stage of construction such as cleaning work of construction joint areas, etc.

REFERENCES

[1] ASME BPV code Sec. XI, Division 1, IWE
[2] KEPIC MIE
[3] Sandia National Laboratory, "Nuclear containment steel

liner corrosion workshop: Final summary and recommendation report," US NRC Adams Accession No. MIL112150012, 2011.