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Containment Performance Analysis for EU-APR1400

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1. Introduction

During a severe accident, as the last barrier of DID (Defense-In-Depth) strategy, the containment has an important role to limit the release of the radioactive material to environment. The containment should be able to maintain its structural integrity to prevent the release of the radioactive materials contained in it.

In this paper, the behavior of pressure and temperature in the containment is evaluated for various accident conditions. EU-APR1400 (European APR1400) is equipped with RDS (Rapid Depressurization System), HMS (Hydrogen Mitigation System), SACSS (Severe Accident Containment Spray System), and PECS (Passive Ex-vessel Cooling System) to mitigate the severe accident consequences and eventually to keep the containment integrity. Depending on the availabilities of these mitigation systems, the containment undergoes different transients in pressure and temperature.

2. Methodology for Calculation

2.1 Requirements for Containment Performance

Based on European Utility Requirements (EUR) [1] section 2.1 6.7.2, the primary containment should withstand any of the severe accident condition without operator action during the first 12 hours from the beginning of the severe accident conditions. According to EUR section 2.9 3.1.8.1 for the worst postulated Design Basis Accident (DBA), the pressure inside the containment is required to be reduced below half of the design pressure within 24 hours after the initiating event. This section also states that the containment temperature should be kept controlled. The pressure reduction requirement is readdressed in section 2.9 4.1.1.1.2 as that containment heat removal system shall be capable of reducing the containment pressure and of terminating all releases in a reasonably short time described in section 2.9 3.1.8.1.

The major pressure criteria for APR1400 [2] are presented in table 1.

Table 1 Containment Pressure Limits for APR1400

Type	Pressure(Bar)
Ultimate Pressure for Rupture Mode	14.6
Ultimate Pressure for Leak Mode	12.6
Factored Load Category Limit (FLC)	8.5
Design Pressure	5.1
50% of Design Pressure	3.1

2.2 Analysis Tool

The Modular Accident Analysis Program (MAAP) 4.07 code [3] is used for this analysis. MAAP code is a computer code which simulates light water reactor system and containment performance for severe accident events.

2.3 Selection of the Scenarios

In order to account over-pressurization characteristics, SBLOCA (small break loss of coolant accident) is selected as the sequences initiated by the RCS (Reactor Coolant System) breaks. The condition of success/failure of core catcher flooding is accounted to evaluate the over-pressurization behavior given by each of the non-condensable gases and the continuous steam generation.

2.4 Conditions of the Analysis

For the containment performance analysis, basically all of the ESFs (Engineered Safety Features) for DBA including SIPs (Safety Injection Pumps), AFW (Auxiliary Feedwater) and DBA spray system are assumed to be failed. Only SITs (Safety Injection Tanks) are assumed as available considering its passive characteristics.

3. Result of Analysis

3.1 Containment Responses in SBLOCA without mitigation

The containment pressure is increasing continuously and the increasing rate is slow to be nearly flattened as shown in Fig. 1. At around 10 hours, the pressure increase deviated from those of other compartments appears. This is brought by the hydrogen jet burn in the upper reactor vessel annulus compartment. Despite this jet burn, the pressurization is not so considerable.

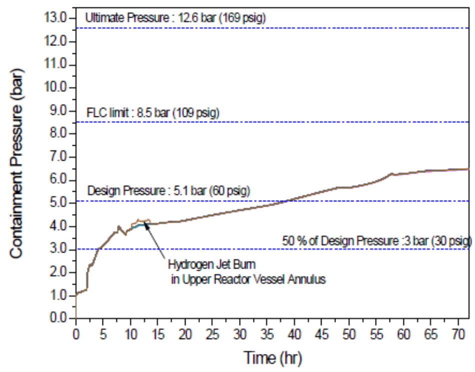

Fig. 1 Containment Pressure for SBLOCA without mitigation

The containment atmospheric temperature is presented in Fig. 2. Right after RPV (reactor pressure vessel) failure, the temperature in the compartment receiving the core materials abruptly rises and it reaches about 1120 K as the maximum.

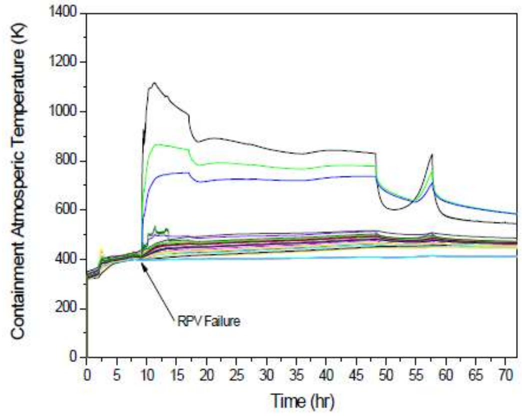

Fig. 2 Containment Temperature for SBLOCA without mitigation

3.2 Containment Responses in SBLOCA with normal mitigations

The containment pressure is increasing continuously by steam generation in the core catcher compartment as shown in Fig. 3. The pressure exceeds FLC(Factored Load Category) limit at about 20.3 hour and gives a peak when SACSS operation begins. After the peak, the pressure decreases gradually due to the condensation of steam enabled by SACSS operation.

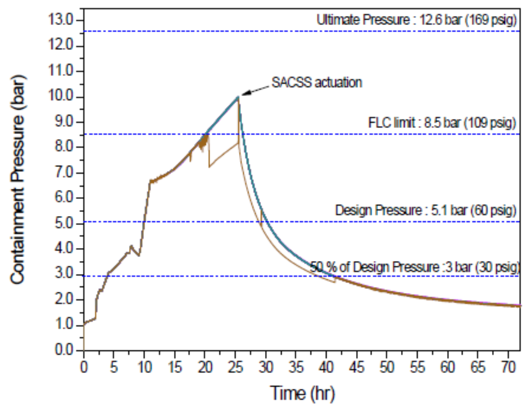

Fig. 3 Containment Pressure for SBLOCA with normal mitigation

The containment atmospheric temperature is presented in Fig. 4. Right after RPV failure, the temperature in the compartment receiving the core materials abruptly rises and it reaches about 808 K making a peak. After the peak, the overall temperature is kept below about 470 K.

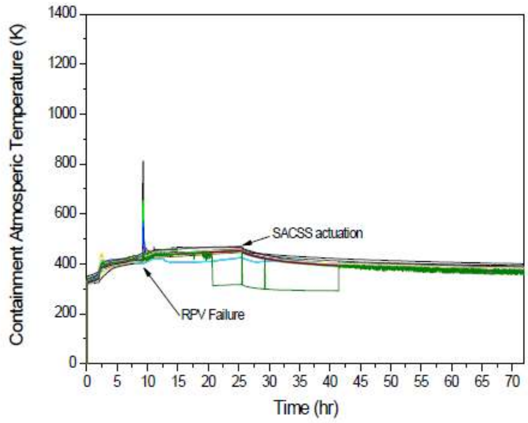

Fig. 4 Containment Temperature for SBLOCA with normal mitigation

4. Conclusions

The containment performance analysis is performed to evaluate the thermal-hydraulic responses of the EU-APR1400 containment with the condition of SBLOCA.

The overall result of this analysis presents that the containment of EU-APR1400 can function as a leak-tight barrier for at least 24 hours from the severe accident initiation even if partial or whole severe accident mitigation systems are not available.

Acknowledgement

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REFERENCES

[1] “European Utility Requirements (EUR) for LWR Nuclear Power Plants”, Vol. 2, Rev. C, April 2001.
[2] “Advanced Power Reactor 1400 Standard Safety Analysis Report”, Rev.0, Korea Hydro & Nuclear Power Co., Ltd.
[3] R.E.Henry, et al., “Modular Accident Analysis Program (MAAP4),” Fauske & Associates, Inc., Vol. 1-4, 1994.