# An Evaluation of Improved Distributed Heat Sink Models in MAAP-ISAAC 4.03 Code

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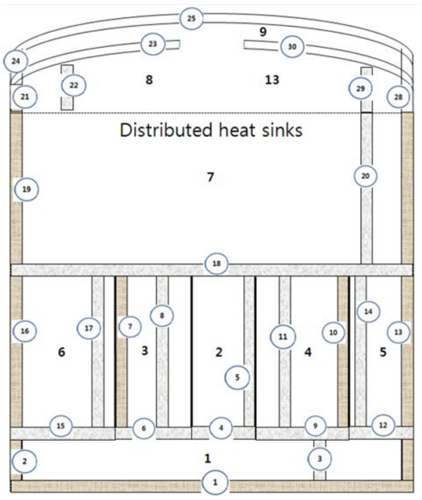
## 1. Introduction

The MAAP-ISAAC (Modular Accident Analysis Program - Integrated Severe Accident Analysis Code for CANDU Plant) [1], which is the severe accident analysis code for pressurized heavy water reactors (PHWR), has been improved based on severe accident analysis results from version 1.0 to 4.03 [1]. The main purpose of this paper is to evaluate the effect on improved distributed heat sink during severe accident initiated by the station blackout (SBO) in the Wolsong plants which are a typical CANDU-6 type using the MAAP-ISAAC 4.03 computer program.

## 2. Improvement for Distributed Heat Sinks Model

Distributed heat sinks in the containment are treated as either one-sided or two-sided and as either vertical or horizontal [2]. One-sided horizontal distributed heat sinks are considered to be thermally insulated at the other side. Figure 1 shows the distributed heat sink in the reactor building.




* 1~13 : Compartments, ①~㉚ : Distributed heat sinks
Fig. 1. Distributed heat sinks in the reactor building [3].

The distributed heat sink 18 in Fig. 1, which is the floor of SG (steam generator) room, has been modeled as one-sided horizontal distributed heat sink in the present parameter file of MAAP-ISAAC 4.03. However, actually the distributed heat sink 18 is two-sided horizontal distributed heat sink, one side is faced with SG room (comp. 7) and the other side is faced with access area (comp. 6), F/M (R-107) room (comp. 3), calandria vault (comp. 2), F/M (R-108) room (comp. 4), moderator room (comp. 5), respectively. Therefore, existing distributed heat sink 18 modeled simply as one heat sink is divided in detail as five distributed heat sinks (18, 31, 32, 33 and 34) and is improved from one-sided to two-sided. Also, a few index of the compartment facing on the heat sink in the two-sided wall are modified. Major improvements are as shown in table I.

Table I: Major improvements

| Definition | Before | | After | |
|---|---|---|---|---|
| | **Variable** | **Value** | **Variable** | **Value** |
| The modified distributed heat sinks | | | | |
| The orientation designator for heat sink | NIWALL(18) | -1 | NIWALL(18) | -2 |
| | | | NIWALL(31) | -2 |
| | | | NIWALL(32) | -2 |
| | | | NIWALL(33) | -2 |
| | | | NIWALL(34) | -2 |
| Total one-sided wall area of heat sink | AHSRB(18) | 1289.373 | AHSRB(18) | 322.647 |
| | | | AHSRB(31) | 273.052 |
| | | | AHSRB(32) | 54.162 |
| | | | AHSRB(33) | 273.052 |
| | | | AHSRB(34) | 309.645 |
| The compartment index that faces heat sink (side 1) | N1HSRB(18) | 7 | N1HSRB(18) | 7 |
| | | | N1HSRB(31) | 7 |
| | | | N1HSRB(32) | 7 |
| | | | N1HSRB(33) | 7 |
| | | | N1HSRB(34) | 7 |
| The compartment index that faces heat sink (side 2) | N2HSRB(18) | 7 | N2HSRB(18) | 6 |
| | | | N2HSRB(31) | 3 |
| | | | N2HSRB(32) | 2 |
| | | | N2HSRB(33) | 4 |
| | | | N2HSRB(34) | 5 |
| The perimeter of heat sink | XPERHS(18) | 100 | XPERHS(18) | 71.8496 |
| | | | XPERHS(31) | 66.0971 |
| | | | XPERHS(32) | 29.4381 |
| | | | XPERHS(33) | 66.0971 |
| | | | XPERHS(34) | 70.3869 |
| The corrected index of the compartment that faces heat sink | | | | |
| The compartment index (side 1) | N1HSRB(25) | 10 | N1HSRB(25) | 9 |
| The compartment index (side 2) | N2HSRB(25) | 9 | N2HSRB(25) | 14* |

* Compartment 14 is environment

[1] MAAP is an Electric Power Research Institute (EPRI) software program that performs severe accident analysis for nuclear power plants including assessments of core damage and radiological transport. A valid license to MAAP4 and/or MAAP5 from EPRI is required.

## 3. Analysis and Results

### *3.1 Description of Analyzed Case and Assumptions*

Selected case is the station blackout (SBO) scenario. A station blackout is a typical high-pressure accident due to a failure of an emergency diesel generator after a loss of Class IV power. In the SBO, all AC and DC power are lost, so the steam generator feed water system, the cooling system of all systems including the calandria, and the engineered safety devices don't work and operator actions don't be considered. The assumptions regarding the availability of systems are as follows:

- Auxiliary Feed Water System (AFWS), Emergency Core Cooling System (ECCS), Emergency Water Supply System (EWS), Moderator Cooling System (MCS), End Shield Cooling System (ESCS), Local Air Cooler (LAC), Containment Filtered Venting System (CFVS) are assumed to be not available during the transient.
- The liquid relief valves (LRVs) are assumed to fail-open at the initiation of SBO. And the valves of dousing system in the reactor building are operated by a battery but they are assumed to be not expected to operate in this assessment. The DCRV (Degasser Condenser tank Relief Valve) is assumed to act strictly as a spring loaded relief valve in normal mode.
- Primary pumps run down and PHTS Loop isolation is assumed to not work due to a loss of power.
- The main steam safety valves (MSSVs) are assumed to be opened at the set point when the pressure of the secondary system increases.
- All passive autocatalytic recombiners (PARs) are credited normally.
- When the pressure in the reactor building increases above 420 kPa(g), it is assumed that the reactor building is destroyed and the radioactive nuclides are released into the atmosphere. The pressure setpoint, 420 kPa(g), is assumed arbitrarily for this sensitivity analysis.

### *3.2 Results and Discussion*

The results of the analysis are shown in Fig. 2 and Fig. 3. As shown in the figures, when the improved input parameter values are applied (Modified), it can be confirmed that the progress of the severe accident is delayed or mitigated slightly more than when the existing distributed heat sink input variables are applied (Reference). In other words, as shown in Fig. 2, the failure of the reactor building occurred at about 26.26 hours after the accident when the existing parameter values were applied, but about 30.95 hours when the improved variable values were applied. This is because the input variables for the area of the reactor building heat sinks were improved. Due to the effect of improved distributed heat sink model the total mass fraction of CsI released from the reactor building to the external environment is slightly reduced from 0.0364 to 0.0321 as shown in Fig. 3.

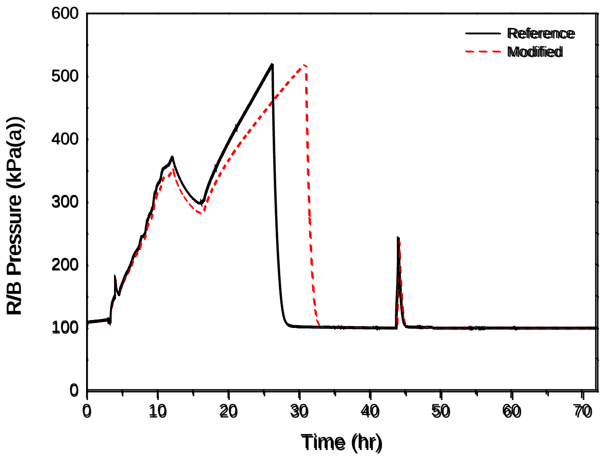



Fig. 2. The pressure in the reactor building at the SBO.

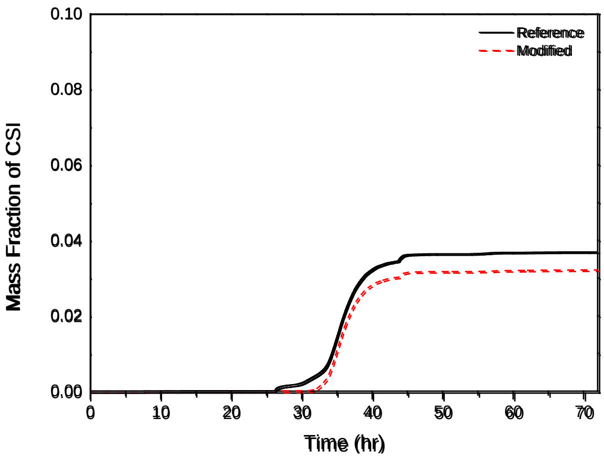



Fig. 3. The total mass fraction of CsI released to the environment at the SBO.

## 4. Conclusions

The station blackout (SBO) scenario in the Wolsong plant was selected as a representative accident, and some of the distributed heat sinks of MAAP-ISAAC 4.03 which is the severe accident analysis code were improved and their effects were evaluated. As a result of the analysis, it was confirmed that when the improved values (Modified) compared to the existing values (Reference) of distributed heat sinks were applied, the progress of the severe accident was slightly delayed or mitigated. Therefore, it is necessary to improve the model in detail for the distributed heat sinks. The analysis result that reflects the modification of the input parameters can be applied to the improvements such as the Level 2 PSA or the severe accident management guidance (SAMG) which use the result of the severe accident analysis.

## REFERENCES

[1] KAERI, MAAP-ISAAC Computer Code User's Manual, KAERI/TR-3645, 2008.
[2] Fauske & Associates, Inc., MAAP4 User Guidance, 2006.
[3] KHNP, MAAP-ISAAC Modeling for PAS-based Severe Accidents, 59RF-03500-AR-068 Rev.2, February, 2012.