Radionuclide Release after Channel Flow Blockage Accident in CANDU-6 Plant

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1. Introduction

The channel flow blockage accident is one of the in-core loss of coolant accidents, the release path of radionuclide is very different from conventional loss of coolant accidents. The large amount of radionuclide released from broken channel is being washed during it passes through the moderator in Calandria. The objective of containment behavior analysis for channel flow blockage event is to assess the amount of radionuclide release to the ambient atmosphere. Radionuclide release rates in case of channel flow blockage with all safety system available, that is containment building is intact, as well as with containment system impairment are analyzed with GOTHIC and SMART code.

2. Analysis Method

Various leak paths in containment building, that is ventilation inlet, ventilation outlet, leak through containment wall and hole such as equipment airlock door and personnel airlock door are considered as leakage path of radionuclide.

2.1 Containment Model

The compartments of containment building are modeled with 15 nodes and 76 flow paths [1]. Compartments linked with opening are lumped into on node. Fig. 1 shows the nodes and flow paths of model.

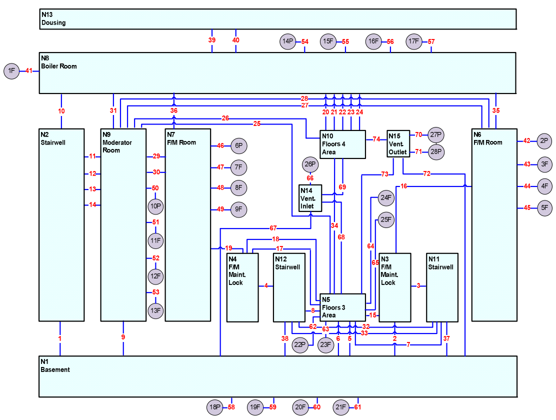

Fig.1. Nodes and flow paths of containment model

2.2 Assumption

Basically, the assumption used for radionuclide release analysis is similar to that used for peak pressure analysis but leakage rate of 5% of containment volume per day. To get conservative results of radio nuclide release analysis, effects of pressure and temperature suppression measures are under-estimated and additional heat sources are considered. Dousing water sprayed into containment through nozzles mounted on 6 headers. 6 headers are assumed to be available to exhaust dousing water inventory to minimize dousing water washout. Among 35 local air coolers, only 8 local air coolers, 4 in steam generator room and 2 in each of two fueling machine rooms, are assumed to be available. All additional heat sources are assumed constant throughout the accident except for the case of loss of local air coolers. Additional heat source reduces to 15% one day after event start for the event with the loss of local air coolers.

2.3 Containment System Impairment

Three categories of containment system impairment are considered. The first one is the impairments of the containment isolation system. This category includes total loss of isolation, open ventilation inlet line and open ventilation outlet line. For these cases, ventilation line is the direct release path of radionuclide to the outside atmosphere. The second one is the impairments of containment envelope. The airlock seals deflation, airlock door opening and maximum allowable hole in the containment perimeter wall are included in this category. Radionuclide releases directly through these impairments. The last one is impairments of pressure reduction measures such as dousing system and local air coolers. Leakage through the containment perimeter wall is the main leak path for the last category.

2.4 Radionuclide Source

Fission product released from the broken fuel is assessed by ELESTRES[2] code.

2.5 Radionuclide Behavior

Analysis of the behavior of airborne radionuclide both gaseous and liquid aerosol inside containment is performed using the computer code SMART[3]. Analysis the transport of airborne radionuclide from node to node and leakage from containment is calculated from the inter-nodal flow rate predicted by GOTHIC. Steam condensation rates on coolers and surfaces and surface temperatures at each time step are also transferred from GOTHIC to SMART.

Seventeen radionuclides which are modeled directly by SMART are as follows;

H-3, I-131, I-132, I-133, I-134, I-135, Iodine mixture, Kr-87, Kr-88, Kr-89, Xe-133m, Xe-133, Xe-135m, Xe-135, Xe-137, Xe-138, Noble gas mixture

These sources come from failed fuel, moderator and coolant.

3. Analysis Result

The mass and energy discharged from the moderator system are taken from primary system thermal hydraulic analysis as shown in Fig. 2.

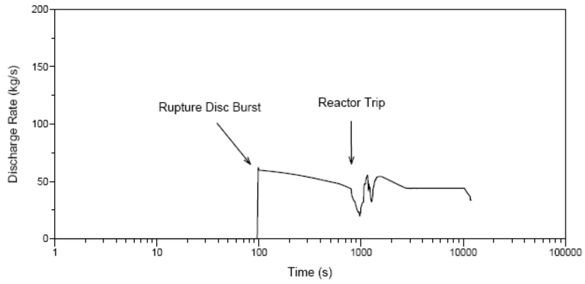

Fig. 2. Mass discharge from moderator to the inside containment

Fig. 3 shows the energy discharge from the moderator system.

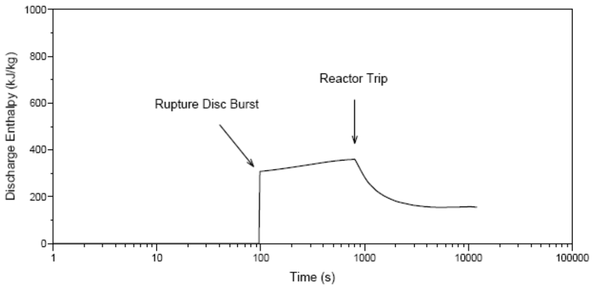

Fig. 3. Energy discharge from moderator to the inside containment

Analysis results focused on integrated I-131 release to the environment for channel flow blockage with all safety system available and various containment impairments are shown as below.

3.1 All safety system available

Fig. 4 shows the integrated I-131 release of CFB with the all safety system available.

3.2 Loss of Containment Isolation

Fig. 5 shows the integrated I-131 release of CFB with the loss of containment isolation.

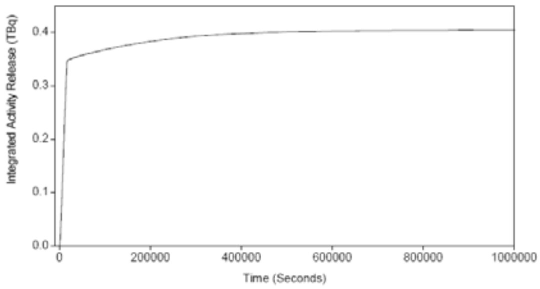

Fig. 4 Integrated I-131 release for ASSA

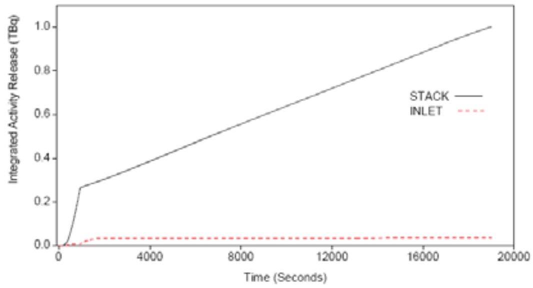

Fig. 5 Integrated I-131 release for LOCI

3.3 Open Equipment Airlock door Open

Fig. 6 shows the integrated I-131 release of CFB with equipment airlock door open.

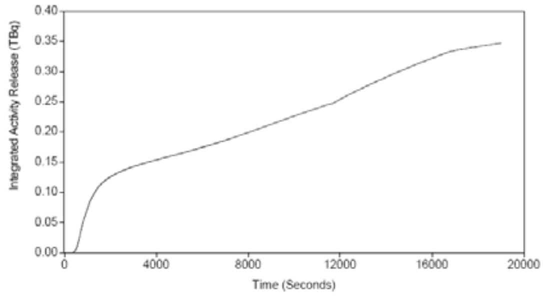

Fig. 6 Integrated I-131 release for OEAD

4. Conclusions

Radionuclide release to the environment in the event of channel flow blockage with all safety system available and containment impairments is analyzed with GOTHIC and SMART code. Analysis results show that the integrated release of radionuclide is well below acceptance criteria described in CNSC C-6 rev.0.

REFERENCES

[1] J. Y. Lee, Containment Analysis Model, 59RF-03500-AR-006 Rev.2, 2010.

[2] G. G. Chassie, "ELESTRES-IST 1.2: User's Manual," AECL-153-113370-UM-001, Rev.0, 2006.

[3] S.R. Mulpuru, "Software Theory Manual for SMART-IST VER-0.300", RC-2681, 2001.