Radionuclide Release after End Fitting Failure Accident in CANDU-6 Plant

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1. Introduction

The total amount of mass and energy discharged into containment building from primary heat transport system in the event of end fitting failure accident in CANDU-6 plant is similar to that of small loss of coolant accident. But the ejection of fuel bundles into fuelling machine room is unique phenomenon and causes radio nuclides release from the physically broken fuel rod to outside containment building. The only objective of containment behavior analysis for end fitting failure event is to assess the amount of radio nuclides release to the ambient atmosphere. Radionuclide release rates in case of end fitting failure 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, 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.

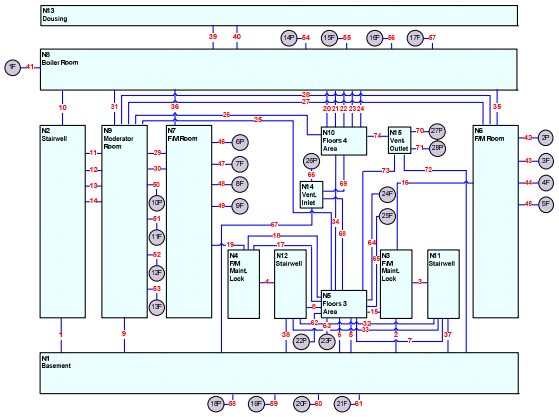

Fig.1. Nodes and flow paths of containment model

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. But 4 headers are assumed to be available. 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] and REDOU[3] code.

2.5 Radionuclide Behavior

Analysis of the behavior of airborne radionuclides both gaseous and liquid aerosol inside containment is performed using the computer code SMART[4]. Analysis the transport of airborne radionuclides 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 failed end fitting are taken from primary system thermal hydraulic analysis as shown in Fig. 2.

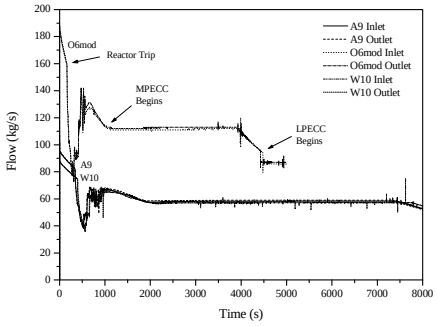

Fig. 2. Total break discharge for inlet EFF

Fig. 3 shows the Iodine nuclides from the broken fuel bundle.

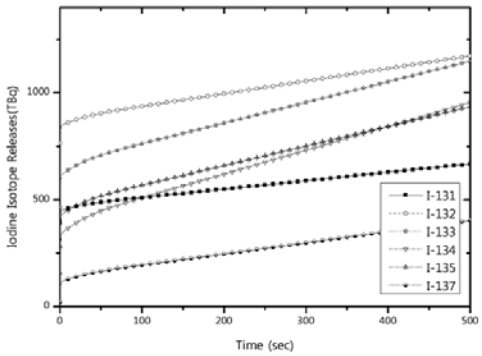

Fig. 3. Iodine release transient from O6_mod

Analysis results focused on integrated I-131 release to the environment for end fitting failure with various containment impairments are shown as below.

3.1 All safety system available

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

3.2 Loss of Containment Isolation

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

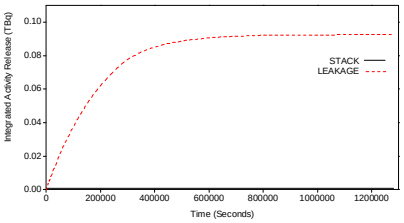

Fig. 4 Integrated I-131 release for ASSA

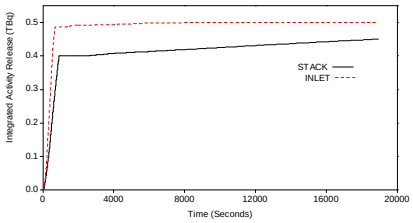

Fig. 5 Integrated I-131 release for LOCI

3.3 Open Equipment Airlock door Open

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

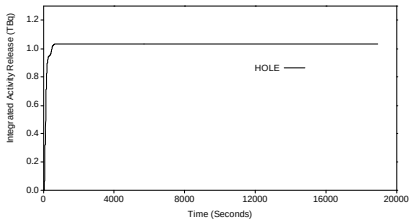

Fig. 6 Integrated I-131 release for OEAD

4. Conclusions

Radionuclide release to the environment in the event of end fitting failure 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] R. Aboud, “REDOU Version 1.0 : Fractional Fission Product Releases Due to Oxidation of Uranium Dioxide-Program Description, User’s Manual and Validation”, TTR-378, Volume 1, 1992.

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