

# Development of the Preliminary Risk Profile for Hanaro Research Reactor



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## Introduction

- ❖ According to the requirements of the Citizen Verification Team (2019.4 ~ 2018.3), a research project was launched in 2019
- ❖ The objective of the project is to prove that the operating research facilities are fully satisfied with the domestic nuclear safety goals (e.g., less than 0.1% of individual risks) through the risk profile assessment of the research site.
- ❖ The paper focuses on the preliminary risk profile(RP) based on the preliminary level 1/2/3 PSA for the Hanaro research reactor.

❖ The release characteristics of radioactive materials by accident type of Hanaro facility were divided into four source term categories(STC):

- STC 1: No release
- STC 2: Early ground release
- STC 3: Early release through chimney
- STC 4: Late release through chimney

## Preliminary Off-site Release Accident Sequences for Hanaro Research Reactor

- ❖ The following range of level 1 & 2 PSA models was developed in order to obtain the main off-site release accident scenarios and quantify their frequencies for Hanaro Research Reactor:
  - Preliminary full-power PSA model for internal and external events (seismic only) at Hanaro facilities
  - Qualitative assessment of low power and shutdown PSA model for Hanaro facilities (screening-out)
  - Qualitative assessment of Hanaro spent fuel pool including bounding thermal-hydraulic analysis (screening-out)
  - Seismic hazard analysis of the research site
  - Preliminary evaluation of seismic fragility for major structures and equipment of Hanaro facilities
  - Development of preliminary MELCOR input model and severe accident analysis for Hanaro facilities

## Preliminary Risk Profile For Hanaro

❖ Risk quantification with very conservative assumptions

- The release time of the source term is assumed very conservatively to be 1 hour after accident occurrence, even though all accident sequences have a lot of time to core damage without any mitigation measures due to the design characteristics of research reactor.
- The release amount of the source term through the chimney was determined by the results of MELCOR simulations under the very conservative assumptions that all fission products of the core inventory are released from core to reactor building.
- In the event of an earthquake-induced collapse of the reactor building, it was assumed that all source terms were immediately released at the ground level.

❖ The Results of Risk Quantification

- The results of health effect for Hanaro facility were evaluated by population-weighted risks, i.e., a 5 km radius for acute fatality (EF) and a 20 km radius of latent cancer fatality (CF), using on the site-specific MACCS2 model developed for this study.
- Summary of preliminary average individual risks
  - ✓ No acute fatality.
  - ✓ The total average individual risk for Hanaro facility was evaluated as 3.19e-11/yr, which was due to only CF.

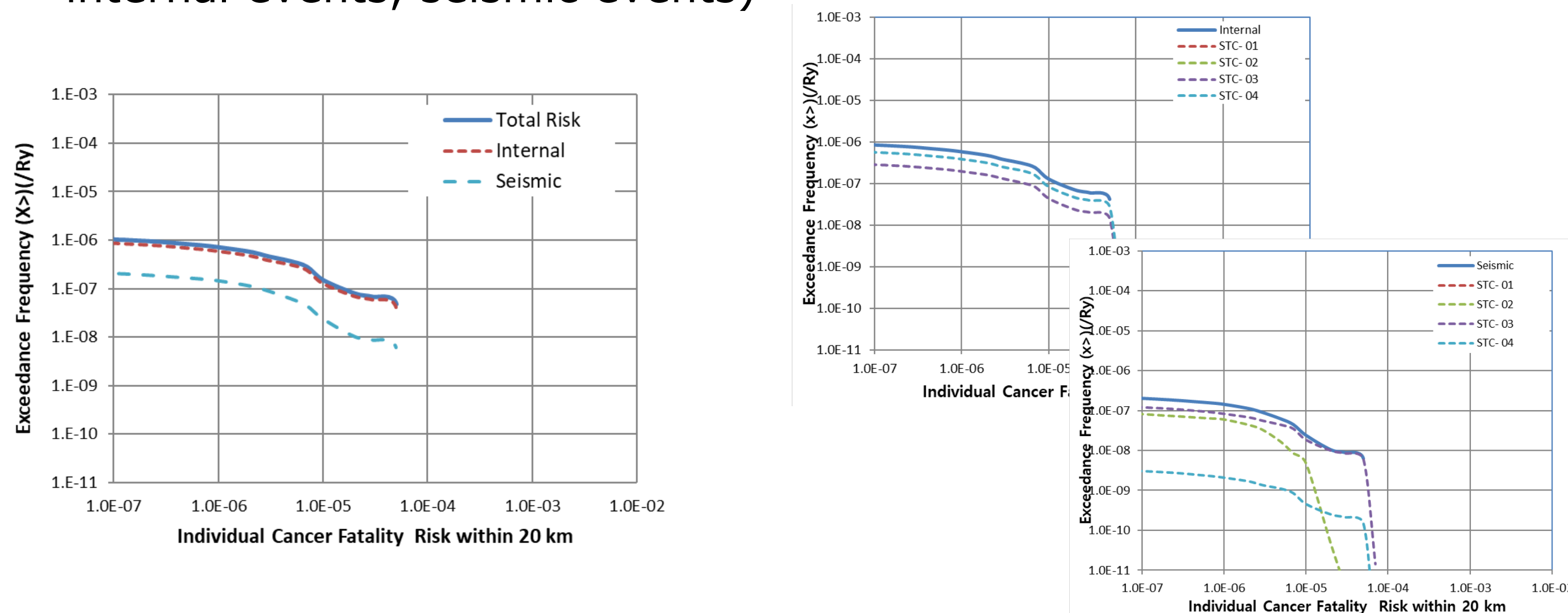
❖ The preliminary frequency and release characteristics of each major accident scenario for Hanaro facility.

Event Type	Initiating Event(IE)	Core Damage(CD) Accident Seq.	IE Frequency	CD Frequency	Early /Late	STC*
Internal Event	%BT-LOCA	#BT-LOCA-4	6.85E-06	4.50E-14	E	3
	%BT-LOCA	#BT-LOCA-3	6.85E-06	1.31E-11	L	4
	%BT-LOCA	#BT-LOCA-2	6.85E-06	4.49E-07	L	4
	%GTRN-AT	#GTRN-AT-3	5.65E+00	1.90E-09	L	1
	%GTRN-AT	#GTRN-AT-4	5.65E+00	2.56E-08	E	3
	%GTRN-MT	#GTRN-MT-4	1.43E+00	1.70E-12	E	3
	%GTRN-MT	#GTRN-MT-3	1.43E+00	4.80E-10	L	1
	%LOCA	#LOCA-3	9.89E-04	6.50E-12	E	3
	%LOCA	#LOCA-2	9.89E-04	1.89E-09	L	4
	%LOEP	#LOEP-2	1.92E+00	3.68E-06	L	1
	%LOPCS	#LOPCS-2	6.20E-02	1.19E-07	L	4
	%LOPCS	#LOPCS-3	6.20E-02	1.40E-09	E	3
	%LOSCS	#LOSCS-3	6.20E-02	2.08E-11	L	1
	%LOSCS	#LOSCS-4	6.20E-02	2.81E-10	E	3
	%RIA	#RIA-3	1.67E+00	5.60E-10	L	1
	%RIA	#RIA-4	1.67E+00	7.57E-09	E	3
%SCFB	#SCFB-4	1.30E-05	2.62E-07	E	3	
%SCFB	#SCFB-3	1.30E-05	4.23E-15	L	1	
Seismic	Bin 1 (0.1-0.3g)	%SEIS #GS-LOCA-2!	1.88E-04	1.84E-14	L	4
		%SEIS #GS-LOCA-3!	1.88E-04	2.20E-13	E	3
		%SEIS #GS-LOEP-2!	1.88E-04	4.54E-10	L	1
		%SEIS #GS-LOEP-3!	1.88E-04	5.44E-09	E	3
		%SEIS #GSEISMIC-3!	1.88E-04	4.63E-10	E	2
	Bin 2 (0.3-0.5g)	%SEIS #GS-LOCA-2!	4.22E-06	1.16E-10	L	4
		%SEIS #GS-LOCA-3!	4.22E-06	1.67E-09	E	3
		%SEIS #GS-LOEP-2!	4.22E-06	4.19E-09	L	1
		%SEIS #GS-LOEP-3!	4.22E-06	6.04E-08	E	3
		%SEIS #GSEISMIC-3!	4.22E-06	2.75E-08	E	2
	Bin 3** (0.5-1.0g)	%SEIS #GS-LOCA-2!	3.29E-07	3.03E-09	L	4
		%SEIS #GS-LOCA-3!	3.29E-07	1.94E-08	E	3
%SEIS #GS-LOEP-2!	3.29E-07	5.99E-09	L	1		
%SEIS #GS-LOEP-3!	3.29E-07	3.83E-08	E	3		
%SEIS #GSEISMIC-3!	3.29E-07	5.85E-08	E	2		

\*) STC(source term category): 1(no release), 2(Ground early release), 3(Chimney early release), 4(Chimney late release)  
 \*\*) Includes the seismic frequency more than 1.0g

STC*	Event type CDF(RV)(a)		population-weighted risk(b)/(person)		Average Individual Risk by Event Type (c=a*b)/(person-Ry)			
	Internal	Seismic	EF(within 5km)	CF(within 20Km)	EF(5km)		CF(20Km)	
					Internal	Seismic	Internal	seismic
1	3.68E-06	1.06E-08	0	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2	0.00E+00	8.64E-08	0	3.16E-06	0.00E+00	0.00E+00	0.00E+00	2.73E-13
3	2.96E-07	1.25E-07	0	7.24E-06	0.00E+00	0.00E+00	2.15E-12	9.06E-13
4	5.70E-07	3.14E-09	0	7.07E-06	0.00E+00	0.00E+00	4.03E-12	2.22E-14
Sub-total (A=Σa)	4.55E-06	2.25E-07	Sum of Individual Risk(C=Σc)	0.00E+00	0.00E+00	6.17E-12	1.20E-12	
Total (E=ΣA)	4.77E-06		Freq.-weighted Sub-total individual risk(D=Σcd)	0.00E+00	0.00E+00	1.36E-06	5.33E-06	6.69E-06
			Total Average Individual Risk (F=E*D)			0.00E+00	3.19E-11	

❖ Preliminary Risk Profiles for Hanaro Research Reactor (RP for total, internal events, seismic events)



## Conclusions

- ❖ A risk profile for the Hanaro research reactor was developed based on the conservative results of the preliminary level 1/2/3 PSA.
- ❖ The preliminary average individual risk for Hanaro facility was evaluated as 3.19e-11/yr, which can be regarded to be insignificant through the comparison on the regulatory-side safety goal reference (presented at the 14<sup>th</sup> NSIC Conference, KINS, 2009).