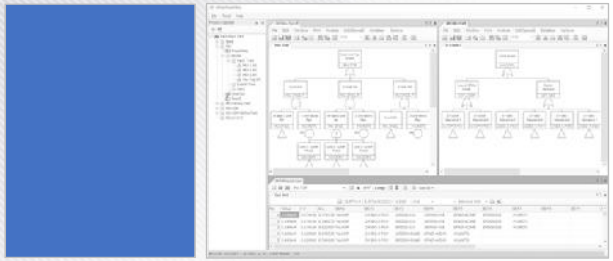
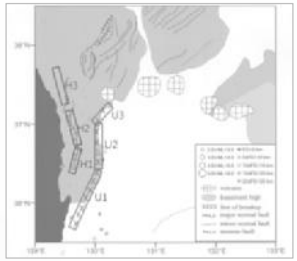
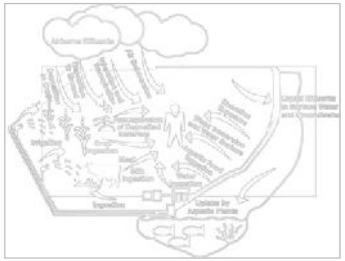
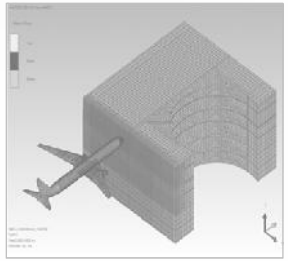

A Level 1 Fire PRA on PGSFR

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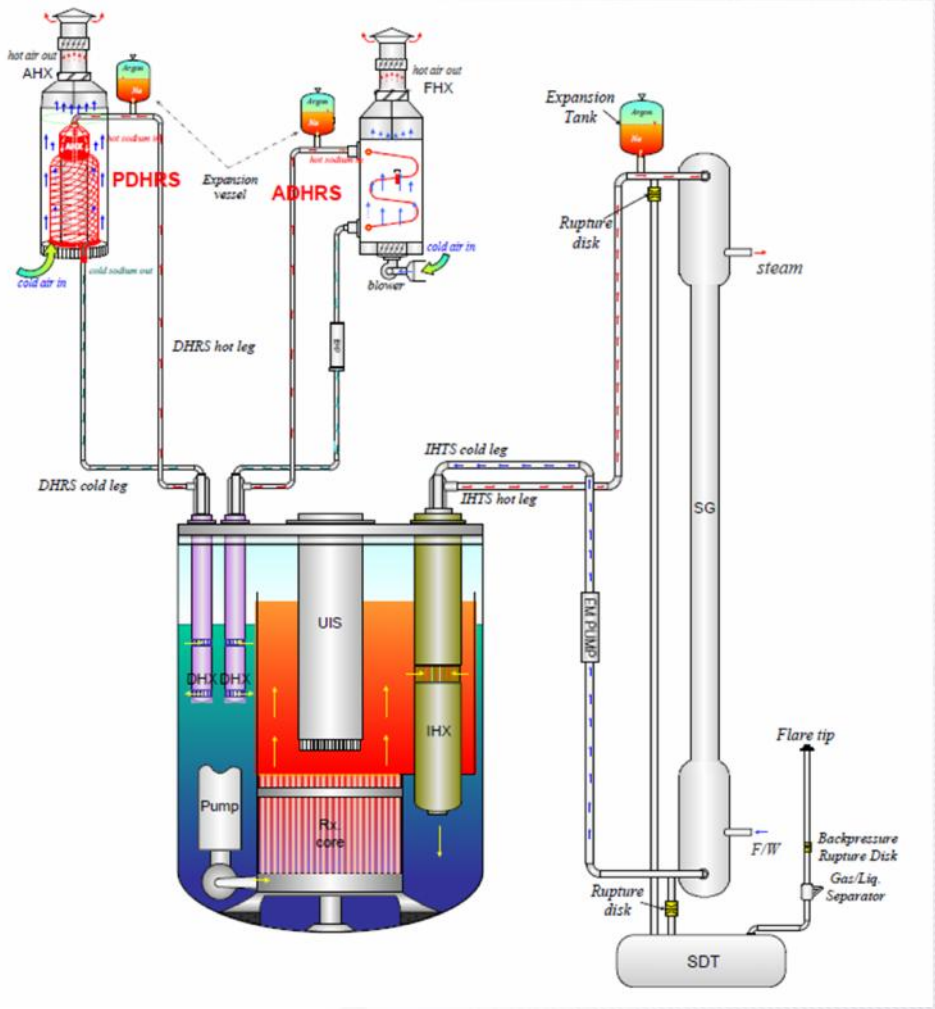
CONTENTS

Introduction

- **Prototype Generation IV Sodium Fast Reactor (PGSFR)**
- **Characteristics of PGSFR :**
  - Very simple plant
  - PGSFR has sodium which can be an ignition source.
- **Fire Areas**
  - 197 fire areas are determined,
  - Among them, 36 fire areas (including 7 sodium leak areas) are quantitatively in detail analysed.



Ignition Frequency of PGSFR

- Generic ignition frequencies of the fire areas

  NUREG/CR-6850 → NUREG-2169

- Ignition sources:
  - fixed source due to the fire of equipment such as pumps, electric cabinets, etc.,
  - transient source due to the maintenance work, welding, etc.
  - Table 1 are based on the commercial NPPs
    - The equipment number
      - PGSFR : commercial NPPs = 592 : 1177

        → Small Reactor Factor : (592/1177)

Table 1: Example of Ignition Frequencies of PGSFR

Fire Area	Fire Area Name	Fixed	Transient	Total
F-C101	REACTOR CAVITY	1.37E-03	1.26E-06	1.37.E-03
F-C206	CONTAINMENT ANNULUS AREA	4.75E-04	5.63E-05	5.31.E-04
F-C303	CONTAINMENT ANNULUS AREA	2.98E-04	5.63E-05	3.54.E-04
F-C311	SP SODIUM SURGE TANK RM	0	1.26E-05	1.26.E-05
F-C312	SP EM PUMP RM	0	1.26E-05	1.26.E-05
F-C313	SP VACCUM PUMP RM	5.44E-04	1.26E-05	5.57.E-04
F-A106A	ESSENTIAL CHILLED WATER PUMP RM	1.09E-03	4.44E-05	1.13.E-03
F-A106B	ESSENTIAL CHILLED WATER PUMP RM	1.09E-03	4.44E-05	1.13.E-03
F-A108A	ESSENTIAL CHILLED WATER PUMP RM	5.44E-04	4.44E-05	5.88.E-04
F-A108B	ESSENTIAL CHILLED WATER PUMP RM	5.44E-04	4.44E-05	5.88.E-04

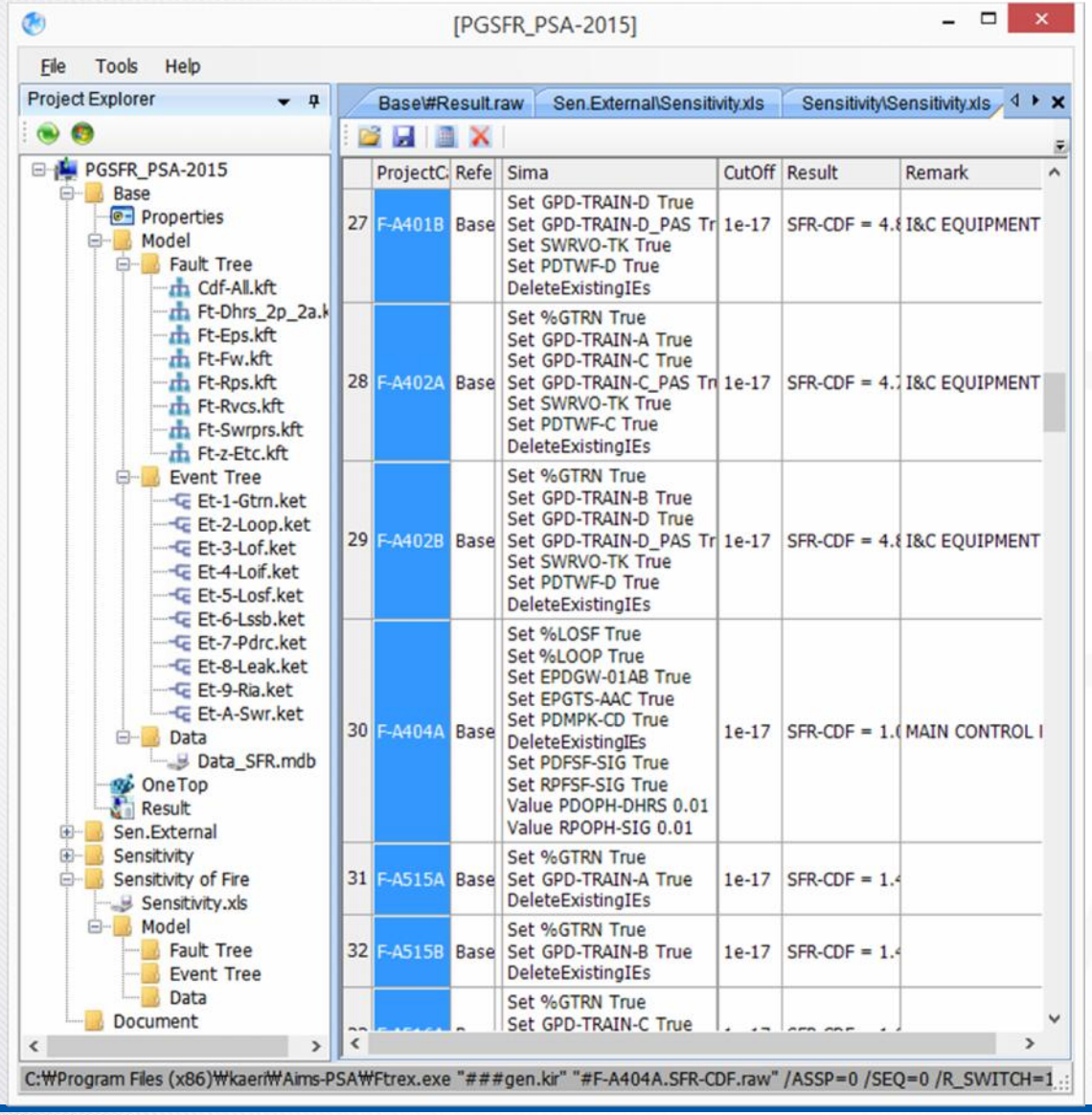
Increased Fire Frequency By Sodium Leak

- There would be a fire caused by sodium leak.
- Assumed conservatively that there is a sodium fire if there is a leak from sodium piping.
- History data of BN-600
  - 30 years(1980~2010)
  - 0.2/yr

Ignition Frequencies of PGSFR Due To Sodium Leak Fire

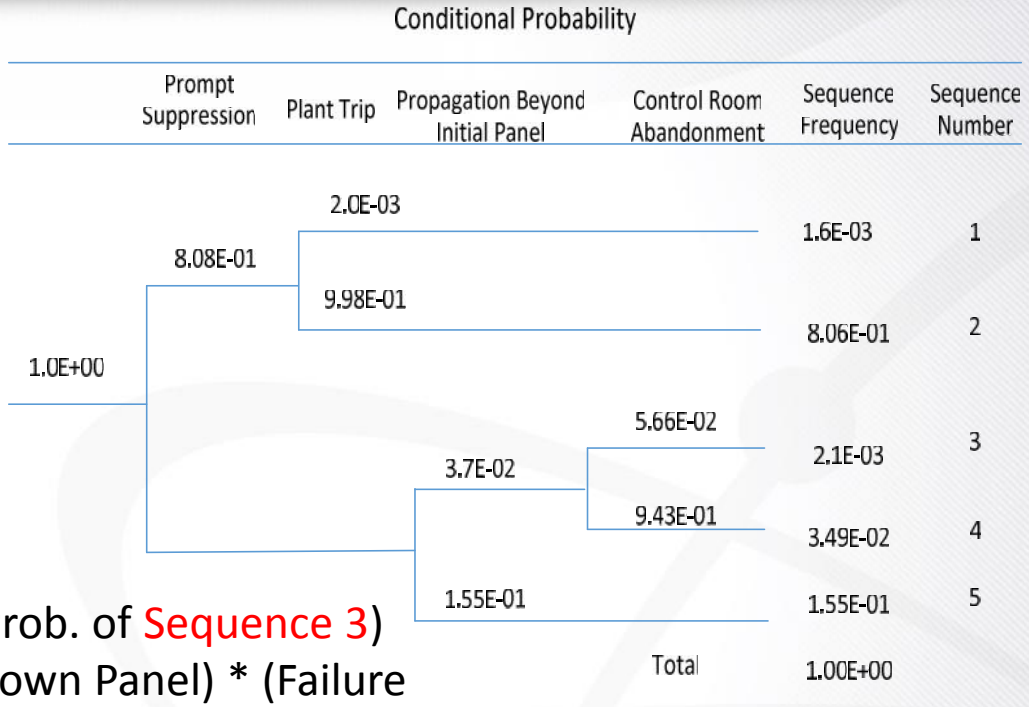
Fire Area		Piping length (%)	Ignition freq. (/y)
F-C304	HEAD ACCESS AREA	0.228	0.046
F-C303	CONTAINMENT ANNULUS AREA	0.1	0.02
F-A122A	Steam Generator room	0.102	0.02
F-A122B	Steam Generator room	0.102	0.02
F-A316A	PIPE CHASE	0.055	0.011
F-A316B	PIPE CHASE	0.055	0.011
F-A123A	SWRPR SODIUM DUMP TANK RM	0.09	0.018
F-A123B	SWRPR SODIUM DUMP TANK RM	0.09	0.018
F-A518A	AHX RM	0.038	0.008
F-A518B	AHX RM	0.038	0.008
F-A519A	FHX RM	0.051	0.01
F-A519B	FHX RM	0.051	0.01
	SUM	1	0.2

An Example Screen of PGSFR PSA Model



CDF By MCR Fire of PGSFR

- **MCR abandonment**



MCR Abandonment (Seq. 3)

$CDF_{(abandon)}$ = (Ignition Freq. in Console) * (Prob. of Sequence 3) * (Operator's Failure to Use Remote Shutdown Panel) * (Failure of Manually Open of PDRC Damper) ------ (1)

MCR Non-abandonment (Seq. 4, 5)

$CDF_{(No\ abandon)}$ = (Ignition Freq. in Console) * (1/2) * (Prob. of Sequence 5) * [CCDP(DHRS) + CCDP(EPS)] + (Ignition Freq. in Console) * (Prob. of Sequence 4) * [CCDP(EPS + DHRS)] ----- (2)

- If HFE increased by Double

→ *13% More Dangerous With Doubled Operator Error Prob.*

Table 2. CDF portion of each fire area

Fire Area		Ignition Freq.	Sodium Fire Freq.	CDF %
F-C304	HEAD ACCESS AREA	1.26E-05	4.56E-02	16.55%
F-C303	CONTAINMENT ANNULUS AREA	3.54E-04	2.01E-02	7.36%
F-A122A	Steam Generator room	1.15E-05	2.05E-02	5.12%
F-A122B	Steam Generator room	1.15E-05	2.05E-02	5.12%
F-A202A	480V CLASS 1E LOAD CENTER & MCC RM	9.50E-04		5.95%
F-A202B	480V CLASS 1E LOAD CENTER & MCC RM	9.50E-04		5.95%
…	…	…		
F-A209A	4.16kV CLASS 1E SWGR RM	1.99E-03		1.25%
F-A209B	4.16kV CLASS 1E SWGR RM	1.99E-03		1.25%
F-A518B	AHX RM	4.52E-04	7.68E-03	9.77%
F-A519A	FHX RM	4.45E-04	1.02E-02	9.76%
F-A519B	FHX RM	4.45E-04	1.02E-02	12.88%
F-D202	SWITCHGEAR ROOM	2.83E-03		1.36%
…	….	….		
F-A433B	MCR			13%
				100%

Results (1/2)

◆Core Damage Frequency (CDF)

– **The 3rd column (ignition frequency) of Table 2 is derived by multiplying the small reactor factor (592/1177)**

– **The 4th column is the ignition frequency caused by the sodium piping leak.**

– **Head access area (F-C304)**

- CDF portion is 16.55%
- the sodium fire could occur frequently because many sodium piping lines pass through this area.

– **MCR (F-A433B)**

- 13%, Eq.(1) + Eq.(2).

Results (2/2)

◆ Sensitivity Analysis

- **Different sodium fire ignition frequency**
  - **Sodium piping leakage rate (3.0E-9/ft/h)**
  - **Optimistic : 3.4 Times**

→ ***51% Safer With Sodium piping leakage rate***

- **Small Reactor Factor**

➢ The equipment number

- PGSFR : commercial NPPs = 592 : 1177

→ ***27% More Dangerous Without Small Reactor Factor***

- **Operator Error**

– Operator's 'Failure to use Remote Shutdown Panel' and 'Failure of Manually Open of PDRC Damper' in Eq. (1)

– If HFE increased by Double

→ ***13% More Dangerous With Doubled Operator Error Prob.***

Conclusions

- CDF of level 1 fire PSA on PGSFR is several order lower than those of commercial NPPs.
- The characteristics of PGSFR are described in this paper; 1) sodium fire ignition, 2) small reactor factor, 3) a console type MCR and MCR abandonment logic.
- The fire area having the highest CDF portion is where a lot of sodium piping lines are passing through.
- The next higher CDF portion fire area is MCR.
- The sensitivity analysis that the result of level 1 fire PSA on PGSFR can be feasible.

THANK YOU