# Accident Scenarios for ATF Performance Evaluation of BWR and PWR in Japan

Central Research Institute of Electric Power Industry,
Japan Atomic Energy Agency,
Global Nuclear Fuel - Japan Co., Ltd.,
Hitachi-GE Nuclear Energy, Ltd.,
Mitsubishi Heavy Industries, Ltd.,
Mitsubishi Nuclear Fuel Co., Ltd.,
Nippon Nuclear Fuel Development Co., Ltd.,
Nuclear Fuel Industries, Ltd.,
Toshiba Corporation

EGATFL 3rd meeting

3rd-5th March 2015

OECD/NEA HQ, Paris



CRIEPI Central Research Institute of Electric Power Industry

# Purposes

**To evaluate quantitatively the improvement in safety performance by introducing ATF concepts into current commercial LWR plants, the following preconditions are determined.**

- **Reference plant: Reactor type and output scale**
  Representative BWR & PWR where ATF will be introduced.

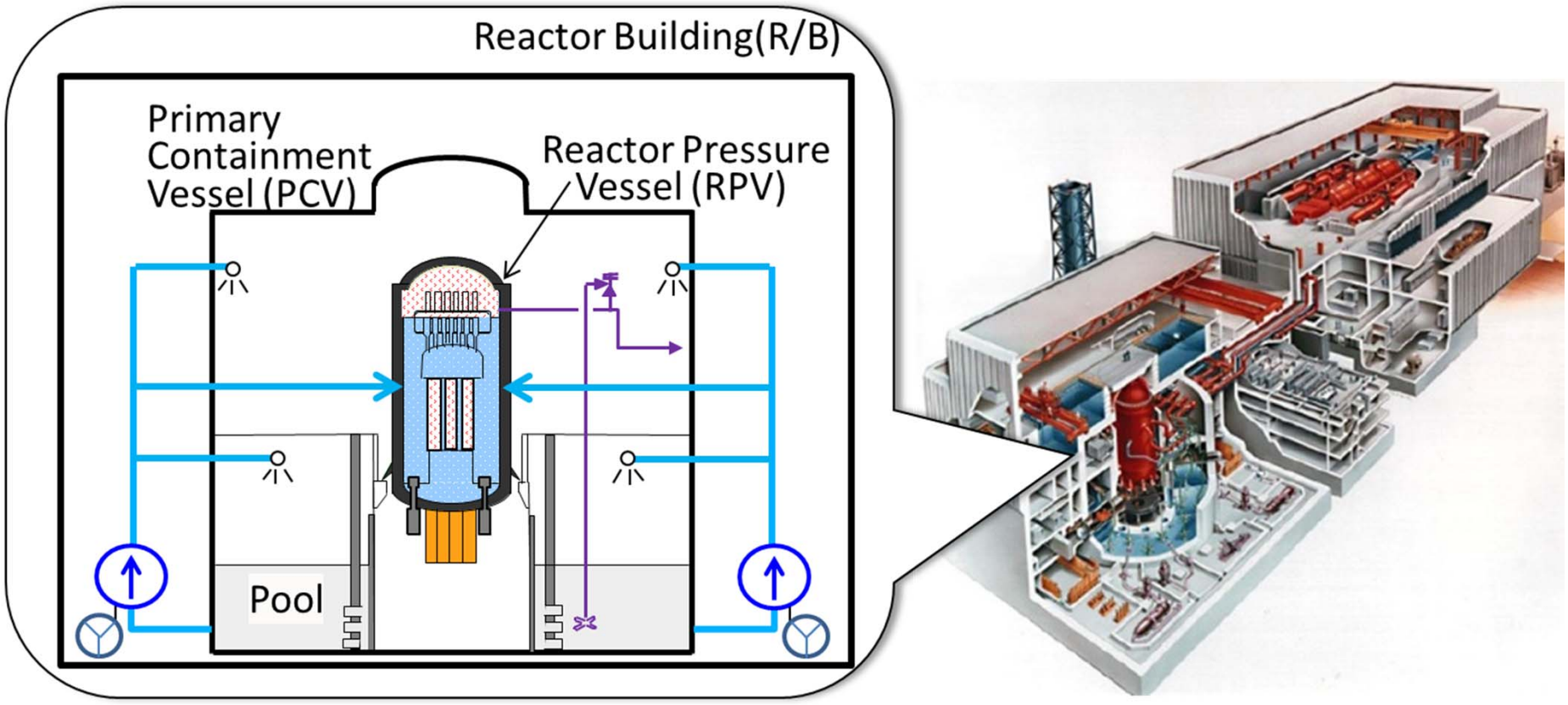
- **Severe accident (SA) scenario**
  A typical and simple scenario for each of BWR & PWR,
  Common sequence independent of a specific NPP site condition

# The reference plant for ATF performance evaluation (BWR)

We selected a large scale Boiling Water Reactor (BWR) as a reference plant of BWR for ATF performance evaluation.

The following information is needed for evaluation,

- ✓ Detailed plant information such as fuel type, RPV configuration, PCV size, etc.
- ✓ Appropriate scenario for the reference BWR



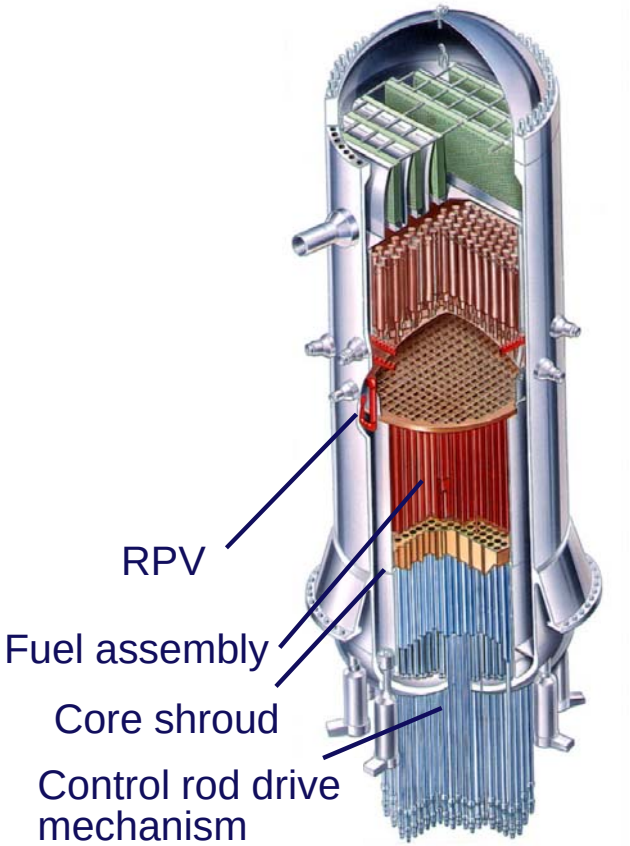



CRIEPI Central Research Institute of Electric Power Industry

# Plant information for ATF performance evaluation (BWR)

Major plant information for the reference BWR is shown below.

| Items | Reference BWR |
|---|---|
| Thermal power | 3926MWt |
| Fuel type | 9x9 |
| Number of fuel assemblies | 872 |
| Control rod type | Cross shaped control blade |
| Number of control rods | 205 |
| Neutron absorber | $B_4C$ |
| RPV diameter | About 7.1m |
| RPV height | About 21m |
| ATF applications for: | Fuel cladding, channel box |




Reference BWR

# Appropriate scenario for ATF performance evaluation (BWR)

The accident scenarios of the reference BWR are categorized based on timing and mode of RPV/core/PCV failures as well as availability of measures for molten debris cooling and heat removal. Representative scenarios are grouped into 6 PDSs (Plant Damage States) shown below:

| | |
|---|---|
| ・TQUV | The PDS “TQUV” is Transient (T) including planned manual shutdown and special initiators, followed by failures of feed water system (Q), high pressure ECCS (U) and low pressure ECCS (V). |
| ・TQUX | The PDS “TQUX” is Transient (T) including planned manual shutdown and special initiators, followed by failures of feed water system (Q), high pressure ECCS (U) and reactor depressurization (X). |
| ・LOCA | This PDS includes AE: large LOCA (A) with injection failure (E), S1E: medium LOCA (S1) with injection failure (E) and S2E small LOCA (S2) with injection failure (E). |
| ・TW | Water injection to the core is successful but heat removal from PCV fails (W). |
| ・TC | Water injection to the core is successful but heat removal from PCV is not enough due to failure to remain subcritical (C). |
| ・TB | In station blackout (TB), including failure to recover offsite power by 30 minutes and by 8 hours, high pressure injection is maintained until DC power is exhausted. |

TW and TC are milder on $H_2$ generation than TQUV because core cooling functions are available.

A frequency of occurrence of TQUV is higher than TQUX and TB as well as LOCA because depressurization measures and power recovery measures are strengthened for the latest typical BWR, therefore TQUV has a priority on ATF performance evaluation.

⇨ TQUV* is selected as the representative PDS for ATF performance evaluation in BWR from the viewpoint of $H_2$ generation rate and its frequency of occurrence.

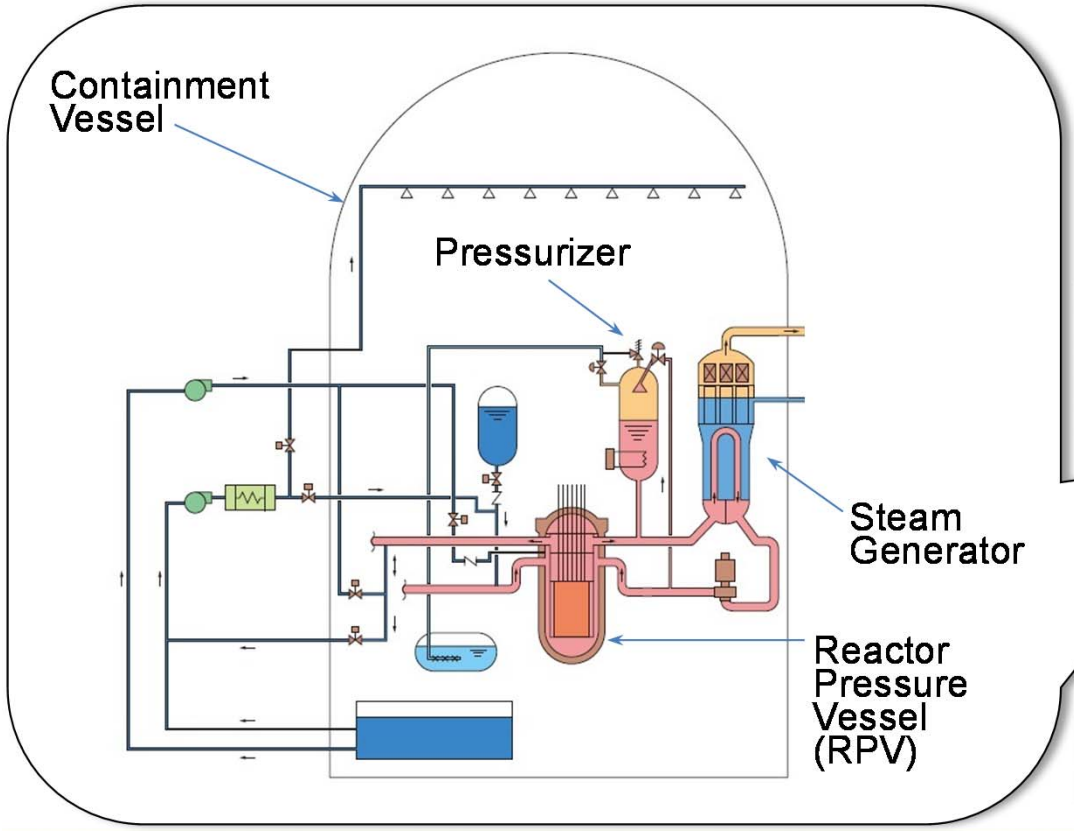
*Anticipated transient with failures of feedwater system, high-pressure ECCS & low-pressure ECCS.

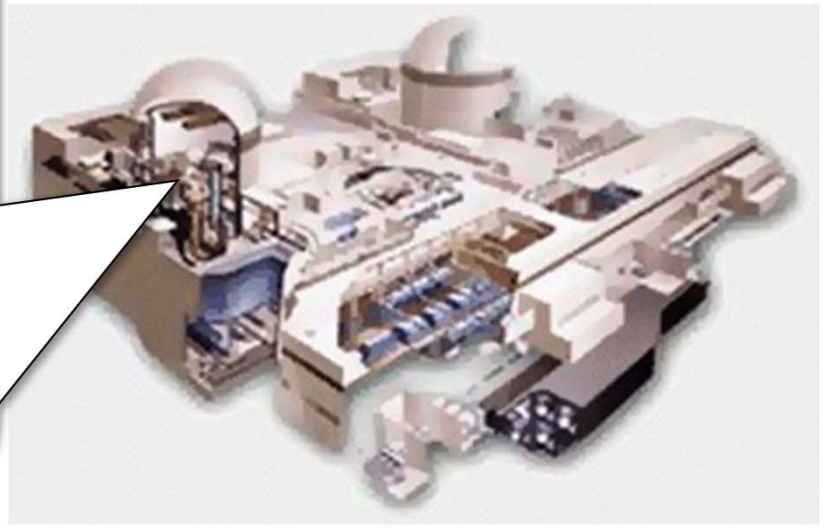
# The reference plant for ATF performance evaluation (PWR)

We selected a large scale Pressurized Water Reactor (PWR) as a reference plant of PWR for ATF performance evaluation.

The following information is needed for evaluation.

- ✓ Detailed plant information such as fuel type, RPV configuration, etc.
- ✓ Appropriate scenario for ATF performance evaluation using the reference PWR

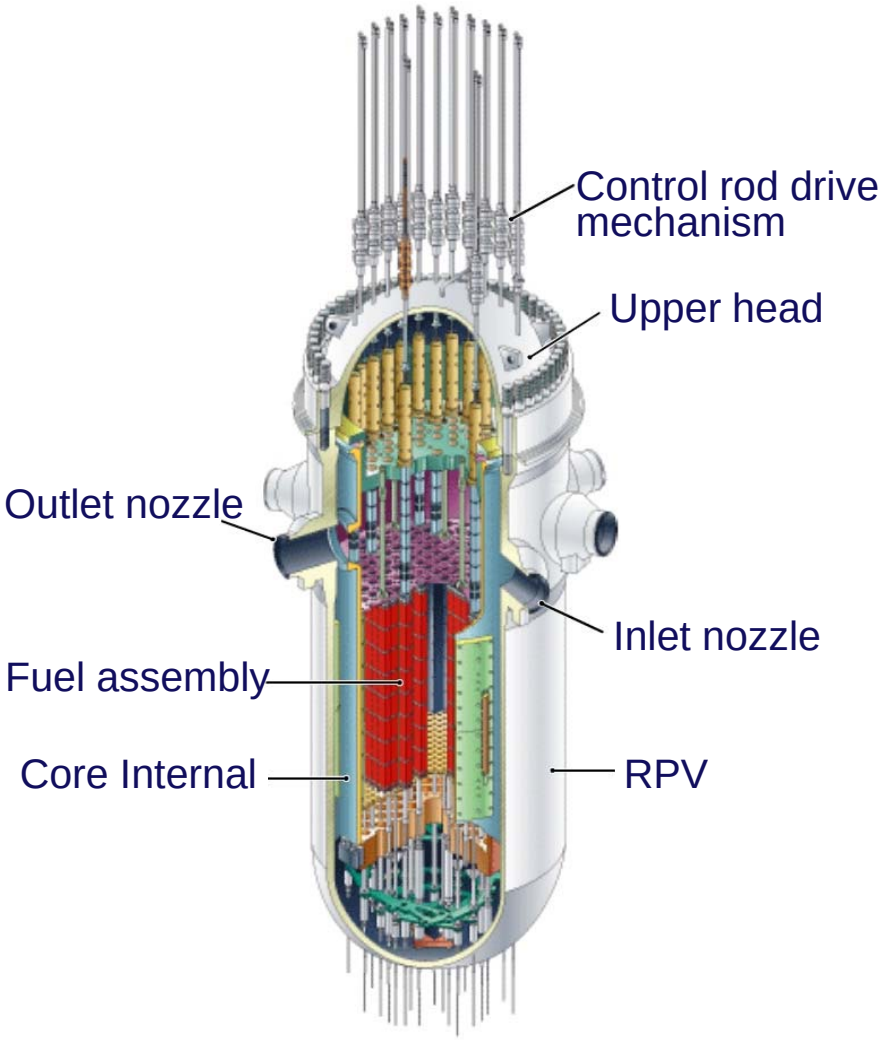


# Plant information for ATF performance evaluation (PWR)

Major plant information for the reference PWR are shown below.

| Items | Reference PWR |
|---|---|
| Thermal power | 3,411MWt |
| Fuel type | 17x17 |
| Number of fuel assemblies | 193 |
| Control rod type | Rod cluster control assemblies |
| Number of control rods | 53 |
| Neutron absorber | Ag-In-Cd |
| RPV diameter | About 4.4 m |
| RPV height | About 12.9 m |
| ATF applications for: | Fuel cladding |




Reference PWR (4 loops)

# Appropriate scenario for ATF performance evaluation (PWR)

The accident scenarios of the reference PWR are grouped into 22 PDSs (Plant damage states). PDSs are represented by combination of three letters shown below:

| |
|---|
| ・RCS pressure at RV failure (High: T**, Medium: S**, Low : A**) |
| ・Timing of core damage (Early: *E*, Late : *L*) |
| ・Timing of containment failure (Before core damage: **C, After core damage: **D, **F, **W, **H, **I)<br>・Availability of molten debris cooling measures (Available: **W, **H, **I, Unavailable: **D, **F)<br>・Availability of containment heat removal measures (Available: **F, **H, **I, Unavailable: **D, **W) |
| ・Containment bypass (V, G) |

Core damage in earlier phase of accidents is severer for ATF performance evaluation, and also lower RCS pressure is severer in terms of the pressure difference between the inside and outside of the fuel pin. Then AE* is appropriate.

AEF, AEW, AEH and AEI are comprehended by AED because containment condition is not dominant.

⇨ AED is selected as the representative PDS for ATF performance evaluation in PWR.

*: A large break LOCA combined with failures of ESSC and heat removal from containment vessel

# Summary

**Reference plant & SA scenario were selected for ATF performance evaluation in Japan.**

**BWR**

Output scale: 3,926MWt
Fuel type: 9x9
CR type: Cross shaped ($B_4C$)
SA scenario: TQUV
Depressurization and power recovery measures are strengthened based on a lesson from Fukushima-Daiichi accident.

**PWR**

Output scale: 3,411MWt
Fuel type: 17x17
CR type: Cluster (Ag-In-Cd)
SA scenario: AED
The severest accident scenario assumed in PWRs were selected as a representative PDS.

**Based on these preconditions, the ATF performance will be analytically evaluated using SA analysis code.**

# Thank you for your attention !!