US-APWR

4th Pre-Application Review Meeting
LOCA Mass and Energy Release
Code and Methodology Applicability

February 1, 2007

Mitsubishi Heavy Industries, Ltd.

Meeting Attendees

Makoto Toyama (Responsible for Safety Analysis for US-APWR)
General Manager
Reactor Safety Engineering Department
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Shigemitsu Umezawa (Responsible for LOCA methodology development)
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Michitaka Kikuta (Responsible for LOCA Analysis for US-APWR)
Engineering Manager
Safeguard System Engineering Section
Nuclear Energy Systems Engineering Center
Mitsubishi Heavy Industries, LTD.

Objectives of Meeting

- **The purpose of the meeting is to:**
  - ✓ Present information to the NRC on the scope of proposed topical report on "Code and Methodology Applicability for the US-APWR Large Break LOCA" to ensure NRC's expectations for the topical report are met
  - ✓ Provide an opportunity for the NRC to explain its process, schedule, expectations, and to provide feedback to MHI

Presentation Summary

1. **SATAN / WREFLOOD codes and methodology will be used for US-APWR LOCA Mass and Energy Release analysis**
   The methodology was approved by NRC
   - ✓ **Westinghouse design 2/3/4 Loop PWRs**
   - ✓ **AP600 and AP1000**
2. **US-APWR design features to be evaluated for applicability of code have been identified and discussed**
   - ✓ **New design**
     - Advanced Accumulator
   - ✓ **Improved design**
     - Direct Vessel Injection (DVI) for Safety Injection Pump
     - Refueling Water Storage Pit (RWSP)
     - Neutron Reflector (NR)

LOCA M&E Release Code and Methodology

- **Approved by NRC as WCAP-10325-P-A**

  Also approved for AP600 and AP1000

  - ✓ SATAN
    - Used for the blowdown phase of the LOCA transient
  - ✓ WREFLOOD
    - Used for the reflood phase of the LOCA transient
  - ✓ Assumptions
    - Conservative initial conditions to maximize initial stored mass and energy
    - Conservative assumptions for releases used to maximize containment pressure

US-APWR Plant Parameter Summary (1)

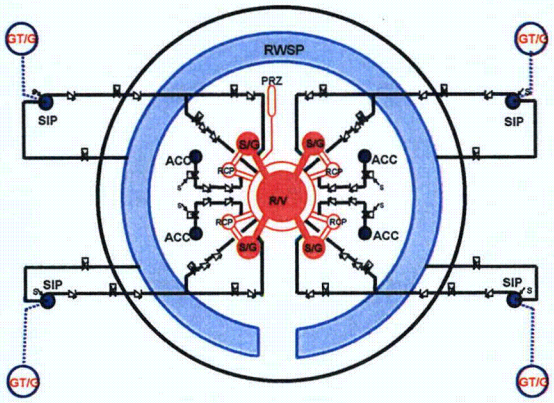
- **Plant class of US-APWR**

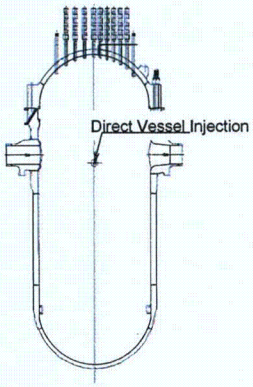
Features	US-APWR	US Current 4 Loop Plant
Core thermal output (MWt)	4,451	3,565
Number of loops, SGs and RCPs	4	4
Number of fuel assemblies	257	193
Fuel rod lattice	17 x 17	17 x 17
Active fuel length (ft)	14	12
Design of Steam generators	U-Tube	U-Tube
Refueling Water Storage Pit location	Inside CV	Outside CV

- **US-APWR ECCS Component Configuration**
  - ✓ 4 accumulators with flow damper (Advanced Accumulator)
  - ✓ 4 safety injection pumps
  - ✓ Refueling Water Storage Pit (RWSP)

US-APWR Plant Parameter Summary (2)

- Four Advanced Accumulators: cold leg injection
- Four safety injection pumps: Direct Vessel Injection (DVI)
- DVI nozzle is located below elevation of centerline of hot-leg and cold-leg nozzles





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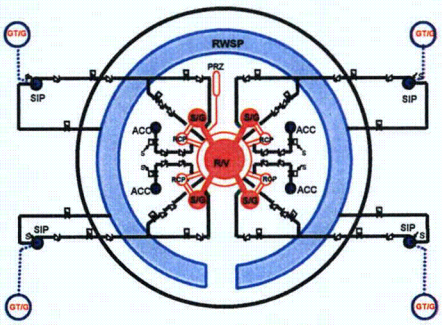
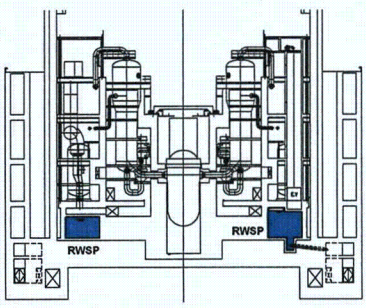
US-APWR Plant Parameter Summary (3)

- RWSP is located at the lowest part of containment vessel
- Provides a continuous suction source for the safety injection pumps
  (Eliminates the switchover of suction source)





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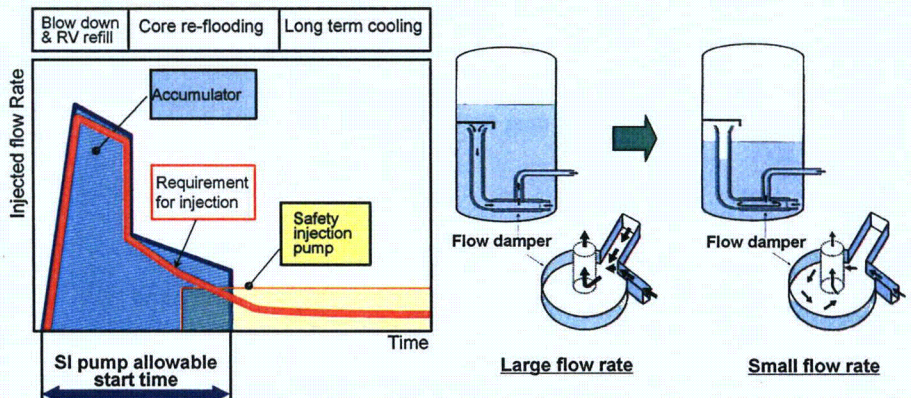
Evaluation Approach

- **US-APWR features which need to be evaluated**
  - ✓ **New Design**
    - Advanced Accumulator
  - ✓ **Improved Design**
    - Direct Vessel Injection (DVI) for Safety Injection Pump
    - Refueling Water Storage Pit (RWSP)
    - Neutron Reflector (NR)

New Features of US-APWR Advanced Accumulator - 1

- **Automatic switching of injection flow rate by flow damper**
- **Integrated function of low head injection system**
- **Long-lasting injection of ACC allows more time for safety injection pump to start**

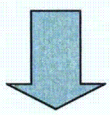


New Features of US-APWR
Advanced Accumulator - 2

- **Parameter that affects LOCA M&E release**
  - ✓ Injection Flow Rate
    - Resistance coefficient changes according to accumulator water level, thereby affects the injection flow rate

New Features of US-APWR
Advanced Accumulator - 3

- **Necessary to simulate**
  - ✓ Automatic switching of injection flow rate by flow damper design
  - ✓ Resistance coefficient of flow damper changes according to accumulator water level and fluid conditions



Empirical correlation will be incorporated into LOCA M&E release codes to model Advanced Accumulator characteristics

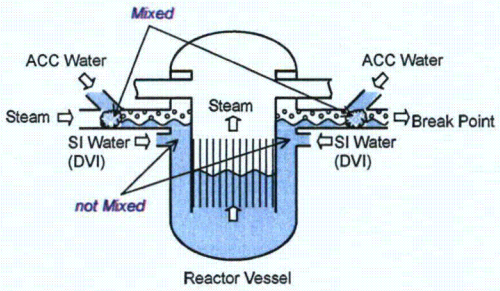
New Features of US-APWR
Direct Vessel Injection (DVI)

➢ Parameters that affect LOCA M&E release

✓ Steam/Water Mixing Model

- Potential for the incomplete interaction between loop steam and safety injection water due to DVI nozzle location
- No mixing of steam and safety injection water should be assumed to calculate energy release to CV conservatively

Necessary to modify LOCA M&E release codes to model no mixing of steam and safety injection water



New Features of US-APWR
Refueling Water Storage Pit (RWSP)

➢ Parameters that affect LOCA M&E release

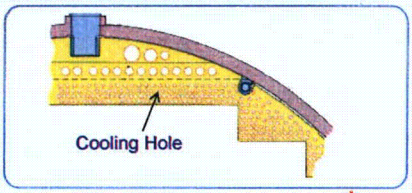
✓ Condition of safety injection water

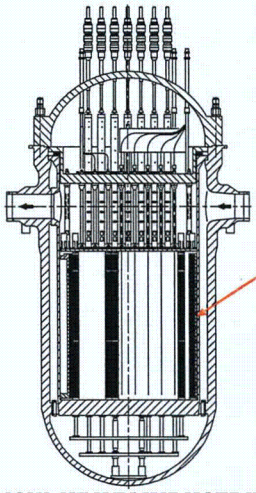
- Following a break, RWSP temperature will change
- ECCS switchover from an external refueling water storage tank is not employed
- The condition of safety injection water is modeled as a fixed or a stepwise changed value in M&E release codes

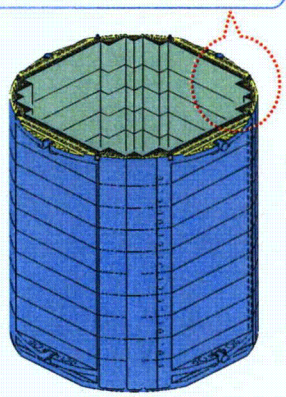
Necessary to modify LOCA M&E release codes to model the continuous change of safety injection water temperature conservatively

New Features of US-APWR
Neutron Reflector (NR) - 1

➢ **Metal Heat Release for LOCA phenomena**
- ✓ Thick metal structure
- ✓ Cooled by water flow with cooling holes







New Features of US-APWR
Neutron Reflector (NR) - 2

➢ **Related Phenomena**
- ✓ Metal Heat Release from NR may affect the mass and energy release to the containment volume
- ✓ Phenomena related to metal heat release from NR
  - Heat transfer mode prediction
  - Vapor generation in NR
  - Reflood phenomena in NR

➢ **Code Application**
- ✓ Metal Heat Release from NR will be calculated by conservative heat release model in WREFLOOD to maximize energy release to CV

Summary

- SATAN / WREFLOOD codes and methodology will be used for US-APWR LOCA M&E release analysis
- SATAN / WREFLOOD codes and methodology were approved by NRC for Westinghouse design 2/3/4 Loop PWRs, AP600 and AP1000
- US-APWR design features to be evaluated have been identified and conservative modeling will be utilized
- Topical Report for code and methodology applicability will be submitted by the end of July, 2007