US-APWR Fukushima Evaluation

February 7, 2012

US-APWR DCWG

Agenda

- Presentation Purpose and Objective
- Lessons from Fukushima
- US-APWR Hazard Design Bases
- US-APWR Fukushima Related Design Features
- US-APWR Strategy for Major Design-Related Fukushima Actions
- US-APWR DCD Licensing Strategy
- Conclusions

Presentation Purpose

To discuss US-APWR plans for addressing design-related safety enhancements in response to the Fukushima Near Term Task Force (NTTF) recommendations

Presentation Objective

Demonstrate that the US-APWR Design provides enhanced safety features and safety margin consistent with Commission policy statement for advanced reactors and NTTF recommendations

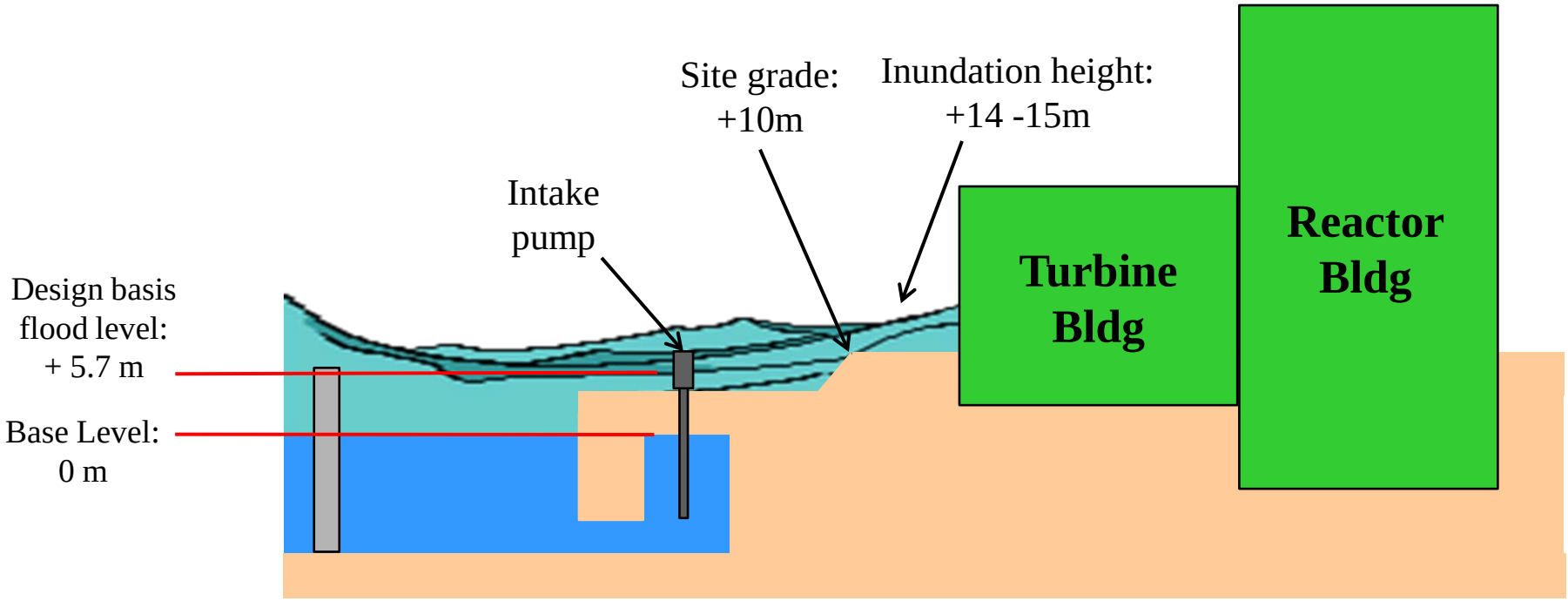
Lessons from Fukushima

Summary of Events

- Earthquake strikes Japan
  - 14:46 Japan Standard Time on March 11, 2011
  - Magnitude 9.0
  - Epicenter approximately 180 km from Fukushima Dai-ichi
- Grid is lost
  - Operating Units trip
  - EDGs start as designed (one EDG on Unit 4 was out for maintenance)
  - ESF appear to operate properly
- Approximately 40 min later, plant is struck by tsunami
  - All AC power lost – Units 1, 2, 3, 4, 5
  - All DC power lost – Units 1 and 2
  - 1 air cooled EDG on Unit 6 continued to function

Source: INPO 11-005, Special Report on the Nuclear Accident at the Fukushima Daiichi Nuclear Power Station

Fukushima Flood Level



Summary of Events

- Earthquake – Loss of Offsite Power
  - Operating plants trip as designed
  - Available EDGs start and load as designed
- Tsunami
  - Loss of Ultimate Heat Sink
  - Total loss of AC power (Units 1, 2, 3, 4, & 5*)
  - Loss of DC power (Units 1 & 2)
  - Loss of core cooling (Units 1, 2, & 3)
  - Disruption of communication systems
  - Loss of monitoring capability

* Power was restored to Unit 5 from the Unit 6 operating air-cooled EDG

US-APWR Hazard Design Bases

US-APWR Design Bases for External Hazards

	US-APWR DCD	CPNPP 3 and 4	North Anna Unit 3
Power Block Grade Elevation	2 ft- 7 in	822 ft	290 ft
Maximum Flood Level (Local probable maximum precipitant(PMP))	1 ft below grade	1.1 ft below grade	1.1 ft below grade
Maximum Groundwater Level	1 ft below grade	1 ft below grade	5.6 ft below grade
Tornado **a. Max. Wind Speed** **b. Translational Speed** **c. Max. Rotational Speed** **d. Radius of Max. Rotation Speed** **e. Pressure Drop** **f. Rate of Pressure Drop**	 a. 230 mph b. 46 mph c. 184 mph d. 150 ft e. 1.2 psi f. 0.5 psi/s	 a. 230 mph b. 46 mph c. 184 mph d. 150 ft e. 1.2 psi f. 0.5 psi/s	 a. 200 mph b. 40 mph c. 160 mph d. 150 ft e. 0.9 psi f. 0.4 psi/s
Seismic bases	0.3 g horizontal and vertical	0.1 g horizontal and vertical	> 0.3 g horizontal and vertical

US-APWR Fukushima Related Design Features

US-APWR Current Design Features (1/4)

System/ Equipment	Specification	Design Features	Design Basis		
			Safety Class	Seismic Category	Location
Containment Protection Systems	• Containment Spray/Residual Heat Removal System	• 4 independent trains • 50% capacity per train • Loss of any two trains will not compromise safety function • Four interconnected concentric spray rings located at different elevations to ensure reliable coverage	Safety Related	Seismic Category I	Reactor Building /PCCV (Seismic Category 1)
	• Combustible Gas Control	• 20 H_2 igniters distributed throughout containment • Automatic or manual operation	Non- Safety Related	Non-Seismic	PCCV (Seismic Category 1)
	• Containment Vent	• Pre-stressed concrete containment vessel with large internal volume • Venting not necessary even for severe accident	Safety Related	Seismic Category I	PCCV (Seismic Category 1)

US-APWR Current Design Features (2/4)

System/ Equipment	Specification	Design Features	Design Basis		
			Safety Class	Seismic Category	Location
Emergency AC Power Source (EPS)	• Emergency Gas Turbine Generators (EPS GTG 4500 kW)	• Air-cooled – UHS independent • 4 independent trains • 7-day supply of fuel for each GTG • Located above design basis flood level • Automatically started and loaded on LOOP	Class 1E	Seismic Category I	Power Source Buildings (Seismic Category I)
Alternate AC Power Source (AAC)	• Alternate Power Sources (AAC GTG 4000 kW)	• Dual systems • Air-cooled – UHS independent • 7-day supply of fuel per GTG • Located above design basis flood level • Automatically started upon LOOP and manually loaded if EPS fails	Non-Class 1E	Non Seismic	Power Source Buildings (Seismic Category I)

US-APWR Current Design Features (3/4)

System/ Equipment	Specification	Design Features	Design Basis		
			Safety Class	Seismic Category	Location
Direct Current Power Supply	• 4 dc batteries • 4 battery chargers • 2 installed spare battery chargers	• Supported by AACs during SBO • Battery capacity: - 2 hours per train	Class 1E	Seismic Category I	Power Source Buildings (Seismic Category I)
Emergency Feedwater System	• 2 M/D EFW Pumps • 2 T/D EFW Pumps • 2 EFW Pits	• Redundant T/D-EFW Pumps capable of manual operation (power independent). • 2 EFW Pits (482,000 gallons total) can supply water to EFW Pumps for 24 hours to maintain hot stand-by (The Demineralized Water tank is an available back-up -- 500,000 gallons: 2-days equivalent, non-safety, non-seismic)	Safety-related	Seismic Category I	Reactor Building (Seismic Category I)

US-APWR Current Design Features (4/4)

System/ Equipment	Specification	Design Features	Design Basis		
			Safety Class	Seismic Category	Location
Ultimate Heat Sink	• Mechanical Draft Cooling Towers • Water Supply Basins	• [4] 50% capacity mechanical draft cooling towers • Loss of any two towers will not compromise safety function • [4] 33⅓% water basins • Minimum 30 day water supply • Not shared between units	Safety Related	Seismic Category I	Site Specific (Seismic Category 1)

US-APWR Strategy for Major Design-Related Fukushima Action Items

US-APWR Strategy (SBO)

(1) 8-hr Coping

a. Operational Strategy

- Use a T/D EFW Pump for core cooling (water source: EFW Pit)
- Manually align AAC to reenergize essential SSCs including DC power systems within 1 hour of SBO

b. Design Enhancement

- AAC GTGs will undergo additional seismic testing to enhance safety margin
- Enhance protection of essential SSCs from beyond design basis external flood by addition of water-tight features to one floor above the DB flood level

c. RCP Seals Safety Margin

- Test RCP Seals to validate seal integrity during SBO without seal cooling capability for a minimum of 8 hrs to ensure safety margin

US-APWR Strategy (SBO)

(2) 72-hr Coping

a. Operational Strategy

- Use a T/D EFW Pump for core cooling (two EFW Pits and a Demineralized Water Tank as water sources)
- Continue use of a diverse AAC to supply essential SSCs

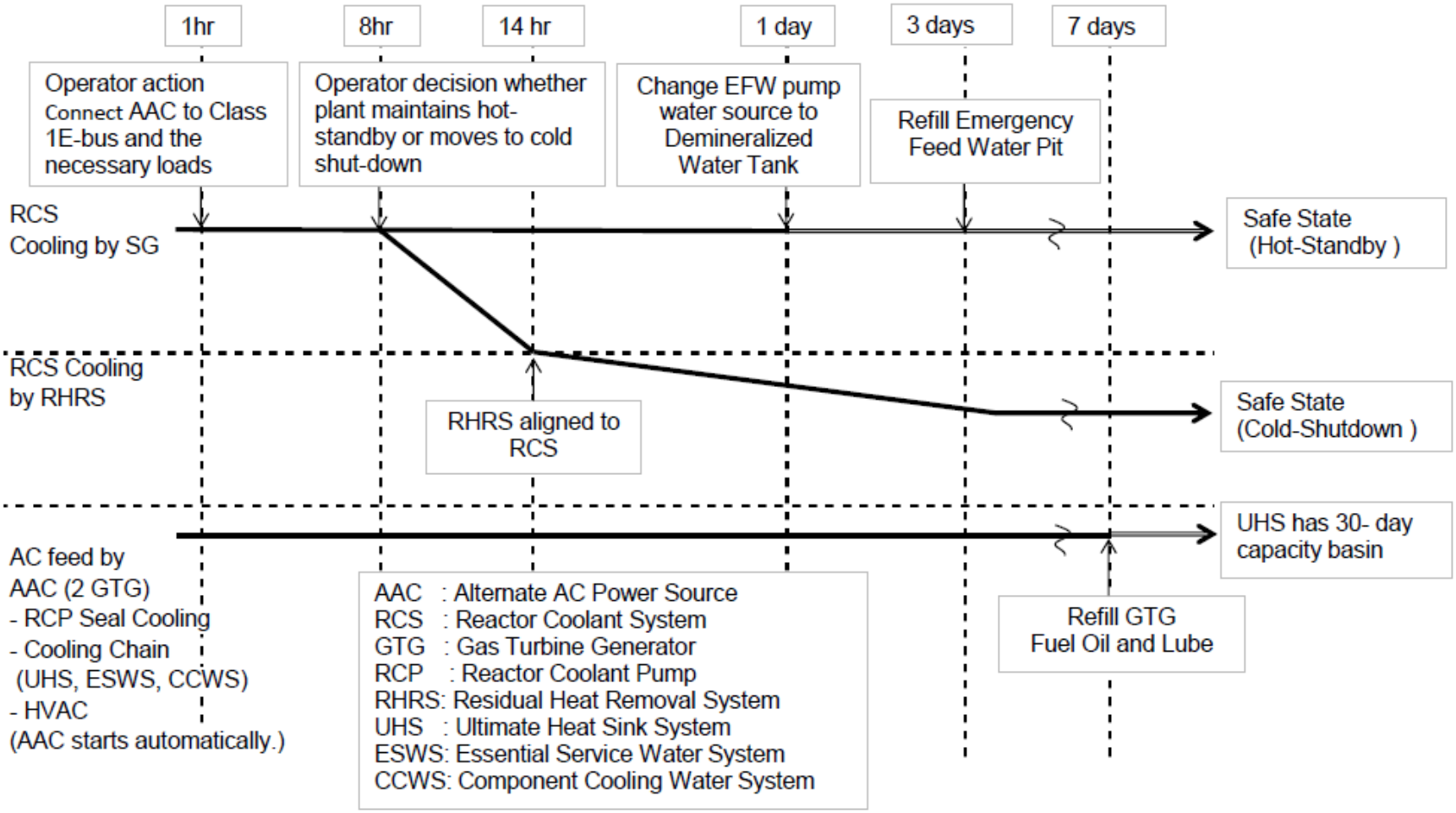
b. Design Enhancement

- Same as 8-hr coping

(3) Extended Coping

- Install additional permanent connections to external portable water pump for the EFWS
- Minimum specifications will be established for required external resources (portable pumps, water sources, etc. – to be supplied by licensee)

Core Cooling Timeline for SBO



AAC start automatically.

US-APWR Strategy (Loss of UHS)

- T/D EFW Pump for core cooling through SGs (two EFW Pits and a Demineralized Water Tank as water sources)
- An AAC GTG can supply power to battery chargers
- An AAC GTG can supply power to a Charging pump (CHP) for RCP seal cooling
- Cooling water can be supplied to CHP by Fire Protection System (FPS)

US-APWR Strategy (SFP)

7.1 SFP Instrumentation

– Intent of NTTF recommendation already met by current design

- Two safety-related SFP level instruments and one non safety-related SFP level instrument with high accuracy
- Two safety-related SFP water temperature instruments
- One non safety-related SFP radiation area monitor

US-APWR Strategy (SFP)

7.2 SFP Makeup System

- Intent of NTTF recommendation already met by current design
- SFP makeup system
  - Water source
    - Refueling Water Storage Pit (safety-related)
    - One Refueling Water Storage Auxiliary Tank (non safety-related)
  - Transfer

    Two Refueling Water Pumps (safety-related) to supply water from RWSP or RWSAT to SFP
- Back-up
  - EFWP water can be fed by gravity to SFP as backup

US-APWR Strategy (SFP)

7.4 Spray Water into SFP

– Implement as recommended by NTTF (design enhancement)

  - Two seismic Category I spray water lines to SFP

Strategy for Extended Beyond-Design-Basis Events

- Current Situation
  - Awaiting criteria for “extended beyond-design-basis events”
  - Awaiting criteria for new vs. existing plants
  - Regulatory Uncertainty for resolving issues related to extended beyond-design-basis events
  - US-APWR design has design attributes that provide differing and varied capabilities

Strategy for Extended Beyond-Design-Basis Events

- US-APWR design attributes provide capability for coping with “extended beyond-design-basis events” of loss of AC and loss of AAC for an extended period
  - Water Inventory
  - RCP Seals
  - Steam Driven Emergency Feedwater pumps
- Additional minor design changes for FLEX coping will be evaluated to ensure NRC requirements are met

US-APWR design has robust capability for coping with Extended Beyond-Design-Basis Events

Licensing Strategy

Licensing Strategy

Licensing Action Plan

- Describe Capability of US-APWR Design
- Provide Technical Report and DCD change markups describing enhancements (December 2012)
- Address RAIs and complete NRC review prior to Phase 4 (Issuance of SER with no Open Items)

Needed NRC Support

- Provide a focused review of Fukushima related issues
- Conduct review of MHI response to Fukushima Task Force Recommendations as part of ongoing DCD review
- Provide review independently of any other anticipated rulemaking in order to maintain current review schedule

Conclusions

Conclusions

- The US-APWR design provides enhanced safety features and safety margin
- Additional design enhancements will be made to the US-APWR standard design to provide assurance of maintaining reactor safety margins during “extended beyond-design-basis events”
- The US-APWR design has substantial SBO capability and can withstand “extended beyond-design-basis events” similar to Fukushima Dai-ichi
- MHI believes US-APWR “Fukushima-like” event mitigation capability can be certified as part of the DCD Rulemaking