Development of the APR+ Auxiliary Building General Arrangement (GA)

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1. Introduction

The general arrangement (GA) drawing of a nuclear power plant is the most basic drawing which contains all of the plant equipment, systems, and rooms. Therefore, it should be issued at an early design stage to provide the contours of the overall plant structure. This type of drawing is typically used widely throughout the design stages.

The development project of APR+ (Advanced Power Reactor+), as a succeeding model of the APR1400 (Advanced Power Reactor 1400) design, has its own GA that encompasses all of its power buildings. This was developed starting in October of 2009. Among several of the buildings in this design, the Auxiliary Building (AB) is one of the most important buildings to produce electricity, and to protect against undesirable radiation emissions.

This paper focuses on the design characteristics of the general arrangement of the AB.

2. Design requirements for the GA

The main purpose of the APR+ GA is not only to develop an economical structure but also to ensure a safe structure so as to gain a competitive advantage in world markets.

The design requirements for the auxiliary building GA are described in several documents as a specific item. The requirements listed below are related to the building structure. A diverse range of other requirements is also described in this paper.

- NRC Standard Review Plan
  - Ch.3.2 Classification of Structures, Components, and Systems
  - Ch.3.5 Missile Protection
  - Ch.12.3 Radiation Protection Design Features
- APR+ Top-Tier Requirements
  - Spent fuel pool storage capacity
  - Structure modularization
  - Air-Craft Crash

3. The GA of the Auxiliary Building

3.1 Arrangement Criteria

Most of the basic allocation criteria were established during the initial GA development stage. The two units of at the plants are arranged alongside each other, and the common Compound Building, which can handle radwaste materials, was located between the two unit plants. An AB structure wrapped around the Reactor Containment Building (RCB), and it was divided into four quadrant areas. The fuel handling facilities were located in the AB quadrant C Area. The Emergency Diesel Generators were located outside the AB area, and the CCW pumps were located in the interior of the AB area, unlike in the APR1400 plant.

3.2 The design features of AB

The Auxiliary Building (AB) is designed as a Steel Concrete (SC) structure with seismic category 1. It shares a common basement with the RCB.

The AB houses the Main Control Room (MCR), the Fuel Handling Area (FHA), and safety-related components such as the Safety Injection System (SIS). The systems and internal structures in the AB are arranged to provide physical separation to minimize hazards from internal and external events such as flooding, fires, security problems, and sabotage.

Table 1. Design features of the AB between APR+ and APR1400

Item	APR+	APR1400
Type	Wrap-around RCB, & 4 Quadrant areas	Wrap-around RCB, & 4 Quadrant areas
Height	37~182 ft	55~200 ft
Aux. feed water Sys.	2 PCCTs 2 Heat exchangers	2 Pumps 2 Tanks
MCR	Level 4 (EL. 100 ft)	Level 6 (EL. 156 ft)
CCW Pump	Inside in rectangle area	Quadrant C, D extended area
4 EDG	independent building	Quadrant C, D inner area of the AB
Total Area	$\approx 8.7 \times 10^4$ ft^2	$\approx 8.2 \times 10^4$ ft^2
Total Volume	$\approx 10.6 \times 10^6$ ft^3	$\approx 10.1 \times 10^6$ ft^3

The internal arrangement of the components is divided into the radiation area and a clean area to reduce the occupational exposure dose. In an effort to improve the level of convenience during the operation and maintenance of plants, the internal layout of the AB was designed to provide the sufficient space.

The location of the MCR is lowered from EL.156 ft to EL. 100 ft to increase accessibility to all building levels. And it can also reduce the overall construction duration by early supplying the electric power. The TSC (Technical Support Center) is located adjacent to the MCR to improve communications between operators and technical crews during abnormal plant situations.

3.3 Perfect Quadrant Arrangement

The APR+ AB was developed to enclose the physically separated four-train safety system, and to protect its SSCs (Structure, System and Components) from spreading as a result of accident, such as an aircraft crash, fire, flood, or missile.

Each piece of the quadrant-separated equipment is fully separated mechanically and electrically, as shown in Fig. 1. It is expected that this design concept will considerably increase safety reliability issues.

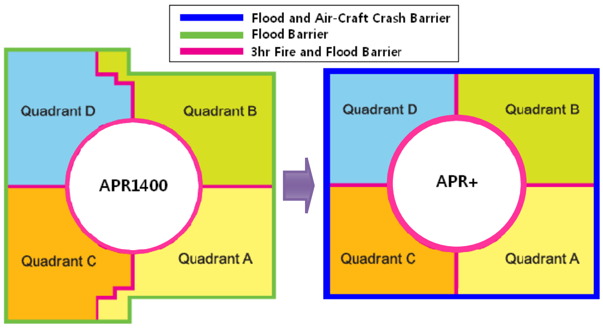

Fig. 1. Quadrant Arrangement of the AB's base floor

3.3 A lower the basement with one-more floor

The building basement of the APR+ AB was lowered from 55 ft to 37 ft. That is, the APR1400 has only two basement floors, whereas the APR+ AB has three basement floors. As the height of the AB building above the ground was lowered, the danger from aircraft crash was lowered as well. This measure also makes it easier to use the construction machinery such as a crane.

Nevertheless, the new construction method also has several side effects. These measures can lead to a rise in the soil excavation quantity, as well as some internal and external flooding problems in the building.

3.4 Separate the EDGs into independent buildings

One of the most important design changes is the separation of the EDG from the AB. Most competitive NPPs (Nuclear Power Plants) have also allocated space for the EDG outside of the AB. The advantage of this design is that such an arrangement could fundamentally resolve the vibration and noise, generated from EDG operations, in the main control room.

As the EDG installation is no longer in the critical construction path, the overall plant construction duration can also be reduced.

In addition, so as not to affect the reliability of C-1E electricity with the change in the location, every EDG is disposed of in the vicinity of each quadrant safety systems.

3.5 Passive Condensate Cooling Tank

The APR+ AB has two PCCTs (Passive Condensate Cooling Tanks) on top of the building to supply the steam generator (SG) with condensed water. The PCCT, one of the new design features, consequently substitutes for a conventional active auxiliary feed-water system. To guarantee minimum water pressure between the SG water level and the PCCT heat exchanger condensate, its required height was evaluated, after which it was allocated to the top area of the AB, as shown in Fig. 2.

3.6 Reinforcing wall thickness

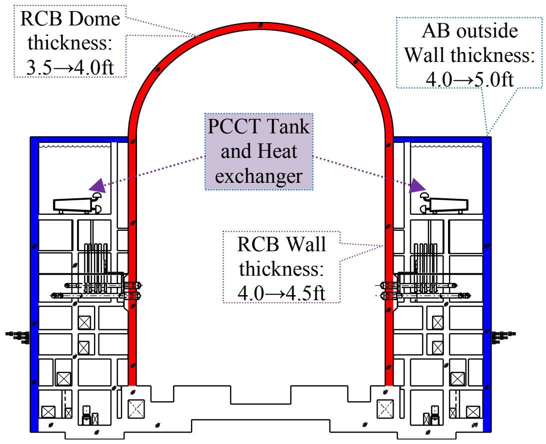

Fig. 2. Reinforced APR+ AB outer wall thickness

According to the recently issued aircraft crash requirements 10CFR52 RIN 3150-AI19 'Consideration of Aircraft Impacts for NPPs', the APR+ has a reinforced wall thickness for not only the RCB but also for the AB, as shown in Fig. 2. Recently, to meet the new requirements, WEC evaluated the potential for an aircraft crash accident of a Boeing 767 and a F18C.

An APR+ structural analysis was also conducted to evaluate the aircraft crash effect by the aforementioned large commercial airplane and military plane. The reinforced outer wall is also expected to prevent destruction by a seismic tsunami.

4. Conclusions

The APR+ AB was developed on the basis of the APR1400 quadrant arrangement design. It was developed to meet the several international requirements. It accommodates four-train physically separated safety related equipment, and two-train PCCTs. Its outer wall is thickened and therefore reinforced for protection against an air-craft crash. The EDGs are located in an independent building which is separated from the AB.

The overall structure volume of the AB is increased somewhat owing to several new pieces of safety related equipment, and the new EDG buildings.

REFERENCES

[1] NETEC, APR+ General Arrangement drawing, Rev.B, 2010.

[2] NETEC, APR+ BOP and Plant Design Report, Vol.1, Rev.1, 2011.