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Characteristics 0f EU-APR General Arrangement and Structure Design

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1. Introduction

General arrangement (GA) development process for the EU-APR is based on the EUR Rev.D[1].
Stringent design criteria are taken into account from all stages of plant design. The EU-APR plant consists of Nuclear Island (NI), Turbine Island (TI) and yard facilities. The NI houses the Containment Building, the Auxiliary Building, the Emergency Diesel Generator Buildings and the Compound Building.

The location of each building is decided considering the functional relationship between the NI+TI, ancillary buildings and circulating water flow routes. Equipment in a building is discriminately located in radiation zone and non-radiation zone to reduce radiation exposure to operators.

The purpose of this paper is to introduce the basic design principles such as separation, segregation, diversity, radiation protection, ALARA consideration applicable to the EU-APR GA configurations as well as design description for the Containment Building and the Auxiliary Building of EU-APR.

2. Design principles for EU-APR

The EU-APR GA is developed based on the EUR Rev.D. This section describes the design principles which are applied in the EU-APR GA layout design.

2.1 Design for Internal and External Hazards

In the development of the EU-APR GA, design hazards have been carefully appraised. The hazards considered include fire, flood, high energy line break, and missiles. The EU-APR GA incorporates several features to accommodate these design hazards.

2.1.1 General Requirements for Design against Hazards

The EU-APR GA is designed to ensure that it can be brought to and maintained at safe shutdown conditions following the occurrence of a design basis hazard. The plant shall be designed to meet the single failure criterion required by the EUR Rev.D for the design of safety systems.

2.1.2 Internal Hazards

Potential hazards originating from inside of the station site boundary shall be considered in the plant design. This shall include, but be not limited to fires, explosions, disruptive failures of pressure parts or rotating machinery, flooding, releases of potentially damaging substances, dropped loads, and failure of static structures.

2.1.3 External Hazards

Potential hazards originating from outside of the plant site boundary shall be considered in the plant design. The EUR Rev.D requires that structures, systems, and components important to safety be designed to withstand the effects of natural phenomena without loss of capability to perform their safety functions. This includes, but is not limited to earthquakes, tornadoes, hurricanes and other extreme winds, flooding from seiche, extreme ambient temperatures, precipitation, and lightning.

Man-made hazards, such as aircraft and other transportation, military, and industrial installations, and requirements for their treatment in nuclear plant design are also covered by other regulations. The EU-APR GA is designed in accordance with applicable regulations.

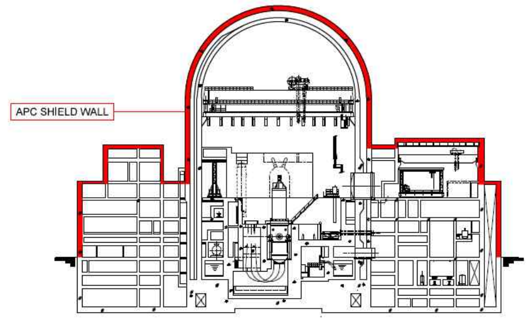

Fig. 1. Protection against Aircraft Crash

2.2 Separation and Diversity of Different Safety Class SSC

The EU-APR employs the use of divisional separation, and quadrant separation for the purposes of flood, fire, high energy line break, and missile hazard protection. A barrier, i.e., divisional wall, is provided between divisions of safety-related equipment located in the Auxiliary Building. Mechanical and electrical systems/components of one division are completely separated from the other division by this divisional wall, which has no unsealed penetrations up to the maximum flood elevation. The arrangement is further divided by quadrant walls. The divisional and quadrant walls serve as the fire resistant barriers classified as EI-M 120, flood barriers (at a lower elevation), and prevent interdivisional system/component interaction from seismic movements, pipe whip, or jet impingement.

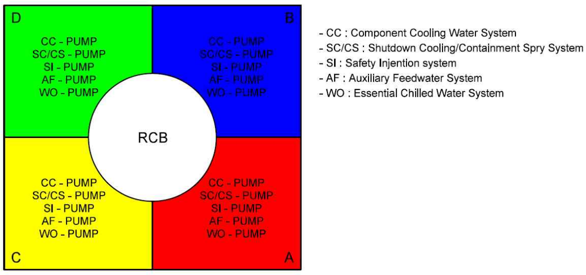

Fig. 2. Separation Concept

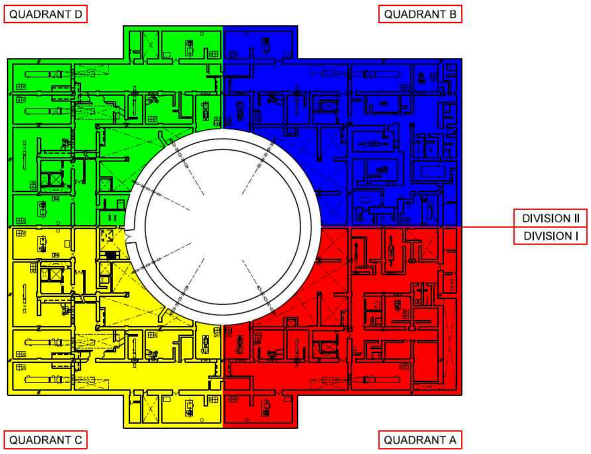

Fig. 3. Physical Separation

Safety related electrical components are divided into four redundant and independent load group train A, B, C and D. The components of each train are located in physically separated SC1 areas of Auxiliary Building so that any single design basis event cannot cause redundant equipment to be simultaneously inoperable.

Separation concept of Hot and Clean zone is applied in the plant design. High radioactive equipment is centrally placed on the lowest floor (elevation -15.0 m). Clean zone is completely separated from Hot zone by physical barrier to prohibit allowance of potentially radioactive contamination as shown in Figure 4 and 5. Radioactive equipment is centrally arranged in Quadrant A and B areas,

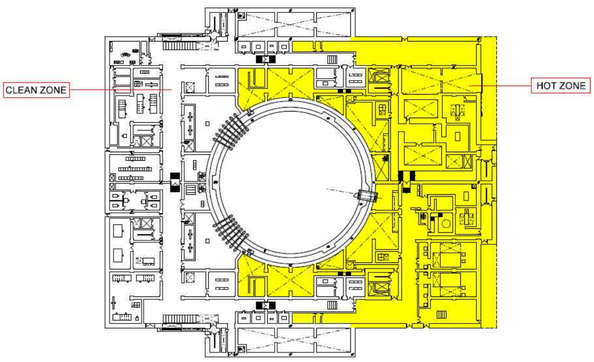

Fig. 4. Clean Zone and Hot Zone at EL 0.0 M(Plan view)

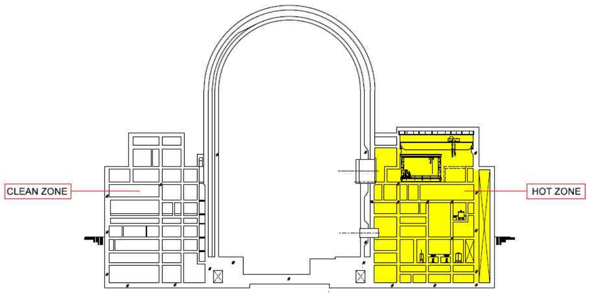

Fig. 5. Clean Zone and Hot Zone (Section View)

whereas Non-Radioactive equipment in Quadrant C and D areas. The physical boundary between Hot and Clean zone is made of concrete with the fire resistant door, and the door opens during construction and tightly closes during normal operation except emergency situations.

2.3 Radiation Protection and ALARA Consideration

The EU-APR design incorporates ALARA principles per the EUR Rev.D to minimize the onsite exposure of plant personnel and operators during normal operation and maintenance activities.

2.3.1 Radiation Access Control

The EU-APR design provides for a single point access into the Radioactive Controlled Area (RCA) from the access control facility; however, mergency egress is provided on all elevations. The access area to the RCA provides a flexible and adaptable layout sufficient to accommodate outage work crews and enhance the availability of immediate interaction with radiation protection personnel stationed at this point. High radiation areas are provided with the capability to have locked doors to prevent inadvertent access by plant personnel. A sufficient quantity of access paths (general access areas) within the RCA are furnished to allow personnel access to equipment. Access to radioactive equipment is designed so that, with properly trained personnel, radiation exposures during all modes of plant operation will meet the ALARA requirements.

Provisions are furnished for access control points to be established in low-level radiation areas so that personnel that may spend a significant time in these areas changing protective clothing and respiratory equipment will absorb a minimum amount of dose in these areas. Adequate space is furnished outside of equipment rooms for personnel to remain in low-level dose areas as much as possible.

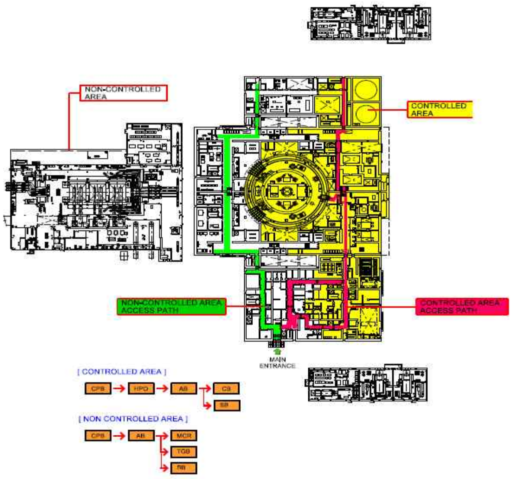

Fig. 6. Power Block Access Route

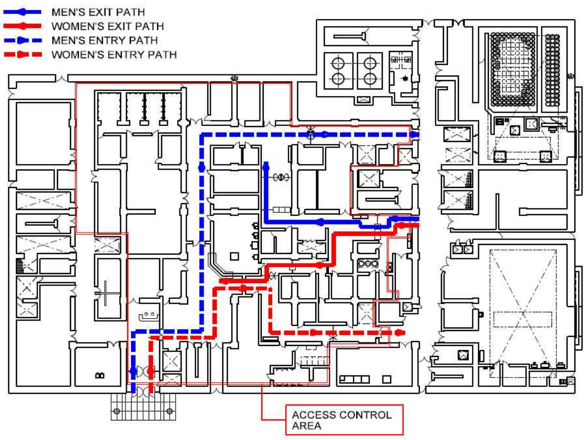

Fig. 7. Access Control Area Arrangement

Space for personnel decontamination areas is provided in the Access Control Facility. Protective clothing, respirators, shower and toilet facilities, lockers, and containers for contaminated clothing may be provided in these areas.

2.3.2 Contamination Control

For the EU-APR, plant ventilation systems are designed so that air flow is from areas of lower potential contamination to areas of higher potential contamination. This design minimizes the potential for the spread of contamination. Curbing is used at the entrance of rooms in which equipment may leak a significant amount of radioactive. This will prevent the spread of contamination in the event of leakage from this type of equipment. Major components are segregated into rooms. The spread of contamination can be minimized by controlled access to these rooms during maintenance activities. Equipment with higher potential for leakage, higher potential radioactivity, and the higher potential for the spread of contamination are segregated from equipment with lower potential. This minimizes the spread of contamination. The vessels containing the noxious substances are located in yard area considering the potential release to reduce the adverse effect.

2.4 Operation, Maintenance and Constructability

2.4.1 Operation and Maintenance

In the development of the EU-APR GA, the viewpoint of operation and maintenance is carefully appraised. The plant operations and maintenance (O&M) considered include the common basemat for the Containment Building and the Auxiliary Building, location of the ECCS pumps in the lowest floor elevation without necessitating pits or a lowered partial floor, the large staging area in front of the equipment hatch, a hot tool crib located in the staging area, and provision of additional space for access, laydown, maintenance and equipment removal. These features not only provide improved O&M capabilities, but also provide improvements in ALARA and Constructability.

2.4.2 Constructability

The EU-APR GA has several features which improve plant constructability. The common basemat is easier to construct since the buildings are tied together. There is no shake space that needs to be sealed for fire, flood and radiation protection. In addition, differential building movements do not need to be considered for piping, cable tray, HVAC duct, doorways, and other structural and building interfaces. This is expected to reduce overall concrete volume of the structures.

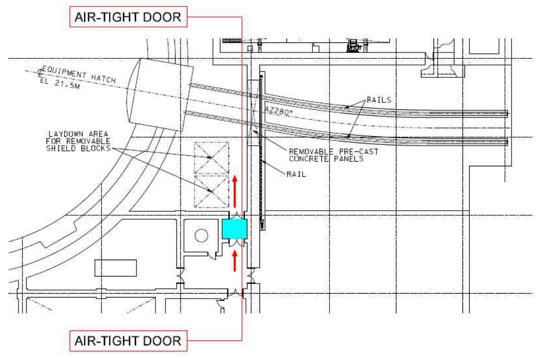

Fig. 8. Outage Staging Area Arrangement Concept

3. Building Design Description

The information contained herein is the general description of the EU-APR GA regarding Nuclear Island. The EU-APR GA is developed based on the separation, shielding, nuclear safety, maintainability and inspectability, occupational safety aspects etc. and has been developed as an advanced light water reactor of 1,400MWe class capacity. The Power Block area consists of CB, AB, EDG/AACDGB, TGB and CPB, as shown in Figure 9.

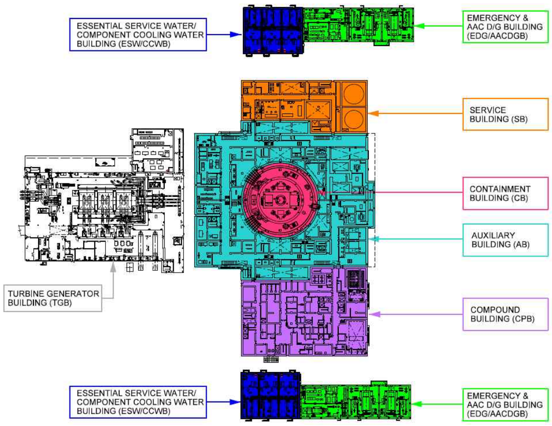

Fig. 9. Figure 4-1 EU-APR GA (Plan View)

The CB consists of a reinforced concrete secondary containment, a steel-lined, post-tensioned concrete primary containment and a reinforced concrete internal structure. The AB provides control and support functions to the CB. The layout of the AB, particularly the physical separation of safety equipment, is designed to improve plant safety. As examples, four-train SISs are arranged to place in the physically separated quadrant of the AB.

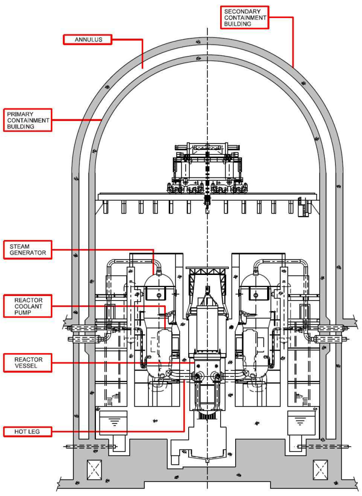

Fig. 9. Containment Building (section view)

The EDG/AACDGBs are seismic category S1 structures which provide protection from fire, missiles and the environment. The TGB houses the turbine generator, the condenser system, feedwater systems and other systems associated with the power generation. The CPB consists of two major areas and functions. These are the access control area system and radwaste treatment systems area.

The major feature of the EU-APR GA is focused on upgrading plant safety, improving economic competitiveness and enhancing plant operation convenience. In compliance with the EUR Rev.D, the plant design is developed and incorporated into the GA of the EU-APR plant.

The Auxiliary Building contains equipment important to safe shutdown and includes the Main Control Room area, electrical and control area, mechanical equipment area, fuel handling area and main steam valve house areas, which provide control and support functions to the Containment Building. The Auxiliary Building completely surrounds the Containment Building and the important part of the external wall is reinforced to provide protection against aircraft crashes and the external missiles. The Auxiliary Building is on a common basemat which forms a monolithic structure with the Containment Building to minimize the seismic interaction problems between the Containment Building and the Auxiliary Building. The structure is designed to withstand the effects of the safe shutdown during earthquake. The Auxiliary Building has eight main floors and three intermediate floors. Both the structural design and physical arrangement of the Auxiliary Building provide protection against both external and internal hazards.

5. Conclusions

This document describes the concept and engineering fundamentals being applied in the preparation of GA for the EU-APR nuclear power plant. The design principles as presented are modeled to satisfy the parameters based on the EUR Rev.D.

Building descriptions reflected the considerations taken into account the safety functions in the formation of GA configurations as shown below:

- separation and segregation for internal and external hazards
- separation and diversity of different safety class SSC
- radiation protection and ALARA considerations
- operations, maintenance and constructability

All of these designs are in progress. Detail information on all of these aspects will be part of the detailed design stages scope.

REFERENCES

[1] "European Utility Requirement document," Vol. 2 Chapter 2.11 Layout, Rev. D, October 2012.