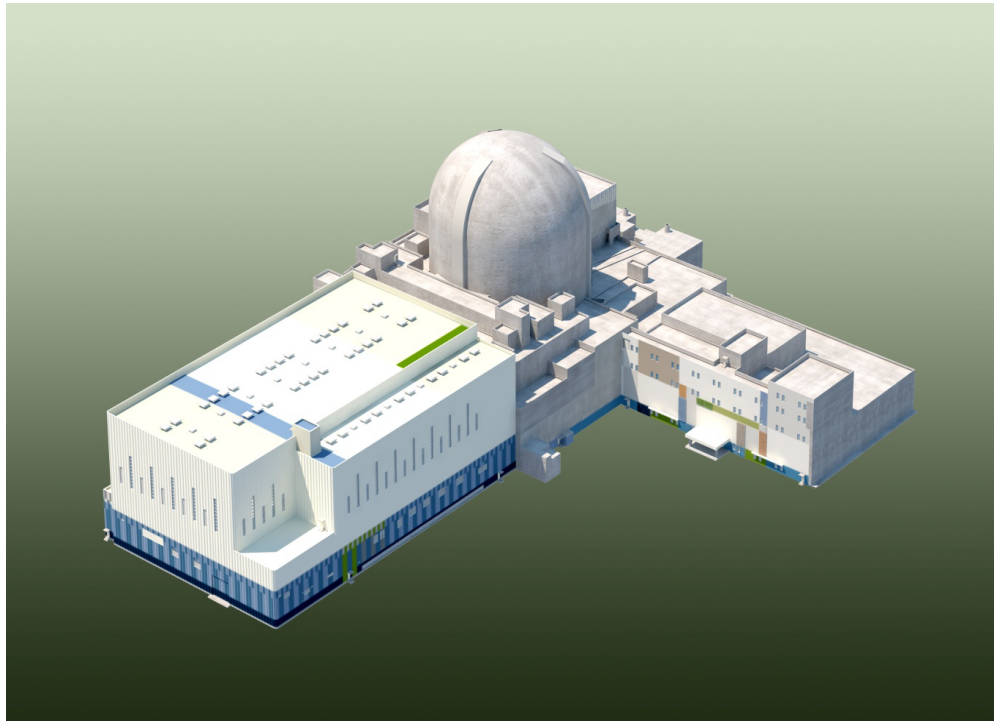
APR1400 Radioactive Waste Management and Radiation Protection



KEPCO/KHNP

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Contents

1. INTRODUCTION

1.1 Design Targets

1.2 RP & RW Design and Analyses

1.1 Design Targets

- **NPP safety design objectives**
  - Protect worker, public & environment from radiation
- **NRC regulations**
  - Developed to achieve the above objectives
- **APR1400 design**
  - Assures to meet NRC regulations

	U.S. NRC Regulations
Definitions	10 CFR 20.1003 • Dose equivalent (H_T) • Effective dose equivalent (H_E) • Total effective dose equivalent (TEDE) • ALI & DAC
Dose limits to worker	10 CFR 20.1201 • 5 rem/y (TEDE) • 50 rem/y (DDE+CEDE) to any organ other than eye lens • 15 rem/y (Dose equivalent) to lens of eye • 50 rem/y (Shallow dose equivalent) to skin
Dose limits to the public	10 CFR 20.1301 • 100 mrem/y (TEDE)
Dose constraints to the public	10 CFR 50 App. I • Gaseous effluents – Gamma air absorbed dose < 10 mrad/y – Beta air absorbed dose < 20 mrad/y – External total body dose < 5 mrem/y – External skin dose equivalent < 15 mren/y – Internal dose equivalent from (I,P) < 15 mrem/y • Liquid effluents – External total body dose < 3 mrem/y – Internal dose equivalent < 5 mrem/y
Accident dose limits	10 CFR 50.34 (Core meltdown) • 25 rem TEDE for any 2 hours at EAB • 25 rem TEDE for entire period at LPZ • 5 rem TEDE for entire period in MCR

1.2 RP & RW Design and Analyses

- Atmospheric Dispersion Analysis (2.3.4-5)
- EQ Total Integrated Dose (TID) Analysis (3.11.5)
- Control Room Habitability Analysis (6.4)
- DBA Fission Product Behavior Analysis (6.5.2)
- Radiation Source Term Analysis (11.1-4, 12.2)
- Radwaste Management Systems (11.2-11.4)
- Radiation Monitoring Systems (11.5, 12.3)
- Dose Assessment for Normal Operation (11.2.3, 11.3.3, 12.4.1)
- Radwaste System Failure Analysis (11.2.3, 11.3.3)
- ALARA Design (12.1, 12.3.1)
- Airborne Source Term & HVAC Design (12.2.2)
- Shielding Design (12.3.2)
- Post-accident Mission Dose Analysis (12.4.1)
- Design to Minimize Contamination (12.4.2)
- Radiological Consequence Analysis for DBAs (15.1-7)

2. APR1400 Design Features

2.1 Effluent Releases During Normal Operations

2.2 Radiological Consequences for DBAs

2.3 Radiation Shielding Design

2.4 Design to Minimize Contamination

2.1 Effluent Releases During Normal Operation (1/3)

❑ Design target

- Ensure doses to the public due to gaseous and liquid effluents are less than 10 CFR 50 App. I

❑ APR1400 design features to minimize normal releases

- Liquid effluents
  - CVCS purifies primary coolant by ion exchangers
  - Radioactive drain system collects and transfers leaking fluids to LWMS
  - Leaks from secondary systems are also monitored and processed
  - LWMS utilizes reverse osmosis and ion exchanger and monitors the releases
- Gaseous effluents
  - Noble gases are degassed by CVCS gas stripper and transferred to GWMS
  - Off-gases are collected and processed by GWMS
  - Containment air is cleaned-up by Containment Purge System
  - Airborne activities are filtered by HEPA and charcoal filters
  - All building vents are monitored

2.1 Effluent Releases During Normal Operation (2/3)

❑ Design Evaluation

- Methods
  - PWR-GALE code is used to estimate annual gaseous/liquid effluent releases
  - Enveloping χ/Q of 2.0E-05 s/m^3 and D/Q of 2.0E-07 /m^2 are used based on EPRI-URD considering DC phase
  - LWMS discharge is assumed to be diluted by cooling water flow of 10,000 gpm
  - GASPAR II and LADTAP II codes are used for dose calculations
- Conclusions
  - Estimated dose results are provided in Table 1
  - APR1400 design complies with public dose limits of 10 CFR 50 App.I and Effluent Concentration Limits (ECL) of 10 CFR 20 App.B

2.1 Effluent Releases During Normal Operation (3/3)

<Table 1> Annual doses to the public due to Normal Operation TS

2.2 Radiological Consequences for DBAs (1/5)

❑ Design targets

- To demonstrate that the doses due to DBAs are within the limits
  - Public at EAB and LPZ : 10 CFR 50.34 (25 rem), SRP 15.0.3 (2.5 – 25 rem)
  - Worker in MCR : GDC 19 (5 rem)

❑ APR1400 design features to minimize accident releases

- SIS with fluidic device to prevent fuel damage
- AFWS with 72-hour capacity for SG cooling
- CSS with 5,000 gpm capacity for fission product removal
- TSP to prevent iodine re-evolution from IRWST
- CREVAS and FHEVAS for emergency filtration by RMS
- CIAS and CPIAS for early isolation of containment bypass
- Steel-lined containment for limitation of leakage
- Automatic selective dual MCR air intakes for less contaminated air supply
- Positive pressure in MCR for minimization of unfiltered in-leakage

2.2 Radiological Consequences for DBAs (2/5)

❑ Design evaluation

- Methods
  - Based on AST and TEDE dose criteria
  - Uses RADTRAD 3.03 and ARCON96 codes
  - Based on thermal-hydraulic safety analyses
  - Conservative X/Q values were used to envelop most U.S. NPP sites
  - Approaches are consistent with RG 1.183 guidance
- Major assumptions and parameters
  - See Table 2-1 through 2-2
- Conclusions
  - Estimated doses are presented in Table 3
  - Doses to the public at EAB/LPZ for all DBAs are well within dose limits of 10 CFR 50.34 (2.5 – 25 rem)
  - MCR habitability is ensured for all DBAs by complying the criteria in GDC 19 (5 rem)

2.2 Radiological Consequences for DBAs (3/5)

<Table 2-1> Assumptions and parameters for LOCA

TS

2.2 Radiological Consequences for DBAs (4/5)

<Table 2-2> Assumptions and parameters for Non-LOCA

TS

2.2 Radiological Consequences for DBAs (5/5)

<Table 3> APR1400 Radiological Consequences for DBAs

TS

2.3 Radiation Shielding Design (1/3)

❑ Design targets

- To ensure the worker exposure ALARA

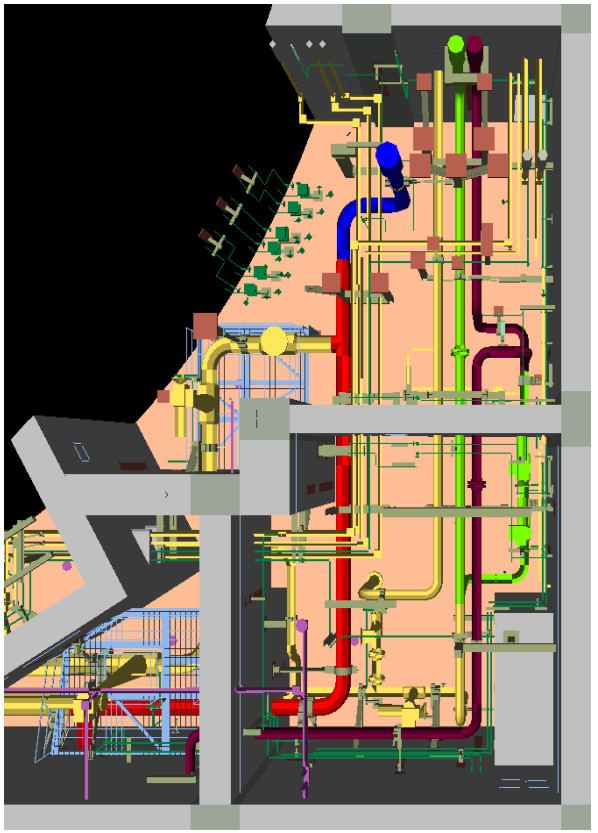
❑ APR1400 design features to minimize exposure

- Source term control
  - High fuel performance of PLUS7
  - Use of low corrosive RCS/SG materials and chemistry to minimize crud production
- Shielding
  - Separation of components by shield walls/floors
  - Pipe routing in shielded pipe chase
  - Adequate shielding and radiation zoning to ensure worker accessibility
- Equipment improvement
  - One-piece removal of SG and use of Alloy-690
  - Integrated Head Assembly(IHA) for ease removal of reactor head

2.3 Radiation Shielding Design (2/3)

❑ Shielding design methods

- Based on 0.25% fuel defect
- Source term calculation codes
  - Core fission product inventory : ORIGEN-S
  - RCS specific activity : DAMSAM
  - CVCS/SCS : SHIELD-APR
  - Radwaste systems : DIJESTER
- Shielding analysis codes
  - Reactor: DORT
  - Primary shield: ANISN
  - Reactor cavity streaming: MCNP
  - Bulk shielding: Microshield
  - Post-accident shielding: RUNT-G



❑ Implementation of shielding design

- Develops radiation zone drawings based on the estimated dose rates, occupancy times and regulatory requirements
- Determines minimum required shield thicknesses (See Figure 1)
- Structure is designed to meet the minimum shield thicknesses

2.3 Radiation Shielding Design (3/3)

<Figure 1> APR1400 Shield design basis drawing (sample) TS

2.4 Design to Minimize Contamination (1/2)

❑ Design Target

- Minimize contamination of facility and environment,
- Facilitate decommissioning and
- Minimize generation of radioactive waste

❑ Regulatory Bases

- 10 CFR 20.1406
- RG 4.21(2008)

❑ Design principles to implement RG 4.21

- Prevention of unintended release
- Early detection, if there is unintended release
- Prompt assessment to support a timely and appropriate response

2.4 Design to Minimize Contamination (2/2)

- **APR1400 design features to minimize contamination**
  - Provides early leak detection
    - Provides trenches in Compound building
    - Provides leak detection instruments for LWMS tanks
    - Segregates the unintended leakage from intended floor drains
  - Minimizes embedded & buried piping
    - Avoid embedded drain pipes to the extent practicable
    - Use of double-walled pipe if applicable
    - Utilize vertical pipe chases for drains
    - Provide underground tunnel for potentially radioactive piping
  - Prevention of facility/environment contamination
    - Leak chases for SFP, IRWST and refueling pool
    - Provides sump maintenance
    - Provides radiation monitoring for leakage from secondary systems

- **APR1400 is designed to comply with RG 4.21**

3. Summary

- Estimation of effluent releases and doses to the public due to normal operation of APR1400 meet 10 CFR 50 App.I limits using conservative X/Qs and default consumption parameters in RG 1.109
- Results of APR1400 radiological consequence analyses for DBAs comply with 10 CFR 50.34 (Public) and GDC 19 (MCR operator) using conservative site-envelope X/Qs
- Shielding design for APR1400 ensure that the occupational exposure comply with 10 CFR 20 and is maintained ALARA
- Implementation of RG 4.21 requirements at the design stage ensures that operation of APR1400 will minimize contamination of facility and environment for future decommissioning