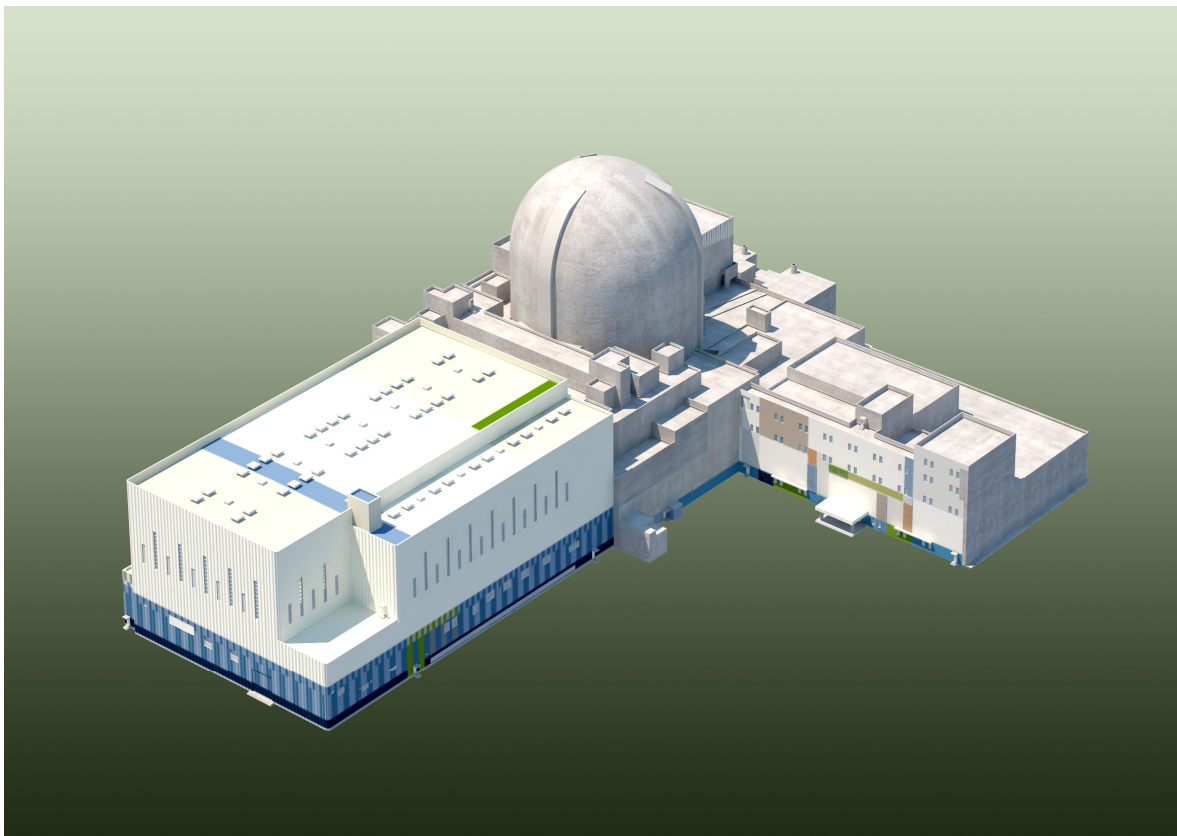


APR1400
DESIGN CONTROL DOCUMENT TIER 2

CHAPTER 11
RADIOACTIVE WASTE MANAGEMENT

APR1400-K-X-FS-13002
REVISION 0
SEPTEMBER 2013



© 2013

KEPCO and KHNP

All Rights Reserved

This document was prepared for the design certification application to the U.S. Nuclear Regulatory Commission and contains technological information that constitutes intellectual property.

Copying, using, or distributing the information in this document in whole or in part is permitted only by the U.S. Nuclear Regulatory Commission and its contractors for the purpose of reviewing design certification application materials. Other uses are strictly prohibited without the written permission of Korea Electric Power Corporation and Korea Hydro & Nuclear Power Co., Ltd.

CHAPTER 11 – RADIOACTIVE WASTE MANAGEMENT

TABLE OF CONTENTS

<u>NUMBER</u>	<u>TITLE</u>	<u>PAGE</u>
CHAPTER 11 – RADIOACTIVE WASTE MANAGEMENT		11.1-1
11.1 Source Terms.....		11.1-1
11.1.1	Design Basis Source Term	11.1-2
11.1.1.1	Fission Product Activities in the Reactor Coolant.....	11.1-2
11.1.1.2	Spent Fuel Pool and Refueling Pool Activities	11.1-5
11.1.1.3	Secondary System Activity.....	11.1-6
11.1.1.4	Radwaste System Activities.....	11.1-10
11.1.1.5	Volume Control Tank Activity	11.1-10
11.1.1.6	Reactor Drain Tank Activity	11.1-10
11.1.1.7	Gas Stripper Activity	11.1-11
11.1.1.8	Equipment Drain Tank Activity.....	11.1-11
11.1.2	Expected Source Term	11.1-11
11.1.2.1	Reactor Coolant Activities.....	11.1-11
11.1.2.2	Spent Fuel Pool and Refueling Pool Activities	11.1-11
11.1.2.3	Secondary System Activities	11.1-12
11.1.3	Neutron Activation Products.....	11.1-12
11.1.3.1	Deposited Crud Activities.....	11.1-12
11.1.3.2	Carbon-14 Production.....	11.1-14
11.1.3.3	Argon-41 Production and Releases	11.1-15
11.1.3.4	Nitrogen-16 Production	11.1-15
11.1.4	Tritium Production in Reactor Coolant.....	11.1-16
11.1.4.1	Activation Sources of Tritium	11.1-16
11.1.4.2	Tritium from Fission.....	11.1-17
11.1.4.3	Tritium Concentrations in the Secondary System	11.1-17
11.1.5	Leakage Sources	11.1-18
11.1.6	Combined License Information	11.1-18
11.1.7	References.....	11.1-18

APR1400 DCD TIER 2

11.2	Liquid Waste Management System.....	11.2-1
11.2.1	Design Bases.....	11.2-2
11.2.1.1	Design Objectives.....	11.2-2
11.2.1.2	Design Criteria.....	11.2-2
11.2.1.3	Method of Treatment	11.2-6
11.2.1.4	Radioactive Source Terms in LWMS	11.2-7
11.2.1.5	Site Cost-Benefit Analysis.....	11.2-8
11.2.1.6	Mobile or Temporary Equipment	11.2-8
11.2.2	System Description.....	11.2-9
11.2.2.1	Liquid Waste Processing System Operation.....	11.2-10
11.2.2.2	Liquid Waste Processing System Operation.....	11.2-13
11.2.2.3	Component Description.....	11.2-14
11.2.2.4	Design Features	11.2-18
11.2.3	Radioactive Effluent Releases	11.2-22
11.2.3.1	Radioactive Effluent Releases and Dose Calculation in Normal Operation	11.2-22
11.2.3.2	Radioactive Effluent Release due to Failure of Radioactive Liquid Tank.....	11.2-24
11.2.3.3	Offsite Dose Calculation Manual	11.2-25
11.2.4	Testing and Inspection Requirements	11.2-25
11.2.5	Combined License Information	11.2-25
11.2.6	References.....	11.2-27
11.3	Gaseous Waste Management System.....	11.3-1
11.3.1	Design Bases.....	11.3-2
11.3.1.1	Design Objectives.....	11.3-2
11.3.1.2	Design Criteria.....	11.3-2
11.3.1.3	Other Design Considerations.....	11.3-5
11.3.1.4	Method of Treatment	11.3-8
11.3.1.5	Radioactive Source Terms in the GRS	11.3-9
11.3.1.6	Site-Specific Cost-Benefit Analysis	11.3-10
11.3.1.7	Mobile or Temporary Equipment	11.3-11
11.3.2	GRS Description.....	11.3-11

APR1400 DCD TIER 2

11.3.2.1	Component Description	11.3-14
11.3.2.2	Design Features	11.3-15
11.3.3	Radioactive Effluent Releases	11.3-20
11.3.3.1	Radioactive Effluent Releases and Dose Calculation in Normal Operation	11.3-20
11.3.3.2	Radioactive Effluent Releases and Dose Calculation Due to Gaseous Waste Management System Leak or Failure	11.3-22
11.3.3.3	Offsite Dose Calculation Manual	11.3-24
11.3.4	Process Vent Subsystem.....	11.3-24
11.3.5	Testing and Inspection Requirements	11.3-24
11.3.5.1	Instrumentation Testing Requirements	11.3-25
11.3.5.2	Preoperational Inspection	11.3-25
11.3.6	Instrumentation Requirements	11.3-25
11.3.7	Combined License Information	11.3-26
11.3.8	References.....	11.3-27
11.4	Solid Waste Management System	11.4-1
11.4.1	Design Bases.....	11.4-1
11.4.1.1	Design Objectives.....	11.4-1
11.4.1.2	Design Criteria.....	11.4-2
11.4.1.3	Other Design Considerations.....	11.4-4
11.4.1.4	Method of Treatment	11.4-6
11.4.1.5	Radioactive Source Terms in SWMS	11.4-7
11.4.1.6	Site-Specific Cost-Benefit Analysis	11.4-8
11.4.1.7	Mobile Equipment	11.4-9
11.4.2	System Description	11.4-9
11.4.2.1	Dry Solid Waste	11.4-11
11.4.2.2	Wet Solid Waste.....	11.4-12
11.4.2.3	Packaging, Storage, and Shipping	11.4-14
11.4.2.4	Operation and Personnel Doses	11.4-15
11.4.2.5	Design Features	11.4-16
11.4.3	Radioactive Effluent Releases	11.4-20

APR1400 DCD TIER 2

11.4.4	Process Control Program	11.4-20
11.4.5	Component Descriptions.....	11.4-21
11.4.5.1	Tanks.....	11.4-21
11.4.5.2	Piping and Valves	11.4-21
11.4.5.3	Solid Waste Compactor	11.4-22
11.4.5.4	Sorting and Shredding Facility	11.4-22
11.4.5.5	Traveling Bridge Crane	11.4-22
11.4.5.6	R/O Concentrate Treatment System	11.4-22
11.4.6	Malfunction Analysis.....	11.4-22
11.4.7	Testing and Inspection Requirements	11.4-23
11.4.8	Instrumentation Requirements	11.4-23
11.4.9	Combined License Information	11.4-24
11.4.10	References.....	11.4-25
11.5	Process and Effluent Radiation Monitoring and Sampling Systems	11.5-1
11.5.1	Design Bases.....	11.5-1
11.5.1.1	Design Objective	11.5-1
11.5.1.2	Design Criteria.....	11.5-2
11.5.2	System Description.....	11.5-6
11.5.2.1	Monitor Design and Configuration.....	11.5-6
11.5.2.2	Gaseous PERMSS	11.5-7
11.5.2.3	Liquid PERMSS	11.5-9
11.5.2.4	Design Features for Minimization of Contamination	11.5-12
11.5.3	Effluent Monitoring and Sampling	11.5-14
11.5.4	Process Monitoring and Sampling.....	11.5-16
11.5.5	Combined License Information	11.5-16
11.5.6	References.....	11.5-17
APPENDIX 11A – Core Residence Times		11A-1
APPENDIX 11B – Primary-to-Secondary Leakage Detection		11B-1

APR1400 DCD TIER 2

LIST OF TABLES

<u>NUMBER</u>	<u>TITLE</u>	<u>PAGE</u>
Table 11.1-1	Parameter Values Used to Calculate the Reactor Coolant Fission Product Source Term	11.1-20
Table 11.1-2	Maximum Reactor Coolant Fission Product Source Term (Core Power: 4,063 MWt, 1.0 % Fuel Defect, Continuous Gas Stripping)	11.1-21
Table 11.1-3	Assumptions Used in Determining Activities in the Spent Fuel Pool Cooling and Cleanup System	11.1-22
Table 11.1-4	Maximum and Expected Specific Activities in the Spent Fuel Pool and Refueling Pool (Bq/g)	11.1-23
Table 11.1-5	Assumptions Used in Determining Secondary System Activities	11.1-24
Table 11.1-6	Design Basis Radionuclide Concentrations in the Secondary System (Bq/g) (1 % Fuel Defect)	11.1-25
Table 11.1-7	Radionuclide Crud Concentrations in the High-Capacity Blowdown Liquid (Bq/g)	11.1-26
Table 11.1-8	Design Basis Radionuclide Concentrations of Sources to GWMS (Bq/cm ³)	11.1-27
Table 11.1-9	Expected Specific Activities of Reactor Coolant During Normal Operation (Core Power: 3,983 MWt, No Gas Stripping)	11.1-28
Table 11.1-10	Expected Radionuclide Concentrations in the Secondary System (Bq/g)	11.1-29
Table 11.1-11	Long-Lived Isotopes in Crud	11.1-30
Table 11.1-12	Parameters for Crud Activity	11.1-31
Table 11.1-13	Long-Lived Crud Activity	11.1-32
Table 11.1-14	Calculated Average Crud Activity in the Reactor Coolant	11.1-33
Table 11.1-15	Tritium Activation Reactions	11.1-34
Table 11.1-16	Parameters Used for Calculating Tritium Production	11.1-35
Table 11.1-17	Tritium Production in the Reactor Coolant	11.1-36

APR1400 DCD TIER 2

Table 11.1-18	Maximum Anticipated Leakage Rates from NSSS-Related Components to the Building Environment	11.1-37
Table 11.2-1	Expected Liquid Radioactive Effluents During Normal Operations, Including AOOs (Bq/yr)	11.2-30
Table 11.2-2	PWR-GALE Code Input Parameters Used to Calculate Annual Gaseous and Liquid Effluent Releases.....	11.2-32
Table 11.2-3	Decontamination Factors for CVCS and LWMS.....	11.2-35
Table 11.2-4	Input Parameters Used for LADTAP II Code	11.2-37
Table 11.2-5	Individual Doses from Liquid Effluents (mSv/yr)	11.2-38
Table 11.2-6	Equipment List in the LWMS	11.2-39
Table 11.2-7	Codes and Standards for Equipment in the LWMS	11.2-44
Table 11.2-8	Radioactive Atmospheric Tank Overflow Protection	11.2-45
Table 11.2-9	Radioactive Concentrations in Nearest Portable Water Due to Liquid Waste Containing Tank Failure	11.2-46
Table 11.2-10	Design Basis Liquid Effluent Concentration at the Site Boundary.....	11.2-48
Table 11.2-11	Expected Radioactive Source Terms for LWMS Tanks (Bq/cm ³).....	11.2-50
Table 11.2-12	Expected Radioactive Source Terms for Other LWMS Components (Bq)	11.2-52
Table 11.3-1	Expected Gaseous Radioactive Effluents During Normal Operation Including AOOs (Bq/yr)	11.3-30
Table 11.3-2	Equipment Codes and Standards for Radwaste Equipment (from NRC RG 1.143, Table 1).....	11.3-32
Table 11.3-3	System Design Parameters.....	11.3-33
Table 11.3-4	GWMS Major Equipment Design Information	11.3-34
Table 11.3-5	Input Parameters for the GASPAR II Code	11.3-36
Table 11.3-6	Design Basis Gaseous Effluent Concentration at the Site Boundary.....	11.3-37
Table 11.3-7	Maximum Offsite Individual Dose Resulting from Normal Plant Gaseous Releases.....	11.3-39
Table 11.3-8	Instrument Indication and Alarm Information Page	11.3-42

APR1400 DCD TIER 2

Table 11.3-9	Gaseous Waste Management System Failure Doses.....	11.3-43
Table 11.3-10	Expected Radioactive Source Terms for GRS Components	11.3-44
Table 11.4-1	Estimated Annual Solid Waste Generation	11.4-29
Table 11.4-2	Expected Activities of Solid Radwaste in the SWMS (Bq/year)	11.4-30
Table 11.4-3	Equipment List for the SWMS	11.4-32
Table 11.4-4	Codes and Standards for SWMS Equipment	11.4-34
Table 11.4-5	Instrument Indication and Alarm Information	11.4-35
Table 11.5-1	Gaseous Process and Effluent Radiation Monitors.....	11.5-20
Table 11.5-2	Liquid Process and Effluent Radiation Monitors.....	11.5-23

APR1400 DCD TIER 2

LIST OF FIGURES

<u>NUMBER</u>	<u>TITLE</u>	<u>PAGE</u>
Figure 11.2-1	Liquid Radwaste System Flow Diagram	11.2-55
Figure 11.2-2	Simplified Liquid Process Model	11.2-62
Figure 11.3-1	Gaseous Radwaste System Flow Diagram	11.3-45
Figure 11.3-2	Simplified Airborne Pathway Release Assessment Process.....	11.3-46
Figure 11.3-3	Gaseous Effluent Release Points and Exhaust Parameters	11.3-47
Figure 11.4-1	Solid Radwaste System Flow Diagram	11.4-36
Figure 11.5-1	Radiation Monitoring System (PR)	11.5-25
Figure 11.5-2A	Location of Radiation Monitors at Plant (REACTOR CONTAINMENT BUILDING EL. 156'-0").....	11.5-28
Figure 11.5-2B	Location of Radiation Monitors at Plant (AUXILIARY BUILDING EL. 55'-0")	11.5-29
Figure 11.5-2C	Location of Radiation Monitors at Plant (AUXILIARY BUILDING EL. 55'-0")	11.5-30
Figure 11.5-2D	Location of Radiation Monitors at Plant (AUXILIARY BUILDING EL. 55'-0")	11.5-31
Figure 11.5-2E	Location of Radiation Monitors at Plant (AUXILIARY BUILDING EL. 78'-0")	11.5-32
Figure 11.5-2F	Location of Radiation Monitors at Plant (AUXILIARY BUILDING EL. 100'-0")	11.5-33
Figure 11.5-2G	Location of Radiation Monitors at Plant (AUXILIARY BUILDING EL. 120'-0")	11.5-34
Figure 11.5-2H	Location of Radiation Monitors at Plant (AUXILIARY BLDG EL. 120'-0").....	11.5-35
Figure 11.5-2I	Location of Radiation Monitors at Plant (AUXILIARY BLDG EL. 120'-0").....	11.5-36
Figure 11.5-2J	Location of Radiation Monitors at Plant (AUXILIARY BLDG EL. 120'-0").....	11.5-37
Figure 11.5-2K	Location of Radiation Monitors at Plant (AUXILIARY BUILDING EL. 137'-6")	11.5-38

APR1400 DCD TIER 2

Figure 11.5-2L	Location of Radiation Monitors at Plant (AUXILIARY BUILDING EL. 137'-6")	11.5-39
Figure 11.5-2M	Location of Radiation Monitors at Plant (AUXILIARY BUILDING EL. 137'-6")	11.5-40
Figure 11.5-2N	Location of Radiation Monitors at Plant (AUXILIARY BUILDING EL. 156'-0")	11.5-41
Figure 11.5-2O	Location of Radiation Monitors at Plant (AUXILIARY BUILDING EL. 156'-0")	11.5-42
Figure 11.5-2P	Location of Radiation Monitors at Plant (AUXILIARY BUILDING EL. 174'-0")	11.5-43
Figure 11.5-2Q	Location of Radiation Monitors at Plant (AUXILIARY BUILDING EL. 174'-0")	11.5-44
Figure 11.5-2R	Location of Radiation Monitors at Plant (COMPOUND BUILDING EL. 63'-0").....	11.5-45
Figure 11.5-2S	Location of Radiation Monitors at Plant (COMPOUND BUILDING EL. 85'-0").....	11.5-46
Figure 11.5-2T	Location of Radiation Monitors at Plant (COMPOUND BUILDING EL. 100'-0").....	11.5-47
Figure 11.5-2U	Location of Radiation Monitors at Plant (COMPOUND BUILDING EL. 100'-0").....	11.5-48
Figure 11.5-2V	Location of Radiation Monitors at Plant (COMPOUND BUILDING EL. 120'-0").....	11.5-49
Figure 11.5-2W	Location of Radiation Monitors at Plant (COMPOUND BUILDING EL. 139'-6").....	11.5-50
Figure 11.5-2X	Location of Radiation Monitors at Plant (CCW HX BLDG EL. 113'-0" & 127'-5")	11.5-51
Figure 11.5-2Y	Location of Radiation Monitors at Plant (TURBINE GENERATOR BLDG EL. 73'-0")	11.5-52
Figure 11.5-2Z	Location of Radiation Monitors at Plant (TURBINE GENERATOR BLDG EL. 170'-0")	11.5-53

APR1400 DCD TIER 2

ACRONYM AND ABBREVIATION LIST

AB	Auxiliary Building
ACU	Air Cleaning Unit
ADV	Atmospheric Dump Valve
AHU	Air Handling Unit
ALARA	As Low As Is Reasonably Achievable
ANS	American Nuclear Society
ANSI	American National Standards Institute
AOO	Anticipated Operational Occurrence
API	American Petroleum Institute
APR	Advanced Power Reactor
ASME	American Society of Mechanical Engineers
ASTM	American Society of Testing And Materials
BAC	Boric Acid Concentrator
BTP	Branch Technical Position
CCW	Component Cooling Water
CCWS	Component Cooling Water System
CEA	Control Element Assembly
CFR	Code of Federal Regulations
CIV	Containment Isolation Valve
COL	Combined License
COLA	Combined License Application
CP	1) Condensate Polishing 2) Construction Permit
CREVAS	Control Room Emergency Ventilation Actuation Signal
CTS	Concentrate Treatment System
CVCS	Chemical and Volume Control System
CWT	Chemical Waste Tank
DAC	1) Derived Air Concentration 2) Design Acceptance Criteria

APR1400 DCD TIER 2

DAW	Dry Active Waste
DC	1) Direct Current 2) Design Certification
DCD	Design Control Document
DF	Decontamination Factor
DOT	Department of Transportation
EAB	Exclusion Area Boundary
EDT	Equipment Drain Tank
EFPD	Effective Full Power Day
EPRI	Electric Power Research Institute
ESW	Essential Service Water
EWI	Equipment Waste Tank
FDS	Floor Drain System
FDT	Floor Drain Tank
GDC	General Design Criteria (of 10 CFR 50, Appendix A)
GRS	Gaseous Radwaste System
GWMS	Gaseous Waste Management System
HEPA	High Efficiency Particulate Air
HIC	High Integrity Container
HVAC	Heating, Ventilation, and Air Conditioning
HX	Heat Exchanger
IRWST	In-Containment Refueling Water Storage Tank
LASRT	Low Activity Spent Resin Tank
LPZ	Low Population Zone
LRS	Liquid Radwaste System
LWMS	Liquid Waste Management System
LWR	Light Water Reactor
MCR	Main Control Room
MF	Membrane Filter
MTR	Material Testing Reactor

APR1400 DCD TIER 2

NEI	Nuclear Energy Institute
NNS	Non-Nuclear Safety
NRC	Nuclear Regulatory Commission
NRX	Nuclear Research Reactor
NSSS	Nuclear Steam Supply System
NUREG	U.S. Nuclear Regulatory Commission Regulation
OBE	1) Operating Basis Earthquake 2) Operating Basis Event
P&ID	Piping and Instrumentation Diagram
PTS	Primary-to-Secondary
PWR	Pressurized Water Reactor
QA	Quality Assurance
QAP	Quality Assurance Procedure
QIAS	Qualified Indication and Alarm System
QIAS-N	Qualified Indication and Alarm System – Non-Safety
QIAS-P	Qualified Indication and Alarm System – Post-Accident Monitoring Instrument
RCPB	Reactor Coolant Pressure Boundary
RCS	Reactor Coolant System
RDT	Reactor Drain Tank
RG	Regulatory Guide
R/O	Reverse Osmosis
SC	1) Shutdown Cooling 2) Safety Console
SFP	Spent Fuel Pool
SFPCCS	Spent Fuel Pool Cooling and Cleanup System
SG	Steam Generator
SGBDS	Steam Generator Blowdown System
SRLST	Spent Resin Long Term Storage Tank
SRP	Standard Review Plan
SRS	Solid Radwaste System

APR1400 DCD TIER 2

SSC	Structures, Systems, and Components
SWMS	Solid Waste Management System
TEDE	Total Effective Dose Equivalent
T/G	Turbine-Generator
TID	1) Technical Information Document 2) Total Integrated Dose
TMI	Three Mile Island
USNRC	United States Nuclear Regulatory Commission
VCT	Volume Control Tank