ENCLOSURE 6

WCAP-17712 Addendum 1, Revision 0, "Westinghouse SMR Test Plan – SPES4 Test"

(Non-Proprietary)

Westinghouse Non-Proprietary Class 3

WCAP-17712-NP, Addendum 1
Revision 0

January 2013

Westinghouse SMR Test Plan – SPES4 Test

Westinghouse

WCAP-17712-NP, Addendum 1
Revision 0

Westinghouse SMR Test Plan – SPES4 Test

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Research and Technology

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1 INTRODUCTION

The Westinghouse Electric Company and ENEA[1] have a cooperative agreement to perform a set of integral system tests to provide thermal-hydraulic data for computer code validation and to simulate the operation of Westinghouse Small Modular Reactor (SMR) plant for design licensing.

ENEA commissioned the original SPES[2] facility (located in Piacenza, Italy and operated by SIET[3]) to simulate a Westinghouse 312 Pressurized Water Reactor system with Italian specific design features. In the 1990s, the SPES facility was modified (SPES-2 facility) to simulate the Westinghouse AP600 pressurized water reactor system. SIET will modify the existing SPES-2 facility to simulate the Westinghouse SMR Pressurized Water Reactor system. This modified facility is referred to as SPES-4 in this document.

1. Ente per le Nuove tecnologie, l'Energia e l'Ambiente, Lungotevere Thaon di Revel 76, 00196 Rome, Italy, www.enea.it.
2. Simulatore Per Esperienze di Sicurezza
3. Società Informazioni Esperienze Termoidrauliche, Via Nino Bixio 27, 29100 Piacenza-Italy, www.siet.it

2 TEST OBJECTIVES

The overall objectives of the SPES-4 integral system testing are as follows:
[

]^{a,b,c}

3 TEST FACILITY REQUIREMENTS

3.1 DESIGN

The design of the SPES-4 experimental facility shall comply with the following design constraints.
[

]^{a,b,c}

[

]a,b,c

Westinghouse will be responsible for:

[

]a,b,c

Based on the Westinghouse system level scaling:

[

]a,b,c

SIET is responsible for:
[

]a,b,c

3.2 DESIGN DOCUMENTATION

[

]a,b,c

[

]a,b,c

4 TEST ARTICLE DESCRIPTION

The test articles include simulators for the following components:
[

]a,b,c

a,b,c

Figure 4-1 Schematic representation of SMR SPES-4 test articles

Legend:

ADS: Automatic Depressurization System
UP: Upper Plenum
SG: Steam Generator
ICP: In-containment pool
OCP: Outer containment pool
CMT: Core Makeup Tank
RCP: Reactor Coolant Pump
Accu: Accumulator
HX: Heat Exchanger
Prz: Pressurizer

4.1 REACTOR VESSEL

[

]a,b,c

The following subsections describe the Westinghouse SMR components represented in the reactor vessel.

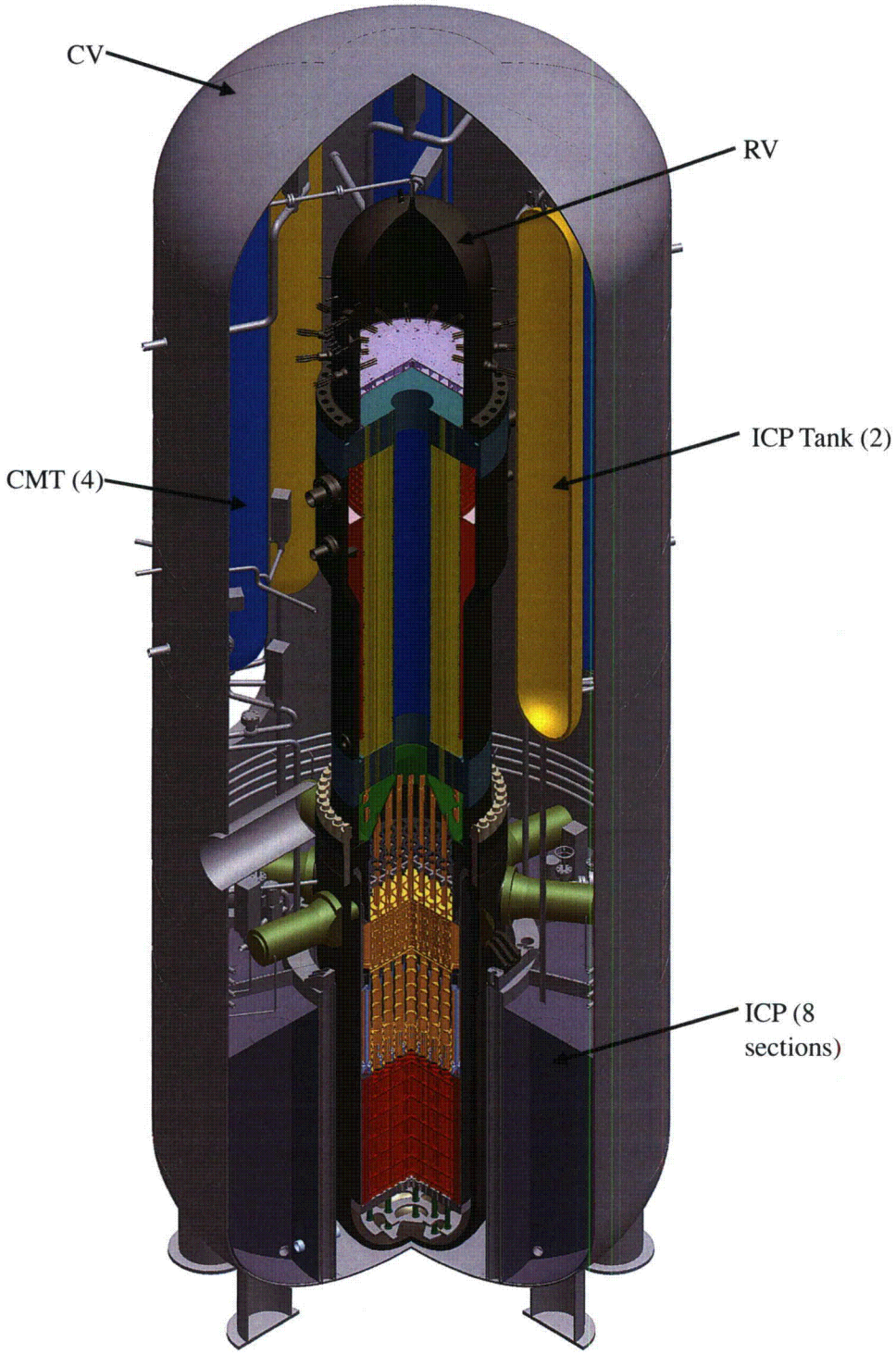

Figure 4-2 SMR Containment Vessel (Reactor Vessel included)

4.1.1 Reactor Core Simulator:

[

]^{a,b,c}

4.1.2 Pressurizer Simulator

[

]a,b,c

4.1.3 Downcomer Simulator

[

]a,b,c

4.2 REACTOR CONTAINMENT

[

]a,b,c

[

]a,b,c

4.3 OUTER CONTAINMENT POOL (OCP)

[

]a,b,c

4.4 AUTOMATIC DEPRESSURIZATION SYSTEM (ADS)

[

]a,b,c

[

]^{a,b,c}

[

]a,b,c

4.5 CORE MAKEUP TANKS/PRHR HX

4.5.1 CMT

[

]a,b,c

[

]a,b,c

4.5.2 CMT Passive Residual Heat Removal Heat Exchanger (PRHR HX)

[

]a,b,c

4.6 IN-CONTAINMENT POOL TANKS

[

]a,b,c

4.7 PXS SECONDARY CMT COOLING SYSTEM

[

]a,b,c

4.8 OUTER CONTAINMENT POOL (OCP)

[

]a,b,c

4.9 PRIMARY CENTRAL RISER

[

]a,b,c

4.10 BORIC ACID TANK

[

]a,b,c

[

]a,b,c

4.11 STEAM GENERATOR PRIMARY SIDE SIMULATOR (SGPSS)

[

]a,b,c

4.12 RCP

[

]a,b,c

5 TEST FACILITY CONTROL

[

]^{a,b,c}

[

]^{a,b,c}

6 DATA ACQUISITION SYSTEM AND INSTRUMENTATION

[

]a,b,c

[

]a,b,c

Table 6-1 Minimum Measurements List

Fluid Temperatures		
N°	**Location**	**Comments**

a,b,c

Table 6-1 (cont.) Minimum Measurements List

Metal Temperatures

N°	Location	Comments

a,b,c

Absolute Pressures

N°	Location	Comments

a,b,c

Table 6-1 (cont.) Minimum Measurements List

Absolute Pressures

N°	Location	Comments

a,b,c

Two phase flow exit quality

N°	Location	Comments

a,b,c

Mass Flow Rates

N°	Location	Comments

a,b,c

Table 6-1 (cont.) Minimum Measurements List

Liquid Levels		
N°	**Location**	**Comments**

a,b,c

Table 6-2 Expected Experimental Uncertainties

a,b,c

7 TEST OPERATION

[

]^{a,b,c}

Table 7-1 SMR SPES-4 Integral Test Matrix

a,b,c

Table 7-1 (cont.) **SMR SPES-4 Integral Test Matrix**

a,b,c

8 TEST REPORT AND DATA REQUIREMENTS

[

]a,b,c

9 QUALITY ASSURANCE REQUIREMENTS

[

]a,b,c

[

]a,b,c

APPENDIX A
SPES-4 SCALING BASIS

[

]a,b,c

A.1 POWER-TO-VOLUME SCALING CRITERIA

[

]a,b,c

Tables A-1 and A-2 show the input that is used for the scaling factor calculation:

a,b,c

[

]a,b,c

a,b,c

[

]a,b,c

[

]a,b,c

A.2 COMPONENT SCALING

[

]a,b,c

A.2.1 Lower Plenum

[ ]a,b,c

Figure A-1 is a pictorial of the SMR lower plenum component:

a,b,c

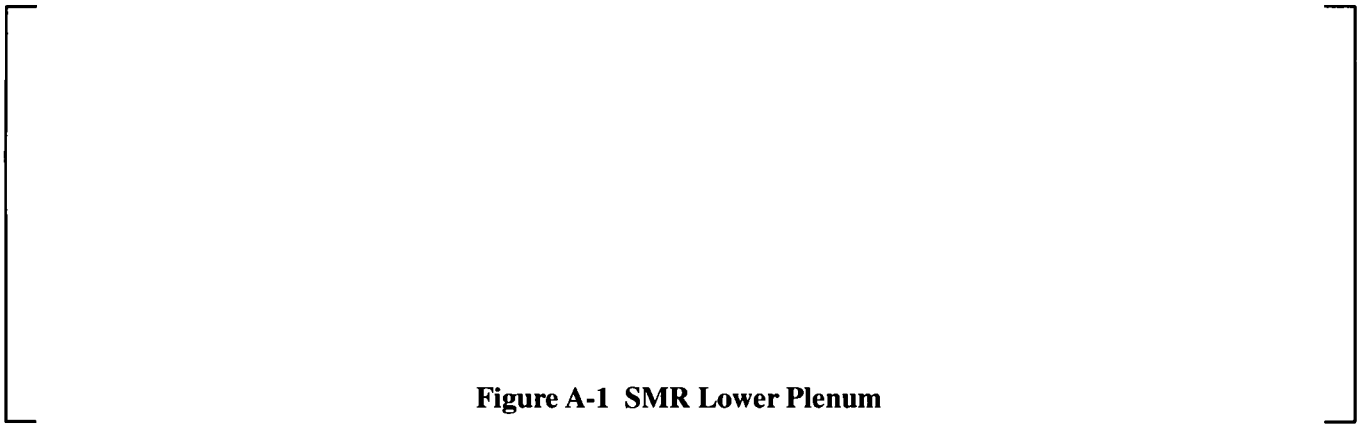

Figure A-1 SMR Lower Plenum

[ ]a,b,c

a,b,c

[

]a,b,c

a,b,c

A.2.2 Downcomer

[

]a,b,c

a,b,c

The downcomer drawing is shown in Figure A-2.

a,b,c

Figure A-2 Downcomer Drawing

A.2.3 Reactor Core

The core parameters for the SMR are listed in Table A-6:

a,b,c

[

]a,b,c

The scaled SPES-4 reactor core parameters are shown in Table A-7.

a,b,c

[

[

]a,b,c

a,b,c

[

[

]a,b,c

a,b,c

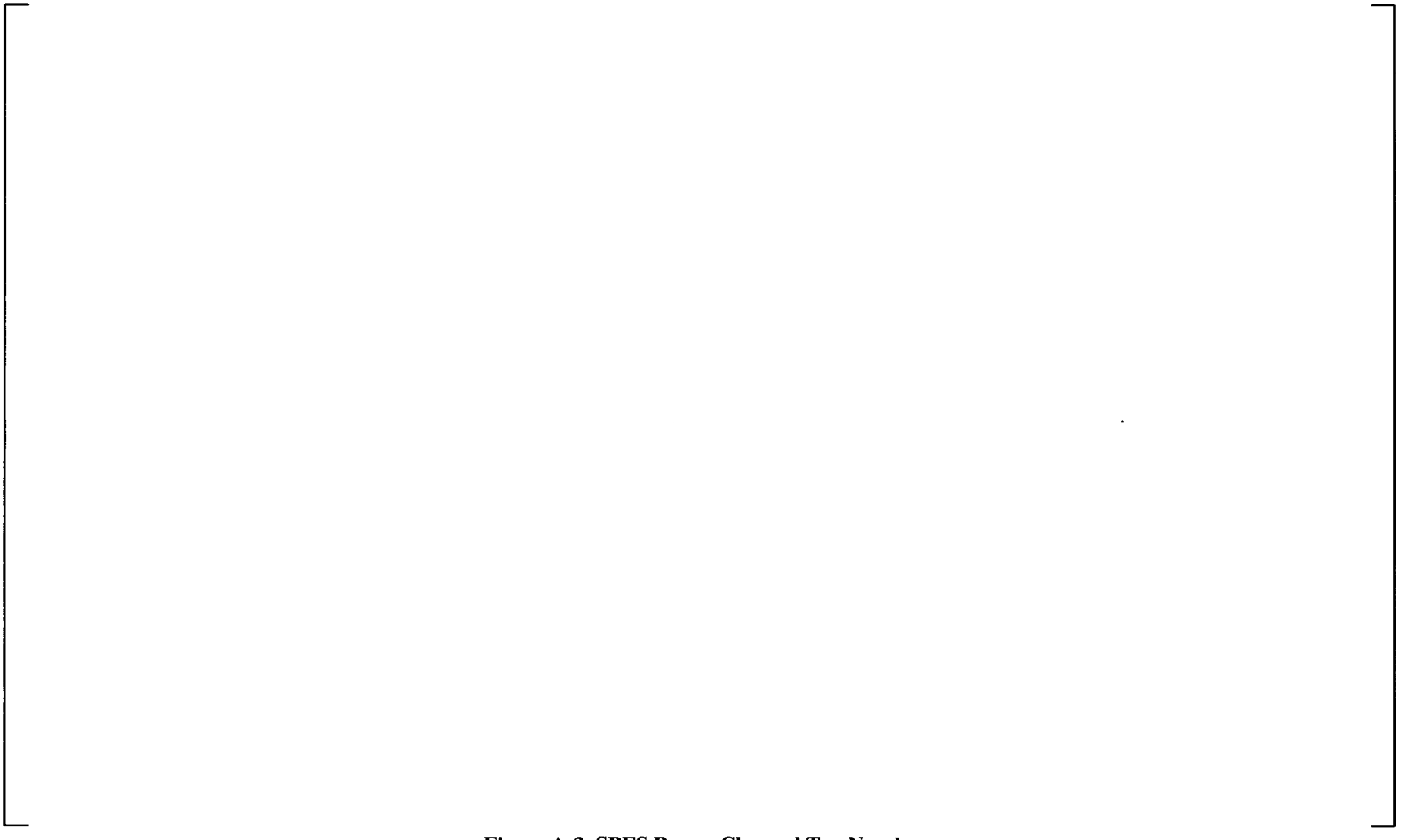

Figure A-3 SPES Power Channel Top Nozzle

a,b,c

Figure A-4 Mounting Plate to Transition from Power Channel to Upper Plenum

A.2.4 Upper Plenum

[

]a,b,c

a,b,c

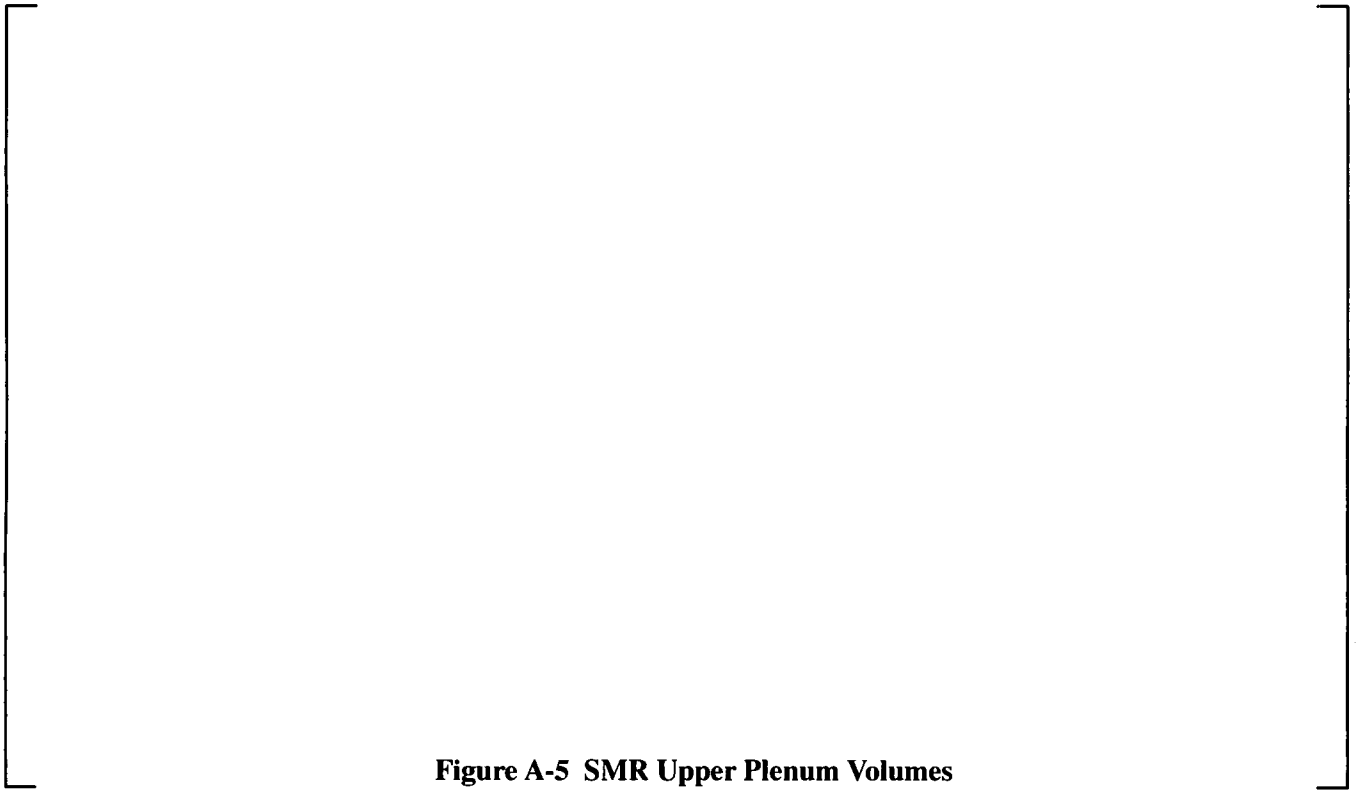

Figure A-5 SMR Upper Plenum Volumes

[

]a,b,c

SMR and SPES-4 design parameters are shown in Table A-9.

a,b,c

[

]a,b,c

A.2.4.1 Upper Support Plate

[ ]a,b,c

a,b,c

[

a,b,c

A.2.4.2 From Upper Support Plate to Transition Cone

[

]a,b,c

a,b,c

[

a,b,c

[

]a,b,c

a,b,c

[

Figure A-6 shows a sketch of the SPES-4 upper plenum:

a,b,c

Figure A-6 Upper Plenum

A.2.5 Transition Cone (Connection to Primary Central Riser)

[

]a,b,c

a,b,c

[

]a,b,c

a,b,c

Figure A-8 shows the Transition Cone.

a,b,c

Figure A-8 Transition Cone

A.2.6 SMR & SPES Primary Central Riser

[

]a,b,c

a,b,c

[ ]a,b,c

a,b,c

a,b,c

The Primary Central Riser drawing is shown in Figure A-10.

a,b,c

Figure A-10 Primary Central Riser

A.2.7 Pressurizer

[ ]a,b,c

a,b,c

[ ]a,b,c

a,b,c

[

]a,b,c

a,b,c

The Pressurizer drawing is shown in Figure A-12.

a,b,c

Figure A-12 Pressurizer Drawing

Pressurizer Plate:

[

]a,b,c

a,b,c

[

]

Figure A-13 SMR Pressurizer Surge Plate

a,b,c

[

]

Figure A-14 Pressurizer Surge Plate Flow Path

a,b,c

Figure A-15 SMR Pressurizer Cut-away View

a,b,c

[

]a,b,c

A.2.8 Steam Generator Primary Simulator (SGPSS)

[

]a,b,c

[

]a,b,c

a,b,c

[ ]a,b,c

a,b,c

Primary Central Riser to Steam Generator Connection

[

]a,b,c

a,b,c

[

]a,b,c

The following table contains the results of the calculation:

a,b,c

Table A-20 Primary Central Riser - Steam Generator connection Specifications	

a,b,c

Figure A-18 Primary Central Riser to Steam Generator Connection

A.2.9 Reactor Coolant Pumps (RCP)

[

]a,b,c

a,b,c

[

]a,b,c

a,b,c

[

]

[

]a,b,c

A.2.10 PRHR/CMT System

[

]a,b,c

a,b,c

Figure A-20 PRHR Heat Exchanger Sketch

Table A-22 shows the SMR PRHR heat exchanger characteristics:

a,b,c

[

]a,b,c

Table A-23 contains the SPES-4 PRHR heat exchanger characteristics:

a,b,c

[

]

Figure A-21 shows the SPES-4 PRHR heat exchanger tube pattern.

a,b,c

Figure A-21 SPES-4 PRHR Heat Exchanger Tube Pattern

[

]a,b,c

Table A-24 shows the SPES-4 CMT geometric characteristics.

a,b,c

[

]a,b,c

Table A-25 shows the SPES-4 CMT design characteristics.

a,b,c

A drawing of the CMT/PRHR component is shown in Figure A-22.

a,b,c

Figure A-22 CMT / PRHR Component Drawing

A.2.11 CMT Balance Line

[

]^{a,b,c}

[

]a,b,c

The CMT balance line characteristics are described in Table A-26:

a,b,c

[

]a,b,c

[

]a,b,c

Table A-27 summarizes the SPES CMT Balance line characteristics:

a,b,c

[

]

A.2.12 CMT DVI Line

Table A-28 describes the SMR DVI line:

a,b,c

[

]

a,b,c

[

]a,b,c

Table A-29 summarizes the SPES-4 DVI line characteristics:

a,b,c

A.2.13 Sump Injection Line

[

]a,b,c

a,b,c

[

]a,b,c

a,b,c

A.2.14 In-Containment Pool (ICP) Tanks and Injection Lines

[

]a,b,c

a,b,c

[

]a,b,c

a,b,c

[

[

]a,b,c

[ ]a,b,c

a,b,c

[

]a,b,c

a,b,c

[

]a,b,c

[

]a,b,c

a,b,c

Figure A-23 Upper ICP Tank Drawing

A.2.15 In-Containment Pool

[

]a,b,c

a,b,c

[

]a,b,c

a,b,c

[ ]a,b,c

a,b,c

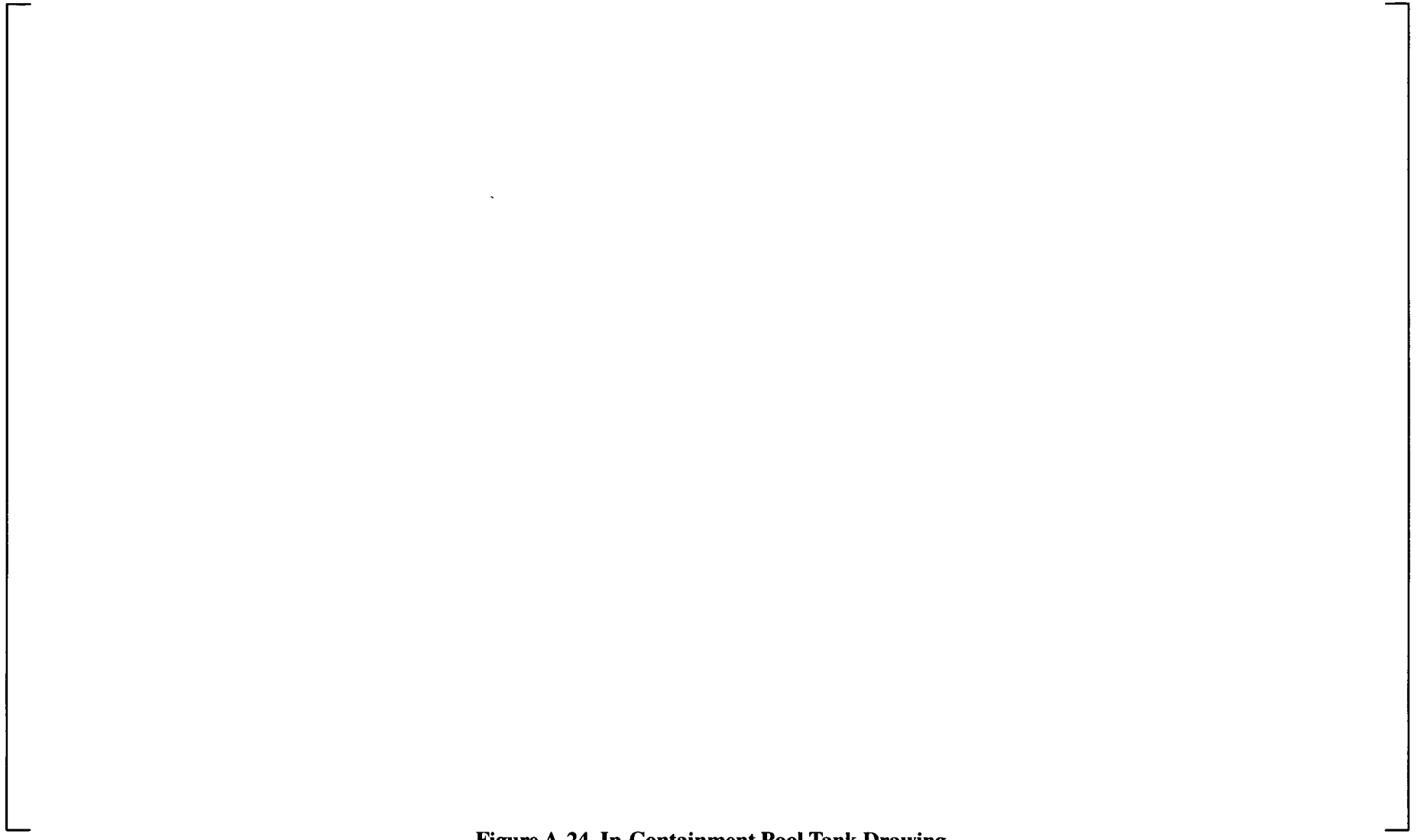

Figure A-24 In-Containment Pool Tank Drawing

A.2.16 Automatic Depressurization System (ADS) Lines

[

]a,b,c

a,b,c

[ ]a,b,c

a,b,c

[

]a,b,c

[

]^{a,b,c}

[

]^{a,b,c}

[

]^{a,b,c}

[

]a,b,c

a,b,c

[

]

SPES-4 ADS-2 scaling

[

]a,b,c

a,b,c

[

]

A.2.17 Containment

[

]a,b,c

[

]a,b,c

a,b,c

[

]

[

]a,b,c

a,b,c

[

]a,b,c

a,b,c

[

]a,b,c

a,b,c

[

]a,b,c

[ ]a,b,c

a,b,c

[

]a,b,c

a,b,c

[

]a,b,c

a,b,c

[

[

]a,b,c

a,b,c

[

]a,b,c

a,b,c

Here is the summary of the containment for SPES test facility:

a,b,c

a,b,c

[

]a,b,c

a,b,c

Figure A-25 Containment Tanks

A.2.18 Containment Heat Sinks

[

]a,b,c

a,b,c

[

]a,b,c

a,b,c

[

]a,b,c

[

]a,b,c

a,b,c

[

]

[ ]a,b,c

a,b,c

[

]

[

]a,b,c

a,b,c

[

]a,b,c

[

]^{a,b,c}

[

]a,b,c

a,b,c

[

]

[

]a,b,c

a,b,c

[

]

[

]a,b,c

[

]^{a,b,c}

[

]a,b,c

A.2.19 Outer Containment Pool

[

]a,b,c

a,b,c

[

]a,b,c

a,b,c

[

]a,b,c

[

]a,b,c

a,b,c

[

[

]a,b,c

a,b,c

[

]a,b,c

a,b,c

[

]a,b,c

A.2.20 Boric Acid Tank

[

]a,b,c

a,b,c

[ ]a,b,c

a,b,c

[

]

A.2.21 Core Makeup Tank Secondary Side Cooling System

[

]a,b,c

Table A-49 shows the requirements for the secondary side heat removal system.

a,b,c

a,b,c

a,b,c

Figure A-26 Core Makeup Tank Secondary Side Cooling System

[

]a,b,c

[

]a,b,c

a,b,c

[

]

Figure A-27 PXS Loop Pressure/PRHR Secondary Side Pressure

a,b,c

Figure A-28 Secondary Side Flow Rate per CMT/PRHR

a,b,c

Figure A-29 PXS Temperatures (Inlet PRHR/Outlet PRHR)

a,b,c

Figure A-30 UHS Tank Temperature

A sketch of the CMT Secondary Side Cooling System is shown in Figure A-31.

a,b,c

Figure A-31 CMT Secondary Side Cooling System – Forced Flow

APPENDIX B
SUMMARY OF COMPONENT VOLUMES AND DIMENSIONS

Tables B-1 to B-18 list the key volumes and dimensions for the Reference SMR and SPES-4:

a,b,c

a,b,c

a,b,c

a,b,c

a,b,c

a,b,c

a,b,c

a,b,c

a,b,c

a,b,c

[

]a,b,c

[

]^{a,b,c}

APPENDIX C
INITIAL WATER VOLUMES AND LEVELS

[

]a,b,c

a,b,c

a,b,c

APPENDIX D
INITIAL TEMPERATURES AND PRESSURES

[

]a,b,c

a,b,c

a,b,c

[

]a,b,c

APPENDIX E
TWO-PHASE FLOW SCALING FOR THE CORE OUTLET AND UPPER PLENUM

[

]a,b,c

a,b,c

[

]a,b,c

a,b,c

[

]a,b,c

[ ]a,b,c

a,b,c

[

]a,b,c

a,b,c

[ ]

[

]a,b,c

a,b,c

Figure E-4 SMR Upper Plenum

a,b,c

Figure E-5 Detailed SMR Upper Plenum

[

]a,b,c

[

]^{a,b,c}

[

]^{a,b,c}

[

]a,b,c

[

]a,b,c

a,b,c

[

]

[

]a,b,c

a,b,c

[

]a,b,c

a,b,c

[

]

[

]a,b,c

a,b,c

[

]a,b,c

[

]a,b,c

a,b,c

[

]a,b,c

a,b,c

[

]a,b,c

a,b,c

a,b,c

[

]a,b,c

a,b,c

[

]a,b,c

[

]a,b,c

a,b,c

[

]a,b,c

a,b,c

[

]a,b,c

[

]a,b,c

a,b,c

[

]

[

]a,b,c

a,b,c

[

]a,b,c

a,b,c

a,b,c

[

]

APPENDIX F
DETAILS OF THE BORIC ACID TANK DESIGN

[

]a,b,c

F.1 SMR BORIC ACID TANK LINE RESISTANCE CALCULATION

[

]a,b,c

[

]a,b,c

a,b,c

[

]a,b,c

F.2 SMR BAT INJECTION FLOW RATE CALCULATION

[

]a,b,c

a,b,c

[

]^{a,b,c}

[ ]a,b,c

a,b,c

[

[ ]a,b,c

[

]^{a,b,c}

F.3 SPES BAT DESIGN DATA

[ ]a,b,c

a,b,c

[

[

]a,b,c

SPES-4 Boric Acid Storage Tank Line Resistance Calculation

[ ]a,b,c

a,b,c

[ ]a,b,c

a,b,c

[ ]a,b,c

APPENDIX G
SPES-4 P&ID

The SPES-4 P&ID is shown in Figure G-1.

a,b,c

Figure G-1 SPES-4 P&ID