

PCC TEST PLAN & PROCEDURES

(J. Vescovi

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SIET	Document	Rev	Page	of
Sezione Reattori Innovativi	00098PP01	0	3	225

NOMENCLATURE

AO	Air Operated
CGA	Color Graphic Adapter
CPU	Central Process Unit
CT	Condensate Drain Tank
d	Throat Diameter / diameter
D	Inside Diameter
DAN	Nuclear Area Direction
DAS	Data Acquisition System
DL	Drain Line
DOS	Disk Operative System
DRF	Design Record File
DSSI	Disk Storage System Interface
F	Flowrate
FCV	Flow Control Valve
FFT	Fast Fournier Transtormer
FP	Feed Pump
FWL	Feed Water Line
GDCS	Gravity Driven Cooling System
h	Pressure Tap Height Difference
H	Height / Elevation
HCV	Hand Control Valve
HV	Hand Valve
I/O	Input / Output
L	Level

SIET	Document	Rev	Page	of
Process Reactors Innovativ	00098PP91	0	2	225

INDEX

NOMENCLATURE	3
INTRODUCTION	6
PART I - TEST PLAN	7
PART II - TEST PROCEDURES	108
PART III - QUALITY ASSURANCE PLAN	212
ENCLOSURES	
ENCLOSURE 1 - PANTHERS - PCC TEST FACILITY P&ID: 00209 DD 93 Rev 1	221
ENCLOSURE 2 - SCHEMATIC OF PLANT CONFIGURATION FOR TEST C-03	222
ENCLOSURE 3 - SCHEMATIC OF PLANT CONFIGURATION FOR TEST C-04	223
ENCLOSURE 4 - SCHEMATIC OF PLANT CONFIGURATION FOR TEST H-01	224
ENCLOSURE 5 - SCHEMATIC OF PLANT CONFIGURATION FOR TEST H-02	225

SIET	Document	Rev	Page	of
Sezione Reattori Innovativi	00098PP91	0	5	225

T	Temperature
TC	Thermocouple
TCV	Temperature Control Valve
TP&P	Test Plan and Procedures
TW	Wall Temperature
UQA	Quality Assurance Office
V	Volume
v	Fluid Velocity
VL	Vent Line
VME	Versa European Module
VMS	Virtual Memory System

SIET	Document	Rev	Page	of
Sezione Reattori Innovativi	00098PP01	0	4	225

LCV	Level Control Valve
LSB	Last Significant Bit
LVDT	Linear Variable Differential Transformer
MIPS	Mega Instruction Per Second
MO	Motor Operated
NWL	Normal Water Level
OD	Outside Diameter
P	Pressure
PANTHERS	Performance, Analysis and Testing of Heat Removal Systems
PCC	Passive Containment Condenser
PCV	Pressure Control Valve
P&ID	Process and Instrumentation Diagram
PLC	Programmable Logical Controller
PSD	Power Spectral Densities
r	Radius
RAM	Random Access Memory
RISC	Reduced Instruction Set Computer
RTD	Thermoresistance
RTE	Responsible Test Engineer
S	Speed
SG	Strain Gage
S/RV	Safety / Relief Valve
SBWR	Simplified Boiling Water Reactor
ST	Storage Tank

SIET	Document	Rev	Page	of
Sezione Reattori Innovativi	00098PP91	0	7	225

PART I TEST PLAN

TABLE OF CONTENTS

1. INTRODUCTION	13
2. REFERENCE DOCUMENTS	14
3. TEST PROGRAM OBJECTIVES	15
4. PANTHERS-PCC TEST FACILITY DESCRIPTION	17
4.1 Test facility general design	17
4.2 Test facility location	18
4.3 PCC heat exchanger	19
4.4 PCC containment pool	20
4.4.1 Pool description	20
4.4.2 Pool make-up and drain system	21
4.5 Steam supply system	21
4.6 Noncondensable supply system	22
4.7 Drain and vent lines	23
4.7.1 Drain line	23
4.7.2 Vent line	23
4.8 Condensate drain tank	23
4.9 Vent tank	24
4.10 Catch tank	25

SIET	Document	Rev	Page	of
Sezione Reattori Innovativi	(00098PP01)	0	6	225

INTRODUCTION

The tests specified in this document are part of the program to design and certify the SBWR. The PCC system perform vital roles in removing heat from the containment during accident conditions. Full-scale prototypical condenser for this systems are to be tested at full pressure, temperature and flow conditions. The test facility specified for this program are not representative of the SBWR system of which this condenser will be part. The specified tests are "component" tests and therefore the test system performance is not intended to be representative of the SBWR system performance.

This Test Plan and Procedures document consists of 3 parts:

Part I : contains the Test Plan including a general description of the PANTHERS - PCC program; its objectives, the experimental facility, including the instrumentation, the control system, the data acquisition system, the different types of tests, including cold and hot shakedown.

Part II : contains the specific instruction on how the testing shall be performed.

Part III : contains the Quality Assurance Plan.

SIET	Document	Rev	Page	of
Sezione Reazioni Innovative	00098PP91	0	9	225

7. DATA ACQUISITION SYSTEM	47
7.1 Hardware configuration	47
7.2 Software	53
7.2.1 Measurement channel block	57
7.2.2 Alarm condition code block	57
7.2.3 Action code block	57
7.2.4 Monitor page block	57
7.3 Software qualification	58
8. DATA ANALYSIS AND RECORDING	59
8.1 Data reduction	59
8.1.1 Digitally acquired quantities	59
8.1.1.1 Directly measured quantities	59
8.1.1.1.1 Absolute and differential pressures	59
8.1.1.1.2 Temperatures	60
8.1.1.1.3 Displacements	61
8.1.1.2 Derived quantities	62
8.1.1.2.1 Flowrates	62
8.1.1.2.2 Levels	65
8.1.1.2.3 Pool density	67
8.1.1.2.4 Strain	67
8.1.1.2.5 Condensation thermal power	68
8.1.1.2.6 Heat flux coefficient	71
8.1.2 Analogically acquired quantities	71
8.2 Errors evaluation	72

SIET	Document	Rev	Page	of
Sezione Reazione Innovativa	0009RPP01	0	8	225

4.11	Piping and valves	25
5.	TEST INSTRUMENTATION	26
5.1	Instrument type and characteristics	26
5.1.1	Absolute and differential pressure transmitters and transducers	27
5.1.2	Thermocouples and thermoresistances	28
5.1.3	Flowmeters	29
5.1.4	Fluid level sensor	29
5.1.5	LVDT	29
5.1.6	Strain gages	30
5.1.7	Accelerometers	30
5.2	Instrument calibrations	31
6.	TEST PLANT CONTROL AND SAFETY CONSIDERATION	44
6.1	Controls system description	44
6.1.1	Steam flowrate control loop	44
6.1.2	Temperature control loop of the steam-air mixture	44
6.1.3	Air flowrate control loop	44
6.1.4	Condensate tank level control loop	45
6.1.5	Pressure control loop	45
6.1.6	PCC pool level control loop	45
6.2	Safety consideration	46

SIET	Document	Rev	Page	of
Sezione Reattori Innovativi	00098PP91	0	11	225

10.7.2 Test A.3.2 : simulated pneumatic leak test pressurizations	88
10.8 Description of test type A.4	89
10.9 Description of test type B.1	89
10.10 Description of test type B.2	90
11. TEST MATRICES	92
11.1 Acceptance criteria	93
12. REPORTS	94
13. QA REQUIREMENTS	95
14. TEST HOLD/DECISION POINTS	96

LIST OF TABLES

Tab. 1 - Explanation of PCC instrumentation plant code	32
Tab. 2 - PANTHERS-PCC experimental measurement tag list	33
Tab. 3 - PANTHERS- PCC flowmeter device characteristics	43
Tab. 4 - SBWR-PANTHERS: Full-Scale Prototypes PCC Test Cold pre-operational Test Matrix	97
Tab. 5 - SBWR-PANTHERS: Full-Scale Prototypes PCC Test Hot pre-operational Test Matrix	98
Tab. 6 - PCC First Priority Test Matrix	99
Tab. 7 - Part A. Test with two modules. Test type A.1.1 Steady State Performance - Saturated Steam / Air Mixtures. Test Conditions	100

SIET	Document	Rev	Page	of
Sezione Reattori Innovativi	0009RPP01	0	10	225

8.3	Data processing and analysis	73
8.4	Data records	73
8.5	Data sheets	74
9.	SHAKEDOWN AND PLANT CHARACTERIZATION	76
9.1	Plant characterization	76
9.1.1	General description of test C-01	77
9.1.2	General description of test C-02	77
9.1.3	General description of test C-03	77
9.1.4	General description of test C-04	78
9.1.5	General description of test H-01	78
9.1.6	General description of test H-02	79
9.1.7	General description of test H-03	80
9.1.8	General description of test H-04	80
9.1.9	General description of test H-05	80
9.2	Shakedown matrix	81
10.	PASSIVE CONTAINMENT CONDENSER TESTS	82
10.1	Types of tests required for the PCC	82
10.2	First priority tests	83
10.3	Description of test type A.1.1	83
10.4	Description of test type A.1.2	84
10.5	Description of test type A.1.3	84
10.6	Description of test type A.2	86
10.7	Description of test type A.3	87
10.7.1	Test A.3.1 : simulated LOCA pressurizations	87

SIET	Document	Rev	Page	of
Sezione Reattori Innovativi	0098PP91	0	13	225

1. INTRODUCTION

Part I, Test Plan, contains a general description of the PANTHERS - PCC program: its objectives, the experimental facility, including the instrumentation, the control systems, the data acquisition system, the different types of tests, including cold and hot shakedown.

SIET	Document	Rev	Page	of
Section: Reaction Innovations	00098PP01	0	12	225

Tab. 8 -	Part A. Test with two modules-Test type A.1.2 Steady State Performance - Superheated Steam/Air Mixtures. Test Conditions	101
Tab. 9 -	Part A. Test with two modules-Test type A.1.3 Steady State Performance - Steam Only. No Air in PCC tubes. Test Conditions	102
Tab. 10 -	Part A. Test with two modules-test type A.1.3 Steady State Performance- Steam Only Air in PCC tubes. Test conditions	103
Tab. 11 -	Part A. Test with two modules Test type A.2.1 Effect of Pool Water Level - Saturated Steam Test type A.2.2 Effect of Pool Water Level - Saturated Steam/Air Mixture Test Conditions	104
Tab. 12 -	Part B. Test with one module-test type B.1 Steady State Performance - Steam Only. No Air in PCC tubes. Test Conditions	105
Tab. 13 -	Part B. Test with one module-test type B.1 Steady State Performance - Steam Only. Air in PCC tubes. Test Conditions	106
Tab. 14 -	Part B. Test with one module-test type B.2 Effect of Low Density Non Condensibles. Test Conditions	107

SIET	Document	Rev	Page	of
McDermott Reaction Innovations	00098PP91	0	15	225

3. TEST PROGRAM OBJECTIVES

The general objectives of the full scale PCC test are (ref. 2.1.1):

- a) **Thermalhydraulic** : confirm that designed PCC meets the thermalhydraulic performance requirements for use in the SBWR
- b) **Structural** : confirm that the mechanical design of PCC is adequate to assure the structural integrity of the unit for the expected SBWR lifetime service conditions.
- c) **Single Module Test** : confirm, with PCC tests, that the test performance of a half-unit IC is an adequate representation of the performance of a full-unit IC.

The thermalhydraulic specific objectives are:

- a) measure the steady-state heat removal capability over the expected range of SBWR conditions:
 - inlet pressure
 - concentration of noncondensable gases
 - PCC differential pressure
 - pool-side bulk average water temperature
 - pool-side water level
- b) confirm that when a mixture of steam and noncondensable gases flows into the PCC, the uncondensed gases will be discharged from the vent line and the condensate will be discharged from the drain line.
- c) confirm that tube-side heat transfer and flow rates are stable and without large fluctuations.
- d) confirm that there is no condensation water hammer during the expected startup, shutdown and operating modes of the PCC.
- e) measure the inside and outside wall temperature at typical tube locations to:

SIET	Document	Rev	Page	of
Sezione Reattori Innovativi	(0098PPQ)	0	14	225

2. REFERENCE DOCUMENTS

2.1 GE documents

- 1) ISOLATION CONDENSER & PASSIVE CONTAINMENT CONDENSER TEST REQUIREMENTS. Document Number 23A6999 Rev. 1

2.2 SIET documents

- 1) PCC TEST FACILITY DESCRIPTION. 00094 RI 91 Rev. 0
- 2) IC & PCC TEST FACILITY DATA ACQUISITION, INSTRUMENTATION AND PROCESSING SPECIFICATION . 00095 RS 91 Rev.0
- 3) PANTHERS PCC TEST FACILITY P&ID. 00209 DD 93 Rev.1

2.3 Other documents

- 1) CAPSULATE STRAIN GAGE KHC, KYOWA Operation manual
- 2) THERMOCOUPLES - CLASSIFICATION AND STATIC CHARACTERISTICS
UNI7938
- 3) PLATINUM RESISTANCE THERMOMETERS - MARKING AND STATIC CHARACTERISTICS
UNI7937
- 4) MEASUREMENT OF FLUID FLOW BY MEANS OF ORIFICE PLATES, NOZZLES OR VENTURI
TUBES INSERTED IN CIRCULAR CROSS - SECTION CONDUITS
UNI10023

SIET	Document	Rev	Page	of
Direzione Ricerca Innovativa	00098PP91	0	17	225

4 PANTHERS PCC TEST FACILITY DESCRIPTION

4.1 Test facility general design

The flow diagram of Panthers-PCC test facility is shown in (enclosure 1). The main components of the plant are:

- PCC condenser
- PCC pool
- makeup water system
- drain line
- vent line
- condensate drain tank
- noncondensable vent tank
- steam supply system
- noncondensable supply system

The design criteria are:

- a) PCC condenser: a full scale prototype of the SBWR Passive Containment Condenser
- b) PCC pool: the total volume (173 m^3), the pool area (29.84 m^2), the boiloff opening area (2 m^2) and the nominal water level (4.4 m) of the reference pool, are preserved. The PCC pool volume can be reduced by a diaphragm to perform PCC single module tests, maintaining the same pool area per module
- c) makeup water system: it allows to maintain a constant pool level at the maximum condensation rate
- d) drain line: it is prototypical as in practical with respect to inside diameter (6") and elevation difference

SIET	Document	Rev	Page	of
Section: Reactor Innovative	(0098PP9)	0	16	225

- ii) provide diagnostic information for investigation of unexpected condenser performance
- iii) provide information useful to confirm the understanding of tubeside performance
- iii) provide a fundamental data base for confirmation of TRACG simulation of poolside performance.
- f) establish PCC unit pressure losses with air flow only as a benchmark against which to compare in plant PCC air flow performance.

The structural specific objectives are:

- a) measure the stress levels at the critical locations on the PCC in the following conditions:
 - i) steady operation at different containment pressure, temperature and air mass fraction
 - ii) pneumatic leak testing
 - iii) transition from operation at normal containment conditions to LOCA and severe accident conditions.
- b) measure the vibration at critical locations on the PCC resulting from flow and/or condensation.
- c) demonstrate by performing 5 times the expected number of pressure and thermal cycles that the PCC will successfully service 60 years of SBWR.
- d) confirm, with PCC tests, that the test performance of a half-unit IC is an adequate representation of the performance of a full-unit IC.

SIET	Document	Rev	Page	of
Sezione Reattori Innovativi	00098PP91	0	19	225

c) elevation between the PCC pool bottom and the NWL of the PSP (15210 mm)

4.3 PCC heat exchanger

The PCC heat exchanger consists of the following major components:

- a) a 10" vertical inlet line for steam-air mixture supply with integral flange for connection to pool floor
- b) a steam-air distributor
- c) two 8" horizontal feed line
- d) two horizontal upper and two horizontal lower headers (660 mm inside diameter) with integral nozzle and bolted covers
- e) 496 stainless steel tubes, 2" OD
- f) two 10" vertical drain line
- g) two 8" vertical vent lines
- h) seven 2" nozzle for instrumentation cable penetrations
- i) ten 1/4" NPT nozzle for thermalhydraulic measurements

The PCC is composed by two identical modules with total thermal capacity of 10 MWt. The vertical 10" main steam supply line feeds two horizontal headers through an upper distributor and two 8" pipes. Steam is condensed inside a bundle of 248x2 stainless steel (SA 213 TP 304L) 2" vertical tubes, with 58.8 mm OD and 1.65 mm of thickness, and is collected in two lower headers. The condensate is removed through two 10" pipe connected, by means of two 4" pipe, to a common 6" main drain line to the condensate tank. At the header outlet the drain nozzle contains also the vent line for driving the

SIET	Document	Rev	Page	of
Sezione Reattori Innovativi	(0098PP9)	0	18	225

- e) vent line: it is prototypical as in practical with respect to inside diameter (10") and elevation difference
- f) condensate drain tank: it reproduces the presence of the GDCS pool. It collects the steam condensed by the PCC and it keeps the pressure in the drain line equal to the inlet pressure: the tank has been designed to maintain a good control of water level during testing with the greatest expected condensate flowrate, by means of 6" internal tube as overflow system or by a bottom discharge line and a level control system;
- g) noncondensable vent tank: it reproduces the presence of the PSP, it controls the discharge pressure of the PCC and collects the air / uncondensed steam mixture separated in the PCC. The tank has been arranged such as testing may be performed with the end of vent line either submerged or unsubmerged
- h) steam supply system: saturated steam is supplied to the PCC at a controllable flowrate in the range up to 6.6 kg/s with a pressure in the range of 170 to 790 kPa
- i) noncondensable supply system: air is supplied to the PCC at a controllable flowrate in the range up to 1 kg/s with a pressure in the range of 170 to 790 kPa

The Panthers-PCC capabilities, summarized in (ref. 2.1.1), cover the range of the SBWR accident conditions.

4.2. Test facility location

The Panthers-PCC test facility is located in the SIET-Piacenza laboratories and is built inside the "EMILIA" power station. The position of main components have been chosen so as to respect the elevations of the SBWR reference plant. The following elevation differences are preserved:

- a) normal water level of containment pool at 4400 mm
- b) elevations between the PCC pool bottom and the normal water level of the GDCS pool (2500 mm)

SIET	Document	Rev	Page	of
Sezione Ricerca Innovativa	00098PP91	0	21	225

The PCC pool is also provided with :

- a) a 4" drain line
- b) a 2" drain line
- c) a 4" overflow line
- d) a 14" emergency discharge line

PCC pool total volume is 173 m³ ; PCC pool water volume (at NWL) is 131.3 m³ ;
 IC pool total volume is 98 m³ ; IC pool water volume (at NWL) is 74.4 m³ .

4.4.2 Pool make-up and drain system

During PCC testing the IC pool is used as makeup tank. The makeup tank is connected to the PCC pool by means of an 8" lower line to replace the boil off and the water that overflows through the 2 m² opening area, to the catch tank.

The PCC pool water level is maintained constant controlling the IC pool water level by means of an external water makeup line and an overflow line. The external make up line is designed to maintain a constant pool water level at a maximum condensation rate. The maximum water temperature is 40 °C.

4.5 Steam supply system

The required thermal power for PCC testing is supplied using superheated steam bled from the ENEL PC-Levante power station, situated nearby the SIET laboratories. The superheated steam is bled at the following conditions:

$$\begin{aligned}
 T &= 540 \text{ } ^\circ\text{C} \\
 P &= 17 \text{ MPa} \\
 F_{\text{max}} &= 6.5 \text{ kg/s}
 \end{aligned}$$

SIET	Document	Rev	Page	of
Sezione Reattori Innovativi	0009RPP91	0	20	225

noncondensable gases to the vent tank. This line consists in two 8" pipes that join in a common 10" line. At the ends the headers are closed by two bolted flat covers. The PCC unit is supported by saddles located at the extremities of each lower headers. For the single module tests the horizontal 8" feed line of module 2 will be excluded.

4.4 PCC containment pool

4.4.1 Pool description

The PCC full-scale prototype with inlet, vent and noncondensate drain piping are installed inside a rectangular water tank. This pool is covered and open to the atmosphere. The tank is supported by means of a bolted beam system layed to the fifth floor of the building.

During testing the nominal level of the cooling water in the pool is maintained at 4400 mm; therefore the horizontal axis of the upper header is placed 1.3 m below the pool NWL. The pool floor is provided with proper openings for the pipe crossing and have provisions for the saddle supports. The pool wall is provided with a rectangular opening of 2 x 1 m, located 250 mm above the NWL, for boil-off.

For manufacturing and transport purpose the PCC pool is composed by 24 panels to be assembled in the pool installation area. Each panel is made of laminated plastic (fiberglass) reinforced by an internal steel structure. Two continuous sections are connected by means of internal plastic welding and fixed together with stainless steel bolts. This solution ensures a good mechanical resistance and thermal insulation. The pool walls and floor can easily support contained liquid temperature up to 130 °C. The total average thickness of the laminated fiberglass is 12 mm. Accounting the internal steel reinforcement and the final fiberglass coating, the total thickness of the pool walls and floor is 163 mm.

To control the pool level and replace boil-off during a test the PCC pool is directly connected to IC pool by means of:

a) an upper circular steam duct, in fiberglass, 1 m OD and about 11 m long;

b) a lower 8" pipe, in carbon steel, for PCC pool water make up, with stop valve.

SIET	Document	Rev	Page	of
Sezione Reattori Innovativi	00098PP91	0	23	225

maximum delivery pressure : 2.8 MPa

The air produced by the compressors is appropriately dehumidified and sent to the plenum chambers. The air is then sent to the mixing point passing through a flow-rate regulation system, a flowrate measurement orifice plate system and a manual valve operating as critical flow orifice. This device, operating with different flow area keeps the flowrates independent from the PCC inlet pressure.

4.7 Drain and vent line

4.7.1 Drain line

The drain line connects the PCC outlet to the condensate tank inlet. The characteristics of the pipe (length, volume, cross area, metal surface and weight, with the instrumentation location are reported in (ref. 2.2.1).

4.7.2 Vent line

The vent line connects the PCC outlet to the vent tank inlet. The characteristics of the pipe (length, volume, cross area, metal surface and weight are reported in (ref. 2.2.1).

4.8 Condensate drain tank

The condensate tank is a closed, pressurized tank partially filled with water that simulates the functions of the reference GDCS pool. The dimensions of the CT have been set accounting the following factors:

- a) dimensions of pre-existent structures and other components of the test facility.
- b) observance of the elevation between the PCC pool bottom and the GDCS pool NWL in the SBWR plant (2500 mm)

SIET	Document	Rev	Page	of
Sezione Ricerca Innovativa	0098PP91	0	22	225

The conditions of the superheated steam available for the test facility are affected by the heat losses and pressure drops along the adduction line.

The superheated steam is supplied to the test facility by gradually opening the valve F001. The steam is desuperheated supplying cold water at the following maximum temperature, pressure, and flow-rate conditions:

$$T_{\max} = 100 \text{ }^{\circ}\text{C}$$

$$P_{\max} = 26 \text{ MPa}$$

$$F_{\max} = 6.5 \text{ kg/s}$$

The cold water is mixed to the superheated steam in two mixing points. The first desuperheating is obtained through the three way valve F004. Downstream this mixing point the steam is still superheated in order to avoid phase change through the flowrate measurement device. The second desuperheating mixing point is located at the end of the steam supply line and it is used to bring the steam to the required test conditions.

4.6 Noncondensable supply system

The noncondensable supply system is composed by:

- a) two three-stage displacement compressors
- b) two plenum chambers connected in parallel
- c) pressure reduction group
- d) flow-rate measurement system

Each air compressor produces:

maximum air flow : 1500 Nm^3/h

SIET	Document	Rev	Page	of
Sezione Reattori Innovativi	0009RPP01	0	25	225

discharge line to adjust the water level during the tests. Thermalhydraulic instrumentation is provided to monitor the following main parameters:

- a) steam-air mixture discharge flowrate
- b) gas space temperature and pressure
- c) liquid temperature and pressure
- d) water level

4.10 Catch tank

The PCC test facility is provided with a water storage tank that has the function of collecting and measuring the amount of water that overflows from the PCC pool during the tests.

The geometrical characteristics of the tank with the instrumentation location are reported in (ref. 2.2.1).

4.11 Piping and Valves

The steam/ air mixture inlet line, the drain and vent lines are made of stainless steel; carbon steel material is used for other piping, flanges, bolts and nuts. Panthers-PCC main components are thermal insulated by means of rock wool.

The valve specifications of the Panthers-PCC are reported in ref. 2.2.1).

SIET	Document	Rev	Page	of
Sezione Reattore Innovativo	00098PP01	0	24	225

The CT is located beneath the PCC pool at an elevation such that the tank NWL is 2500 mm lower than the PCC pool bottom. The condensate drain line is connected to the CT beneath the water level and has a 2500 mm loop seal inside the tank with an outlet section at 250 mm below the NWL. The drain line can also be connected to a nozzle at an elevation 5250 mm lower than the PCC pool bottom. This connection can be used to perform tests with a controlled water head. In order to maintain the CT gas space pressure at the same value as the PCC inlet steam-air mixture line, the CT dome is connected to the test section inlet line by a 1" OD pipe provided with a spectacle flange. The CT gas space pressure can also be controlled by means of an air 1" injection line and a gas 1" outlet line. In this case the spectacle flange will be closed. The air injection line is connected with the main air supply line and is equipped with a pressure control valve. A constant water level in the tank is maintained by use of a 6" OD drain line. This line is equipped with a level control valve and a flowrate measurement device. The line drains water through a pipe situated inside the tank with an inlet section at the tank NWL. The drain line can also be connected directly to a 4" nozzle near the bottom of the tank.

Thermalhydraulic instrumentation is provided to monitor the following main parameters:

- a) condensate flowrate
- b) liquid temperature and pressure
- c) gas space temperature and pressure
- d) water level

4.9 Vent tank

The Vent Tank (VT) is a closed, pressurized tank.

The VT is located beneath the PCC pool at an elevation such that the NWL is 15210 mm below the PCC pool bottom. The noncondensable gases separated in the PCC and the entrained uncondensed steam are vented through a 10" OD line to the vent tank. The vent line is connected to the tank beneath water level at 750 mm below the NWL. The gases are discharged from the vent tank directly to the atmosphere through a control valve. This valve controls the pressure of the circuit. The vent tank is also provided with a 3"

SIET	Document	Rev	Page	of
sezioni Reazione Innovativi	00098PP91	0	27	225

- the instrument type
- the instrument plant code
- the instrument span
- the measurement unit
- the instrument measurement accuracy
- the instrument SIET code
- the reference drawing of documents SIET 00095RS91/00209DD93

5.1.1 Absolute and differential pressure transmitters and transducers

Absolute and differential pressures are measured by means transmitters and transducer. The transmitters have the following main features:

- Silicon piezoresistive sensor:
- Microprocessor based electronics:
- Compensation of temperature and static pressure changes:
- Measuring ranges: 0-10 MPa; 0-2 MPa; 0-100kPa; 0-250 kPa; 0-700 kPa;
- Rangeability: 5 or 10;
- Accuracy: $\pm 0.25\%$; $\pm 0.5\%$; $\pm 1\%$ of calibrated Span;

SIET	Document	Rev	Page	of
Sezione Reattori Innovativi	00098PP01	0	26	225

5. TEST INSTRUMENTATION

5.1 Instrument type and characteristics

The thermalhydraulic parameters to be measured are both direct quantities (absolute and differential pressure, temperature, displacement and vibration) and derived quantities (density, flowrate level and strain).

Different methods are used to measure the above parameters:

- 1) Pressure - pressure transmitters
- 2) Differential pressure - differential pressure transmitters
- 3) Temperature - thermocouples/thermoreistances
- 4) Level - differential pressure transmitters
- 5) Pool density - differential pressure transmitters
- 6) Flowrate - differential pressure across orifices, venturi tubes and variable area orifices
- 7) Displacement - LVDT (linear variable differential transformer)
- 8) Differential elongation/strain - strain gages
- 9) Vibrations - accelerometers

The overall instrumentation location on the plant is reported in the documents SIET 00095RS91 and 00209DD93 (enclosure 1).

The explanation of the measurement identification tag is shown in Tab. 1. Tab. 2 reports the measurement list with:

- the instrument component or line location

SIET	Document	Rev	Page	of
Sezione Ricerca Innovativa	00098PP01	0	29	225

- Diameters: 0.5-3 mm;
- Sheat material: Inconel 600/AISI 316;
- Measuring range: 273-1533 K;
- Accuracy class: ANSI special (min. $\pm 1.1^\circ\text{K}$);
- Time constant: 0.2-0.3 s.

The temperatures of the fluid in the PCC pool will be measured using RTD thermoresistances type PT100 (DIN 43760)100, diameter = 4 mm.

5.1.3 Flowmeters

The flowrate of single phase fluid (water, steam/air) is measured by using different primary elements: calibrated orifices, Venturi tubes and variable area orifices "GILFLO". Flowrate measurement device specifications are given in Tab. 3.

5.1.4 Fluid level sensors

Liquid level in single phase or collapsed level in two-phase are measured by differential pressure transmitters.

5.1.5 LVDT

Displacements and positions are measured by means of high temperature waterproof transducers type LVDT (linear variable differential transformer) having the following features:

SIET	Document	Rev	Page	of
Mezzione Reazione Innovativi	0009RPP91	0	28	225

Applications:

- a) pressure drops on piping, orifices and Venturi tubes;
- b) absolute pressure measurements;
- c) liquid and collapsed level measurements.

In some cases pressure drops on piping are measured using differential pressure transducers (instead of transmitters) having the following main features:

- strain gage sensor
- measuring range : +/- 34 kPa
- accuracy : \leq +/- 0.25 ; +/- 0.5 ; +/- 1.0 % f.s.

2.1.2 Thermocouples and thermoresistances

The temperatures of the fluid, piping, components and pool water are measured using undergrounded sheathed thermocouples type K.

The fluid thermocouples will be installed on the plant pipelines normally with the hot junction on the pipe axis (D/2); some thermocouple will be inserted into the pipe with different criterion (i.e. D/4). Welded plate wall thermocouples are installed on the PCC heat exchanger mixture inlet line upper and lower headers tube bundle and drain line.

Brazed wall thermocouples are installed on the PCC heat exchangers tube bundle. The detail of the instrumentation location is reported in document SIET 00095RS91.

The characteristics of the type K thermocouples are:

- Chromel-Alumel junction;
- Isolation by MgO;

SIET	Document	Rev	Page	of
Division Reaction Innovativa	00098PP91	0	31	225

5.2 Instrument calibrations

The absolute and differential pressure transmitters and transducers will be calibrated in laboratory before the installation on the plant according with SIET 00118PO91 procedure. The transmitters maximum error will be calculated, comparing the calibration points to the correspondent values calculated with the manufacturer instrument constants.

The transducers maximum error will be calculated performing the least square method linear interpolation of the calibration points. If the calibration error is lower or equal than the assigned accuracy, this one will be assumed as instrument maximum error, else the higher accuracy rating will be assumed.

The thermocouples will be calibrated in laboratory before the installation according with SIET 00165PO92 procedure: if the instrument meets the ANSI-MC96.1 special specification, the relative ANSI special accuracy (± 1.1 °C or 0.4% whichever is greater) will be assumed to evaluate the measurement error, else the calibration error will be assumed.

The thermoresistance will be calibrated in laboratory according with SIET 00166PO92 procedure: if the calibration error is lower or equal than the error defined by UNI 7937 specification this one will be assumed as instrument maximum error, else the calibration error will be used.

The flowrates measurements will be performed using calibrated nozzles, according with SIET 00221PP93 procedure. Flowrate error will be calculated taking into account the nozzle flux coefficient calibration errors: for not calibrated nozzles (i.e. $D \geq 50$ mm) the flux coefficient error as suggested by UNI 10023 specifications will be used.

The LVDT will be calibrated in laboratory before the installation according with SIET 00235PO93 procedure.

The accelerometers will be calibrated in laboratory before the installation according with SIET 00234PO93 procedure.

Calibrated strain gage will be used, the calibration certificate will be given by the manufacturer.

SIET	Document	Rev	Page	of
Sezione Reattore Innovativi	00098PP91	0	30	225

- Range: +/- 25 mm

- Linearity: 0.5 % f.s.

The LVDTs are installed on the steam distributor, the conjunction between feed line and upper header module 1 and on the PCC heat exchanger supports.

The detail of the LVDT locations is reported in SIET document 00095RS91.

5.1.6 Strain gages

The PCC local strains are measured by means of capsulated high temperature strain gages. The strain gages are installed on the PCC mixture inlet line, upper and lower header, tube bundles, supports and drain line. The strain gages sheath material is SUS316L.

The detail of the strain gage locations is reported in SIET document 00095RS91.

5.1.7 Accelerometers

High temperature waterproof accelerometers with built in electronics are installed on the steam distributor, the upper header of module 1 and at mid length of some condensation tubes. The main characteristics of the accelerometers are:

- Range: +/- 1000 g

- Resolution: +/- 0.02 g

- Frequency range: +/- 5%: 1-5000 Hz

- Resonant frequency: > 40 kHz

The detail of the accelerometer locations is reported in SIET document 00095RS91.

Tab. 2 - PANTHERS-PCC experimental measurement tag list

Component or line location	Instrument type	Plant code	Span	m. u.	Accuracy	SIET code	Ref Dwg
UPPER HEADER MODULE 1 (A)							
Internal fluid temperature (back side)	Thermocouple K	T A001	0 : 200	°C	+/- 1.1 °C	TCK028	Fig 1
Internal fluid temperature (front side)	Thermocouple K	T A002	0 : 200	°C	+/- 1.1 °C	TCK029	Fig 1
Near back cover flange (int., sup.) (*)	Thermocouple K	TW A001	0 : 200	°C	+/- 1.1 °C	TCK247	Fig 1
Near back cover flange (ext., inf.) (*)	Thermocouple K	TW A002	0 : 200	°C	+/- 1.1 °C	TCK248	Fig 1
Near back cover flange (int., inf.) (*)	Thermocouple K	TW A003	0 : 200	°C	+/- 1.1 °C	TCK249	Fig 1
Front cover, int. (*)	Thermocouple K	TW A004	0 : 200	°C	+/- 1.1 °C	TCK250	Fig 1
Front cover, ext. (*)	Thermocouple K	TW A005	0 : 200	°C	+/- 1.1 °C	TCK251	Fig 1
Near back cover flange (ext., sup.) (*)	Thermocouple K	TW A006	0 : 200	°C	+/- 1.1 °C	TCK252	Fig 1
Upper header - tube 2A, elevation c	DP Transducer	DP 005	-34 : +34	kPa	0.25 % f.s.	TSD026	Fig 2.3
Upper header - tube 3C, elevation c	DP Transducer	DP 006	-34 : +34	kPa	0.25 % f.s.	TSD027	Fig 2.3
Upper header - tube 4D, elevation c	DP Transducer	DP 007	-34 : +34	kPa	0.25 % f.s.	TSD028	Fig 2.3
Upper header - tube 3R, elevation c	DP Transducer	DP 008	-34 : +34	kPa	0.25 % f.s.	TSD029	Fig 2.3
Upper header - tube 5R, elevation c	DP Transducer	DP 009	-34 : +34	kPa	0.25 % f.s.	TSD031	Fig 2.3
Upper header - tube 5Y, elevation c	DP Transducer	DP 027	-34 : +34	kPa	0.25 % f.s.	TSD032	Fig 2.3
Upper header - tube 8R, elevation c	DP Transducer	DP 010	-34 : +34	kPa	0.25 % f.s.	TSD034	Fig 2.3
Upper header - tube 1V, elevation c	DP Transducer	DP 011	-34 : +34	kPa	0.25 % f.s.	TSD037	Fig 2.3
Upper header - tube 5-1, elevation c	DP Transducer	DP 012	-34 : +34	kPa	0.25 % f.s.	TSD036	Fig 2.3
Upper header - tube 5-6, elevation c	DP Transducer	DP 013	-34 : +34	kPa	0.25 % f.s.	TSD043	Fig 2.3
Internal fluid pressure	P Transmitter	P A001	0 : 1.0	MPa	0.25 % f.s.	TMA014	Fig 3
Front cover bolt, angular pos. 1 (*)	Thermocouple K	TW AB001	0 : 200	°C	+/- 1.1 °C	TCK225	Fig 1
Front cover bolt, angular pos. 2 (*)	Thermocouple K	TW AB002	0 : 200	°C	+/- 1.1 °C	TCK226	Fig 1
Front cover bolt, angular pos. 3 (*)	Thermocouple K	TW AB003	0 : 200	°C	+/- 1.1 °C	TCK227	Fig 1
Back cover, X direction	Accelerometer	VB A001	0 : 500	g	0.02 g	ACC001	Fig 1
Back cover, Y direction	Accelerometer	VB A002	0 : 500	g	0.02 g	ACC002	Fig 1
Back cover, Z direction	Accelerometer	VB A003	0 : 500	g	0.02 g	ACC003	Fig 1
Near back flange (ext., sup., ax. dir)	Strain gage	DX A001	+/- 0.5 %	mm/mm	+/- 5 % m.v.	SG072	Fig 1
Near back flange (ext., sup., cir. dir)	Strain gage	DX A002	+/- 0.5 %	mm/mm	+/- 5 % m.v.	SG073	Fig 1
Near back flange (int., sup., ax. dir)	Strain gage	DX A003	+/- 0.5 %	mm/mm	+/- 5 % m.v.	SG074	Fig 1
Near back flange (int., sup., cir. dir)	Strain gage	DX A004	+/- 0.5 %	mm/mm	+/- 5 % m.v.	SG075	Fig 1
Near back flange (ext., inf., ax. dir)	Strain gage	DX A005	+/- 0.5 %	mm/mm	+/- 5 % m.v.	SG076	Fig 1
Near back flange (ext., inf., cir. dir)	Strain gage	DX A006	+/- 0.5 %	mm/mm	+/- 5 % m.v.	SG077	Fig 1
Near back flange (int., inf., ax. dir)	Strain gage	DX A007	+/- 0.5 %	mm/mm	+/- 5 % m.v.	SG078	Fig 1
Near back flange (int., inf., cir. dir)	Strain gage	DX A008	+/- 0.5 %	mm/mm	+/- 5 % m.v.	SG079	Fig 1
Front cover central position (int.), X dir	Strain gage	DX A009	+/- 0.5 %	mm/mm	+/- 5 % m.v.	SG080	Fig 1
Front cover central position (int.), Z dir	Strain gage	DX A010	+/- 0.5 %	mm/mm	+/- 5 % m.v.	SG081	Fig 1
Front cover central position (ext.), X dir	Strain gage	DX A011	+/- 0.5 %	mm/mm	+/- 5 % m.v.	SG082	Fig 1
Front cover central position (ext.), Z dir	Strain gage	DX A012	+/- 0.5 %	mm/mm	+/- 5 % m.v.	SG083	Fig 1
Front cover bolt 1, pos. E	Strain gage	DX AB001	+/- 0.5 %	mm/mm	+/- 5 % m.v.	SG084	Fig 1

SIET	Document	Rev	Page	of
SIET	0009RPP91	0	12	225

Tab. 1 - Explanation of PCC instrumentation plant code

X - Y Z T

where:

X = PHYSICAL PARAMETER

DP = Differential pressure
 DX = Differential elongation
 F = Flowrate
 L = Level
 P = Absolute pressure
 PO = Position
 T = Fluid temperature
 TW = Wall temperature
 VB = Vibration

Z = PROGRESSIVE NUMBER

T = SPECIAL TAG

i = internal wall
 e = external wall
 sm = scribe mark
 r = right side
 l = left side

Y = PLANT LINE OR COMPONENT

1 = Steam inlet line
 2 = Non condensible inlet line
 3 = Desuperheating line
 4 = Mixture inlet line
 5 = Condensate drain line
 6 = Vent line
 7 = Steam bypass line
 8 = Main desuperheating line
 A = Upper header module 1
 B = Tube bundle module 1
 C = Lower header module 1
 D = Upper header module 2
 E = Tube bundle module 2
 F = Lower header module 2
 G = Drain line first length
 I = Vent tank
 L = Condensate tank
 M = Make up line
 N = IC/PCC pools connecting line
 O = Catch tank
 P = PCC pool
 Q = IC pool
 R = IC/PCC pools drain line
 S = Vent tank air-steam discharge line
 U = plenum chamber

Tab 2 - Cont'd

Component or line location	Instrument type	Plant code	Span	m. u.	Accuracy	SIET code	Ref Dwg
TUBE BUNDLE MODULE 1 (B)							
Tube 1B, elevation a, angular pos. 7 (*)	Thermocouple K	TW B001	0 : 200	°C	+/- 1.1 °C	TCK228	Figgs 8, 9
Tube 1R, elevation a, angular pos. 7 (*)	Thermocouple K	TW B002	0 : 200	°C	+/- 1.1 °C	TCK229	Figgs 8, 9
Tube 1R, elevation l, angular pos. 7 (*)	Thermocouple K	TW B004	0 : 200	°C	+/- 1.1 °C	TCK230	Figgs 8, 9
Tube 5A, elevation l, angular pos. 1 (*)	Thermocouple K	TW B005	0 : 200	°C	+/- 1.1 °C	TCK231	Figgs 8, 10
Tube 7A, elevation a, angular pos. 3 (*)	Thermocouple K	TW B006	0 : 200	°C	+/- 1.1 °C	TCK232	Figgs 8, 10
Tube 5A, elevation a, angular pos. 3 (*)	Thermocouple K	TW B008	0 : 200	°C	+/- 1.1 °C	TCK233	Figgs 8, 10
Upper - lower header	DP Transducer	DP 026	34 : +34	kPa	0.25 % fs	TSD045	00209(D193)
Tube 8S, elevation a, angular pos. 3 (*)	Thermocouple K	TW B009	0 : 200	°C	+/- 1.1 °C	TCK234	Figgs 8, 10
Tube 8S, elevation l, angular pos. 3 (*)	Thermocouple K	TW B010	0 : 200	°C	+/- 1.1 °C	TCK235	Figgs 8, 10
Tube 1A elevation a, ext. wall	Thermocouple K	TW B011e	0 : 200	°C	+/- 1.1 °C	TCK056	Figgs 3, 11
Tube 1A elevation a, int. wall	Thermocouple K	TW B011i	0 : 200	°C	+/- 1.1 °C	TCK057	Figgs 3, 11
Tube 1A elevation b, ext. wall	Thermocouple K	TW B012e	0 : 200	°C	+/- 1.1 °C	TCK058	Figgs 3, 11
Tube 1A elevation b, int. wall	Thermocouple K	TW B012i	0 : 200	°C	+/- 1.1 °C	TCK059	Figgs 3, 11
Tube 1A elevation c, ext. wall	Thermocouple K	TW B013e	0 : 200	°C	+/- 1.1 °C	TCK060	Figgs 3, 11
Tube 1A elevation c, int. wall	Thermocouple K	TW B013i	0 : 200	°C	+/- 1.1 °C	TCK061	Figgs 3, 11
Tube 1A elevation d, ext. wall	Thermocouple K	TW B014e	0 : 200	°C	+/- 1.1 °C	TCK062	Figgs 3, 11
Tube 1A elevation d, int. wall	Thermocouple K	TW B014i	0 : 200	°C	+/- 1.1 °C	TCK063	Figgs 3, 11
Tube 1A elevation e, ext. wall	Thermocouple K	TW B015e	0 : 200	°C	+/- 1.1 °C	TCK064	Figgs 3, 11
Tube 1A elevation e, int. wall	Thermocouple K	TW B015i	0 : 200	°C	+/- 1.1 °C	TCK065	Figgs 3, 11
Tube 1A elevation f, ext. wall	Thermocouple K	TW B016e	0 : 200	°C	+/- 1.1 °C	TCK066	Figgs 3, 11
Tube 1A elevation f, int. wall	Thermocouple K	TW B016i	0 : 200	°C	+/- 1.1 °C	TCK067	Figgs 3, 11
Tube 1A elevation g, ext. wall	Thermocouple K	TW B017e	0 : 200	°C	+/- 1.1 °C	TCK068	Figgs 3, 11
Tube 1A elevation g, int. wall	Thermocouple K	TW B017i	0 : 200	°C	+/- 1.1 °C	TCK069	Figgs 3, 11
Tube 1A elevation h, ext. wall	Thermocouple K	TW B018e	0 : 200	°C	+/- 1.1 °C	TCK070	Figgs 3, 11
Tube 1A elevation h, int. wall	Thermocouple K	TW B018i	0 : 200	°C	+/- 1.1 °C	TCK071	Figgs 3, 11
Tube 1A elevation i, ext. wall	Thermocouple K	TW B019e	0 : 200	°C	+/- 1.1 °C	TCK072	Figgs 3, 11
Tube 1A elevation i, int. wall	Thermocouple K	TW B019i	0 : 200	°C	+/- 1.1 °C	TCK073	Figgs 3, 11
Tube 4A elevation a, ext. wall	Thermocouple K	TW B020e	0 : 200	°C	+/- 1.1 °C	TCK074	Figgs 3, 11
Tube 4A elevation a, int. wall	Thermocouple K	TW B020i	0 : 200	°C	+/- 1.1 °C	TCK075	Figgs 3, 11
Tube 4A elevation b, ext. wall	Thermocouple K	TW B021e	0 : 200	°C	+/- 1.1 °C	TCK076	Figgs 3, 11
Tube 4A elevation b, int. wall	Thermocouple K	TW B021i	0 : 200	°C	+/- 1.1 °C	TCK077	Figgs 3, 11
Tube 4A elevation c, ext. wall	Thermocouple K	TW B022e	0 : 200	°C	+/- 1.1 °C	TCK078	Figgs 3, 11
Tube 4A elevation c, int. wall	Thermocouple K	TW B022i	0 : 200	°C	+/- 1.1 °C	TCK079	Figgs 3, 11
Tube 4A elevation d, ext. wall	Thermocouple K	TW B023e	0 : 200	°C	+/- 1.1 °C	TCK080	Figgs 3, 11
Tube 4A elevation d, int. wall	Thermocouple K	TW B023i	0 : 200	°C	+/- 1.1 °C	TCK081	Figgs 3, 11
Tube 4A elevation e, ext. wall	Thermocouple K	TW B024e	0 : 200	°C	+/- 1.1 °C	TCK082	Figgs 3, 11
Tube 4A elevation e, int. wall	Thermocouple K	TW B024i	0 : 200	°C	+/- 1.1 °C	TCK083	Figgs 3, 11

Tab. 2 - Cont'd

Component or line location	Instrument type	Plant code	Span	unit	Accuracy	SIET code	Ref Dwg
UPPER HEADER MODULE 1 (A)							
Front cover bolt 1, pos. 1	Strain gage	DX AB002	+/- 0.5 %	mm/mm	+/- 5 % m.v.	SG085	Fig. 1
Front cover bolt 2, pos. E	Strain gage	DX AB003	+/- 0.5 %	mm/mm	+/- 5 % m.v.	SG086	Fig. 1
Front cover bolt 2, pos. i	Strain gage	DX AB004	+/- 0.5 %	mm/mm	+/- 5 % m.v.	SG087	Fig. 1
Front cover bolt 3, pos. E	Strain gage	DX AB005	+/- 0.5 %	mm/mm	+/- 5 % m.v.	SG088	Fig. 1
MIXTURE INLET LINE (4)							
Downstream mixing point	Thermocouple K	T 4001	0 : 200	°C	+/- 1.1 °C	TCK030	00209DD93
Inlet section (outside PCC pool)	Thermocouple K	T 4002	0 : 200	°C	+/- 1.1 °C	TCK031	Fig. 4
Below steam distributor	Thermocouple K	T 4003	0 : 200	°C	+/- 1.1 °C	TCK032	Fig. 4
Downstream mixing point	P transmitter	P 4001	0.1 : 1.2	MPa	0.25 % f.s.	TMA007	00209DD93
Inlet section (outside PCC pool)	P transmitter	P 4002	0.1 : 1.2	MPa	0.25 % f.s.	TMA008	00209DD93
Inlet section upper header mod 1	DP Transmitter	DP 001	0 : 100	kPa	0.25 % f.s.	TMD024	00209DD93
Distributor - upper header mod 1	DP Transmitter	DP 003	0 : 25	kPa	0.25 % f.s.	TMD168	00209DD93
Inlet section upper header mod 2	DP Transmitter	DP 002	0 : 100	kPa	0.25 % f.s.	TMD162	00209DD93
Distributor - upper header mod 2	DP Transmitter	DP 004	0 : 20	kPa	0.25 % f.s.	TMD160	00209DD93
Upper part of steam distributor (*)	Thermocouple K	TW 4001	0 : 200	°C	+/- 1.1 °C	TCK253	Fig. 4
Feed line curve mod 1, intrados (*)	Thermocouple K	TW 4002	0 : 200	°C	+/- 1.1 °C	TCK254	Fig. 4
Feed line curve mod 1, extrados (*)	Thermocouple K	TW 4003	0 : 200	°C	+/- 1.1 °C	TCK255	Fig. 4
Upper header mod 1 conj., pos. 7 (*)	Thermocouple K	TW 4004	0 : 200	°C	+/- 1.1 °C	TCK256	Fig. 4
Upper header mod 1 conj., pos. 1 (*)	Thermocouple K	TW 4005	0 : 200	°C	+/- 1.1 °C	TCK257	Fig. 4
Upper part of steam distributor, X dir	Accelerometer	VB 4001	0 : 500	g	0.02 g	ACC004	Fig. 4
Upper part of steam distributor, Y dir	Accelerometer	VB 4001	0 : 500	g	0.02 g	ACC005	Fig. 4
Upper part of steam distributor, Z dir	Accelerometer	VB 4001	0 : 500	g	0.02 g	ACC006	Fig. 4
Upper part of steam distributor	LVDT	PO 4001	0 : 10	mm	+/- 0.5 % f.s.	LDT001	Fig. 4
Upper header mod 1 conj., pos. 7, X dir	LVDT	PO 4002	0 : 2	mm	+/- 0.5 % f.s.	LDT002	Fig. 4
Upper header mod 1 conj., pos. 7, Z dir	LVDT	PO 4003	0 : 10	mm	+/- 0.5 % f.s.	LDT003	Fig. 1
Upper header mod 1 conjunction, pos. 3	Scribe mark	DX 4 1sm		mm			Fig. 4
Feed line curve (mod 1), extrados	Strain gage	DX 4001	+/- 0.5 %	mm/mm	+/- 5 % f.s.	SG089	Fig. 4
Feed line curve (mod 1), intrados	Strain gage	DX 4002	+/- 0.5 %	mm/mm	+/- 5 % f.s.	SG090	Fig. 4
Upper header mod 1 conjunction, pos. 7	Strain gage	DX 4003	+/- 0.5 %	mm/mm	+/- 5 % f.s.	SG091	Fig. 4
Upper header mod 1 conjunction, pos. 1	Strain gage	DX 4004	+/- 0.5 %	mm/mm	+/- 5 % f.s.	SG092	Fig. 4
UPPER HEADER MODULE 2 (D)							
Fluid temperature, back side, pos. D	Thermocouple K	T D001	0 : 200	°C	+/- 1.1 °C	TCK034	Fig. 5
Near back flange, ext., angular pos. 1 (*)	Thermocouple K	TW D001	0 : 200	°C	+/- 1.1 °C	TCK258	Fig. 5
Near back flange, ext., angular pos. 5 (*)	Thermocouple K	TW D002	0 : 200	°C	+/- 1.1 °C	TCK259	Fig. 5
Upper header - tube 1V, elevation c	DP Transducer	DP 015	34 : +34	kPa	0.25 % f.s.	TSD035	Fig. 6, 7
Lower header - tube 5R, elevation c	DP Transducer	DP 028	34 : +34	kPa	0.25 % f.s.	TSD044	Fig. 6, 7

Tab. 2 - Cont'd

Component or line location	Instrument type	Plant code	Span	m. u.	Accuracy	SIET code	Ref. Dwg.
TUBE BUNDLE MODULE 1 (B)							
Tube 8Q elevation f, int. wall	Thermocouple K	TW B043i	0 : 200	°C	+/- 1.1 °C	TCK121	Fig. 3.11
Tube 8Q elevation g, ext. wall	Thermocouple K	TW B044e	0 : 200	°C	+/- 1.1 °C	TCK122	Fig. 3.11
Tube 8Q elevation g, int. wall	Thermocouple K	TW B044i	0 : 200	°C	+/- 1.1 °C	TCK123	Fig. 3.11
Tube 8Q elevation h, ext. wall	Thermocouple K	TW B045e	0 : 200	°C	+/- 1.1 °C	TCK124	Fig. 3.11
Tube 8Q elevation h, int. wall	Thermocouple K	TW B045i	0 : 200	°C	+/- 1.1 °C	TCK125	Fig. 3.11
Tube 8Q elevation i, ext. wall	Thermocouple K	TW B046e	0 : 200	°C	+/- 1.1 °C	TCK126	Fig. 3.11
Tube 8Q elevation i, int. wall	Thermocouple K	TW B046i	0 : 200	°C	+/- 1.1 °C	TCK127	Fig. 3.11
Tube 5R, elevation c, lower header	DP-Transducer	DP-014	34 : +34	kPa	0.25 % f.s.	TSD045	Fig. 2.3
Tube 5A, angular pos. 3, X dir, el. g.	Accelerometer	VB B001	0 : 500	g	0.02 g	ACC007	Fig. 8.10
Tube 5A, angular pos. 5, Y dir, el. g.	Accelerometer	VB B002	0 : 500	g	0.02 g	ACC008	Fig. 8.10
Tube 7A, angular pos. 3, X dir, el. g.	Accelerometer	VB B003	0 : 500	g	0.02 g	ACC009	Fig. 8.10
Tube 7A, angular pos. 5, Y dir, el. g.	Accelerometer	VB B004	0 : 500	g	0.02 g	ACC010	Fig. 8.10
Tube 1B, angular pos. 7, X dir, el. g.	Accelerometer	VB B005	0 : 500	g	0.02 g	ACC011	Fig. 8.9
Tube 1B, angular pos. 5, Y dir, el. g.	Accelerometer	VB B006	0 : 500	g	0.02 g	ACC012	Fig. 8.9
Tube 1R, angular pos. 7, X dir, el. g.	Accelerometer	VB B007	0 : 500	g	0.02 g	ACC013	Fig. 8.9
Tube 1R, angular pos. 5, Y dir, el. g.	Accelerometer	VB B008	0 : 500	g	0.02 g	ACC014	Fig. 8.9
Tube 8S, angular pos. 3, X dir, el. g.	Accelerometer	VB B009	0 : 500	g	0.02 g	ACC015	Fig. 8.10
Tube 8S, angular pos. 5, Y dir, el. g.	Accelerometer	VB B010	0 : 500	g	0.02 g	ACC016	Fig. 8.10
Tube 8T, extr., el. a, angular pos. 3	Scribe mark	DX B-1sm		mm			Fig. 8.10
Tube 1S, extr., el. a, angular pos. 7	Scribe mark	DX B-2sm		mm			Fig. 8.9
Tube 3A, extr., el. a, angular pos. 7	Scribe mark	DX B-3sm		mm			Fig. 8.9
Tube 5A, extr., el. a, angular pos. 3	Strain gage	DX-B001	+/- 0.5 %	mm/mm	+/- 5 % m.v.	SG093	Fig. 8.10
Tube 7A, el. a, angular pos. 5	Strain gage	DX-B002	+/- 0.5 %	mm/mm	+/- 5 % m.v.	SG094	Fig. 8.10
Tube 7A, extr., el. a, angular pos. 3	Strain gage	DX-B003	+/- 0.5 %	mm/mm	+/- 5 % m.v.	SG095	Fig. 8.10
Tube 1B, extr., el. a, angular pos. 7	Strain gage	DX-B004	+/- 0.5 %	mm/mm	+/- 5 % m.v.	SG096	Fig. 8.9
Tube 1R, extr., el. a, angular pos. 7	Strain gage	DX-B005	+/- 0.5 %	mm/mm	+/- 5 % m.v.	SG097	Fig. 8.9
Tube 1R, el. a, angular pos. 5	Strain gage	DX-B006	+/- 0.5 %	mm/mm	+/- 5 % m.v.	SG098	Fig. 8.9
Tube 8S, extr., el. a, angular pos. 3	Strain gage	DX-B007	+/- 0.5 %	mm/mm	+/- 5 % m.v.	SG099	Fig. 8.10
Tube 1R, extr., el. l, angular pos. 7	Strain gage	DX-B008	+/- 0.5 %	mm/mm	+/- 5 % m.v.	SG100	Fig. 8.9
Tube 5A, el. l, angular pos. 1	Strain gage	DX-B009	+/- 0.5 %	mm/mm	+/- 5 % m.v.	SG101	Fig. 8.10
Tube 8S, extr., el. l, angular pos. 3	Strain gage	DX-B010	+/- 0.5 %	mm/mm	+/- 5 % m.v.	SG102	Fig. 8.10
TUBE BUNDLE MODULE 2 (E)							
Tube 1R, el. a, ext. wall, angular pos. 7	Thermocouple K	TW E001	0 : 200	°C	+/- 1.1 °C	TCK236	Fig. 7.12
Tube 1R, el. l, ext. wall, angular pos. 7	Thermocouple K	TW E002	0 : 200	°C	+/- 1.1 °C	TCK237	Fig. 7.12
Tube 5A, el. a, ext. wall, angular pos. 3	Thermocouple K	TW E003	0 : 200	°C	+/- 1.1 °C	TCK238	Fig. 7.12
Tube 5A, el. l, ext. wall, angular pos. 3	Thermocouple K	TW E004	0 : 200	°C	+/- 1.1 °C	TCK239	Fig. 7.12
Tube 8S, el. a, ext. wall, angular pos. 3	Thermocouple K	TW E005	0 : 200	°C	+/- 1.1 °C	TCK240	Fig. 7.12
Tube 8S, el. l, ext. wall, angular pos. 3	Thermocouple K	TW E-006	0 : 200	°C	+/- 1.1 °C	TCK241	Fig. 7.12

Tab 2 - Cont'd

Component or line location	Instrument type	Plant code	Span	m. u.	Accuracy	SIET code	Ref Dwg
TUBE BUNDLE MODULE 1 (B)							
Tube 4A elevation f, ext wall	Thermocouple K	TW B025e	0 : 200	°C	+/- 1.1 °C	TCK084	Fig 3.11
Tube 4A elevation f, int wall	Thermocouple K	TW B025i	0 : 200	°C	+/- 1.1 °C	TCK085	Fig 3.11
Tube 4A elevation g, ext wall	Thermocouple K	TW B026e	0 : 200	°C	+/- 1.1 °C	TCK086	Fig 3.11
Tube 4A elevation g, int wall	Thermocouple K	TW B026i	0 : 200	°C	+/- 1.1 °C	TCK087	Fig 3.11
Tube 4A elevation h, ext wall	Thermocouple K	TW B027e	0 : 200	°C	+/- 1.1 °C	TCK088	Fig 3.11
Tube 4A elevation h, int wall	Thermocouple K	TW B027i	0 : 200	°C	+/- 1.1 °C	TCK089	Fig 3.11
Tube 4A elevation i, ext wall	Thermocouple K	TW B028e	0 : 200	°C	+/- 1.1 °C	TCK090	Fig 3.11
Tube 4A elevation i, int wall	Thermocouple K	TW B028i	0 : 200	°C	+/- 1.1 °C	TCK091	Fig 3.11
Tube 5Q elevation a, ext wall	Thermocouple K	TW B029e	0 : 200	°C	+/- 1.1 °C	TCK092	Fig 3.11
Tube 5Q elevation a, int wall	Thermocouple K	TW B029i	0 : 200	°C	+/- 1.1 °C	TCK093	Fig 3.11
Tube 5Q elevation b, ext wall	Thermocouple K	TW B030e	0 : 200	°C	+/- 1.1 °C	TCK094	Fig 3.11
Tube 5Q elevation b, int wall	Thermocouple K	TW B030i	0 : 200	°C	+/- 1.1 °C	TCK095	Fig 3.11
Tube 5Q elevation c, ext wall	Thermocouple K	TW B031e	0 : 200	°C	+/- 1.1 °C	TCK096	Fig 3.11
Tube 5Q elevation c, int wall	Thermocouple K	TW B031i	0 : 200	°C	+/- 1.1 °C	TCK097	Fig 3.11
Tube 5Q elevation d, ext wall	Thermocouple K	TW B032e	0 : 200	°C	+/- 1.1 °C	TCK098	Fig 3.11
Tube 5Q elevation d, int wall	Thermocouple K	TW B032i	0 : 200	°C	+/- 1.1 °C	TCK099	Fig 3.11
Tube 5Q elevation e, ext wall	Thermocouple K	TW B033e	0 : 200	°C	+/- 1.1 °C	TCK100	Fig 3.11
Tube 5Q elevation e, int wall	Thermocouple K	TW B033i	0 : 200	°C	+/- 1.1 °C	TCK101	Fig 3.11
Tube 5Q elevation f, ext wall	Thermocouple K	TW B034e	0 : 200	°C	+/- 1.1 °C	TCK102	Fig 3.11
Tube 5Q elevation f, int wall	Thermocouple K	TW B034i	0 : 200	°C	+/- 1.1 °C	TCK103	Fig 3.11
Tube 5Q elevation g, ext wall	Thermocouple K	TW B035e	0 : 200	°C	+/- 1.1 °C	TCK104	Fig 3.11
Tube 5Q elevation g, int wall	Thermocouple K	TW B035i	0 : 200	°C	+/- 1.1 °C	TCK105	Fig 3.11
Tube 5Q elevation h, ext wall	Thermocouple K	TW B036e	0 : 200	°C	+/- 1.1 °C	TCK106	Fig 3.11
Tube 5Q elevation h, int wall	Thermocouple K	TW B036i	0 : 200	°C	+/- 1.1 °C	TCK107	Fig 3.11
Tube 5Q elevation i, ext wall	Thermocouple K	TW B037e	0 : 200	°C	+/- 1.1 °C	TCK108	Fig 3.11
Tube 5Q elevation i, int wall	Thermocouple K	TW B037i	0 : 200	°C	+/- 1.1 °C	TCK109	Fig 3.11
Tube 8Q elevation a, ext wall	Thermocouple K	TW B038e	0 : 200	°C	+/- 1.1 °C	TCK110	Fig 3.11
Tube 8Q elevation a, int wall	Thermocouple K	TW B038i	0 : 200	°C	+/- 1.1 °C	TCK111	Fig 3.11
Tube 8Q elevation b, ext wall	Thermocouple K	TW B039e	0 : 200	°C	+/- 1.1 °C	TCK112	Fig 3.11
Tube 8Q elevation b, int wall	Thermocouple K	TW B039i	0 : 200	°C	+/- 1.1 °C	TCK113	Fig 3.11
Tube 8Q elevation c, ext wall	Thermocouple K	TW B040e	0 : 200	°C	+/- 1.1 °C	TCK114	Fig 3.11
Tube 8Q elevation c, int wall	Thermocouple K	TW B040i	0 : 200	°C	+/- 1.1 °C	TCK115	Fig 3.11
Tube 8Q elevation d, ext wall	Thermocouple K	TW B041e	0 : 200	°C	+/- 1.1 °C	TCK116	Fig 3.11
Tube 8Q elevation d, int wall	Thermocouple K	TW B041i	0 : 200	°C	+/- 1.1 °C	TCK117	Fig 3.11
Tube 8Q elevation e, ext wall	Thermocouple K	TW B042e	0 : 200	°C	+/- 1.1 °C	TCK118	Fig 3.11
Tube 8Q elevation e, int wall	Thermocouple K	TW B042i	0 : 200	°C	+/- 1.1 °C	TCK119	Fig 3.11
Tube 8Q elevation f, ext wall	Thermocouple K	TW B043e	0 : 200	°C	+/- 1.1 °C	TCK120	Fig 3.11

Tab 2 - Cont'd

Component or line location	Instrument type	Plant code	Span	m. u.	Accuracy	SIET code	Ref Dwg
DRAIN LINE (G,5)							
First length, mod 1, (upper header / tap B)	DP Transmitter	DP 019	0 : 50	kPa	0.25 % f.s.	TMD165	00209DD93
First length, mod 2, (upper header / tap C)	DP Transmitter	DP 020	0 : 50	kPa	0.25 % f.s.	TMD157	00209DD93
Under Tee conj. (common length, pos. 5A)	Thermocouple K	T 5001	0 : 200	°C	+/- 1.1 °C	TCK038	Fig 15
CT inlet section	Thermocouple K	T 5002	0 : 200	°C	+/- 1.1 °C	TCK039	00209DD93
Common length	DP Transmitter	DP 029	0 : 100	kPa	0.5 % f.s.	TMD156	00209DD93
Tee conjunction (common length, pos. 5A)	P Transmitter	P 5001	0 : 1.0	MPa	0.25 % f.s.	TMA010	Fig 15
Lower header mod 1 conj. (ang. pos. 1)	Scribe mark	DX G 1sm		mm			Fig 15
Lower header mod 1 conj. (ang. pos. 2)	Scribe mark	DX G 2sm		mm			Fig 15
Lower header mod 1 conj. (ang. pos. 1)	Strain gage	DX G001	+/- 0.5 %	mm/mm	+/- 5 % m.v.	SG116	Fig 15
Lower header mod 1 conj. (ang. pos. 3)	Strain gage	DX G002	+/- 0.5 %	mm/mm	+/- 5 % m.v.	SG117	Fig 15
VENT LINE (6)							
Under Tee conjunction (pos. 6A)	Thermocouple K	T 6001	0 : 200	°C	+/- 1.1 °C	TCK040	Fig 15
VT inlet section	Thermocouple K	T 6002	0 : 200	°C	+/- 1.1 °C	TCK041	00209DD93
Lower header mod 1 Tee conjunction	DP Transmitter	DP 021	0 : 100	kPa	0.25 % f.s.	TMD185	00209DD93
Lower header mod 2 Tee conjunction	DP Transmitter	DP 022	0 : 100	kPa	0.25 % f.s.	TMD184	00209DD93
Common length	DP Transmitter	DP 030	0 : 60	kPa	0.5 % f.s.	TMD004	00209DD93
VT inlet section - Vent tank	DP Transmitter	DP 023	0 : 50	kPa	0.25 % f.s.	TMD183	00209DD93
NON CONDENSIBLE INLET LINE (2)							
Downstream orifice	Thermocouple K	T 2001	0 : 200	°C	+/- 1.1 °C	TCK042	00209DD93
Upstream orifice	P Transmitter	P 2001	0 : 1	MPa	0.25 % f.s.	TMA013	00209DD93
High flowrate measurement device	Orifice - DP	F 2001	0 : 200	kPa	1 % f.s.	TMD017	00209DD93
Low flowrate measurement device	Orifice - DP	F 2002	0 : 100	kPa	0.25 % f.s.	TMD025	00209DD93
STEAM INLET LINE (1)							
Downstream orifice	Thermocouple K	T 1001	0 : 500	°C	+/- 2 °C	TCK001	00209DD93
Upstream orifice	P Transmitter	P 1001	0 : 20.1	MPa	0.25 % f.s.	TMR077	00209DD93
High flowrate measurement device	Orifice - DP	F 1001	0 : 700	kPa	0.25 % f.s.	TMD028	00209DD93
Medium flowrate measurement device	Orifice - DP	F 1001	0 : 100	kPa	0.25 % f.s.	TMD007	00209DD93
Low flowrate measurement device	Orifice - DP	F 1001	0 : 10	kPa	0.25 % f.s.	TMD171	00209DD93
Desuperheating line (water temperature)	Thermocouple K	T 3001	0 : 150	°C	+/- 1.1 °C	TCK033	00209DD93
Desuperheating line	Venturi - DP	F 3001	0 : 100	kPa	0.25 % f.s.	TMD006	00209DD93
PCC POOL (P)							
Loc. F6, tap elevation 5650 - 3220 mm (5)	DP Transmitter	DP P001	0 : 30	kPa	0.25 % f.s.	TMD158	Fig 16
Loc. F6, tap elevation 5025 - 3220 mm (5)	DP Transmitter	DP P002	0 : 30	kPa	0.5 % f.s.	TMD178	Fig 16
Loc. F6, tap elevation 3220 - 50 mm (5)	DP Transmitter	DP P003	0 : 50	kPa	0.25 % f.s.	TMD176	Fig 16
Loc. F6, tap elevation 3220 - 1945 mm (5)	DP Transmitter	DP P004	0 : 35	kPa	0.25 % f.s.	TMD181	Fig 16
Loc. F6, tap elevation 1945 - 1125 mm (5)	DP Transmitter	DP P005	0 : 10	kPa	0.5 % f.s.	TMD169	Fig 16
Loc. F6, tap elevation 1125 - 50 mm (5)	DP Transmitter	DP P006	0 : 35	kPa	0.5 % f.s.	TMD182	Fig 16

SIET	Document	Rev	Page	of
SECTION RETURN (INNOVATIVE)	00098PP01			

Tab 2 - Cont'd

Component or line location	Instrument type	Plant code	Span	u	Accuracy	SIET code	Ref Dwg
TUBE BUNDLE MODULE 2 (E)							
Upper - lower header	DP Transducer	DP 016	-34 : +34	kPa	0.25 % f.s.	TSD004	(0)209(D)93
LOWER HEADER MODULE 1 (C)							
Near back cover flange, ext, pos C, sup (*)	Thermocouple K	TW C001	0 : 200	°C	+/- 1.1 °C	TCK260	Fig 13
Near back cover flange, ext, pos C, inf (*)	Thermocouple K	TW C002	0 : 200	°C	+/- 1.1 °C	TCK261	Fig 13
Front cover, central position (*)	Thermocouple K	TW C003	0 : 200	°C	+/- 1.1 °C	TCK262	Fig 13
Fluid temperature, pos. D, (back side)	Thermocouple K	T C001	0 : 200	°C	+/- 1.1 °C	TCK035	Fig 13
Fluid temperature, pos. I, (front side)	Thermocouple K	T C002	0 : 200	°C	+/- 1.1 °C	TCK036	Fig 13
Lower header - drain line (first length)	DP Transmitter	DP 017	0 : 50	kPa	0.25 % f.s.	TMD164	(0)209(D)93
Front cover bolt, pos. 1 (*)	Thermocouple K	TW CB001	0 : 200	°C	+/- 1.1 °C	TCK242	Fig 13
Front cover bolt, pos. 2 (*)	Thermocouple K	TW CB002	0 : 200	°C	+/- 1.1 °C	TCK243	Fig 13
Front cover bolt, pos. 3 (*)	Thermocouple K	TW CB003	0 : 200	°C	+/- 1.1 °C	TCK244	Fig 13
Near back flange, ext, sup, ax direction	Strain gage	DX C001	+/- 0.5 %	mm/mm	+/- 5 % m.v.	SG103	Fig 13
Near back flange, ext, sup, cir direction	Strain gage	DX C002	+/- 0.5 %	mm/mm	+/- 5 % m.v.	SG104	Fig 13
Near back flange, ext, inf, ax direction	Strain gage	DX C003	+/- 0.5 %	mm/mm	+/- 5 % m.v.	SG105	Fig 13
Near back flange, ext, inf, cir direction	Strain gage	DX C004	+/- 0.5 %	mm/mm	+/- 5 % m.v.	SG106	Fig 13
Front cover, central pos, ext, X dir	Strain gage	DX C005	+/- 0.5 %	mm/mm	+/- 5 % m.v.	SG107	Fig 13
Front cover, central pos, ext, Z dir	Strain gage	DX C006	+/- 0.5 %	mm/mm	+/- 5 % m.v.	SG108	Fig 13
Front cover bolt 1, pos. E	Strain gage	DX CB001	+/- 0.5 %	mm/mm	+/- 5 % m.v.	SG109	Fig 13
Front cover bolt 1, pos. I	Strain gage	DX CB002	+/- 0.5 %	mm/mm	+/- 5 % m.v.	SG110	Fig 13
Front cover bolt 2, pos. E	Strain gage	DX CB003	+/- 0.5 %	mm/mm	+/- 5 % m.v.	SG111	Fig 13
Front cover bolt 2, pos. I	Strain gage	DX CB004	+/- 0.5 %	mm/mm	+/- 5 % m.v.	SG112	Fig 13
Front cover bolt 3, pos. E	Strain gage	DX CB005	+/- 0.5 %	mm/mm	+/- 5 % m.v.	SG113	Fig 13
LOWER HEADER MODULE 2 (F)							
Fluid temperature (back side), pos. D	Thermocouple K	T F001	0 : 200	°C	+/- 1.1 °C	TCK037	Fig 14
Near back flange, ext, angular pos. 1 (*)	Thermocouple K	TW F001	0 : 200	°C	+/- 1.1 °C	TCK263	Fig 14
Near back flange, ext, angular pos. 5 (*)	Thermocouple K	TW F002	0 : 200	°C	+/- 1.1 °C	TCK264	Fig 14
Lower header - drain line (first length)	DP Transmitter	DP 018	0 : 50	kPa	0.25 % f.s.	TMD163	(0)209(D)93
PCC SUPPORTS (S)							
Support S1, right side (*)	Thermocouple K	TW S001r	0 : 200	°C	+/- 1.1 °C	TCK265	Fig 13
Support S1, left side (*)	Thermocouple K	TW S002l	0 : 200	°C	+/- 1.1 °C	TCK266	Fig 13
Back support, Y direction	LVDT	PO S001	0 : 2	mm	+/- 0.5 % f.s.	LDT004	Fig 13
Front support, Y direction	LVDT	PO S002	0 : 2	mm	+/- 0.5 % f.s.	LDT005	Fig 13
Support S1, Z dir, left side	Strain gage	DX S001	+/- 0.5 %	mm/mm	+/- 5 % m.v.	SG114	Fig 13
Support S1, Z dir, right side	Strain gage	DX S002	+/- 0.5 %	mm/mm	+/- 5 % m.v.	SG115	Fig 13
DRAIN LINE (G;5)							
Inlet section, ext, angular pos. 1 (*)	Thermocouple K	TW G001	0 : 200	°C	+/- 1.1 °C	TCK267	Fig 15
Inlet section, ext, angular pos. 3 (*)	Thermocouple K	TW G002	0 : 200	°C	+/- 1.1 °C	TCK268	Fig 15

Tab 2 - Cont'd

Component or line location	Instrument type	Plant code	Span	m u	Accuracy	SIET code	Ref Dwg
PCC POOL (P)							
Location D3 - elevation 3810 mm (S)	RTD-PT100	T P036	0 : 150	°C	1.05 °C	TR041	Fig 17
Location E3 - elevation 3810 mm (S)	RTD-PT100	T P037	0 : 150	°C	1.05 °C	TR042	Fig 17
Location F3 - elevation 3810 mm (S)	RTD-PT100	T P038	0 : 150	°C	1.05 °C	TR043	Fig 17
Location H3 - elevation 3810 mm (S)	RTD-PT100	T P040	0 : 150	°C	1.05 °C	TR044	Fig 17
Location I3 - elevation 3810 mm (S)	RTD-PT100	T P041	0 : 150	°C	1.05 °C	TR045	Fig 17
Location J3 - elevation 3810 mm (S)	RTD-PT100	T P042	0 : 150	°C	1.05 °C	TR046	Fig 17
Location A6 - elevation 2355 mm (S)	RTD-PT100	T P043	0 : 150	°C	1.05 °C	TR047	Fig 17
Location B6 - elevation 2355 mm (S)	RTD-PT100	T P044	0 : 150	°C	1.05 °C	TR048	Fig 17
Location C6 - elevation 2355 mm (S)	RTD-PT100	T P045	0 : 150	°C	1.05 °C	TR049	Fig 17
Location D6 - elevation 2355 mm (S)	RTD-PT100	T P046	0 : 150	°C	1.05 °C	TR050	Fig 17
Location E6 - elevation 2355 mm (S)	RTD-PT100	T P047	0 : 150	°C	1.05 °C	TR051	Fig 17
Location F6 - elevation 2355 mm (S)	RTD-PT100	T P048	0 : 150	°C	1.05 °C	TR052	Fig 17
Location G6 - elevation 2355 mm (S)	RTD-PT100	T P049	0 : 150	°C	1.05 °C	TR053	Fig 17
Location H6 - elevation 2355 mm (S)	RTD-PT100	T P050	0 : 150	°C	1.05 °C	TR054	Fig 17
Location I6 - elevation 2355 mm (S)	RTD-PT100	T P051	0 : 150	°C	1.05 °C	TR055	Fig 17
Location L6 - elevation 2355 mm (S)	RTD-PT100	T P052	0 : 150	°C	1.05 °C	TR056	Fig 17
Location D5 - elevation 5650 mm (S)	RTD-PT100	T P053	0 : 150	°C	1.05 °C	TR057	Fig 17
Location D5 - elevation 5025 mm (S)	RTD-PT100	T P054	0 : 150	°C	1.05 °C	TR058	Fig 17
Location C1 - elevation 2765 mm (S)	RTD-PT100	T P055	0 : 150	°C	1.05 °C	TR059	Fig 17
Location C2 - elevation 2765 mm (S)	RTD-PT100	T P056	0 : 150	°C	1.05 °C	TR060	Fig 17
Location C3 - elevation 2765 mm (S)	RTD-PT100	T P057	0 : 150	°C	1.05 °C	TR061	Fig 17
Location D5 - elevation 525 mm (S)	RTD-PT100	T P058	0 : 150	°C	1.05 °C	TR062	Fig 17
Tap elevation 5025 - 1125 mm (S)	DP - Transmitter	L P001	0 : 50	kPa	0.25 % f.s.	TMD019	00210DD93
Make-up line	Thermocouple K	T M001	0 : 150	°C	+/- 1.1 °C	TCK395	00210DD93
Make-up line	Gilflo DP	F M001	0 : 100	kPa	0.250 % f.s.	TMD015	00210DD93
Discharge line	Thermocouple K	T R001	0 : 200	°C	+/- 1.1 °C	TCK395	00210DD93
Discharge line	Gilflo-DP	F R001	0 : 30	kPa	0.25 % f.s.	TMD177	00210DD93
IC pool lower connecting line	Thermocouple K	T N001	0 : 150	°C	+/- 1.1 °C	TCK045	00209DD93
IC POOL (Q)							
Tap elevation 5140 - 1440 mm (S)	DP - Transmitter	L Q001	0 : 50	kPa	0.25 % f.s.	TMD019	00209DD93
Tap elevation 5140 - 3420 mm (S)	DP - Transmitter	L Q002	0 : 20	kPa	0.25 % f.s.	TMD009	00209DD93
CONDENSATE TANK (L)							
Elevation 4040 mm (E)	Thermocouple K	T L001	0 : 200	°C	+/- 1.1 °C	TCK046	00209DD93
Elevation 3545 mm (E)	Thermocouple K	T L002	0 : 200	°C	+/- 1.1 °C	TCK047	00209DD93
Elevation 1800 mm (E)	Thermocouple K	T L003	0 : 200	°C	+/- 1.1 °C	TCK048	00209DD93
Elevation 388 mm (E)	Thermocouple K	T L004	0 : 200	°C	+/- 1.1 °C	TCK049	00209DD93
Condensate tank - Vent tank	DP-Transmitter	DP-025	0 : 100	kPa	0.5 % f.s.	TMD003	00209DD93
6" discharge line	DP-Transmitter	L L001	0 : 100	kPa	0.5 % f.s.	TMD002	00209DD93

SIET	Document	Rev	Page	of
	00098PP01			
SIET	0	41	225	

TAG	TYPE	LOCATION	D (mm)	d (mm)	α (m ²)	FLUID
F-2001	ORIFICE	Non condensible inlet line	102.26	24.2	3.8038 E-04	AIR
F-2002	ORIFICE	Non condensible inlet line	26.64	7	3.2618 E-05	AIR
F-1001	ORIFICE	Steam Inlet Line	66.65	42.1	1.3053 E-03	STEAM
F-T001	ORIFICE	Vent Tank Mixture Discharge Line	128.2	94.7	7.2220 E-03	STEAM - AIR
F-T002	ORIFICE	Vent Tank Mixture Discharge Line	52.5	13.2	1.1579 E-04	STEAM - AIR
F-3001	VENTURI	Desuperheating Line	24.3	7.8	6.68 E-05	WATER
F-L001	GILFLO	Condensate Tank Discharge Line	102.26	//	M=4.795525E-7(*) K=1.494639E-4	WATER
F-M001	GILFLO	Pools make-up line	102.26	//	M=4.909911E-7(*) K=9.98417E-6	WATER
F-R001	GILFLO	Pools discharge line	102.26	//	M=4.916536E-7(*) K=3.51008E-5	WATER

(*) M (m²/(s*Pa)), K (m/s) calibration constants

D = tube inside diameter

d = throat diameter

α = calibrated or calculated flux coefficient

Tab. 3 - PANTHERS-PCC FLOWMETER DEVICES CHARACTERISTICS

Tab 2 - Cont'd

Component or line location	Instrument type	Plant code	Span	m. u.	Accuracy	SIET code	Ref. DWG
CONDENSATE TANK (L)							
Tap elevation 4040 - 1800 mm (E)	DP Transmitter	L L002	0 : 50	kPa	0.25 % f.s.	TMD166	00209DD93
4" discharge line	Venturi DP	F L001	0 : 35	kPa	0.25 % f.s.	TMD026	00209DD93
Condensate tank upper header mod. 1	DP Transmitter	DP 024	0 : 100	kPa	0.5 % f.s.	TMD010	00209DD93
Discharge line (fluid temperature)	Thermocouple K	T L005	0 : 200	°C	+/- 1.1 °C	TCK050	00209DD93
CT gas space	P Transmitter	P L001	0 : 1	MPa	0.25 % f.s.	TMA009	00209DD93
VENT TANK (I)							
Elevation 6106 mm (E)	Thermocouple K	T I001	0 : 200	°C	+/- 1.1 °C	TCK051	00209DD93
Elevation 3228 mm (E)	Thermocouple K	T I002	0 : 200	°C	+/- 1.1 °C	TCK052	00209DD93
Elevation 570 mm (E)	Thermocouple K	T I003	0 : 200	°C	+/- 1.1 °C	TCK053	00209DD93
Air/vapor discharge line (tank top)	Thermocouple K	T T001	0 : 200	°C	+/- 1.1 °C	TCK054	00209DD93
Tap elevation 3228 - 570 mm (E)	DP Transmitter	L I001	0 : 20	kPa	0.25 % f.s.	TMD005	00209DD93
VT gas space	P Transmitter	P I001	0 : 1.0	MPa	0.25 % f.s.	TMA011	00209DD93
Air / Vapor discharge line	P Transmitter	P T001	0 : 1	MPa	0.25 % f.s.	TMA012	00209DD93
Air / Vapor discharge line (high flowrate)	Orifice - DP	F T001	0 : 100	kPa	0.25 % f.s.	TMD027	00209DD93
Air / Vapor discharge line (low flowrate)	Orifice - DP	F T002	0 : 10	kPa	0.5 % f.s.	TMD170	00209DD93
CATCH TANK (O)							
Tap elevation 3910 - 610 mm (E)	DP Transmitter	L O001	0 : 50	kPa	0.25 % f.s.	TMD167	00209DD93
STEAM BYPASS LINE (7)							
Steam bypass line	P Transmitter	P 7001	0 : 20	MPa	0.25 % f.s.		00209DD93
Steam bypass line	Thermocouple K	T 7001	0 : 400	°C	+/- 1.1 °C		00209DD93
MAIN DESUPERHEATING LINE (8)							
Main desuperheating line	P Transmitter	P 8001	0 : 25	MPa	0.25 % f.s.		00209DD93

Abbreviations

- (*) Compensation thermocouple for mechanical measurement
- (S) Elevation referred to the bottom of FCC or IC pool
- (E) Elevation referred to the tank internal bottom

- e / ext. = external
- i / int. = internal
- sup = superior
- inf = inferior
- ax = axial
- cir. = circumferential
- extr. = extrados
- intr. = intrados
- dir. = direction
- mod. = module
- g = gravity acceleration
- f.s. = full scale
- m.u. = measurement unit
- m.v. = measured value
- loc. = location
- el. = elevation

- ang. = angular
- pos. = position

SIET	Document	Rev	Page	of
Sezione Reattori Innovativi	10075279501	0	45	225

6.1.4 Condensate tank level control loop

The level in the condensate tank is controlled using a digital PID device to which are connected the level measurement signal as process variable and a pneumatic valve, inserted in the discharge line, as actuator device.

6.1.5 Pressure control loop

In order to control the pressure inside the PCC plant two different control loop are foreseen. One will be used in the steam-noncondensibile matrix tests and it consists of a digital PID electronic device with the inlet pressure value as process variable and a pneumatic valve, inserted in the Vent Tank discharge line, as actuator device.

6.1.6 PCC pool level control loop

The PCC tank level will be controlled using a digital PID device with the level as process variable and a pneumatic valve, inserted in the pool discharge line, as actuator device.

SIET	Document	Rev	Page	of
Sezione Ricerca Innovativa	(X098PP9)	0	44	225

6. TEST PLANT CONTROLS AND SAFETY CONSIDERATIONS

6.1 Control system descriptions

In order to perform the PCC experimental test seven control loops are foreseen. These control loops are provided in order to manage and regulate the key tests parameters. A main control board is foreseen to contain the electronic controllers that will perform the operations.

6.1.1 Steam flowrate control loop

The control of the steam flow-rate is performed using a digital PID electronic controller to which are connected the steam orifice pressure drop instrument as process variable and a pneumatic valve, inserted in the steam supply line, as actuator. The temperature and the pressure of the steam are used in order to adjust the engineering value of the flow-rate.

6.1.2 Steam-noncondensibile gas mixture temperature control loop

The temperature of the steam-noncondensibile gas mixture will be controlled using a digital PID electronic controller with the mixture temperature as process variable and a pneumatic valve, inserted in the desuperheating line, as actuator.

6.1.3 Air flowrate control loop

The control of the air flow-rate is performed using a digital PID electronic device to which are connected the air orifice pressure drop as process variable and a pneumatic valve, inserted in the air supply line gas as actuator. The temperature and the pressure of the air are used in order to adjust the engineering value of the air flow rate.

SIET	Document	Rev	Page	of
McLone Repton Innovations	1009RPP91	0	46	125

6.2 Safety considerations

To assure the structural integrity of the PCC full scale prototype and to meet the design requirements of the Panthers-PCC components and piping the following safety valves are installed:

- a) F016 on steam-air mixture supply line, set to high pressure signal (1.0 MPa)
- b) F050 on the line connecting the main noncondensable line to the gas space of the condensate tank, set to high pressure signal (1.0 MPa).
- c) F040 on the vent tank, set to high pressure signal (1.0 MPa).

SIET	Document	Rev	Page	of
Divisione Ricerca Innovativa	0009RPP01	0	47	225

7. DATA ACQUISITION SYSTEM

The data acquisition and elaboration system is designed to match all the needs to measure and handle measured signals from the plant. A supervisor computer provides a protected work-area and the access is restricted to the authorized users only. The large amount of the user operation are standardized and collect in a set of software procedures to avoid errors and loss of information.

7.1 Hardware configuration

The data acquisition and elaboration system consists of some components completely integrated in order to make the user able to perform all the significant action connected with the data acquisition and elaboration process.

The schematics in (ref. 2.2.2) show the arrangements of PCC DATA ACQUISITION and ELABORATION system. It basically consist of four main central components:

- supervisory computer DEC VAX4000-200
- graphics workstation DEC VAXSTATION 2000
- remote I/O driver DEC MICROVAX II
- file transfer DOS device

and of two data logger subsystems:

- digital data acquisition subsystem RTVAX 300
- analogical magnetic tape recorder system HONEYWELL model.101 connected with a FFT system (HEWLETT PACKARD HP3567A)

SIET	Document	Rev	Page	of
Unione Reazioni Innovative	(009RPP0)	0	48	225

The signals coming from instruments are sended to the two data loggers by means of particular measurement chains.

The supervisory computer is a DEC VAX4000-200 elaborator with the following features:

- CPU 5 VUPS
- 1 controller DSSI 10 MIPS in RISC technology
- 1 ETHERNET controller 10 MIPS in RISC technology
- 64 Mbyte of RAM memory
- mass storage: 1 Gbyte of hard disk RF72 DEC 1.2 Gbyte removable cartndge TLZ04 DEC
- peripherals: 2 console 4 color video terminal
 - 1 printer DEC LA100
- communication : 4 serial ports
 - 1 interface adapter for data acquisition subsystem CS85RU
 - 1 ETHERNET port

The graphic workstation is a DEC VAXSTATION 2000 elaborator with the following features :

- 1 CPU
- 6 Mbyte of RAM memory
- 1 ETHERNET controller

SIET	Document	Rev	Page	of
Sezione Ricerca Innovativa	K009RPP01	0	19	225

mass storage : 130 Mbyte of hard disk

peripherals: 19" 8 floor color video XWINDOW

terminal DEC VR290

The remote I/O driver is a DEC MICROVAX II elaborator with the following features :

- 1 CPU
- 5 Mbyte of RAM memory
- 1 ETHERNET controller
- mass storage :
 - 130 Mbyte of hard disk
 - 90 Mbyte of hard disk
 - 70 Mbyte tape streamer removable cartridge
- peripherals :
 - 4 serial port
 - 14" monochrome video (PC based computer + VT240 terminal emulator software)

The file transfer elaborator is a DEC VAXMATE computer AT IBM compatible with the following features

- CPU 80286
- 1 Mbyte of RAM memory
- 1 floppy disk drive high density 5 1/4

SIET	Document	Rev	Page	of
SECTION: Keaton Innovatives	0009RPP91	0	50	225

- 1 virtual hard disk for a total amount of 60 Mbyte
- 1 ETHERNET controller
- 1 serial port
- 1 printer port
- 1 monochrome CGA 14" video

The digital data acquisition subsystem RTVAX 300 is a set of "remote" data logger linked in a star configuration, by using a thin Ethernet cable, to the supervisory computer in which is installed a virtual central node. Every of this remote units has this main characteristics:

- 1 buffer memory 1 Mbyte
- 1 microprocessor card with 32 bit bus, 20 MHz clock
- 1 Ethernet controller 10 Mbyte/s throughput
- 1 switch mode power box
- 1 100 Hz maximum adjustable sampling rate
- 1 set of data conditioning and amplifier card

The analog data acquisition subsystem consists of a magnetic tape analog recorder and a Fast Fourier Transform system

The HONEYWELL Model.101 Magnetic Tape Record/Reproduce Portable System is a multitrack record/reproduce system for recording and reproducing data on magnetic tape. The system uses FM rec/reproduce electronics which may be mixed to suit the requirements of the application. The main characteristics of this device are:

SIET Sri Leone Reardon Innovative	Document (009RPP9)	Rev 0	Page 51	of 225
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input channels	24
input level	0.5 + 10 V peak to peak with adjusting +/- 40 %
minimum input impedance	18 k Ω
maximum input capacitance	10 pF
operating temperature	0 + 50 °C
adjustable bandwidth	DC + 80 kHz

TAPE SPEED (inches per second)	CENTER FREQUENCY (kHz)	BANDWIDTH (kHz)
120	432	DC + 80
60	216	DC + 40
30	108	DC + 20
15	54	DC + 10
7 1/2	27	DC + 5
3 3/4	13.5	DC + 2.5
1 7/8	6.75	DC + 1.25
1.5 / 16	3.375	DC + 0.625

The HP 3567A PC spectrum/network analyzer is a expandable FFT analyzers that characterize signals in both time and frequency domains. consists of a set of measurement hardware and signal-processing software which is on an IBM-PC compatible computer. The measurement hardware is connect to the computer using an HP-IB (GPIB) interface.

The measurement hardware HP3567A is of modular type consists of the HP35650A mainframe, HP35651B HP-IB / signal processor module, three HP35652A one channel input module nad the HP35653A source module for calibration.

The signal processing software controls the measurement hardware and computer to make and display measurement. Its digitize and stores analog input signal; applies extensive library of pre-programmed analysis function to store data and display the signal and/or the processed information on the screen. It incorporates all of the features of:

- a) high performance data acquisition and signal conditioning system
- b) microprocessor-controlled digital storage and analog/digital display system

SIET	Document	Rev	Page	of
Division: Research, Innovative	0009XPP01	0	52	225

A non-volatile storage of waveform data, control setups and programs is possible with the floppy disk drive of the IBM-PC compatible computer. This device is configured with a plug-in module with three timebase independently adjustable. It is possible to select the sampling speed (the number of acquired data points and extent of pre or post trigger recording for optimum acquisition and analysis of waveform data). In detail the characteristic parameters are:

- CPU 16 bit 68010
- 3 display trace modes
- data records up to 8 K word
- interface: HP-IB (GPIB)
- 3 input channels
- input coupling AC, DC, GND
- Dynamic input range 80 dB
- input range from 1.26 mVpk to 39.8 Vpk, and frequency from 6 μ Hz to 51 kHz
- switchable 3 input modes: voltage, charge, 4 mA constant current source
- A/D converter resolution 16 bit with maximum conversion rate 600 kbyte/second

The measurement chain is composed of three main hard components as shown in (ref. 2.2.2):

- instrument
- signal conditioner card
- A/D converter card (for digital measurements only)

SIET	Document	Rev	Page	of
Sezione Ricerca Innovativa	0009RPP91	0	93	225

The digital measurements need additional informations that are contained in five logical software archives:

- transducer descriptor block
- physical acquisition channel
- measurement channel
- alarm condition
- action code
- monitor page

The instrumentation for PCC test to be recorded is divided in two group referred as digitally acquired and analogically acquired. The digital instruments are intended to determine the thermodynamic performances of the PCC component. In addition these instruments are used where high frequency resolution is not necessary. Sampling frequency for each measurements is adjustable; preliminary sampling frequency is setted to 1 Hz, but this value may be changed in function of the experimental test.

Analogically recorded instruments are used in location where there is an important frequency content. The instrument signal designed as analog transducers (accelerometers) are recorded on magnetic tape in FM mode. The preliminary record bandwidth for these instruments is setted to 0 - 625 Hz but this value may be changed in function of experimental test..

7.2 Software

The software used to perform the data acquisition process is based on VAX/VMS (DEC) operative system and on VAX/RDB (DEC) relational data base. All applied software use the properties and the libraries of this two main work environments. The applied software perform the operation to drive the data loggers, to record the instruments values, to reduce (convert) them in engineering units (i.e. kPa for differential pressures, MPa for absolute pressures, etc.), to print and plot the results and to store the data into

SIET	Document	Rev	Page	of
Divisione Realtà Innovativa	10009RPP01	0	54	225

appropriate magnetic media. The applied software consist in a set of program integrated into a Similar Operative System Utility that only allows standard and tested operation. Inside these programs there are some subroutines (i.e. the calculational subroutine that elaborates flow rates or water levels, etc from real time values) that are treated as verified engineering calculation.

The software that drives the digital data loggers RTVAX300 is transparent to the users and will run in background during the experimental operations. In particular this data acquisition system is based on a network architecture in which there is one control and elaboration unit and some remote unit with data sampling function. Every remote units is linked to each other in a star logical configuration with the information flowing from the central control unit to the remote unit and viceversa. Any communication between the remote units is not allowed.

The entire activity of control, acquisition and elaboration is divided in specialized task. Inside the remote units the communication task dialog using MailBoxes and shared area memory. This MailBoxes are FIFO type communicating channels. When a task want get information starts an own input MailBox. Two specialized task (NET_IN and NET_OUT) routing the communication between tasks resident on different remote units. A task that send information to another task on a different remote unit put the message and the address of the target into the NET_OUT MailBox that write this message to NET_IN task on target remote unit.

The data acquisition process is performed using same tasks resident on different remote units. The peripherals units sample the physical signals and convert they in number. This number are send to the control unit where goes on the first elaboration and the data are permanently stored on disk. The kernel of the process of acquisition and elaboration is constituted of a shared area memory that contains the image of the earlier acquired data of all the active measurements channels. Around this kernel runs some specialized tasks, in particular there re three tasks:

ELAB_PHIS_DATA read data from network, convert it into engineering units and put them in the data structure resident in memory; when reads data of channels involved in the determination of logical results that must be computed on-line starts the **ELAB_LOG_DATA** task

ELAB_LOG_DATA calculates the value of all logical measurements

SAVE_ON_DISK parses the shared area memory and save on disk every complete **DATA_BLOCK** setting a flag of "save" on the relative block in memory.

SIET	Document	Rev	Page	of
Sezione Ricerca Innovativa	[0098PP9]	0	55	225

The array of active tasks on the central node have available shared area memory in which are same differentis type of informations :

- system configuration image loaded during the start-up of all network process
- updated acquisition's parameters image (alarm_sampling frequency, ecc...) This structure reflects all the changes in the system parameters modified by the user during data acquisition process.
- one image (temporal shift window) of data.

This area is a buffer for build the data structure on disk.

The data organization has the same logical structure in memory and on disk store unit. This structure is a bidirectional linked list. The data acquisition process measure the trend of a phenomena during a period and will handle a sequency of value for each measurements channels . The condition in which the value will be costant for an amount of sampling is foreseen to allow a best use of mass storage space. The elementary unit of acquisition is the DATA that represents the measure make or calculated for one time and for one acquisition channel. To handle a very large amount of data and allocate memory the process use a structure derived from the DATA: the DATA_BLOCK. This is a fixed long structure that contains :

- sequentially sampled data array
- auxiliary informations
- forward and backward DATA_BLOCK pointer

This DATA_BLOCK structure is contained into another high level structure named ENTRY_BLOCK with the links to first and last DATA_BLOCK structure, too. Starting from ENTRY_BLOCK and tracking the forward link chain is possible known the history of acquired data, or backstepping it using the backward link (for example see the last 50 points). When the sampled data fill a DATA_BLOCK it's stored into a disk's file and is allocated another DATA_BLOCK in which put new data. Before DATA_BLOCK saturates the memory the process discharge the oldest DATA_BLOCK to free space for new data. The dimension of this temporal window is function of channels number and their sampling frequency. There's one ENTRY_BLOCK structure for each measurement channel.

Inside the recorded data file will be write an header containing the experimental test identification code , the used archives configuration identification code, the starting date of recording and further internal system information.

SIET	Document	Rev	Page	of
Meziona Keaton Innovativ	0009RPPQ1	0	56	225

To complete the measurement chain for the digitally recorded signals the system needs additional information contained into six logical software archives:

- transducer descriptor block
- physical acquisition channel
- measurement channel
- alarm condition
- action code
- monitor page

The first functional box in the measurement chain is the transducer description block. It has in input a physical signal (pressure, temperature, ecc...) and give in output another physical signal (electrical or electrically measurable) proportional to the input. The input and output parameters are simply described by using a label and a measurement unit. If the input/output relation is linear is sufficient define the straight-line parameter in this formula:

$$\text{OUTPUT} = \text{PARAM_Q} + \text{INPUT} * \text{PARAM_M}$$

it is also possible to use an externally defined conversion table

Every acquisition channel capture in input the transducer's output, elaborates it (conditioning, amplification, A/D conversion) and presents in output a numerical value with n bit of resolution.

The input/output transfer function is linearly defined by using the operators OFFSET and GAIN:

$$\text{OUTPUT} = \text{OFFSET} + \text{INPUT} * \text{GAIN}$$

This channel make available the measurement of the primitiv physical value to the Measurement channel because in general the physical channel may or must be linked with other to obtain the right calculation of a value.

Document	Rev	Page	of
XGRPP01	0	57	116

x the user to perform the acquisition data process: display,
s block contain the reference to the algorithm, to the list of all
putation of the engineering value.
the value that may be shown in tables or plot, the print format
ck.

ed one or more alarm condition control functions. This means
measured value to verify the overtaking of a threshold. When an
start the foreseen actions. During the data acquisition process
abled or enabled by the user. The image of this information is
of the data acquisition process.

out the action to be performed in relation with the alarm
an alarm condition is reached. Generally this action may be
insist to send a message to a physical control channel. The
and correct format parameter in function of the type of
ility to record an event (identification channel code, time,
alarm process) is foreseen.

monitor pages organization. In this archive are stored the
ay limits. These information are organized for each monitor

SIET	Document	Rev	Page	of
Divisione Ricerca Innovativa	00098PP91	0	58	225

3.3 Software qualification

The data acquisition system software will be qualified performing the following actions:

- 1) send calibrated voltage signals to the data acquisition system input channels and verify that the signals are correctly acquired and recorded by DAS;
- 2) check that the instrument conversion constants are correctly input and allocated in the DAS;
- 3) check that the conversion formulas are perfectly inserted in the DAS;
- 4) verify the correctness of the conversion calculations performed by DAS, sending calibrated voltage signals to the DAS input channels and comparing the DAS conversion results with the same signal conversions carried out by means of hand calculations.

These verifications will be carried out only once before starting the tests both for directly measured quantities and for derived quantities. The results of the verifications will be archived in the DRF. If some instruments is replaced as consequence of instrument failure or if some instrument spans is changed, the verifications concerning the instruments in object will be repeated.

The instrument zero will be verified every day before test starting.

SIET	Document	Rev	Page	of
Sezione Ricerca Innovativa	00098PP91	0	59	225

8. DATA ANALYSIS AND RECORDING

8.1 Data reduction

8.1.1 Digitally acquired quantities

During testing all the instrumentation signals (compensation thermocouples included) are recorded and stored in real time. The sampling frequency is normally fixed at 1.0 Hz and can be adjusted in the range 0.1 + 100 Hz. The recorded data are converted in engineering units (S.I.) and plotted versus time for the entire test period or selected time interval. The mean value, the standard deviation, the maximum and minimum value of the acquired quantities are also calculated.

8.1.1.1 Directly measured quantities

8.1.1.1.1 Absolute and differential pressure

Absolute and differential pressures are measured by means of transmitters and transducers. The electrical signals coming from instrument (mV) are converted in engineering units (kPa) as follows:

$$Y = M * (mV - Q) + K$$

where:

M, Q = calibration constants

K = instrument hydraulic head

The instruments are calibrated in laboratory to verify if they meet the required accuracy. After installation a measurement chain check is performed to control the correspondence between the data acquisition system recording channels and the primary instrument.

The instrument zero are also verified every day before test starting.

SIET	Document	Rev	Page	of
Sezione Reattori Innovativi	00098PP91	0	60	225

8.1.1.1.2 Temperatures

The temperature of the fluid, piping, components and pool water are measured by using:

- sheathed thermocouples type K Chromel-Alumel, 0.5-1.5 mm OD
- RTD thermoresistances type PT 100

A matrix E (mV), T(°C), for "k" type thermocouple is generated by the following formula:

$$E = \left(\sum_{i=0}^9 d_i T^i - 128 \exp \left[-1/2 * (T - 127/65)^2 \right] \right) / 1000 \quad (\text{UNI7938 specifications})$$

where:

E	=	electric signal (mV)
T	=	temperature (°C)
d ₀	=	- 1.853306 * 10 ¹
d ₁	=	3.891834 * 10 ¹
d ₂	=	1.664515 * 10 ⁻²
d ₃	=	- 7.870237 * 10 ⁻⁵
d ₄	=	2.283579 * 10 ⁻⁷
d ₅	=	- 3.570023 * 10 ⁻¹⁰
d ₆	=	2.997291 * 10 ⁻¹³
d ₇	=	- 1.284985 * 10 ⁻¹⁶
d ₈	=	2.223997 * 10 ⁻²⁰

The value of temperature T(°C) is obtained from the signals coming from thermocouples E(mV), performing a linear interpolation of the matrix E, T.

SIET	Document	Rev	Page	of
Sezione Ricerca Innovativa	00098PP91	0	61	225

In the same way the signals coming from thermoresistance (Ω) are converted in engineering units ($^{\circ}\text{C}$) performing the linear interpolation of the PT100 type thermoresistance data characteristics generated by the following formula :

$$R = 100 * (1 + 3.90802E-3 * T - 0.5802E-6 * T^2) \quad (\text{UNI7313 specifications})$$

where:

T = temperature ($^{\circ}\text{C}$)

R = measured RTD resistance (Ω)

Thermoresistances and thermocouples are calibrated in laboratory to verify if they meet the required accuracy. Before testing a check to control the correspondence between the data acquisition system recording channels and the instruments is also performed.

8.1.1.1.3 Displacements

Displacements and positions are measured by means of high temperature, waterproof transducers type LVDT (linear variable differential transformer). The signals coming from the instrument (mV) are converted in engineering units (mm) as follows:

$$Y = \text{mV} / (S * V)$$

where:

mV = electric signal coming from instrument (mV)
S = sensitivity coefficient (mV/(V/mm))
V = feeding voltage (V)

The instruments are calibrated in laboratory to verify if they meet the required accuracy. After installation a measurement chain check is performed to control the correspondence between the data acquisition system recording channels and the instrument.

SIET	Document	Rev	Page	of
Edizione Revisione Innovativa	00098PP91	0	62	225

X.1.1.2 Derived quantities

X.1.1.2.1 Flowrates

The flowrate of single phase fluid (steam, air, water) is measured by means of different primary elements: orifice plates, nozzles, venturi tubes and Gifflo. Except for the Gifflo flowmeters, the reference formula, in accordance with UNI 10023 specifications, are:

$$F = \alpha_c \cdot \epsilon \cdot \sqrt{\rho} \cdot \sqrt{\Delta P_c} \quad \text{for compressible fluid} \quad (\text{kg/s})$$

$$F = \alpha_c \cdot \sqrt{\rho} \cdot \sqrt{\Delta P_c} \quad \text{for incompressible fluid} \quad (\text{kg/s})$$

with:

$$\Delta P_c = \Delta P \pm \rho \cdot g \cdot h \quad (\text{Pa})$$

for orifice plate

$$\epsilon = 1 - (0.41 + 0.35 \cdot \beta^4) \cdot \Delta P_c / (\sigma \cdot P_1)$$

for Venturi tubes and nozzles

$$\epsilon = \left(\frac{P_1}{P_2} \right)^{\frac{1}{\sigma}} \cdot \frac{\sigma}{\sigma - 1} \cdot \frac{1 - \left(\frac{P_2}{P_1} \right)^{\frac{\sigma - 1}{\sigma}}}{1 - \frac{P_2}{P_1}} \cdot \frac{1 - \beta^4}{1 - \beta^4 \cdot \left(\frac{P_2}{P_1} \right)^{\frac{1}{\sigma}}} \quad 0.5$$

where:

$$\alpha_c = \left(\frac{\pi}{4} \right) \cdot d^2 \cdot \sqrt{2} \cdot \alpha \quad \text{calibrated or calculated flux coefficient} \quad (\text{m}^2)$$

SIET	Document	Rev	Page	of
Sezione Ricerca Innovativa	00098PP91	0	63	225

α	=	flux coefficient	
ϵ	=	compressibility coefficient ($\epsilon = 1$ for liquid)	
d	=	throat diameter	(m)
ρ	=	fluid density upstream the measurement device	(kg / m ³)
ΔP	=	measured pressure drop	(Pa)
ΔP_c	=	local pressure drops across the nozzle	(Pa)
P_1	=	absolute pressure upstream the measurement device	(Pa)
h	=	pressure taps height difference	(m)
P_2 / P_1	=	downstream / upstream pressure ratio	
σ	=	$C_p / C_v =$ isentropic exponent (steam supply line = 1.27 ; air = 1.4)	
β	=	diameter ratio (d / D)	
D	=	tube inside diameter	(m)
F	=	flowrate	(kg / s)

The α_c flux coefficient value is corrected taking account of the fluid temperature upstream the measurement device by means of the following formula:

$$\alpha_c = \alpha_c \cdot (1 + \lambda \cdot (T - T_{cal}))^2 \quad (m^2)$$

where:

T	=	working temperature	(°C)
T_{cal}	=	calibration temperature	(°C)
λ	=	linear thermal expansion coefficient = 1.2 E-5	(1 / °C)

With the GILFLO variable area orifices the water flowrate is measured as:

SIET	Document	Rev	Page	of
Reazione Reattore Innovativi	00098PP91	0	64	225

$$F = \rho \cdot (M \cdot \Delta P + K) \quad (\text{kg/s})$$

where:

M	=	calibration constant (see table 3)	(m ² / (s Pa))
K	=	calibration constant (see table 3)	(m ³ /s)
ΔP	=	GILFLO pressure drops	(Pa)
ρ	=	water density	(kg/m ³)

The steam / air mixture flowrate discharged from vent tank, is measured by means of two orifice plates. The reference formula is:

$$F = \alpha_c \cdot \epsilon_{mix} \cdot (\rho_{mix} \cdot \Delta P_c)^{0.5} \quad (\text{kg/s})$$

with:

ϵ_{mix}	=	$1 - (0.41 + 0.35 \cdot \beta^4) \cdot \Delta P_c / (\sigma_{mix} \cdot P_1)$	
σ_{mix}	=	$C_p \cdot C_v = X_{steam} \cdot \sigma_{steam} + X_{air} \cdot \sigma_{air}$	mixture isentropic exponent
X_{air}	=	$1 / (1+x)$	air quality
X_{steam}	=	$x / (1+x)$	steam quality
ρ_{mix}	=	$\rho_{air} \cdot [(x+1) / x]$	(Kg / m ³)

where:

α_c	=	$\left(\frac{\pi}{4}\right) \cdot d^2 \cdot \sqrt{2} \cdot \alpha$	calibrated or calculated flux coefficient	(m ²)
α	=	flux coefficient		
ΔP_c	=	orifice pressure drop		(Pa)

SIET	Document	Rev	Page	of
Sezione Reattori Innovativi	00098PP91	0	65	225

ρ_{mix}	=	vent tank discharge line steam-air density	(Kg / m ³)
ρ_{sat}	=	vent tank discharge line saturated steam density at the measured temperature	(Kg / m ³)
x	=	$M_{steam} / M_{air} = \text{specific / absolute humidity} = 0.622 * \frac{P_{sat}}{P_1 - P_{sat}}$	
M_{steam}	=	steam mass	(kg)
M_{air}	=	air mass	(kg)
σ_{steam}	=	vent tank discharged steam isentropic exponent = 1.31	
σ_{air}	=	air isentropic exponent = 1.40	
P_1	=	absolute pressure upstream the measurement device	(Pa)
β	=	diameter ratio (d / D)	
P_{sat}	=	saturated steam partial pressure at the measured temperature	(Pa)

8.1.1.2.2 Levels

Liquid level in single phase or level in two phase (steam and water, air and water) are measured by means of differential transmitters. The reference formula is:

$$L = (\Delta P \cdot g \cdot \rho_{gas} \cdot h) / [g \cdot (\rho_l - \rho_{gas})] \quad (m)$$

where:

ρ_{gas}	=	gas density	(kg/m ³)
ρ_{gas}	= 0	in single phase	
ρ_{gas}	= ρ_{steam}	for steam and water	(kg/m ³)
ρ_{gas}	= $\rho_{air} = P / (R \cdot T)$	for air and water	(kg/m ³)
P	=	air pressure	(Pa)

SIET	Document	Rev	Page	of
we Done Reason Innovative	00098PP91	0	66	225

T	=	air temperature	(K)
R	=	air gas constant = 287.037	(J / kg K)
ρ_l	=	liquid density	(kg/m ³)
ΔP	=	static pressure difference	(Pa)
h	=	pressure taps height difference	(m)
g	=	gravity acceleration	(m / s ²)

Liquid level in presence of steam / air mixture is calculated as :

$$L = \frac{|\Delta P - g \cdot \rho_{mix} \cdot h|}{|g \cdot (\rho_l - \rho_{mix})|} \quad (m)$$

with:

$$\rho_{mix} = \rho_{sat} \cdot \left[\frac{(x+1)}{x} \right] \quad (kg/m^3)$$

$$x = 0.622 \cdot \left[\frac{P_{sat}}{(P - P_{sat})} \right]$$

where:

ρ_{mix}	=	mixture density	(kg / m ³)
ρ_{sat}	=	saturated steam density at the measured temperature	(kg / m ³)
ρ_l	=	liquid density	(kg / m ³)
x	=	specific / absolute humidity	
P_{sat}	=	saturated steam partial pressure at the measured temperature	(Pa)
P	=	gas space absolute pressure	(Pa)
ΔP	=	differential pressure	(Pa)
h	=	pressure taps height difference	(m)

SIET	Document	Rev	Page	of
Sezione Ricerca Innovativa	00098PP91	0	67	225

= gravity acceleration (m / s²)

8.1.1.2.3 Pool density

The pool water density is measured by means of differential pressure transmitters, as follows :

$$\rho = \Delta P / (g \cdot h) \quad (\text{kg} / \text{m}^3)$$

where:

ΔP = differential pressure (Pa)

h = pressure taps height difference (m)

g = gravity acceleration (m / s²)

8.1.1.2.4 Strain

The IC & PCC local strains are measured by means of capsulated high temperature strain gages. The reference calculation formula for the specific strain is:

$$\epsilon = \epsilon_m + j$$

with:

$$\epsilon_m = \frac{\Delta R}{R} \cdot K$$

where:

ΔR = strain gage active resistance change (Ω)

R = strain gage active resistance (Ω)

SIET	Document	Rev	Page	of
Subsone Reaktor Inovativni	00098PP91	0	68	225

K = GF * k instrument gage factor at operating temperature

ϵ_m = measured strain (mm / mm)

GF = instrument gage factor at room temperature

k = temperature correction factor = $1.001 - 5.688E-5 * T - 2.499E-7 * T^2$

j = pressure correction factor = $4.677E-6 * P$

T = temperature of measurement point (°C)

P = pressure on the strain gage (MPa)

The k and j factors are calculated following the reference document 2.3.1).

8.1.1.2.5 Condensation thermal power

The PCC thermal power is calculated by means of a global energy balance. The adopted formula is:

$$W = F_{mix} * h_{mix} - F_{cond} * h_{cond} - F_{out} * h_{out} - F_{entr-cond} * h_{entr-cond} - W_{Lout} \quad (\text{kW})$$

where:

F_{mix} = PCC inlet mixture flowrate ($F_{mix} = F_{steam} + F_{air} + F_{liq}$) (kg/s)

F_{steam} = supply superheated steam flowrate (kg/s)

F_{air} = supply air flowrate (kg/s)

F_{liq} = desuperheating water flowrate (kg/s)

h_{mix} = PCC inlet mixture enthalpy =
 $= (F_{steam} * h_{steam.in} + F_{air} * h_{air.in} + F_{liq} * h_{liq.in} - W_{Lin}) / F_{mix}$ (kJ / kg)

$h_{steam.in}$ = superheated steam enthalpy upstream supply line mixing point (kJ / kg)

$h_{air.in}$ = air enthalpy upstream supply line mixing point (kJ / kg)

$h_{liq.in}$ = desuperheating water enthalpy (kJ / kg)

SIET	Document	Rev	Page	of
Version: Revision: Innovative	00098PP91	0	69	225

W_{Lin}	=	power lost in the mixture supply line between mixing point and PCC inlet	(kW)
F_{cond}	=	PCC outlet condensate flowrate	(kg / s)
h_{cond}	=	PCC outlet condensate enthalpy	(kJ / kg)
F_{out}	=	vent tank steam/air mixture discharge line flowrate	(kg / s)
h_{out}	=	vent tank discharge line mixture enthalpy =	
	=	$h_{air,out} * X_{air} + h_{sat,out} * X_{steam}$	(kJ / kg)
X_{air}	=	$1 / (1+x)$ = air quality	
X_{steam}	=	$x / (1+x)$ = steam quality	
x	=	specific / absolute humidity = $0.622 * \frac{P_{sat}}{P - P_{sat}}$	
P_{sat}	=	saturated steam partial pressure at the vent tank discharge line measured temperature	(MPa)
P	=	vent tank discharge line absolute pressure	(MPa)
$h_{air,out}$	=	vent tank air enthalpy at the measured temperature and air partial pressure ($P - P_{sat}$)	(kJ / kg)
$h_{sat,out}$	=	vent tank discharge line saturated steam enthalpy at the measured temperature	(kJ / kg)
$F_{entr-cond}$	=	vent line entrained condensate flowrate	(kg / s)
$h_{entr-cond}$	=	vent line entrained condensate enthalpy	(kJ / kg)
W_{Lout}	=	vent line and vent tank power lost	(kW)

The entrained liquid in the vent line flow is collected in the vent tank. The liquid flowrate is measured taking account the vent tank level increase (ΔL), during a measured time interval (Δt) with the liquid discharge line shut off, as

$$F_{entr-cond} = (\Delta L / \Delta t) * \rho_{entr-cond} * A \quad (\text{kg / s})$$

SIET	Document	Rev	Page	of
Divisione Ricerca Innovativa	00098PP91	0	70	225

where:

$\rho_{entr-cond}$ = entrained condensate density (kg/m³)

A = vent tank cylindrical cross section = 2.27 (m²)

The instruments used to measure the above mentioned quantities for the PANTHERS-PCC are reported in the following table:

QUANTITY	USED INSTRUMENT TAG
F_{cream}	F-1001; F-1002; F-1003; T-1001; P-1001
F_{air}	F-2001; F-2002; T-2001; P-2001
F_{lin}	F-3001; T-3001
$h_{cream in}$	T-1001; P-1001
$h_{air in}$	T-2001; P-2001
$h_{lin in}$	T-3001
$W_{T in}$	T-4001; P-4001; T-4002; P-4002
F_{cond}	F-L001; T-L005
h_{cond}	T-5001; P-5001
F_{out}	F-T001; F-T002; P-T001; T-T001
$h_{air out}$	T-T001; P-T001
$h_{cat out}$	T-T001; P-T001
P_{cat}	T-T001
p	P-T001
$F_{entr-cond}$	L-1001; T-1001; T-1002; T-1003; P-1001
$\rho_{entr-cond}$	T-1001; T-1002; T-1003; P-1001
$h_{entr-cond}$	T-1001; T-1002; T-1003; P-1001
$W_{T out}$	F-out; T-6001; T-6002; T-1001; T-1002; T-1003; P-1001

SIET	Document	Rev	Page	of
Sezone Reaction Innovative	00098 PP91	0	71	225

K.1.1.2.6 Heat flux coefficient

The local heat flux coefficient is measured as :

$$\text{with } h_h = \frac{Q^*}{(T_e - T_{\text{pool}})} \quad (\text{W} / \text{K m}^2)$$

$$Q^* = k / R_e * (T_i - T_e) / \ln(R_e / R_i) \quad (\text{W} / \text{m}^2)$$

where :

Q^*	=	local thermal flux	(W / m ²)
k	=	AISI 304L or INCONEL 600 thermal conductivity	(W / m K)
R_e	=	external TC hot junction radius	(m)
R_i	=	internal TC hot junction radius	(m)
T_e	=	external tube wall temperature	(K)
T_i	=	internal tube wall temperature	(K)
T_{pool}	=	pool temperature	(K)

K.1.2 Analogically acquired quantities

During testing the signals coming from accelerometers are recorded analogically using a magnetic tape recorder and later analyzed by a FFT.

The data recording is performed only during certain time periods with tape speed set during the shakedown test.

The signals will be later reproduced at the same tape speed and sent to the FFT to obtain Power Spectral Densities (PSD) for research of the main frequencies.

SIET	Document	Rev	Page	of
szjone Keaton Innovative	00098PP91	0	72	225

8.2 Errors evaluation

The absolute maximum error (Δ) and the standard deviation (σ) of the directly measured physical quantities (absolute and differential pressures, temperature, etc.) are defined as:

$$\Delta = \pm (\Delta_I + \Delta_{BV} + \Delta_{RJ}) \quad \text{maximum error}$$

$$\sigma = \pm (\Delta_I^2 + \Delta_{BV}^2 + \Delta_{RJ}^2)^{0.5} \quad \text{standard deviation}$$

where:

Δ_I = assigned accuracy rating of the instrument for absolute and differential pressure; ANSI special error for thermocouples or calibration maximum error; UNI 7937 specification accuracy or calibration maximum error for thermoresistance; manufacturer accuracy or calibration maximum error for LVDT

Δ_{BV} = error in acquisition: word A/D converter bit value

Δ_{RJ} = maximum error of the cold junction (only for thermocouples)

The absolute maximum error and the standard deviation of the derived quantities (flowrate, levels, etc.) will be calculated using the following error propagation formulas:

$$\Delta Y = \pm \sum_{i=1}^n \left| \frac{\partial Y}{\partial X_i} \right| \cdot \Delta X_i$$

$$\sigma Y = \pm \left[\sum_{i=1}^n \left(\frac{\partial Y}{\partial X_i} \right)^2 \cdot (\sigma X_i)^2 \right]^{-0.5}$$

$$Y = Y(X_i), i = 1, 2, \dots, n$$

SIET	Document	Rev	Page	of
McDermott Reaction Innovations	00098PP91	0	73	225

where ΔX_i and σX_i are the maximum error and the standard deviation of the X_i quantities. The error calculations will be carried out using, in a conservative way, the upper value range of the instrument.

8.3 Data processing and analysis

The data analysis will be performed in order to evaluate the goodness of the experimental test. During the experimental phase the operators will perform a monitoring of the measurement values in order to verify the most important test parameters and to check the congruency of the values. If necessary an on-line instrument check is foreseen in order to recover the error.

The data processing and analysis will be performed in three steps which are describes as "quick look", "preview" and full processing and analysis.

A "quick look" phase will be performed in order to provide the information needed to proceed with the preparation for the next test. This will consist primarily of identification of the instrument which have failed or performed incorrectly during the test, verification that the objectives of the test were achieved, and the control of the structural data to insure the integrity of the condenser. More detailed information will be performed in the "preview" phase that has the purposes of providing representative results from the most significant measurements to be used in the "Apparent Test Results" report, and to aid in defining the remainder of the analysis. The time history plots and digital data tables of key parameters will be performed and examined to determine time periods of significant interest for more detailed analysis. The plots and tables for the Final Test Report will be generated in the "full processing and analysis" phase which has the purpose to organize the data in a form that provides an integrated interpretation of the test results to show the performance of the condenser and demonstrate that the objectives have been achieved.

8.4 Data records

The digitally acquired data values will be directly write on magnetic disk in real time for the entire duration of the experimental test. Immediately after the end of the experimental test will be done a copy of the data file on a magnetic streamer tape in order to have a saved image of the data file. More will be copied into the magnetic streamer tape the complementary information about the experimental test: the transducers, the

SIET	Document	Rev	Page	of
Madison Keaton Innovative	00098PP91	0	74	225

physical input channel, the measurement channels, the alarm, the action archives and the monitor page archives. The information about daily instrument check, about the happened alarm conditions, the change operated by the user inside the database will be logged in relative file and saved on magnetic streamer tape too.

The analogically recorded data will be acquired on analog tapes at fixed tape speed. The recording of these data will be performed only during interesting transient. In according with the tape speed chosen the life of a 3600" analog magnetic tape will be about 3500 s. The analog tapes will be replayed through the FFT device and the resulting information copied and stored on magnetic disk for future interpretation and analysis.

The distance between scribe marks will be measured prior testing and at the end of the tests, the measured distances will be recorded in writing on suitable data sheets. All the test records, analysis and verification record will be stored into a Design Record File (DRF)

8.5 Data sheets

The following data sheets will be prepared for each experimental test:

- 1) print table containing the list of the measurements with their main characteristics (identification, span, calibration constants, associated error, location on the facility, measurement channel number and sampling frequency)
- 2) print table containing the daily instrumentation check
- 3) print tables of digital values of the recorded signals in engineering units for selected time periods
- 4) print tables of mean, standard deviation, minimum and maximum value of all the measurements in engineering units during a specified time period
- 5) plot graphs of any selected test variable as a function of time (time history) for any selected test time window. The single plot graphs will show group of 1 to 8 test variables

SIET	Document	Rev	Page	of
Sezione Ricerca Innovativa	00098 PF91	0	75	225

7) tables containing the results of spectral analysis for determination of the primary frequencies present in the accelerometers.

The experimental test identification code will be printed on all print tables and plot graphs

Table containing the measure of the distances between scribe marks performed prior of testing and at the end of tests will be prepared too.

SIET	Document	Rev	Page	of
Sezione Ricerca Innovativa	00098PP91	0	76	225

9. SHAKEDOWN AND PLANT CHARACTERIZATION

9.1 PLANT CHARACTERIZATION

The plant will be characterized by two kinds of pre-operational tests: cold and hot tests.

The purposes of cold pre-operational tests are:

- verify the pool support structure (test n. C-01);
- verify the adequacy of pool make-up and level control system, determine the adequacy of the pool connection line and verify flowmeter calibration (test n.C-02);
- determine the hydraulic resistance of the injection line, riser, condenser vent line and discharge line, verify the air compressor capability and the adequacy of the vent tank pressure control system (test n. C-03);
- determine the hydraulic resistance of drain line, verify the adequacy of condensate tank level control systems and of the pressurization systems (test n. C-04).

The purposes of hot pre-operational tests are:

- determine the heat losses of the injection line, vent line and the vent tank, verify the tube bundle wall thermocouple calibrations and verify the vent tank project (test n. H-01);
- determine the heat losses of the drain line and the condensate tank and verify the condensate tank project (test n. H-02);
- determine the heat losses of pool connection line to catch tank and verify the stack discharge capability (test n. H-03);

SIET	Document	Rev	Page	of
Reazione Reazione Innovativa	00098PP91	0	77	225

to return plant stability (i.e. to reach steady state conditions) to perform matrix test number 22 and 43 (test n. H-04 and H-05)

9.1.1 General description of test C-01

The test will be performed by filling with water IC and PCC pools at seven different levels from 1 m to 4.5 m and by measuring the pool support structure deformation in order to verify if the existing support structure is able to withstand the maximum load without exceeding the maximum allowable deformation.

The test detailed procedure with its check lists are reported in part II of this TP&P document.

9.1.2 General description of test C-02

The test will be performed feeding with four different flowrates, the IC pool with level set point LIC-Q001 fixed to 4.2 m, and draining the PCC pool in order to verify the adequacies of the pool make-up, level control systems and flowmeter calibrations. The test detailed procedure with its checklists are reported in part II of this TP&P document.

9.1.3 General description of test C-03

The test will be performed with complete closed PANTHERS-PCC facility. The condensate tank will be filled by water to reach level L-L002 = 1.75 m (corresponding to 2.5 m above the condensate tank inlet nozzle) and pressurized with air at the same PCC inlet pressure; the steam supply line will be closed, the PCC inlet pressure will be controlled using vent tank discharge valve F020 and PIC-4002 controller.

The test will be carried out sending air flow through the riser to vent tank at four different air flowrates and two pressure levels, in order to determine the pressure drops of injection line, riser condenser, vent line and to verify the air compressor capability and the adequacy of the pressure control system.

The test detailed procedure with its check lists are reported in part II of this TP&P document.

Enclosure 2 is a schematic view of the plant configuration for test C-03.

SIET	Document	Rev	Page	of
SIET SOLUTION Realization Innovative	00098PP91	0	78	225

9.1.4 General description of test C-04

The test will be performed with complete closed PANTHERS-PCC facility. The vent line and vent tank will be excluded closing spectacle flange SF002; the steam supply line will be closed; condensate tank will be connected to injection line opening spectacle flange SF001; a temporary feed water line will be connected to module 1 upper header and water flow will be sent through module 1 Hx and drain line to the condensate tank.

The condensate tank will be filled by water to reach level L-L002 = 1.75 m (corresponding to 2.5 m above the condensate tank inlet nozzle) and the level will be controlled by means of pneumatic control valve F019 and LIC-L001 controller.

The system will be pressurized sending air to the riser and to the condensate tank and the pressure will be regulated by means of pneumatic control valve F021 and PIC-L001 controller.

The test will be carried out feeding the module 1 upper header with four different water flowrates and two different pressure, in order to determine the pressure drops of drain line and to verify the adequacy of the two condensate tank level control systems (discharge from overflow line or from bottom of condensate tank) and of pressurization system.

The test detailed procedure with its check lists are reported in part II of this TP&P document.

Enclosure 3 is a schematic view of the plant configuration for test C-04.

9.1.5 General description of test H-01

The test will be performed with complete closed PANTHERS-PCC facility, with pools P, Q and condensate tank empty and the condensate tank liquid discharge line connected to bottom.

The condensate tank will not be connected to injection line closing spectacle flange SF001 and the air feed line will be excluded. The condensate tank mixture discharge line will be excluded closing F015 valve.

The system will be pressurized at four different pressure levels sending a small flowrate (about 0.2 kg/s or less) of superheated steam (superheating level less or equal to 10°C) through the riser and PCC to the vent tank; the pressure will be regulated by means of control valve F020 and PIC-4002 controller on vent tank mixture discharge line.

The superheating degree of the riser inlet steam will be adjusted in order to have saturated steam in PCC tube bundle vent line and vent tank. The heat losses of the vent line and vent tank will be determined by means of thermal balance measuring and plotting the condensed water level of vent tank versus time.

SIET	Document	Rev	Page	of
Sezione Reazione Innovativa	00098PP91	0	79	225

The test will be carried out with four different temperatures of steam in the range 130°C - 170°C. The steam condensed by PCC heat exchangers will be drained to the condensate tank. The heat losses of the injection line will be calculated performing the thermal balance between the injection line steam - air mixing point and the riser inlet. The calibrations of the PCC bundle wall thermocouples will be verified and eventually adjusted comparing the steam saturation temperatures with the temperature values given by wall thermocouples.

The test detailed procedure with its check lists are reported in part II of this TP&P document.

Enclosure 4 is a schematic view of the plant configuration for the test H-01.

9.1.6 General description of test H-02

The test will be performed with complete closed PANTHERS-PCC facility with pools P and Q empty. The PCC's heat exchangers will be isolated by closing the vent and drain lines using the spectacle flanges SF002 and SF003. The PCC's heat exchangers will be filled with water by connecting a temporary feed water line to the module 1 upper header.

The condensate tank will be connected to injection line opening the spectacle flange SF001 and the condensate tank liquid and steam discharge lines will be excluded closing the manual valves F017, F018 and F015 respectively. The drain line and condensate tank will be pressurized at four different pressure levels by feeding with a very small steam flowrate the PCC riser (superheating degree less or equal to 10 °C). The steam temperature will be adjusted in order to have saturated steam in the drain line and condensate tank.

The test will be carried out starting with condensate tank empty at four different saturation temperatures of steam in the range 130°C - 170°C. The steam pressure will be controlled discharging steam to the atmosphere through the manual valve F503. The heat losses of the common drain line and the condensate tank will be determined by means of thermal balance measuring and plotting the condensed water level of condensate tank versus time. The test detailed procedure with its check lists are reported in part II of this TP & P document.

Enclosure 5 is a schematic view of the plant configuration for the H-02.

SIET	Document	Rev	Page	of
Sezione Reattori Innovativi	00098PP91	0	80	225

9.1.7 General description of test H-03

The test will be performed with complete close PANTHERS - PCC facility, with pools P and Q filled at a level lower than 0.5 m respect to the normal water level (4.26 m in IC pool) in order to avoid the overflow of the PCC water to the catch tank during boil off. The test will be performed heating the PCC pool water till to reach steady equilibrium bulk (steady - state) average temperature.

The PCC pool water heating will be carried out feeding the PCC with saturated steam and allowing the pool to reach steady state bulk average temperature. When the PCC pool is in boiling conditions the steam flowrate will be reduced at the minimum value capable to maintain the pool boiling in order to minimize the steam velocity and so reducing the carry over effect.

The steam generated by PCC pool will be sent to the stack through the pool steam connection line, the condensated liquid generated by the heat losses of the pool connection line to the catch tank will be measured in the loop seal of the catch tank line.

The heat losses will be measured performing thermal balance plotting the loop seal water level versus time. The detailed procedure of test H-03 with its check lists are reported in part II of this TP&P document.

9.1.8 General description of test H-04

The experimental conditions and procedures of this test are the same of test type A.1.3 (two modules, steady state - steam only - no air in PCC tubes) test condition n.43 and therefore the general description of this test is reported in paragraph 10.5 while the detailed procedure of test H-04 with its check lists are reported in part II of this TP&P document.

9.1.9 General description of test H-05

The experimental conditions and procedures of this test are the same of test type A.1.1 (two modules, steady state - saturated steam/air) test condition n.22 and therefore the general description of this test is reported in paragraph 10.3 while the detailed procedure of test H-05 with its check lists are reported in part II of this TP&P document.

SIET	Document	Rev	Page	of
Reazione Reattori Innovativi	00098PP91	0	81	225

9.2 Shakedown matrix

The cold pre-operational test matrix is shown in tab.4; the hot pre-operational test matrix is shown in tab.5.
The pre-operational test detailed procedure check lists are reported in part II of this TP&P document.

SIET	Document	Rev	Page	of
Division: Reactor Innovative	00098PP91	0	82	225

10. PASSIVE CONTAINMENT CONDENSER TESTS

The PCC tests will be a series of steady - state tests at specified steam flow rate, non condensible flow rate, inlet gas temperature and inlet pressure (equivalent to drywell). The condensate tank pressure will be equal to inlet pressure and the vent tank pressure will be adjusted to obtain the specified PCC inlet pressure. The PCC pool will be maintained at a constant level (full) and equilibrium bulk average temperature during most tests. The PCC will be brought to the specified conditions and allowed to stabilize, i.e. reach a condition of steady - state heat transfer and allowed to operate for approximately 15 minutes at these conditions. Data will be recorded during pool heatup and for the period of steady operation.

Initial testing will be performed using a complete PCC unit (two module). The performance of this unit will be tested over the expected range to SBWR conditions. Following the performance tests, additional testing will be performed to complete the required structural testing.

After successful completion of these tests, one PCC module will be removed from the facility and the pool halved to reduce the effective size. The single module PCC will be tested at conditions equivalent to some of the full PCC tests. The purpose of these tests is to accomplish the objective of IC test modeling described in chapter 2. Tests using helium/air mixtures will also be done with the single module.

10.1 Types of tests required for the PCC

The types of tests to be performed with the PCC have been defined as follows:

A. Tests with two modules:

- A.1.1. Steady state performance-saturated steam/air mixtures.
- A.1.2. Steady state performance-superheated steam/air mixtures.
- A.1.3. Steady state performance-steam only.
- A.2.1. Effect of pool water level-saturated steam.
- A.2.2. Effect of pool water level-saturated steam/air mixtures.

SIET	Document	Rev	Page	of
Sezione Reattore Innovativo	00098PP91	0	83	225

A.3.1. Additional Structural Tests-simulated LOCA pressurization.

A.3.2. Additional Structural Tests-simulated leak testing.

A.4. Steady state-air only pressure loss measurement.

B. Tests with one module:

B.1. Steady state performance-steam only.

B.2. Effect of low density noncondensibles.

10.2 FIRST PRIORITY TESTS

The first priority tests are a series of steady - state tests that will be performed using a complete PCC unit immediately after the completion of the shakedown tests. These tests will be performed just with saturated steam / air and just with saturated steam only (no air in PCC tubes). The general description and procedure of these tests are equal to those of tests type A.1.1 and test type A.1.3 reported in paragraph 10.3 and 10.5 respectively. Four of these tests will be carried out at inlet conditions corresponding to some of the Toshiba Giraffe phase 1 tests.

10.3 DESCRIPTION OF TEST TYPE A.1.1

Two Modules, Steady State-Saturated Steam/Air.

General Test procedure

The selected constant values of air and steam flow rates (m_a and m_s respectively) are set up according to procedures determined during shakedown testing. The PCC inlet pressure is adjusted to maximum value, P_i (max) using vent tank discharge valve. Inlet mixture temperature is set to saturated condition. The PCC

SIET	Document	Rev	Page	of
Division: Kearton Innovative	00098PP91	0	84	225

pool water is allowed to heat up to steady state bulk average temperature. Valve settings are trimmed to adjust inlet temperature and pressure to prescribed values.

Data are recorded at approximately 5 inlet pressure values between P_i (max) and P_i (min) or until a specified PCC delta P limit is reached. The delta P limit will be approximately 14 kPa (2 psi), but will be specified by the Responsible Test Engineer prior to the test. The test will be repeated for each selected value of m_a and m_s .

For what concerns independent variables, the pool level is maintained constant at normal level (full). The inlet gas temperature is set at saturation value corresponding to the inlet pressure and gas mixture or the specified degrees of superheated above saturation. The detailed procedures of test type A.1.1 with its checklists are reported in Part II of this TP&P document.

10.4 DESCRIPTION OF TEST TYPE A.1.2

Two Modules, Steady State-Superheated Steam/Air.

General Test Procedure

Procedure is the same as Test A.1.1. Some of the saturated test conditions will be repeated from A.1.1., each at two values of superheat, i.e. six test conditions (each with 5 inlet pressure values). The superheated values are to be determined (TBD) by analysis prior to testing.

Independent variables are the same as in A.1.1. The detailed procedures of test type A.1.2 with its checklists are reported in Part II of this TP&P document.

10.5 DESCRIPTION OF TEST TYPE A.1.3

Two Modules, Steady State-Steam Only.

When the PCC is tested with steam flow only, the performance can be affected by the presence of noncondensable gas trapped in the PCC tubes. Two conditions will be considered for Tests A.1.3.: 1) No air in PCC tubes, and 2) Air in PCC tubes.

SIET	Document	Rev	Page	of
Sezione Ricerca Innovativa	00098PP91	0	85	225

1) General Test Procedure- No air in PCC tubes

The spectacle flange in the vent line may or may not be closed for these tests. This will be decided on the basis of the shakedown tests.

All air is purged from the system prior to start of testing. The condenser is now similar to the IC, i.e. with steam flow rate as the independent variable, the inlet pressure will be adjusted to match the capacity of the PCC. The PCC is operated at different steam flow rates and data are recorded. Inlet pressure should not be allowed to increase above 690 kPag (100 psig).

For what concerns independent variables, the pool level is maintained constant at normal level. The inlet gas temperature is adjusted according to the measured PCC inlet pressure. Values of superheat are to be determined (TBD) by analysis prior to testing.

No conditions are provided for inlet air flow for these tests. The detailed procedures of test type A.1.3 (no air in PCC tubes) with its checklists are reported in Part II of this TP&P document.

2) General Test Procedure- Air in PCC tubes

Spectacle flange is closed on vent line. The air is purged from system with steam prior to start of test. The specified saturated steam flow rate is set up and operation (inlet pressure) stabilized. Air is bled slowly into inlet line to PCC at a metered rate and data are recorded as inlet pressure increases. Test is ceased when pressure stops increasing or approaches 690 kPag (100 psig).

For independent variables, the pool level is maintained constant at normal level (full). The inlet gas temperature is adjusted to the saturated temperature (or the specified superheat) of the steam at the initial (purged) pressure and maintained constant throughout the test. The inlet air flow rate is adjusted to a rate which will fill the condenser in approximately 15 to 30 minutes at the stabilized inlet pressure. The detailed procedures of test type A.1.3 (air in PCC tubes) with its checklists are reported in Part II of this TP&P document.

SIET	Document	Rev	Page	of
Rezone Reaction Innovativ	00098PP91	0	36	225

10.6 DESCRIPTION OF TEST TYPE A.2

Two Modules, Effect of Pool Water Level

General Test Procedure

These tests will demonstrate, for a limited set of conditions, the effect of pool water level decrease on the performance of the PCC. It is proposed to do this by recording data while slowly lowering pool water level either by allowing the water to boil away without refilling or by slowly draining. When the low level is reached in the pool, ambient water will be slowly added to refill the pool, while continuing to record the data. Two test conditions are foreseen: saturated steam and saturated steam / air mixture respectively.

A.2.1 Saturated steam: all air will be purged from the system and test condition n. 41 will be repeated.

allowing the pool water level to decrease to about 50% of normal level or until the inlet pressure reaches approximately 100 psig (690 kPag). The detailed procedures of test type A.2.1 with its checklists are reported in Part II of this TP&P document.

A.2.2 Saturated steam/air mixture: the test conditions n. 15 and 30 will be repeated allowing the pool water level to decrease to about 50% of normal level or until the inlet pressure reaches approximately 100 psig. Test is started with the minimum values of inlet pressure and the vent tank discharge valve position is maintained throughout the test.

For what concerns independent variables, test is begun with normal pool level (full) and this is allowed to decrease to 50% of normal. Slowly it is refilled and test is ended with pool again at the normal level. The inlet gas temperature is adjusted to saturation value corresponding to the inlet pressure and gas mixture. The detailed procedures of test type A.2.2 with its checklists are reported in Part II of this TP&P document.

SIET	Document	Rev	Page	of
Sezione Reattori Innovativi	00098PP91	0	87	225

10.7 DESCRIPTION OF TEST TYPE A.3

Two Modules, Additional Structural Tests.

To confirm the PCC structural design adequacy for the SBWR design lifetime, the test program must include testing the PCC for at least five times the number of design basis pressure/temperature cycles. The performance test includes most of these conditions, except for the LOCA and the pneumatic leak testing.

10.7.1 Test type A.3.1: simulated LOCA pressurizations

The design basis is two LOCAs during the sixty year design life of the PCC. For the test, 10 simulated LOCA cycles must be performed.

General Test Procedure

The PCC is to be rapidly pressurized with saturated steam to 379 kPa(g) (55 psig) and 151 °C (303 °F). The vent tank discharge valve must be partly open during pressurization to purge air from the PCC tubes and permit heating. The total time period for the pressurization and data recording is approximately 30 minutes. The flow rate of steam required to achieve these conditions can be determined either by shakedown testing or from previously run two-module tests. If the steam supply is not large enough to maintain the required pressure with a steam-only inlet flow to the PCC, air flow can be added. Pre adjustment of the vent tank discharge valve position by "trial and error" may be necessary.

The pool level is maintained constant at normal level (full). The pool temperature is initialized with pool at ambient temperature and allowed to heat up in response to PCC performance. The inlet gas temperature is adjusted to saturated temperature at 379 kPa g (55 psig).

No inlet air flow rate is provided for these tests unless it is required to achieve the final required pressure. This procedure will be performed a total of 10 times. The pressurization transient for PCC will be about the following:

SIET	Document	Rev	Page	of
Section 10.7.2.1	00098 PP91	0	88	225

PCC inlet pressure kPa(g) (psig)	Required time to reach pressure (sec)
0 (0)	(start)
175 (25.4)	2.3
249 (36.1)	32
261 (37.8)	67
379 (55)	1800

The detailed procedures of test type A.3.1 with its checklists are reported in Part II of this TP&P document.

10.7.2 Test type A.3.2 : Simulated Pneumatic Leak Test Pressurizations.

The PCC design basis assumes that the unit will be pneumatically pressurized for leak testing 60 times during its design life. Each leak test will consist of closing the vent and condensate lines and pressurizing the PCC with air to 758 kPa(g) (110 psig). The pressure will be maintained long enough to demonstrate that the PCC does not leak. For the structural test, it is required to simulate five times the number of load cycles produced by these leak tests and therefore a total of 300 tests will be performed.

General Test Procedure

The vent and condensate lines are closed off as necessary to permit pressurization with air to 758 kPa(g) (110 psig). The system is pressurized with air to the required pressure, pressure is held for approximately 1-2 minutes and then released. The unit may be partially filled with water to reduce the time required for pressurizing. The PCC should be checked for leaks by verifying the absence of air bubbles in the pool approximately once for each fifty cycles.

SIET	Document	Rev	Page	of
SECTION: Reason: INNOVATIVE	00098PP91	0	89	225

Pool level is maintained constant at normal level (full), while pool temperature is ambient temperature. Inlet gas temperature is less than 60 °C (140 °F). Inlet air flow rate is sufficient to perform approximately 8 cycles per hour. The detailed procedures of test type A.3.2 with its checklists are reported in Part II of this TP&P document.

10.8 DESCRIPTION OF TEST TYPE A.4

Steady State Pressure Losses, Air-Only.

General Test Procedure

The PCC is operated with air only at several selected flow rates. At each flow rate, the vent tank discharge valve is adjusted to give 8.3 kPag (1.2 psig) pressure at the PCC vent pipe connection. Condensate drain line should be submerged. PCC inlet pressure, vent connection pressure and the differential pressure are recorded.

The pool level is maintained constant at normal level (full). Pool temperature, is ambient temperature. Inlet air temperature is maintained constant for all air flow rates at a convenient value between 20 °C (68 °F) and 49 °C (120 °F). Vent tank pressure discharge valve is adjusted at each air flow rate to maintain PCC vent connection pressure to 8.3 kPag (1.2 psig). The PCC will be operated with 6 different air flowrates covering the range from 25 % of the maximum available up to the maximum available. The detailed procedures of test type A.4 with its checklists are reported in Part II of this TP&P document.

10.9 DESCRIPTION OF TEST TYPE B.1

Single Module, Steady State-Steam Only.

These tests repeat some of the test conditions from the two module test A.1.3 as follows:

SIET	Document	Rev	Page	of
Sezone Kearson Innovations	00098 PP91	0	90	225

1) General Test Procedure - No air in PCC tubes

The spectacle flange in the vent line will be as it was for Tests A.1.3 Part 1. All air is purged in from the system prior to start of testing. As in A.1.3, the steam flow rate is set and the inlet pressure is allowed to adjust to match the capacity of the PCC. The PCC is operated at one-half the steam flow rates used in A.1.3 and data are recorded. Inlet pressure should not be allowed to increase above 100 psig.

The pool level is maintained constant at normal level. Inlet gas temperature is adjusted to the saturated value at the measured PCC inlet pressure. The detailed procedures of test type B.1 (no air in PCC tubes) with its checklists are reported in Part II of this TP&P document.

2) General Test Procedure - Air in PCC tubes

Perform tests similar to the two module tests, A.1.3, part 2. Spectacle flange is closed on the vent line. All air is purged from system with steam prior to start of test. The specified saturated steam flow rate is set up and operation (inlet pressure) stabilized. Air is bled slowly into inlet line to PCC at a metered rate and data are recorded as inlet pressure increases. Testing is ceased when pressure levels out or approaches 100 psig. Pool level is maintained constant at normal level (full). Inlet gas temperature is adjusted to the saturated temperature (or the specified superheat) of the steam at the initial (purged) pressure and maintained constant throughout the test inlet air flow rate is adjusted to a rate which will fill the condenser in approximately 15 to 30 minutes. The detailed procedures of test type B.1 (air in PCC tubes) with its checklists are reported in Part II of this TP&P document.

10.10 DESCRIPTION OF TEST TYPE B.2

Single Module: Effect of low density noncondensibles.

General Test Procedure

Tests are performed similar to the two module tests, A.1.3, Part 2, except using helium and helium/air mixtures in place of air.

SIET	Document	Rev	Page	of
Seizone Reaction Innovations	00098PP91	0	91	225

Spectacle flange is closed on PCC vent line. All air is purged from system with steam prior to start of test. Saturated steam flow rate is set up and operation (inlet pressure) stabilized. The noncondensable gas is bled slowly into inlet line to PCC at a metered rate and data are recorded as inlet pressure increases. Test is ceased when pressure levels out or approaches 100 psig (690 kPa g).

Pool level is maintained constant at normal level. Inlet gas temperature is adjusted to the saturated temperature of the steam at the initial (purged) pressure and maintained constant throughout the test. Inlet helium flow rate is adjusted to a rate which will fill the condenser in approximately 15 to 30 minutes. The detailed procedures of test type B.2 with its checklists are reported in Part II of this TP&P document.

SIET	Document	Rev	Page	of
ΕΛΛΗΝΙΚΗ ΗΛΕΚΤΡΟΝΙΚΗ ΕΠΙΧΕΙΡΗΣΗ	00098PP91	0	92	225

11 TEST MATRICES

The reference experimental test conditions foreseen for each PCC test type group or sub-group with TWO MODULES are reported in :

Tab. 6 : PCC FIRST PRIORITY TEST MATRIX

Tab. 7 : PART A - TESTS WITH TWO MODULES - TEST TYPE A.1.1
Steady State Performance - Saturated Steam / Air Mixture

Tab. 8 : PART A - TESTS WITH TWO MODULES - TEST TYPE A.1.2
Steady State Performance - Superheated Steam / Air Mixture

Tab. 9 : PART A - TESTS WITH TWO MODULES - TEST TYPE A.1.3
Steady State Performance - Steam Only - No Air in PCC tubes

Tab. 10 : PART A - TESTS WITH TWO MODULES - TEST TYPE A.1.3
Steady State Performance - Steam Only - Air in PCC tubes

Tab. 11 : PART A - TESTS WITH TWO MODULES - TEST TYPE A.2.1
Effect of Pool Water Level - Saturated Steam - TEST TYPE A.2.2
Effect of Pool Water Level - Saturated Steam / Air Mixture

Ch. 10.7.1 : Additional Structural Tests - Test type A.3.1: Simulated LOCA Pressurizations

Ch. 10.7.2 : Additional Structural Tests - Test type A.3.2: Simulated Pneumatic Leak test
Pressurizations

Ch. 10.8 : Test type A.4: Steady State Pressure Losses, Air only

SIET	Document	Rev	Page	of
Divisione Ricerca e Innovazione	00098PP91	0	93	225

The reference experimental test conditions foreseen for each PCC test type group with ONE MODULE are reported in :

Tab. 12 : PART B - TESTS WITH ONE MODULE - TEST TYPE B.1
Steady State Performance - Steam Only - No Air in PCC tubes

Tab. 13 : PART B - TESTS WITH ONE MODULE - TEST TYPE B.1
Steady State Performance - Steam Only - Air in PCC tubes

Tab. 14 : PART B - TESTS WITH ONE MODULE - TEST TYPE B.2
Effect of Low Density Noncondensibles

11.1 Acceptance criteria

The experimental conditions will be accepted if they meet the following acceptance conditions (*):

- 1) PCC inlet pressure (P-4002) = reference matrix value +/- 50 kPa
- 2) PCC inlet temperature (T-4002) = reference matrix value +/- 5 °C (**)
- 3) PCC air inlet flowrate (F-2001 / F-2002) = reference matrix value +/- 10 %
- 4) PCC steam inlet flowrate (F-1001) = reference matrix value +/- 10 %

*): These acceptance criteria can be changed after the shakedown tests

**): Applicable only to tests : 31 + 36, 44 + 49, 52, 53

SIET	Document	Rev	Page	of
Divisione Ricerca Innovativa	00098PP91	0	94	225

12 REPORTS

A brief Apparent Test Result (ATR) report will be prepared for each test, as described in CH.7.3, within approximately one week following performance of the test. The ATR report, approved by the Responsible Test Engineer, will be transmitted to the Test Requestor (TR).

A Final Test Report (FTR) containing the data, analysis and results of all tests will be prepared, as described in CH.7.3, within approximately two months after the end of the tests. The FTR, approved by the Responsible Test Engineer, will be transmitted to the Test Requestor.

SIET	Document	Rev	Page	of
Advanced Reactors Innovation	00098PP91	0	95	225

13. QA REQUIREMENTS

The tests in the PANTHERS facilities are performed by SIET under a research contract with ENEA, in the framework of the four-party Agreement (General Electric, Ansaldo, Enel and Enea) on the Design Development, Procurement, Fabrication and Testing of ICS and PCCS Components.

The QA procedures applicable to the tests are in compliance with GE's Test Requirements and with Enea's (Advanced Reactors Department) Quality Manual, and are actuated according to Siet's Quality Plan summarized in Part III of this document.

In particular, Siet:

- will provide copies of their QA documents to GE, upon request, for review and approval
- acknowledges GE's right to perform an audit to verify the application of the Test Quality Plan
- will timely notify Enea's Responsible Test Engineer (RTE) with documentation of the actual test calendar and of any significant changes in the test configurations or test procedures.

A Design Record File (DRF - IC & PCC) has been opened for QA record storage of documents relating to the design phase. A separate DRF will be opened for the test phase.

SIET	Document	Rev	Page	of
Enelione Reaction Innovativa	00098PP91	0	96	225

14. TEST HOLD / DECISION POINTS

Enea's RTE must have reviewed and approved the Test Plan and Procedures Document before the test program can start.

Further hold/decision points, which require Enea's RTE to review and approve the test setup, configuration and conditions, are established as follows:

- at the end of the shakedown tests;

- prior to starting the performance of each PCC test group or sub-group as defined in ch. 10 and 11 of this document.

**Tab. 4 - SBWR-PANTHERS: Full - Scale Prototypes PCC Test
Cold pre-operational Test Matrix (Notes 1, 2)**

TEST RUN #	TEST DESCRIPTION	PURPOSE OF TEST	COMMENTS
C-01	Pool's Filling	<ul style="list-style-type: none"> ° Verify the Pool's Support Structure 	<ul style="list-style-type: none"> * 7 levels to be tested
C-02	Pool P Drain down	<ul style="list-style-type: none"> ° Verify level control system adequacy ° Determine the resistance of the Pools Connection Line ° Verify flow meter calibration 	<ul style="list-style-type: none"> * 4 flowrates to be tested
C-03	Air Flow through the Riser to the Vent Tank	<ul style="list-style-type: none"> ° Determine the resistance of the Injection Line, Riser, Condenser, Vent and Discharge Lines ° Verify Pressure control system adequacy 	<ul style="list-style-type: none"> * Injection line connected with CT * 4 flowrates to be tested * 2 pressures to be tested
C-04	Water Flow through the Hx of module 1 to the Condensate Tank; Air Flow to the Riser and to the Condensate Tank	<ul style="list-style-type: none"> ° Determine the resistance of Drain Line ° Verify level control system adequacy ° Verify pressurization system 	<ul style="list-style-type: none"> * Injection Line connected with CT * Temporary feed water line connected to module 1 upper header * 2 pressures and 4 water flowrates to be tested

Notes: 1) Pre-operational tests are all conducted with adapted open or closed plant configuration.
2) Test performance implies that required instrumentation is calibrated, DAS is operating and valves are operational

Tab. 5 - SBWR-PANTHERS: Full - Scale Prototypes PCC Test
Hot pre-operational Test Matrix (Notes 1, 2)

TEST RUN #	TEST DESCRIPTION	PURPOSE OF TEST	COMMENTS
11-01	Steam Flow through the Riser to the Vent Tank	<ul style="list-style-type: none"> ° Determine the heat losses of the Vent Line, Injection Line and the Vent Tank ° Verify the tube bundle wall thermocouple calibrations ° Verify Vent Tank projec 	<ul style="list-style-type: none"> * 4 Temperatures to be tested
11-02	Steam Flow through the Riser to the Condensate Tank	<ul style="list-style-type: none"> ° Determine the heat losses of the Drain Line and the Condensate Tank ° Verify Condensate Tank project 	<ul style="list-style-type: none"> * 4 Temperatures to be tested
11-03	Steam Flow through the Pool Connection Line to the Stack	<ul style="list-style-type: none"> ° Determine the heat losses of the Pool Connection line to the Catch Tank ° Verify the Stack Discharge capability 	<ul style="list-style-type: none"> * Steam flow at the minimum value capable to maintain the pool boiling conditions
11-04	Steady State Performance Steam - Only Test n. 43	<ul style="list-style-type: none"> ° Confirm the Steady State heat removal capability in the expected conditions ° Confirm the stability of Plant Parameters ° Confirm the proposed test procedure 	<ul style="list-style-type: none"> * 6.6 kg/s steam flow rate to be tested * Maximum Pressure value : 690 kPa g
11-05	Steady State Performance Saturated Steam / Air Mixtures Test n. 22	<ul style="list-style-type: none"> ° Measure the decrease of the Steady State heat removal capability ° Confirm the stability of Plant Parameters ° Confirm the proposed test procedure 	<ul style="list-style-type: none"> * 5 Pressures to be tested

Notes: 1) Pre-operational tests are all conducted with adapted open or closed plant configuration.

2) Test performance implies that required instrumentation is calibrated, DAS is operating and valves are operational

Tab. 6 - FCC FIRST PRIORITY TEST MATRIX

TEST # in Test Specification	Corresponding Toshiba TEST #	Steam Flow kg/s	Air Flow kg/s	Inlet Pressure kPa	Test Type
43	3	6.6	0	N A	A.1.3
9	4	5.0	0.076	304	A.1.1
15	6	5.0	0.16	304	A.1.1
18	8	5.0	0.41	304	A.1.1
23	11	5.0	0.86	304	A.1.1

N A = Not Applicable

Tab. 7 - PART A. TESTS WITH TWO MODULES
 Test Type A.1.1. Steady State Performance - Saturated Steam / Air Mixtures Test Conditions

Test Condition Number	Steam Flow kg/s (lb/s)	Air Flow kg/s (lb/s)	Inlet Pressure kPa					Superheat °C (°F)
			P1	P2	P3	P4	P5	
1	0.45 (1.0)	0.014 (0.030)	294.33	418.83	542.33	666.33	790.33	< 10 (18)
2	1.4 (3.0)	0.014 (0.030)	308.33	428.83	549.33	669.83	790.33	< 10 (18)
3	2.5 (5.5)	0.027 (0.060)	308.33	428.83	549.33	669.83	790.33	< 10 (18)
4	3.6 (8.0)	0.027 (0.060)	308.33	428.83	549.33	669.83	790.33	< 10 (18)
5	5.0 (11.0)	0.027 (0.060)	308.33	428.83	549.33	669.83	790.33	< 10 (18)
6	5.7 (12.5)	0.027 (0.060)	308.33	428.83	549.33	669.83	790.33	< 10 (18)
7	6.6 (14.5)	0.027 (0.060)	308.33	428.83	549.33	669.83	790.33	< 10 (18)
8	1.4 (3.0)	0.073 (0.16)	294.33	418.33	542.33	666.83	790.33	< 10 (18)
9	5.0 (11.0)	0.076 (0.17)	308.33	428.83	549.33	669.83	790.33	< 10 (18)
10	5.7 (12.5)	0.073 (0.16)	308.33	428.83	549.33	669.83	790.33	< 10 (18)
11	6.6 (14.5)	0.073 (0.16)	308.33	428.83	549.33	669.83	790.33	< 10 (18)
12	0.45 (1.0)	0.14 (0.31)	239.33	313.33	387.33	461.33	535.33	< 10 (18)
13	2.5 (5.5)	0.14 (0.31)	294.33	384.33	473.83	563.33	653.33	< 10 (18)
14	3.6 (8.0)	0.14 (0.31)	294.33	418.33	542.33	666.33	790.33	< 10 (18)
15	5.0 (11.0)	0.16 (0.35)	294.33	401.33	542.33	666.33	790.33	< 10 (18)
16	6.6 (14.5)	0.14 (0.31)	301.33	421.33	542.33	666.33	790.33	< 10 (18)
17	2.5 (5.5)	0.36 (0.79)	273.33	356.33	438.33	521.33	604.33	< 10 (18)
18	5.0 (11.0)	0.41 (0.90)	287.33	375.33	463.33	551.33	639.33	< 10 (18)
19	5.7 (12.5)	0.36 (0.79)	294.33	384.33	473.83	563.33	653.33	< 10 (18)
20	5.0 (11.0)	0.59 (1.29)	280.33	363.33	445.83	528.33	611.33	< 10 (18)
21	6.6 (14.5)	0.59 (1.29)	287.33	375.33	463.33	551.33	639.33	< 10 (18)
22	1.4 (3.0)	0.86 (1.9)	198.33	262.33	325.83	389.33	453.33	< 10 (18)
23	5.0 (11.0)	0.86 (1.9)	260.33	341.33	422.33	503.33	584.33	< 10 (18)
24	5.7 (12.5)	0.86 (1.9)	266.33	349.33	431.83	514.33	597.33	< 10 (18)
25	6.6 (14.5)	0.86 (1.9)	280.33	363.33	445.83	528.33	611.33	< 10 (18)
26	2.5 (5.5)	1.08 (2.37)	225.33	294.33	363.33	432.33	501.33	< 10 (18)
27	3.6 (8.0)	1.08 (2.37)	239.33	313.33	387.33	461.33	535.33	< 10 (18)
28	5.0 (11.0)	1.08 (2.37)	253.33	329.33	404.83	480.33	556.33	< 10 (18)
29	5.7 (12.5)	1.08 (2.37)	260.33	341.33	422.33	503.33	584.33	< 10 (18)
30	6.6 (14.5)	1.08 (2.37)	266.33	349.33	431.83	514.33	597.33	< 10 (18)

Tab. 8 - PART A - TESTS WITH TWO MODULES
 Test Type A.1.2. Steady State Performance - Superheated Steam / Air Mixtures Test Conditions

Test Condition Number	Steam Flow kg/s (lb/s)	Air Flow kg/s (lb/s)	Range of Inlet Pressure kPa					Superheat °C (°F)
			P1	P2	P3	P4	P5	
31	2.5 (5.55)	0.027 (0.060)	308	428.5	549	669.5	790	20 (36)
32	2.5 (5.55)	0.027 (0.060)	308	428.5	549	669.5	790	30 (54)
33	6.6 (14.5)	0.027 (0.060)	308	428.5	549	669.5	790	20 (36)
34	6.6 (14.5)	0.027 (0.060)	308	428.5	549	669.5	790	30 (54)
35	5 (11.0)	0.83 (1.83)	260	341	422	503	584	20 (36)
36	5 (11.0)	0.83 (1.83)	260	341	422	503	584	30 (54)

Tab. 9 - PART A. TESTS WITH TWO MODULES
 Test Type A.1.3. Steady State Performance - Steam Only. No air in PCC tubes Test Conditions

Test Condition Number	Steam Flow kg/s (lb/s)	Air Flow kg/s (lb/s)	Superheat	
			°C	(°F)
37	0.45 (1.0)	0 (0)	< 10	(18)
38	1.4 (3.0)	0 (0)	< 10	(18)
39	2.5 (5.5)	0 (0)	< 10	(18)
40	3.6 (8.0)	0 (0)	< 10	(18)
41	5 (11.0)	0 (0)	< 10	(18)
42	5.7 (12.5)	0 (0)	< 10	(18)
43	6.6 (14.5)	0 (0)	< 10	(18)
44	1.4 (3.0)	0 (0)	15	(27)
45	1.4 (3.0)	0 (0)	20	(36)
46	1.4 (3.0)	0 (0)	30	(54)
47	5 (11.0)	0 (0)	15	(27)
48	5 (11.0)	0 (0)	20	(36)
49	5 (11.0)	0 (0)	30	(54)

Tab. 10 - PART A. TESTS WITH TWO MODULES
 Test Type A.L3. Steady State Performance - Steam Only. Air in PCC tubes Test Conditions

Test Condition Number	Steam Flow kg/s (lb/s)	Air Flow kg/s (lb/s)	Superheat °C (°F)
50	1.4 (3.0)	very low	< 10 (18)
51	5 (11.0)	very low	< 10 (18)
52	1.4 (3.0)	very low	20 (36)
53	5 (11.0)	very low	30 (54)

Tab. 11 - PART A. TESTS WITH TWO MODULES
 Test Type A.2.1. Effect of Pool Water Level - Saturated Steam
 Test Type A.2.2. Effect of Pool Water Level - Saturated Steam / Air Mixture
 Test Conditions

Test Condition Number	Steam Flow kg/s (lb/s)	Air Flow kg/s (lb/s)	Range of Inlet Pressure kPa	Superheat °C (°F)
54 (41)	5 (11.0)	0 (0)	(dependent variable) < 790	< 10 (18)
55 (15)	5 (11.0)	0.14 (0.31)	(start at 294 stop at 790)	< 10 (18)
56 (30)	6.6 (14.5)	1.08 (2.37)	(start at 266 stop at 790)	< 10 (18)

4

Tab. 12 - PART B. TESTS WITH ONE MODULE
 Test Type B.I. Steady State Performance-Steam Only Test Conditions-No air in PCC tubes

Test Condition Number	Steam Flow kg/s (lb/s)	Air Flow kg/s (lb/s)	Superheat °C (°F)
66 (37)	0.23 (0.5)	0 (0)	< 10 (18)
67 (38)	0.68 (1.5)	0 (0)	< 10 (18)
68(39)	1.3 (2.8)	0 (0)	< 10 (18)
69(40)	1.8 (4.0)	0 (0)	< 10 (18)
70(41)	2.3 (5.0)	0 (0)	< 10 (18)
71(42)	2.8 (6.3)	0 (0)	< 10 (18)
72(43)	3.5 (7.7)	0 (0)	< 10 (18)

Tab. 13 - PART B. TESTS WITH ONE MODULE
Test Type B.1. Steady State Performance-Steam Only
Test Conditions- Air in PCC tubes

Test Condition Number	Steam Flow kg/s (lb/s)	Air Flow kg/s (lb/s)	Superheat °C (°F)
73(50)	0.7 (1.5)	very low	< 10 (18)
74(51)	2.5 (5.5)	very low	< 10 (18)

Tab. 14 - PART B. TEST WITH ONE MODULE
Test Type B.2. Effect of Low Density Noncondensibles
Test Conditions

Test Condition Number	Steam Flow kg/s (lb/s)	Air Flow kg/s (lb/s)	Helium Flow kg/s (lb/s)	Superheat ° C (° F)
75	0.7 (1.5)	0 (0)	very low	< 10 (18)
76	2.5 (5.5)	0 (0)	very low	< 10 (18)
77	0.7 (1.5)	3.4 x He flow	very low	< 10 (18)
78	2.5 (5.5)	3.4 x He flow	very low	< 10 (18)

SIET	Document	Rev	Page	of
SIET Kazuo Innovation	0009RPP91	0	108	225

PART II : TEST PROCEDURES

TABLE OF CONTENTS

1.	INTRODUCTION	111
2.	VERIFICATION OF STRUCTURAL CAPABILITY OF POOL SUPPORT STRUCTURES TEST C-01: PRE-TEST CHECK LIST	112
	2.1 Verification of structural capability of pool support structures test C-01: TEST PROCEDURE	114
3.	POOL MAKE-UP SYSTEM VERIFICATION TEST C-02: PRE-TEST CHECK LIST	121
	3.1 Pool make-up system verification test C-02: TEST PROCEDURE	123
4.	AIR FLOW TEST C-03: PRE-TEST CHECK LIST	125
	4.1 Air flow test C-03: TEST PROCEDURE	127
5.	WATER DRAIN TEST C-04: PRE-TEST CHECK LIST	130
	5.1 Water drain test C-04: TEST PROCEDURE	132
6.	HEAT LOSSES IN INJECTION LINE, VENT LINE AND VENT TANK TEST H-01: PRE-TEST CHECK LIST	135
	6.1 Heat losses in injection line, vent line and vent tank test H-01: TEST PROCEDURE	137
7.	HEAT LOSSES IN DRAIN LINE AND CONDENSATE TANK TEST H-02: PRE-TEST CHECK LIST	140
	7.1 Heat losses in drain line and condensate tank test H-02: TEST PROCEDURE	142
8.	HEAT LOSSES OF POOL CONNECTION LINE TO THE CATCH TANK TEST H-03: PRE-TEST CHECK LIST	145
	8.1 Heat losses of pool connection line to the catch tank test H-03: TEST PROCEDURE	147
9.	STEAM ONLY TEST H-04: PRE-TEST CHECK LIST	149
	9.1 Steam only test H-04: TEST PROCEDURE	151

SIET	Document	Rev	Page	of
Reazione Reattori Innovativi	00098PP91	0	109	225

10. SATURATED STEAM / AIR MIXTURES TEST H-05: PRE-TEST CHECK LIST	153
10.1 Saturated steam / air mixtures test H-05: TEST PROCEDURE	155
11. TEST TYPE A.1.1 - SATURATED STEAM / AIR MIXTURES: PRE-TEST CHECK LIST	159
11.1 Test type A.1.1 - Saturated steam / air mixtures: TEST PROCEDURE	161
12. TEST TYPE A.1.2 - SUPERHEATED STEAM / AIR MIXTURES: PRE-TEST CHECK LIST	166
12.1 Test type A.1.2 - Superheated steam / air mixtures: TEST PROCEDURE	168
13. TEST TYPE A.1.3 - STEAM ONLY (NO AIR IN PCC TUBE): PRE-TEST CHECK LIST	172
13.1 Test type A.1.3 - Steam only (NO AIR IN PCC TUBE): TEST PROCEDURE	174
14. TEST TYPE A.1.3 - STEAM ONLY (AIR IN PCC TUBE): PRE-TEST CHECK LIST	176
14.1 Test type A.1.3 - Steam only (AIR IN PCC TUBE): TEST PROCEDURE	178
15. TEST TYPE A.2.1 - EFFECT OF POOL WATER LEVEL - SATURATED STEAM: PRE-TEST CHECK LIST	180
15.1 Test type A.2.1 - Effect of pool water level - Saturated steam: TEST PROCEDURE	182
16. TEST TYPE A.2.2 - EFFECT OF POOL WATER LEVEL - SATURATED STEAM / AIR MIXTURES: PRE-TEST CHECK LIST	184
16.1 Test type A.2.2 - Effect of pool water level - Saturated steam / air mixtures: TEST PROCEDURE	186
17. TEST TYPE A.3.1 - SIMULATED LOCA PRESSURIZATION: PRE-TEST CHECK LIST	189
17.1 Test type A.3.1 - Simulated LOCA pressurization: TEST PROCEDURE	191
18. TEST TYPE A.3.2 - SIMULATED LEAK TESTING: PRE-TEST CHECK LIST	193
18.1 Test type A.3.2 - Simulated leak testing: TEST PROCEDURE	194
19. TEST TYPE A.4 - PRESSURE LOSSES AIR ONLY: PRE-TEST CHECK LIST	196
19.1 Test type A.4 - Pressure losses air only: TEST PROCEDURE	198

SIET	Document	Rev	Page	of
Rezone Reactors Innovations	XXGRPP01	0	110	225

20. TEST TYPE B.1 - STEAM ONLY (NO AIR IN PCC TUBES):PRE-TEST CHECK LIST	200
20.1 Test type B.1 - Steam only (NO AIR IN PCC TUBE): TEST PROCEDURE	202
21. TEST TYPE B.1 - STEAM ONLY (AIR IN PCC TUBES):PRE-TEST CHECK LIST	204
21.1 Test type B.1 - Steam only (AIR IN PCC TUBE): TEST PROCEDURE	206
22. TEST TYPE B.2 - EFFECT OF LOW DENSITY NON CONDENSIBLES: PRE-TEST CHECK LIST	208
22.1 Test type B.2 - Effect of low Density Non Condensibles: TEST PROCEDURE	210

SIET	Document	Rev	Page	of
Region Region Innovativ	00098PP91	0	111	225

1. INTRODUCTION

This part of the TP&P document reports on the pre-test check lists and detailed procedures of cold and hot shakedown tests, and on the pre-tests check list and detailed procedure of experimental tests foreseen for PANTHERS PCC facility.

For similar test, belonging to the same group or sub-group, only one pre-test check list and one test procedure is reported for each group or sub-group; each test of the same group or sub-group has different PCC inlet conditions, but all the tests are performed in the same way.

SIET	Document	Rev	Page	of
Division: Keaton Innovations	0009RPP01	0	112	225

PANTHERS PCC PRE-TEST CHECK LIST

Page 1 of 2

Title Verification of structural capability of pool support structures Test # C-01

Phase #	Description	Note	Status	Oper. Signal.
10	Verify that the plant configuration is complete and suitable for the scope of test C-01			
20	Verify the correctness of installation of structural instrumentation. LDT-011, -012, -013, -014, -015, -016, -017	Instruments supplied and installed by 4 EMME company		
30	Verify that the following instrumentation has been calibrated, installed, filled, vented and is in operation : F-M001, F-R001, L-Q001, L-Q002, L-P001, LDT-011, -012, -013, -014, -015, -016, -017			
40	Verify that the Data Acquisition System is operational and the conversion constants and formulas have been correctly inserted in the DAS			
50	Verify that the following valves are closed • F027 • F028 • F029 • F030 • F031 • F032 • F034 • F035 • F036	F035 and F036 are not installed		
60	Verify that the following valves are open • F033 • F045			
70	Verify that the following tanks are full A001, A002, A003			
80	Verify that the pump C004 is available			

SIET	Document	Rev	Page	of
Section: REASON INNOVATIVE	0098PP01	0	114	125

PANTHERS PCC TEST PROCEDURE

Page 1 of 7

Title Verification of structural capability of pool support structures Test # C-01

Phase #	Description	Note	Status	Oper. Signal
10	Start the water supply pump C004			
20	Open valve F026 till to reach the maximum flow			
25	Measure water flow rate F-M001			
30	When level L-Q001 \geq 1 m, stop pump C-004 and close valve F026			
40	Measure displacements • LDT-011, -012, -013, -014, -015, -016, -017 every 30 s for 30 minutes	This duration can be changed during the test		
50	Compare the measured values with allowable deformation shown in table	Table with allowable displacement should be attached to this Check List		
60	If any measured deformation is \geq the correspondent allowable value, then stop the test and drain the pools P, Q else continue			
70	Verify the leakage from the pool P, Q			
80	If leakage is $>$ 1 g/s then stop the test and drain the pools P, Q else continue			
90	Start the water supply pump C004			
100	Open valve F026 till to reach the maximum flow			
110	When level LQ001 \geq 2 m, stop pump C004 and close valve F026			

SIET	Document	Rev	Page	of
Sezione Reattori Innovativi	XXXXRPP01	0	115	225

PANTHERS PCC TEST PROCEDURE

Page 2 of 7

Title Verification of structural capability of pool support structures Test # C-01

Phase #	Description	Note	Status	Oper. Signat.
120	Repeat phase 40			
130	Repeat phase 50			
140	Repeat phase 60			
150	Repeat phase 70			
160	Repeat phase 80			
170	Start the water supply pump C004			
180	Open valve F026 till to reach the maximum flow			
190	When level L-Q001 \cong 2.5 m. stop pump C004 and close valve F026			
200	Repeat phase 40			
210	Repeat phase 50			
220	Repeat phase 60			
230	Repeat phase 70			
240	Repeat phase 80			
250	Start the water supply pump C004			
260	Open valve F026 till to reach the maximum flow			
270	When level L-Q001 \cong 3 m. stop pump C004 and close valve F026			
280	Repeat phase 40			

SIET	Document	Rev	Page	of
Sezione Reazione Innovativa	00098PP91	0	116	225

PANTHERS PCC TEST PROCEDURE

Page 1 of 7

Title Verification of structural capability of pool support structures Test # C-01

Phase #	Description	Note	Status	Oper. Signat.
290	Repeat phase 50			
300	Repeat phase 60			
310	Repeat phase 70			
320	Repeat phase 80			
330	Start the water supply pump C004			
340	Open valve F026 till to reach the maximum flow			
350	When level L-Q001 \cong 3.5 m. stop pump C004 and close valve F026			
360	Repeat phase 40			
370	Repeat phase 50			
380	Repeat phase 60			
390	Repeat phase 70			
400	Repeat phase 80			
410	Start the water supply pump C004			
420	Open valve F026 till to reach the maximum flow			
430	When level L-Q001 \cong 4 m. stop pump C004 and close valve F026			
440	Repeat phase 40			
450	Repeat phase 50			

SIET Iniziativa Ricerca Innovativa	Document 00098PP01	Rev 0	Page 117	of 225
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PANTHERS PCC TEST PROCEDURE

Page 4 of 7

Title *Verification of structural capability of pool support structures* Test # C-01

Phase #	Description	Note	Status	Oper. Signal
460	Repeat phase 60			
470	Repeat phase 70			
480	Repeat phase 80			
490	Start the water supply pump C004			
500	Open valve F026 till to reach the maximum flow			
510	When level L-Q001 = 4.5 m. stop pump C004 and close valve F026			
520	Close hand valve F033			
530	Measure displacements a • LDT-011, -012, -013, -014, -015, -016, -017 every 30 s for 10 minutes	This duration can be changed during the test		
540	Repeat phase 530 after 16 h			
550	Open hand valves F029, F028	Open 1 or both the valves, according to the maximum discharge flow rate achievable		
560	Measure and record flow rate F-R001			
570	When level L-Q001 = 4 m. close valves F028, F029			
580	Repeat phase 40	The duration can be changed according to the results of the loading phase		

SIET	Document	Rev	Page	of
Sezione Ricerca Innovativa	00098PP91	0	118	225

PANTHERS PCC TEST PROCEDURE

Page 5 of 7

Title Verification of structural capability of pool support structures Test # C-01

Phase #	Description	Note	Status	Oper. Signal.
590	Open hand valves F029, F028	Open 1 or both the valves, according to the maximum discharge flow rate achievable		
600	Measure and record flow rate F-R001			
610	When level L-Q001 \cong 3.5 m, close valves F028, F029			
620	Repeat phase 40	The duration can be changed according to the results of the loading phase		
630	Open hand valves F029, F028	Open 1 or both the valves, according to the maximum discharge flow rate achievable		
640	Measure and record flow rate F-R001			
650	When level L-Q001 \cong 3 m, close valves F028, F029			
660	Repeat phase 40	The duration can be changed according to the results of the loading phase		
670	Open hand valves F029, F028	Open 1 or both the valves, according to the maximum discharge flow rate achievable		
680	Measure and record flow rate F-R001			

SIET	Document	Rev	Page	of
McBride Research Innovations	XXXXRPPQ1	0	119	225

PANTHERS PCC TEST PROCEDURE

Page 6 of 7

Title Verification of structural capability of pool support structures Test # C-01

Phase #	Description	Note	Status	Oper. Signal
690	When level L-Q001 \cong 2.5 m, close valves F028, F029			
700	Repeat phase 40	The duration can be changed according to the results of the loading phase		
710	Open hand valves F029, F028	Open 1 or both the valves, according to the maximum discharge flow rate achievable		
720	Measure and record flow rate F-R001			
730	When level L-Q001 \cong 2 m, close valves F028, F029			
740	Repeat phase 40	The duration can be changed according to the results of the loading phase		
750	Open hand valves F029, F028	Open 1 or both the valves, according to the maximum discharge flow rate achievable		
760	Measure and record flow rate F-R001			
770	When level L-Q001 \cong 1 m, close valves F028, F029			

SIET	Document	Rev	Page	of
McGraw Hill Construction	0098PP01	0	121	225

PANTHERS PCC PRE-TEST CHECK LIST

Page 1 of 2

Title Pool Make-up System Verification

Test # C-02

Phase #	Description	Note	Status	Oper. Signal
10	Verify that the pool support structure is suitable to perform test C-02			
20	Verify that the plant configuration is complete and suitable for the scope of test C-02			
30	Verify that the following instrumentation has been calibrated, installed, filled, vented and is in operation: <ul style="list-style-type: none"> • F-M001 • F-R001 • L-Q001, L-Q002 • L-P001 • T-M001 • T-R001 			
40	Verify that the Data Acquisition System is operational and the conversion constants and formulas have been correctly inserted in the DAS			
50	Verify that the following valves are closed: <ul style="list-style-type: none"> • F028 • F029 • F031 • F032 • F034 • F035 • F036 	F035 and F036 are not installed		
60	Verify that the following valves are open <ul style="list-style-type: none"> • F027 • F030 • F033 • F045 			

SIET	Document	Rev	Page	of
Bechtel Realtime Innovations	0098PP91	0	123	225

PANTHERS PCC TEST PROCEDURE

Page 1 of 2

Title Pool Make-up System Verification

Test # C-02

Phase #	Description	Note	Status	Oper. Signat.
10	Set up the pool Q level control LIC-Q001 to 4.2 m	This value can be changed during the test		
20	Start the water supply pump C004			
25	Fill the pools P, Q to level L-Q001, L-P001 = 4.2 m	This value can be changed during the test		
30	Open and regulate the pool P drain valves F031 F032 to obtain a discharge flow rate F-R001 = 1.0 kg/s	Open 1 or both the valves according to the discharge flow rate achievable		
40	Measure and record: • F-M001, F-R001 • L-Q001, L-Q002, L-P001 for 600 s			
50	Adjust the parameter of controller LIC-Q001 to optimize the level control			
60	Regulate the pool P drain valves F031 F032 to obtain a discharge flow rate F-R001 = 3.0 kg/s			
70	Repeat phase 40	It could be necessary to adjust again the controller parameters as in phase 50		
80	Regulate the pool P drain valves F031 F032 to obtain a discharge flow rate F-R001 = 6.0 kg/s			
90	Repeat phase 40	It could be necessary to adjust again the controller parameters as in phase 50		
100	Regulate the pool P drain valves F031 F032 to obtain a discharge flow rate F-R001 = 9.0 kg/s or the maximum achievable.			

SIET	Document	Rev	Page	of
Keaton Innovation	Y098PP01	11	125	225

PANTHERS PCC PRE-TEST CHECK LIST

Page 1 of 2

Title Air Flow Test

Test # C-03

Phase #	Description	Note	Status	Oper. Signat.
10	Verify that the plant configuration is complete and suitable for the scope of test C-03			
20	Verify that the following instrumentation has been calibrated, installed, filled, vented and is in operation: <ul style="list-style-type: none"> • F-2001, P-2001, T-2001 • F-T001, P-T001, T-T001 • P-4001, P-4002 • L-L001, L-L002, P-L001 • DP-001, DP-002, DP-003, DP-004, DP-005 • DP-006, DP-007, DP-008, DP-009, DP-010 • DP-011, DP-012, DP-013 • DP-014, DP-015, DP-016, DP-017, DP-018, • DP-019, DP-020, DP-021, DP-022, DP-023, • DP-024, DP-026, DP-027, DP-028, DP-029, • DP-030, • P-A001 • P-C001 			
30	Verify that the Data Acquisition System is operational and the conversion constants and formulas have been correctly inserted in the DAS			
40	Verify that the following valves are closed: <ul style="list-style-type: none"> • F001, F002, F003, F011, F013, F015, F017, F018 • F023, F025, F037, F038, F41, F047, F048 	All the purge and vent valves must be close		
50	Verify that the following valves are open <ul style="list-style-type: none"> • F009, F020, F039, F044, F049 • SF001, SF002 			
60	Verify that the following safety valves are set at 1 MPa: <ul style="list-style-type: none"> • F016, F050, F040 and the valve F-043 is set at 4 MPa			
70	Verify that the air compressors C002, C003 are available			

SIET	Document	Rev	Page	of
Reason Realism Innovative	00098PP91	0	127	225

PANTHERS PCC TEST PROCEDURE

Page 1 of 3

Title Air Flow Tests

Test # C-03

Phase #	Description	Note	Status	Oper. Signat.
10	Open the valve F041 and fill the Condensate Tank to reach level L-L002 = 1.75 m			
20	Start air compressors C002 C003			
25	Set PIC-4002 at 281.3 kPa			
30	Set FIC-2001 at 0.10 kg/s			
40	Wait to stabilize the inlet pressure P-4002 and flow F-2002 (steady state)			
50	Measure and record all instruments for 1000 s			
60	Close valve F-039 and open valve F-038	It changes the orifice measuring the inlet flow rate		
70	Set FIC-2001 at 0.3 kg/s			
80	Wait to stabilize the inlet pressure P-4002 and flow F-2001 (steady state)			
90	Repeat phase 50			
100	Set FIC-2001 at 0.6 kg/s			
110	Repeat phase 80			
120	Repeat phase 50			
130	Set FIC-2001 at the maximum flow rate available	About 1 kg/s		
140	Repeat phase 80			
150	Repeat phase 50			
160	Set PIC-4002 at 701.3 kPa			
170	Repeat phase 30			

SIET	Document	Rev	Page	of
Division Kearton Innovative	00098PP91	0	128	225

PANTHERS PCC TEST PROCEDURE

Page 2 of 3

Title Air Flow Tests

Test # C-03

Phase #	Description	Note	Status	Oper. Signal
180	Open valve F-039 and close valve F-038	It changes the orifice measuring the inlet flow rate		
190	Repeat phase 40			
200	Repeat phase 50			
210	Close valve F039 and open valve F-038	It changes the orifice measuring the inlet flow rate		
220	Set FIC-2001 at 0.3 kg/s			
230	Repeat phase 80			
240	Repeat phase 50			
250	Set FIC-2001 at 0.6 kg/s			
260	Repeat phase 80			
270	Repeat phase 50			
280	Set FIC-2001 at the maximum flow rate available	About 1 kg/s		
290	Repeat phase 80			
300	Repeat phase 50			
310	Turn off the air compressors C002 C003			
320	Depressurize the system			

SIET	Document	Rev	Page	of
Divisione Ricerca e Innovazione	1009RPP01	0	130	225

PANTHERS PCC PRE-TEST CHECK LIST

Page 1 of 2

Title Water Drain Test

Test # C-04

Phase #	Description	Note	Status	Oper. Signal.
10	Verify that the plant configuration is complete and suitable for the scope of test C-04, in particular that the temporary 2" sch 40 feed water line connects line M (before the valve F-034) and the Upper Header A. nozzle A	because this line is temporary and there are no valves and instruments, it is not shown in the P&ID		
20	Verify that the following instrumentation has been calibrated, installed, filled, vented and is in operation: <ul style="list-style-type: none"> • P-2001, F-2001, F-2002, T-2001 • P-4002, P-A001, DP-026, P-C001 • DP-017, DP-019, P-5001, DP-029 • P-L001, L-L002, L-L001, F-L001, T-L005 • DP-024, F-M001, T-M001, DP020, DP-018 • DP-016 			
30	Verify that the Data Acquisition System is operational and the conversion constants and formulas have been correctly inserted in the DAS			
40	Verify that the following valves are closed: <ul style="list-style-type: none"> • F001, F025, F011, F037, F018 • SF002, F033, F034, F013, F021 • FF041, F046, F038, F026 			
50	Verify that the following valves are open <ul style="list-style-type: none"> • F044, F039, F009, SF001, F017, F015, SF003 			
60	Verify that the following safety valves are set at 1 MPa: <ul style="list-style-type: none"> • F016, F050 and the valve F043 is set at 4.0 MPa			
70	Verify that the following control systems are available: LIC-L001, PIC-L001			

SIET	Document	Rev	Page	of
Online Realtime Innovative	X009RPP91	0	132	225

PANTHERS PCC TEST PROCEDURE

Page 1 of 3

Title Water Drain Test

Test # C-04

Phase #	Description	Note	Status	Oper. Signal.
10	Set LIC-L001 in manual mode and fully open pneumatic valve F019			
20	Start pump C-004 and fill Condensate Tank to reach level L-L002=1.75 m (when this level is reached, the water starts to drain in line L, through F-L001)	Discharge of CT is from the overflow pipe. The level is 2.5 above CT inlet nozzle		
30	Set PIC-L001 in automatic mode and set pressure set point PIC-L001 = 281.3 kPa	Pressure is an absolute value and is controlled by F021 valve		
40	Start air compressor C-002			
50	Open F008 and pressurize the system till to reach steady state pressure condition P-L001=281.3 kPa			
60	Adjust water flow rate F-M001 = F-L001 = 1.0 kg/s, acting on valve F-026	LIC-L001 is in manual mode		
70	Wait to reach steady-state flow rate F-M001=F-L001=1.0kg/s and pressure P-L001=281.3 kPa			
80	Measure and record all instruments for 1000 s			
90	Adjust water flow rate F-M001 = F-L001 = 3.0 kg/s, acting on valve F-026			
100	Wait to reach steady-state flow rate F-M001=F-L001=3.0 kg/s and pressure P-L001=281.3 kPa			
110	Measure and record all instruments for 1000 s			
120	Adjust water flow rate F-M001 = F-L001 = 6.0 kg/s, acting on valve F-026			
130	Wait to reach steady-state flow rate F-M001=F-L001=6.0 kg/s and pressure P-L001=281.3 kPa			

SIET	Document	Rev	Page	of
Sezione Ricerca Innovativa	00098PP01	0	133	221

PANTHERS PCC TEST PROCEDURE

Page 2 of 3

Title Water Drain Test

Test # C-04

Phase #	Description	Note	Status	Oper. Signal
140	Measure and record all instruments for 1000 s			
150	Adjust water flow rate F-M001 = F-L001 = 9.0 kg/s, acting on valve F-026			
160	Wait to reach steady-state flow rate F-M001=F-L001=9.0 kg/s and pressure P-L001=281.3 kPa			
170	Measure and record all instruments for 1000 s			
180	Open valve F-018 and close valve F-017	Discharge of CT is from the bottom of CT		
190	Switch level controller LIC-L001 to automatic mode and set level set point = 1.75 m			
200	Set PIC-L001 pressure set point = 701.3 kPa			
210	Adjust water flow rate F-M001 = F-L001 = 9.0 kg/s, acting on valve F-026			
220	Wait to reach steady-state flow rate F-M001=F-L001=9.0 kg/s and pressure P-L001=701.3 kPa			
230	Measure and record all instruments for 1000 s			
240	Adjust water flow rate F-M001 = F-L001 = 6.0 kg/s, acting on valve F-026			
250	Wait to reach steady-state flow rate F-M001=F-L001=6.0 kg/s and pressure P-L001=701.3 kPa			
260	Measure and record all instruments for 1000 s			
270	Adjust water flow rate F-M001 = F-L001 = 3.0 kg/s, acting on valve F-026			
280	Wait to reach steady-state flow rate F-M001=F-L001=3.0 kg/s and pressure P-L001=701.3 kPa			

SIET	Document	Rev	Page	of
©2006 Kvaerner Innovation	XXXXPP01	0	135	225

PANTHERS PCC PRE-TEST CHECK LIST

Page 1 of 2

Title Heat Losses in Injection line, Vent Line and Vent Tank

Test # H-01

Phase #	Description	Note	Status	Oper. Signal
10	Verify that the plant configuration is complete and suitable for the scope of test H-01: pool P, Q and CT empty, steam supply line 1, desuperheating lines, injection line 4, PCC, vent line 6, vent tank, line T, drain line 5, Condensate tank, CT discharge line L are available			
20	Verify that the following instrumentation has been calibrated, installed, filled, vented and is in operation: <ul style="list-style-type: none"> • P-1001, T-1001, T-4001 • P-4001, T-4002, T-4003, P-4002, T-5001, P-A001 • T-5002, T-L001, T-L002, T-L003, T-L004 • P-5001, P-L001, L-L001, L-L002, T-L005, L-L003 • DP-001, DP-002, DP-003, DP-004, DP-024 • DP-026, DP-017, DP-019, DP-021, DP-029 • P-A001, DP-016, DP-018, DP-020 • DP-022, T-6001, T-6002, T-1001, T-1002 • T-1003, L-1001, L-1002, P-1001, DP-023 • P-T001, T-T001, PCC fluid and tube wall thermocouples 			
30	Verify that the Data Acquisition System is operational and the conversion constants and formulas have been correctly inserted in the DAS			
40	Verify that the following valves are closed: <ul style="list-style-type: none"> • F001, F002, F003, F011, F009, F013, F017, F015, F023, F049, SF004, F059, F004, SF001, F046 			
50	Verify that the following valves are open: <ul style="list-style-type: none"> • F025, F007, F018, SF002, F058, F048, SF003 			
60	Verify that the following safety valves are set at 1.0 MPa: <ul style="list-style-type: none"> • F016, F050, F040 			
70	Verify that the following control systems are available: <ul style="list-style-type: none"> • PIC-4002, TIC-4002, LIC-L001 			
80	Verify that the pump C001 is available			
90	Verify that the condensers are cooled (Fluivale pump is in operation)			

SIET	Document	Rev	Page	of
Section: Reaction Innovative	X00RPP01	0	137	225

PANTHERS PCC TEST PROCEDURE

Page 1 of 3

Title Heat Losses in injection line, Vent Line and Vent Tank Test # H-01

Phase #	Description	Note	Status	Oper. Signal
10	Open the valve F019 at its minimum value	Discharge of the CT is from the bottom		
20	Set PIC-4002 pressure set point = 281.3 kPa	Pressure in absolute value		
30	Set TIC-4002 temperature set point = 141 °C	About 10°C of superheat at PCC inlet		
40	Open valves F003, F002, F001, F004 and open steam flow control valve F-005 at its minimum value compatible with the possibility to control the pressure P-4002 discharging some uncondensed steam from PCV F020	The steam flow rate should be about 0.2 kg/s. If it is difficult maintain the required pressure close valve F019		
50	Start pump C001, open valves, F059 / F011 and begin to desuperheat steam			
60	Adjust steam temperature till to reach the required temperature of T-4002 (about 10°C of superheat)			
70	Decrease furtherly steam temperature till yo have saturated steam in the PCC upper headers	The steam must be superheated in the injection line		
80	Wait to reach steady state condition in pressure P-4002 and temperature T-6001, T-6002, T-T001, T-4002, T-4003, T-A001, T-A002, T-D001, T-D002	The steam in the PCC upper headers and in Vent line must be in saturated conditions		
90	Measure and record all instruments and plot water level in vent tank versus time for 1200 s			
100	Set PIC-4002 pressure set point = 501.3 kPa			
110	Set TIC-4002 temperature set point = 162°C	About 10°C of superheat at PCC inlet		
120	Repeat phases 60 and 70			

SIET	Document	Rev	Page	of
Region: Realtime Innovation	0009RPP01	0	138	225

PANTHERS PCC TEST PROCEDURE

Title *Heat Losses in injection line, Vent Line and Vent Tank* Test # H-01

Phase #	Description	Note	Status	Oper. Signal
130	Wait to reach steady state condition in pressure P-4002 and temperature T-6001, T-6002, T-T001, T-4002	The steam in vent line must be in saturated conditions		
140	Measure and record all instruments and plot water level in vent tank versus time for 1200 s			
150	Set PIC-4002 pressure set point = 701.3 kPa			
160	Set TIC-4002 temperature set point = 175 °C	About 10°C of superheat at PCC inlet		
170	Repeat phases 60 and 70			
180	Wait to reach steady state condition in pressure P-4002, P-A001 and temperature T-6001, T-6002, T-T001, T-4002, T-4003, T-A001, T-A002, T-D001, T-D002	The steam in the PCC upper headers and in vent line must be in saturated conditions		
190	Measure and record all instruments and plot water level in vent tank versus time for 1200 s			
200	Set PIC-4002 pressure set point = 825.3 kPa			
210	Set TIC-4002 temperature set point = 181 °C	About 10°C of superheat at PCC inlet		
220	Repeat phases 60 and 70			
230	Wait to reach steady state condition in pressure P-4002, P-A001 and temperature T-6001, T-6002, T-T001, T-4002, T-H003, T-A002, T-D001, T-D002	The steam in vent line must be in saturated conditions		
240	Measure and record all instruments and plot water level in vent tank versus time for 1200 s			
	Close steam flow control valves F-001, F-005, F-002, F-003			
	Turn off pump C001 and close valves F011 / F049			
	Depressurize and drain the system			

SIET	Document	Rev	Page	of
© 2006 Kvaerner Innovativ	0009RPP91	0	138	225

PANTHERS PCC TEST PROCEDURE

Page 2 of 3

Title *Heat Losses in injection line, Vent Line and Vent Tank* Test # H-01

Phase #	Description	Note	Status	Oper. Signal
130	Wait to reach steady state condition in pressure P-4002 and temperature T-6001, T-6002, T-T001, T-4002	The steam in vent line must be in saturated conditions		
140	Measure and record all instruments and plot water level in vent tank versus time for 1200 s			
150	Set PIC-4002 pressure set point = 701.3 kPa			
160	Set TIC-4002 temperature set point = 175 °C	About 10°C of superheat at PCC inlet		
170	Repeat phases 60 and 70			
180	Wait to reach steady state condition in pressure P-4002, P-A001 and temperature T-6001, T-6002, T-T001, T-4002, T-4003, T-A001, T-A002, T-D001, T-D002	The steam in the PCC upper headers and in vent line must be in saturated conditions		
190	Measure and record all instruments and plot water level in vent tank versus time for 1200 s			
200	Set PIC-4002 pressure set point = 825.3 kPa			
210	Set TIC-4002 temperature set point = 181°C	About 10°C of superheat at PCC inlet		
220	Repeat phases 60 and 70			
230	Wait to reach steady state condition in pressure P-4002, P-A001 and temperature T-6001, T-6002, T-T001, T-4002, T-H003, T-A002, T-D001, T-D002	The steam in vent line must be in saturated conditions		
240	Measure and record all instruments and plot water level in vent tank versus time for 1200 s			
250	Close steam flow control valves F-001, F-005, F-002, F-003			
260	Turn off pump C001 and close valves F011 / F019			
270	Depressurize and drain the system			

SIET	Document	Rev	Page	of
Sezione Reattori Innovativi	0098PP91	0	140	225

PANTHERS PCC PRE-TEST CHECK LIST

Page 1 of 2

Title Heat Losses in Drain Line and Condensate Tank Test # H-02

Phase #	Description	Note	Status	Oper. Signat.
10	Verify that the plant configuration is complete and suitable for the scope of test H-02 : Pool P and Q empty and the following lines are available: steam supply line 1, desuperheating line 3, injection line 4, drain line 5, condensate tank, temporary feedwater line to module 1 upper header			
20	Verify that the following valves are closed: F038, F039, F009, F013, SF003, SF002, F017, F018, F015, F001, F002, F003, F025, F011, F059, F033, F034, F005			
30	Verify that the following valves are open: F058, F007, SF001, F506			
40	Verify that the following instrumentation has been calibrated, installed, filled, vented and is in operation : P-1001, F-1001, T-1001, T-4001, P-4001, T-4002, T-4003, P-4002, P-L001, T-L001, T-L002, T-L003, T-L004, T-5002, DP-029, L-L001, L-L002			
50	Verify that the following safety valves are set at 1.0 MPa: • F016 • F050			
60	Verify that the steam desuperheating control system TIC-4002 is available			
70	Verify that the Data Acquisition System is operational and the conversion constants and formulas have been correctly inserted in the DAS			
80	Verify that the condensers are cooled (Fluviale pump is operational)			

SIET	Document	Rev	Page	of
SIET	009KPP01	0	142	225

PANTHERS PCC TEST PROCEDURE

Page 1 of 3

Title Heat Losses in Drain line and Condensate Tank

Test # H-02

Phase #	Description	Note	Status	Oper. Signal
10	Open the valve F037 and close F506			
20	Start pump C004 and fill fully PCC with water			
30	When the water comes out from F037 valve stop C004 and close valve F037			
40	Open fully valve F503, and drain injection line			
50	Open valves F025, F003, F004, and open F005 at its minimum value and begin to feed the riser, the drain line and the condensate tank with steam	Maintain valves F001 and F002 closed because the leakage of these valves should be sufficient to perform the test		
60	Start pump C001, open valves F040 / F011 and begin to desuperheated steam			
70	Throttle valve F503 till to have a absolute pressure P-4002 = 281.3 kPa	If required open very little F001 and F002 valves		
80	Set TIC-4002 temperature set point = 141°C	About 10°C of superheat at PCC inlet		
90	Adjust steam temperature till to reach required temperature of T-4002 (10°C of superheat or less)			
100	Wait to reach steady state conditoun in pressure P-4002, P-L001 and temperature T-L001, T-L002, T-L003, T-L004, T-5002	The steam in condensate tank must be in saturated conditions		
110	Measure and record all instruments and plot water level in condensate tank versus time for 1200 s			

SIET	Document	Rev	Page	of
XXXXXXXXXX	XXXXXXXXXX	1	143	225

PANTHERS PCC TEST PROCEDURE

Page 2 of 3

Title Heat Losses in Drain line and Condensate Tank

Test # H-02

Phase #	Description	Note	Status	Oper. Signat.
120	Throttle valve F503 till to have a absolute pressure P-4002 = 501.3 kPa			
130	Set TIC-4002 temperature set point = 162°C	About 10°C of superheat at PCC inlet		
140	Repeat phase 90			
150	Repeat 100			
160	Repeat 110			
170	Throttle valve F503 till to have a absolute pressure P-4002 = 701.3 kPa			
180	Set TIC-4002 temperature set point 175°C	About 10°C of superheat at PCC inlet		
190	Repeat phase 90			
200	Repeat 100			
210	Repeat 110			
220	Throttle valve F503 till to have a absolute pressure P-4002 = 825.3 kPa			
230	Set TIC-4002 temperature set point 181°C	About 10°C of superheat at PCC inlet		
240	Repeat phase 90			
250	Repeat 100			
260	Repeat 110			
270	Close valves F005, F004, F003, F025 and if opened close valves F002 and F001			

SIET	Document	Rev	Page	of
Horizon Reaction Innovative	0009RPP01	0	145	225

PANTHERS PCC PRE-TEST CHECK LIST

Page 1 of 2

Title Heat Losses of the Pool Connection Line and Line to Catch Tank Test # H-03

Phase #	Description	Note	Status	Oper. Signal
10	Verify that the plant configuration is complete and suitable for the scope of test H-03: complete closed PANTHERS-PCC test loop			
20	Verify that all the instrumentation (with the exception of instrumentation of air injection line 2) has been calibrated, installed, filled, vented and is in operation	The PCC instrumentation is included		
30	Verify that the Data Acquisition System is in operation and the conversion constants and formulas have been correctly inserted in DAS			
40	Verify that the following valves are closed: • F044, F038, F039, F009, F013, F037, F047, F023, F048, F015, F018, F036, F031, F032, F030, F034, F028, F029, F035, F042, F041, F002, F003, F025, F059, F011			
50	Verify that the following valves are open: • F058, F007, SF001, F017, F019, SF003, SF002, F049, F046, F045, F033, F027, F055, F020, F022, F060	F019 and F007 are partially open		
60	Verify that the following safety valves are set at 1.0 MPa: • F016, F050, F040			
70	Verify that the following control systems are available: • LIC-Q002, TIC-1001, FIC-1001			
80	Verify that the pump C001 and C004 are available			
90	verify that the tanks A001, A002, A003 are full	If pools P and Q are full, the tanks can be partially full		
100	verify that the condensers are cooled ("Fluviale" pump is in operation)			

SIET Suezone Reaction Innovative	Document (0098PP91)	Rev 0	Page 147	of 225
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PANTHERS PCC TEST PROCEDURE

Page 1 of 2

Title Heat Losses of the Pool Connection Line and Line to Catch Tank Test # H-03

Phase #	Description	Note	Status	Oper. Signal.
10	Set LIC-Q001 level set point = 3.75 m	5 m below the normal water level, to reduce the carry over during the boil off		
20	Start pump C004 and fill the pools till the required level			
30	Open valve F041 and fill the condensate tank up to level L-L002 = 1.75 m (When this level is reached, the water start to drain il line L, through F-L001)	The level is 2.5 m above the CT inlet nozzle		
40	Open valves: F002, F003, F025, F059, F011 and purge the PCC by steam			
50	Start pump C001			
60	Open valve F006 and valve F012 beginning to desuperheat the steam			
70	Throttle valve F019 (in manual mode) in order to keep level L-L001 higher than 0.5 m and L-L002 = 1.75 m			
80	Open valves F005 and F006, to reach the maximum steam flow rate, controlling that temperature T-4002 shall be less then 180°C and pressure P-4002 less than 790 kPA			
90	Measure the PCC inlet pressure P-4002 and adjust temperature T-4002 acting on valve F006 in order to have superheated steam at PCC inlet with less than 10°C of superheating			
100	Heat up the PCC pool water till to reach the equilibrium bulk average temperature (steady state conditions) repeating periodically phase 90 in order to have superheated steam at PCC inlet with less than 10°C of superheating			
110	Decrease steam flowrate to about 0.5 kg/s (F-1001+F-3001), adjusting the desuperheating in order to have superheated steam at PCC inlet with less than 10°C of superheating	This flowrate should be sufficient to maintain the PCC pool in boiling conditions		

SIET	Document	Rev	Page	of
McDermott Reaction Innovatives	0098PP91	0	149	225

PANTHERS PCC PRE-TEST CHECK LIST

Page 1 of 2

Title *Steam Only Test*

Test # H-04

Phase #	Description	Note	Status	Oper. Signat.
10	Verify that the plant configuration is complete and suitable for the scope of test H-04: complete closed PANTHERS-PCC test loop			
20	Verify that all the instrumentation (with the exception of instrumentation of air injection line 2) has been calibrated, installed, filled, vented and is in operation	The PCC instrumentation is included		
30	Verify that the Data Acquisition System is in operation and the conversion constants and formulas have been correctly inserted in DAS			
40	Verify that the following valves are closed: • F044, F038, F039, F009, F013, F037, F047, F023, F049, F015, F018, F036, F031, F032, F030, F034, F028, F029, F035, F042, F041, F002, F003, F025, F059, F011, F060, F022, F053			
50	Verify that the following valves are open: • F058, F007, SF001, F017, F019, SF003, SF002, F048, F046, F045, F033, F027, F055, F020	F019 and F007 are partially open		
60	Verify that the following safety valves are set at 1.0 MPa: • F016, F050, F040			
70	Verify that the following control systems are available: • LIC-Q001, TIC-1001, FIC-1001			
80	Verify that the pump C001 and C004 are available			
90	verify that the tanks A001, A002, A003 are full	if pools P and Q are full, the tanks can be partially full		
100	Verify that the condensers are cooled ("Fluviale" pump is in operation)			

SIET	Document	Rev	Page	of
Process Realization Innovatives	009RPP91	0	151	225

PANTHERS PCC TEST PROCEDURE

Page 1 of 2

Title Steam Only Test

Test # H-04

Phase #	Description	Note	Status	Oper. Signal.
10	Set LIC-Q001 level set point = 4.26 m	normal water level		
20	Start pump C004 feed the ponds and control level L-Q001 = 4.26 m			
30	Open valve F041 and fill the condensate tank up to level L-L002 = 1.75 m (When this level is reached, the water start to drain line L through F-L001)	The level is 2.5 m above the CT inlet nozzle		
40	Open valves: F002, F003, F004, F025, F059, F011 and purge the PCC by steam (F003 must be fully open)	At the opening of valve F003 steam starts to flow		
50	Start pump C001 and begin to desuperheat the steam opening valve F012, F006			
60	Measure and record all instrument signals including accelerometers	Accelerometers will be recorded for 10 minutes every 30 minutes		
70	Open valve F001 and increase the steam flowrate			
80	Throttle valve F019 (in manual mode) in order to keep level L-L001 higher than 0.5 m and L-L002 = 1.75 m			
90	Open valves F005, F001 and F006, to reach steam flow rate F-1001 + F-3001 = 6.6 kg/s, controlling that temperature T-4002 shall be less than 180°C and pressure P-4002 less than 790 kPa	10°C of superheat or less at PCC inlet		
100	Measure the PCC inlet pressure P-4002 and adjust temperature T-4002 acting on valve F006 in order to have superheated steam at PCC inlet with less than 10°C of superheating			
110	Heat up the PCC pool water till to reach the equilibrium bulk average temperature (steady state conditions) repeating periodically phase 90 in order to have superheated steam at PCC inlet with less than 10°C of superheating			

SIET	Document	Rev	Page	of
Version: Reactor Innovativ	00098PP91	0	153	225

PANTHERS PCC PRE-TEST CHECK LIST

Page 1 of 2

Title Saturated steam/air mixtures test Test # H-05

Phase #	Description	Note	Status	Oper. Signat.
10	Verify that the plant configuration is complete and suitable for the scope of test H-05: complete closed PANTHERS-PCC test loop			
20	Verify that all instrumentation has been calibrated, installed, filled, vented and is in operation	The PCC instrumentation is included		
30	Verify that the Data Acquisition Systems is in operation and the conversion constants and formulas have been correctly inserted in DAS			
40	Verify that the following valves are closed: F039, F009, F013, F037, F047, F023, F048, F015, F018, F036, F031, F032, F030, F028, F029, F035, F042, F041, F001, F002, F003, F004, F059, F011, F060, F022, F003, F034			
50	Verify that the following valves are open: SF001, SF002, SF003, F007, F038, F025, F044, F058, F049, F017, F027, F045, F033, F055	F055, F007 and F025 are partially open		
60	Verify that the following safety valves are set at 1.0 MPa: F016, F050, F040			
70	Verify that the following control systems are available: PIC-4002, FIC-1001, FIC-2001, TIC-1001, LIC-Q001			
80	Verify that pumps C001, C004 and compressors C002, C003 are available			
90	Verify that the tanks A001, A002, A003 are full	If pools P, Q, are full, the tanks can be partially full		
100	Verify that the condensers are cooled ("Fluviale" pump is in operation)			

SIET	Document	Rev	Page	of
McDermott Realtime Innovations	0098PP91	0	155	225

PANTHERS PCC TEST PROCEDURE

Page 1 of 4

Title Saturated steam/air mixtures test

Test # H-05

Phase #	Description	Note	Status	Oper. Signal
10	Set LIC-Q001 level set point = 4.26 m	normal water level		
20	Start pump C004 feed the pools and control level L-Q001 = 4.26 m			
30	Open valve F041 and fill the condensate tank up to level L-L002 = 1.75 m (when this level is reached, the water starts to drain in line L through F-L001)	The level is 2.5 m above the CT inlet nozzle		
40	Open valves: F002, F003, F004, F059, F011 and purge the PCC by steam. (Valve F003 must be fully open)	At the opening of valve F003 steam starts to flow		
50	Start pump C001 and begin to desuperheat the steam opening valves F012, F006			
60	Measure and record all instrument signals including accelerometers	Accelerometers will be recorded for 10 minutes every 30 minutes		
70	Open valves F001, F005, F006 to reach a steam flow rate F-1001 + F-3001 > 5 Kg/s controlling that temperature T-4002 shall be less than 180° C and pressure P-4002 less than 790 kPa			
80	Heat up the PCC pool water till to reach the equilibrium bulk average temperature (steady state conditions)			
90	Start compressors C002 and C003, open partially valve F008 and wait till to have pressure P-2001 = 2.5 MPa			
100	Open partially valve F009 and begin to inject air			
110	Set PIC-4002 pressure set point = 453 kPa and control the pressure in automatic mode	pressure is in absolute value		

SIET	Document	Rev	Page	of
SIET - The One Reason Innovative	00098PP01	0	156	225

PANTHERS PCC TEST PROCEDURE

Page 2 of 4

Title Saturated steam/air mixtures test Test # H-05

Phase #	Description	Note	Status	Oper. Signal
120	Open valve F008 till to have a air flow $F-2001=0.83$ kg/s verifying that the air pressure P-2001 must be higher than 2.0 MPa	If it is not possible to reach the required air flow increase the opening of the valve F009		
130	Operate valves F001, F005, F006. (If required adjust valves F025 and F007) to reach steam flowrate $F-1001 + F-3001 = 1.4$ Kg/s, controlling that temperature T-4002 shall be less than 180° C			
140	Measure the PCC inlet pressure P-4002 and adjust PCC inlet conditions in order to have the required following test conditions: $F-1001 + F-3001 = 1.4$ Kg/s $F-2001 = 0.83$ kg/s $P-4002 = 453$ KPa (maximum inlet test value) $T-4002 \leq 158^{\circ}$ C	10° C of superheat or less at PCC inlet		
150	When steady state conditions are reached measure DP-025. if DP-05 is higher than 14 KPa stop the test else keep measuring and recording all instrument signals for 15 minutes			
160	Decrease the pressure set point of PIC-4002 of about a quarter of the PCC inlet pressure variation range: the set point of PIC-4002 is = 390 KPa			
170	Measure the PCC inlet pressure P-4002 and adjust PCC inlet conditions in order to have the required steam ($F-1001 + F-3001$) and air ($F-2001$) flowrates controlling that the inlet temperature T-4002 shall have a superheating degree less than 10 °C	10° C of superheat or less at PCC inlet		

SIET Suzhou Keaton Innovativ	Document 0098PP91	Rev 0	Page 157	of 225
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PANTHERS PCC TEST PROCEDURE

Page 3 of 4

Title Saturated steam/air mixtures test Test # H-05

Phase #	Description	Note	Status	Oper. Signal.
180	Repeat phase 150			
190	Decrease the pressure set point of PIC-4002 of about a quarter of the PCC inlet pressure variation range; the set point of PIC-4002 is = 325 KPa			
200	Repeat phase 170			
210	Repeat phase 150			
220	Decrease the pressure set point of PIC-4002 of a quarter of the PCC inlet pressure variation range; the set point of PIC-4002 is = 260 KP			
230	Repeat phase 170			
240	Repeat phase 150			
250	Decrease the pressure set point of PIC-4002 of about a quarter of the PCC inlet pressure variation range; the set point of PIC-4002 is = 198 KPa			
260	Repeat phase 170			
270	Repeat 170			
280	Stop the test			

SIET	Document	Rev	Page	of
soluzioni. Reason. Innovativi	(X098PP01)	0	159	225

**PANTHERS PCC PRE-TEST CHECK LIST
TESTS WITH TWO MODULES**

Page 1 of 2

Title Test type A.1.1 - Saturated steam/air mixtures test Test # 1+30

Phase #	Description	Note	Status	Oper. Signal
10	Verify that the plant configuration is complete and suitable for the scope of test A.1.1.: complete closed PANTHERS - PCC test loop			
20	Verify that all instrumentation has been calibrated, installed, filled, vented and is in operation	The PCC instrumentation is included		
30	Verify that the Data Acquisition Systems is in operation and the conversion constants and formulas have been correctly inserted in DAS			
40	Verify that the following valves are closed : F038, F039, F009, F013, F037, F047, F023, F048, F015, F018, F036, F031, F032, F030, F028, F029, F035, F042, F041, F001, F002, F003, F004, F059, F011, F060, F022, F503, F034			
50	Verify that the following valves are open: SF001, SF002, SF003, F007, F025, F044, F058, F049, F017, F027, F045, F033, F055	F055, F007 and F025 are partially open		
60	Verify that the following safety valves are set at 1.0 MPa: F016, F050, F040			
70	Verify that the following control systems are available: PIC-4002, FIC-1001, FIC-2001, TIC-1001, LIC-Q001			
80	Verify that pumps C001, C004 and compressors C002, C003 are available			
90	Verify that the tankes A001, A002, A003 are full	If pools P, Q, are full, the tankes can be partially full		
100	Verify that the condensers are cooled ("Fluviale" pump is in operation)			

SIET	Document	Rev	Page	of
Siemens Kearton Innovative	10098PP91	0	161	225

**PANTHERS PCC TEST PROCEDURE
TESTS WITH TWO MODULES**

Page 1 of 5

Title Test type - A.I.I Saturated steam/air mixtures test Test # 1+30

Phase #	Description	Note	Status	Oper. Signal.
10	Set LIC-Q001 level set point = 4.26 m	normal water level		
20	Start pump C004 feed the pools and control level L-Q001 = 4.26 m			
30	Open valve F041 and fill the condensate tank up to level L-L002 = 1.75 m (when this level is reached, the water starts to drain in line L through F-L001)	The level is 2.5 m above the CT inlet nozzle		
40	Open valves: F002, F003, F004, F059, F011 and purge the PCC by steam. (Valve F003 must be fully open)	At the opening of valve F003 steam starts to flow		
50	Start pump C001 and begin to desuperheat the steam opening valves F012, F006			
60	Measure and record all instrument signals including accelerometers	Accelerometers will be recorded for 10 minutes every 30 minutes		
70	Open valves F001, F005, F006 to reach a steam flow rate F-1001 + F-1001 > 5 Kg/s controlling that temperature T-4002 shall be less than 180° C and pressure P-4002 less than 790 kPa			
80	Heat up the PCC pool water till to reach the equilibrium bulk average temperature (steady state conditions)			
90	Start compressors C002 and C003, open partially valve F008 and wait till to have pressure F-2001 = 2.5 MPa			
100	Open valve F038 or F039 to insert the adequate orifice for the test	From 1 Kg/s to 0.1 Kg/s open valve F038 below open valve F039		
110	Open partially valve F009 and begin to inject air			

SIET	Document	Rev	Page	of
sezione Ricerca Innovativa	0098PP01	0	162	224

**PANTHERS PCC TEST PROCEDURE
TESTS WITH TWO MODULES**

Page 2 of 5

Title Test type - A.1.1 Saturated steam/air mixtures test Test # 1+30

Phase #	Description	Note	Status	Oper. Signal.
120	Set the PIC-4002 pressure set point equal to the PCC maximum inlet absolute pressure value required for the test: (see table n.7 for the required pressure value)	pressure in absolute value		
130	Open valve F008 till to have a air flow F-2001 or F-2002= (see table n.7 for the required air flow value) verifying that the air pressure P-2001 must be higher than 2.0 MPa	If it is not possible to reach the required air flow increase the opening of the valve F009		
140	Operate valves F001, F005, F006. (If required adjust valves F025 and F007) to reach steam flow F-1001 + F-3001 = (see table n.7 for the required steam flow value) controlling that temperature T-4002 shall be less than 180° C			
150	Measure the PCC inlet pressure P-4002 and adjust PCC inlet conditions in order to have the required following test conditions: F-1001 + F-3001 = (*) kg/s F-2001 = (*) kg/s P-4002 = (*) kPa (maximum PCC inlet pressure) temperature T-4002 must be superheated with a superheating degree less than 10 °C	(*) See table N.7 for steam flow, air flow and PCC inlet pressure values		
160	When steady state conditions are reached measure DP-025. if DP-05 is higher than 14 KPa stop the test else keep measuring and recording all instrument signals for 15 minutes			
170	Decrease the pressure set point of PIC-4002 of about a quarter of the PCC inlet pressure variation range: (see table N.7)			

SIET	Document	Rev	Page	of
Medone Keaton Innovations	Y0098PP91	0	163	225

**PANTHERS PCC TEST PROCEDURE
TESTS WITH TWO MODULES**

Page 3 of 5

Title Test type - A.I.I Saturated steam/air mixtures test Test # 1+30

Phase #	Description	Note	Status	Oper. Signat.
180	Measure the PCC inlet pressure P-4002 and adjust PCC inlet conditions in order to have the required steam (F-1001 + F3001) and air flow (F-2001 or F-2002) as specified in table N.7 controlling that the inlet temperature T-4002 must be superheated with a superheating degree less than 10 °C	10° C of superheat or less at PCC inlet		
190	Repeat phase 160			
200	Decrease the pressure set point of PIC-4002 of about a quarter of the PCC inlet pressure variation range (see table N.7)			
210	Repeat phase 180			
220	Repeat phase 160			
230	Decrease the pressure set point of PIC-4002 of about a quarter of the PCC inlet pressure variation range (see table N.7)			
240	Repeat phase 180			
250	Repeat phase 160			
260	Decrease the pressure set point of PIC-4002 of about a quarter of the PCC inlet pressure variation range till to reach the PCC minimum inlet absolute pressure value required for the test (see table N.7)			
270	Repeat phase 180			
280	Repeat phase 160			
290	Stop the test			

SIET	Document	Rev	Page	of
szobone Realtime Innovativi	00098PP91	0	164	225

**PANTHERS PCC TEST PROCEDURE
TESTS WITH TWO MODULES**

Page 4 of 5

Title Test type - A.L.L Saturated steam/air mixtures test Test # 1÷30

Phase #	Description	Note	Status	Oper. Signat.
200	Repeat phase 170			
210	Repeat phase 150			
220	Decrease the pressure set point of PIC-4002 of a quarter of the PCC inlet pressure variation range; the set point of PIC-4002 is = 260 KPa			
230	Repeat phase 170			
240	Repeat phase 150			
250	Decrease the pressure set point of PIC-4002 of about a quarter of the PCC inlet pressure variation range; the set point of PIC-4002 is = 198 KPa			
260	Repeat phase 170			
270	Repeat 170			
280	Stop the test			

SIET	Document	Rev	Page	of
Reazione Reattori Innovativi	00098PP91	0	166	225

**PANTHERS PCC PRE-TEST CHECK LIST
TESTS WITH TWO MODULES**

Page 1 of 2

Title Test type A.1.2. Superheated steam/air mixtures Test # 31+36

Phase #	Description	Note	Status	Oper. Signat.
10	Verify that the plant configuration is complete and suitable for the scope of test A.1.2.: complete closed PANTHERS - PCC test loop			
20	Verify that all instrumentation has been calibrated, installed, filled, vented and is in operation	The PCC instrumentation is included		
30	Verify that the Data Acquisition Systems is in operation and the conversion constants and formulas have been correctly inserted in DAS			
40	Verify that the following valves are closed : F038, F039, F009, F013, F037, F047, F023, F048, F015, F018, F036, F031, F032, F030, F028, F029, F035, F042, F041, F001, F002, F003, F004, F059, F011, F060, F022, F503, F034			
50	Verify that the following valves are open: SF001, SF002, SF003, F007, F025, F044, F058, F049, F017, F027, F045, F033, F055	F055, F007 and F025 are partially open		
60	Verify that the following safety valves are set at 1.0 MPa: F016, F050, F040			
70	Verify that the following control systems are available: PIC-1002, FIC-1001, FIC-2001, TIC-1001, LIC-Q001			
80	Verify that pumps C001, C004 and compressors C002, C003 are available			
90	Verify that the tanks A001, A002, A003 are full	If pools P, Q, are full, the tanks can be partially full		
100	Verify that the condensers are cooled ("Fluviale" pump is in operation)			

SIET	Document	Rev	Page	of
Science Reaction Innovative	00098PP01	0	168	225

**PANTHERS PCC PRE-TEST CHECK LIST
TESTS WITH TWO MODULES**

Page 1 of 4

Title Test type A.1.2. Superheated steam/air mixtures Test # 31+36

Phase #	Description	Note	Status	Oper. Signal.
10	Set LIC-Q001 level set point = 4.26 m	normal water level		
20	Start pump C004 feed the pools and control level L-Q001 = 4.26 m			
30	Open valve F041 and fill the condensate tank up to level L-L002 = 1.75 m (when this level is reached, the water starts to drain in line L through F-L001)	The level is 2.5 m above the CT inlet nozzle		
40	Open valves: F002, F003, F004, F059, F011 and purge the PCC by steam. (Valve F003 must be fully open)	At the opening of valve F003 steam starts to flow		
50	Start pump C001 and begin to desuperheat the steam opening valves F012, F006			
60	Measure and record all instrument signals including accelerometers	Accelerometers will be recorded for 10 minutes every 30 minutes		
70	Open valves F001, F005, F006 to reach a steam flow rate $F-1001 + F-3001 > 5$ Kg/s controlling that temperature T-4002 shall be less than 180° C and pressure P-4002 less than 790 kPa			
80	Heat up the PCC pool water till to reach the equilibrium bulk average temperature (steady state conditions)			
90	Start compressors C002 and C003, open partially valve F008 and wait till to have pressure P-2001 \approx 2.5 MPa			
100	Open valve F038 or F039 to insert the adequate onifice for the test	From 1 Kg/s to 0.1 Kg/s open valve F038 below open valve F039		
110	Open partially valve F009 and begin to inject air			

SIET	Document	Rev	Page	of
Sebone Keaton Innovative	Y0098PP91	0	169	225

**PANTHERS PCC PRE-TEST CHECK LIST
TESTS WITH TWO MODULES**

Page 2 of 4

Title Test Type A.1.2 Superheated steam/air mixtures Test # 31+76

Phase #	Description	Note	Status	Oper. Signal.
120	Set the PIC-4002 pressure set point equal to the PCC maximum inlet absolute pressure value required for the test: (see table n.8 for the required pressure value)	pressure in absolute value		
130	Open valve F008 till to have a air flow F-2001 or F-2002= (see table n.8 for the required air flow value) verifying that the air pressure P-2001 must be higher than 2.0 MPa	If it is not possible to reach the required air flow increase the opening of the valve F009		
140	Operate valves F001, F005, F006. (If required adjust valves F025 and F007) to reach steam flow F-1001 + F-3001 = (see table n.8 for the required steam flow value) controlling that temperature T-4002 shall be less than 180 °C			
150	Measure the PCC inlet pressure P-4002 and adjust PCC inlet conditions in order to have the required following test conditions: F-1001 + F-3001 = (*) kg/s F-2001 = (*) kg/s P-4002 = (*) kPa (maximum PCC inlet pressure) temperature T-4002 must be superheated with a superheating degree of (*) °C	(*) See table N.8 for steam flow, air flow, PCC inlet pressure and super-heating degree values		
160	When steady state conditions are reached measure DP-025, if DP-05 is higher than 14 kPa stop the test else keep measuring and recording all instrument signals for 15 minutes			
170	Decrease the pressure set point of PIC-4002 of about a quarter of the PCC inlet pressure variation range: (see table N.8)			
180	Measure the PCC inlet pressure P-4002 and adjust PCC inlet conditions in order to have the required steam flow (F-1001 + F3001) and air flow (F-2001 or F-2002) as specified in table N.8 controlling that the inlet temperature T-4002 must be superheated with a superheating degree of 20 °C or 30 °C (see table N.8)			

SIET	Doc# 7 01	Rev	Page	of
Division: Research & Innovation	1009RPP01	0	170	225

**PANTHERS PCC PRE-TEST CHECK LIST
TESTS WITH TWO MODULES**

Page 3 of 4

Title Test type A.1.2. Superheated steam/air mixtures Test # 31+36

Phase #	Description	Note	Status	Oper. Signal.
190	Repeat phase 160			
200	Decrease the pressure set point of PIC-4002 of about a quarter of the PCC inlet pressure variation range (see table N.8)			
210	Repeat phase 180			
220	Repeat phase 160			
230	Decrease the pressure set point of PIC-4002 of about a quarter of the PCC inlet pressure variation range (see table N.8)			
240	Repeat phase 180			
250	Repeat phase 160			
260	Decrease the pressure set point of PIC-4002 of about a quarter of the PCC inlet pressure variation range till to reach the PCC minimum inlet absolute pressure value required for the test (see table N.8)			
270	Repeat phase 180			
280	Repeat phase 160			
290	Stop the test			

SIET	Document	Rev	Page	of
Keystone Reaction (Innovative)	0009RPP01	0	172	225

**PANTHERS PCC PRE-TEST CHECK LIST
TESTS WITH TWO MODULES**

Page 1 of 2

Title Test type A.1.3 Steam Only (No air in PCC tubes) Test # 37+49

Phase #	Description	Note	Status	Oper. Signal
10	Verify that the plant configuration is complete and suitable for the scope of test A.1.3.: complete closed PANTHERS - PCC test loop			
20	Verify that all instrumentation (with the exception of instrumentation of air injection line 2) has been calibrated, installed, filled, vented and is in operation	The PCC instrumentation is included		
30	Verify that the Data Acquisition Systems is in operation and the conversion constants and formulas have been correctly inserted in DAS			
40	Verify that the following valves are closed : FO44, FO38, FO39, FO09, FO13, FO37, FO47, FO23, FO49, FO15, FO18, FO36, FO31, FO32, FO30, FO34, FO28, FO29, FO35, FO42, FO41, FO02, FO03, FO25, FO59, FO11, FO60, FO22, FO53.			
50	Verify that the following valves are open: FO58, FO07, SF001, FO17, FO19, SF003, SF002, FO48, FO46, FO45, FO33, FO27, FO55, FO20	FO19, and FO07 are partially open		
60	Verify that the following safety valves are set at 1.0 MPa: FO16, FO50, FO40			
70	Verify that the following control systems are available: LIC-Q001, TIC-1001, FIC-1001			
80	Verify that pumps C001, C004 and are available			
90	Verify that the tanks A001, A002, A003 are full	If pools Pand Q are full, the tanks can be partially full		
100	Verify that the condensers are cooled ("Fluviale" pump is in operation)			

SIET	Document	Rev	Page	of
Keystone Realtime Innovations	00098PP91	0	174	225

**PANTHERS PCC TEST PROCEDURE
TESTS WITH MODULES**

Page 1 of 2

Title Test Type A 1.3 - Steam Only (No Air in PCC Tubes) Test # 37+49

Phase #	Description	Note	Status	Oper. Signal
10	Set LIC-Q001 level set point = 4.26 m	normal water level		
20	Start pump C004 feed the pools and control level L-Q001 = 4.26 m			
30	Open valve F041 and fill the condensate tank up to level L-L002 = 1.75 m (When this level is reached, the water starts to drain line L through F-L001)	The level is 2.5 m above the CT inlet nozzle		
40	Open valves: F002, F003, F004, F059, F011 and purge the PCC by steam. (Valve F003 must be fully open)	At the opening of valve F003 steam starts to flow		
50	Start pump C001 and begin to desuperheat the steam opening valves F012, F006			
60	Measure and record all instrument signals including accelerometers	Accelerometers will be recorded for 10 minutes every 30 minutes		
70	Open valve F001 and increase the steam flowrate			
80	Throttle valve F019 (in manual mode) in order to keep level L-L001 higher than 0.5 m and L-L002 = 1.75 m			
90	Open valves F001, F005, F006 to reach a steam flow rate $F-1001 + F-3001 = (*)$ Kg/s controlling that temperature T-4002 shall be less than 180° C and pressure P-4002 less than 790 kPa	(*) See table N. 9 for steam flow inlet conditions		
100	Measure the PCC inlet pressure P-4002 and adjust temperature T-4002 acting on valve F006 in order to have superheated steam at PCC inlet as: - less than 10°C of superheating for tests 37+43 - from 10°C to 30°C of superheating for tests 44+49			

SIET	Document	Rev	Page	of
Arizona Reaction Innovations	(0098PP9)	0	175	225

**PANTHERS PCC TEST PROCEDURE
TESTS WITH MODULES**

Page 2 of 2

Title Test type A.1.3 - Steam Only (No Air in PCC Tubes) Test # 37+49

Phase #	Description	Note	Status	Oper. Signal
110	Heat up the PCC pool water till to reach the equilibrium bulk average temperature (steady state conditions) repeating periodically phases 90 and 100			
120	Adjust steam flowrate to the required value $F-1001 + F-3001 = (*)$ kg/s. controlling that the steam at the PCC inlet shall be superheated with the required superheating degree (T-4002)	(*) See table N.9 for steam flow inlet conditions		
130	When Steady state conditions are reached, keep measuring and recording all instrument signals for 15 minutes			
140	Stop the test			
150	Change PCC steam inlet conditions			

Note _____

Date _____ Experiment Manager Signature _____

SIET	Document	Rev	Page	of
McDermott KBR/STI Innovation	K098PP91	0	176	225

PANTHERS PCC PRE-TEST CHECK LIST
TESTS WITH TWO MODULES

Page 1 of 2

Title Test type A.1.3. Steam Only (Air in PCC tubes) Test # 50+53

Phase #	Description	Note	Status	Oper. Signal
10	Verify that the plant configuration is complete and suitable for the scope of test A.1.3.: complete closed PANTHERS - PCC test loop with temporary line connecting the 1" air supply line with valve F051	Vent line closed: temporary line not shown in the P&ID		
20	Verify that all instrumentation has been calibrated, installed, filled, vented and is in operation	The PCC instrumentation is included		
30	Verify that the Data Acquisition Systems is in operation and the conversion constants and formulas have been correctly inserted in DAS			
40	Verify that the following valves are closed: F038, SF004, F009, F013, F037, F047, F015, SF002, F051, F017, F036, F031, F032, F030, F028, F029, F035, F042, F041, F001, F002, F003, F004, F059, F011, F060, F022, F503, F034			
50	Verify that the following valves are open: SF001, F038, SF003, F007, F025, F044, F058, F018, F027, F045, F033.	F007, and F025 are partially open		
60	Verify that the following safety valves are set at 1.0 MPa: F016, F050, F040			
70	Verify that the following control systems are available: LIC-L001, FIC-1001, FIC-2001, TIC-1001, LIC-Q001			
80	Verify that pumps C001, C004 and compressors COO2, C003 are available			
90	Verify that the tanks A001, A002, A003 are full	If pools P, Q are full, the tanks can be partially full		
100	Verify that the condensers are cooled ("Fluviale" pump is in operation)			

SIET <small>Process Reaction Innovative</small>	Document K0098PP01	Rev 0	Page 178	of 225
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**PANTHERS PCC TEST PROCEDURE
TESTS WITH TWO MODULES**

Page 1 of 2

Title Test type A.1.3 - Steam Only (Air in PCC Tubes) Test # 50+53

Phase #	Description	Note	Status	Oper. Signal
10	Set LIC-Q001 level set point = 4.26 m Set LIC-L001 level set point = 1.75 (level controlled by L-L002)	normal water level		
20	Start pump C004 feed the pools and control level L-Q001 = 4.26 m			
30	Open valve F041 and fill the condensate tank up to level L-L002 = 1.75 m. When the level L-L002=1.75 m is reached, close valve F041 and control the level L-L002 in automatic mode.	The level is 2.5 m above the CT inlet nozzle		
40	Open valves: F002, F003, F004, F059, F011 and purge the PCC by steam, acting on valves F037 and F0507	At the opening of valve F003 steam starts to flow		
50	Start pump C001 and begin to desuperheat the steam opening valves F012, F006			
60	Measure and record all instrument signals including accelerometers	Accelerometers will be recorded for 10 minutes every 30 minutes		
70	Open valve F001, F005, F006 to reach a steam flow rate F-1001 + F-3001 > 5 kg/s controlling that temperature T-4002 shall be less than 180 °C and pressure P-4002 less than 790 kPa			
80	Start compressors C002 and C003, open a little valve F008 and wait till to have pressure P-2001 = 2.5 MPa			
90	Heat up the PCC pool water till to reach the equilibrium bulk average temperature (steady state conditions)			
100	Operate valves F001, F005, F006 (if required adjust valves F025 and F007) to reach steam flow F-1001+F-3001=(see table N.10 for the required steam flow) controlling that the temperature T-4002 shall be less than 180 °C			

SIET	Document	Rev	Page	of
Sezone Reaction Innovatives	00098PP01	0	179	225

**PANTHERS PCC TEST PROCEDURE
TESTS WITH TWO MODULES**

Title Test type A.1.3 - Steam Only (Air in PCC Tubes) Test # 50+53

Phase #	Description	Note	Status	Oper. Signat.
110	Measure the PCC inlet pressure P-4002 and adjust PCC inlet conditions in order to have the required following conditions: - F-1001 + F-3001 = (*) Kg/s T-4002 = (*) °C (minimum superheating degree 6°C) and wait to reach steady state conditions	(*) See table N.10		
120	Open partially valve F051 and adjust valves F051 and F008 till to have an air flowrate F-2002 \cong 0.006 kG/S	F-2002 has been calculated at P=300 kPa and t=134°C		
130	Cease testing when pressure P-4002 stops increasing or pressure P-4002 \cong 790 kPa			

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Date _____ Experiment Manager Signature _____

SIET	Document	Rev	Page	of
McDermott Hamilton Innovativi	0009RPP91	0	180	225

PANTHERS PCC PRE-TEST CHECK LIST
TESTS WITH TWO MODULES

Page 1 of 2

Title Test type A.2.1. Effect of Pool Water level-Saturated Steam Test # 54

Phase #	Description	Note	Status	Oper. Signat.
10	Verify that the plant configuration is complete and suitable for the scope of test type A.2.1: complete closed PANTHERS - PCC test loop			
20	Verify that all instrumentation (with the exception of instrumentation of air injection line 2) has been calibrated, installed, filled, vented and is in operation	The PCC instrumentation is included		
30	Verify that the Data Acquisition Systems is in operation and the conversion constants and formulas have been correctly inserted in DAS			
40	Verify that the following valves are closed : F044, F038, F039, F009, F013, F037, F047, F023, F049, F015, F018, F036, F031, F032, F030, F034, F028, F029, F035, F042, F041, F002, F003, F025, F059, F011, F060, F022, F503			
50	Verify that the following valves are open: F058, F007, SF001, F017, F019, SF003, SF002, F048, F046, F045, F033, F027, F055, F020	F019, and F007 are partially open		
60	Verify that the following safety valves are set at 1.0 MPa: F016, F050, F040			
70	Verify that the following control systems are available: LIC-0001, TIC-1001, FIC-1001			
80	Verify that pumps C001, C004 are available			
90	Verify that the tanks A001, A002, A003 are full	If pools P and Q are full, the tanks can be partially full		
100	Verify that the condensers are cooled (Fluviale pump is in operation)			

SIET	Document	Rev	Page	of
Reactive Reaction (Innovative)	K09RPP01	0	182	225

**PANTHERS PCC TEST PROCEDURE
TESTS WITH TWO MODULES**

Page 1 of 2

Title Test type A.2.1 Effect of Pool Water level-Saturated Steam Test # 54

Phase #	Description	Note	Status	Oper. Signal.
10	Set LIC-Q001 level set point = 4.26 m	normal water level		
20	Start pump C004 feed the pools and control level L-Q001 = 4.26 m			
30	Open valve F041 and fill the condensate tank up to level L-L002 = 1.75 m. (when this level is reached, the water starts to drain in line L, through F-L001)	The level is 2.5 m above the CT inlet nozzle		
40	Open valves: F002, F003, F004, F025, F059, F011 and purge the PCC by steam. (F003 must be fully open)	At the opening of valve F003 steam starts to flow		
50	Start pump C001 and begin to desuperheat the steam opening valves F012, F006			
60	Measure and record all instrument signals including accelerometers	Accelerometers will be recorded for 10 minutes every 30 minutes		
70	Open valve F001 and increase the steam flowrate			
80	Throttle valve F019 (in manual mode) in order to keep level L-L001 higher than 0.5 m and L-L002 = 1.75 m			
90	Open valves F005, F001 and F006 to reach a steam flow rate F-1001 + F-3001 = 5 kg/s, controlling that temperature T-4002 shall be less than 180°C and pressure P-4002 less than 790 Kpa			
100	Measure the PCC inlet pressure P-4002 and adjust temperature T-4002 acting on valve F006 in order to have superheated steam at PCC inlet as: - less than 10°C of superheating			
110	Heat up the PCC pool water till to reach the equilibrium bulk average temperature (steady state conditions) repeating periodically phases 90 and 100			
120	Adjust steam flowrate to the required value F-1001+F-3001=5 Kg/s, controlling that the steam at the PCC inlet shall be superheated with the required superheating degree (T-4002)			
130	Stop pump C004			

SIET	Document	Rev	Page	of
SCIENCE REACTION INNOVATIVE	009RPP91	0	184	225

**PANTHERS PCC PRE-TEST CHECK LIST
TESTS WITH TWO MODULES**

Page 1 of 2

Test # 55-56

Title Test type A.2.2 Effect of Pool Water level-Saturated Steam/air mixtures.

Phase #	Description	Note	Status	Oper. Signat.
10	Verify that the plant configuration is complete and suitable for the scope of test type A.2.2: complete closed PANTHERS PCC test loop			
20	Verify that all instrumentation has been calibrated, installed, filled, vented and is in operation	The PCC instrumentation is included		
30	Verify that the Data Acquisition Systems is in operation and the conversion constants and formulas have been correctly inserted in DAS			
40	Verify that the following valves are closed : F038, F039, F009, F013, F037, F047, F023, F048, F015, F018, F036, F031, F032, F030, F028, F029, F035, F042, F041, F001, F002, F003, F004, F059, F011, F060, F022, F503, F034			
50	Verify that the following safety valves are open: SF001, SF002, SF003, F007, F025, F044, F058, F049, F017, F027, F045, F033, F055	F055, F007 and F025 are partially open		
60	Verify that the following valves are set at 1.0 MPa: F016, F050, F040			
70	Verify that the following control systems are available: PIC-1002, FIC-1001, FIC-2001, TIC-1001, LIC-Q001			
80	Verify that pumps C001, C004 and compressors C002, C003 are available			
90	Verify that the tanks A001, A002, A003 are full	If pools Pand Q are full, the tanks can be partially full		
100	Verify that the condensers are cooled ("Fluviale" pump is in operation)			

SIET	Document	Rev	Page	of
Sezione Ricerca Innovativa	0009RPP91	0	146	225

PANTHERS PCC TEST PROCEDURE
TESTS WITH TWO MODULES

Page 1 of 3

Test # 55-56

Title Test type A.2.2 Effect of Pool Water level-Saturated Steam/air mixtures

Phase #	Description	Note	Status	Oper. Signal
10	Set LIC-Q001 level set point = 4.26 m	normal water level		
20	Start pump C004 feed the pools and control level L-Q001 = 4.26 m			
30	Open valve F041 and fill the condensate tank up to level L-L002 = 1.75 m (when this level is reached, the water starts to drain line L through F-L001)	The level is 2.5 m above the CT inlet nozzle		
40	Open valves: F002, F003, F004, F059, F011 and purge the PCC by steam. (Valve F003 must be fully open)	At the opening of valve F003 steam starts to flow		
50	Start pump C001 and begin to desuperheat the steam opening valves F012, F006			
60	Measure and record all instrument signals including accelerometers	Accelerometers will be recorded for 10 minutes every 30 minutes		
70	Open valves F001, F005 and F006 to reach a steam flowrate $F-1001 + F-3001 = 5$ kg/s, controlling that temperature T-4002 shall be less than 180°C and pressure P-4002 less than 700 kPa			
80	Heat up the PCC pool water till to reach the equilibrium bulk average temperature (steady state conditions)			
90	Start compressors C002 and C003, open partially valve F008 and wait till to have pressure P-2001 = 2.5 MPa			
100	Open valve F038			
110	Open partially valve F009 and begin to inject air			
120	Set the PIC-4002 pressure set point equal to the PCC minimum inlet absolute pressure value required for the test: (see table N.11 for the required pressure value)	Pressure in absolute value		

SIET	Document	Rev	Page	of
McDermott Realtime Innovations	0009RPP91	0	187	225

**PANTHERS PCC TEST PROCEDURE
TESTS WITH TWO MODULES**

Page 2 of 3

Test # 55-56

Title Test type A.2.2 Effect of Pool Water level-Saturated Steam/air mixtures

Phase #	Description	Note	Status	Oper. Signal
130	Open valve F008 till to have a air flow F-2001 or F-2002 = (see table N.11 for the required air flow value) verifying that the air pressure P-2001 must be higher than 2.0 MPa	If it is not possible to reach the required air flow increase the opening of the valve F009		
140	Operate valves F001, F005, F006 (if required adjust valves F025 and F007) to reach steam flow F-1001 + F-3001=(see table N.11 for the required steam flow value) controlling that the temperature T-4002 shall be less than 180°C			
150	Measure the PCC inlet pressure P-4002 and adjust PCC inlet conditions in order to have the required following test conditions: F-1001+F-3001=(*) Kg/s F-2001=(*) Kg/s P-4002=(*) kPa (minimum PCC inlet pressure) temperature T-4002 must be superheated with a superheating degree less than 10 °C	(*) See table N.11 for steam flow, air flow, PCC inlet pressure		
160	Measure DP-025: if DP-025 ≥ 14 KPa increase PCC inlet pressure (adjusting PIC-4002 set point till to have DP-025 < 14 KPa			
170	If the pressure set point of PIC-4002 has been changed adjust PCC inlet conditions in order to have the required following conditions: F-1001+F-3001=(*) Kg/s F-2001=(*) Kg/s P-4002= PIC-4002 up date set point T-4002=superheating with a superheating degree less than 10 °C	(*) See table N.11 for required PCC inlet conditions		
180	Set PIC-4002 controller in manual mode and maintain vent tank discharge valve (F020) position throughout the test			
190	Measure PCC inlet pressure P-4002 and adjust inlet temperature T-4002 in order to have superheated steam at PCC inlet with less than 10°C of superheating			

SIET <small>Science Reaction Innovative</small>	Document	Rev	Page	of
	0009RPP91	0	188	225

**PANTHERS PCC TEST PROCEDURE
TESTS WITH TWO MODULES**

Page 3 of 3

Test # 55-56

Title Test type A.2.2 Effect of Pool Water level-Saturated Steam/air mixtures.

Phase #	Description	Note	Status	Oper. Signal.
200	Stop pump C004			
210	Open valves F028, F029, F031, F032 and begin to decrease the level L-Q001 and L-P001	Open fully		
220	Measure flowrate F-R001: if F-R001 is lower than 5 Kg/s then open partially valve F035			
230	Periodically repeat phase 190			
240	Measure pressure P-4002 and level L-Q001: if P-4002=790 KPa and/or L-Q001=2.2 m then start pump C004 and close valves F028, F029, F031, F032 and if open F035			
250	Fill the pools till to reach the normal water level L-Q001=4.26 m			
260	Repeating periodically phase 100			
270	Stop the test			

Note _____

Date _____ Experiment Manager Signature _____

SIET	Document	Rev	Page	of
Edone Keaton Innovativi	0098PP91	0	189	225

**PANTHERS PCC PRE-TEST CHECK LIST
TESTS WITH TWO MODULES**

Page 1 of 2

Title Test type A.3.1 - Simulated LOCA Pressurization Test # A.3.1

Phase #	Description	Note	Status	Oper. Signal
10	Verify that the plant configuration is complete and suitable for the scope of test type A.3.1: complete closed PANTHERS PCC loop, steam bypass line 7 connected to steam line 1 and bypass valve F053 in operation			
20	Verify that all instrumentation, with exception of PCC tube wall thermocouples, has been calibrated, installed, filled, vented and is in operation			
30	Verify that the Data Acquisition Systems is in operation and the conversion constants and formulas have been correctly inserted in DAS			
40	Verify that the following valves are closed: F001, F002, F003, F005, F039, F008, F013, F018, F027, F028, F029, F031, F032, F035, F036, F015, F037, F041, F042, F047, F004, F503, F048, F011, F059, F017, F046, F034, F053			
50	Verify that the following valves are open: SF001, SF002, SF003, F007, F025, F044, F058, F049, F055, F030, F045, F033, F038, F009	F009, F055, F007 and F025 are partially open		
60	Verify that the following safety valves are set at 1.0 MPa: F016, F040, F050			
70	Verify the following control systems are available: LIC-L001, PIC-4002			
80	Verify that pumps C001, C004 and compressors C002, C003 are available			
90	Verify that the tanks A001, A002, A003 are full	If pools P and Q are full, the tanks can be partially full		
100	Verify that the condensers are cooled ("Fluviale" pump is in operation)			
110	Verify that the steam bypass loop is suitable and in operation			

SIET	Document	Rev	Page	of
© 2006 Realton Innovativ	0098PP01	0	191	225

PANTHERS PCC TEST PROCEDURE
TESTS WITH TWO MODULES

Page 1 of 2

Title Test type A.3.1- Simulated LOCA Pressurization Test # A.3.1

Phase #	Description	Note	Status	Oper. Signal.
10	Open valve F041 and fill the condensate tank up level L-L002= 1.75 m then close F041			
20	Set PIC-4002 set point=480 KPa, set PIC-4002 controller in "manual mode" and open valve F020			
30	Measure and record all instrument signals including accelerometers			
40	Start air compressor C002,C003 and wait till to reach a pressure P.2001= 2.5 MPa	If required adjust valve F009		
50	Operate valve F008 till to have an air flowrate F-2001= (*) kg/s.	(*) this value will be determined later		
60	Open fully valves F004, F053,F003	Opening valve F003 steam starts slowly to flow		
70	Open valves F059,F006 and start pump C001 to desuperheat the steam			
80	Open partially valve F002			
90	Open fully valve F001			
100	Adjust desuperheating acting on valve F006 in order to have steam in line 7 in saturation conditions controlling pressure P-7001 and temperature T-7001			
110	Set LIC-L001 set point = 1.75 m and set LIC-L001 controller in "automatic mode" controlling level L-L002			
120	Open valve F018			
130	Simultaneously perform these actions: - switch controller PIC-4002 in "automatic mode"; - open valve F005 - close valve F053 - adjust desupeaheating in order to have saturated steam in line 4 controlling P-4002 and T-4002			
140	Wait till to reach pressure P-4002=480 kPa in steady state conditions			
150	Stop the test			

SIET	Document	Rev	Page	of
Sezione Realtà Innovativa	0098PP01	0	193	225

**PANTHERS PCC PRE-TEST CHECK LIST
TESTS WITH TWO MODULES**

Page 1 of 1

Title Test type A.3.2- Simulated Leak Testing Test # A.3.2

Phase #	Description	Note	Status	Oper. Signat.
10	Verify that the plant configuration is complete and suitable for the scope of the test A.3.2: PCC pool full up to NWL, vent and drain line closed.			
20	Verify that the following instrumentations has been calibrated, installed, filled, vented and is in operation: P-2001,F-2001,T-2001,P-A001,P-4002,L-Q001,L-P001,L-L002.			
30	Verify that the Data Acquisition Systems is operational and the conversion constants and formulas have been correctly inserted in the DAS			
40	Verify that the following valves are closed : F001, F002, F003, F059, F011, F013, F018, F007, SF002, SF003, F017, F018, F033, F034, F503, F039, F028, F029, F031, F032, F008.			
50	Verify that the following valves are open: F038, F009, SF001, F044, F015.	F009, partly open		
60	Verify that the control system PIC-L001 is available			
70	Verify that the following safety valves are set at 1.0 MPa: F016,F050			
80	Verify that compressors C002, C003 are available			

Note _____

Date _____ Experiment Manager Signature _____

PANTHERS PCC TEST PROCEDURE
TESTS WITH TWO MODULES

Page 1 of 2

Title Test type A.3.2- Simulated Leak Testing Test # A.3.2

Phase #	Description	Note	Status	Oper. Signal.
10	Open valve F041 and fill condensate tank till to have a water level L-L002 \approx 2 m. when the required level is reached close valve F041			
20	Set PIC-L001 pressure set point equal to 859 MPa and set the pressure controller PIC-L001 in "automatic mode"			
30	Start compressors C002, C003 and wait to pressurize tank U till to about 2.8 MPa	this phase shall be performed only at the first cycle of each testing day		
40	Measure and record all instruments			
50	Operate valve F008 and adjust air flowrate in order to have F-2001 \approx 0.2 Kg/s.			
60	When P-L001 \approx 859 MPa (steady state conditions) is reached wait for 1 minute if the check for leaks is not performed			
70	Look at PCC pool water surface from the manhole and check for leaks of PCC by verifying the absence of air bubbles	this phase shall be performed at the first cycle and after every 50 pressurization cycles		
80	Close valve F008, set PIC-L001 in "manual mode", open valve F021 and depressurize the system			
90	Start a new pressurization cycle repeating phases 20,40,50,60,70,80.			
100	Perform 300 pressurization cycles to complete the test.			

SIET	Document	Rev	Page	of
Johnson-Kearson, Inc.	0009RPP01	0	195	225

PANTHERS PCC TEST PROCEDURE
TESTS WITH TWO MODULES

Page 2 of 2

Title Test type A.3.2- Simulated Leak Testing Test # A.3.2

Note _____

Date _____ Experiment Manager Signature _____

SIET	Document	Rev	Page	of
Divisione Ricerca Innovativa	0098PP91	0	196	225

**PANTHERS PCC PRE-TEST CHECK LIST
TESTS WITH TWO MODULES**

Page 1 of 2

Title Test type A.4 Pressure losses air only Test # A.4

Phase #	Description	Note	Status	Oper. Signat.
10	Verify that the plant configuration is complete and suitable for the scope of test A.4			
20	Verify that the following instrumentation has been calibrated, installed, filled, vented and is operation: F-2001, P-2001, T-2001 F-T001, P-T001, T-T001 P-4001, P-4002 L-L001, L-L002, P-L001 DP-001, DP-002, DP-003, DP-004, DP-005 DP-006, DP-007, DP-008, DP-009, DP-010 DP-011, DP-012, DP-013 DP-014, DP-015, DP-016, DP-017, DP-018 DP-019, DP-020, DP-021, DP-022, DP-023 DP-024, DP-026, DP-027, DP-028, DP-029 DP-030 P-A001, P-1001			
30	Verify that the Data Acquisition Systems is in operational and the conversion constants and formulas have been correctly inserted in DAS			
40	Verify that the following valves are closed: F001, F002, F003, F011, F013, F015, F017, F018, F023, F025, F037, F039, F041, F047, F048, F055	All the purge and vent valves must be closed		
50	Verify that the following valves are open: F009, F020, F038, F044, F049, SF001, SF002, SF003	F009 is partially open		
60	Verify that the following safety valves are set at 1.0 MPa: F016, F050, F040 and the valve F-043 is set at 4 MPa			
70	Verify that the air compressors C002, C003 are available			
80	Verify that the following control systems are available: PIC-4002 FIC-2001	PIC-4002 in "manual mode"		

**PANTHERS PCC TEST PROCEDURE
TESTS WITH TWO MODULES**

Title Test type A.4. Pressure losses air only Test # A.4

Phase #	Description	Note	Status	Oper. Signal
10	Open the valve F041 and fill the condensate tank up to level L-L002 = 1.75 m. then close F041			
20	Start air compressors C002, C003 and wait till to reach an air pressure P-2001 = 2.5 Mpa	If required adjust valve F009		
30	Operate valve F008 (if required adjust valve F009) till to have an air flowrate F-2001=0.25 kg/s	P-2001 must be ≥ 1.0 MPa		
40	Operate in "manual mode" valve F020 till to reach a pressure P-1001+DP-023+DP-030=110 kPa	If required open valve F055		
50	When steady state conditions are reached measure and record all instrument for 300 s			
60	Operate valve F008 (if required adjust valve F009) till to have an air flowrate F-2001=0.4 kg/s	P-2001 must be ≥ 1.0 MPa		
70	Repeat phase 40			
80	Repeat phase 50			
90	Operate valve F008 (if required adjust valve F009) till to have an air flowrate F-2001=0.6 kg/s	P-2001 must be ≥ 1.0MPa		
100	Repeat phase 40			
110	Repeat phase 50			
120	Operate valve F008 (if required adjust valve F009) till to have an air flowrate F-2001=0.7 kg/s	P-2001 must be ≥ 1.0 MPa		
130	Repeat phase 40			
140	Repeat phase 50			
150	Operate valve F008 (if required adjust valve F009) till to have an air flowrate F-2001=0.8 Kg/s	P-2001 must be ≥ 1.0MPa		
160	Repeat phase 40			

SIET	Document	Rev	Page	of
SIETONE Keaton Innovativ	(0098PP9)	0	200	225

**PANTHERS PCC PRE-TEST CHECK LIST
TESTS WITH ONE MODULE**

Page 1 of 2

Title Test type B.1 Steam Only (No Air in PCC tubes) Test # 66+72

Phase #	Description	Note	Status	Oper. Signal.
10	Verify that the plant configuration is complete and suitable for the scope of test type B.1: complete closed PANTHERS - PCC test loop, one module, pool P with diaphragm			
20	Verify that all instrumentation (with the exception of instrumentation of air injection line 2) has been calibrated, installed, filled, vented and is in operation	The PCC instrumentation is included		
30	Verify that the Data Acquisition Systems is in operation and the conversion constants and formulas have been correctly inserted in DAS			
40	Verify that the following valves are closed: F044, F038, F039, F009, F013, F037, F047, F023, F049, F015, F018, F036, F031, F032, F030, F034, F028, F029, F035, F042, F041, F002, F003, F025, F059, F011, F060, F022, F503			
50	Verify that the following valves are open: F058, F007, SF001, F017, F019, SF003, SF002, F048, F046, F045, F033, F027, F055, F020	F019, and F007 are partially open		
60	Verify that the following safety valves are set at 1.0 MPa: F016, F050, F040			
70	Verify that the following control systems are available: LIC-0001, TIC-1001, FIC-1001			
80	Verify that pumps C001, C004 are available			
90	Verify that the tanks A001, A002, A003 are full	If pools P, Q are full, the tanks can be partially full		
100	Verify that the condensers are cooled ("Fluviale" pump is in operation)			

SIET	Document	Rev	Page	of
Realtime Realtime Innovative	K09KPP91	0	202	225

**PANTHERS PCC TEST PROCEDURE
TESTS WITH ONE MODULE**

Page 1 of 2

Title Test type B, I- Steam Only (No air PCC tubes) Test # 66+72

Phase #	Description	Note	Status	Oper. Signat.
10	Set LIC-Q001 level set point = 4.26 m	normal water level		
20	Start pump C004 feed the pools and control level L-Q001 = 4.26 m			
30	Open valve F041 and fill the condensate tank up to level L-L002 = 1.75 m. (when this level is reached, the water starts to drain in line L, through F-L001)	The level is 2.5 m above the CT inlet nozzle		
40	Open valves: F004, F002, F003, F025, F059, F011 and purge the PCC by steam (F003 must be fully open)	At the opening of valve F003 steam starts to flow		
50	Start pump C001 and begin to desuperheat the steam opening valves F012, F006			
60	Measure and record all instrument signals including accelerometers	Accelerometers will be recorded for 10 minutes every 30 minutes		
70	Open valve F001 and increase the steam flowrate			
80	Throttle valve F019 (in manual mode) in order to keep level L-L001 higher than 0.5 m and L-L002 = 1.75 m			
90	Open valves F005 and F006 to reach a steam flowrate $F-1001 + F-3001 = * \text{ kg/s}$, controlling that temperature T-4002 shall be less than 180°C and pressure P-4002 less than 790 Kpa	* See table 12 for steam flow inlet conditions		
100	Measure the PCC inlet pressure P-4003 and adjust temperature T-4002 acting on valve F006 in order to have superheated steam at PCC inlet as: - less than 10°C of superheating			
110	Heat up the PCC pool water till to reach the equilibrium bulk average temperature (steady state conditions) repeating periodically phases 90 and 100			
120	Adjust steam flowrate to the required value $F-1001 + F-3001 = * \text{ Kg/s}$, controlling that the steam at the PCC inlet shall be superheated with the required superheating degree (T-4002)	* See table 12 for steam flow inlet conditions		

SIET	Document	Rev	Page	of
Keaton Innovations	0009RPP01	0	204	225

**PANTHERS PCC PRE-TEST CHECK LIST
TESTS WITH ONE MODULE**

Page 1 of 2

Title Test type B.1 - Steam Only (Air in PCC tubes) Test # 73+74

Phase #	Description	Note	Status	Oper. Signal
10	Verify that the plant configuration is complete and suitable for the scope of test type B.1: one module. PCC pool buffed test loop with temporary line connecting the 1" air supply line with valve F051	Vent line closed; temporary line not shown in the P&ID		
20	Verify that all instrumentation has been calibrated, installed, filled, vented and is in operation	The PCC instrumentation is included		
30	Verify that the Data Acquisition Systems is in operation and the conversion constants and formulas have been correctly inserted in DAS			
40	Verify that the following valves are closed: F038, SF004, F009, F013, F037, F047, F015, SF002, F051, F017, F036, F031, F032, F030, F028, F029, F035, F042, F041, F001, F002, F003, F004, F059, F011, F040, F022, F503, F034			
50	Verify that the following valves are open: SF001, F039, SF003, F007, F025, F044, F058, F018, F027, F045, F033	F007 and F025 are partially open		
60	Verify that the following valves are set at 1.0 MPa: F016, F050, F040			
70	Verify that the following control systems are available: LIC-L001, FIC-1001, FIC-2001, TIC-1001, LIC-Q001			
80	Verify that pumps C001, C004 and compressors C002, C003 are available			
90	Verify that the tanks A001, A002, A003 are full	If pools Pand Q are full, the tanks can be partially full		
100	Verify that the condensers are cooled (Fluviale pump is in operation)			

SIET	Document	Rev	Page	of
Division: Reaction Innovation	XXXXRPP91	0	206	225

PANTHERS PCC TEST PROCEDURE
TESTS WITH ONE MODULE

Page 1 of 2

Title Test type B.1.-Steam Only (Air in PCC tubes) Test # 73+74

Phase #	Description	Note	Status	Oper. Signal
10	Set LIC-Q001 level set point = 4.26 m. Set LIC-L001 level set point = 1.75 m (level controlled by L-L002)	normal water level		
20	Start pump C004 feed the pools and control level L-Q001 = 4.26 m			
30	Open valve F041 and fill the condensate tank up to level L-L002 = 1.75 m When the level L-L002 = 1.75 m is reached, close valve F041 and control the level L-L002 in automatic mode	The level is 2.3 m above the CT inlet nozzle		
40	Open valves: F002, F003, F004, F059, F011 and purge the PCC by steam, acting on valves F037 and F507			
50	Start pump C001 and begin to desuperheat the steam opening valves F012, F006			
60	Measure and record all instrument signals including accelerometers	Accelerometers will be recorded for 10 minutes every 30 minutes		
70	Open valves F001, F005 and F006 to reach a steam flow rate $F-1001 + F-3001 > 5$ KG/S, controlling that temperature T-4002 shall be less than 180°C and pressure P-4002 less than 790 kPa			
80	Start compressors C002 and C003, open a little valve F008 and wait till to have pressure P-2001 = 2.5 MPa			
90	Heat up the PCC pool water till to reach the equilibrium bulk average temperature (steady state conditions)			
100	Operate valves F001, F005, F006 (if required adjust valves F025 and F007) to reach steam flow $F-1001 + F-3001 =$ (see table N.13 for the required steam flow) controlling that the temperature T-4002 shall be less than 180°C			
110	Measure the PCC inlet pressure P-4002 and adjust PCC inlet conditions in order to have the required following conditions: F-1001+F-3001=(*) Kg/s T-4002=(*)°C (minimum superheating degree 6°C) and wait to reach steady state conditions	(*) See table N.13		

SIET	Document	Rev	Page	of
SIET	0009RPP91	0	108	225

PANTHERS PCC PRE-TEST CHECK LIST
TESTS WITH ONE MODULE

Page 1 of 2

Title Test type - B.2 Effect of Low Density Noncondensibles Test # 75+78

Phase #	Description	Note	Status	Oper. Signal
10	Verify that the plant configuration is complete and suitable for the scope of test type B.2.: one module. PCC pool buffed test loop with temporary line connecting the 1" air supply line with valve F051	Vent line closed: temporary line not shown in the P&ID		
20	Verify that all instrumentation has been calibrated, installed, filled, vented and is in operation	The PCC instrumentation is included		
30	Verify that the Data Acquisition Systems is in operation and the conversion constants and formulas have been correctly inserted in DAS			
40	Verify that the following valves are closed : F038, SF004, F009, F013, F037, F047, F015, SF002, F051, F017, F036, F031, F032, F030, F028, F029, F035, F042, F041, F001, F002, F003, F004, F059, F011, F060, F022, F003, F034			
50	Verify that the following valves are open: SF001, F039, SF003, F007, F025, F044, F058, F018, F027, F045, F033	F007 and F025 are partially open		
60	Verify that the following valves are set at 1.0 MPa: F016, F050, F040			
70	Verify that the following control systems are available: LIC-L001, FIC-1001, FIC-2001, TIC-1001, LIC-Q001			
80	Verify that pumps C001, C004 are available			
90	Verify that the tanks A001, A002, A003 are full	If pools Pand Q are full, the tanks can be partially full		
100	Verify that the condensers are cooled ("Fluviale" pump is in operation)			

SIET	Document	Rev	Page	of
Science Reactions Innovative	0009RPP91	1	210	225

PANTHERS PCC TEST PROCEDURE
TESTS WITH ONE MODULE

Page 1 of 2

Title Test type - B.2 Effect of Low Density Noncondensibles Test # 75+78

Phase #	Description	Note	Status	Oper. Signal.
10	Set LIC-Q001 level set point = 4.26 m Set LCI-L001 level set point=1.75m (level controlled by L-L002)	normal water level		
20	Start pump C004 feed the pools and control level L-Q001 = 4.26 m			
30	Open valve F041 and fill the condensate tank up to level L-L002 = 1.75 m. when the level L-L002=1.75m is reached, close valve F041 and control the level L-L002 in automatic mode	The level is 2.5 m above the CT inlet nozzle		
40	Open valves: F002, F003, F004, F059, F011 and purge the PCC by steam, acting on valves F037 and F507	At the opening of valve F003 steam starts to flow		
50	Start pump C001 and begin to desuperheat the steam opening valves F012, F006			
60	Measure and record all instrument signals including accelerometers	Accelerometers will be recorded for 10 minutes every 30 minutes		
70	Open valves F001, F005 and F006 to reach a steam flowrate $F-1001 + F-3001 > 5$ kg/s, controlling that temperature T-4002 shall be less than 180°C and pressure P-4002 less than 790 kPa			
80	Heat up the PCC pool water till to reach the equilibrium bulk average temperature (steady state conditions)			
90	Operate valves F001, F005, F006 (if required adjust valves F025 and F007) to reach steam flow $F-1001+F-3001$ (see table N.14 for the required steam flow) controlling that the temperature T-4002 shall be less than 180°C			
100	Measure the PCC inlet pressure P-4002 and adjust PCC inlet conditions in order to have the required following conditions: $F-1001+F-3001=(*)$ Kg/s $T-4002=(*)$ °C (minimum superheating degree 6°C) and wait to reach steady state conditions	(*) See table N.14		
110	Weight the bottle the weight is Kg			

SIET	Document	Rev	Page	of
Keaton Innovativ	00098PP91	0	212	225

PART III : QUALITY ASSURANCE PLAN

TABLE OF CONTENTS

1. INTRODUCTION	212
2. DESIGN RECORD FILE	214
3. PRE TEST CONTROLS AND PROCEDURES	215
4. TESTING CONTROLS, PROCEDURES AND RECORDS	218
5. DATA REDUCTION AND ANALYSIS PROCEDURES	219
6. DESIGN VERIFICATION	220
6.1 Document verification	220

SIET	Document	Rev	Page	of
Sezione Realtà Innovativa	00098PP01	0	213	225

1. INTRODUCTION

The tests in the PANTHERS facilities are performed by SIET under a research contract with ENEA, in the framework of the four-party Agreement (General Electric, Ansaldo, Enel and Enea) on the Design, Development, Procurement, Fabrication and Testing of ICS and PCCS Components. Besides PCC tests performance, the contractual Siel activities include: the design and implementation of the facility modifications necessary to achieve the best conditions for test performance; and all additional services Enea may request, including specific action necessary to perform the tests in compliance with the Quality Assurance Requirements.

This section summarizes the contents of the document "Quality Plan for the Work Orders in the Nuclear Area" (00006-QQ), with particular regard to aspects of interest for - or specific to PCC testing in the PANTHERS facility.

The purpose of the QA Plan is to define the actions necessary to assure that the tests are performed in a manner such that high quality, non ambiguous data is obtained, that the data have been processed, reduced, interpreted, and published in compliance with fully qualified procedures, that all these steps have been checked using appropriate verification means, and that adequate records of these data are kept. Siel's Organization (staff: Technical Service: QA Units) is extensively illustrated in the above mentioned Quality Plan. Enea's Organization is represented by:

- the Test Program Manager (RPS), who coordinates all the technical/administrative activities relating to the Test Program, and the official relationships among the Organizations involved;
- the Responsible Test Engineer (RTE), appointed with the agreement of the Test Requestor (GE) as the RPS's delegate with the assigned responsibility for making the reviews, approvals verifications and decisions on technical matters as designated in Sections 3.6, 3.7 and 3.8 of GE's IC/PCC Test Requirements Specification

SIET	Document	Rev	Page	of
Resource Reason Innovative	XX98PP91	0	214	225

2. DESIGN RECORD FILE (DRF)

All information received by SIET or issued by SIET for external distribution are recorded and filed in the DRF under the responsibility of the IC-PCC Project Manager (RPG) in order to keep full traceability of input data.

DRF is formed by files where documents, letters, faxes, telexes, reports, etc. are subdivided according to the issuing Organization and collected in a progressive and chronological order.

Documentation filed in the DRF enables to reconstruct at any time the development of project activities. Input data contained in the DRF and actually used, are taken from official documents, which are verified and issued by SIET and then approved by ENEA's Test Program Manager (RPS) (or Responsible Test Engineer -RTE-) and (if required by the Work Order provisions) by other external Organizations.

(DOC. SIET 0006 - QQ-92 QUALITY PLAN Sect. 4.3.1)

SIET	Document	Rev	Page	of
Zeolone Reaction Innovations	00098PP91	0	215	225

3. PRE-TEST CONTROLS AND PROCEDURES

Before the beginning of tests, the correctness of plant configuration is verified by using a Check-List of preliminary controls. Final control of correct plant preparation is performed by the Experiments Manager, and confirmed by his signing the Check-List.

The signed Check-Lists are filed in DRF and in SIET File.

DOC. SIET 0006 - QQ - 92 QUALITY PLAN Sect. 7.1)

SIET	Document	Rev	Page	of
Sezione Ricerca Innovativa	00098PP91	0	216	225

**IC-PCC / PANTHERS
PRE-TEST QA CHECK LIST**

TEST SERIES.....

1. The personnel meet the requirements for any of their position. They have been trained in the requirements and responsibilities of each of them for the test program.

POSITION	QUALIFICATION

DAN UGQ
.....

2. The following procedures related to test performance have been regularly issued and verified:

PROCEDURE	APPROVED	NOT APPR.	DAN	UGQ

3. The DAS (Data Acquisition System) has been verified as prescribed in Doc. 00098-PP-91 Rev. 0, Part 1 and it was found in accordance with prescriptions.

YES NO
.....
DAN UGQ
.....

4. Plant Log and SAD Log have been regularly prepared.

YES NO
.....
DAN UGQ
.....

Date.....

SIET	Document	Rev	Page	of
Sezione Ricerca Innovativa	00098PP91	0	217	225

IC-PCC / PANTHERS

PRE-TEST QA CHECK LIST

TEST SERIES.....

TEST TYPE.....

1. The following systems of the facilities used for the test have been checked, informing all the Units involved.

SYSTEM FACILITY	UNIT RESPONSIBLE	OK	NOT OK

DAN UGQ

.....

2. Test Briefing has been performed.

YES NO

.....

DAN UGQ

.....

PRESENTS	QUALIFICATION

Date.....

SIET	Document	Rev	Page	of
Sezione Ricerca Innovativa	0009RPP91	0	218	225

4. TESTING CONTROLS, PROCEDURES AND RECORDS

As stated before, the Experiments Manager is responsible for the quality of test performance and for the quality of results obtained in the tests. In order to assure such quality, each Test Procedure is completed by a Check-List which is used to verify the correct performance of every single step in the test.

In this phase, the Experiments Manager has the authority to introduce some modifications to the Test Procedures if he deems such modifications necessary for attaining the required quality level of test results.

Such modifications are reported in an appropriate Deviation Form (Doc. SIET 0006 QQ 92 QP Sect. 7.2).

When the modifications affect Test Procedures approved by the Test Requesor, the Experiments Manager has the duty to obtain approval by the Responsible Test Engineer directly or via telex or fax.

Such modifications are included in the applicable Check-List, filed in the Test DRF.

Any instrument replacements are recorded both in the Test DRF and in the Instrument List.

SIET	Document	Rev	Page	of
Sezione Reattori Innovativi	0009RPP91	0	219	225

5. DATA REDUCTION AND ANALYSIS PROCEDURES

Test results are reported in documents called "Experimental Data Reports", containing balances and congruence analyses, as required by the single test procedures.

These documents are sent to the Test Requestors for approval and to a working group including SIET, ENEA, ANSALDO and Test Requestor, for review and analysis. The working group is co-ordinated by ENEA's Experimental Program Manager (RPS).

The procedures for data elaboration and evaluation are dealt with in specific documents.

Magnetic supports are archived in the Acquisition Data room as well. This Documentation is kept by SIET for a five years' period maintaining also reading system of programs and magnetic supports efficient.

The originals of all the technical Documents contained in DRF and of Work Order documents: the documents produced during test activities (Plant and Test Logs; completed Check-Lists; training reports and audits, etc.); the magnetic supports of data recordings, are archived in a dedicated room, in order to assure their retrieval (File Cards) and their protection against damage or loss and in order to prevent the access by unauthorized people.

(Doc. - SIET 0006 QQ 92 QP Sect. 9 and 4.3)

SIET	Document	Rev	Page	of
Section Reason: Innovative	0009RPPQ1	0	220	225

6. DESIGN VERIFICATION

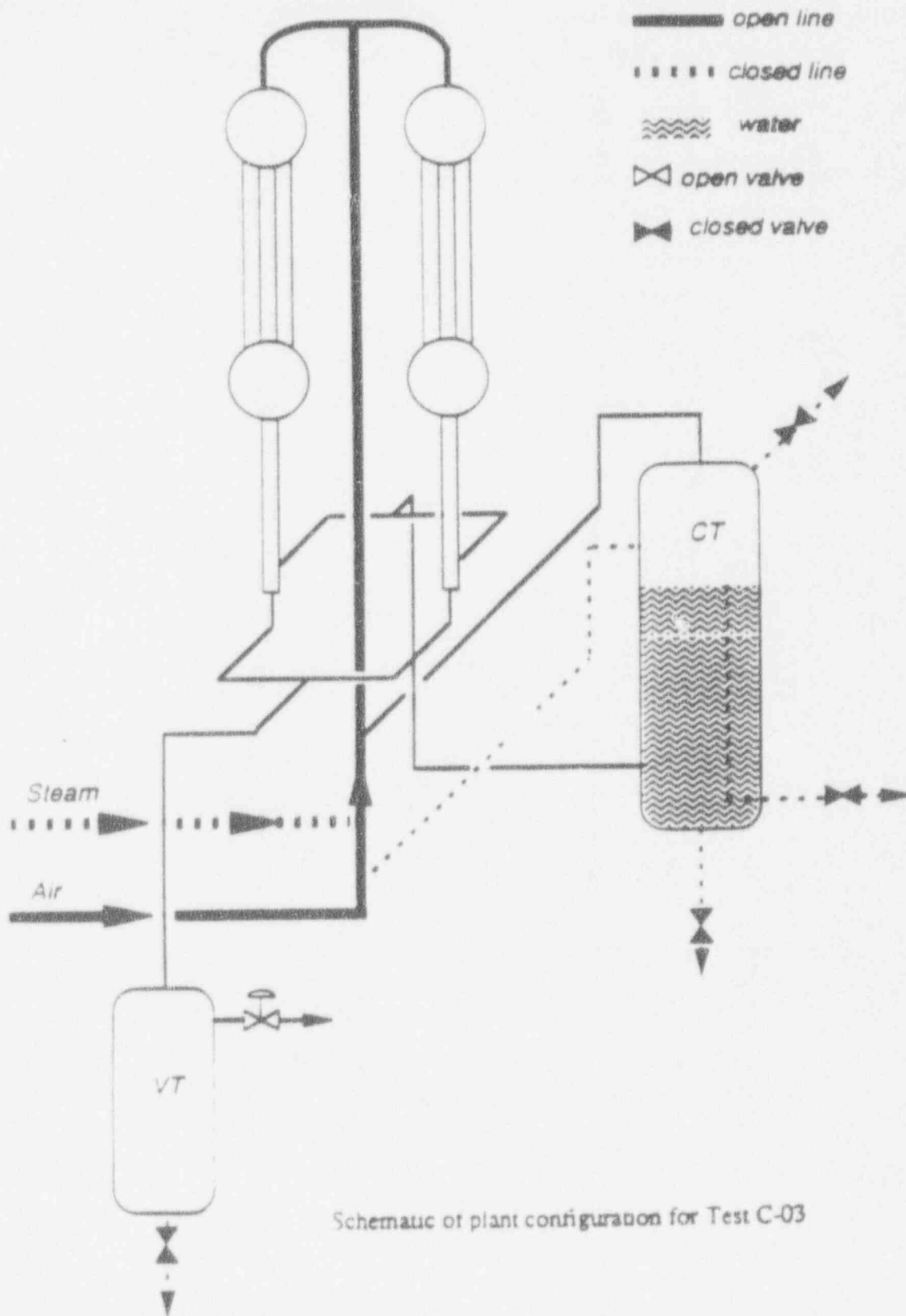
This section relates to the steps which must be taken in order to assure that all aspects of test planning, facility construction, testing procedures, data reduction and data analysis are appropriately verified, and that adequate records of this verification process are kept.

6.1 Document verification

Actually, the steps concerning documents issue and verification procedures are dealt with in the internal procedure "Document Control" (0002-QQ), par. 5 + 12 and SIET 0006 QQ 92 QP Sect. 4 . Facility verification, mechanical and electrical sub-systems and controls, instrument installation, instrument calibration are specified in appropriate PRE TEST CHECK - LISTS. (SIET 0006 QQ 92 QP Sect. 7.1)

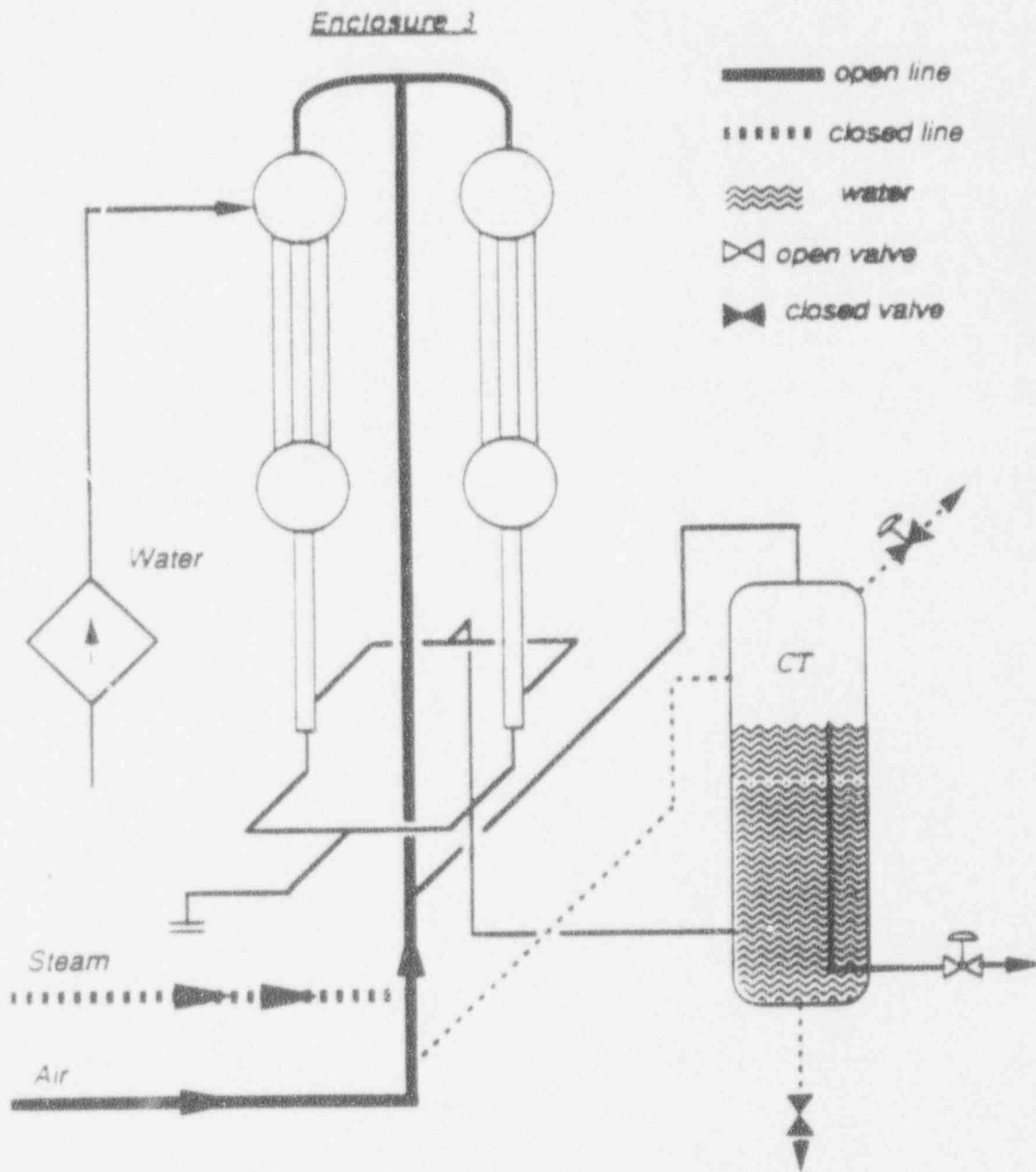
SIET	Document	Rev	Page	of
Sezione Ricerca Innovativa	00098PP91	0	222	225

Enclosure 2



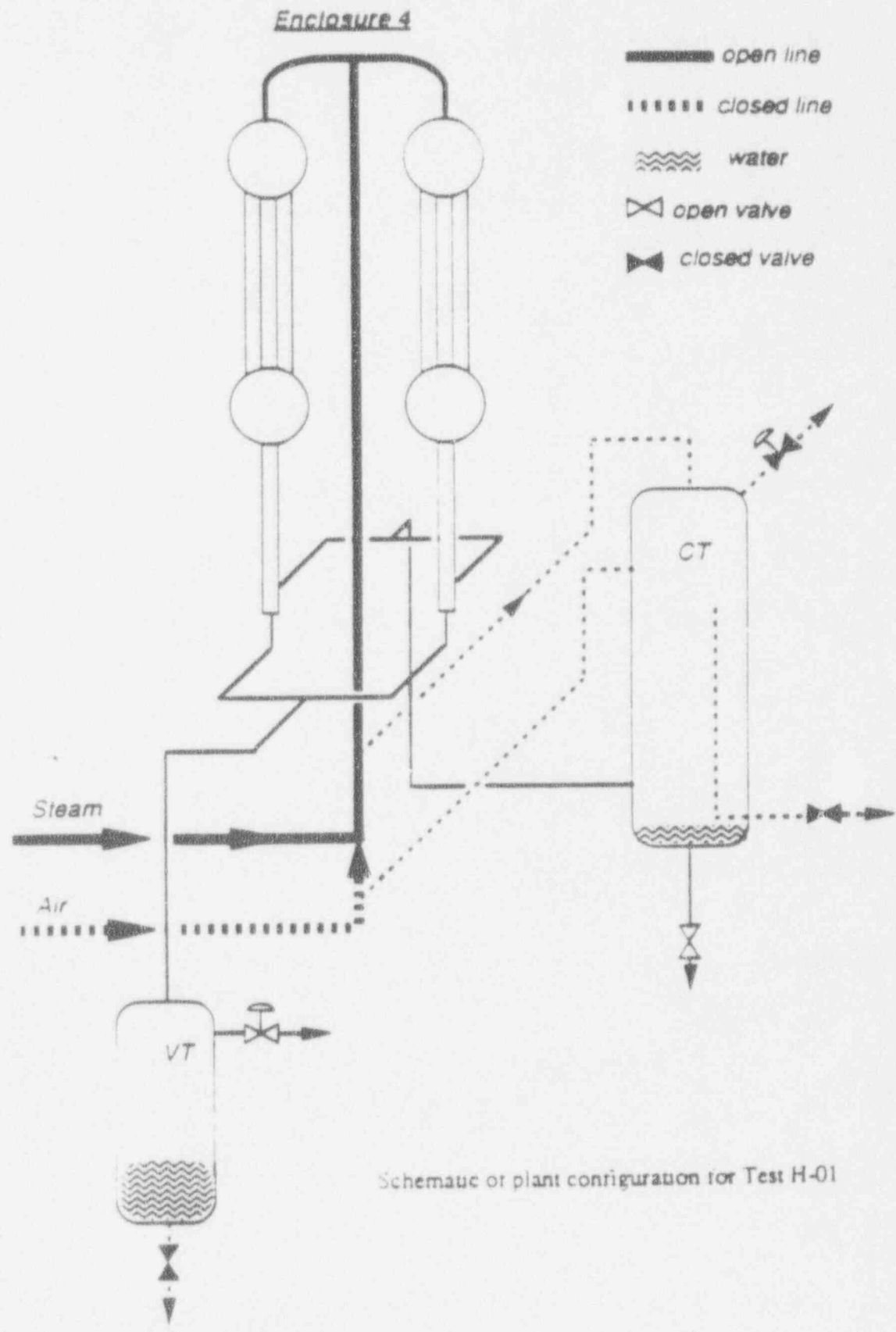
Schematic of plant configuration for Test C-03

SIET	Document	Rev	Page	of
Sezione Reattori Innovativi	00098PP91	0	223	225

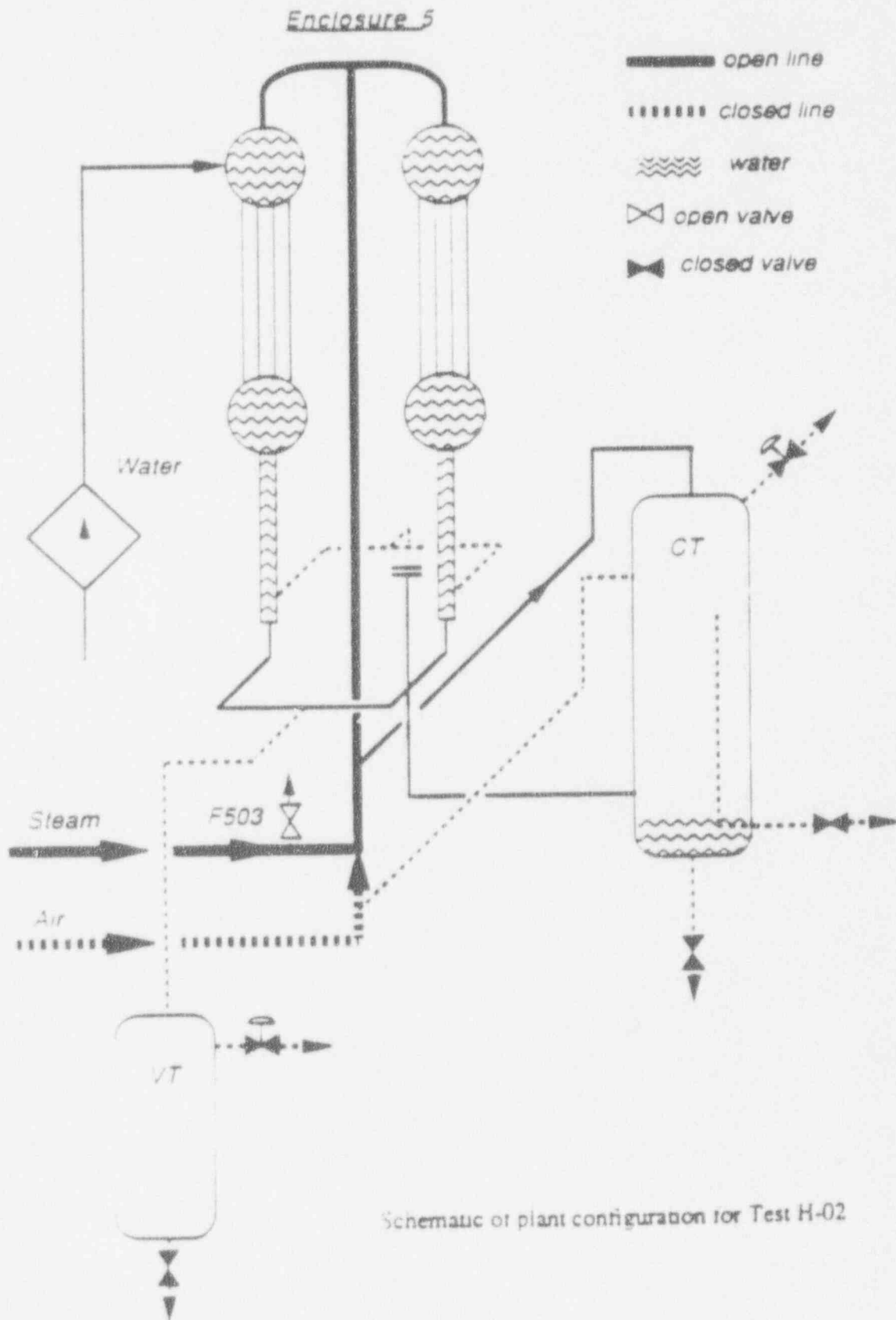


Schematic of plant configuration for test C-04

SIET	Document	Rev	Page	of
Sezione Reattori Innovativi	00098PP91	0	224	225



Schematic of plant configuration for Test H-01



Schematic of plant configuration for Test H-02

RAI Number: 950.24

Question:

Provide a description of PANTHERS that contains information to facilitate review of the test plan and to develop a RELAP5 input deck, including:

- a. geometrical design data
- b. valve characteristic data
- c. instrumentation and calibration data
- d. control system data
- e. test documentation

GE Response:

- a. Geometrical design data for the test facility will be contained in the document "PANTHERS-PCC TEST FACILITY DESCRIPTION" to be issued November 15, 1993.
- b. PANTHERS-PCC test facility valves are standard, "off-the-shelf" valves. The only readily available characteristics are the valve size and type which are indicated on the P&ID included in the Test Plan and Procedures. Since the tests are to be performed at steady-state and the valves are not part of the PCC, the valve characteristics do not impact the PCC performance.
- c. The instrumentation is described in the Test Plan and Procedures. The calibration data for the PCC instrumentation will not be available until the instruments have been calibrated, which is expected to be in November 1993.
- d. The PANTHERS-PCC test facility control system is shown on the P&ID drawing, which is included in the Test Plan and Procedures.
- e. GE believes that the available documentation on the PANTHERS-PCC tests have been supplied either with this submittal or previously.

RAI Number: 950.25

Question:

To facilitate the transfer of information on the PANTHERS facility, provide the TRACG input deck, nodding diagram, and input description.

GE Response:

TRACG is currently being used for PANTHERS-PCC pretest performance predictions but the inputs have not been finalized and adjustments are still being made to the model. The requested input deck, nodding diagram and input discription are expected to be available by the first week of January 1994.

RAI Number: 950.26

Question:

Provide the following documents:

- a. Isolation Condenser System Piping and Instrumentation Diagram, Drawing No. 107E5154.
- b. Isolation Condenser System Design Specification, Document No. 25A5013.
- c. Isolation Condenser System Interlock Block Diagram, Drawing No. 137C9292.
- d. Isolation Condenser System Process Flow Diagram, Drawing No. 107E6073.
- e. Passive Containment Cooling System Piping and Instrumentation Diagram, Drawing No. 107E5160.
- f. Passive Containment Cooling System Design Specification, Document No. 25A5020.
- g. Passive Containment Cooling System Process Flow Diagram, Drawing No. 107E6072.
- h. SBWR Composite Design Specification, Document No. 23A6723.
- i. Containment Configuration Data Book, Document No. 25A5044.
- j. IC H.X. Equipment Requirements Specification, Document No. SBW 5280 TN1XN014000.
- k. PCC Equipment Requirements Specification, Document No. SBW 5280 TN1XN015000.
- l. Passive Containment Cooling and Isolation Condenser Prototype Structural Instrumentation, Document No. SBW 5280-TN1X-1115000.

m. IC Pool Compartment Arrangement, Drawing No. SBW5280DMNX1103.

Documents listed in this question were referenced in the following:

- a. "Confirmatory Tests of Full-Scale Condensers for the SBWR Isolation Condenser System and the Passive Containment Cooling System," S. Botti, G. Fitzsimmons, and P. Masoni, undated.
- b. "PANTHERS Test Program," Presentation to the ACRS by P. F. Billig, June 2, 1992.
- c. "Isolation Condenser & Passive Containment Condenser Test Requirements," GE MPL Item #B32-3030/T15-3030, November 12, 1992.
- d. "PCC Test Plan & Procedure," SIET 00096 ED 91 Rev. A, undated.
- e. "Technical Specification for PCC Instrumentation Installation," SIET 00157ST92 Rev. A, undated.

GE Response:

Documents a.-SSAR Fig. 21.5.4-1 sh 1-2, c.-21.7.4-5 sh 1-13, and e.-21.6.2-1 are included in the SSAR, although the document numbers have been replaced by figure numbers. Copies of the remaining listed documents are enclosed.