PCC TEST PLAN & PROCEDURES

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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 Fourier Transformer
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

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

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	Responsable Test Engineer
S	Speed
SG	Strain Gage
S/RV	Safety / Relief Valve
SBWR	Semplified Boiling Water Reactor
ST	Storage Tank

PART I TEST PLAN

TABLE OF CONTENTS

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 shakedowns.

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

Part III : contains the Quality Assurance Plan.

LIST OF TABLES

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 shakedowns.

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 noncondensible gases
- PCC differential pressure
- pool-side bulk average water temperature
- pool-side water level

b) confirm that when a mixture of steam and noncondensible 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:

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

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
- noncondensible vent tank
- steam suppiy system
- noncondensible 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

i) provide diagnostic information for investigation of unexpected condenser performance

ii) 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) demostrate 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.

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

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) noncondesible 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 beenarranged 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) noncondensible 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)

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 m^3 ; PCC pool water volume (at NWL) is 131.3 m^3;
IC pool total volume is 98 m^3 ; IC pool water volume (at NWL) is 74.4 m^3.

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 m^2 opening area. to the cacth 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 bleeded from the ENEL PC-Levante power station, situated nearby the SIET laboratories. The superheated steam is bleeded at the following conditions:

T	=	540	°C
P	=	17	MPa
F_{max}	=	6.5	kg/s

noncondensible 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 mantained 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 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 enshures 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.

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 indipendent 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 :lengh, 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 : lengh, 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)

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 gradualy opening the valve F001. The steam is desuperheated supplying cold water at the following maximum temperature, pressure, and flow-rate conditions :

Tmax = 100 °C

Pmax = 26 MPa

Fmax = 6.5 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 Noncondensible 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

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).

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 noncondensible gases seperated 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"

- 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: =+/-0.25 %; +/-0.5%; +/- 1% of calibrated Span;

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 quantaties (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/thermoresistances

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

- Diameters: 0.5-3 mm;

- Sheat material: Inconel 600/AISI 316;

- Measuring range: 273-1533 K;

- Accuracy class: ANSI special (min.+/-1.1°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:

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 : ≤ +/- 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:

- Cromel-Alumel junction;

- Isolation by MgO;

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% whicherer 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>=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.

- 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	Figg. 2,3
Upper header - tube 3C, elevation c	DP Transducer	DP-006	-34 : +34	kPa	0.25 % f.s.	TSD027	Figg. 2,3
Upper header - tube 4D, elevation c	DP Transducer	DP-007	-34 : +34	kPa	0.25 % f.s.	TSD028	Figg. 2,3
Upper header - tube 3R, elevation c	DP Transducer	DP-008	-34 : +34	kPa	0.25 % f.s.	TSD029	Figg. 2,3
Upper header - tube 5R, elevation c	DP Transducer	DP-009	-34 : +34	kPa	0.25 % f.s.	TSD031	Figg. 2,3
Upper header - tube 5Y, elevation c	DP Transducer	DP-027	-34 : +34	kPa	0.25 % f.s.	TSD032	Figg. 2,3
Upper header - tube 8R, elevation c	DP Transducer	DP-010	-34 : +34	kPa	0.25 % f.s.	TSD034	Figg. 2,3
Upper header - tube 1V, elevation c	DP Transducer	DP-011	-34 : +34	kPa	0.25 % f.s.	TSD037	Figg. 2,3
Upper header - tube 5-1, elevation c	DP Transducer	DP-012	-34 : +34	kPa	0.25 % f.s.	TSD036	Figg. 2,3
Upper header - tube 5-6, elevation c	DP Transducer	DP-013	-34 : +34	kPa	0.25 % f.s.	TSD043	Figg. 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

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	Figg. 8, 9
Tube 1R, elevation a, angular pos. 7 (*)	Thermocouple K	TW-B002	0 : 200	°C	+/- 1.1 °C	TCK229	Figg. 8, 9
Tube 1R, elevation l, angular pos. 7 (*)	Thermocouple K	TW-B004	0 : 200	°C	+/- 1.1 °C	TCK230	Figg. 8, 9
Tube 5A, elevation l, angular pos. 1 (*)	Thermocouple K	TW-B005	0 : 200	°C	+/- 1.1 °C	TCK231	Figg. 8, 10
Tube 7A, elevation a, angular pos. 3 (*)	Thermocouple K	TW-B006	0 : 200	°C	+/- 1.1 °C	TCK232	Figg. 8, 10
Tube 5A, elevation a, angular pos. 3 (*)	Thermocouple K	TW-B008	0 : 200	°C	+/- 1.1 °C	TCK233	Figg. 8, 10
Upper - lower header	DP - Transducer	DP-026	-34 : +34	kPa	0.25 % f.s.	TSD045	00209DD93
Tube 8S, elevation a, angular pos. 3 (*)	Thermocouple K	TW-B009	0 : 200	°C	+/- 1.1 °C	TCK234	Figg. 8, 10
Tube 8S, elevation l, angular pos. 3 (*)	Thermocouple K	TW-B010	0 : 200	°C	+/- 1.1 °C	TCK235	Figg. 8, 10
Tube 1A elevation a, ext. wall	Thermocouple K	TW-B011e	0 : 200	°C	+/- 1.1 °C	TCK056	Figg. 3, 11
Tube 1A elevation a, int. wall	Thermocouple K	TW-B011i	0 : 200	°C	+/- 1.1 °C	TCK057	Figg. 3, 11
Tube 1A elevation b, ext. wall	Thermocouple K	TW-B012e	0 : 200	°C	+/- 1.1 °C	TCK058	Figg. 3, 11
Tube 1A elevation b, int. wall	Thermocouple K	TW-B012i	0 : 200	°C	+/- 1.1 °C	TCK059	Figg. 3, 11
Tube 1A elevation c, ext wall	Thermocouple K	TW-B013e	0 : 200	°C	+/- 1.1 °C	TCK060	Figg. 3, 11
Tube 1A elevation c, int. wall	Thermocouple K	TW-B013i	0 : 200	°C	+/- 1.1 °C	TCK061	Figg. 3, 11
Tube 1A elevation d, ext. wall	Thermocouple K	TW-B014e	0 : 200	°C	+/- 1.1 °C	TCK062	Figg. 3, 11
Tube 1A elevation d, int. wall	Thermocouple K	TW-B014i	0 : 200	°C	+/- 1.1 °C	TCK063	Figg. 3, 11
Tube 1A elevation e, ext. wall	Thermocouple K	TW-B015e	0 : 200	°C	+/- 1.1 °C	TCK064	Figg. 3, 11
Tube 1A elevation e, int. wall	Thermocouple K	TW-B015i	0 : 200	°C	+/- 1.1 °C	TCK065	Figg. 3, 11
Tube 1A elevation f, ext. wall	Thermocouple K	TW-B016e	0 : 200	°C	+/- 1.1 °C	TCK066	Figg. 3, 11
Tube 1A elevation f, int. wall	Thermocouple K	TW-B016i	0 : 200	°C	+/- 1.1 °C	TCK067	Figg. 3, 11
Tube 1A elevation g, ext. wall	Thermocouple K	TW-B017e	0 : 200	°C	+/- 1.1 °C	TCK068	Figg. 3, 11
Tube 1A elevation g, int. wall	Thermocouple K	TW-B017i	0 : 200	°C	+/- 1.1 °C	TCK069	Figg. 3, 11
Tube 1A elevation h, ext. wall	Thermocouple K	TW-B018e	0 : 200	°C	+/- 1.1 °C	TCK070	Figg. 3, 11
Tube 1A elevation h, int. wall	Thermocouple K	TW-B018i	0 : 200	°C	+/- 1.1 °C	TCK071	Figg. 3, 11
Tube 1A elevation i , ext. wall	Thermocouple K	TW-B019e	0 : 200	°C	+/- 1.1 °C	TCK072	Figg. 3, 11
Tube 1A elevation i , int. wall	Thermocouple K	TW-B019i	0 : 200	°C	+/- 1.1 °C	TCK073	Figg. 3, 11
Tube 4A elevation a, ext. wall	Thermocouple K	TW-B020e	0 : 200	°C	+/- 1.1 °C	TCK074	Figg. 3, 11
Tube 4A elevation a, int. wall	Thermocouple K	TW-B020i	0 : 200	°C	+/- 1.1 °C	TCK075	Figg. 3, 11
Tube 4A elevation b, ext. wall	Thermocouple K	TW-B021e	0 : 200	°C	+/- 1.1 °C	TCK076	Figg. 3, 11
Tube 4A elevation b, int. wall	Thermocouple K	TW-B021i	0 : 200	°C	+/- 1.1 °C	TCK077	Figg. 3, 11
Tube 4A elevation c, ext wall	Thermocouple K	TW-B022e	0 : 200	°C	+/- 1.1 °C	TCK078	Figg. 3, 11
Tube 4A elevation c, int. wall	Thermocouple K	TW-B022i	0 : 200	°C	+/- 1.1 °C	TCK079	Figg. 3, 11
Tube 4A elevation d, ext. wall	Thermocouple K	TW-B023e	0 : 200	°C	+/- 1.1 °C	TCK080	Figg. 3, 11
Tube 4A elevation d, int. wall	Thermocouple K	TW-B023i	0 : 200	°C	+/- 1.1 °C	TCK081	Figg. 3, 11
Tube 4A elevation e, ext. wall	Thermocouple K	TW-B024e	0 : 200	°C	+/- 1.1 °C	TCK082	Figg. 3, 11
Tube 4A elevation e, int. wall	Thermocouple K	TW-B024i	0 : 200	°C	+/- 1.1 °C	TCK083	Figg. 3, 11

Tab 2 Cont'd

Component or line location	Instrument type	Plant code	Span	m. u.	Accuracy	SIET code	Ref Dwg
UPPER HEADER MODULE 1 (A)							
Front cover bolt 1, pos. I	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
Dowstream 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	Figg 6, 7
Lower header - tube 5R, elevation c	DP Transducer	DP 028	-34 : +34	kPa	0.25 % f.s.	TSD044	Figg 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	Figg. 3, 11
Tube 8Q elevation g, ext. wall	Thermocouple K	TW B044e	0 : 200	°C	+/- 1.1 °C	TCK122	Figg. 3, 11
Tube 8Q elevation g, int. wall	Thermocouple K	TW B044i	0 : 200	°C	+/- 1.1 °C	TCK123	Figg. 3, 11
Tube 8Q elevation h, ext. wall	Thermocouple K	TW B045e	0 : 200	°C	+/- 1.1 °C	TCK124	Figg. 3, 11
Tube 8Q elevation h, int. wall	Thermocouple K	TW B045i	0 : 200	°C	+/- 1.1 °C	TCK125	Figg. 3, 11
Tube 8Q elevation i , ext. wall	Thermocouple K	TW B046e	0 : 200	°C	+/- 1.1 °C	TCK126	Figg. 3, 11
Tube 8Q elevation i , int. wall	Thermocouple K	TW B046i	0 : 200	°C	+/- 1.1 °C	TCK127	Figg. 3, 11
Tube 5R, elevation c - lower header	DP-Transducer	DP-014	-34 : +34	kPa	0.25 % f.s.	TSD045	Figg. 2, 3
Tube 5A, angular pos. 3, X dir, el. g	Accelerometer	VB-B001	0 : 500	g	0.02 g	ACC007	Figg. 8, 10
Tube 5A, angular pos. 5, Y dir, el. g	Accelerometer	VB-B002	0 : 500	g	0.02 g	ACC008	Figg. 8, 10
Tube 7A, angular pos. 3, X dir, el. g	Accelerometer	VB-B003	0 : 500	g	0.02 g	ACC009	Figg. 8, 10
Tube 7A, angular pos. 5, Y dir, el. g	Accelerometer	VB-B004	0 : 500	g	0.02 g	ACC010	Figg. 8, 10
Tube 1B, angular pos. 7, X dir, el. g	Accelerometer	VB-B005	0 : 500	g	0.02 g	ACC011	Figg. 8, 9
Tube 1B, angular pos. 5, Y dir, el. g	Accelerometer	VB-B006	0 : 500	g	0.02 g	ACC012	Figg. 8, 9
Tube 1R, angular pos. 7, X dir, el. g	Accelerometer	VB-B007	0 : 500	g	0.02 g	ACC013	Figg. 8, 9
Tube 1R, angular pos. 5, Y dir, el. g	Accelerometer	VB-B008	0 : 500	g	0.02 g	ACC014	Figg. 8, 9
Tube 8S, angular pos. 3, X dir, el. g	Accelerometer	VB-B009	0 : 500	g	0.02 g	ACC015	Figg. 8, 10
Tube 8S,angular pos. 5, Y dir., el. g	Accelerometer	VB-B010	0 : 500	g	0.02 g	ACC016	Figg. 8, 10
Tube 8T, extr., el. a, angular pos. 3	Scribe mark	DX-B-1sm		mm			Figg. 8, 10
Tube 1S, extr., el. a, angular pos. 7	Scribe mark	DX-B-2sm		mm			Figg. 8, 9
Tube 3A, extr., el. a, angular pos. 7	Scribe mark	DX-B-3sm		mm			Figg. 8, 9
Tube 5A, extr., el. a, angular pos. 3	Strain gage	DX-B001	+/- 0.5 %	mm/mm	+/- 5 % m.v.	SG093	Figg. 8, 10
Tube 7A, el. a, angular pos. 5	Strain gage	DX-B002	+/- 0.5 %	mm/mm	+/- 5 % m.v.	SG094	Figg. 8, 10
Tube 7A, extr., el. a, angular pos. 3	Strain gage	DX-B003	+/- 0.5 %	mm/mm	+/- 5 % m.v.	SG095	Figg. 8, 10
Tube 1B, extr., el. a, angular pos. 7	Strain gage	DX-B004	+/- 0.5 %	mm/mm	+/- 5 % m.v.	SG096	Figg. 8, 9
Tube 1R, extr., el. a, angular pos. 7	Strain gage	DX-B005	+/- 0.5 %	mm/mm	+/- 5 % m.v.	SG097	Figg. 8, 9
Tube 1R, el. a, angular pos. 5	Strain gage	DX - B006	+/- 0.5 %	mm/mm	+/- 5 % m.v.	SG098	Figg. 8, 9
Tube 8S, extr., el. a, angular pos. 3	Strain gage	DX-B007	+/- 0.5 %	mm/mm	+/- 5 % m.v.	SG099	Figg. 8, 10
Tube 1R, extr., el. l, angular pos. 7	Strain gage	DX-B008	+/- 0.5 %	mm/mm	+/- 5 % m.v.	SG100	Figg. 8, 9
Tube 5A, el. l, angular pos. 1	Strain gage	DX-B009	+/- 0.5 %	mm/mm	+/- 5 % m.v.	SG101	Figg. 8, 10
Tube 8S, extr., el. l, angular pos. 3	Strain gage	DX-B010	+/- 0.5 %	mm/mm	+/- 5 % m.v.	SG102	Figg. 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	Figg. 7, 12
Tube 1R, el. l, ext. wall, angular pos. 7	Thermocouple K	TW-B002	0 : 200	°C	+/- 1.1 °C	TCK237	Figg. 7,12
Tube 5A, el. a, ext. wall, angular pos. 3	Thermocouple K	TW-B003	0 : 200	°C	+/- 1.1 °C	TCK238	Figg. 7,12
Tube 5A, el. l, ext. wall, angular pos. 3	Thermocouple K	TW-B004	0 : 200	°C	+/- 1.1 °C	TCK239	Figg. 7,12
Tube 8S, el. a, ext. wall, angular pos. 3	Thermocouple K	TW-B005	0 : 200	°C	+/- 1.1 °C	TCK240	Figg. 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	Figg. 3.11
Tube 4A elevation f, int. wall	Thermocouple K	TW-B025i	0 : 200	°C	+/- 1.1 °C	TCK085	Figg. 3.11
Tube 4A elevation g, ext. wall	Thermocouple K	TW-B026e	0 : 200	°C	+/- 1.1 °C	TCK086	Figg. 3.11
Tube 4A elevation g, int. wall	Thermocouple K	TW-B026i	0 : 200	°C	+/- 1.1 °C	TCK087	Figg. 3.11
Tube 4A elevation h, ext. wall	Thermocouple K	TW-B027e	0 : 200	°C	+/- 1.1 °C	TCK088	Figg. 3.11
Tube 4A elevation h, int. wall	Thermocouple K	TW-B027i	0 : 200	°C	+/- 1.1 °C	TCK089	Figg. 3.11
Tube 4A elevation i, ext. wall	Thermocouple K	TW-B028e	0 : 200	°C	+/- 1.1 °C	TCK090	Figg. 3.11
Tube 4A elevation i, int. wall	Thermocouple K	TW-B028i	0 : 200	°C	+/- 1.1 °C	TCK091	Figg. 3.11
Tube 5Q elevation a, ext. wall	Thermocouple K	TW-B029e	0 : 200	°C	+/- 1.1 °C	TCK092	Figg. 3.11
Tube 5Q elevation a, int. wall	Thermocouple K	TW-B029i	0 : 200	°C	+/- 1.1 °C	TCK093	Figg. 3.11
Tube 5Q elevation b, ext. wall	Thermocouple K	TW-B030e	0 : 200	°C	+/- 1.1 °C	TCK094	Figg. 3.11
Tube 5Q elevation b, int. wall	Thermocouple K	TW-B03[illegible]	0 : 200	°C	+/- 1.1 °C	TCK095	Figg. 3.11
Tube 5Q elevation c, ext. wall	Thermocouple K	TW-B031e	0 : 200	°C	+/- 1.1 °C	TCK096	Figg. 3.11
Tube 5Q elevation c, int. wall	Thermocouple K	TW-B031i	0 : 200	°C	+/- 1.1 °C	TCK097	Figg. 3.11
Tube 5Q elevation d, ext. wall	Thermocouple K	TW-B032e	0 : 200	°C	+/- 1.1 °C	TCK098	Figg. 3.11
Tube 5Q elevation d, int. wall	Thermocouple K	TW-B032i	0 : 200	°C	+/- 1.1 °C	TCK099	Figg. 3.11
Tube 5Q elevation e, ext. wall	Thermocouple K	TW-B033e	0 : 200	°C	+/- 1.1 °C	TCK100	Figg. 3.11
Tube 5Q elevation e, int. wall	Thermocouple K	TW-B033i	0 : 200	°C	+/- 1.1 °C	TCK101	Figg. 3.11
Tube 5Q elevation f, ext. wall	Thermocouple K	TW-B034e	0 : 200	°C	+/- 1.1 °C	TCK102	Figg. 3.11
Tube 5Q elevation f, int. wall	Thermocouple K	TW-B034i	0 : 200	°C	+/- 1.1 °C	TCK103	Figg. 3.11
Tube 5Q elevation g, ext. wall	Thermocouple K	TW-B035e	0 : 200	°C	+/- 1.1 °C	TCK104	Figg. 3.11
Tube 5Q elevation g, int. wall	Thermocouple K	TW-B035i	0 : 200	°C	+/- 1.1 °C	TCK105	Figg. 3.11
Tube 5Q elevation h, ext. wall	Thermocouple K	TW-B036e	0 : 200	°C	+/- 1.1 °C	TCK106	Figg. 3.11
Tube 5Q elevation h, int. wall	Thermocouple K	TW-B036i	0 : 200	°C	+/- 1.1 °C	TCK107	Figg. 3.11
Tube 5Q elevation i, ext. wall	Thermocouple K	TW-B037e	0 : 200	°C	+/- 1.1 °C	TCK108	Figg. 3.11
Tube 5Q elevation i, int. wall	Thermocouple K	TW-B037i	0 : 200	°C	+/- 1.1 °C	TCK109	Figg. 3.11
Tube 8Q elevation a, ext. wall	Thermocouple K	TW-B038e	0 : 200	°C	+/- 1.1 °C	TCK110	Figg. 3.11
Tube 8Q elevation a, int. wall	Thermocouple K	TW-B038i	0 : 200	°C	+/- 1.1 °C	TCK111	Figg. 3.11
Tube 8Q elevation b, ext. wall	Thermocouple K	TW-B039e	0 : 200	°C	+/- 1.1 °C	TCK112	Figg. 3.11
Tube 8Q elevation b, int. wall	Thermocouple K	TW-B039i	0 : 200	°C	+/- 1.1 °C	TCK113	Figg. 3.11
Tube 8Q elevation c, ext. wall	Thermocouple K	TW-B040e	0 : 200	°C	+/- 1.1 °C	TCK114	Figg. 3.11
Tube 8Q elevation c, int. wall	Thermocouple K	TW-B040i	0 : 200	°C	+/- 1.1 °C	TCK115	Figg. 3.11
Tube 8Q elevation d, ext. wall	Thermocouple K	TW-B041e	0 : 200	°C	+/- 1.1 °C	TCK116	Figg. 3.11
Tube 8Q elevation d, int. wall	Thermocouple K	TW-B041i	0 : 200	°C	+/- 1.1 °C	TCK117	Figg. 3.11
Tube 8Q elevation e, ext. wall	Thermocouple K	TW-B042e	0 : 200	°C	+/- 1.1 °C	TCK118	Figg. 3.11
Tube 8Q elevation e, int. wall	Thermocouple K	TW-B042i	0 : 200	°C	+/- 1.1 °C	TCK119	Figg. 3.11
Tube 8Q elevation f, ext. wall	Thermocouple K	TW-B043e	0 : 200	°C	+/- 1.1 °C	TCK120	Figg. 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 lenght	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 : 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. 7)	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	0.1 : 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 ($)	DP Transmitter	DP P001	0 : 30	kPa	0.25 % f.s.	TMD158	Fig. 16
Loc. F6, tap elevation 5025 - 3220 mm ($)	DP Transmitter	DP P002	0 : 30	kPa	0.5 % f.s.	TMD178	Fig. 16
Loc. F6, tap elevation 3220 - 50 mm ($)	DP Transmitter	DP P003	0 : 50	kPa	0.25 % f.s.	TMD176	Fig. 16
Loc. F6, tap elevation 3220 - 1945 mm ($)	DP Transmitter	DP P004	0 : 35	kPa	0.25 % f.s.	TMD181	Fig. 16
Loc. F6, tap elevation 1945 - 1125 mm ($)	DP Transmitter	DP P005	0 : 10	kPa	0.5 % f.s.	TMD169	Fig. 16
Loc. F6, tap elevation 1125 - 50 mm ($)	DP Transmitter	DP P006	0 : 35	kPa	0.5 % f.s.	TMD182	Fig. 16

Tab. 2 - Cont'd

Component or line location	Instrument type	Plant code	Span	m.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.	TSD044	00209DD93
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	00209DD93
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	00209DD93
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 ($)	RTD-PT100	T-P036	0 : 150	°C	1.05 °C	TR041	Fig. 17
Location E3 - elevation 3810 mm ($)	RTD-PT100	T-P037	0 : 150	°C	1.05 °C	TR042	Fig. 17
Location F3 - elevation 3810 mm ($)	RTD-PT100	T-P038	0 : 150	°C	1.05 °C	TR043	Fig. 17
Location H3 - elevation 3810 mm ($)	RTD-PT100	T-P040	0 : 150	°C	1.05 °C	TR044	Fig. 17
Location I3 - elevation 3810 mm ($)	RTD-PT100	T-P041	0 : 150	°C	1.05 °C	TR045	Fig. 17
Location L3 - elevation 3810 mm ($)	RTD-PT100	T-P042	0 : 150	°C	1.05 °C	TR046	Fig. 17
Location A6 - elevation 2355 mm ($)	RTD-PT100	T-P043	0 : 150	°C	1.05 °C	TR047	Fig. 17
Location B6 - elevation 2355 mm ($)	RTD-PT100	T-P044	0 : 150	°C	1.05 °C	TR048	Fig. 17
Location C6 - elevation 2355 mm ($)	RTD-PT100	T-P045	0 : 150	°C	1.05 °C	TR049	Fig. 17
Location D6 - elevation 2355 mm ($)	RTD-PT100	T-P046	0 : 150	°C	1.05 °C	TR050	Fig. 17
Location E6 - elevation 2355 mm ($)	RTD-PT100	T-P047	0 : 150	°C	1.05 °C	TR051	Fig. 17
Location F6 - elevation 2355 mm ($)	RTD-PT100	T-P048	0 : 150	°C	1.05 °C	TR052	Fig. 17
Location G6 - elevation 2355 mm ($)	RTD-PT100	T-P049	0 : 150	°C	1.05 °C	TR053	Fig. 17
Location H6 - elevation 2355 mm ($)	RTD-PT100	T-P050	0 : 150	°C	1.05 °C	TR054	Fig. 17
Location I6 - elevation 2355 mm ($)	RTD-PT100	T-P051	0 : 150	°C	1.05 °C	TR055	Fig. 17
Location L6 - elevation 2355 mm ($)	RTD-PT100	T-P052	0 : 150	°C	1.05 °C	TR056	Fig. 17
Location D5 - elevation 5650 mm ($)	RTD-PT100	T-P053	0 : 150	°C	1.05 °C	TR057	Fig. 17
Location D5 - elevation 5025 mm ($)	RTD-PT100	T-P054	0 : 150	°C	1.05 °C	TR058	Fig. 17
Location C1 - elevation 2765 mm ($)	RTD-PT100	T-P055	0 : 150	°C	1.05 °C	TR059	Fig. 17
Location C2 - elevation 2765 mm ($)	RTD-PT100	T-P056	0 : 150	°C	1.05 °C	TR060	Fig. 17
Location C3 - elevation 2765 mm ($)	RTD-PT100	T-P057	0 : 150	°C	1.05 °C	TR061	Fig. 17
Location D5 - elevation 525 mm ($)	RTD-PT100	T-P058	0 : 150	°C	1.05 °C	TR062	Fig. 17
Tap elevation 5025 - 1125 mm ($)	DP - Transmitter	L-P001	0 : 50	kPa	0.25 % f.s.	TMD019	00210DD93
Make-up line	Thermocouple K	T-M001	0 : 150	°C	+/- 1.1 °C	TCK398	00210DD93
Make-up line	Gilflo DP	F-M001	0 : 100	kPa	0.250 % f.s.	TMD015	00210DD93
Discharge line	Thermocouple K	T-R001	0 : 200	°C	+/- 1.1 °C	TCK395	00210DD93
Discharge line	Gilflo-DP	F-R001	0 : 30	kPa	0.25 % f.s.	TMD177	00210DD93
IC pool lower connecting line	Thermocouple K	T-N001	0 : 150	°C	+/- 1.1 °C	TCK045	00209DD93
IC POOL (Q)							
Tap elevation 5140 - 1440 mm ($)	DP - Transmitter	L-Q001	0 : 50	kPa	0.25 % f.s.	TMD019	00209DD93
Tap elevation 5140 - 3420 mm ($)	DP - Transmitter	L-Q002	0 : 20	kPa	0.25 % f.s.	TMD009	00209DD93
CONDENSATE TANK (L)							
Elevation 4040 mm (£)	Thermocouple K	T-L001	0 : 200	°C	+/- 1.1 °C	TCK046	00209DD93
Elevation 3545 mm (£)	Thermocouple K	T-L002	0 : 200	°C	+/- 1.1 °C	TCK047	00209DD93
Elevation 1800 mm (£)	Thermocouple K	T-L003	0 : 200	°C	+/- 1.1 °C	TCK048	00209DD93
Elevation 388 mm (£)	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

Tab. 2 – Cont'd

Component or line location	Instrument type	Plant code	Span	m. u.	Accuracy	SIET code	Ref Dwg
PCC POOL (P)							
Loc. H6, tap elevation 5650 - 3220 mm ($)	DP Transmitter	DP P007	0 : 30	kPa	0.25 % f.s.	TMD175	Fig 16
Loc. H6, tap elevation 3220 - 1945 mm ($)	DP Transmitter	DP P008	0 : 20	kPa	0.25 % f.s.	TMD161	Fig 16
Loc. H6, tap elevation 1945 - 1125 mm ($)	DP Transmitter	DP P009	0 : 10	kPa	0.25 % f.s.	TMD172	Fig 16
Loc. H6, tap elevation 1125 - 50 mm ($)	DP Transmitter	DP P010	0 : 20	kPa	0.25 % f.s.	TMD194	Fig 16
Location B3 - elevation 2765 mm ($)	RTD-PT100	T-P001	0 : 150	°C	1.05 °C	TR006	Fig 17
Location B3 - elevation 2355 mm ($)	RTD-PT100	T-P002	0 : 150	°C	1.05 °C	TR007	Fig 17
Location B3 - elevation 1945 mm ($)	RTD-PT100	T-P003	0 : 150	°C	1.05 °C	TR008	Fig 17
Location B3 - elevation 1535 mm ($)	RTD-PT100	T-P004	0 : 150	°C	1.05 °C	TR009	Fig 17
Location B3 - elevation 1125 mm ($)	RTD-PT100	T-P005	0 : 150	°C	1.05 °C	TR010	Fig 17
Location D3 - elevation 2765 mm ($)	RTD-PT100	T-P006	0 : 150	°C	1.05 °C	TR011	Fig 17
Location D3 - elevation 2355 mm ($)	RTD-PT100	T-P007	0 : 150	°C	1.05 °C	TR012	Fig 17
Location D3 - elevation 1945 mm ($)	RTD-PT100	T-P008	0 : 150	°C	1.05 °C	TR013	Fig 17
Location D3 - elevation 1535 mm ($)	RTD-PT100	T-P009	0 : 150	°C	1.05 °C	TR014	Fig 17
Location D3 - elevation 1125 mm ($)	RTD-PT100	T-P010	0 : 150	°C	1.05 °C	TR015	Fig 17
Location D5 - elevation 2765 mm ($)	RTD-PT100	T-P011	0 : 150	°C	1.05 °C	TR016	Fig 17
Location D5 - elevation 2355 mm ($)	RTD-PT100	T-P012	0 : 150	°C	1.05 °C	TR017	Fig 17
Location D5 - elevation 1945 mm ($)	RTD-PT100	T-P013	0 : 150	°C	1.05 °C	TR018	Fig 17
Location D5 - elevation 1535 mm ($)	RTD-PT100	T-P014	0 : 150	°C	1.05 °C	TR019	Fig 17
Location D5 - elevation 1125 mm ($)	RTD-PT100	T-P015	0 : 150	°C	1.05 °C	TR020	Fig 17
Location F5 - elevation 2765 mm ($)	RTD-PT100	T-P016	0 : 150	°C	1.05 °C	TR021	Fig 17
Location F5 - elevation 2355 mm ($)	RTD-PT100	T-P017	0 : 150	°C	1.05 °C	TR022	Fig 17
Location F5 - elevation 1945 mm ($)	RTD-PT100	T-P018	0 : 150	°C	1.05 °C	TR023	Fig 17
Location F5 - elevation 1535 mm ($)	RTD-PT100	T-P019	0 : 150	°C	1.05 °C	TR024	Fig 17
Location F5 - elevation 1125 mm ($)	RTD-PT100	T-P020	0 : 150	°C	1.05 °C	TR025	Fig 17
Location G3 - elevation 5650 mm ($)	RTD-PT100	T-P021	0 : 150	°C	1.05 °C	TR026	Fig 17
Location G3 - elevation 5025 mm ($)	RTD-PT100	T-P022	0 : 150	°C	1.05 °C	TR027	Fig 17
Location G3 - elevation 3810 mm ($)	RTD-PT100	T-P023	0 : 150	°C	1.05 °C	TR028	Fig 17
Location G3 - elevation 3220 mm ($)	RTD-PT100	T-P024	0 : 150	°C	1.05 °C	TR029	Fig 17
Location G3 - elevation 2765 mm ($)	RTD-PT100	T-P025	0 : 150	°C	1.05 °C	TR030	Fig 17
Location G3 - elevation 2355 mm ($)	RTD-PT100	T-P026	0 : 150	°C	1.05 °C	TR031	Fig 17
Location G3 - elevation 1945 mm ($)	RTD-PT100	T-P027	0 : 150	°C	1.05 °C	TR032	Fig 17
Location G3 - elevation 1535 mm ($)	RTD-PT100	T-P028	0 : 150	°C	1.05 °C	TR033	Fig 17
Location G3 - elevation 1125 mm ($)	RTD-PT100	T-P029	0 : 150	°C	1.05 °C	TR034	Fig 17
Location G3 - elevation 670 mm ($)	RTD-PT100	T-P030	0 : 150	°C	1.05 °C	TR035	Fig 17
Location G3 - elevation 525 mm ($)	RTD-PT100	T-P031	0 : 150	°C	1.05 °C	TR036	Fig 17
Location G3 - elevation 50 mm ($)	RTD-PT100	T-P032	0 : 150	°C	1.05 °C	TR037	Fig 17
Location A3 - elevation 3810 mm ($)	RTD-PT100	T-P033	0 : 150	°C	1.05 °C	TR038	Fig 17
Location B3 - elevation 3810 mm ($)	RTD-PT100	T-P034	0 : 150	°C	1.05 °C	TR039	Fig 17
Location C3 - elevation 3810 mm ($)	RTD-PT100	T-P035	0 : 150	°C	1.05 °C	TR040	Fig 17

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 ($m^3/(s*Pa)$); K (m^3/s) calibration costants

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 (£)	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 (£)	Thermocouple K	T I001	0 : 200	°C	+/- 1.1 °C	TCK051	00209DD93
Elevation 3228 mm (£)	Thermocouple K	T I002	0 : 200	°C	+/- 1.1 °C	TCK052	00209DD93
Elevation 570 mm (£)	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 (£)	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 (£)	DP Transmitter	L O001	0 : 50	kPa	0.25 % f.s.	TMD167	00209DD93
STEAM BYPASS LINE (7)							
Steam bupass line	P Transmitter	P 7001	0 : 20	MPa	0.25 % f.s.		00209DD93
Steam bypass lin	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

(*) Compensation thermocouple for mechanical measurement

($) Elevation referred to the bottom of PCC or IC pool

(£) Elevation referred to the tank internal bottom

Abbreviations

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

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.

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-noncondensible 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.

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 noncondensible 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).

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)

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 tecnology
- 1 ETHERNET controller 10 MIPS in RISC tecnology
- 64 Mbyte of RAM memory
- mass storage: 1 Gbyte of hard disk RF72 DEC 1.2 Gbyte removible cartridge TLZ04 DEC
- peripherals: 2 consolle 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

- 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 removible 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

- 4 virtual hard disk for a total amount of 60 Mbyte
- ETHERNET controller
- 1 serial port
- 1 printer port
- 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:

- buffer memory 1 Mbyte
- microprocessor card with 32 bit bus, 20 MHz clock
- Ethernet controller 10 Mbyte/s througput
- switch mode power box
- 100 Hz maximum adjustable sampling rate
- 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:

input channels 24

input level 0.5 ÷ 10 V peak to peak with adjusting +/- 40 %

minimum input inpedance 18 kΩ

maximum input capacitance 10 pF

operating temperature 0 ÷ 50 °C

adjustable bandwith DC ÷ 80 kHz

TAPE SPEED (inches per second)	CENTER FREQUENCY (kHz)	BANDWITH (kHz)
120	432	DC ÷ 80
60	216	DC ÷ 40
30	108	DC ÷ 20
15	54	DC ÷ 10
7 ½	27	DC ÷ 5
3 ¾	13.5	DC ÷ 2.5
1 ⅞	6.75	DC ÷ 1.25
15 / 16	3.375	DC ÷ 0.625

TheHP 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 wich is on an IBM-PC compatible computer. The measurament hardware is connect to the computer using an HP-IB (GPIB) interface.

The measurament 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 measurament hardware and computer to make and display measurament. 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

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 indipendently 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 61 µHz to 51 kHz
- switchable 3 input modes voltage, charge, 4 mA costant 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)

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

- 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 intruments 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 bandwith 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

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 same 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 backgruond 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 same 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 beetwen 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 beetwen 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 sended 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 costituited of a shared area memory that contains the image of the earlier acquired data of all the active measurements channels. Around this kernel runs same 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.

The array of active tasks on the central node have available shared area memory in which are same differents 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 discarge 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 archivies configuration identification code, the starting date of recordingand further internal system information.

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

- 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 sufficent define the straigth-line parameter in this formula:

OUTPUT = PARAM_Q + INPUT * 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:

OUTPUT = OFFSET + INPUT * 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 rigth calculation of a value

r the user to perform the acquisition data process: display. s block contain the reference to the algoritm, to the list of all nputation of the engineering value.

the value that may be shown in tables or plot, the print format ock.

ed one or more alarm condition control functions.This means neasured value to verify the overtaking of a treshold. 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.

bout the action to be performed in relation with the alarm an alarm condition is reached. Generally this action may be nsist to send a message to a physical control channel. The and correct format parameter in function of the type of bility 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

7.3 Sofware 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 carryed 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.

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 rec..ded 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.

8.1.1.1.2 **Temperatures**

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

- sheated thermocouples type K Cromel-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:

$$E = \left(\sum_{i=0}^{8} d_i \, T^i + 125 \exp\left[-1/2 * (T - 127/65)^2 \right] \right) / 1000 \qquad \text{(UNI7938 specifications)}$$

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	=	$2.993291 * 10^{-13}$
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.

In the same way the signals coming from thermoresistance (Ω) are converted in engineering units (°C) performing the linear interpolation of the PT100 type thermoresistance data characteristics generated by the following formula :

$$R = 100 * (1 + 3.90802E\text{-}3 * T - 0.5802E\text{-}6 * T^2)$$ (UNI [illegible] specifications)

where:

T =	temperature	(°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:

$$Y = mV / (S * V)$$

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.

8.1.1.2 Derived quantities

8.1.1.2.1 Flowrates

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

$$F = \alpha_c * \varepsilon * \sqrt{\rho} * \sqrt{\Delta Pc}$$ for compressible fluid (kg/s)

$$F = \alpha_c * \sqrt{\rho} * \sqrt{\Delta Pc}$$ for incompressible fluid (kg/s)

with:

$$\Delta Pc = \Delta P \pm \rho * g * h$$ (Pa)

for orifice plate

$$\varepsilon = 1 - (0.41 + 0.35 * \beta^4) * \Delta P_c / (\sigma * P1)$$

for Venturi tubes and nozzles

$$\varepsilon = \left(\left(\frac{P1}{P2}\right)^{\frac{2}{\sigma}} * \frac{\sigma}{\sigma - 1} * \frac{1 - \left(\frac{P_2}{P_1}\right)^{\frac{\sigma - 1}{\sigma}}}{1 - \left(\frac{P_2}{P_1}\right)} * \frac{1 - \beta^4}{1 - \beta^4 * \left(\frac{P_2}{P_1}\right)^{\frac{2}{\sigma}}} \right)^{0.5}$$

where:

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

α	=	flux coefficient	
ε	=	compressibility coefficient (ε = 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 = isoentropic 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:

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

where:

T	=	working temperature	(°C)
Tcal	=	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:

$$F = \rho * (M * \Delta P + K) \qquad (kg/s)$$

where:

M	=	calibration constant (see table 3)	$(m^3 / (s\ Pa))$
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 :

$$F = \alpha_c * \varepsilon_{mix} * (\rho_{mix} * \Delta P_c)^{0.5} \qquad (kg/s)$$

with :

ε_{mix} = $1 - (0.41 + 0.35 * \beta^4) * \Delta P_c / (\sigma_{mix} * P_1)$

σ_{mix} = C_p / C_v = $X_{steam} * \sigma_{steam} + X_{air} * \sigma_{air}$ = mixture isoentropic exponent

X_{air} = $1 / (1+x)$ = air quality

X_{steam} = $x / (1+x)$ = steam quality

ρ_{mix} = $\rho_{sat} * [(x+1) / x]$ (Kg / m^3)

where :

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

α = flux coefficient

ΔP_c = orifice pressure drop (Pa)

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} = 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 isoentropic exponent = 1.31

σ_{air} = air isoentropic 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 trasmitters. The reference formula is:

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

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} = ρ_{air} = P / (R * T) for air and water (kg/m^3)

P = air pressure (Pa)

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 :

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

with:

ρ_{mix} = $\rho_{sat} * [(x+1) / x]$ (kg/m^3)

x = $0.622 * [P_{sat} / (P - P_{sat})]$

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)

g = gravity acceleration (m / s^2)

8.1.1.2.3 **Pool density**

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

$$\rho = \Delta P / (g * h) \qquad (kg / m^3)$$

where:

ΔP = differential pressure (Pa)

h = pressure taps height difference (m)

g = gravity acceleration (m / s^2)

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:

$$\varepsilon = \varepsilon_m + j$$

with:

$$\varepsilon_m = \frac{\frac{\Delta R}{R}}{K}$$

where:

ΔR = strain gage active resistance change (Ω)

R = strain gage active resistance (Ω)

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:

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

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)

$h_{liq,in}$ = desupheating water enthalpy (kJ / kg)

$W_{L in}$ = 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)

$F_{entr\text{-}cond}$ = vent line entrained condensate flowrate (kg /s)

$h_{entr\text{-}cond}$ = 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:

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

where:

$\rho_{entr\text{-}cond}$ = entrained condensate density (kg/m^3)

A = vent tank cylindrical cross section = 2.27 (m^2)

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

QUANTITY	USED INSTRUMENT TAG
F_{steam}	F-1001; F-1002; F-1003; T-1001; P-1001
F_{air}	F-2001; F-2002; T-2001; P-2001
F_{liq}	F-3001; T-3001
$h_{steam\ in}$	T-1001; P-1001
$h_{air\ in}$	T-2001; P-2001
$h_{liq\ in}$	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
$h_{sat\ out}$	T-T001; P-T001
P_{sat}	T-T001
P	P-T001
$F_{entr\text{-}cond}$	L-1001; T-1001; T-1002; T-1003; P-1001
$\rho_{entr\text{-}cond}$	T-1001; T-1002; T-1003; P-1001
$h_{entr\text{-}cond}$	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

8.1.1.2.6 **Heat flux coefficient**

The local heat flux coefficient is measured as :

$$h_h = Q" / (T_e - T_{pool}) \qquad (W / K m^2)$$

with

$$Q" = k / R_e * (T_i - T_e) / \ln (R_e / R_i) \qquad (W / m^2)$$

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)

8.1.2 **Analogically acquired quantities**

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

8.2 Errors evaluation

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

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

$$\sigma = \pm \left(\Delta_I^2 + \Delta_{BV}^2 + \Delta_{RJ}^2\right)^{0.5} \qquad \text{standard devation}$$

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 board 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:

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

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

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

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 goodnes 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 intrument 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 proced with the preparation for the next test. This will consist primarily of indentification 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

physical input channel, the measurement channels, the alarm, the action archivies and the monitor page archivies. 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 analisys.

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 graps 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

h) tables containg the results of spectrall 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.

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 adequancy 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);

...onfirm plant stability (i.e. to reach steady state conditions) to perform matrix test number 22 ...d 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.

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 spectable flange SF002; the steam supply line will be closed; condensate tank will be connected to injection line opening spectable 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 controll 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 spectable flange SF001 and the air feed line will be excluded. The condensate tank mixture discharge line will be excluded closing F015 valve.

The system wil be pressurized at four differnt 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 condensated water level of vent tank versus time.

The test will be carried out with four different temperatures of steam in the range 130°C - 170°C. The steam condensated 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 PCCs heat exchangers will be isolated by closing the vent and drain lines using the spectacle flanges SF002 and SF003. The PCCs heat exchangers will be filled with water by connecting a temperorary 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 condensated water level of condensated tank versus time.The test datailed 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.

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 mantain 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 wil 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.

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.

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 costant 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 perfomance of this unit will be tested over the expected range to SBWR conditions. Following the perfomance 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 baffled 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.

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 same 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, Pi (max) using vent tank discharge valve. Inlet mixture temperature is set to saturated condition. The PCC

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 Pi (max) and Pi (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 ma and ms.

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 cheklists 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 it is A.1.1. The detailed procedures of test type A.1.2 with its cheklists 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 noncondensible gas trapped in the PCC tubes. Two conditions will be considered for Tests A1.3.: 1) No air in PCC tubes, and 2) Air in PCC tubes.

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 varaibles, 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 cheklists 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 cheklists are reported in Part II of this TP&P document.

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 cheklists 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 cheklists are reported in Part II of this TP&P document.

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:

PCC inlet pressure kPag (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 cheklists 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.

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 cheklists 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 cheklists 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:

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 cheklists are reported in Part II of this TP&P document.

2) General Test Procedure - Air in PCC tubes

Perform tests similar to the two modules 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 cheklists 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.

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 noncondensible 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 cheklists are reported in Part II of this TP&P document.

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

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

12 REPORTS

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

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

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.

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	**Pools Filling**	° Verify the Pool's Support Structure	• 7 levels to be tested
C-02	**Pool P Drain down**	° Verify level control system adequacy ° Determine the resistance of the Pools Connection Line ° Verify flow meter calibration	• 4 flowrates to be tested
C-03	**Air Flow through the Riser to the Vent Tank**	° Determine the resistance of the Injection Line, Riser, Condenser, Vent and Discharge Lines ° Verify Pressure control system adequacy	• 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**	° Determine the resistance of Drain Line ° Verify level control system adequacy ° Verify pressurization system	• 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
H-01	**Steam Flow through the Riser to the Vent Tank**	° 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	• 4 Temperatures to be tested
H-02	**Steam Flow through the Riser to the Condensate Tank**	° Determine the heat losses of the Drain Line and the Condensate Tank ° Verify Condensate Tank project	• 4 Temperatures to be tested
H-03	**Steam Flow through the Pool Connection Line to the Stack**	° Determine the heat losses of the Pool Connection line to the Catch Tank ° Verify the Stack Discharge capability	• Steam flow at the minimum value capable to mantain the pool boiling conditions
H-04	**Steady State Performance Steam - Only Test n. 43**	° Confirm the Steady State heat removal capability in the expected conditions ° Confirm the stability of Plant Parameters ° Confirm the proposed test procedure	• 6.6 kg/s steam flow rate to be tested • Maximum Pressure value : 690 kPa g
H-05	**Steady State Performance Saturated Steam / Air Mixtures Test n. 22**	° Measure the decrease of the Steady State heat removal capability ° Confirm the stability of Plant Parameters ° Confirm the proposed test procedure	• 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 - PCC 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 (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 1[illegible])	308 33	428 83	549 33	669 83	790 33	< 10 (18)
11	6 6 (14 5)	0 073 (0 1[illegible])	308 33	428 83	549 33	669 83	7[illegible] 33	< 10 (18)
12	0 45 (1 0)	0 14 (0 31)	239 33	313 3	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 (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 (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.1.3 . 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)

Tab. 12 - PART B. TESTS WITH ONE MODULE

Test Type B.1. 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)

PART II : TEST PROCEDURES

TABLE OF CONTENTS

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.

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. Signat.
10	Verify that the plant configuration is complete and suitable for the scope of test C-01			
20	Verify the correcteness 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 Aquisition System is operational and the conversion costants 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			

PANTHERS PCC PRE-TEST CHECK LIST

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

Note ____________________

Date ________ Experiment Manager Signature ____________________

PANTHERS PCC TEST PROCEDURE

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

Phase #	Description	Note	Status	Oper. Signat.
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 ≡ 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 ≥ 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 ≡ 2 m, stop pump C004 and close valve F026			

PANTHERS PCC TEST PROCEDURE

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 ≡ 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 ≡ 3 m, stop pump C004 and close valve F026			
280	Repeat phase 40			

PANTHERS PCC TEST PROCEDURE

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 ≅ 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 ≅ 4 m, stop pump C004 and close valve F026			
440	Repeat phase 40			
450	Repeat phase 50			

PANTHERS PCC TEST PROCEDURE

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

Phase #	Description	Note	Status	Oper. Signat.
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		

PANTHERS PCC TEST PROCEDURE

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

Phase #	Description	Note	Status	Oper. Signat.
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 ≅ 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 ≅ 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			

PANTHERS PCC TEST PROCEDURE

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

Phase #	Description	Note	Status	Oper. Signat.
690	When level L-Q001 ≅ 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 ≅ 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 ≅ 1 m, close valves F028, F029			

PANTHERS PCC TEST PROCEDURE

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

Phase #	Description	Note	Status	Oper. Signat
780	Repeat phase 40	The duration can be changed according to the results of the loading phase		
790	Drain the pools P, Q			
800	Repeat phase 40	The duration can be changed according to the results of the loading phase		

Note ______________________________

Date ____________ Experiment Manager Signature ____________________

PANTHERS PCC PRE-TEST CHECK LIST

Title *Pool Make-up System Verification* Test # C-02

Phase #	Description	Note	Status	Oper. Signat.
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: • F-M001 • F-R001 • L-Q001, L-Q002 • L-P001 • T-M001 • T-R001			
40	Verify that the Data Aquisition System is operational and the conversion costants and formulas have been correctly inserted in the DAS			
50	Verify that the following valves are closed: • F028 • F029 • F031 • F032 • F034 • F035 • F036	F035 and F036 are not installed		
60	Verify that the following valves are open • F027 • F030 • F033 • F045			

PANTHERS PCC PRE-TEST CHECK LIST

Page 2 of 2

Title *Pool Make-up System Verification*

Test # C-02

Phase #	Description	Note	Status	Oper. Signat.
70	Verify that the following tanks are full - A001 - A002 - A003			
80	Verify that the following control system is available: - LIC-Q001			
90	Verify that the pump C004 is available			

Note ____

Date ______________ Experiment Manager Signature ______________________________

PANTHERS PCC TEST PROCEDURE

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			

PANTHERS PCC TEST PROCEDURE

Title *Pool Make-up System Verification* Test # C-02

Phase #	Description	Note	Status	Oper. Signat.
110	Repeat phase 40	It could be necessary to adjust again the controller parameters as in phase 50		

Note ____

Date __________ Experiment Manager Signature ____________________________

PANTHERS PCC PRE-TEST CHECK LIST

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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: - 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 Aquisition System is operational and the conversion costants and formulas have been correctly inserted in the DAS			
40	Verify that the following valves are closed: - 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 - F009, F020, F039, F044, F049 - SF001, SF002			
60	Verify that the following safety valves are set at 1 MPa: - F016, F050, F040 and the valve F-043 is set at 4 MPa			
70	Verify that the air compressors C002, C003 are available			

PANTHERS PCC PRE-TEST CHECK LIST

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Title *Air Flow Test* Test # C-03

Phase #	Description	Note	Status	Oper. Signat.
80	Verify that the following control systems are available: - PIC-4002 - FIC-2001			

Note ______________________________

Date ____________ Experiment Manager Signature ______________________

PANTHERS PCC TEST PROCEDURE

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			

PANTHERS PCC TEST PROCEDURE

Title *Air Flow Tests*

Test # C-03

Phase #	Description	Note	Status	Oper. Signat.
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			

PANTHERS PCC TEST PROCEDURE

Title Air Flow Tests

Test # C-03

Note

Date ________ Experiment Manager Signature ______________________

PANTHERS PCC PRE-TEST CHECK LIST

Title *Water Drain Test* Test # C-04

Phase #	Description	Note	Status	Oper. Signat.
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: - 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 Aquisition System is operational and the conversion costants and formulas have been correctly inserted in the DAS			
40	Verify that the following valves are closed: - F001, F025, F011, F037, F018 - SF002, F033, F034, F013, F021 - FF041, F046, F038, F026			
50	Verify that the following valves are open - F044, F039, F009, SF001, F017, F015, SF003			
60	Verify that the following safety valves are set at 1 MPa: - 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			

PANTHERS PCC PRE-TEST CHECK LIST

Title *Water Drain Test* Test # C-04

Phase #	Description	Note	Status	Oper. Signat.
80	Verify that the pump C004 and the air compressors C002 C003 are available			

Note ______________________________

Date ____________ Experiment Manager Signature ______________________

PANTHERS PCC TEST PROCEDURE

Test # C-04

Title *Water Drain Test*

Phase #	Description	Note	Status	Oper. Signat.
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 in 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			

PANTHERS PCC TEST PROCEDURE

Title *Water Drain Test* Test # C-04

Phase #	Description	Note	Status	Oper. Signat.
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			

PANTHERS PCC TEST PROCEDURE

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Title *Water Drain Test*

Test # C-04

Phase #	Description	Note	Status	Oper. Signat.
290	Measure and record all instruments for 1000 s			
300	Adjust water flow rate F-M001 = F-L001 = 1.0 kg/s, acting on valve F-026			
310	Wait to reach steady-state flow rate F-M001=F-L001=1.0 kg/s and pressure P-L001=701.3 kPa			
320	Measure and record all instruments for 1000 s			
330	Turn off air compressor C-002			
340	Turn off pump C-004			

Note ______________________________

Date __________ Experiment Manager Signature ______________________

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. Signat.
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: • 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 Aquisition System is operational and the conversion costants and formulas have been correctly inserted in the DAS			
40	Verify that the following valves are closed: • F001, F002, F003, F011, F009, F013, F017, F015, F023, F049, SF004, F059, F004 , SF001, F046			
50	Verify that the following valves are open: • F025, F007, F018, SF002, F058, F048, SF003			
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, TIC-4002, LIC-L001			
80	Verify that the pump C001 is available			
90	Verify that the condensers are cooled ("Fluviale pump is in operation)			

PANTHERS PCC PRE-TEST CHECK LIST

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

Note ______

Date ______ Experiment Manager Signature ______

PANTHERS PCC TEST PROCEDURE

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

Phase #	Description	Note	Status	Oper. Signat.
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	About10°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 mantain 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	About10°C of superheat at PCC inlet		
120	Repeat phases 60 and 70			

PANTHERS PCC TEST PROCEDURE

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

Phase #	Description	Note	Status	Oper. Signat.
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	About 10°C of superheat at PCC inlet		
160	Set TIC-4002 temperature set point = 175 °C			
170	Repeat phases 60 and 70	The steam in the PCC upper headers and in vent line must be in saturated conditions		
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			
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	About 10°C of superheat at PCC inlet		
210	Set TIC-4002 temperature set point = 181°C			
220	Repeat phases 60 and 70	The steam in vent line must be in saturated conditions		
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			
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 / F059			
	Depressurize and drain the system			

PANTHERS PCC TEST PROCEDURE

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

Note

Date ________ Experiment Manager Signature ________________

PANTHERS PCC TEST PROCEDURE

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

Phase #	Description	Note	Status	Oper. Signat.
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 / F059			
270	Depressurize and drain the system			

PANTHERS PCC TEST PROCEDURE

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

Note ____

Date __________ Experiment Manager Signature ______________________

PANTHERS PCC PRE-TEST CHECK LIST

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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 folowing lines are avaible: 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 avaible			
70	Verify that the Data Aquisition System is operational and the conversion costants and formulas have been correctly inserted in the DAS			
80	Verify that the condensers are cooled ("Fluviale pump is operational)			

PANTHERS PCC PRE-TEST CHECK LIST

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

Note ______________________________

Date ______________ Experiment Manager Signature ______________________________

PANTHERS PCC TEST PROCEDURE

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

Phase #	Description	Note	Status	Oper. Signat.
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	Mantain valves F001 and F002 closed because the leakage of these valves should be sufficient to perform the test		
60	Start pump C001, open valves F050 / 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 temperarure till to reach required temperature of T-4002 (10°C of superheat or less)			
100	Wait to reach steady state condition 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			

PANTHERS PCC TEST PROCEDURE

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

Phase #	Description	Note	Status	Oper. Signat.
120	Trhottle valve F053 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			

PANTHERS PCC TEST PROCEDURE

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

Phase #	Description	Note	Status	Oper. Signat.
280	Stop pump C001 and close valves F059 / F011			
290	Depressurize the system			
300	Close valve F053			

Note

Date ______ Experiment Manager Signature ______

PANTHERS PCC PRE-TEST CHECK LIST

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

Phase #	Description	Note	Status	Oper. Signat.
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)			

PANTHERS PCC PRE-TEST CHECK LIST

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

Note ______

Date ______ Experiment Manager Signature ______

PANTHERS PCC TEST PROCEDURE

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

Phase #	Description	Note	Status	Oper. Signat.
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		

PANTHERS PCC TEST PROCEDURE

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

Phase #	Description	Note	Status	Oper. Signat.
120	Close valve F060			
130	Measure and record all instruments and plot water level in catch tank line loop seal (L-O002) for 1200 s	If required the measuring and recording time can be changed		
140	Stop the test			

Note ______________________________

Date __________ Experiment Manager Signature ______________________________

PANTHERS PCC PRE-TEST CHECK LIST

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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, 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-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)			

PANTHERS PCC PRE-TEST CHECK LIST

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Title *Steam Only Test*

Test # H-04

Note

Date ________ Experiment Manager Signature ______________________

PANTHERS PCC TEST PROCEDURE

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Title *Steam Only Test* Test # H-04

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 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 then 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			

PANTHERS PCC TEST PROCEDURE

Title *Steam Only Test*

Test # H-04

Phase #	Description	Note	Status	Oper. Signat.
120	Adjust steam flow rate to the required value F-1001 + F-3001 = 6.6 kg/s, controlling that the steam at the PCC inlet shall be superheated with less than 10°C of superheating (temperature T-4002)			
130	When Steady state conditions are reached, keep measuring and recording all instrument signals for 15 minutes			
140	Stop the test			

Note ____

Date __________ Experiment Manager Signature ______________________________

PANTHERS PCC PRE-TEST CHECK LIST

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, F503, 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 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)			

PANTHERS PCC PRE-TEST CHECK LIST

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

Note

Date ______ Experiment Manager Signature ______

PANTHERS PCC TEST PROCEDURE

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

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: 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		

PANTHERS PCC TEST PROCEDURE

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

Phase #	Description	Note	Status	Oper. Signat.
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 ≤ 158° 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 + F3001) 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		

PANTHERS PCC TEST PROCEDURE

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

Phase #	Description	Note	Status	Oper. Signat.
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			

PANTHERS PCC TEST PROCEDURE

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

Note

Date ______ Experiment Manager Signature ______

PANTHERS PCC PRE-TEST CHECK LIST
TESTS WITH TWO MODULES

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

Phase #	Description	Note	Status	Oper. Signat.
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 : FO38, 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)			

PANTHERS PCC PRE-TEST CHECK LIST
TESTS WITH TWO MODULES

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

Note ____

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Date ____________ Experiment Manager Signature ____________________

PANTHERS PCC TEST PROCEDURE
TESTS WITH TWO MODULES

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

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: 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 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			

PANTHERS PCC TEST PROCEDURE
TESTS WITH TWO MODULES

Title *Test type - A 1.1 Saturated steam/air mixtures test* Test # 1÷30

Phase #	Description	Note	Status	Oper. Signat.
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)			

PANTHERS PCC TEST PROCEDURE
TESTS WITH TWO MODULES

Title *Test type - A.1.1 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-2001or 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 hte 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			

PANTHERS PCC TEST PROCEDURE
TESTS WITH TWO MODULES

Title *Test type - A.1.1 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 et 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			

PANTHERS PCC TEST PROCEDURE
TESTS WITH TWO MODULES

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

Note ____________________

Date ________ Experiment Manager Signature ____________________

PANTHERS PCC PRE-TEST CHECK LIST
TESTS WITH TWO MODULES

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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 : FO38, 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-A002 , 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)			

PANTHERS PCC PRE-TEST CHECK LIST
TESTS WITH TWO MODULES

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

Note ____

Date ____________ Experiment Manager Signature ______________________

PANTHERS PCC PRE-TEST CHECK LIST
TESTS WITH TWO MODULES

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

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: 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 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			

PANTHERS PCC PRE-TEST CHECK LIST
TESTS WITH TWO MODULES

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Title *Test type A.1.2 - Superheated steam/air mixtures* Test # 31÷36

Phase #	Description	Note	Status	Oper. Signat.
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-2001or 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)			

PANTHERS PCC PRE-TEST CHECK LIST
TESTS WITH TWO MODULES

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Title *Test type A.1.2 - Superheated steam/air mixtures* Test # 31÷36

Phase #	Description	Note	Status	Oper. Signat.
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 hte 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			

PANTHERS PCC PRE-TEST CHECK LIST
TESTS WITH TWO MODULES

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

Note ____

Date ____________ Experiment Manager Signature ____________________________

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. Signat.
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, F039, F009, F013, F037, F047, F023, F049, F015, F018, F036, F031, F032, F030, FO34, F028 , F029, F035, F042, F041, F002, F003, F025, F059, F011, F060, F022, F503.			
50	Verify that the following valves are open: FO58, 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 pumps C001, C004 and are available			
90	Verify that the tankes 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)			

PANTHERS PCC PRE-TEST CHECK LIST
TESTS WITH TWO MODULES

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

Note ____________________

Date ____________ Experiment Manager Signature ____________________

PANTHERS PCC TEST PROCEDURE
TESTS WITH MODULES

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

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 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			

PANTHERS PCC TEST PROCEDURE
TESTS WITH MODULES

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

Phase #	Description	Note	Status	Oper. Signat.
110	Heat up the PCC pool water till to reach the equilibrium buvlk 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 ______________________

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. Signat.
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 tankes 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)			

PANTHERS PCC PRE-TEST CHECK LIST
TESTS WITH TWO MODULES

Page 2 of 2

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

Note

Date ______________ Experiment Manager Signature ______________________

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. Signat.
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			

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 (minumum 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 ≅ 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 ≅ 790 kPa			

Note ____

Date ____________ Experiment Manager Signature ____________________

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-Q001, 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)			

PANTHERS PCC PRE-TEST CHECK LIST
TESTS WITH TWO MODULES

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

Note ______________________________

Date ____________ Experiment Manager Signature ____________________

PANTHERS PCC TEST PROCEDURE
TESTS WITH TWO MODULES

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

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: 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			

PANTHERS PCC TEST PROCEDURE
TESTS WITH TWO MODULES

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

Phase #	Description	Note	Status	Oper. Signat.
140	Open valves F028, F029, F031, F032 and begin to decrease the level L-Q001 and L-P001	Open fully		
150	Measure flowratae F-R001: if F-R001 is lower the 5 Kg/s than open partially valve F035			
160	Periodically repeat phase 100			
170	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			
180	Fill the pools till to reach the normal water level L-Q001=4 26 m repeating periodically phase 100			
190	Stop the test			

Note ____________________

Date ____________ Experiment Manager Signature ____________________

PANTHERS PCC PRE-TEST CHECK LIST
TESTS WITH TWO MODULES

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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-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 and Q are full, the tanks can be partially full		
100	Verify that the condensers are cooled ("Fluviale" pump is in operation)			

PANTHERS PCC PRE-TEST CHECK LIST
TESTS WITH TWO MODULES

Page 2 of 2

Test # 55-56

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

Note ______________________________

Date ______________ Experiment Manager Signature ______________________________

PANTHERS PCC TEST PROCEDURE
TESTS WITH TWO MODULES

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	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 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 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		

PANTHERS PCC TEST PROCEDURE
TESTS WITH TWO MODULES

Test # 55-56

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

Phase #	Description	Note	Status	Oper. Signat.
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 mantain 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			

PANTHERS PCC TEST PROCEDURE
TESTS WITH TWO MODULES

Test # 55-56

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

Phase #	Description	Note	Status	Oper. Signat.
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			

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Date __________ Experiment Manager Signature ____________________

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. Signat.
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			

PANTHERS PCC PRE-TEST CHECK LIST
TESTS WITH TWO MODULES

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

Note ______________________________

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PANTHERS PCC TEST PROCEDURE
TESTS WITH TWO MODULES

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

Phase #	Description	Note	Status	Oper. Signat.
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 live 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			

PANTHERS PCC TEST PROCEDURE
TESTS WITH TWO MODULES

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

Phase #	Description	Note	Status	Oper. Signat.
160	Perform 10 Simulated LOCA Pressurizations starting with PCC pool water temperature less than 45°C			

Note

Date ______________ Experiment Manager Signature ____________________________

PANTHERS PCC PRE-TEST CHECK LIST
TESTS WITH TWO MODULES

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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 is 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 partily 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

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

Phase #	Description	Note	Status	Oper. Signat.
10	Open valve F041 and fill condensate tank till to have a water level L-L002 ≅ 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≅ 0.2 Kg/s.			
60	When P-L001≅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 pressurizatio n 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.			

PANTHERS PCC TEST PROCEDURE
TESTS WITH TWO MODULES

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

Note

Date ______ Experiment Manager Signature ______

PANTHERS PCC PRE-TEST CHECK LIST
TESTS WITH TWO MODULES

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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 vavle 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 PRE-TEST CHECK LIST
TESTS WITH TWO MODULES

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

Note ______________________________

Date ____________ Experiment Manager Signature ______________________

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. Signat.
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 vavle 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 vavle 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			

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. Signat.
170	Repeat phase 50			
180	Operate vavle F008 (if required adjust vavle F009) till to have an air flowrate F-2001 ≅ 1 kg/s			
190	Repeat phase 40			
200	Repeat phase 50			
210	Stop the test			

Note ______________________________

Date ____________ Experiment Manager Signature ______________________

PANTHERS PCC PRE-TEST CHECK LIST
TESTS WITH ONE MODULE

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

Phase #	Description	Note	Status	Oper. Signat.
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-Q001, 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)			

PANTHERS PCC PRE-TEST CHECK LIST
TESTS WITH ONE MODULE

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

Note ____________________

Date ____________ Experiment Manager Signature ____________________

PANTHERS PCC TEST PROCEDURE
TESTS WITH ONE MODULE

Title *Test type B.1-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-I001 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= * 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-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=* 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		

PANTHERS PCC TEST PROCEDURE
TESTS WITH ONE MODULE

Title *Test type B.1-Steam Only (No air PCC tubes)* Test # 66÷72

Phase #	Description	Note	Status	Oper. Signat.
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 ____________________

PANTHERS PCC PRE-TEST CHECK LIST
TESTS WITH ONE MODULE

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

Phase #	Description	Note	Status	Oper. Signat.
10	Verify that the plant configuration is complete and suitable for the scope of test typeB.1: one module, PCC pool buffled 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, F050, 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 P and Q are full, the tanks can be partially full		
100	Verify that the condensers are cooled ("Fluviale" pump is in operation)			

PANTHERS PCC PRE-TEST CHECK LIST
TESTS WITH ONE MODULE

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

Note ____

Date ____________ Experiment Manager Signature ____________________

PANTHERS PCC TEST PROCEDURE
TESTS WITH ONE MODULE

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

Phase #	Description	Note	Status	Oper. Signat.
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-L0002=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 F037and 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 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	Start compressors C002 and C003, open a little valve F008 and wait till to have pressure P-2001≅2.5MPa			
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		

PANTHERS PCC TEST PROCEDURE
TESTS WITH ONE MODULE

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

Phase #	Description	Note	Status	Oper. Signat.
120	Open partially valve F051 and adjust valves F051 and F008 till to have an air flowrate F-2002≅0.003 Kg/s	F-2002 has been calculated at P=300MP and t=134°C		
130	Cease testing when pressure P-4002 stops increasing or pressure P-4002≅790KPa			

Note ______________________________

Date ____________ Experiment Manager Signature ______________________

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. Signat.
10	Verify that the plant configuration is complete and suitable for the scope of test type B.2.: one module. PCC pool buffled 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, 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 avaible			
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)			

PANTHERS PCC PRE-TEST CHECK LIST
TESTS WITH ONE MODULE

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

Phase #	Description	Note	Status	Oper. Signat.
110	Verify that Helium bottle or air/Helium (3.4 part of air and 1 part of Helium) bottle has been connected to valve F051	Helium for tests 75, 76 and air/Helium for tests 77, 78		
120	Verify that the Helium or air/Helium bottle has been installed on a suitable weighting machine			

Note ____________________

Date __________ Experiment Manager Signature ____________________

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. Signat.
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			

PANTHERS PCC TEST PROCEDURE
TESTS WITH ONE MODULE

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

Phase #	Description	Note	Status	Oper. Signat.
120	Open valve F051, open bottle valve and adjust the bottle pressure reducing valve. Start a chronometer to measure the bleeding time of the gas into the steam. The Helium mass flowrate (test N.75, 76) should be about 0.0002 kg/s. The air/Helium mixture mass flowrate (test N.77, 78) should be about 0.0008 Kg/s.\	The pressure reducing valve position to obtain the required gas flowrate can be determined before testing		
130	When pressure P-4002 stops increasing or reaches 790 kPa close gas bottle, stop the chronometer and weight the bottle: - the gas injection time is...........s - the bottle weight is..................kg			
140	Stop the test			

Note ____

Date ____________ Experiment Manager Signature ____________________

PART III : QUALITY ASSURANCE PLAN

TABLE OF CONTENTS

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 Siet 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.

Siet'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

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 En..neer -RTE-) and (if required by the Work Order provisions) by other external Organizations.

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

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)

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..............

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..........................

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 Requestor, the Experiments Manager has the duty to obtain approval by the ResponsibleTest 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.

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)

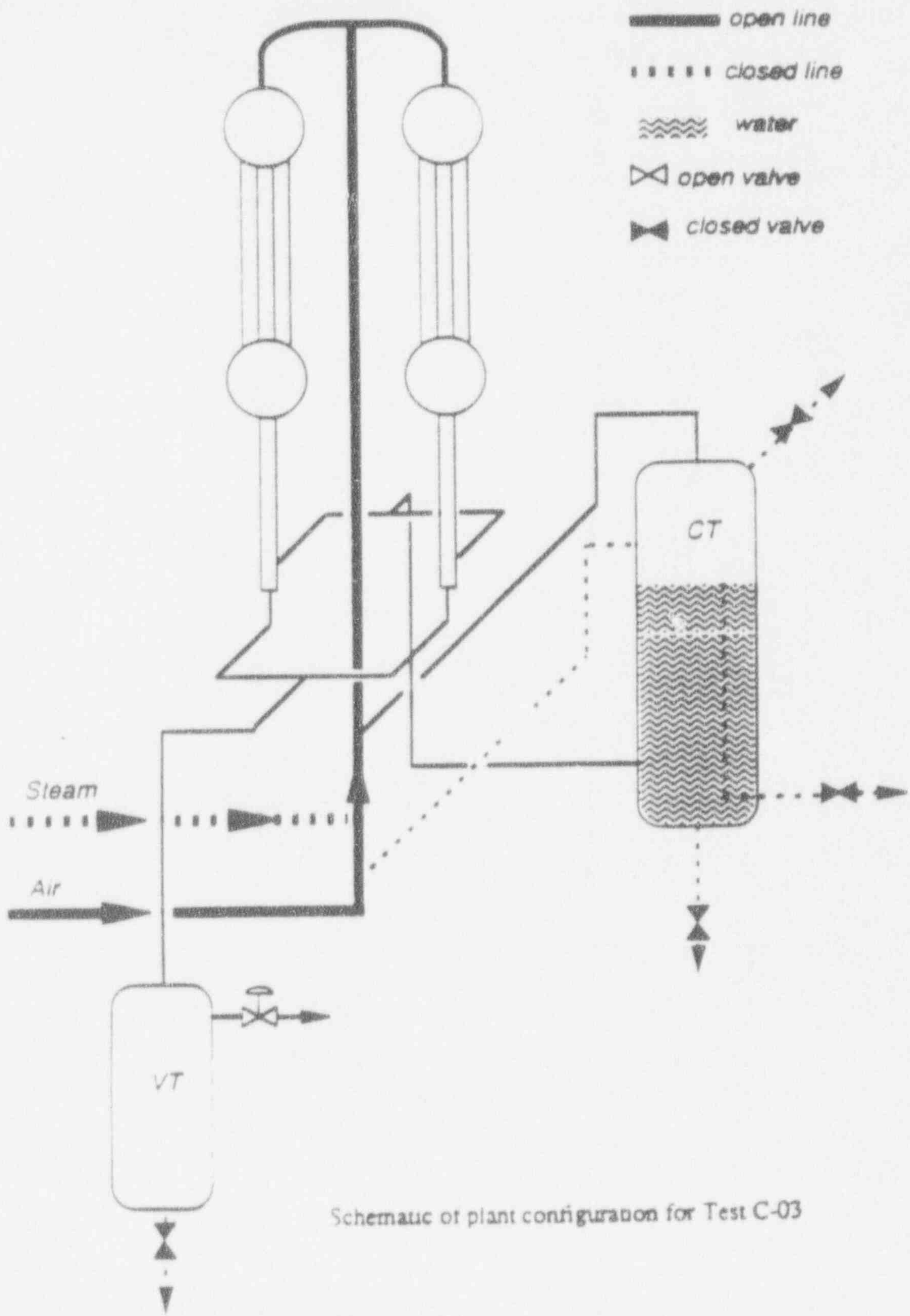
6. DESIGN VERIFICATION

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

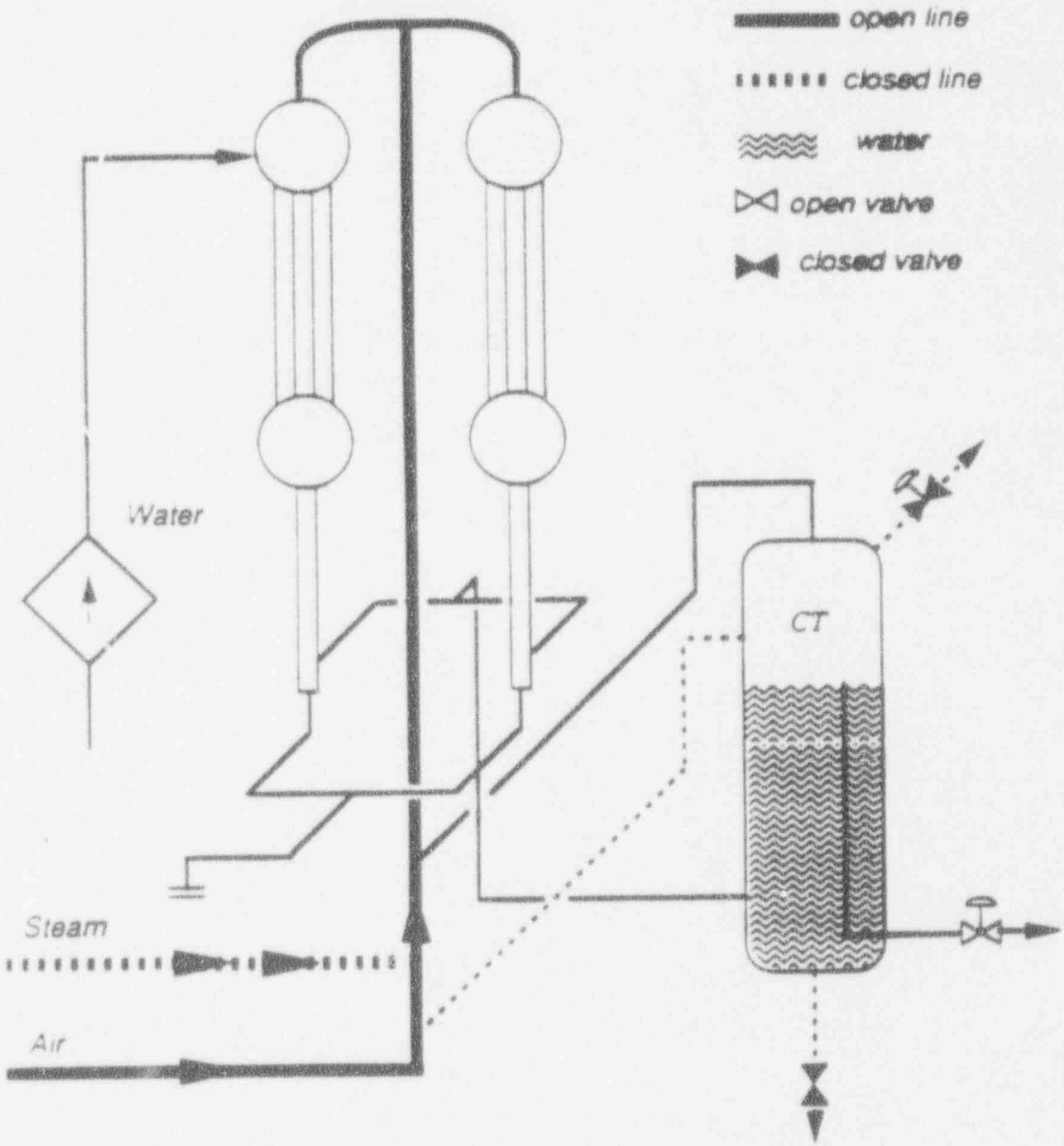
Actually, the steps concerning documents issue and verification procedures are dealt with in the internal procedure "Document Control" (0002-QQ), par. 5 ÷ 12 and SIET 0006 QQ 92 QP Sect. 4 .
Facility verification, mechanical and electrical sub-systems and controls, instrument installation, instrument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

Enclosure 2



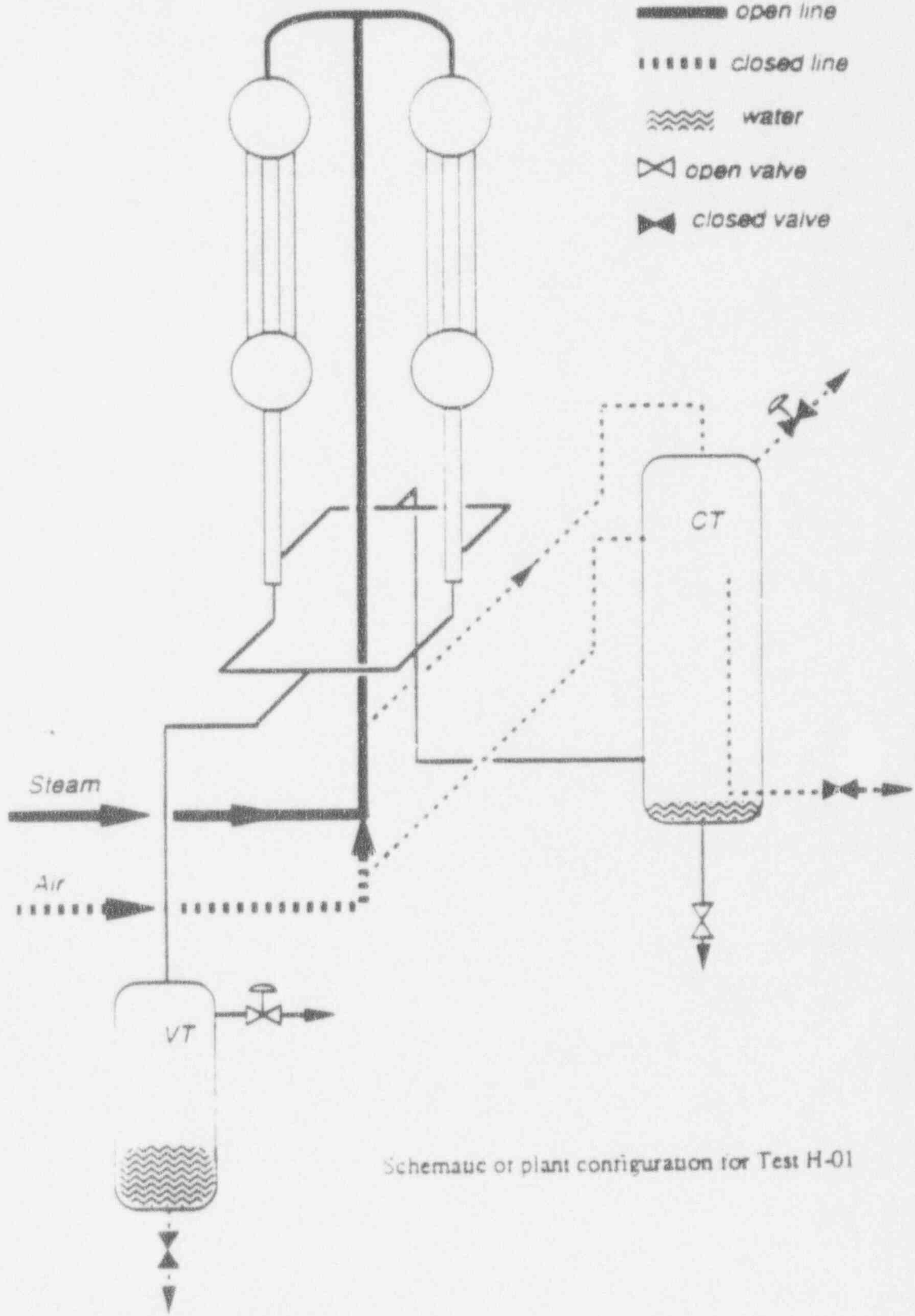
Schematic of plant configuration for Test C-03

Enclosure 3

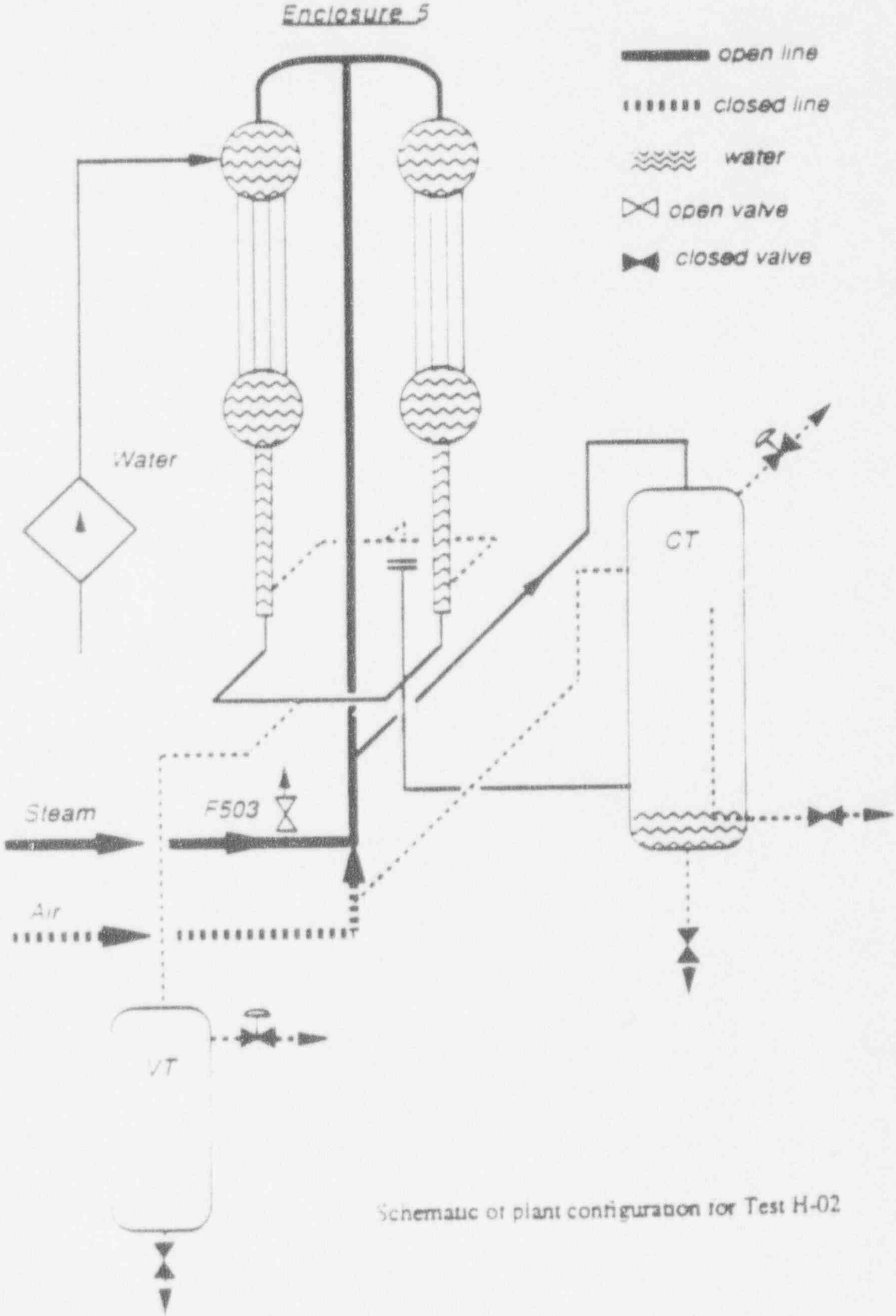


Schematic of plant configuration for test C-04

Enclosure 4



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 thePANTHERS-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, noding 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, noding 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.