ALPHA - THE LONG-TERM PASSIVE DECAY HEAT REMOVAL AND AEROSOL RETENTION PROGRAM

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Abstract

The Paul Scherrer Institute initiated the major new experimental and analytical program ALPHA in 1990. The program is aimed at understanding the long-term decay heat removal and aerosol questions for the next generation of Passive Light Water Reactors. The ALPHA project currently includes four major items: the large-scale, integral system behavior test facility PANDA, which will be used to examine multidimensional effects of the SBWR decay heat removal system; an investigation of the thermal hydraulics of natural convection and mixing in pools and large volumes (LINX); a separate-effects study of aerosol transport and deposition in plenum and tubes (AIDA); while finally, data from the PANDA facility and supporting separate effects tests will be used to develop and qualify models and provide validation of relevant system codes. The paper briefly reviews the above four topics and current status of the experimental facilities.

I Introduction

The Paul Scherrer Institute has recently initiated the major new experimental and analytical program ALPHA Advanced Light Water Reactor Passive Heat Removal and Aerosol Retention Program), which is aimed at understanding the long-term decay heat removal and aerosol questions for the next generation of Passive Light Water Reactors. The ALPHA project currently includes four major items: the large-scale, integral system behavior test facility PANDA (Passive Nachwaermeabfuhr und Druckabbau Testanlage; a separate effect test facility LINX (Large Scale Investigation of Natural Circulation and Mixing) for an investigation of the thermal hydraulics of natural convection and mixing in pools and large volumes; a separate-test facility AIDA (Aerosol Impaction and Deposition Analysis) for the aerosol transport and deposition in plena and tubes; while finally, data from the PANDA facility and supporting separate effects tests will be used to develop and qualify models and provide validation of the relevant system codes.

This paper presents the design concepts and scaling rationale used to define the PANDA facility, and briefly reviews the separate effects programs LINX and AIDA. The supporting system calculations for PANDA are being used to understand the behavior of the facility, relate this to similar calculations for the relevant full scale reactor.

II PANDA - An integral Containment Simulation Facility

IIA Introduction

A good understanding of the behavior of the relatively novel containment concepts proposed for the future advanced passive LWRs is of importance when assessing their safety. These concepts rely on natural circulation cooling modes; their long-term behavior includes the mixing of steam and non-condensable gases, condensation of such mixtures in parallel condenser units, large open tanks and water pools, and the mixing of fluids in large pools, air volumes, etc. Integral containment system behavior may exhibit multi-dimensional effects, due, for example, to incomplete mixing and varying modes of operation of parallel units. The PANDA facility has been designed to address such questions at a relatively large scale.

The PANDA facility consists of a 1.5 MW steam source and a number of large pressure vessels, typically 4 m in diameter and 8 m high, which can be interconnected by external piping and may contain internal structures, representing the various compartments of a variety of reactor containments. The vessels are fitted with instrumentation to measure fluid temperatures, levels, pressures and flows as well as steam and gas concentrations.

Currently the PANDA facility is to be used to examine multidimensional effects for the General Electric Simplified Boiling Water Reactor (SBWR) decay heat removal system. The SBWR utilizes two types of condenser units (Fig. 1) to remove the reactor decay heat, following a Loss-Of-Coolant Accident, from the reactor containment to an outside water pool. First, there are three Isolation Condensers (IC) connected to the reactor primary system, which are to remove the decay heat during a reactor isolation at full pressure. The PANDA facility includes scaled models of these units to investigate their behavior during an accident; it will not, however, simulate their high pressure, reactor isolation, decay heat removal function. Second, there are, currently, for the SBWR and PANDA, three low-pressure condenser units connected directly to the reactor containment (Drywell), referred to as Passive Containment Coolers or PCC units. The experimental facility PANDA will examine, on a large scale (1/25 volumetric), the system interactions between the multiple condenser units, and their heat removal capacity in the presence of non-condensable gases such as nitrogen and helium (as a simulant of hydrogen). The PANDA system behavior tests will extend the data base of previously performed experiments [2] to a much larger scale, study the interaction between the various PCC and IC units, and provide verification of integral system behavior under a variety of conditions.

The PANDA simulation of the SBWR (Fig. 2) consists of a representation of the reactor pressure vessel (RPV), reactor containment (Drywell) and suppression pool (Wetwell), as well as the Isolation Condenser and Passive Containment Cooler units and their associated water pools. Finally, condensate will be collected in a "condensate catch tank" simulating the Gravity Driven Cooling System (GDCS) pool in the SBWR. The PANDA facility is already constructed. The commissioning tests are near completion. An experimental test matrix is defined with the aim to provide necessary information for the US-NRC's certification process.

IIB General Guidelines

Early during the conceptual design phase of the facility, it was recognized that it is neither possible nor desirable to preserve exact geometrical similarity between the reactor containment volumes and the experimental facility. On the other hand, multidimensional containment phenomena such as mixing of gases and natural circulation between compartments may depend on the particular geometry of the containment building. The general philosophy followed in designing the experimental facility was to allow such multidimensional effects to take place by dividing the main containment compartments in two and by providing a variety of well-controlled boundary conditions (e.g. imbalances) during the experiments, so that the various phenomena could be studied parametrically under well-established conditions, and a behavior envelope of the system established. Carefully conducted parametric experiments can also provide more valuable data for code validation than attempts to simulate geometrically, but to an insufficient degree, the rather complex reactor system. Boundary conditions and the behavior of the interconnections between the various containment volumes can be controlled externally by software to study various system scenarios and alternative accident paths.

Beyond the general considerations stated above, in designing the PANDA facility and, in particular, the main vessels, the following general guide lines were followed:

- Full vertical height should be preserved, to correctly represent the various gravity head driving forces.

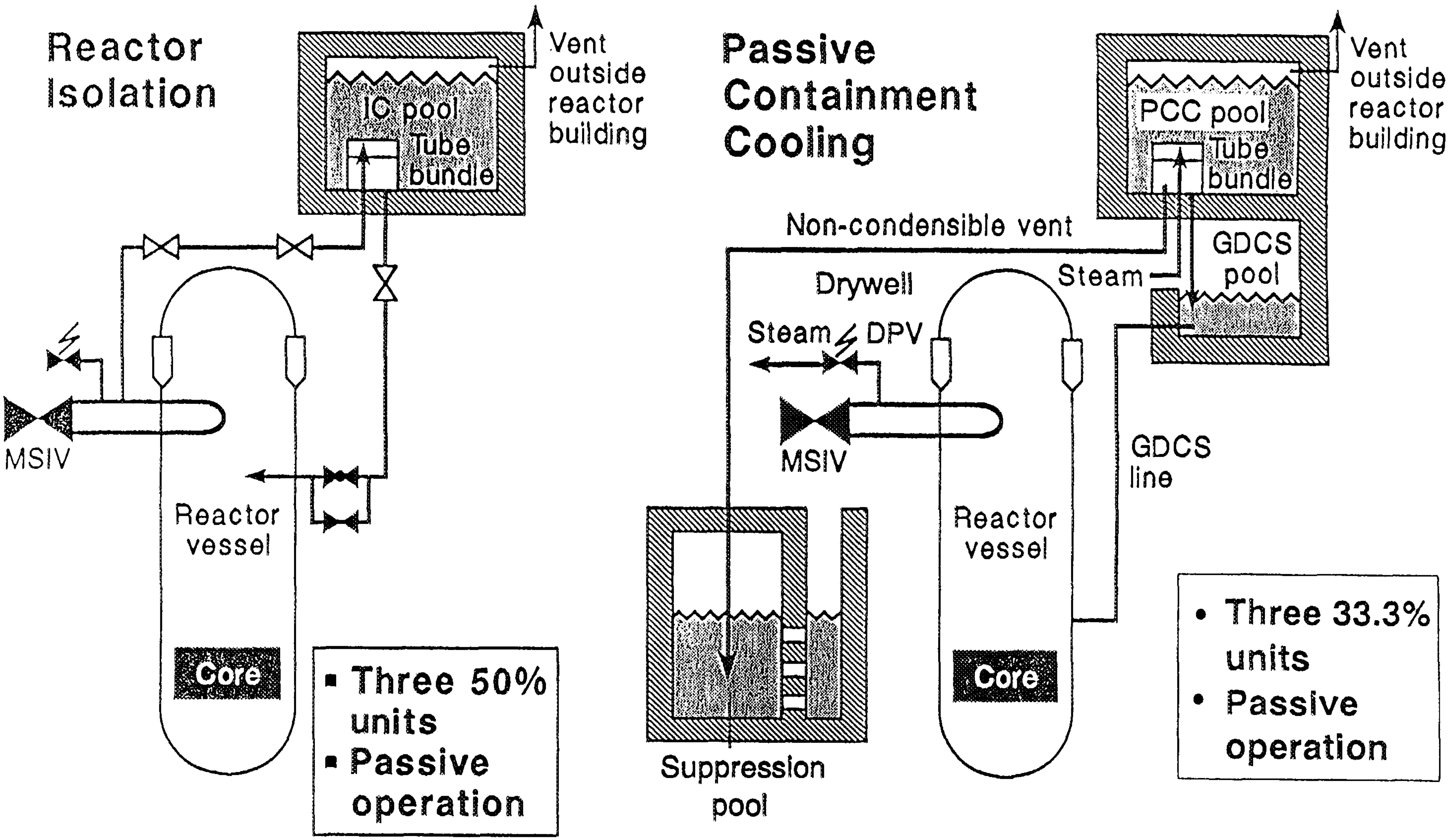


Figure 1 SBWR Isolation Condensers and Passive Containment Coolers

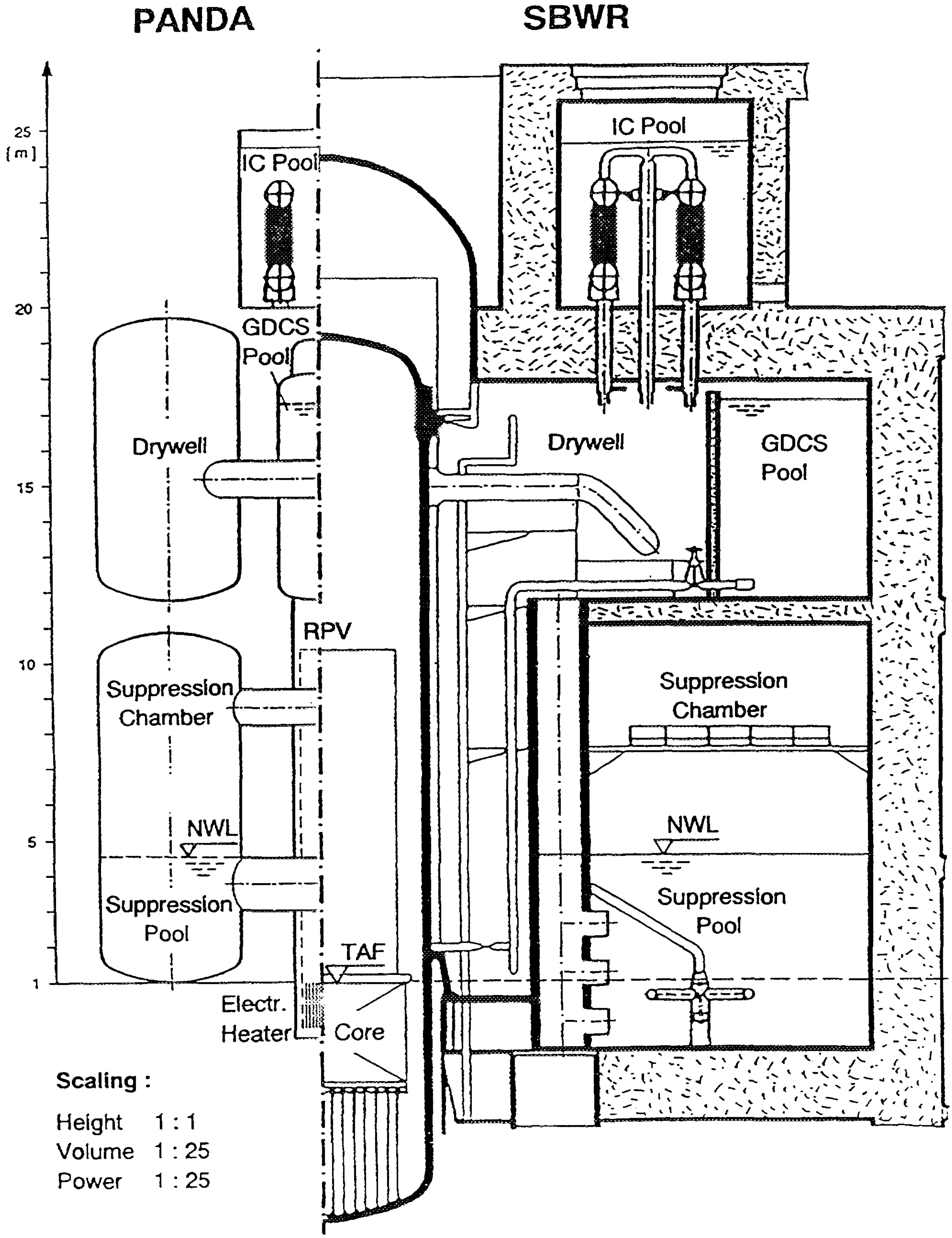


Figure 2 SBWR Containment and PANDA Comparison

- The system should be modular and use simple interconnected cylindrical vessels to simulate possible 3-dimensional effects in the SBWR annular geometry.

- Volumes should be minimized to the extent compatible with the preservation of the scaling factor chosen and the system behavior.

- The power-to-volume scaling ratio should be preserved and should be as large as practically possible.

- The experiments will be conducted under reactor pressure and temperature conditions. (The facility is designed for nominal operation at 10 bar and 180°C).

Figure 3 shows the current geometrical arrangement of the proposed PANDA facility with two interconnected Drywells, two interconnected Wetwells, the reactor pressure vessel (RPV), and a tank (GDCS Pool) to collect the steam condensate prior to returning it to the RPV. It was decided to represent the SBWR Drywell and Wetwell with two units in the PANDA facility, in order to better examine, in a systematic manner, the possible spatially non-uniform mixture of nitrogen and steam flowing through the condenser, IC and PCC units. It was considered necessary to be able to investigate the venting and purging of each of the condenser units for different mixtures of nitrogen and steam flowing into the venting of uncondensed steam, under such asymmetric conditions. The volumetric scaling of the PANDA facility shown in Fig. 3 is 1/25. Figure 2 shows the elevations of PANDA relative to those of the SBWR containment. All the SBWR heights are represented except those below the top of the active fuel (TAF). The argument for reducing the facility height by eliminating the fluid below the TAF was that this liquid is essentially inactive and is not required to correctly simulate the gravity heads. Similarly the large volume of water which is present at the bottom of the Wetwell and is only functional during reactor blowdown phase is not considered in the PANDA simulation since PANDA simulates the SBWR transients after this phase is over. Therefore, for a given facility budget it was considered preferable to eliminate these two volumes from each unit, and also to examine the energy deposition and distribution in the Wetwell pool, resulting from PANDA and so increase the overall scale of the facility. Eliminating dead volumes also decreases preconditioning times and fluid inventories and increases experimental flexibility.

II.C Scaling: The IC and PCC Condenser Units

The 1:25 scaling factor chosen for the PANDA facility is, of course, a compromise between several factors. On the one hand there is the requirement to keep the PANDA vessels within a manageable size and cost, while at the same time the desire is to construct as large a facility as possible, to provide a meaningful basis for extrapolation from the previous 1:400 scale Isolation Condenser decay heat removal experiments [2] to the full reactor scale. A critical factor that led to the choice of a 1:25 scale was the requirement that the condenser unit secondary side behavior should be representative of the units to be used in the SBWR. Figure 4 provides a schematic of a condenser module; there are two such modules per condenser unit in the SBWR (see [3] for more details). We can also see in Fig. 4 how it is possible to construct a unit at the PANDA scale by taking a slice from an SBWR condenser. Having made the decision to fabricate the PANDA condensers from a slice of the SBWR units, the only question then is how wide this should be, and Fig. 4 and shows how a 3-tube-wide slice corresponds to a scale of 1:25. This is the minimum width that will permit some tubes to be totally surrounded by other tubes. In all other respects (height, pitch, diameter, and wall thickness) the PANDA condenser tubes are identical to those to be used in the SBWR.

Adopting the above procedure for the IC produces a single unit in PANDA that has two times the tube area, at the 1:25 scale, of that of an SBWR IC. This means that the PANDA

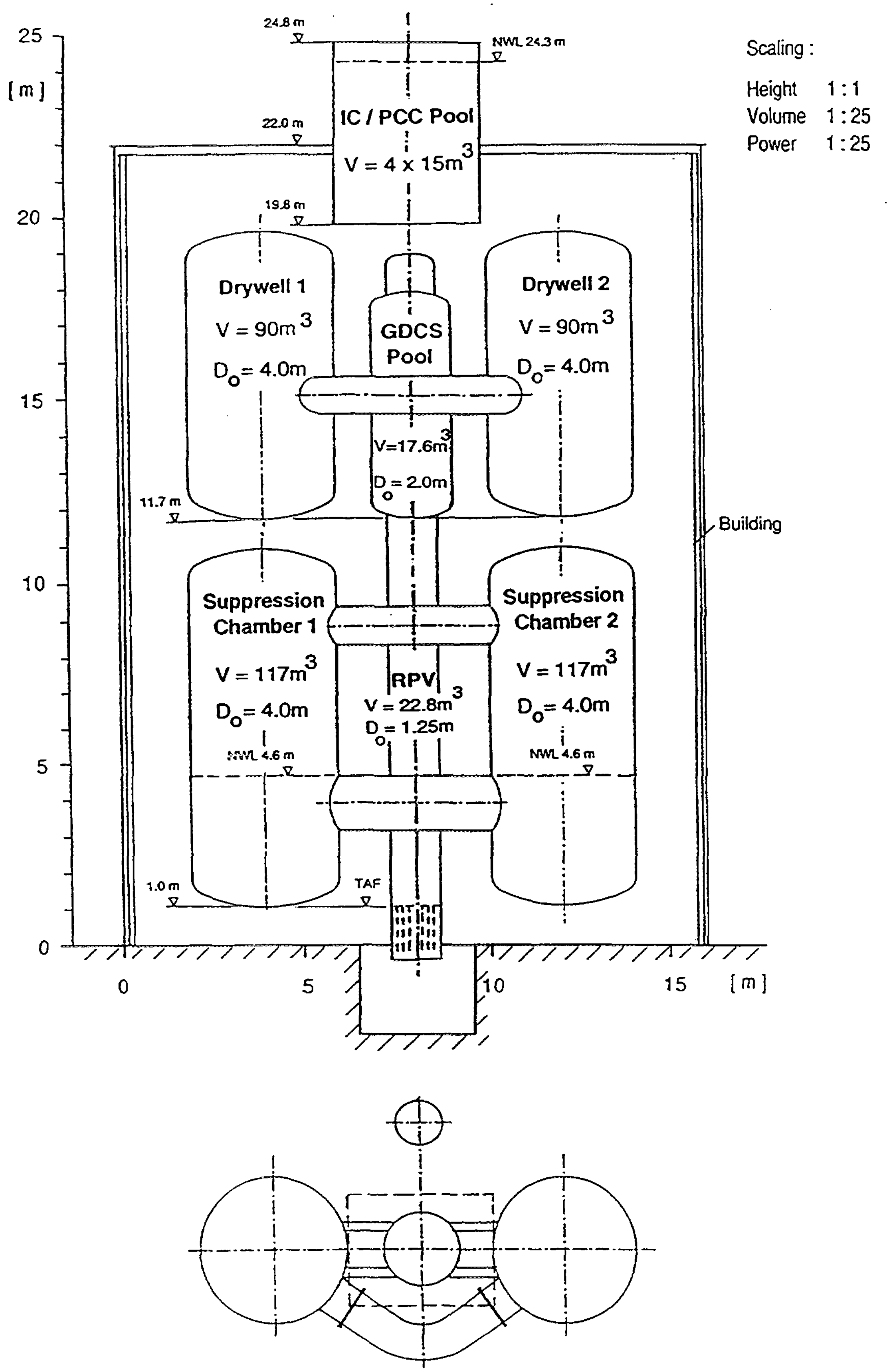


Figure 3 PANDA Experimental Arrangement

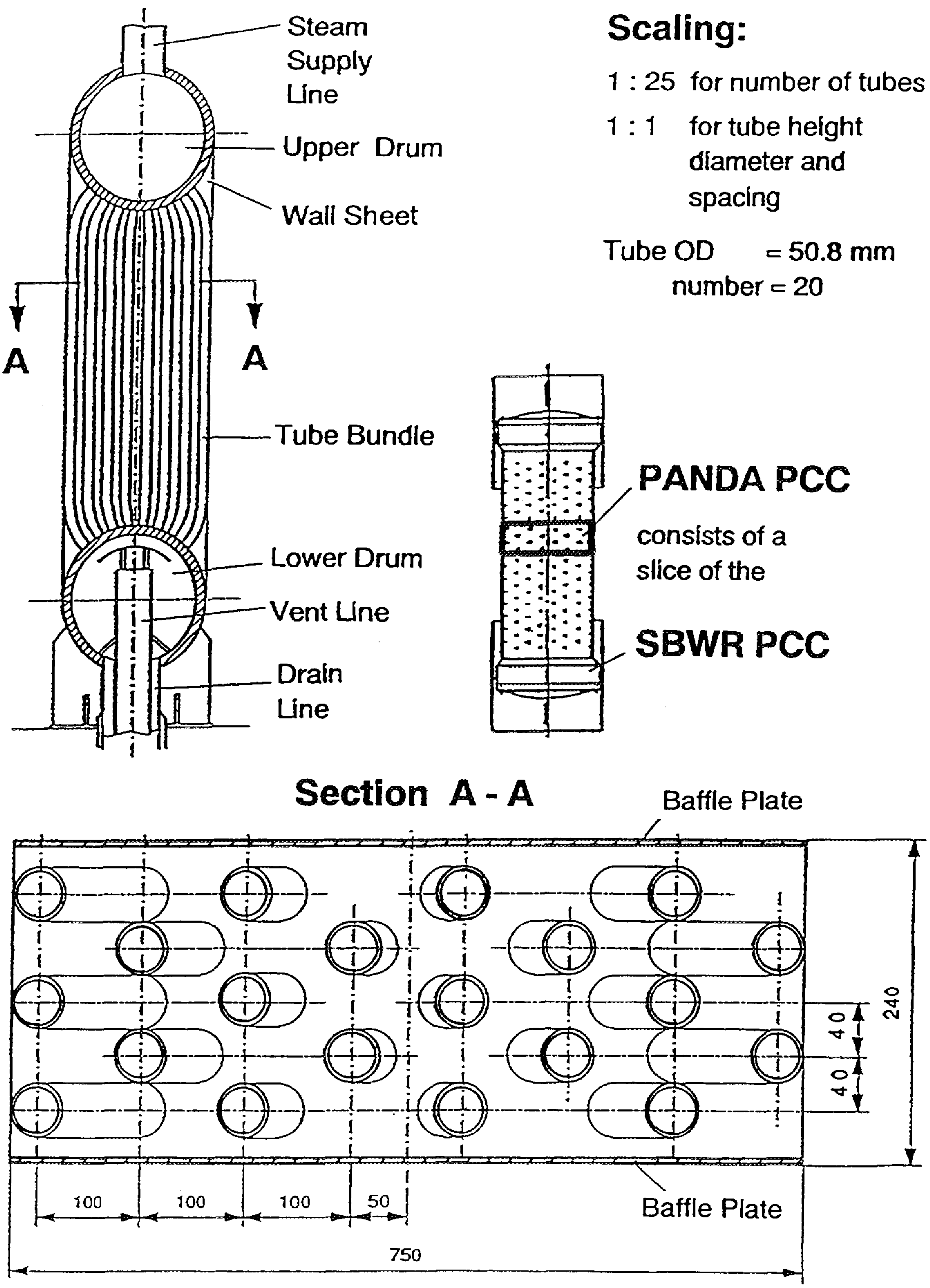


Figure 4 PANDA and SBWR Condensers

facility has four condenser units, three equivalent to the three SBWR PCC and one equivalent to three SBWR ICs.

IID The PANDA Vessels and Power Source

A schematic of the PANDA vessels is given in Fig. 3 while anisometric view is shown in Fig. 5.

As a example of the application of the general guidelines stated above, as well as of other secondary considerations, the design of the PANDA Wetwell vessel is outlined as follows:

- In order to preserve the pressure response of the entrapped non-condensable gas, it is necessary to scale the net Wetwell vapor space.

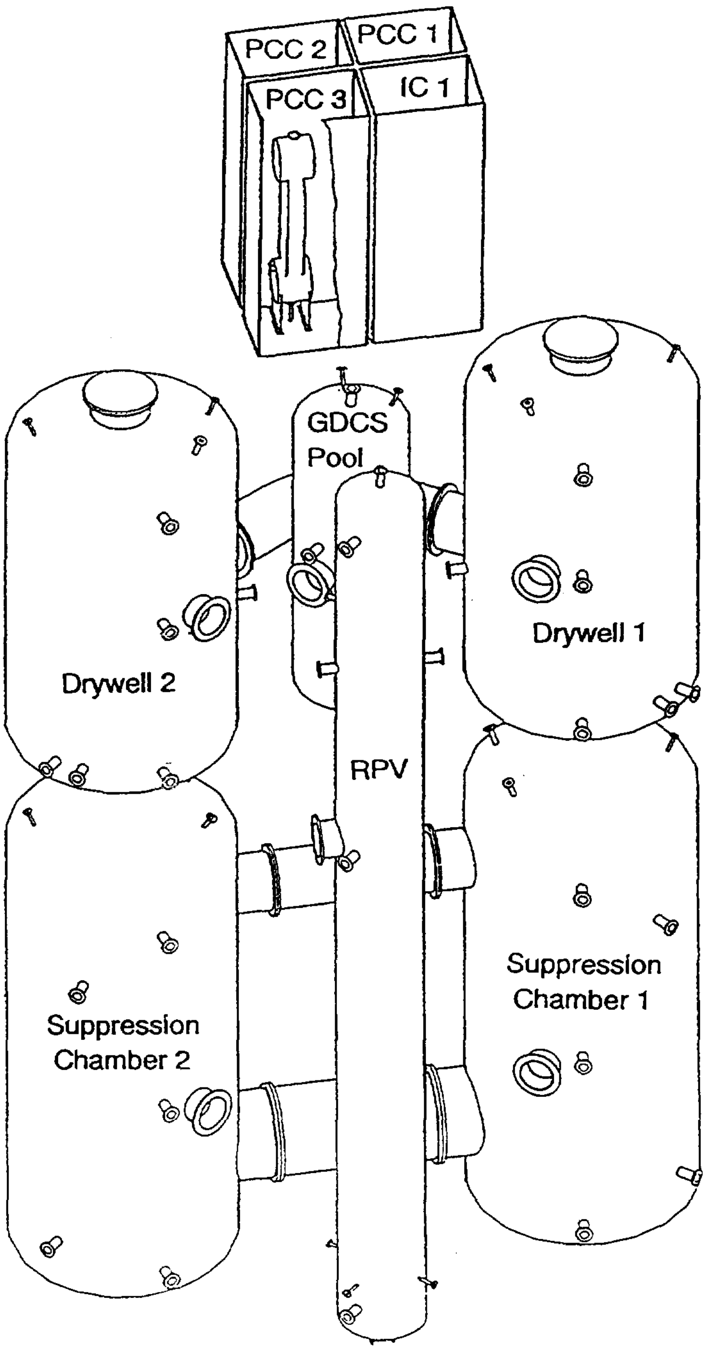


Figure 5 Isometric View of PANDA Vessels

- To have a correct representation of the evaporation/condensation processes at the pool surface, it is necessary to correctly scale the total Wetwell pool surface area.

- To provide a representative volume of water with which the uncondensed steam vented into the suppression pool can mix; the water pool depth must extend sufficiently below the condenser vent line. The suppression pool depth was also required to be large enough to accommodate at least the topmost main (horizontal) vent and the Wetwell-to-RPV equalization line. This was, in fact, the limiting factor in determining the pool depth.

In this manner it was possible to define the Wetwell dimensions. Similar procedures were also used to define the Reactor Pressure Vessel (RPV) and Drywell. In the case of the Drywell, the most important parameter to scale (for a well-mixed system) is the total volume, since this and the power level determine the venting time of the Drywell nitrogen to the PCC units.

The lower part of the Drywell volume surrounding the RPV was not included in the height of the PANDA Drywell volume, since it was felt that possible natural circulation phenomena taking place in this annular volume (heated on one side by the RPV) could not be adequately modeled. The volume of the annular space was, however, included in the PANDA Drywell volume.

For ease of construction it was considered desirable to have the Drywell and Wetwell tanks of the same diameter. Not all processes, and in particular the detailed mixing of the nitrogen and the steam from the RPV in the Drywell and the mixing of the uncondensed steam with the suppression pool water, can be accurately simulated in a scaled facility such as PANDA. In these instances separate effects studies, both experimental and analytical (see Section 3), will be used to guide parametric studies in the PANDA facility.

For example, nitrogen may be injected into the Drywell to simulate the slow convection of trapped nitrogen from a compartment with a restricted connection to the main Drywell.

The last two vessels shown in Figs. 2, 3 and 5, are those of the condensate catch tank (labeled GDCS pool) and the IC/PCC water pool. The requirements for these two vessels are somewhat different from those of the RPV, Drywell, and Wetwell. For example, for the PANDA IC/PCC water pool, in addition to providing sufficient water to keep the condenser tubes covered for a reasonable time (say 24 hours), the main requirement was one of flexibility. An element of the design was the requirement that the IC/PCC units could be re-configured in as many ways as possible, to follow possible changes in the SBWR design, without major impact on the program cost and/or time schedule. Also, there was a requirement to have the capability of re-filling the pool, during the course of an experiment, with water at different temperatures, in order to examine a variety of possible SBWR long-term depressurisation strategies. As can be seen from Fig. 5, the IC/PCC pool has four inter-connected compartments and are placed on the roof of the PANDA building (Fig. 3).

The power to the PANDA facility is provided by electrical heaters placed near the bottom of the RPV (Fig. 6). The heaters are not designed to represent the reactor core, but are placed so that their tops have the same relative elevation as the top of the active fuel (TAF) in the SBWR. The power level required for PANDA was determined on the basis that a PANDA transient would be initiated after reactor blowdown and follow the emptying of the GDCS water into the RPV. These events are predicted to occur within one hour of accident initiation and reactor scram, and so the required PANDA power level was set to be equal to the scaled decay heat one hour after scram. For a 1800 MW reactor, the decay heat after one hour is approx. 24 MW and so, for PANDA, approx. 1 MW of power is required. In order to provide flexibility of operation, the PANDA heaters have a maximum installed capacity of 1.5 MW. A controller is provided to follow accurately any given decay heat curve.

II.E Valves, Piping, and other components

The piping configuration of the PANDA facility is shown in Fig. 6, and a number of features of the design are worthy of explanation.

- All the lines (pipes) are valved to provide maximum flexibility and ease of re-configuring the system with minimum cost and time delay.

- The schematic (Fig. 6) shows the steam line, drain line and vent line to each of the condenser units, and the PANDA simulation of the main (horizontal) vents. The main vents are not be fully scaled, since they are not predicted to clear during the course of a PANDA transient due to the small Drywell to Wetwell pressure drop, which results from the fact that the PANDA transients are not initiated until one hour after scram.

- Also shown are two vacuum breakers, each one connecting one of the two Drywell-Wetwell vessel combinations. The vacuum breakers are predicted [3]to have a major influence on the behavior of the PANDA facility and are therefore a critical element in both the design of the SBWR containment and PANDA. Programmable control valves are therefore used in PANDA to simulate the SBWR vacuum breakers; this will allow a variety of SBWR vacuum breaker designs to be tested with only software, rather than hardware, changes.

Finally, Fig. 6 shows the water and gas supply lines that are used to initialize any given PANDA experiment. Sufficient flexibility is built into the facility to investigate the effect on the transient behavior of, for example:

- A variety of suppression pool water temperature distributions, e.g. well mixed, stratified,...

- Water pools in the Drywell to simulate liquid line breaks, e.g. GDCS or IC return line breaks.

- A variety of IC/PCC water pool temperature distributions.

II.F Heat Losses and Heat Capacities

Major factors that can influence the behavior of a small scale test facility, in comparison to the reactor, are the relative magnitude of heat losses and system heat capacities. In a wide range of integral test facilities it has been necessary to go to significant sophistication, including the use of guard heaters, to reduce heat losses to an acceptable level. In general, heat losses increase in inverse proportion to the scale of the facility, as the surface area to volume ratio increases at smaller scales. In this respect, PANDA at 1:25 scale is in a relatively good position. In addition, test facilities may have extra heat losses associated with additional valves, instrument penetrations, etc. Two design goals have been set for the PANDA facility:

- The heat losses, at all times during any transient, should be less than 10% of the prevailing decay heat level. Initial estimates indicate that this is achievable using commercially available insulation and that guard heaters are not required.

- All the piping, RPV, Drywell, Wetwell, etc. should be capable of being configured to separately estimate their individual heat losses, for the range of power levels expected during the course of a transient.

Heat losses from the SBWR containment during the first 1 to 3 days were evaluated, and found to be very small i.e. less than 1%. The pipes and the vessels are insulated in order to bring the experimental heat loses to the values found for the SBWR.

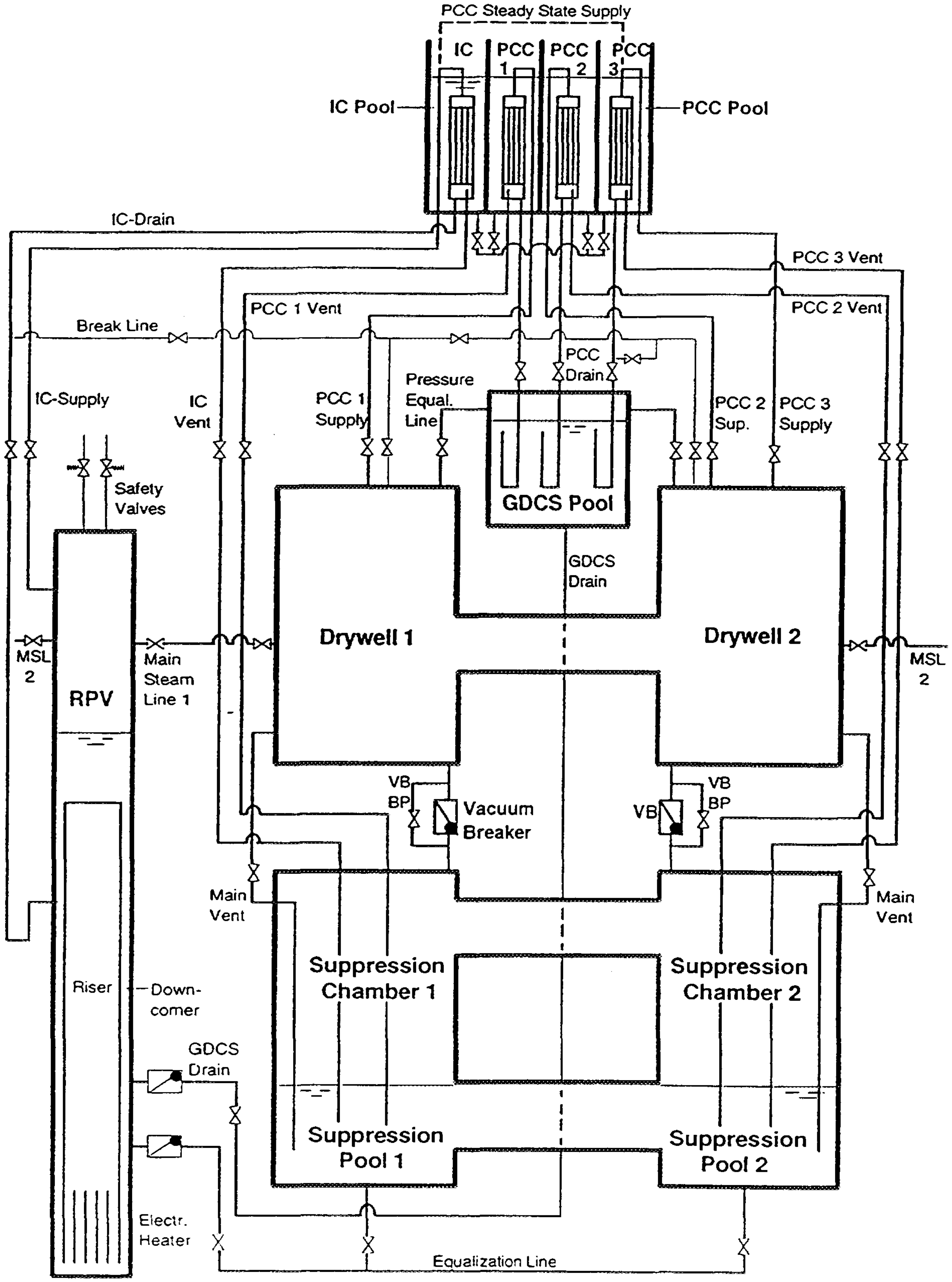


Figure 6 PANDA Schematic Including Piping Configuration

IIG Instrumentation

For basic types of measurements are made to monitor the behavior of the PANDA facility and to provide information for analytical code qualification. These are:

- vessel wall, vapor space and liquid temperatures
- absolute and differential pressures, differential pressures to measure water levels
- vapor and liquid mass.

As an example of the number and location of instrumentation to be used, Figures 7 and 8 show the distribution of the mass flow, phase detectors and oxygen sensors. As can be seen the mass flow measurements are concentrated in the steam/nitrogen and water pipes.

II.H Initial Conditions

As was described above initial conditions will be established in PANDA equivalent to those in the SBWR containment about 1 hour after reactor scram. During the first hour of an SBWR transient, the RPV will blowdown through the depressurisation system, and the emergency core cooling water in the GDCS will pools drain into the RPV. As the blowdown proceeds a large fraction of the nitrogen in the Drywell will be swept into the Wetwell leaving typically less than 10% in the Drywell, while the transfer of this nitrogen and the compression of the Wetwell gas space will raise the pressure to between 2.0 and 3.0 bar.

The following provides an example of the conditions that might be expected at the beginning of a PANDA transient.

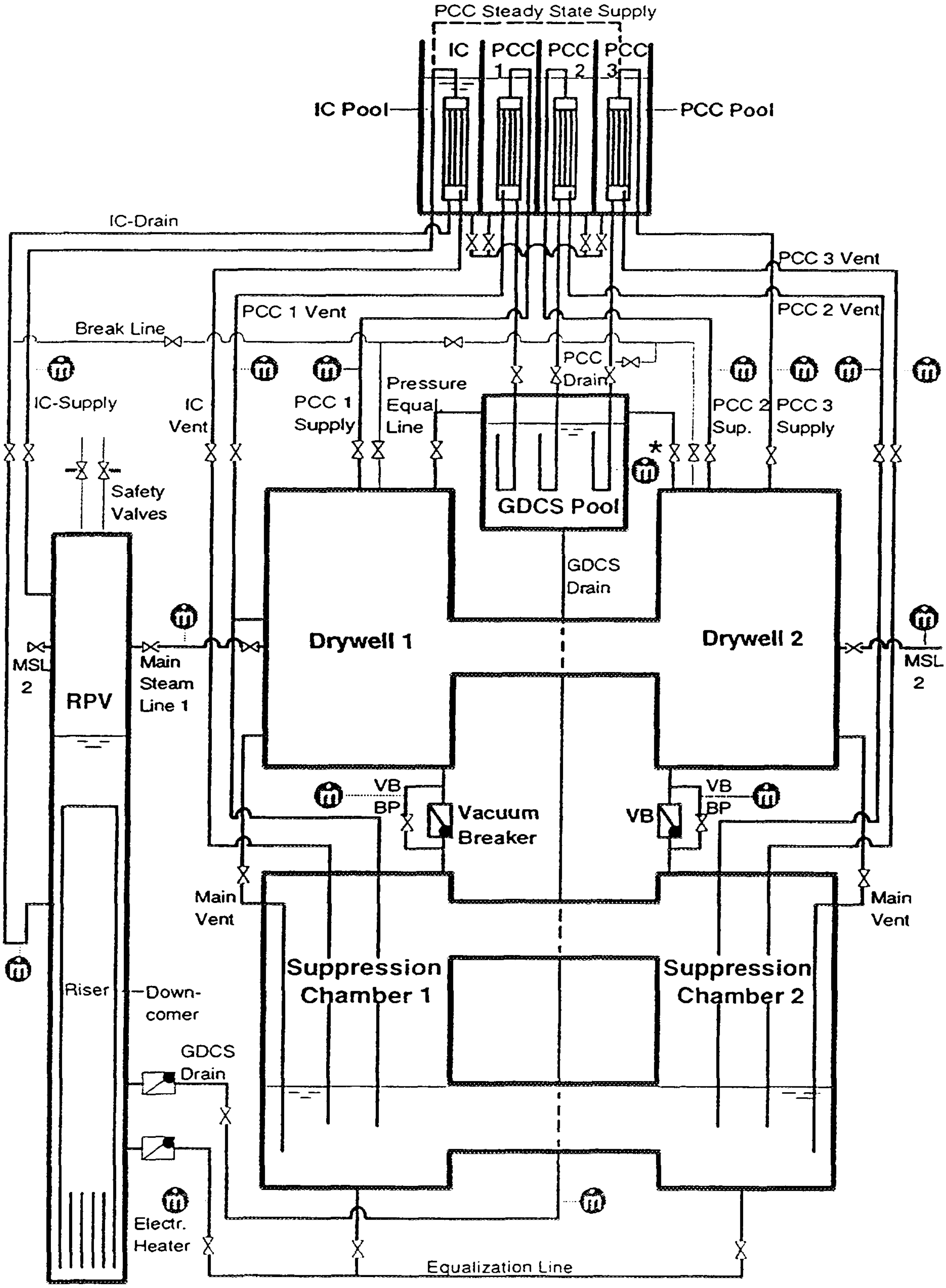
	Wetwell	Drywell	RPV
P_{TOTAL} (bar)	3.0	3.0	3.0
P_{N2} (bar)	2.8	0.3	—
T_{LIQ} (°C)	60	—	—
T_{SAT} (°C)	—	130	133.5

Parameter variations of the above will include

– absolute pressure (bar)	2.0 to 4.0
– Drywell Nitrogen fraction (%)	1 to 40
– Wetwell pool water surfaces temperature (°C)	30 to 70

III The LINX Program

In support of the large-scale integral system behavior PANDA tests, an investigation of natural circulation and mixing phenomena in single- and multi-phase/multicomponent systems in large pools will be conducted. This work will rely heavily on the application of Computational Fluid Dynamics (CFD) tools adapted for multiphase flow and verified against a range of both large- and small-scale separate-effects mixing and natural circulation experiments to be performed at PSI. The areas of interest and investigation include the mixing of hot and cold liquids in open pools, the mixing and energy distribution within liquid pools resulting from the submerged injection (venting) of steam and gas mixtures, and the mixing of steam, nitrogen and, possibly, other gases in large, interconnected volumes.



* For steady state tests only

Figure 7 PANDA Instrumentation (Mass flows/flow indicators)

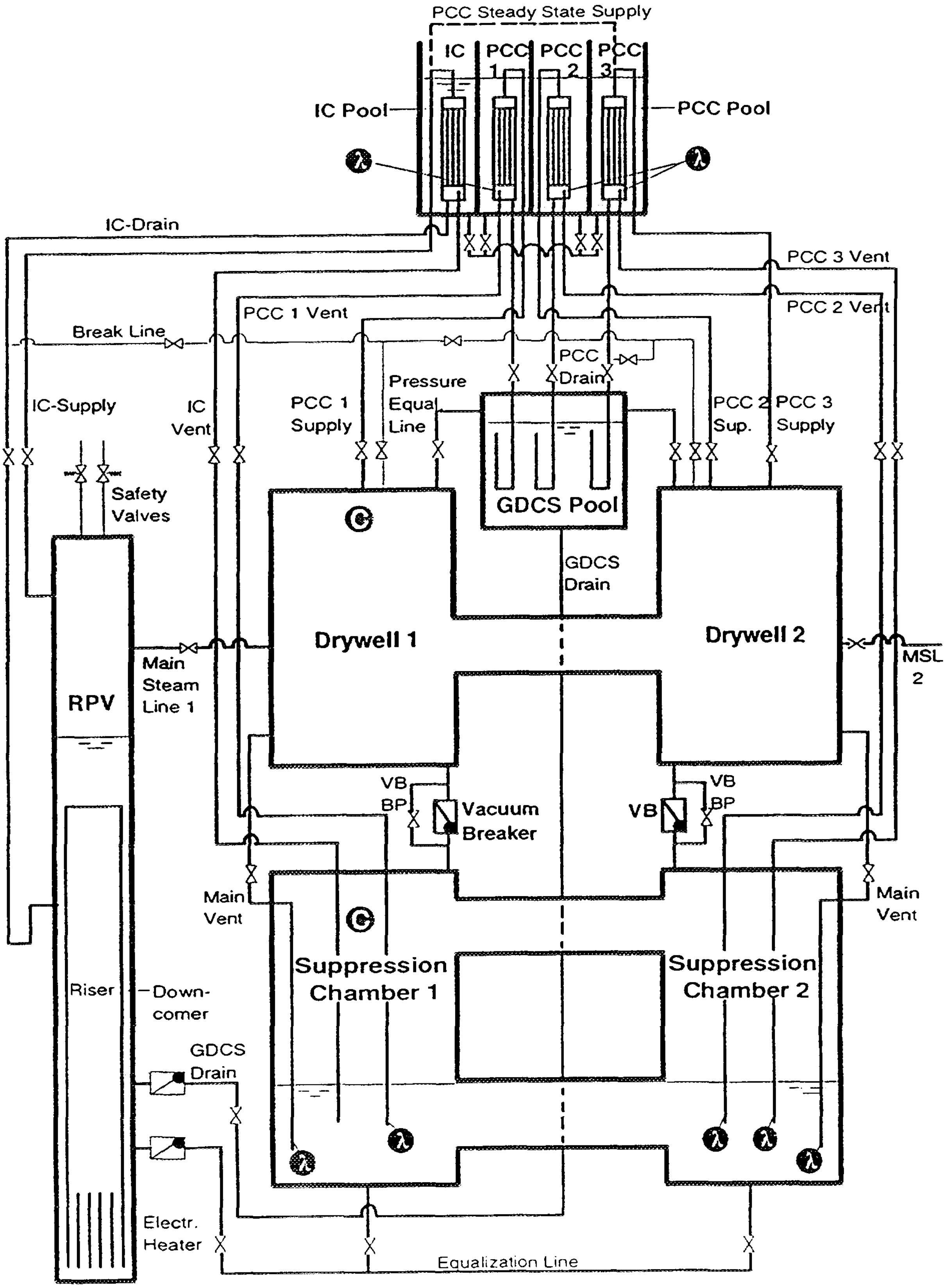


Figure 8 PANDA Instrumentation (Phase detectors and oxygen sensors)

In particular, this program of work will support the PANDA experiments and provide additional help in scaling the PANDA results to the SBWR, in two broad areas. These are: the condensation and mixing of the uncondensed steam that flows into the suppression pool from the IC and PCCs, and the mixing of steam and nitrogen in the Drywell. In the first of the two areas described, there are several phenomena that will need to be investigated separately. For example, there is the condensation of the steam initially in the presence of the non-condensable gas (nitrogen), and then there is the mixing of the resultant hot water with the bulk of the suppression pool as the hot water rises in a narrow buoyant plume to the pool surface. An initial investigation of the last of these effects was initiated at PSI [4]with the performance of some small-scale thermal plume mixing experiments. Figure 9 shows both a schematic of the plexiglas tank and electrical heater used in these experiments, and examples of the resultant rise in the water temperature as the water heated by the electrical heater rises in a very narrow plume to the pool surface and then spreads down in a 1-dimensional manner as the hot water replaces the cold water entrained in the rising plume. The LINX facility, schematically shown in Figure 10, composed of a large pressurized tank, a complex piping system for non-condensable gas and steam injection and a comprehensive data measurement and acquisition system, is currently under construction.

IV The AIDA Program

Under severe accident conditions, fission products in the form of aerosols may escape from the RPV into the various compartments of the reactor containment. It is therefore possible that the PCC units, which remove the decay heat, may be subjected to aerosols. The possible formation of an aerosol layer at the tube entrance (reduction of free flow area at the tube entrance) and on the inside tube surface (reduction of free flow area in the tube) may cause a new flow distribution into the tubes. This may dynamically change the heat removal characteristics of the system. This change may appear as a result of a) the number of tubes which are properly active becomes reduced therefore, b) some of such tubes (reducing in number with time) will continuously receive more steam than they can condense, and hence, the condenser efficiency may substantially be degraded. The long-term pressurization of the SBWR containment, following a postulated severe accident, depends on the continued function of the PCC units, and this in turn on their aerosol behavior. The goals of the AIDA program are to:

a) Experimentally determine the degree of PCC condensation degradation in the presence of aerosols.

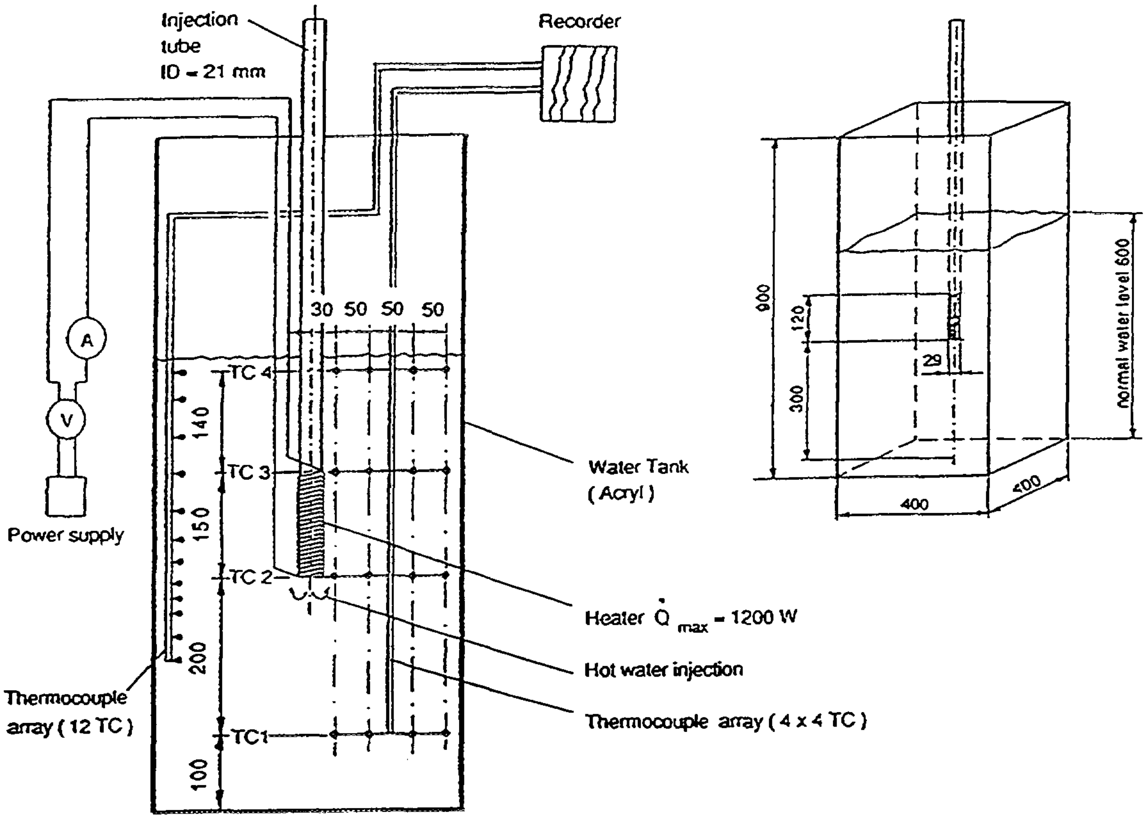
b) Investigate aerosol behavior in the upper dome.

c) Investigate aerosol behavior under strong condensation in condenser tubes.

d) Investigate aerosol transport out of the condenser unit with the condansate and non-condensable gas flow.

e) Provide the basis for the development of a physical model for aerosol behavior and its effects on the thermal-hydraulics in the PCC units.

A versatile and multiple purpose aerosol testing facility was constructed at PSI in conjunction with other aerosol programs. Two plasma torches, two reaction chambers, a mixing tank, steam and non-condensable supply systems are the main components of the facility. The system is computer controlled and can produce aerosol particles at a desired steady mass flow rate and concentration. The particles are carried with a carrier gas, composed of steam and non-condensable gas at a desired composition. The plasma torches used for aerosol generation produces aerosol particles composed of up to three components from CsI, CsOH and MnO or SnO_2 with a maximum concentration of 20 g/m^3. Experiments can be performed with 0 to 95% steam to total gas (steam and non-condensable) ratio, a steam flow rate of up to 250 kg/hr and non-condensable gas flow rate of up to 280 kg/hr and a system pressure of up to 5 bar.



Measured Water Temperature Distribution

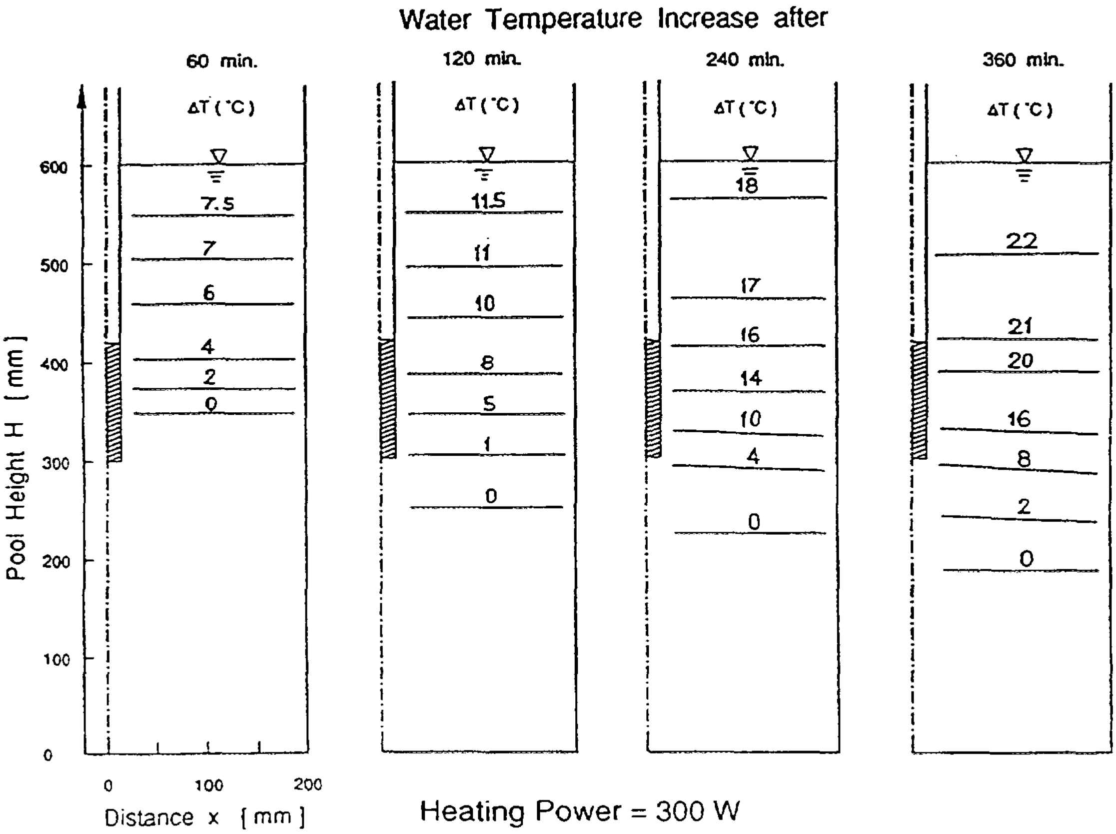


Figure 9 Mixing Experiments; Facility and Results

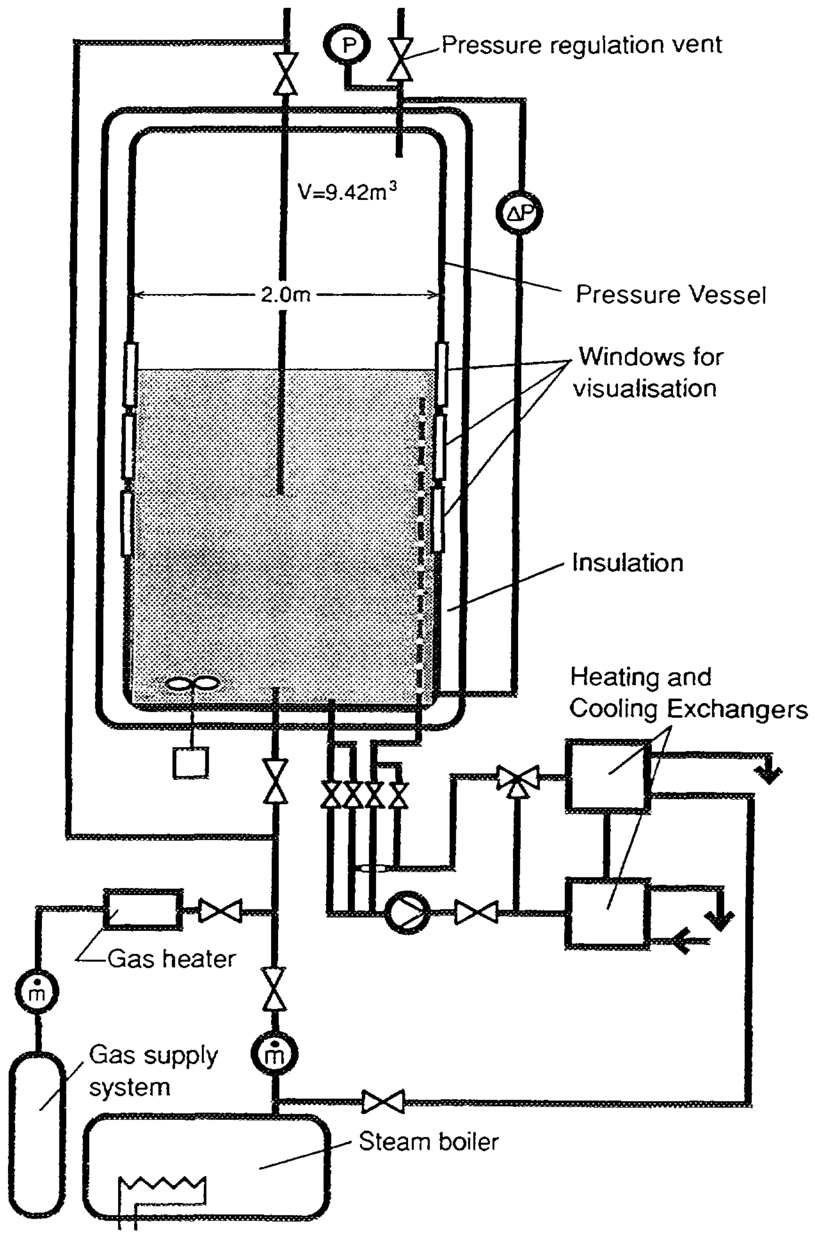


Figure 10 LINX Experimental Arrangement

A slice of the SBWR's PCCS condenser unit, containing full height 8-tubes, full diameter lower and upper dome was constructed. Figure 11 schematically shows the main components of the AIDA facility. Figure 12 presents the AIDA condenser unit. The AIDA condenser tubes are either made of glass or steel. The glass tubes are intended mainly for the visualization of the phenomena. The tubes are heavily instrumented with thermocouples to measure the gas and wall temperatures as well as the heat flux across the tube wall. The coolant channel, surrounding the tubes contain glass windows to facilitate visualization of the possible aerosol deposition-transport phenomena in the glass tubes. The water which is flowing in the coolant at a desired small velocity and at a predifined temperature of up to 80 ^oC simulates the heat transfer conditions expected to occur in the PCCS pool. The condensed water is collected in a tank (Condensate tank) simulating the GDCS pool. The non-condensable gas and uncondensed steam flow in a tank (Scrubber tank) which condenses the steam and scrubs the aerosol particles carried with the steam-gas flow. The condensate which is produced in Scrubbing tank is collected in another tank (Collection tank). Scrubbing and Collection tanks simulate the behavior of the Wetwell. The pressures in the condensate and collection tanks

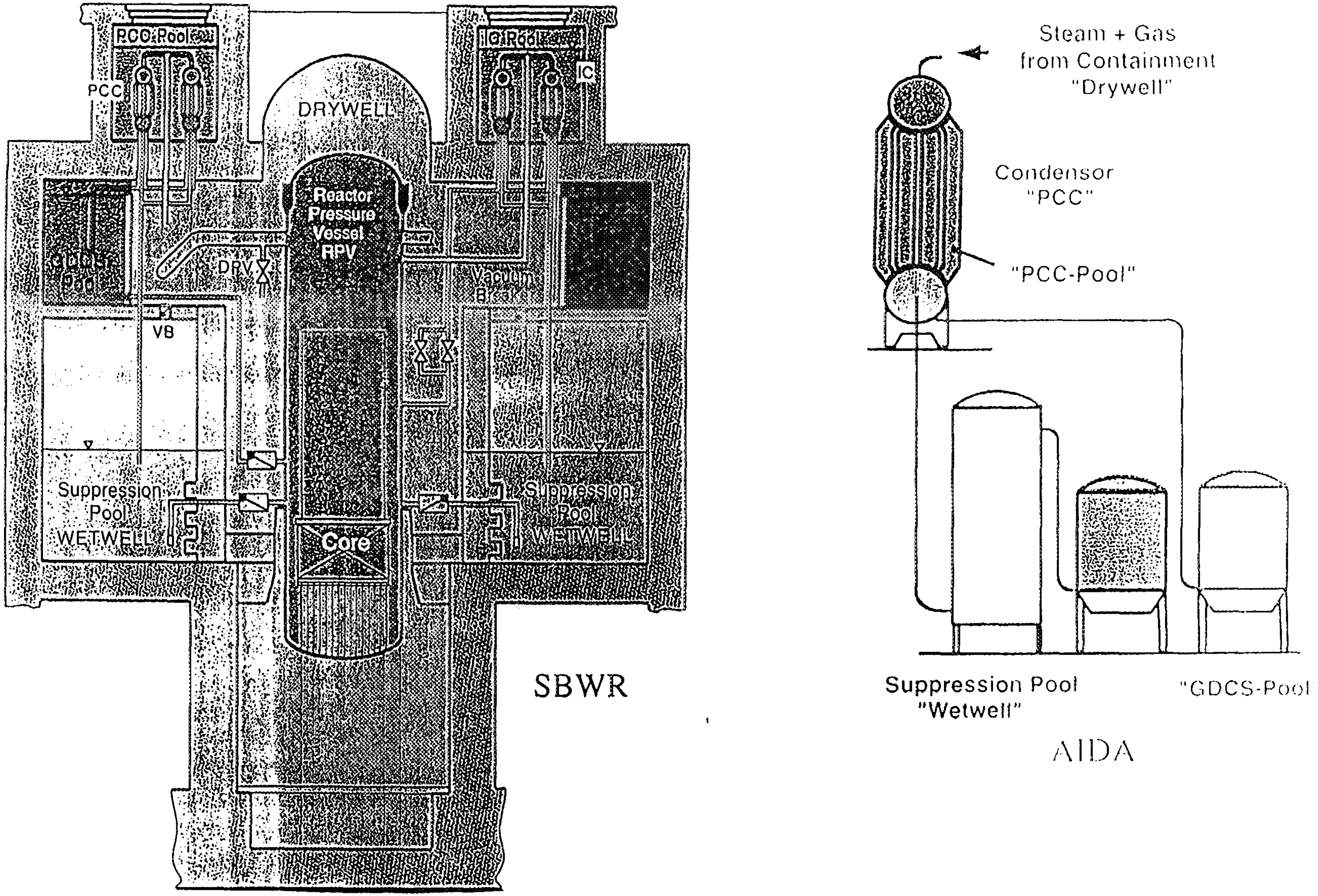


Figure 11 Schematic representation of SBWR and AIDA Test Rig

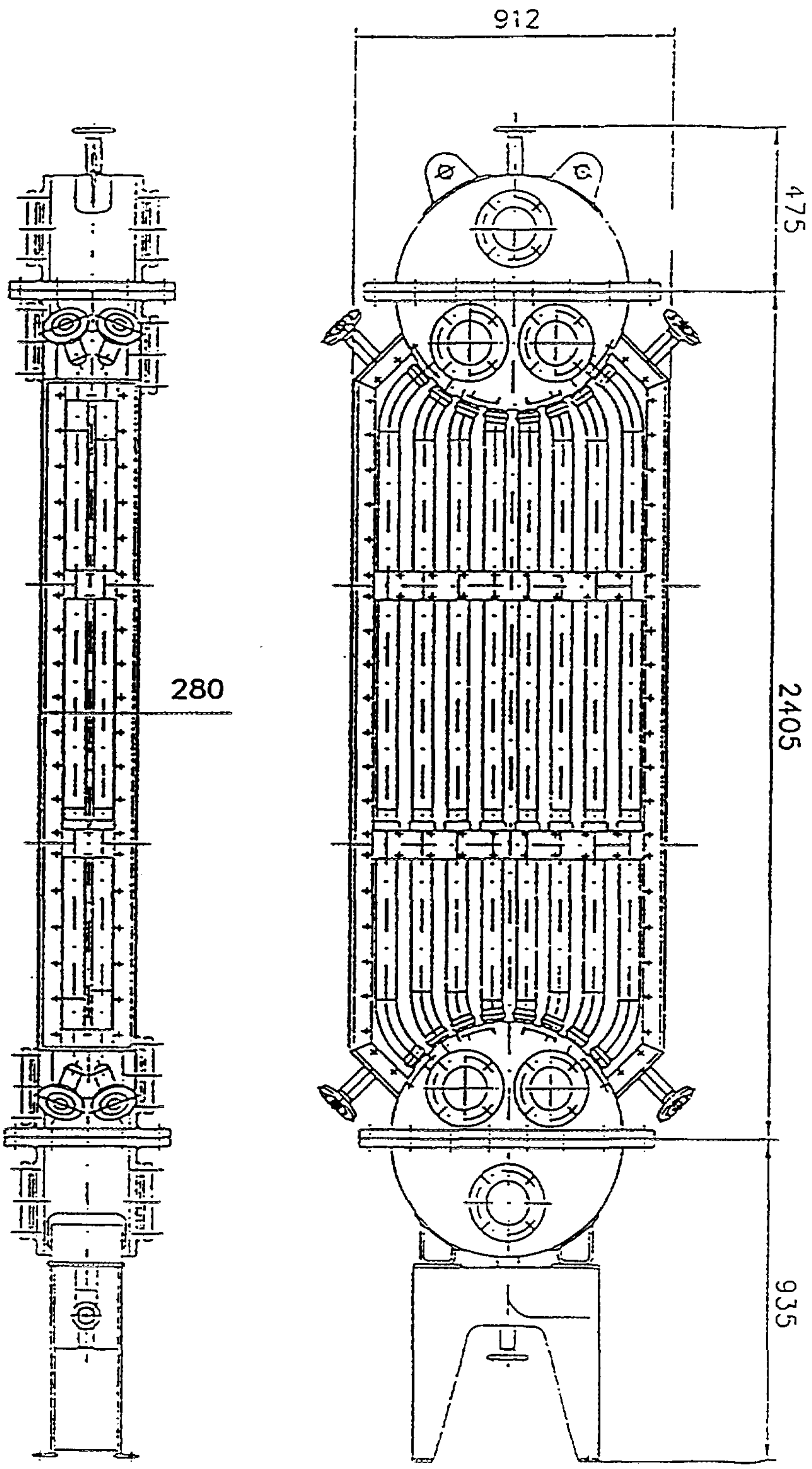


Figure 12 AIDA Condenser

are regulated to obtain the system pressure which simulates the Drywell and Wetwell pressures. The facility is instrumented with several devices to provide information on a) energy transfer due to steam condensation in and outside of the condenser, b) steam mass balance due to steam condensation in and out of the condenser, c) aerosol mass balance. The instruments provide on-line data on thermal-hydraulic behavior. The data is displayed on a computer screen to continuously monitor the system response with or without the presence of the aerosol particles. The aerosol instrumentation comprises of a) off-line devices, like filters, impactors, and deposition coupons and b) on-line devices, like, photometers, ion detection devices. A special data acquisition system is developed. Commissioning phase is close to the completion. A test matrix is prepared.

V Summary and Conclusions

The major new experimental and analytical program ALPHA initiated at the Paul Scherrer Institute has been briefly described. This program is aimed at understanding long-term decay heat removal and aerosol questions for the next generation of Light Water Reactors. The ALPHA project includes four major items: the large-scale, integral system behavior test facility PANDA; an investigation of the thermal hydraulics of natural convection and mixing in pools and large volumes (LINX); a separate-effects study of aerosol transport and deposition in plena and tubes (AIDA); while finally, data from the PANDA facility and supporting separate effects tests will be used to develop and qualify models and provide validation of relevant system codes.

PANDA consists of a 1.5 MW heat source and a number of large pressure vessels that can be interconnected by external piping to represent a variety of reactor containments. In the first instance, PANDA will be used to simulate the response of the SBWR containment to a Loss-Of-Coolant Accident. PANDA represents a 1/25 volumetric scale, the SBWR RPV, Drywell, Wetwell, and condensers. The PANDA facility has been designed to capture the asymmetric behavior of the various IC and PCC units, arising from the non-uniform spatial distribution of non-condensable gases, and their influence on the condensation process. It therefore uses two large tanks to represent the SBWR annular geometry of the Drywell and Wetwell. The facility is erected and is in commissioning phase. A test matrix has been designed to aid General Electric to provide data for the SBWR certification process.

It is recognized that no scaled experiment can possibly provide a perfect simulation of all aspects of the physical behavior of a full scale system. In response to this, and to the fact that two areas of particular importance in determining the SBWR containment pressure are the mixing of the nitrogen (and other non condensable gases) and the steam in the Drywell and the mixing of the uncondensed steam flowing into the Wetwell water pool, a companion, separate-effects program (LINX) was also initiated. LINX comprises both small- and large-scale experiments and analytical work, using simple 1-dimensional methods and 3-D CFD codes, to investigate natural circulation and mixing, of single- and multi-phase/multicomponent systems in large pools. The facility is currently under construction.

Under severe accident conditions, fission products in the form of aerosols may escape from the RPV into the various compartments of the reactor containment. It is possible that the PCC units which remove the decay heat, may be subjected to aerosols. The possible formation of an aerosol layer at the tube entrance (reduction of free flow area at the tube entrance) and on the inside tube surface (reduction of free flow area in the tube) may cause a new flow distribution into the tubes. This may dynamically change the heat removal characteristics of the system. This change may appear as a result of a) the number of tubes which are properly active becomes reduced therefore, b) some of such tubes (reducing in number with time) will continuously receive more steam than they can condense, and hence, the condenser efficiency is reduced. The long-term pressurization of the SBWR containment, following a postulated severe accident, depends on the continued function of the PCC units, and this in turn on their aerosol behavior. The AIDA program is being set up to investigate these phenomena using a scaled down PCCS condenser, associated collection tanks simulating GDCS pool and the Wetwell and the existing aerosol generation facility. The facility is erected and is in commissioning phase.

In conclusion, it is considered that the various elements of the ALPHA program will greatly enhance the understanding of the response of the SBWR containment and other similar concepts to

Loss-Of-Coolant and other accidents, and will provide a large-scale experimental facility that can be used for similar studies of other reactor systems.

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